FUNCTION MODULE

DATA BOOK

NF Corporation

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Filters

LP: Low pass　HP: High pass　BP: Band pass　BE: Band elimination
BW: Band width　SIP: Single-inline package　DIP: Dual-inline package

Model	Type	Order	Rolloff	Attenuation characteristic	Cut-off (center) frequency setting: Range*1	Cut-off (center) frequency setting: Control type	Dimensions	Refer to
SR-4FL	LP	4	42dB/oct equivalent	Elliptic	40Hz to 100kHz	Resistor tunable	20-pin SIP	p6, p8 to 10
SRA-4FL1	LP	4	42dB/oct equivalent	Elliptic	40Hz to 1.6kHz	Resistor tunable	20-pin SIP	p7 to 10
SV-4FL*	LP	4	42dB/oct equivalent	Elliptic	10Hz to 100kHz	Resistor tunable	15-pin SIP	p4 to 5
SR-4FH	HP	4	42dB/oct equivalent	Elliptic	40Hz to 5kHz	Resistor tunable	20-pin SIP	p6, p8 to 10
SRA-4FH1	HP	4	42dB/oct equivalent	Elliptic	40Hz to 1.6kHz	Resistor tunable	20-pin SIP	p7 to 10
SR-4BL	LP	4	24dB/oct	Butterworth	40Hz to 100kHz	Resistor tunable	20-pin SIP	p6, p8 to 10
SRA-4BL1	LP	4	24dB/oct	Butterworth	40Hz to 1.6kHz	Resistor tunable	20-pin SIP	p7 to 10
SV-4BL*	LP	4	24dB/oct	Butterworth	10Hz to 100kHz	Resistor tunable	15-pin SIP	p4 to 5
SR-4BH	HP	4	24dB/oct	Butterworth	40Hz to 5kHz	Resistor tunable	20-pin SIP	p6, p8 to 10
SRA-4BH1	HP	4	24dB/oct	Butterworth	40Hz to 1.6kHz	Resistor tunable	20-pin SIP	p7 to p10
SR-1BP	BP	2(1-pole pair)	6dB/oct BW	Butterworth	40Hz to 10kHz	Resistor tunable	20-pin SIP	p6, p8 to 10
SR-2BP	BP	4(2-pole pair)	12dB/oct BW	Butterworth	40Hz to 10kHz	Resistor tunable	20-pin SIP	p6, p8 to 10
SRA-2BP1	BP	4(2-pole pair)	12dB/oct BW	Butterworth	40Hz to 1.6kHz	Resistor tunable	20-pin SIP	p7 to 10
SR-2BE	BE	4(2-pole pair)	Max. attenuation: 60dB	Butterworth	40Hz to 10kHz	Resistor tunable	20-pin SIP	p6, p8 to 10
SR-2BLH	LP, HP	2	12dB/oct	Butterworth	40Hz to 100kHz	Resistor tunable	20-pin SIP	p6, p8 to 10

* Supply voltage: 5V, 3.3V single power for SV Series

Model	Description				Range	Control type	Dimensions	Refer to
RD-404	Logic frequency setting is available with the combination use of SR and SRA filters. (Filter characteristics of SR and SRA filters applied)				10Hz to 16.9kHz	Digital tunable	20-pin SIP	p11

Model	Type	Order	Rolloff	Attenuation characteristic	Range*1	Control type	Dimensions	Refer to
HR-4FL	LP	4	42dB/oct equivalent	Elliptic	10Hz to 100kHz	Resistor tunable	24-pin DIP	p12 to 15
HR-4FH	HP	4	42dB/oct equivalent	Elliptic	10Hz to 50kHz	Resistor tunable	24-pin DIP	p12 to 15
HR-4BL	LP	4	24dB/oct	Butterworth	10Hz to 100kHz	Resistor tunable	24-pin DIP	p12 to 15
HR-4BH	HP	4	24dB/oct	Butterworth	10Hz to 50kHz	Resistor tunable	24-pin DIP	p12 to 15
HR-2BP	BP	4(2-pole pair)	12dB/oct BW	Butterworth	10Hz to 50kHz	Resistor tunable	24-pin DIP	p12 to 15
RT-8FLA	LP	8	135dB/oct equivalent	Elliptic	10Hz to 20kHz	Resistor tunable	40-pin DIP	p16, p17
RT-8FLB	LP	8	100dB/oct equivalent	Elliptic	10Hz to 20kHz	Resistor tunable	40-pin DIP	p16, p17
RT-3BP	BP	6(3-pole pair)	1/3oct BW	Butterworth	10Hz to 20kHz	Resistor tunable	40-pin DIP	p16, p17
VT-4BLA	LP	4	24dB/oct	Butterworth	100Hz to 100kHz	Voltage tunable	40-pin DIP	p18, p19
VT-4BHA	HP	4	24dB/oct	Butterworth	20Hz to 20kHz	Voltage tunable	40-pin DIP	p18, p19
VT-2BP	BP	4(2-pole pair)	12dB/oct BW	Butterworth	20Hz to 20kHz	Voltage tunable	40-pin DIP	p18, p19
DT-212D	LP, HP, BP	2(1-pole pair)	12dB/oct (HP/LP) 6dB/oct (BP)	Universal	1Hz to 159.9kHz	Digital tunable	40-pin DIP	p20 to 22
DT-408D	LP, HP, BP	2(1-pole pair)	12dB/oct × 2 (HP/LP) 6dB/oct × 2 (BP)	Universal	1kHz to 159kHz	Digital tunable	40-pin DIP	p23 to 26
DT-208D	LP, HP, BP	2(1-pole pair)	12dB/oct (HP/LP) 6dB/oct (BP)	Universal	10kHz to 1.59MHz	Digital tunable	40-pin DIP	p27
DT-5FL	LP	5	60dB/oct equivalent	Elliptic	10Hz to 20kHz	Digital tunable	40-pin DIP	p28, p29
DT-6FL	LP	6	80dB/oct equivalent	Elliptic	10Hz to 20kHz	Digital tunable	40-pin DIP	p28, p29
DT-8FL	LP	8	130dB/oct equivalent	Elliptic	20Hz to 100kHz	Digital tunable	60-pin DIP	p30, p31
DV Series*2	LP, HP, BP, BE	2(1-pole pair) to 8 (4-pole pair)	18dB/oct to 200dB/oct(LP) 18dB/oct to 75dB/oct(HP) 12dB/oct BW to 36dB/oct BW(BP) Max. attenuation: 26 to 72dB (BE)	Butterworth, Chebyshev, Elliptic, Universal	0.01Hz to 20kHz	Frequency fixed		p32 to 35
CF Series*2	LP, HP, BP, BE	2(1-pole pair) to 8 (4-pole pair)	18dB/oct to 300dB/oct(LP/HP) 12dB/oct BW to 36dB/oct BW(BP) Max. attenuation: 26 to 72dB (BE)	Butterworth, Chebyshev, Elliptic, Universal	1Hz to 100kHz	Frequency fixed	28-pin DIP, DIP 40-pin	p36 to 38
SD-1BE	BE	2(1-pole pair)	Max. attenuation: 24dB	Butterworth	50Hz/60Hz	Digital tunable	20-pin SIP	p39
CF-4FPA	BP	8(4-pole pair)	Min.: 15dB (±200Hz) Min.: 45dB (300Hz)	Elliptic	800Hz to 2800Hz	Frequency fixed	40-pin DIP	p40
SF-8FLC-1	LP	8	Max.: –25dB (8kHz), Max.: –50dB (9kHz), Max.: –70dB (14kHz)		7kHz	Frequency fixed	20-pin SIP	p41

*1 Types are determined by the frequency range. E.g.: SR-4FL2 (Type 2) → 400Hz to 20kHz
Some models allow frequency expansion with the adoption of external components.
*2 These filters can be customized to your specifications including the cut-off (center) frequency and filter characteristics that you select from our existing filter characteristics.

Amplifiers

Model	Input configuration	Gain	Frequency	Impedance	Voltage noise (typ.)	Current noise (typ.)	Dimensions	Refer to
CA-251F4	Single-end FET	× 100 fixed	DC to 10MHz	1MΩ	1.4nV/$\sqrt{Hz}$	150fA/$\sqrt{Hz}$	20-pin shielded SIP	p42, p43
CA-261F2	Single-end bipolar	× 100 fixed	DC to 200kHz	100kΩ	0.8nV/$\sqrt{Hz}$	1.5pA/$\sqrt{Hz}$	20-pin shielded SIP	p46, p47
CA-206L2	Single-end FET	× 1 to 100 (variable)	DC to 500kHz	1MΩ	7nV/$\sqrt{Hz}$	–	20-pin SIP	p52, p53
CA-451F4	Differential FET	× 100 fixed	DC to 10MHz	2GΩ	2.5nV/$\sqrt{Hz}$	100fA/$\sqrt{Hz}$	20-pin shielded SIP	p44, p45
CA-461F2	Differential bipolar	× 100 fixed	DC to 200kHz	100kΩ	1.5nV/$\sqrt{Hz}$	2.5pA/$\sqrt{Hz}$	20-pin shielded SIP	p48, p49
CA-406L2	Differential FET	× 1 to 100 (variable)	DC to 200kHz	30GΩ	27nV/$\sqrt{Hz}$	–	20-pin SIP	p50, p51
CA-102R3	Inverting amplifier	Connected with 2 external resistors	DC to 10MHz	–	–	–	12-pin SIP	p55
CA-903N	Adapter to enable CA-206L2/406L2 setting in binary code (endowed with latching functions)							p54

• Low Noise Amplifier

Model	Input configuration	Gain	Frequency	Impedance	Voltage noise (typ.)	Current noise (typ.)	Dimensions	Refer to
SA-220F5	Single-end FET	46dB	300Hz to 100MHz	1MΩ	0.5nV/$\sqrt{Hz}$	200fA/$\sqrt{Hz}$	68 × 43 × 28mm*	p56
SA-230F5	Single-end	46dB	400Hz to 140MHz	50Ω	0.25nV/$\sqrt{Hz}$	5.0pA/$\sqrt{Hz}$	68 × 43 × 17.6mm*	p56
SA-430F5	Differential	46dB	400Hz to 110MHz	50Ω	0.35nV/$\sqrt{Hz}$	7.0pA/$\sqrt{Hz}$	68 × 43 × 28mm*	p56
SA-200F3	Single-end	40dB	DC to 800kHz	1k/10k/100kΩ	0.5nV/$\sqrt{Hz}$	2.2pA/$\sqrt{Hz}$	68 × 43 × 17.6mm*	p57
SA-400F3	Differential	40dB	DC to 700kHz	1k/10k/100kΩ	0.75nV/$\sqrt{Hz}$	3.0pA/$\sqrt{Hz}$	68 × 67 × 28mm*	p57

* Excluding protruding sections

Oscillators

Model	Output waveform	Frequency range	Output voltage	Frequency setting	Dimensions	Refer to
CG-102R1	Sinewave	20Hz to 20kHz	2.5Vrms (variable)	2 external resistors connected	24-pin DIP	p62 to 64
CG-102R2	Sinewave	1kHz to 100kHz	2.5Vrms (variable)	2 external resistors connected	24-pin DIP	p62 to 64
CG-202R3	Sinewave	100kHz to 1MHz	2.5Vrms (variable)	2 external resistors connected	24-pin DIP	p60, p61
CG-302R1	Sinewave	20Hz to 20kHz	2.5Vrms (variable)	2 external resistors connected	20-pin SIP	p62 to 64
CG-302R2	Sinewave	1kHz to 100kHz	2.5Vrms (variable)	2 external resistors connected	20-pin SIP	p62 to 64
CG-402R1	Sinewave	20Hz to 20kHz	2.5Vrms (variable)	2 external resistors connected	12-pin SIP	p58, p59
CG-402R2	Sinewave	1kHz to 100kHz	2.5Vrms (variable)	2 external resistors connected	12-pin SIP	p58, p59
OP-102 + DT-212	Sinewave	1Hz to 159.9kHz	2.5Vrms (variable)	BCD: 3 digits	20-pin SIP	p65 to 67
CG-742N	Random binary	–	±5V	1 external resistor connected/ external clock	40-pin DIP	p69 to 71
CG-742N + LPF	White noise	–	–	1 external resistor connected/ external clock	40-pin DIP	p69 to 71

Phase Detectors

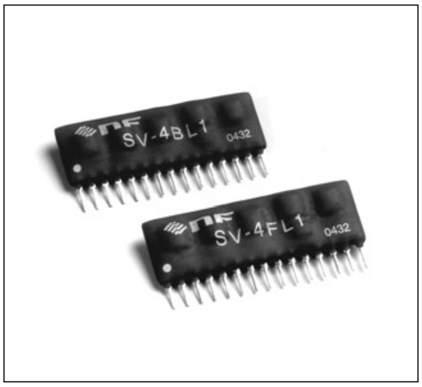
Model	Frequency range	Input amplifier	Detection system	LPF	Gain	Reference signal	Phase shifter	Dimensions	Others	Refer to
CD-552R3	1kHz to 200kHz, × 1	Single-end	Square-wave multiplication	1-pole to 1kHz	× 1 to 10	C-MOS(0/5V)	0/90°	20-pin shielded SIP	2f detection available	p72 to 76
CD-552R4	10kHz to 2MkHz, × 1	Single-end	Square-wave multiplication	1-pole to 10kHz	× 1 to 10	C-MOS(0/5V)	0/90°	20-pin shielded SIP	2f detection available	p72 to 76
CD-505R2	10Hz to 10kHz	Differential, × 1 (band pass embedded)	Square-wave multiplication	1/2-pole to 1kHz	× 1	C-MOS(0/5V)	90°±45° continuous variable	40-pin DIP	Post amplifier available as a phase shifter or signal amplifier	p80 to 84

Voltage Controlled Phase Shifter (for reference signal)

Model	Frequency range	Amount of phase shift	I/O voltage	Refer to
CD-951V4	1kHz to 2MHz	0°/180° switchable, ±90° continuous variable	C-MOS (0/5V)	p77 to 79

Resistor Tunable Filter

SV-4BL1 SV-4BL2 SV-4FL1 SV-4FL2



SV series filters are resistor tunable low-pass filters that are powered by 5V or 3.3V of single supply voltage. The setting of cutoff frequency is facilitated with the external resistors (4 pcs.). Butterworth and Elliptic are incorporated into filter characteristics, and the filters fall into two types (Type 1 and Type 2) according to the frequency range. The downsizing of filters has been achieved to actualize a 15-pin single-inline package (SIP).

SV4BL1/2 : 4-pole Butterworth slow pass
SV4FL1/2 : 4-pole elliptic low pass

Model	SV-4BL1	SV-4FL1	SV-4BL2	SV-4FL2
Filter characteristics	Butterworth low pass	Elliptic low pass	Butterworth low pass	Elliptic low pass
Order	4-pole			

▼Absolute maximum ratings

Supply voltage	6V			
Input voltage	Supply voltage or less			

▼Cut-off frequency (fc)

Range*1	10Hz to 10kHz		100Hz to 100kHz	
Accuracy*2	±3%			
Setting method	Connected with external resistors (4 pcs.)			

▼Pass-band characteristic

Gain*3	0±0.3dB			
Ripple	–	0.28dBP-P typ.	–	0.28dBP-P typ.

▼Attenuation characteristics

Rolloff	24dB/oct	42dB/oct equivalent	24dB/oct	42dB/oct equivalent
Attenuation characteristics (2fc)	24dB typ.	55dB typ.	24dB typ.	55dB typ.
Minimum attenuation	–	46dB typ.	–	46dB typ.
High frequency attenuation (up to 1MHz)	Min. 60dB			

▼Input characteristics

Input impedance	Min. 50kΩ			
Maximum input voltage	5V			
Minimum input voltage	0V			

▼Output characteristics

Output impedance	Max. 100Ω			
Maximum output voltage	Min. 4.9V			
Minimum output voltage	Max. 100mV			
Load resistance	Min. 10kΩ			
Voltage noise	Max. 100μVrms			
Distortion*4	0.01% typ.			
Offset voltage*5	±30mV typ.			
Offset drift	30μV/°C typ.			
Mid-potential output accuracy*6	±1%			

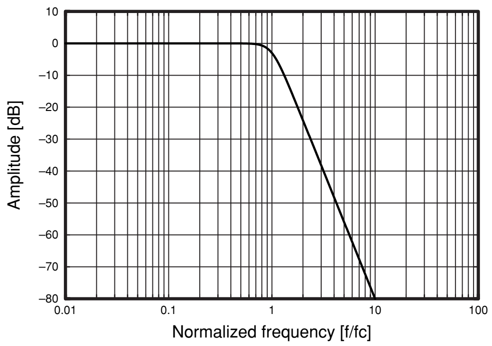
▼Others

Supply voltage	5V (3V to 5.5V)			
Quiescent current	10mA typ.			
Available temperature/ humidity range	–20°C to 70°C, 10 to 95%RH			
Storage temperature/ humidity range	–30°C to 80°C, 10 to 80%RH			
Dimensions	39×15×5.5mm (15pin), Model S15			

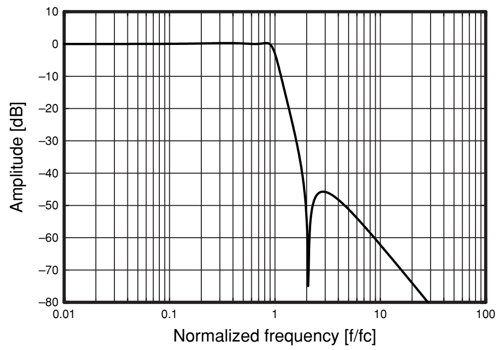
Note: The following specifications are applied unless otherwise specified: R_F= 31.8kΩ, Power: 5V, Mid-potential: 2.5V, Load: 10kΩ, Ambient temp.: 23±5°C
*1: As to SV series, expansion of the lower cut-off (center) frequency with the external capacitors is disabled. *2: –3dB derived with reference to fc/10 *3: Gain in fc/10
*4: Distortion in fc/10 *5: Drift from mid-potential (adjustable with a trimming resistor) *6: Mid-potential output is a supply voltage/2.

Characteristics

SV-4BL1/2

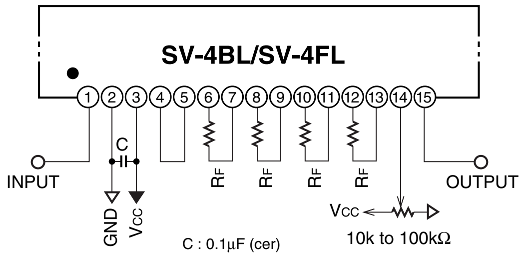


SV-4FL1/2



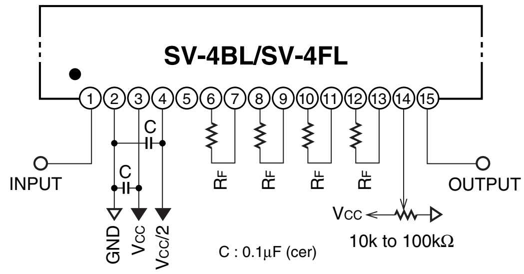
Connection diagram

Example 1 (basic connection)



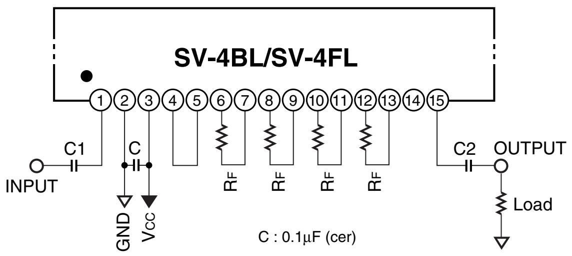
* This circuit is used for normal connection. Pin 14 needs to be disconnected if no offset calibration is required.

Example 2 (when the mid-potential is externally input)



* Noise superimposed in the mid-potential exerts effects on noise characteristics if the mid-potential is externally input.
* If the mid-potential is assigned to the prior and subsequent circuits, this circuit is used. Pin 14 needs to be disconnected if no offset calibration is required.

Example 3 (when input and output are AC-coupled)



* This circuit is used to DC-interrupt the prior and subsequent circuits. Pin 14 needs to be disconnected if no offset calibration is required.

• Calculation of coupling capacitor

Input : $C1\ [\mu F] = \dfrac{3.18}{fch\ [Hz]}$

Output : $C2\ [\mu F] = \dfrac{159}{Load\ [k\Omega] \cdot fch\ [Hz]}$

fch: Coupling frequency (–3dB)

–6dB is gained in coupling frequency (fch) if the coupling frequencies for input and output are equal.
fch: Set at 1/10 or less of cut-off frequency (fc)

■*Cut-off frequency setting*

• Equation of external resistor R_F

Type 1 $R_F\ [k\Omega] = \dfrac{15.9 \times 10^3}{fc\ [Hz]}$

Type 2 $R_F\ [k\Omega] = \dfrac{159 \times 10^3}{fc\ [Hz]}$

Note: Resistance error results in cut-off frequency error and a deterioration of filter characteristics.
Be sure to use a resistor with tolerance of 1%.
R_F: 1.6kΩ to 1.6MΩ

Filters

Resistor Tunable Filter

SR-4BL/4FL SR-4BH/4FH SR-2BLH SR-1BP/2BP SR-2BE

SR series filters are ultrasmall resistor tunable filters in single-inline package (SIP). An easy setting of cutoff (center) frequency is assured with the external resistors. The abundance of filter types extends the range of choices.

- SR-4BL1/2/3: 4-pole Butterworth low pass
- SR-4FL1/2/3: 4-pole elliptic low pass
- SR-4BH1/2: 4-pole Butterworth high pass
- SR-4FH1/2: 4-pole elliptic high pass
- SR-2BLH1/2/3: 2-pole Butterworth low/high pass
- SR-1BP1/2: 1-pole pair band pass
- SR-2BP1/2: 2-pole pair band pass
- SR-2BE1/2: 2-pole pair band elimination

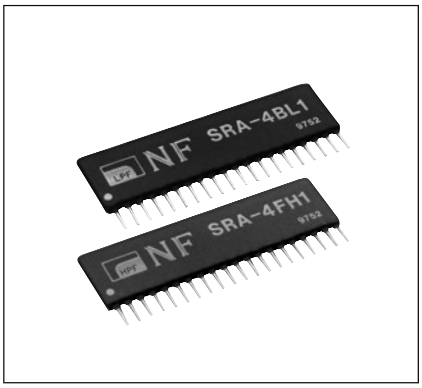
Model	SR-4BL	SR-4FL	SR-4BH	SR-4FH	SR-2BLH	SR-1BP	SR-2BP	SR-2BE
Filter characteristics	Butterworth low pass	Elliptic low pass	Butterworth high pass	Elliptic high pass	Butterworth low/high pass	Butterworth band pass	Butterworth band pass	Butterworth band elimination
Order	4-pole				2-pole	1-pole pair	2-pole pair	2-pole pair
▼Absolute maximum ratings								
Supply voltage(±Vs)	±18V							
Input voltage	±Vs							
▼Cut-off (fc, -3dB)/center (fo) frequency characteristics								
Range — Type 1	40Hz to 1.6kHz*1							
Range — Type 2	400Hz to 20kHz*1		400Hz to 5kHz*1		400Hz to 20kHz*1	400Hz to 10kHz*1		
Range — Type 3	5kHz to 100kHz*1		–		5kHz to 100kHz*1	–		
Accuracy*2	Max. ±3%							
Setting method	Connected with external resistors (4 pcs.)				Connected with external resistors (2 pcs.)	Connected with external resistors (4 pcs.)		
▼Pass-band characteristic								
Gain*3	0±0.3dB		0±1dB		0±0.3dB	0±1dB		0±0.3dB
Ripple	–	0.28dBP-P(typ)	–	0.28dBP-P(typ)	–			
Upper limit frequency (small signal)*2	–		50kHz(±1dB)		100kHz (±1dB, HPF)*5	–		50kHz(±1dB)
▼Attenuation characteristics								
Rolloff	24dB/oct	42dB/oct equiv.	24dB/oct	42dB/oct equiv.	12dB/oct	–		
Q	–					5*4		
Attenuation characteristics (1/2fc or 2fc)	24dB(typ)	55dB(typ)	24dB(typ)	55dB(typ)	12dB(typ)	17.5dB(typ)	35dB(typ)	–
Minimum attenuation	–	46dB(typ)	–	46dB(typ)	–			
High frequency attenuation (up to 1MHz)	Min. 70dB		–		Min. 70dB(LPF)	Min. 70dB		–
Maximum attenuation (fo)	–							60dB(typ)
▼Input characteristics								
Input impedance	Min. 50kΩ							
Maximum input voltage (linear) — ≤10kHz	±10V							
Maximum input voltage (linear) — ≤50kHz	±5V, ±10V for 4BL3/4FL3/2BLH3 filters							
▼Output characteristics								
Output impedance	Max. 100Ω							
Maximum output voltage	±10V (Max.100kHz for 4BL3/4FL3/2BLH3 filters, Max.10kHz for other filters)							
Load resistance	Min. 10kΩ							
Voltage noise	Max. 140µVrms (10Hz to 500kHz)							
DC offset — Voltage	Max. ±30mV							
DC offset — Adjustment	Enabled							
DC offset — Drift	30µV/°C (typ)		15µV/°C (typ)					30µV/°C (typ)
Distortion*3 (typ)	0.01%		0.1%		0.01% (LPF)	0.01%		
Slew rate (typ)	–		2V/µs*6			–		2V/µs
▼Others								
Supply voltage	±15V (±5 to ±18V)							
Quiescent current (typ)	±12mA (Types 1&2) ±27mA (Type 3)	±16mA (Types 1&2) ±36mA (Type 3)	±8mA	±16mA	±8mA (Types 1&2) ±18mA (Type 3)	±8mA	±12mA	±20mA
Temperature/humidity range — Operation	–20°C to 70°C, 10 to 95%RH							
Temperature/humidity range — Storage	–30°C to 80°C, 10 to 80%RH							
Dimensions	51.5 × 14mm, S20 type, 5.5mm in thickness for Type 3 and 2BE filter, 4mm in thickness for other filters							

Note: The following specifications are applied unless otherwise specified: Rf= 31.8kΩ, 23±5°C, ±15V

*1: As to SR series, expansion of the lower cut-off (center) frequency with the external capacitors (2 or 4 pcs.) is enabled. *2: Gain in frequency (*3): 0dB *3: 4FL, 4BL: fc/10, 4FH: 10fc(fc≤3kHz), 3.3fc(fc>3kHz), 4BH:3.3fc, 2BLH:LPF→fc/10, HPF→10fc(Types 1&2), 3.3fc(Type 3) *4: As to 1BP filter, Q = 10, 20, 30, 40, or 50 is available if a designated pin is connected with GND. Range: 1.81≤Q≤50 if connected with the external resistors *5: Type 3: 1MHz+0, Max. –3dB (HPF) *6: SR-2BLH3 (only): 10V/µs

Resistor Tunable Filter

SRA-4BL1 SRA-4BH1 SRA-4FL1 SRA-4FH1 SRA-2BP1



SRA series filters are power-thrifty resistor tunable filters actualizing the reduction in quiescent current to 1 to 2mA that is 1/10 of the current SR series filters. SRA series filters maintain pin-compatible with SR series filters (see P8) and become capable of operation at min. ±2.5V of supply voltage that allows low power consumption as necessary.

Butterworth and elliptic low pass and high pass, and Butterworth band pass are incorporated into filter characteristics. An easy setting of cutoff (center) frequency is assured with the external resistors as with SR series filters, which enables a low-pass expansion with the external capacitors.

Model	SRA-4BL1	SRA-4FL1	SRA-4BH1	SRA-4FH1	SRA-2BP1
Filter characteristics	Butterworth low pass	Elliptic low pass	Butterworth high pass	Elliptic high pass	Butterworth band pass
Order	4-pole	4-pole	4-pole	4-pole	2-pole pair

▼Absolute maximum ratings

Supply voltage (±Vs)	±18V
Input voltage	±Vs

▼Cut-off (fc, -3dB)/center frequency characteristics

Range*1	40Hz to 1.6kHz
Accuracy*2	±3%
Setting method	Connected with external resistors (4 pcs.)

▼Pass-band characteristic

	SRA-4BL1	SRA-4FL1	SRA-4BH1	SRA-4FH1	SRA-2BP1
Gain*3	0±0.3dB	0±1dB	0±0.3dB	0±1dB	
Ripple	–	0.28dBp-p	–	0.28dBp-p(typ)	–
Upper limit frequency (small signal)*2	–		50kHz(±1dB)		–

▼Attenuation characteristics

	SRA-4BL1	SRA-4FL1	SRA-4BH1	SRA-4FH1	SRA-2BP1
Rolloff (typ)	24dB/oct	42dB/oct equivalent	24dB/oct	42dB/oct equivalent	12dB/octBW
Q (typ)	–	5			
Attenuation characteristics (1/2fc or 2fc) (typ)	24dB	55dB	24dB	55dB	35dB
Minimum attenuation (typ)	–	46dB	–	46dB	–
High frequency attenuation (up to 1MHz)	70dB		–		70dB

▼Input characteristics

Input impedance	Min. 50kΩ
Maximum input voltage	±10V

▼Output characteristics

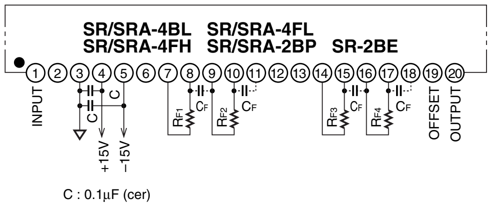
	SRA-4BL1	SRA-4FL1	SRA-4BH1	SRA-4FH1	SRA-2BP1
Output impedance	Max. 100Ω				
Maximum output voltage	±10V				
Load resistance	Min. 10kΩ				
Voltage noise	Max. 140µVrms		Max. 200µVrms	Max. 240µVrms	Max. 140µVrms
DC offset — Voltage	Max. ±30mV				
DC offset — Adjustment	Enabled				
DC offset — Drift	30µV/°C		15µV/°C		
Distortion*3 (typ)	0.01%		0.1%		0.01%
Slew rate (typ)	–		10V/µs		–

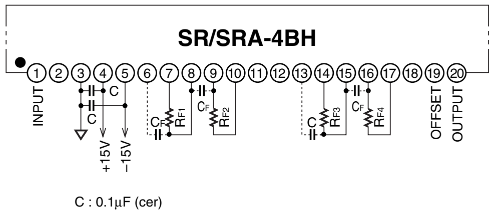
▼Others

	SRA-4BL1	SRA-4FL1	SRA-4BH1	SRA-4FH1	SRA-2BP1
Supply voltage	±2.5V to ±18V				
Quiescent current (typ)	±1.5mA	±2mA	±1mA	±2mA	±1.5mA
Temperature/humidity range — Operation	–20°C to 70°C, 10 to 95%RH				
Temperature/humidity range — Storage	–30°C to 80°C, 10 to 80%RH				
Dimensions	51.5 × 14 × 4mm, S20 type				

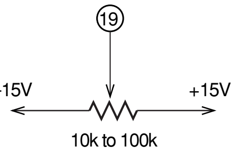
Note: The following specifications are applied unless otherwise specified: R_F= 31.8kΩ, 23±5°C, ±15V (some items may fail to meet specifications if used at other supply voltage) *1: Expansion of the lower cut-off (center) frequency with the external capacitors is enabled. *2: Gain in frequency (*3): 0dB *3: 4FL, 4BL: fc/10 4FH: 10fc 4BH: 3.3fc

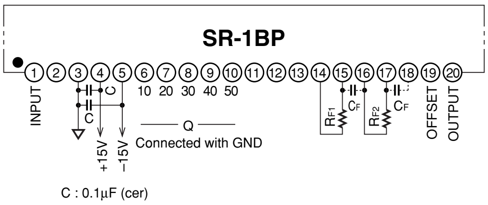
Basic connection diagram

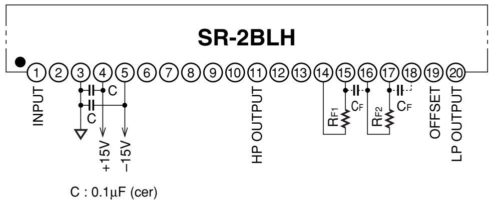




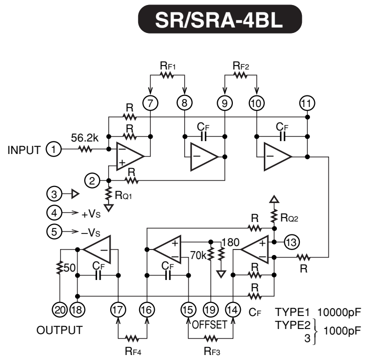
Offset voltage adjustment

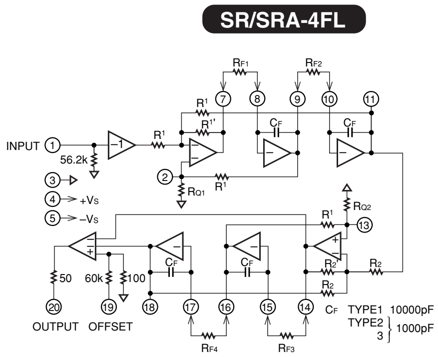


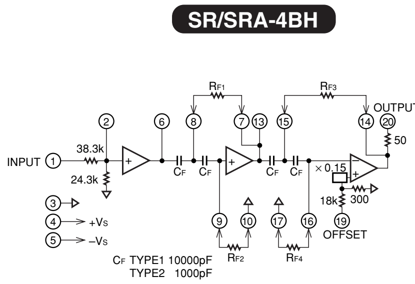


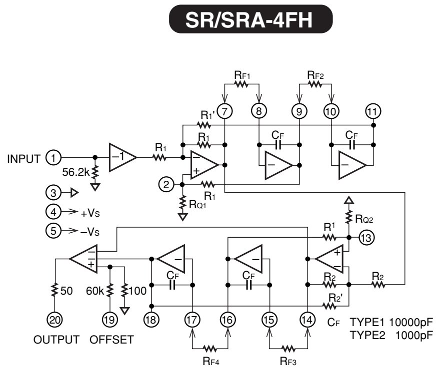


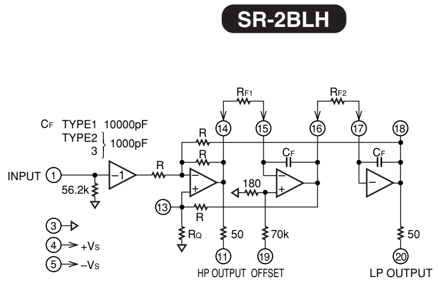
Block diagram

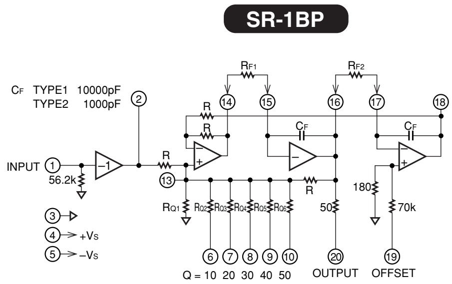


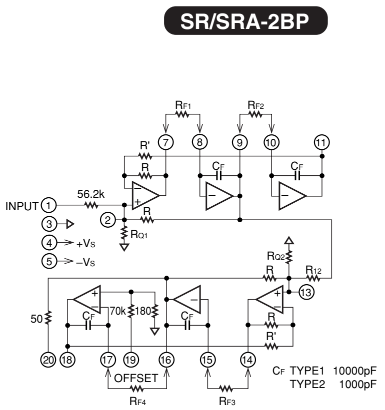


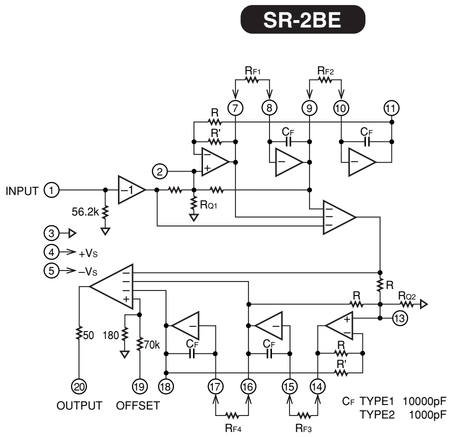












■*Cut-off (center) frequency setting*

- **Equation of external resistor R_F**

Type 1 $R_F = \dfrac{15.9 \times 10^3}{\text{fc or fo}}$ [kΩ]

Types 2&3 $R_F = \dfrac{159 \times 10^3}{\text{fc or fo}}$ [kΩ]

- **Equation of external resistor R_F for expansion of lower cut-off (center) frequency**

An external capacitor (C_F') is used.

Type 1 $R_F = \dfrac{159}{(C_F'+0.01) \times (\text{fc or fo})}$ [kΩ]

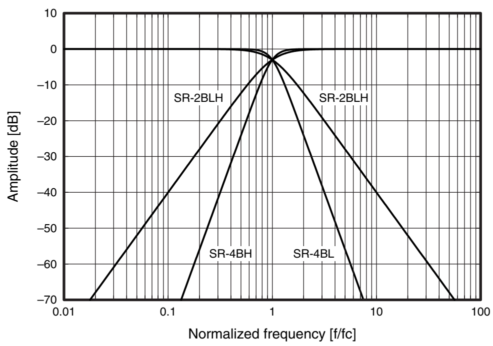
Types 2&3 $R_F = \dfrac{159}{(C_F'+0.001) \times (\text{fc or fo})}$ [kΩ]

Note: Units: fc or fo in Hz, C_F' in μF
R_F: 8k to 400kΩ (10k to 400kΩ for SRA series), 1.5k to 40kΩ for Type 3 filters
Be sure to use a resistor and capacitor with tolerance of 1%.

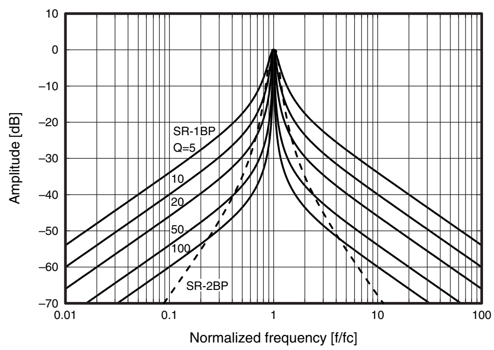
* SRA series carry Type 1 filters only.

Characteristics

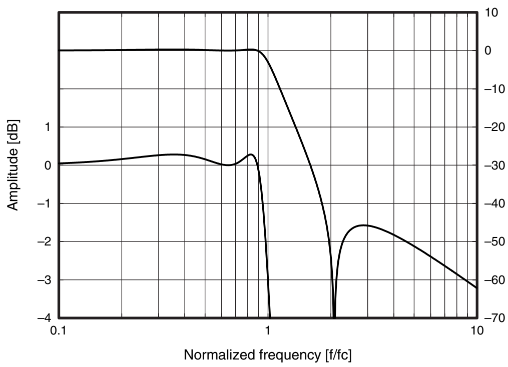
4BL/4BH/2BLH



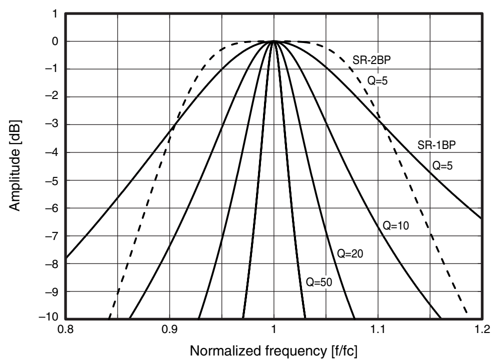
1BP/2BP



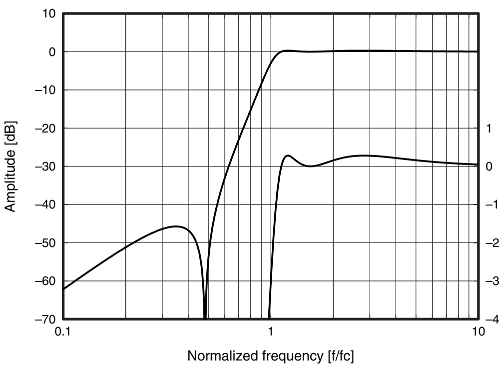
4FL



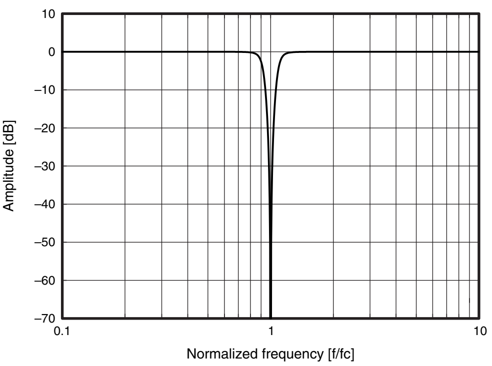
1BP/2BP(Magnified view)



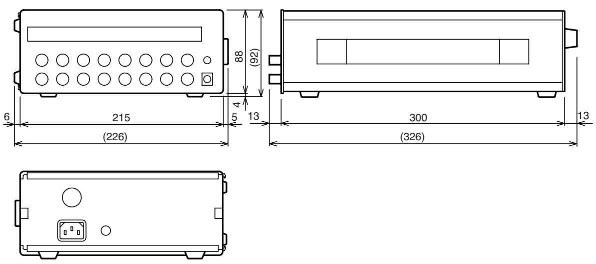
4FH



2BE



■*Multichannel Filter 3315*



Rear panel

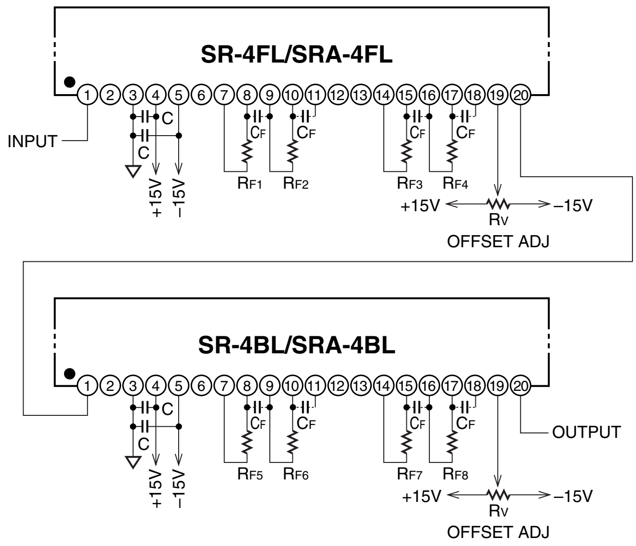
This 3315 is capable of storing up to 8 SR/SRA filters that is utilized as a fixed frequency-allocated multichannel filter.
Filter characteristics vary with type of filters to be stored.

Available filters	: All SR filters and SRA filters
Number of channels	: Max. 8
fc/fo setting	: Fixed resistors (2 or 4 pcs.) are soldered to the discrete platform (accessory) and connected to the socket.
Supply voltage	: AC100V, ±10%, 48Hz to 62Hz
Dimensions	: 215(W)×88(H)×300(D)mm (Protrusion not included)

Filters

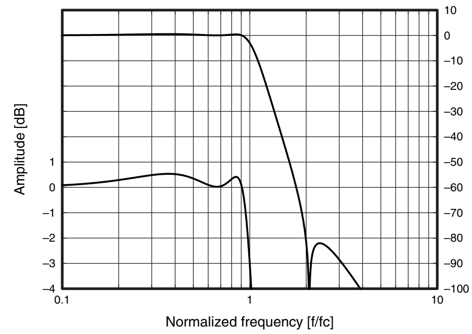
Application

8-pole low pass/ elliptic

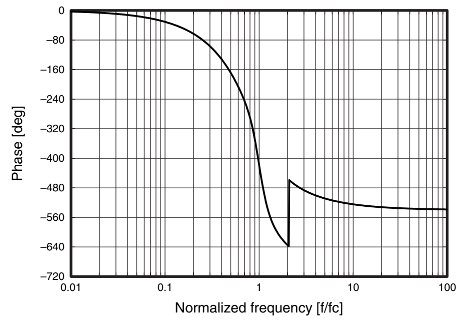


RV : 10 to 50kΩ
C : 0.1µF (cer)

Amplitude characteristics



Phase characteristics



- **Cut-off frequency setting (ripple: 0.53dB)**

External resistor (R_{F1} to R_{F8}) is derived from the following equation.

$R_{F1} = R_{F2} = R_{F3} = R_{F4} = R_F$

$R_{F5} = 1.801R_F$ $\quad R_{F6} = 1.221R_F$

$R_{F7} = 1.797R_F$ $\quad R_{F8} = 0.4788R_F$

Type 1 $\quad R_F = \dfrac{15.9 \times 10^3}{fc}$ (kΩ)

Type 2 $\quad R_F = \dfrac{159 \times 10^3}{fc}$ (kΩ)

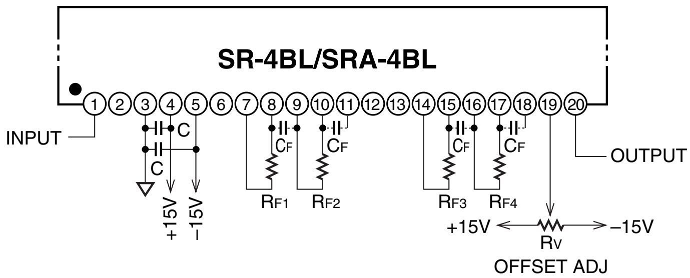
- **Equation of external resistor for expansion of lower cut-off frequency**

Type 1 $\quad R_F = \dfrac{159}{(C_F+0.01) \times fc}$ (kΩ)

Type 2 $\quad R_F = \dfrac{159}{(C_F+0.001) \times fc}$ (kΩ)

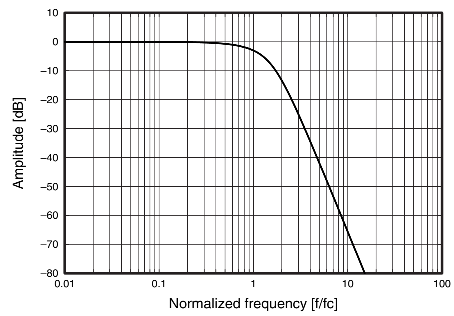
Note: Units: fc in Hz, C_F in µF
*SRA series carry Type 1 filters only.

4-pole low pass/ Bessel

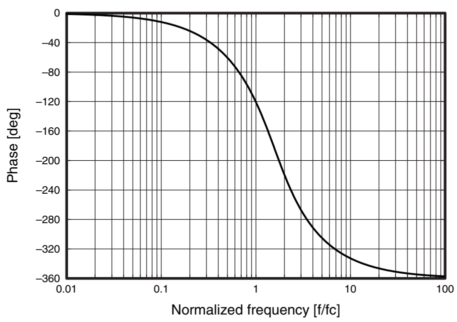


RV : 10 to 50kΩ
C : 0.1µF (cer)

Amplitude characteristics



Phase characteristics



- **Cut-off frequency setting**

External resistor (R_{F1} to R_{F4}) is derived from the following equation.

$R_{F1} = 0.673 \times R_F$ $\quad R_{F2} = 0.712 \times R_F$

$R_{F3} = 0.384 \times R_F$ $\quad R_{F4} = 1.014 \times R_F$

Type 1 $\quad R_F = \dfrac{15.9 \times 10^3}{fc}$ (kΩ)

Types 2&3 $\quad R_F = \dfrac{159 \times 10^3}{fc}$ (kΩ)

- **Equation of external resistor for expansion of lower cut-off frequency**

Type 1 $\quad R_F = \dfrac{159}{(C_F + 0.01) \times fc}$ (kΩ)

Types 2&3 $\quad R_F = \dfrac{159}{(C_F + 0.001) \times fc}$ (kΩ)

Note : Units: fc in Hz, CF in µF
*SRA series carry Type 1 filters only.

BCD Resistor

RD-404D1/2

RD-404D is a logic control resistor designed for SR/SRA series resistor tunable filters. The setting of cutoff (center) frequency under digital signals is enabled if RD-404D resistor is used in combination with SR/SRA series.

▼Absolute maximum ratings

Supply voltage (±Vs)	±18V
Input voltage	±Vs
Control voltage	+5.5V, –0.5V

▼Frequency setting mode

Mode	BCD 1 digit (0 to 15) BCD 1 digit + 1 (1 to 16, specified pin short ⑥-⑧, ⑩-⑪, ⑬-⑮, ⑰-⑱)

▼Frequency setting range

RD-404D1 (or RD-404D2) resistor + SR/SRA filters

SR/SRA type		Type 1		Type 2	
RD mode		BCD	BCD+1	BCD	BCD+1
RD-404D1	Min.	0Hz*	10Hz	0Hz*	100Hz
	Max.	150Hz	160Hz	1.5kHz	1.6kHz
	Resolution	10Hz	10Hz	100Hz	100Hz
RD-404D2	Min.	0Hz*	100Hz	0Hz*	1kHz
	Max.	1.5kHz	1.6kHz	15kHz	16kHz
	Resolution	100Hz	100Hz	1kHz	1kHz

* A voltage of 13V DC is present in filter output if 0Hz is selected.

Parallel connection of RD-404D1/2 resistors + SR/SRA filters

SR/SRA type		Type 1		Type 2	
RD mode	404D2	BCD	BCD+1	BCD	BCD+1
	404D1	BCD	BCD	BCD	BCD
Min.		0Hz*	100Hz	0Hz*	1kHz
Max.		1.59kHz	1.69kHz	15.9kHz	16.9kHz
Resolution		10Hz	10Hz	100Hz	100Hz

▼Frequency setting accuracy

Accuracy	±1% (for RD-404D only)

▼Control characteristics

Code	BCD: 1 digit (8, 4, 2, 1)
Logic and level	0V : ON +5V or open: OFF
Level input process (internal)	Pulled up to +5V at 100kΩ

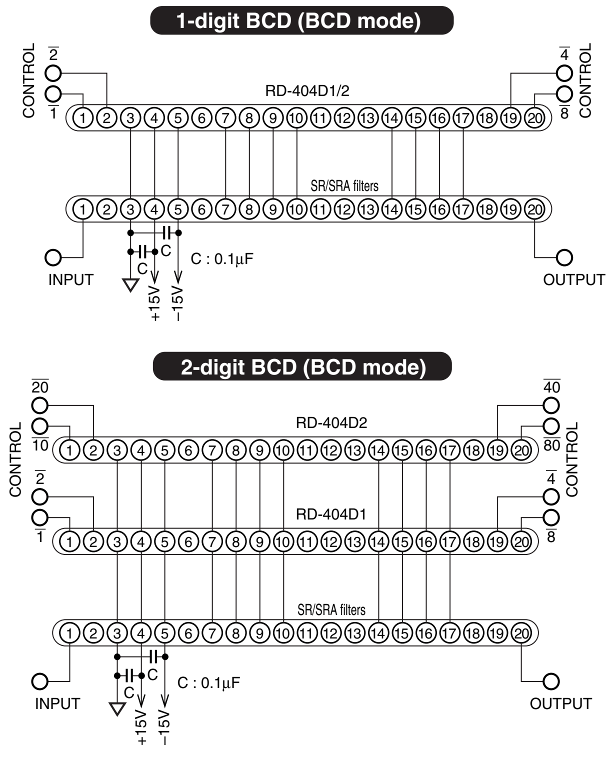
▼Others

Supply voltage		±15V (±5V to ±18V)
Quiescent current (typ)		+6.2mA, –1.2mA (typ)
Temperature/ humidity range	Operation	–20°C to 70°C, 10 to 95%RH
	Storage	–30°C to 80°C, 10 to 80%RH
Dimensions		51.5 × 14 × 4.0mm, S20 type

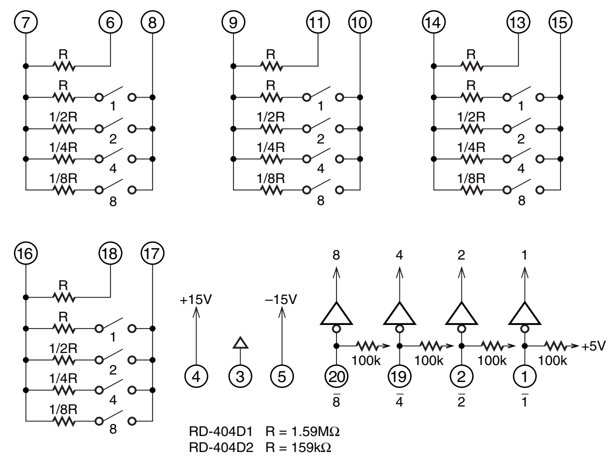
Note: The following specifications are applied unless otherwise specified:
23±5°C, Vs=±15V
SRA series carry Type 1 filters only.

* Potential effects on characteristics including gain and rolloff may be concerned depending on the type of SR/SRA filters to be combined with. (especially if connected in parallel)

Basic connection diagram

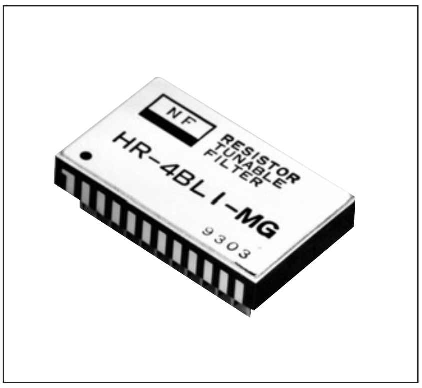


Block diagram



Resistor Tunable Filter

HR-4BL HR-4FL HR-4BH HR-4FH HR-2BP



HR series filters are resistor tunable filters that not only realize a wide operating temperature range but ensure high reliability through the adoption of the hermetic seal method and ceramic packaging. An easy setting of cutoff (center) frequency is assured with four external resistors of the same resistance.
4-pole Butterworth and elliptic low pass and high pass, and 2-pole Butterworth band pass are incorporated into filter characteristics.
The setting range of cutoff (center) frequency falls into two types: Type 1 (10Hz to 1.6kHz) and Type 2 (100Hz to 100kHz (50kHz)).
The operating temperature range is selectable, –40°C to 85°C (most of industrial request) or –55°C to 125°C (MIL-STD).
Screening meets MIL-STD and special reliable tests are available on request.

Model

HR–□□□□–□G–B2

①　②　③　④ (can be specified only if "M" is assigned to ③)

①Filter characteristics
- 4BL: 4-pole Butterworth low pass filter
- 4FL: 4-pole Elliptic low pass filter
- 4BH: 4-pole Butterworth high pass filter
- 4FH: 4-pole Elliptic high pass filter
- 2BP: 2-pole pair Butterworth band pass filter

②Cutoff (center) frequency setting range
- 1: 10Hz to 1.6kHz
- 2: 100Hz to 100kHz (50kHz)

③Operating temperature range
- E: –40°C to 85°C
- M: –55°C to 125°C

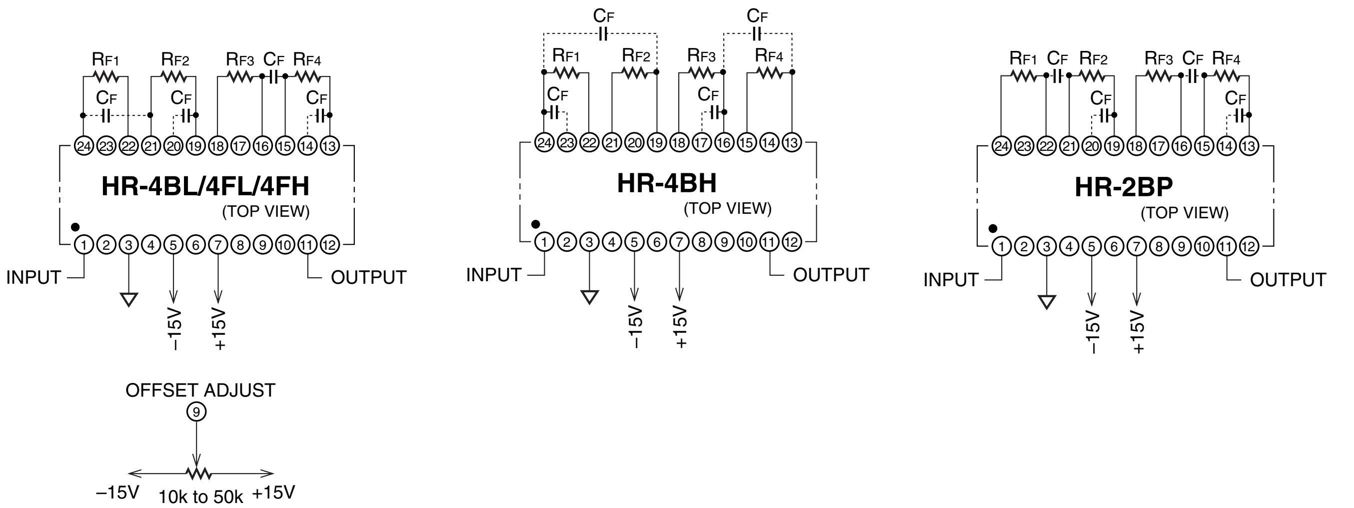
④Reliability level
- B2: Conduct screening

Screening

Item	Applicable standard	Product reliability level	
	MIL-STD-883	MG-B2*	MG, EG
Internal visual	2017	○	○
Stabilization bake	1008 Condition C	○	–
Temperature cycling	1010 Condition C	○	○
Constant acceleration	2001 Condition A, in Y1 direction	○	–
Pre burn-in	According to specifications 23°C	○	–
Burn-in	1015 85°C 160H	○	○ (48 hrs)
Final electrical test	Tests at normal, maximum, and minimum operating temperatures according to specifications	○	○ (23°C only)
Seal	1014 Fine & Gross	○	○
External visual	2009	○	○

* Screened if an order for 10 or more filters is received.

Basic connection diagram



▼Absolute maximum ratings

Supply voltage (±Vs)		±18V
Input voltage		±Vs
Load		2kΩ
Temperature/range	Operation	HR-XXXX-EG : –40°C to +85°C, HR-XXXX-MG : –55°C to +125°C
	Storage	–65°C to +150°C

* Critical damage to products is resulted from the application of physical stress that exceeds the absolute maximum ratings. Long-term operation at the maximum ratings leads to considerable degradation in device reliability. The absolute maximum ratings are the rating of stress, which has no assurance of device proper performance under the condition that the specified electrical performance range and maximum ratings are violated.

Model	HR-4BL1/2	HR-4FL1/2	HR-4BH1/2	HR-4FH1/2	HR-2BP1/2
Filter characteristics	4-pole Butterworth low pass	4-pole Elliptic low pass	4-pole Butterworth high pass	4-pole Elliptic high pass	2-pole pair Butterworth band pass

▼Cut-off (fc, -3dB)/center (fo) frequency characteristics

		HR-4BL1/2	HR-4FL1/2	HR-4BH1/2	HR-4FH1/2	HR-2BP1/2
Range*1	Type 1	10Hz to 1.6kHz				
	Type 2	100Hz to 100kHz		100Hz to 50kHz		
Setting method		Connected with external resistors (4 pcs.)				
Accuracy		Max. ±3%				

▼Pass-band characteristic

		HR-4BL1/2	HR-4FL1/2	HR-4BH1/2	HR-4FH1/2	HR-2BP1/2
Gain	fc<20kHz	0±0.3dB		0±0.5dB		0±1dB
	fc≥20kHz	0±0.3dB		0±1dB		0±2dB
Ripple		–	0.28dB$_{P-P}$ typ	–	0.28dB$_{P-P}$ typ	–
Upper limit frequency	Type 1	–	–	100kHz(±1dB)		–
	Type 2	–	–	400kHz(±1dB)		–

▼Attenuation characteristics

	HR-4BL1/2	HR-4FL1/2	HR-4BH1/2	HR-4FH1/2	HR-2BP1/2
Rolloff	24dB/oct	42dB/oct equivalent	24dB/oct	42dB/oct equivalent	12dB/oct BW
Q	–	–	–	–	5±5%
Attenuation characteristics*2	24dB typ	55dB typ	24dB typ	55dB typ	35dB typ
Minimum attenuation	–	46dB typ	–	46dB typ	–
High frequency attenuation (up to 1MHz)	Min. 70dB	Min. 60dB	–	–	Min. 60dB

▼Input characteristics

Input voltage range	±10V
Input impedance	Min. 50kΩ

▼Output characteristics

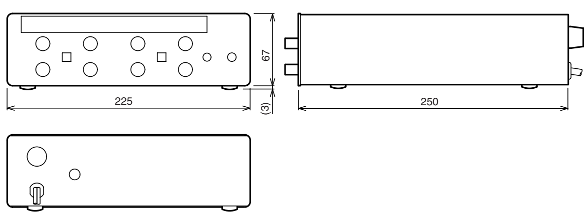
		HR-4BL1/2	HR-4FL1/2	HR-4BH1/2	HR-4FH1/2	HR-2BP1/2
Output voltage range		±10V				
Output impedance		Max. 100Ω				
Load resistance		Min. 10kΩ				
Offset voltage*3		Max. ±30mV				
Offset drift		5µV/°C typ	16µV/°C typ	10µV/°C typ	5µV/°C typ	5µV/°C typ
Noise	Type 1	40µVrms typ	90µVrms typ	120µVrms typ	190µVrms typ	50µVrms typ
	Type 2	35µVrms typ	60µVrms typ	100µVrms typ	140µVrms typ	45µVrms typ
Distortion	Type 1	0.004% typ	0.01% typ	0.02% typ	0.02% typ	0.004% typ
	Type 2	0.003% typ	0.005% typ	0.02% typ	0.02% typ	0.002% typ
Slew rate	Type 1	–	–	10V/µs typ	10V/µs typ	–
	Type 2	–	–	25V/µs typ	25V/µs typ	–

▼Others

		HR-4BL1/2	HR-4FL1/2	HR-4BH1/2	HR-4FH1/2	HR-2BP1/2
Supply voltage		±15V				
Supply voltage range	Type 1	±1.5V to ±18V				
	Type 2	±5V to ±18V				
Quiescent current	Type 1	±1.5mA typ	±2mA typ	±1mA typ	±2mA typ	±1.5mA typ
	Type 2	±15mA typ	±20mA typ	±10mA typ	±20mA typ	±15mA typ
Dimensions		20 × 33 × 7mm (lead excluded) (24-pin DIP), KC type				

*1: Expansion of the lower cut-off (center) frequency with the external capacitors (4 pcs.) is enabled. *2: Attenuation for low pass and band pass: 2fc, for high pass: 1/2fc
*3: Zero adjustment available

■*Multichannel Filter 3314*



Rear panel

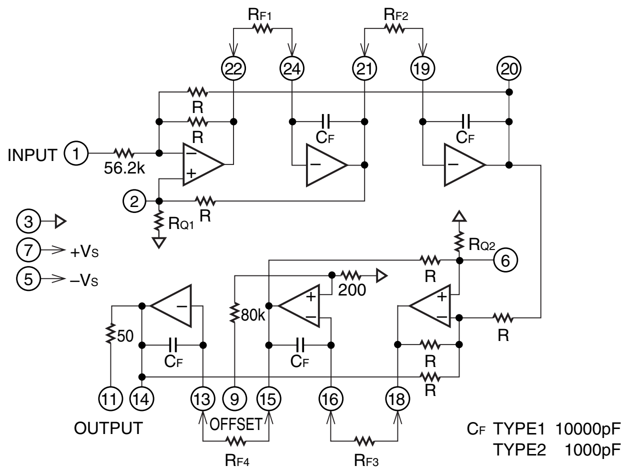
This 3314 is capable of storing up to 4 HR filters that is utilized as a desktop-type fixed frequency filter.

Available filters	All HR filters
Number of channels	Max. 4 Continuous connection of CH1/2 with CH3/4 available
fc/fo setting	Fixed resistors (2 or 4 pcs.) are soldered to the discrete platform (accessory) and connected to the socket.
Supply voltage	AC100V, ±10%, 48Hz to 62Hz
Dimensions	225(W) × 67(H) × 250(D)mm (protrusion not included)

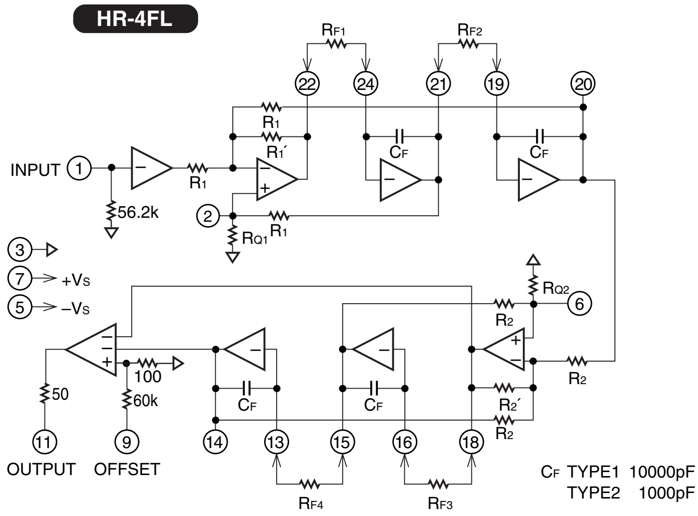
Filters

Block diagram

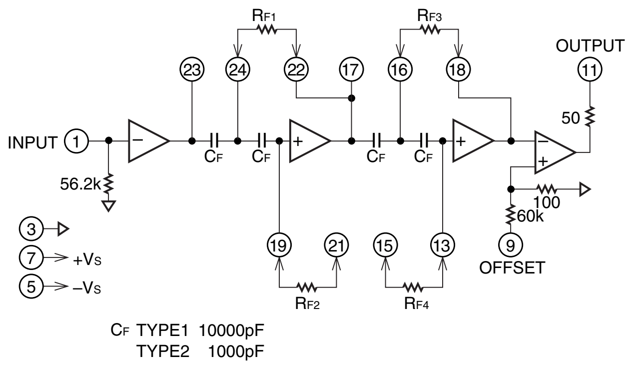
HR-4BL



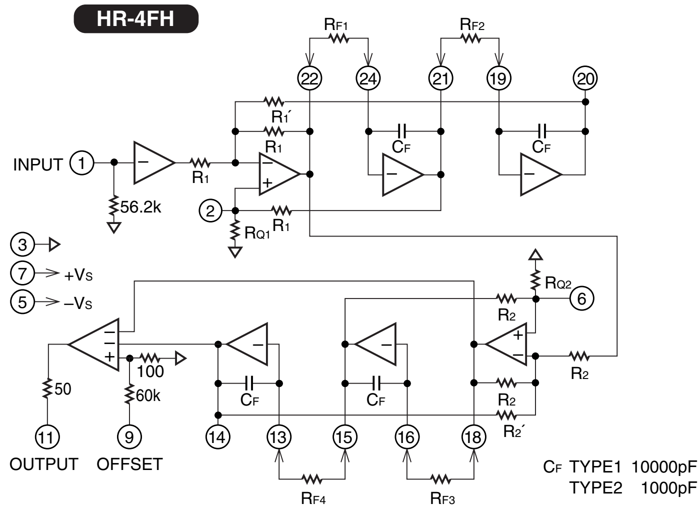
HR-4FL



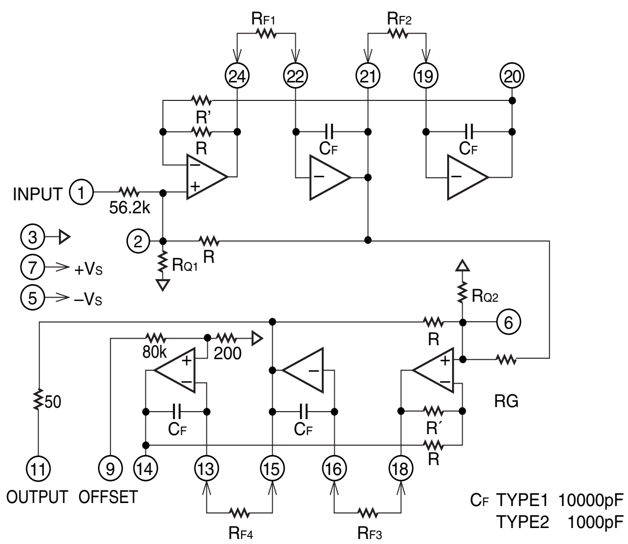
HR-4BH



HR-4FH



HR-2BP



■*Cut-off (center) frequency setting*

- **Equation of external resistor RF**

Type 1 $R_{F1} = R_{F2} = R_{F3} = R_{F4} = R_F$

$$R_F = \frac{15.9 \times 10^3}{fc \text{ or } fo\ [Hz]}\ [k\Omega]$$

Type 2 $R_{F1} = R_{F2} = R_{F3} = R_{F4} = R_F$

$$R_F = \frac{159 \times 10^3}{fc \text{ or } fo\ [Hz]}\ [k\Omega]$$

- **Equation of external resistor RF for expansion of the lower frequency with the use of a capacitor (CF)**

Type 1 $R_{F1} = R_{F2}=R_{F3}=R_{F4}=R_F$

$$R_F = \frac{159}{(C_F[\mu F]+0.01) \times fc \text{ or } fo\ [Hz]}\ [k\Omega]$$

Type 2 $R_{F1} = R_{F2}=R_{F3}=R_{F4}=R_F$

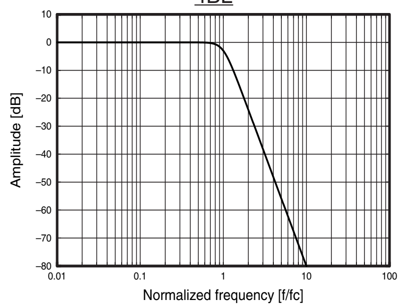
$$R_F = \frac{159}{(C_F[\mu F]+0.001) \times fc \text{ or } fo\ [Hz]}\ [k\Omega]$$

Filters

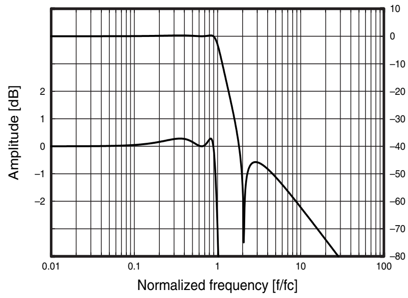
Characteristics

Amplitude

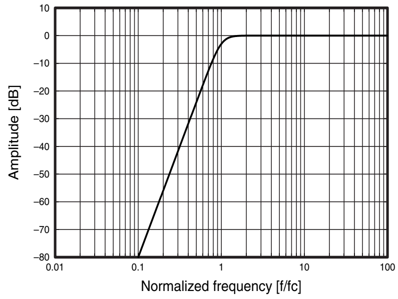
4BL



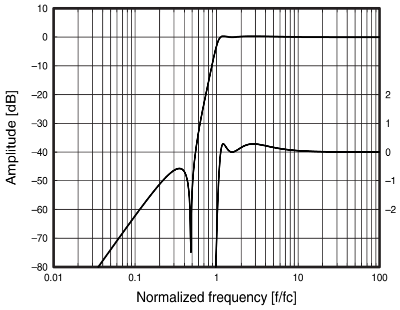
4FL



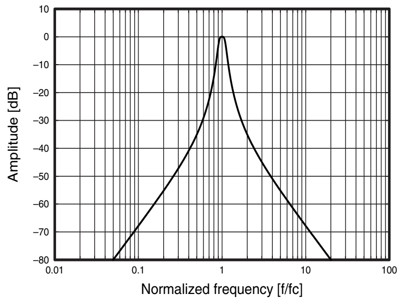
4BH



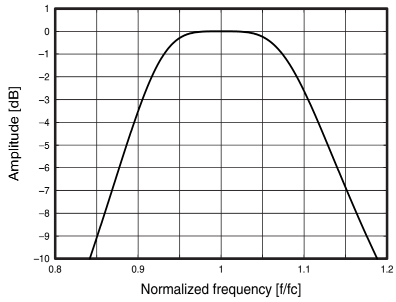
4FH



2BP



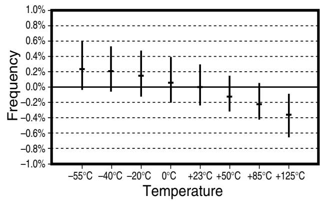
2BP(magnified view)



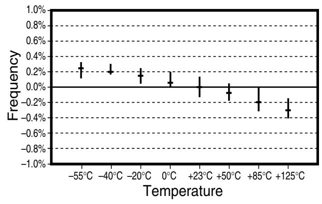
Temperature

▼Cut-off frequency drift (Type 1: fc = 500Hz, Type 2: fc = 5kHz)

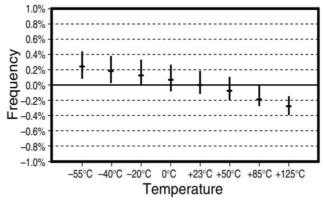
4BL1



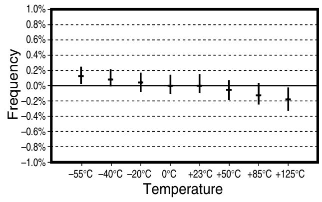
4BL2



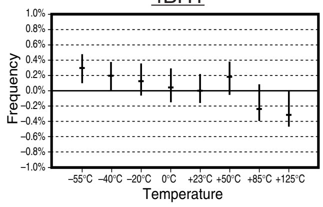
4FL1



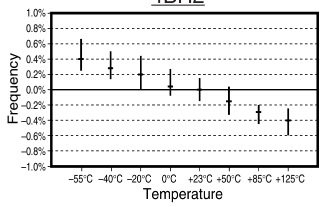
4FL2



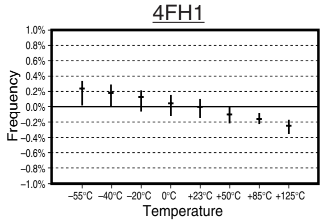
4BH1



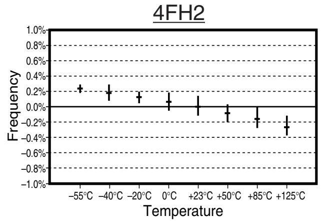
4BH2



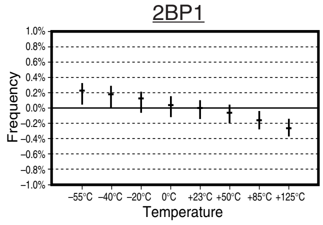
4FH1



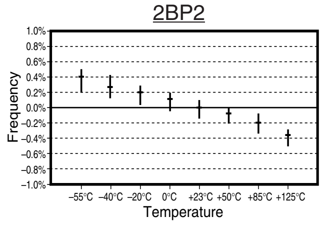
4FH2



2BP1

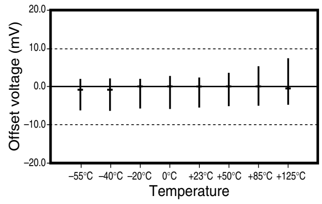


2BP2

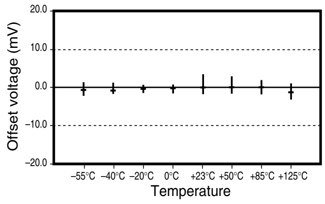


▼Offset voltage drift (Type 1: fc = 500Hz, Type 2: fc = 5kHz)

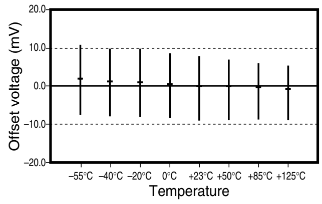
4BL1



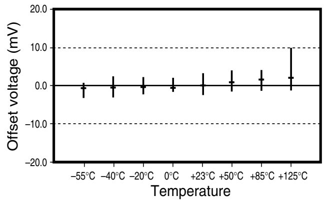
4BL2



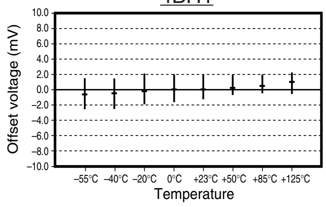
4FL1



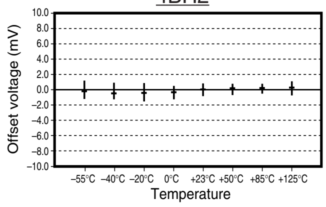
4FL2



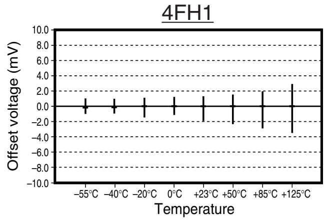
4BH1



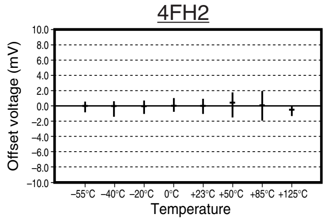
4BH2



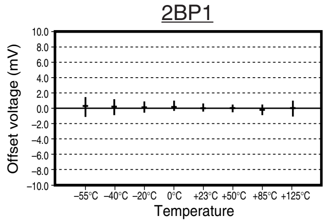
4FH1



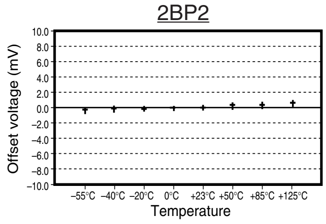
4FH2



2BP1



2BP2



Resistor Tunable Filter

RT-8FLA1/2 RT-8FLB1/2 RT-3BP1/2

RT series filters are resistor tunable filters that allocate cutoff (center) frequencies with the external resistors (6 or 8 pcs.). RT-8FLA/8FLB low pass filters possess steep attenuation characteristics, which are suited to be used as anti-aliasing filters. RT-3BP 1/3-octave-band pass filter is in conformity with IEC-225 standards.

135dB/oct or equivalent: 8-pole Elliptic low pass RT-8FLA
100dB/oct or equivalent: 8-pole Elliptic low pass RT-8FLB
1/3oct bandwidth (Q = 4.32): 3-pole pair band pass RT-3BP

▼Absolute maximum ratings

Supply voltage (±Vs)	±18V
Input voltage	±Vs

▼Filter characteristics

Filter characteristics	RT-8FLA/8FLB: 8-pole Elliptic LPF 3BP: 3-pole pair BPF

▼fc, fo

Setting		Connected with external resistors of the same resistance. RT-8FLA/8FLB: 8 pcs. 3BP: 6 pcs
Range	**Type 1**	10Hz to 2kHz
	Type 2	100Hz to 20kHz
External resistors	**Type 1**	R_F (kΩ) = 15.9 × 10^3/fc or fo (Hz)
	Type 2	R_F (kΩ) = 159 × 10^3/fc or fo (Hz)
Setting accuracy		Max. ±2% (errors of external resistors excluded)

▼Pass-band characteristics

Model	RT-8FLA1/2	RT-8FLB1/2	RT-3BP1/2
Gain	0dB±0.1dB(max)		0dB±1dB(max)
Adjusted R_F	–		0dB±0.1dB(typ)
Ripple (p-p)	0.15dB(typ)	0.15dB(typ)	–
(≤0.9fc)	0.3dB(max)	0.3dB(max)	–
Adjusted R_F	0.1dB(typ)	0.1dB(typ)	–
Distortion	0.005%(typ)at 1kHz		

▼Attenuation characteristics

Model	RT-8FLA1/2	RT-8FLB1/2	RT-3BP1/2
Rolloff	135dB/oct equiv.	100dB/oct equiv.	–
Q	–	–	4.32(BW1/3oct)
Attenuation characteristics	86dB(typ)1.56fc	92dB(typ)2.0fc	18dB/octBW
Minimum attenuation	86dB (typ)	106dB (typ)	–
High frequency attenuation 10fc (fo) to 1MHz	Min. 80dB	Min. 86dB	Min. 80dB

▼Input characteristics

Input impedance	Min. 50kΩ
Maximum input voltage (linear)	±10V

▼Output characteristics

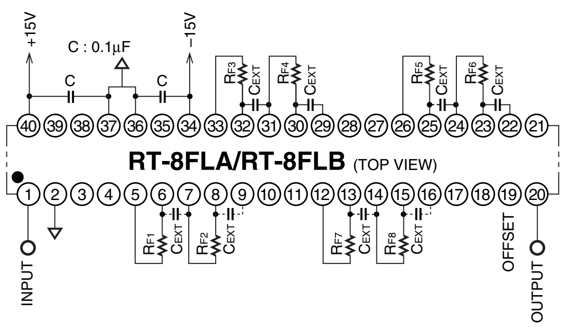
Output impedance	Max. 100Ω
Maximum output voltage	±10V
Voltage noise (input short)	Max. 140μVrms (BW10Hz to 500kHz)
Offset voltage	±10mV(typ) adjustable

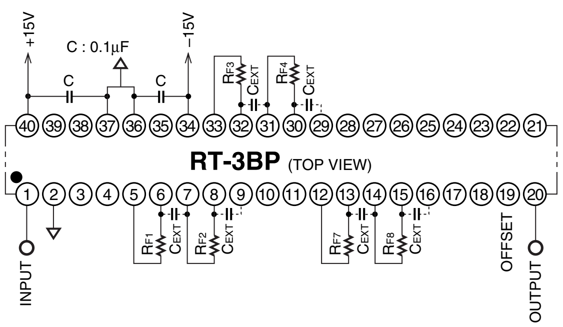
▼Others

Supply voltage		±15V(±5 to ±18V)
Quiescent current		8FLA, 8FLB : ±40mA (typ) 3BP : ±25mA(typ)
Temperature/ humidity range	**Operation**	–20°C to 70°C, 10 to 95%RH
	Storage	–30°C to 80°C, 10% to 80%RH
Dimensions		54.4 × 33.7 × 6.5mm, Type H

Note: The following specifications are applied unless otherwise specified: 23±5°C, Vs = ±15V

Basic connection diagram





Equation of external resistor R_F

Type 1 $R_F = \dfrac{15.9 \times 10^3}{\text{fc or fo}}$ (kΩ)

$R_F = \dfrac{159}{(C_{EXT}+0.01) \times \text{fc or fo}}$ (kΩ)

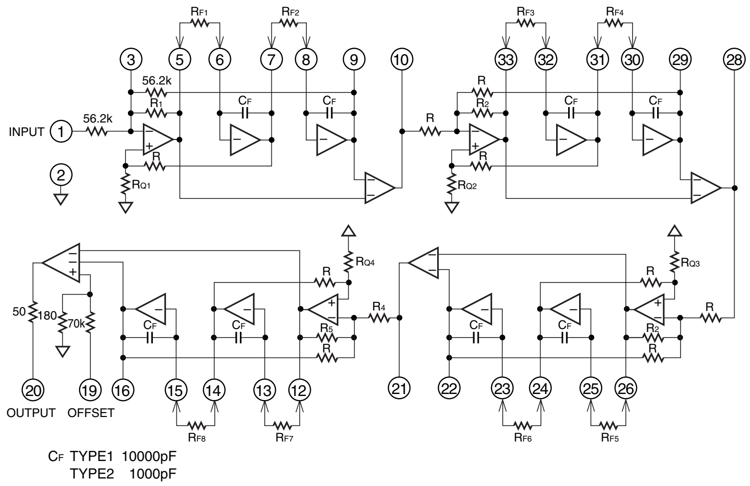
Type 2 $R_F = \dfrac{159 \times 10^3}{\text{fc or fo}}$ (kΩ)

$R_F = \dfrac{159}{(C_{EXT}+0.001) \times \text{fc or fo}}$ (kΩ)

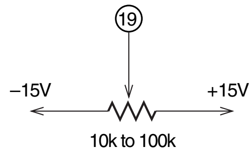
Note: Units: fc or fo in Hz, C_{EXT} in μF
Note: C_{EXT} is required only for expansion of the lower cut-off/center frequency (fc/fo).

Block diagram

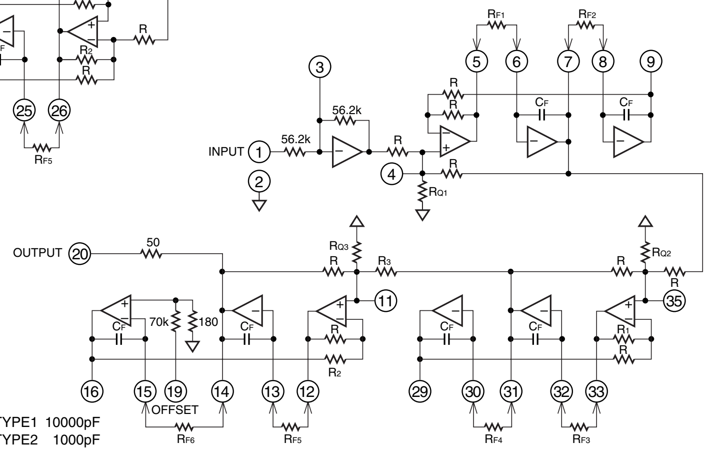
RT-8FLA/RT-8FLB



Offset voltage adjustment

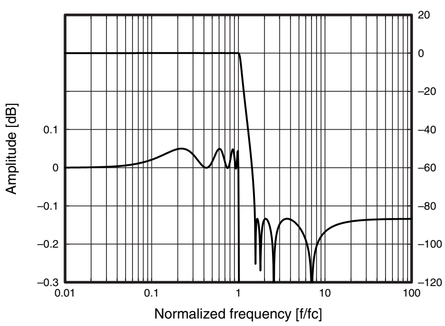


RT-3BP

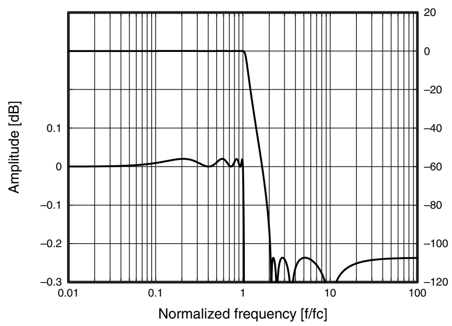


Characteristics

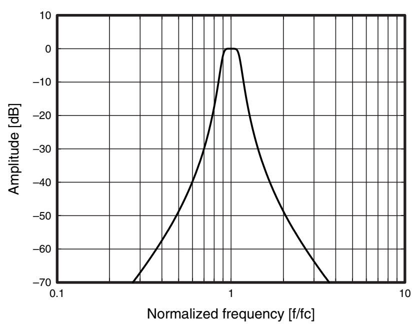
RT-8FLA



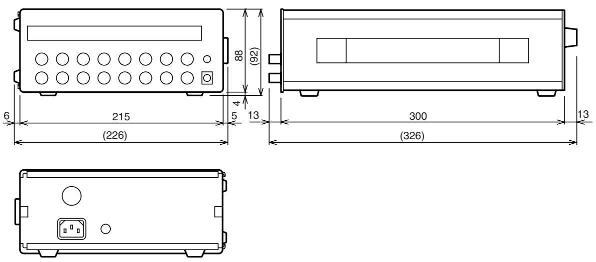
RT-8FLB



RT-3BP



■*Multichannel filter 3316*



Rear panel

This 3316 is capable of storing up to 8 RT filters that is utilized as a fixed frequency-allocated multichannel filter.
Filter characteristics vary with type of filters to be stored.

Available filters	All RT filters
Number of channels	Max. 8
fc/fo setting	Fixed resistors (6 or 8 pcs.) are soldered to the discrete platform (accessory) and connected to the socket.
Supply voltage	AC100V, ±10%, 48Hz to 62Hz
Dimensions	215(W) × 88(H) × 300(D)mm (protrusion not included)

Voltage Tunable Filter

VT-4BLA, VT-4BHA, VT-2BPA

VT-A series filters are capable of controlling frequencies with external voltage and fall into the following three types: 24dB/oct low pass filter (VT-4BLA), 24dB/oct high pass filter (VT-4BHA), and 2-pole pair band pass filter (Q = 5; VT-2BPA).
Frequency rises to a maximum as the external control voltage is at the maximum of +10V, which allows the low pass filters to obtain 100kHz and high/band pass filters to obtain 20kHz. The frequency control range has been increased by a factor of 1000 for low/high pass filters and of 100 for band pass filters. The addition of an external capacitor is to vary frequencies to lower.

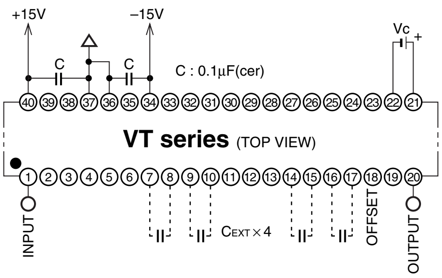
Model	VT-4BLA	VT-4BHA	VT-2BPA
▼Filter characteristics			
Filter characteristics	Butterworth low pass	Butterworth high pass	Butterworth band pass
Order	4		2-pole pair
Rolloff	24dB/oct		12dB/oct • bandwidth
Q	–		5
Set frequency accuracy*1	100Hz to 100kHz	20Hz to 20kHz	200Hz to 20kHz
▼Input characteristics			
Impedance	Min. 50kΩ		
Rated voltage*2	±1V		
Maximum voltage	±10V		±2V
▼Output characteristics			
Impedance	Max. 50kΩ		
Rated voltage*2	±1V		
Load resistance	Min. 10kΩ		
Pass-band gain*3 *4	0±0.5dB		0±1dB
Distortion*5	Max. 0.1%		

Note: The following specifications are applied unless otherwise specified:
Supply voltage: ±15V, Vc (frequency control voltage) = +10V,
Ambient temp.: 23±5°C
*1: Expansion of the lower frequency with the external capacitors is enabled.
*2: I/O voltage range that meets the voltage ratings.

Model		VT-4BLA	VT-4BHA	VT-2BPA
Noise		0.8mVrms (10Hz to 300kHz BW)		
Offset voltage		±10mV(typ)		
Offset voltage fluctuation	vs control voltage	20mV(typ)		
	vs temperature	0.3mV/°C(typ)		
▼Frequency control characteristics				
Set frequency		10Vc × 10³Hz	2Vc × 10³Hz	
Accuracy		±(3% of set value+10Hz)	±(3% of set value+2Hz)	
Control voltage range		+10mV to +10V		+100mV to +10V
Input impedance		Min. 50kΩ		
▼Others				
Supply voltage		±15V, +10%, –5%		
Quiescent current		±36mA(typ), Max. ±54mA		
Temperature/ humidity range	Operation	–20°C to 70°C, 10 to 95%RH		
	Storage	–30°C to 80°C, 10 to 80%RH		
Dimensions		54.4 × 33.7 × 6.5mm, Type H		

*3: 4BLA filters are DC-coupled.
High frequency characteristics of 4BHA : Max. 300kHz
*4: Measurement point: fc/10 (4BLA), 3.3fc (4BHA), fo (2BPA)
*5: Measurement point: fc/2 (4BLA), 2fc (4BHA), fo (2BPA)

Basic connection diagram



Equation of external capacitor (CEXT)

• VT-4BLA

$$C_{EXT} = \frac{25}{\text{Max. set frequency (Hz)}} - 0.00025(\mu F)$$

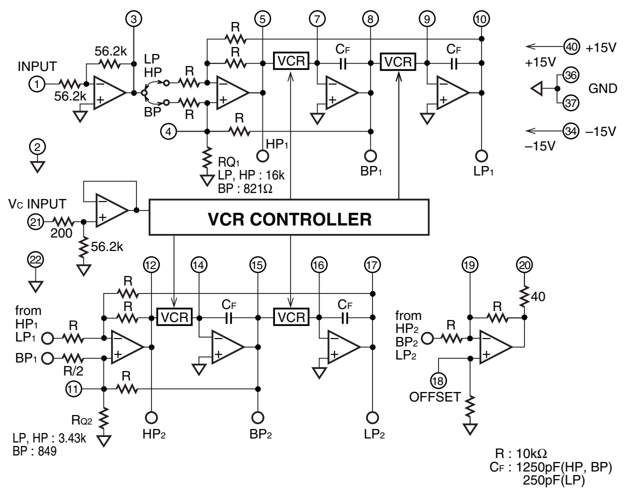
• VT-4BHA/2BPA

$$C_{EXT} = \frac{25}{\text{Max. set frequency (Hz)}} - 0.00125(\mu F)$$

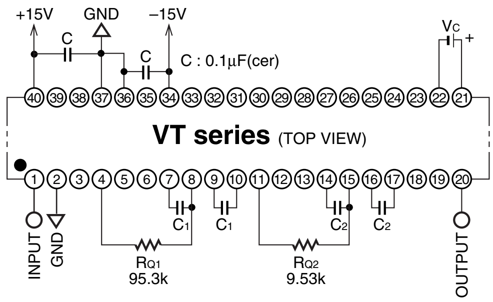
* Max. set frequency: Cut-off or center frequency when +10V is assigned to Vc

Note 1: Do not connect an unused pin with other pins.
Note 2: Internal common connection of Pins 2, 22, 36, and 37 is established.
Note 3: CEXT is required only for frequency control of low pass (100Hz or less), high pass (20Hz or less), and band pass (200Hz or less).

Block diagram



■Configuration of phase linear filter (Bessel)



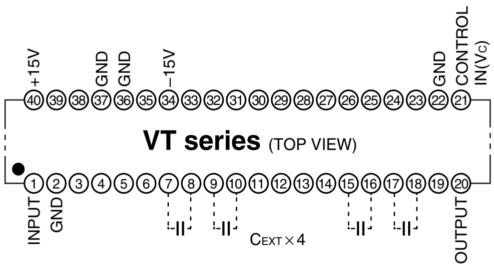
The phase linear filter is completed with two additional resistors and four capacitors as shown below.

$$C_1 = \frac{17.453}{\text{Max. set frequency (Hz)}} - 0.00025(\mu F)$$

$$C_2 = \frac{15.567}{\text{Max. set frequency (Hz)}} - 0.00125(\mu F)$$

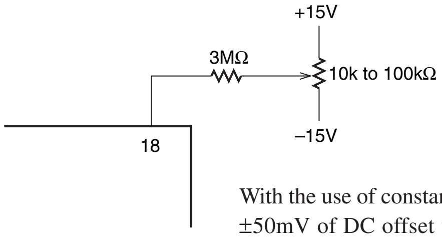
Note: Max. set frequency: 62.2kHz

■Pinout diagram



Note 1: Do not connect an unused pin with other pins.
Note 2: A black circle (●) on the case top denotes Pin 1.

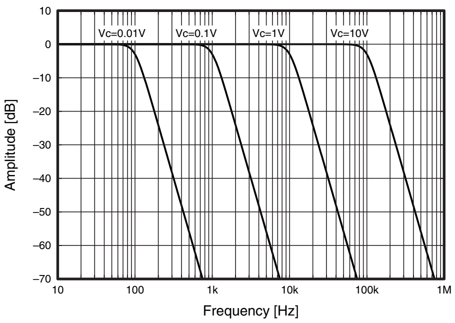
■Offset voltage adjustment



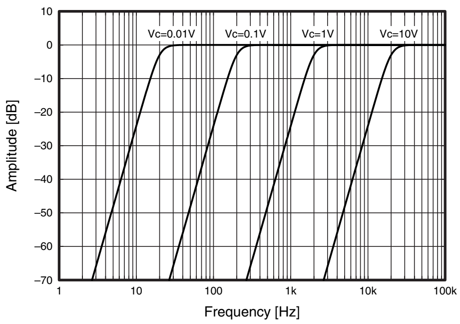
With the use of constants provided in the figure, ±50mV of DC offset voltage can be regulated upon voltage output.

■Control voltage (Vc)

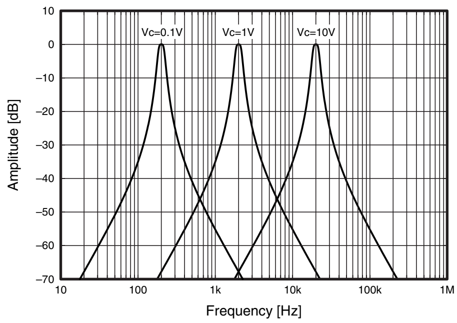
Frequency characteristics of the frequency control circuit are expressed in a flat response between DC and 10kHz. It enables cut-off frequency to vary at several tens µs, which has beneficial effects on dynamic change in frequencies. If noise sources are superposed in control voltage, however, it triggers potential fluctuations in set frequencies. Small control voltage is susceptible to noise, which may result in the instability of set cut-off frequency. Thorough elimination of noise sources from control voltage is required to regain stable frequency.



VT-4BLA
Amplitude – Frequency characteristics

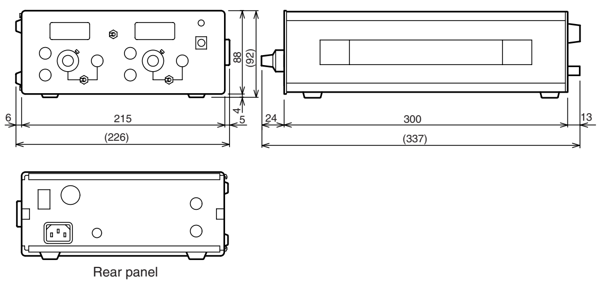


VT-4BHA
Amplitude – Frequency characteristics



VT-2BPA
Amplitude – Frequency characteristics

■Multichannel filter 3334



This 3334 is utilized as a 2-channel desktop-type voltage control filter. Voltage control is performed through a 10-rotating potentiometer or external voltage.

Available filters	All VT-A filters
Number of channels	Max. 2
fc/fo setting	Set with a 10-rotating potentiometer that is located on the panel or external control voltage. Supply voltage: AC100V, ±10%, 48Hz to 62Hz
Dimensions	215(W) × 88(H) × 300(D)mm (protrusion not included)

Programmable Filter

DT-212D, DT-212DC1, DT-212DC2

DT-212 series filters are regarded as universal filters capable of controlling frequencies with digital signal. The following three types of outputs are to be obtained simultaneously: low pass filter with 12dB/oct of rolloff, high pass filter with 12dB/oct of rolloff, and band pass filter with 6dB/oct of bandwidth. DT-212 series filters facilitate the settings of gain and Q through the adoption of the external resistors, besides the configuration of filters possessing various characteristics and high-order filters.
Frequency is controlled by BCD 3 digits (12 lines). The frequency range falls into three types: 1Hz to 1.599kHz (DT-212DC1), 100Hz to 159.9kHz (DT-212DC2), and a range to be designated with the external capacitors (DT-212D).

▼Filter characteristics

Type		Low pass, high pass, band pass
Order		2 (1-pole pair)
Rolloff		12dB/oct low pass, high pass 6dB/oct • BW band pass
Characteristics		Configuration of any high-order filters available. (with external resistors)
Frequency setting range (fc)		DT-212DC1 : 1Hz to 1.599kHz DT-212DC2 : 100Hz to 159.9kHz DT-212D : Range specified with the external capacitors
Q	**Range**	1/3 to 1 × 10^6/fc
	Setting	Set with external resistors.

▼Input characteristics

Impedance	Specified with a gain external resistor. (10kΩ/gain)
Maximum voltage	±10V/gain
Maximum voltage	Same as supply voltage

▼Output characteristics

Impedance	Max. 5Ω
Maximum voltage	±10V(≤100kHz)
Load resistance	Min. 2kΩ
Pass-band gain[*1]	Gained with external resistors.
Distortion[*2]	0.002%(typ)

Note: The following specifications are applied unless otherwise specified:
Supply voltage: ±15V and +5V, Gain: 1, Q=0.707, Ambient temp.: 23±5°C

Noise	Low pass : 35μVrms(typ) High pass : 100μVrms(typ) Band pass : 30μVrms(typ) (in the 10Hz to 500kHz bandwidth)
Offset voltage	±20mV(typ) Adjustable with an external trimmer potentiometer.
Offset voltage drift	5μV/°C(typ)

▼Cut-off frequency control characteristics

Code	BCD: 3 digits, positive logic (+5V)
Input circuit	CMOS4000 series, pulled down to GND (internal) at 100kΩ
Accuracy	±0.1%(typ)(212D), ±0.5%(typ)(212DC1/2)

▼Built-in operational amplifier

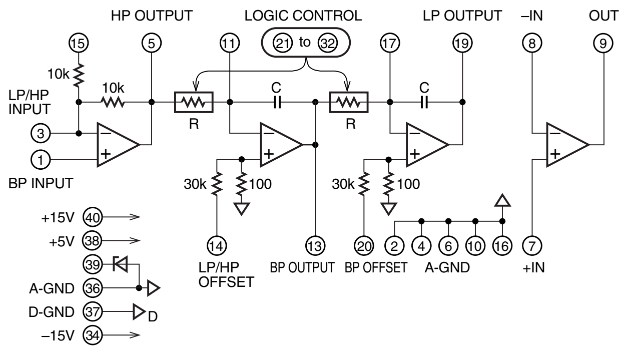
Input bias current	200nA(typ)
f_T	10MHz(typ)
Slew rate	8V/μs(typ)

▼Others

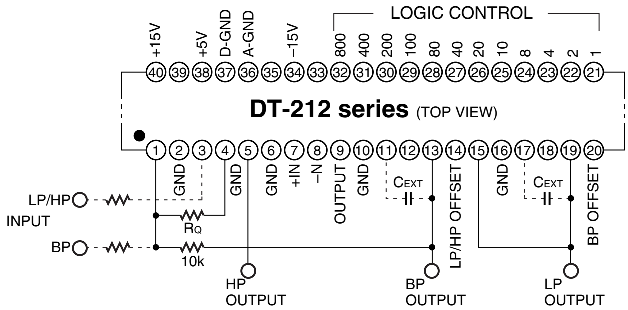
Supply voltage		±15V±10% +5V±10%
Quiescent current		typ : +15mA/–18mA, +2.2mA max: +23mA/–27mA, +3.3mA
Temperature/humidity range	**Operation**	–20°C to 70°C, 10 to 95%RH
	Storage	–30°C to 80°C, 10 to 80%RH
Dimensions		54.4 × 33.7 × 9.4mm, Type HA

*1: Low pass outputs are DC-coupled. High frequency characteristics of high pass outputs: Max. 500kHz
*2: Measurement point: fc/2 (low pass), 2fc (high pass), fo (band pass)

Block diagram

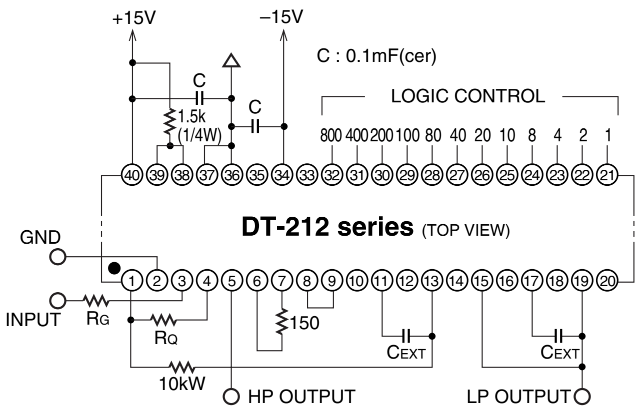


■*Pinout diagram*



Note *1: Do not connect an unused pin with other pins.
*2: Only external capacitors (CEXT) are available.
*3: A black circle (●) on the case top denotes Pin 1.

Basic connection diagram 2-pole low pass/high pass filters



Equation of gain $G_{LP} = G_{HP} = \frac{10}{R_G}$ (I/O phase inversion)

Equation of Q $Q = \frac{R_G}{R_Q} \frac{R_Q+10}{2R_G+10}$

$$R_Q = \frac{10R_G}{(2R_G+10)\,Q - R_G} \ (k\Omega)$$

Units: R_G and R_Q in kΩ

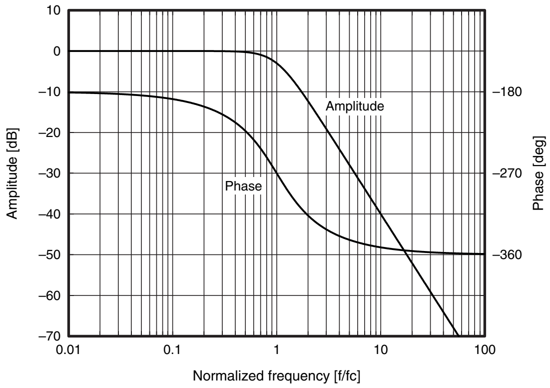
E.g.: Determine R_G and R_Q of Butterworth and Bessel characteristics.
(Gain = 2, a 12dB/oct low pass filter assigned)

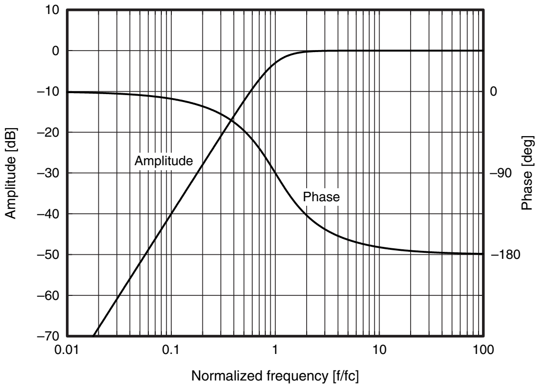
$$R_G = \frac{10}{G_{LP}} = 5k\Omega$$

$$R_Q = \frac{50}{20Q - 5}$$

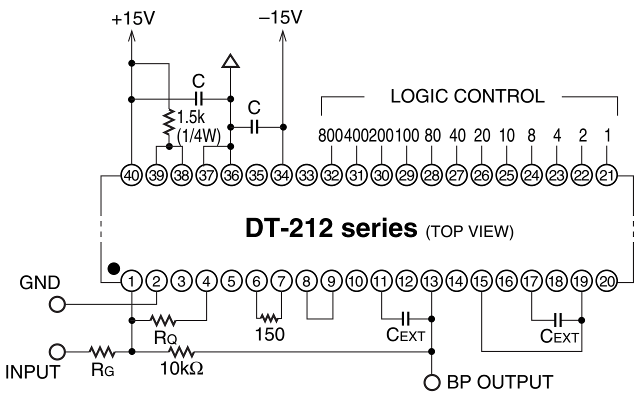
$= 5.469k\Omega$ (Q = 0.70711, Butterworth)

$= 7.637k\Omega$ (Q = 0.57735, Bessel)





Basic connection diagram 1-pole pair band pass filters



Equation of gain $G_{BP} = \frac{10}{R_G}$ (I/O phase inversion)

Equation of Q $Q = 0.5 + \frac{5}{R_G} + \frac{5}{R_Q}$

$$R_Q = \frac{10}{2Q - 1 - G_{BP}} \ (k\Omega)$$

Units: R_G and R_Q in kΩ

E.g.: Determine R_G and R_Q when Q is set at 2, 5, and 10.
(Gain = 5, a 1-pole pair band pass filter assigned)

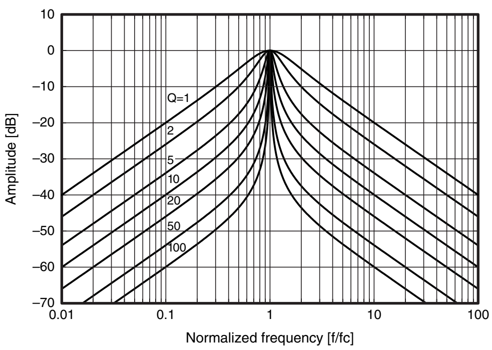
$$R_G = \frac{10}{G_{BP}} = 2k\Omega$$

$$R_G = \frac{10}{2Q - 1 - 5}$$

$= -5k\Omega$ (Q = 2)*

$= 2.5k\Omega$ (Q = 5)

$= 0.71k\Omega$ (Q = 10)



* The following specifications should be satisfied:
Q≥3 is obtained if a gain is "5", and the maximum gain is "3" if Q is set at 2.

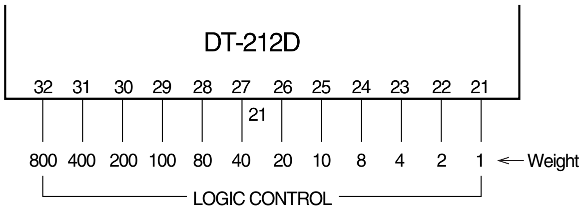
Filters

■Frequency setting

DT-212 series filters allow frequency setting through external contacts or digital signal. The frequency setting (BCD: 3 digits) is completed by assigning weights to the relevant input pins, as shown below. Internal logic reaches “Hi” if +5V is placed to the input pin (bit) and “Lo” if the input pin is set at 0V or open. The sum of bit weights (Hi) denotes frequency, and the frequency (fc) - sum (N) relationship is represented in the following equations.

DT-212DC1	fc = N (Hz)
DT-212DC2	fc = 100N (Hz)
DT-212D	$fc = \frac{N}{20 \cdot C_{EXT}}$ (Hz) (C_{EXT} : µF)

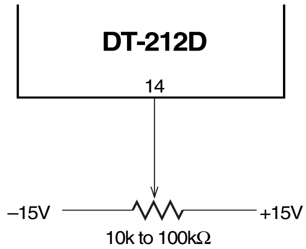
DT-212DC1 built-in capacitor: 50000pF
DT-212DC2 built-in capacitor: 500pF



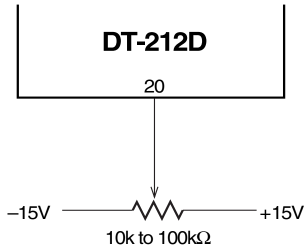
Operation in TTL level requires a voltage of +3.5 or more and a power of +5 or less when Hi level is placed. If the voltage does not attain +3.5V, connect a proper pull-up resistor to TTL output.

■Offset voltage adjustment

• When low pass or high pass output is used



• When band pass output is used

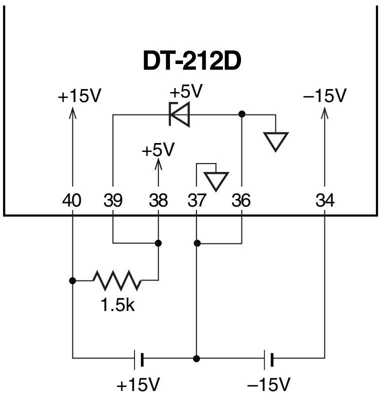


■Supply power and GND connection

DT-212 series filters are powered by ±15V and +5V, and also allow a power of +5V to be diverted from +15V.

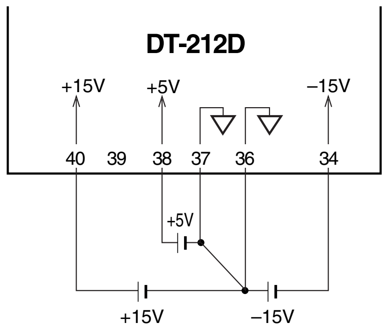
• When only ±15V is supplied

A power of +5V is derived from the connection shown in the following diagram. The Hi level of the logic input signal should be +5.3V at the maximum due to fluctuations in Zener voltage.
The quiescent current for ±15V obtains 22mA (typ) after an increase of 7mA.



• When ±15V and +5V are supplied

The connection of Pins ㊱ and ㊲ requires caution to prevent the return current from flowing into the analog circuit from +5V of logic power. Pins ㊱ and ㊲ are to be connected on the power side as shown below.
Be sure to use a power of +5V that is small in ripple and pulse noise as with ±15V. The method with the use of only ±15V is adopted if a proper power of +5V fails to be obtained.



Programmable Filter

DT-408D DT-408DC2

DT-408 series filters are universal filters embedded with 2-stage 2-pole state variable filters. These filters facilitate the settings of gain and Q through the adoption of the external resistors, besides the configuration of filters possessing various characteristics and high-order filters.
Frequency is controlled by BCD 2 digits (8 lines). The frequency range falls into the following two types: a range to be designated with the external capacitors (DT-408D) and 1kHz to 159kHz (DT-408DC2).
DT-408 series filters are Type HB (54.4 × 33.7 × 8.0mm) with 40-pin DIP.

▼Filter characteristics

Type		Low pass, high pass, band pass
Order		2 (1-pole pair) × 2
Rolloff		12dB/oct low pass, high pass 6dB/oct • BW band pass
Characteristics		Configuration of any high-order filters available. Max. 4-pole filters per unit
Frequency setting range (fc)		DT-408D : Range specified with the external capacitors DT-408DC2 : 1kHz to 159kHz
Q	**Range**	Range: 1/3 to 1 × 10^6/fc
	Setting	Set with external resistors.

▼Input characteristics

Impedance	Specified with a gain external resistor. (10kΩ/gain)
Maximum voltage	±10V/gain
Absolute maximum voltage	Same as supply voltage

▼Output characteristics

Impedance	Max. 5Ω
Maximum voltage	±10V(≤100kHz)
Load resistance	Min. 2kΩ
Pass-band gain	Gained with external resistors.
Distortion	0.003% (typ)

Note: The following specifications are applied unless otherwise specified:
Supply voltage: ±15V, Gain: 1, Q = 0.7071, Ambient temp.: 23±5°C

Noise	Low pass : 15µVrms (typ) High pass : 70µVrms (typ) Band pass : 30µVrms (typ) (fc = 80kHz, in the 10Hz to 500kHz bandwidth)
Offset voltage	±20mV (typ) Zero adjustment available with an external trimmer potentiometer
Offset drift	10µV/°C (typ)

▼Cut-off frequency control characteristics

Code	BCD : 2 digits, negative logic
Input circuit	Pulled up to +5V at 100kΩ
Accuracy	DT-408D : ±0.1% (typ) DT-408DC2 : ±0.5% (typ)

▼Built-in operational amplifier

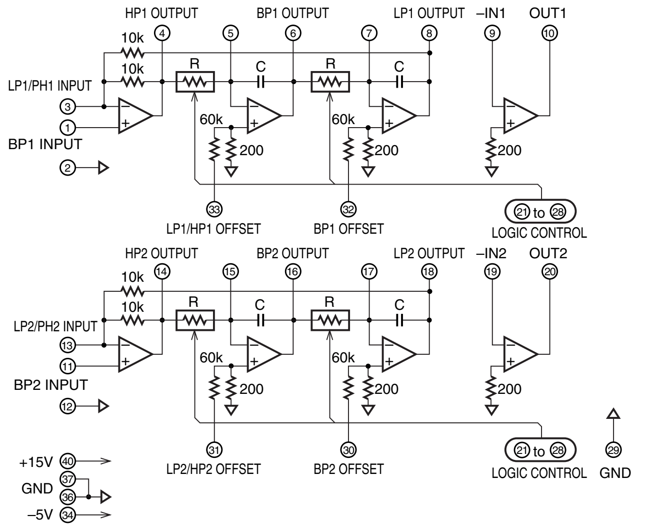
Bias current	200nA (typ)
f_T	10MHz (typ)
Slew rate	8V/µs (typ)

▼Others

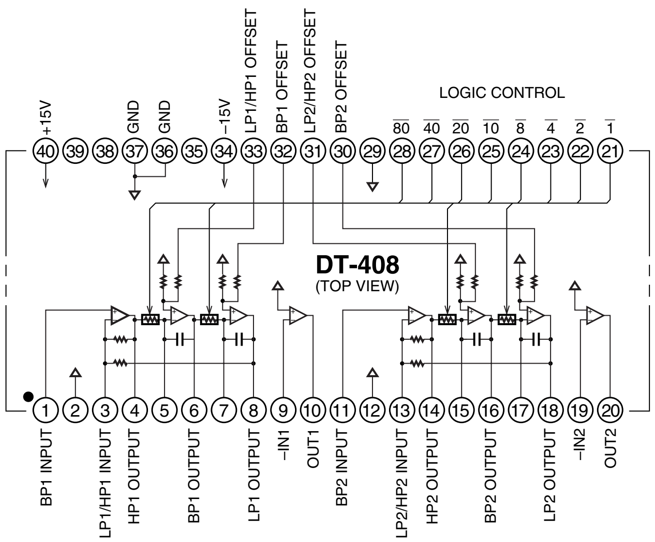
Supply voltage		±15V±10%
Quiescent current		±50mA (typ)
Temperature/ humidity range	**Operation**	–20°C to 70°C, 10 to 95%RH
	Storage	–30°C to 80°C, 10 to 80%RH
Dimensions		54.4 × 33.7 × 8.0mm, Type HB

Filters

Block diagram

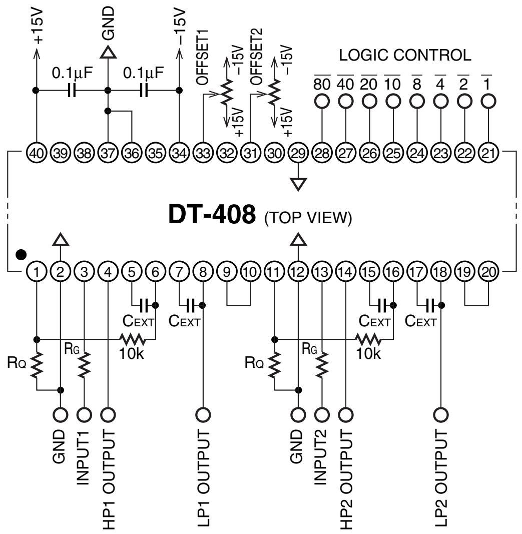


■Pinout diagram



Basic connection diagram

2-channel 2-pole low pass/high pass filters

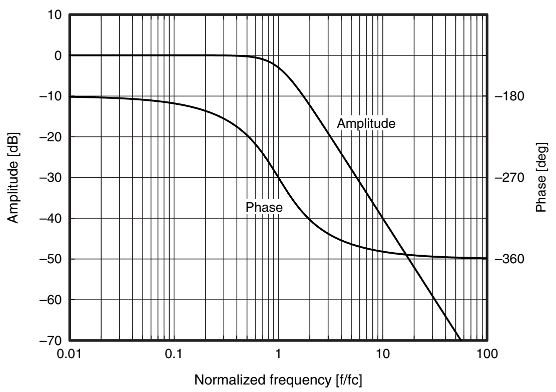


Equation of gain $G_{LP} = G_{HP} = \dfrac{10}{R_G}$

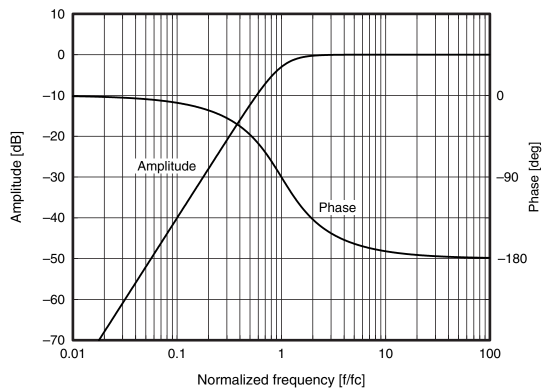
Equation of Q $R_Q = \dfrac{10R_C}{(2R_G+10)\,Q - R_G}$

Units: R_G and R_Q in kΩ

Low-pass characteristics

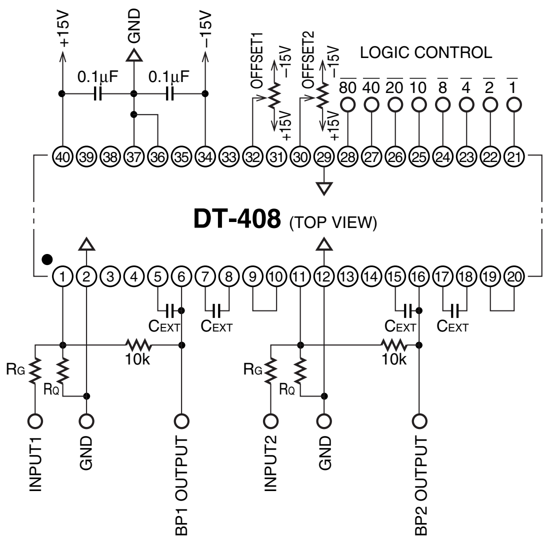


High-pass characteristics



Filters

Basic connection diagram **2-channel 1-pole pair band pass filters**

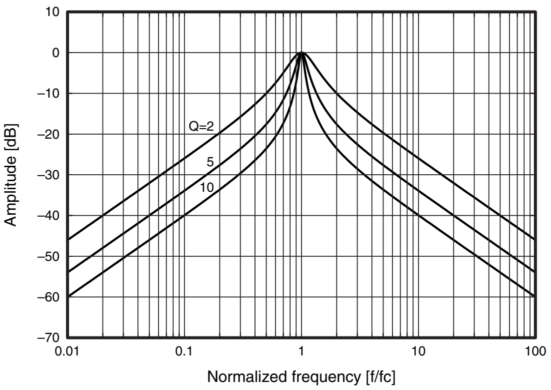


Equation of gain $G_{BP} = \dfrac{10}{R_G}$

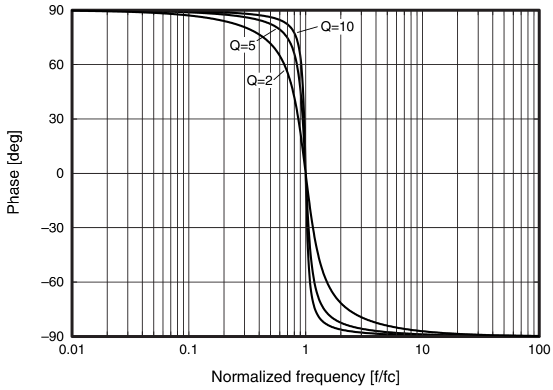
Equation of Q $R_Q = \dfrac{10}{2Q - 1 - G_{BP}}$

Units: R_G and R_Q in kΩ

Amplitude characteristics



Phase characteristics



Frequency setting

DT-408 series filters allow cut-off (center) frequency setting through external contacts or digital signal. The frequency setting (BCD: 2 digits) is completed by assigning weights to the relevant input pins. Internal logic reaches “Lo” if +0V is placed to the input pin and “Hi” if the input pin is set at +5V or open. The sum of bit weights (Lo) denotes frequency.

The frequency (fc) - sum (N) relationship is represented in the following equations.

DT-408DC2 $fc = N$ [kHz]

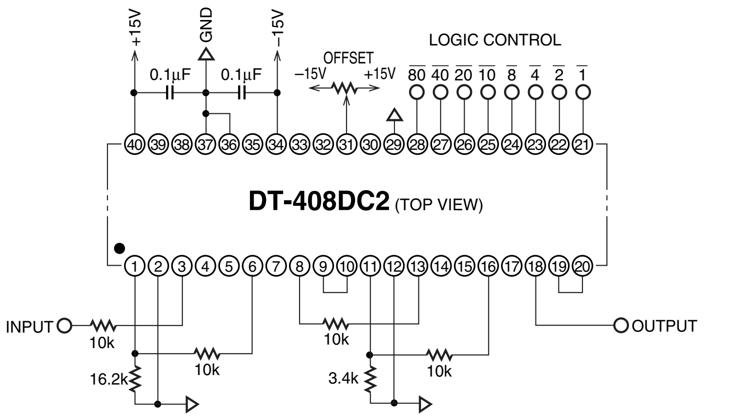
DT-408D $fc = \dfrac{N}{2 \cdot C_{EXT}}$ [Hz]

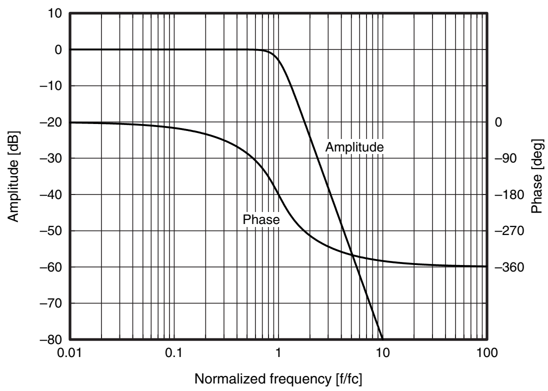
Units: C_{EXT} in µF

Filters

Application 1-channel 4-pole Butterworth low pass filters

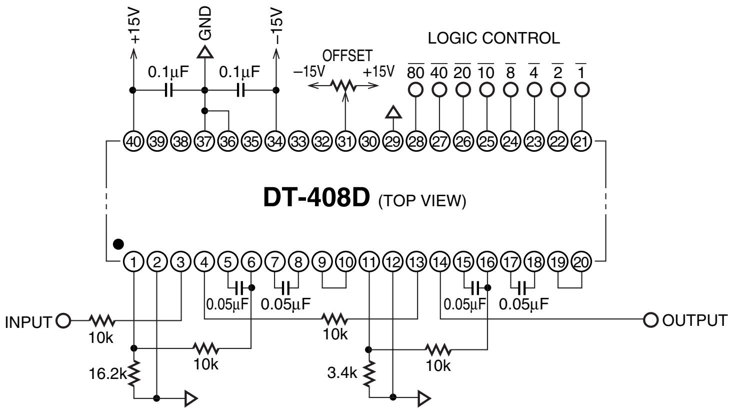
fc = 1kHz to 159kHz

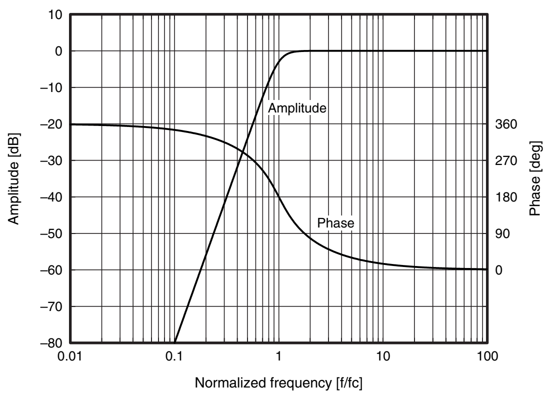




Application 1-channel 4-pole Butterworth high pass filters

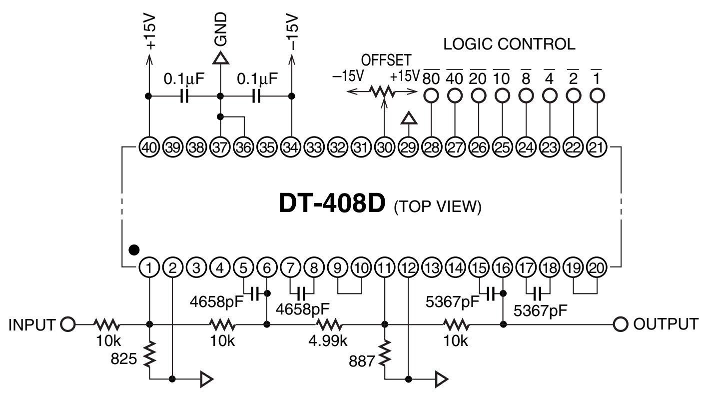
fc = 10Hz to 1590Hz

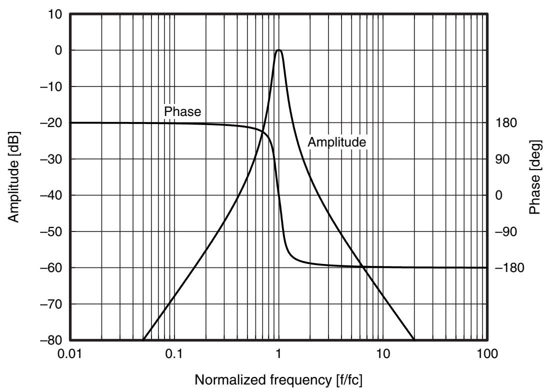




Application 1-channel 2-pole pair band pass filters

fo = 100Hz to 15.9kHz Q = 5





Programmable Filter

DT-208D DT-208DC3

DT-208 series filters are regarded as universal filters capable of controlling frequencies with digital signal (Max. set frequency: 1.59MHz).
The following three types of outputs are to be obtained simultaneously: low pass filter with 12dB/oct of rolloff, high pass filter with 12dB/oct of rolloff, and band pass filter with 6dB/oct of bandwidth. DT-208 series filters facilitate the settings of gain and Q through the adoption of the external resistors, besides the configuration of filters possessing various characteristics and high-order filters.
Frequency is controlled by BCD 2 digits (8 lines). The frequency range falls into the following two types: 10kHz to 1.59MHz (DT-208DC with a built-in capacitor) and a range to be designated with the external capacitors (DT-208D).

▼Filter characteristics

Type		Low pass, high pass, band pass
Order		2 (1-pole pair)
Rolloff		12dB/oct low pass, high pass 6dB/oct • BW band pass
Characteristics		Configuration of any high-order filters available. (Used with high-speed inverter CA-102R3. Established with external resistors.)
Frequency setting range (fc)		DT-208DC3 : 10kHz to 1.59MHz DT-208D : Range specified with the external capacitors
Q	**Range**	1/3 to 1 × 10^7/fc
	Setting	Set with external resistors.

▼Input characteristics

Impedance	Specified with a gain external resistor. (2kΩ/gain)
Maximum voltage	±10V/gain
Absolute maximum voltage	Same as supply voltage

▼Output characteristics

Impedance	Max. 5Ω
Maximum voltage	±10V(≤1MHz)
Load resistance	Min. 2kΩ
Pass-band gain	Gained with external resistors.
Distortion	0.02% (typ)
Noise	60μVrms (typ) Low pass output (in the 10Hz to 500kHz bandwidth)
Offset voltage	±30mV (typ) Adjustable with an external trimmer potentiometer.

▼Cut-off frequency control characteristics

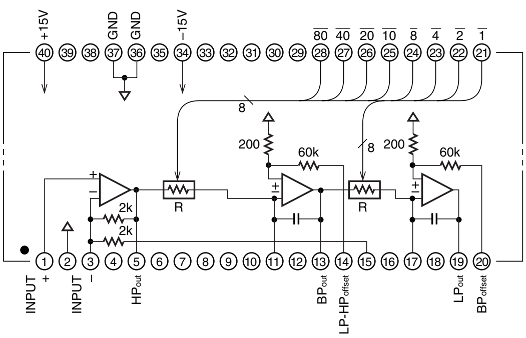
Code	BCD: 2 digits, negative logic
Input circuit	CMOS input, pulled up to +5V at 100kΩ (internal)
Accuracy	DT-208D : ±0.25% (typ), DT-208DC3 : 0.5% (typ)

▼Others

Supply voltage		±15V (±14 to ±16)
Quiescent current		±50mA(typ)
Temperature/ humidity range	**Operation**	–20°C to 70°C, 10 to 95%RH
	Storage	–30°C to 80°C, 10 to 80%RH
Dimensions		54.4 × 33.7 × 9.4mm, Type HA

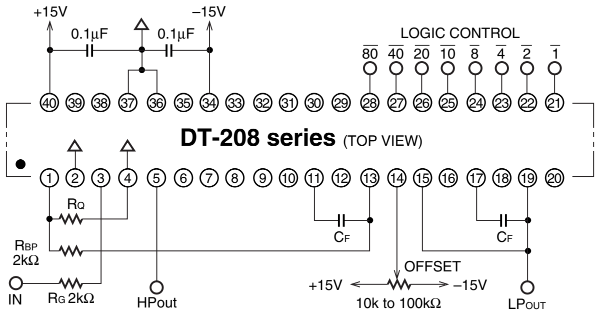
Note: The following specifications are applied unless otherwise specified: 23±5°C, Vs = ±15V

Block diagram



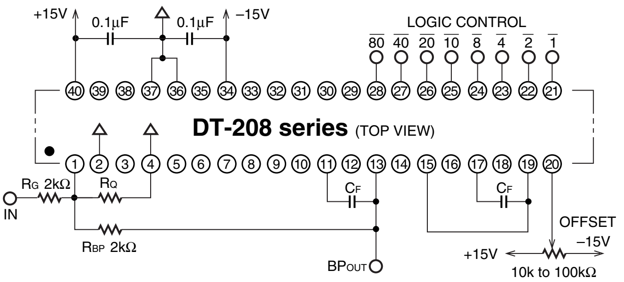
Basic connection diagram

• DT-208 low pass/high pass filters



$$\text{Gain} = \frac{2\times 10^3}{R_G\,[\Omega]} \qquad R_Q\,[W] = \frac{R_{BP}\,[\Omega]}{3Q-1}$$ (I/O phase inversion)

• DT-208 band pass filters



$$\text{Gain} = \frac{R_{BP}\,[\Omega]}{R_G\,[\Omega]} \qquad R_Q\,[\Omega] = \frac{R_{BP}\,[\Omega]}{2\,(Q-1)}$$ (I/O phase inversion)

■*Determination of C_F (DT-208D)*

DT-208D filters possess no frequency-determining capacitor, which requires the installation of external C_F.
The sum of bit weights when logic is controlled to “Lo” is expressed in “N”.

$$fc\,[Hz] = \frac{N}{4\times 10^5 \times C_F\,[F]}$$

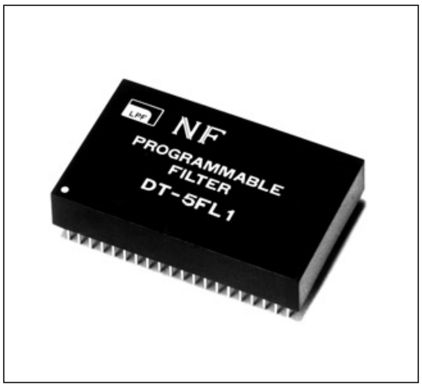
$$C_F\,[F] = 2.5\times 10^{-6} \times \frac{N}{fc\,[Hz]}$$

E.g.: When logic (N) is 100 :
To obtain 1MHz in fc, 250pF (C_F) is pre-assigned to DT-208D (DT-208DC3 has an internal C_F of 250pF).

The configuration of the Elliptic filters and band elimination filters with the use of DT-208 series filters requires the combination use of High-Speed Inverting Amplifier CA-102R3. See Page 55 for further information on CA-102R3.

Programmable Filter

DT-5FL1/2 DT-6FL1/2



DT-5FL/6FL series filters are low pass filters possessing steep attenuation characteristics, which are intended for anti-aliasing at A/D conversion. These filters allow cut-off frequency to be shifted at 8 positions with digital signal, which are suitable for frequent shift in sampling frequency.

60dB/oct or equivalent:	5-pole elliptic low pass	DT-5FL1/2
80dB/oct or equivalent:	6-pole elliptic low pass	DT-6FL1/2

▼Absolute maximum ratings

Supply voltage (±Vs)	±16V
Input voltage	±Vs
Control voltage	±5.5V–0.5V

▼Filter characteristics

DT-5FL1/2	5-pole Elliptic LPF
DT-6FL1/2	6-pole Elliptic LPF

▼Cut-off frequency (fc)

Cut-off frequency (DT-5FL: -3dB, DT-6FL: 0dB*)	Type 1	10, 20, 50, 100, 200, 500, 1k, 2kHz			
	Type 2	100, 200, 500, 1k, 2k, 5k, 10k, 20kHz			
Setting (3-bit binary 1: 0V, 0: +5V or open)	Type 1	Type 2	Control		
			$\overline{C}$	$\overline{B}$	$\overline{A}$
	10Hz	100Hz	0	0	0
	20	200	0	0	1
	50	500	0	1	0
	100	1k	0	1	1
	200	2k	1	0	0
	500	5k	1	0	1
	1k	10k	1	1	0
	2k	20k	1	1	1
Accuracy	±3%				

▼Pass-band characteristics

Gain	0dB±0.3dB (0.05fc)
Ripple	0.13dBp-p (design center value)
Distortion	0.05% (typ)

▼Attenuation characteristics

	DT-5FL	DT-6FL
Rolloff	60dB/oct equivalent	80dB/oct equivalent
Attenuation characteristics	60dB (typ) 1.82fc	74dB (typ) 1.9fc
Minimum attenuation	60dB (typ)	74dB (typ)
High frequency attenuation 10fc to 1MHz	Min. 55dB	Min. 60dB

▼Input characteristics

Input impedance	Min. 50kΩ
Maximum input voltage (linear)	±10V

▼Output characteristics

Output impedance	Max. 100Ω
Maximum output voltage	±10V
Voltage noise (input short)	Max. 140μVrms, input short (10Hz to 500kHz BW)
Offset voltage	±10mV (typ) adjustable

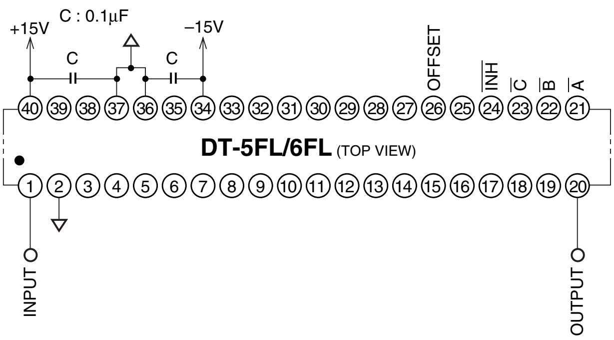
▼Others

Supply voltage		±15V (±14 to ±16V)	
Quiescent current		±28mA (typ)	±33mA (typ)
Temperature/ humidity range	**Operation**	–20°C to 70°C, 10 to 95%RH	
	Storage	–30°C to 80°C, 10 to 80%RH	
Dimensions		54.4 × 33.7 × 9.4mm, Type HA	

Note: The following specifications are applied unless otherwise specified: 23±5°C, Vs = ±15V

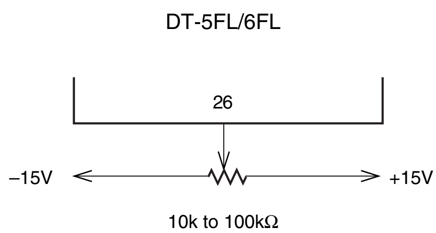
* See the characteristics plot.

Basic connection diagram



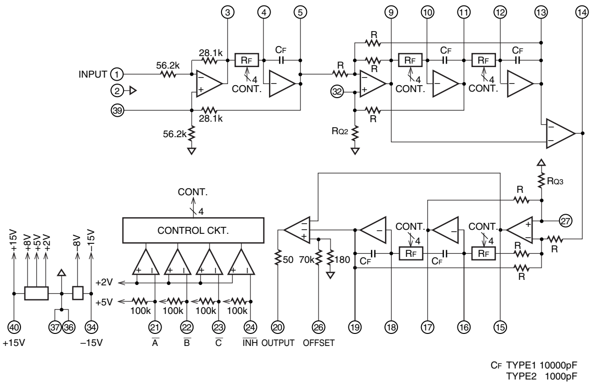
* INH is set at "0" (open or +5V) to allocate cut-off frequency according to 3-bit binary signal (A, B, C). All frequency-determining resistors become opened upon setting of "1" (0V) at INH, which enables the setting of cut-off frequency with the external resistors. Contact us for the calculation and connection of the external resistors.

■*Offset voltage adjustment*

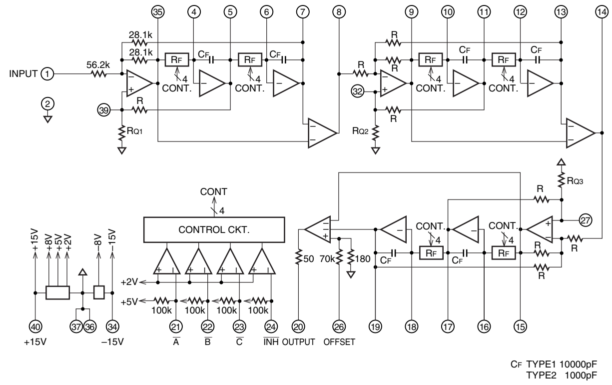


Block diagram

DT-5FL

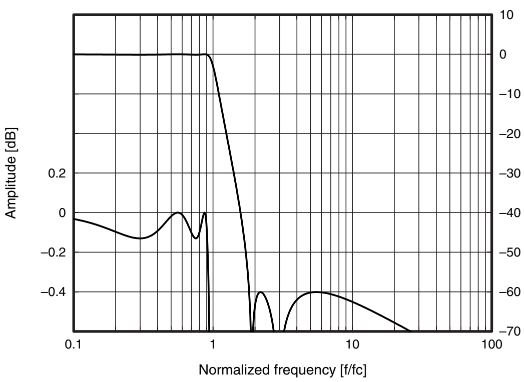


DT-6FL

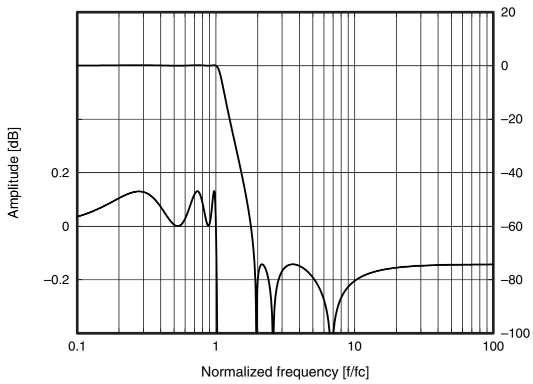


Characteristics

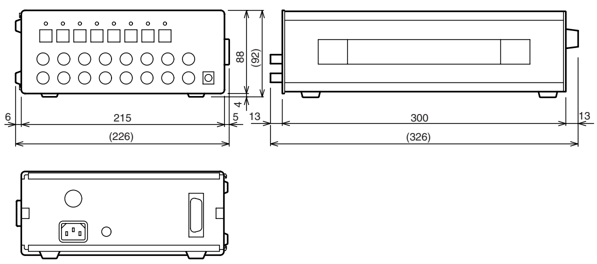
DT-5FL



DT-6FL



■*Multichannel filter 3344*



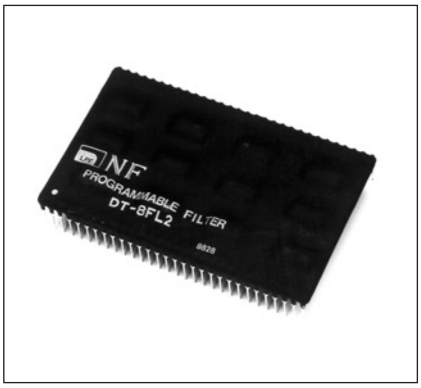
Rear panel

This case outfitted with the power supply is capable of storing up to 8 DT-5FL/6FL filters.

Number of channels	Max. 8
Fc control	8-channel batch control with a push switch on the front panel (remote control available)
Supply voltage	AC100V, ±10%, 48Hz to 62Hz
Dimensions	215 (W) ×88 (H) ×300 (D) mm (protrusion not included)

Programmable Filter

DT-8FL1/2



DT-8FL series filters are designed as anti-aliasing filters possessing 8-pole elliptic characteristics.
These filters are allocated with cut-off frequencies of 20Hz to 20kHz and of 100Hz to 100kHz that can be shifted at 10 positions in accordance with 4-bit external signal (1-, 2-, 5-sequence).
DT-8FL series filters are in 60-pin dual-inline package (DIP) and powered by ±8V.

Filters

▼Absolute maximum ratings

Supply voltage (±Vs)	±10V
Input voltage	±Vs
Control voltage	+8.5V, –0.5V

▼Filter characteristics

Filter characteristics	8-pole elliptic LPF

▼Cut-off frequency (fc)

Cut-off frequency range*	Type 1: 20Hz to 20kHz Type 2: 100Hz to 100kHz 1-, 2-, 5-sequence
Setting	4-bit binary code, negative logic

▼Pass-band characteristics

Gain	0dB±0.1dB (at 0.05fc)
Ripple	0.1dBp-p (typ) (at DC to fc)
Distortion	Max. 0.013% (at 0.5fc, 1Vrms)

▼Attenuation characteristics

Rolloff	130dB/oct equivalent
Attenuation characteristics	82dB (typ) (at 1.56fc to 1MHz)

▼Input characteristics

Input impedance	Min. 10kΩ, 20kΩ (typ)
Maximum input voltage (linear)	±5V

▼Output characteristics

Output impedance	Max. 100Ω, 50Ω (typ)
Maximum output voltage	±5V
Voltage noise	Type 1: 60µVrms (typ) Type 2: 80µVrms (typ) (BW: 10Hz to 500kHz)
Offset voltage	±10mV (typ) adjustable
Load resistance	Min. 2kΩ

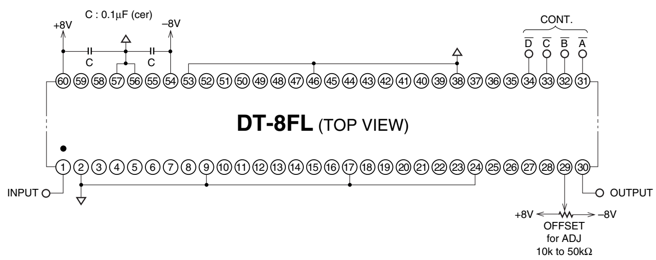
▼Others

Supply voltage		±8V ±10%
Quiescent current		Type 1: ±30mA (typ) Type 2: ±72mA (typ)
Temperature/ humidity range	Operation	–20°C to 70°C, 10 to 95%RH
	Storage	–30°C to 80°C, 10 to 80%RH
Dimensions		76.7 × 47.2 × 8.0mm, Type ID

Note: The following specifications are applied unless otherwise specified: 23±5°C, Vs = ±15V

* fc = A point passing 0dB

Basic connection diagram



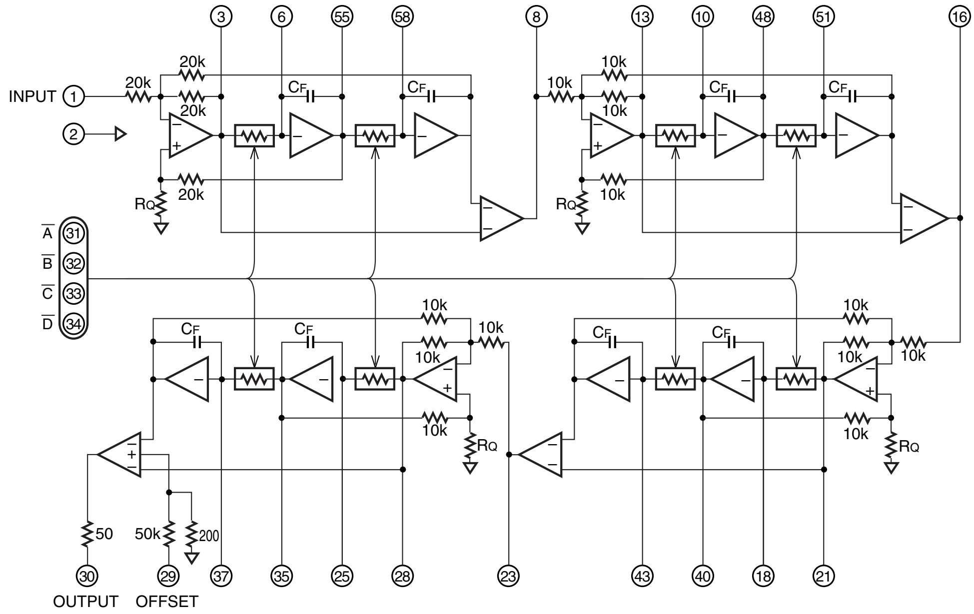
■Control

Control				Cut-off frequency [Hz]	
$\overline{D}$	$\overline{C}$	$\overline{B}$	$\overline{A}$	DT-8FL1	DT-8FL2
0	1	0	0	20k	100k
0	1	0	1	10k	50k
0	1	1	0	5k	20k
0	1	1	1	2k	10k
1	0	0	0	1k	5k
1	0	0	1	500	2k
1	0	1	0	200	1k
1	0	1	1	100	500
1	1	0	0	50	200
1	1	0	1	20	100

1: 0V or GND
0: +8V or open

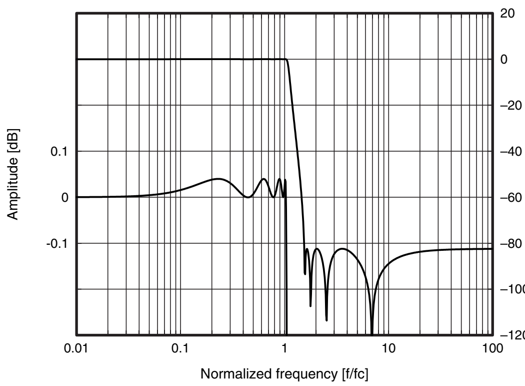
The control terminal is pulled up to +8V at 100kΩ for internal processing.

Block diagram

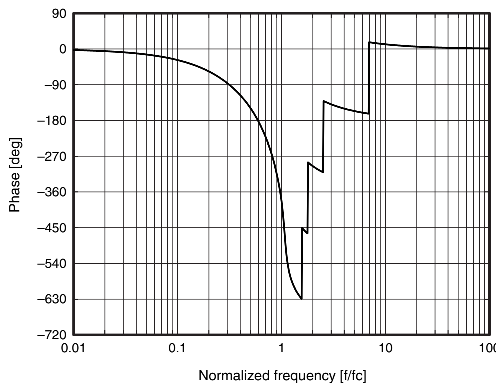


Characteristics

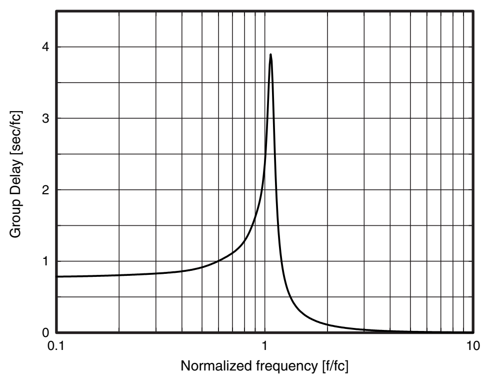
Amplitude



Phase



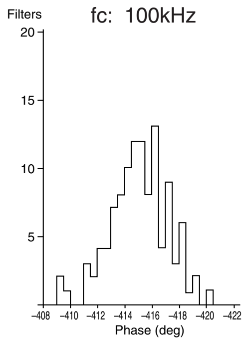
Group delay



Phase matching of cut-off frequency

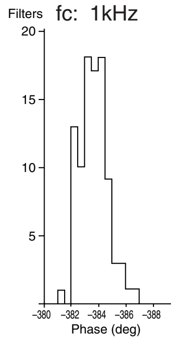
DT-8FL2

fc: 100kHz



DT-8FL2

fc: 1kHz



Fixed Frequency Filter

DV series

DV series filters are semi-custom-designed fixed frequency filters that allow customers to select desirable attenuation characteristics from our various existing characteristics. These filters can be customized to your specifications including the cut-off frequency (fc), center frequency (fo), and selectivity (Q).

■*DV series model and order specifications*

■Model

DV — a b c — d

- a: Order ("2" for 2-pole)
- b: Attenuation characteristics: B: Butterworth L: Bessel F: Elliptic or NF polar
- c: Filter characteristics: H: High pass L: Low pass P: Narrow band W: Wide band E: Band elimination
- d: DC-coupled filter if "DC" is indicated
  DC-coupled filter if no "DC" is indicated as to DV-7FL

E.g.: DV-3BL-DC denotes a 3-pole Butterworth DC-coupled low pass filter.

■Order specifications (Model and the following items are required for an order for customization.)

Filter type	Specifications	Remarks
High pass filter Low pass filter	• Cut-off frequency	–3dB
Narrow band pass filter	• Center frequency • Q	Q= Center frequency / 3dB bandwidth
Wide band pass filter	• Upper limit frequency (f_{CH}) • Lower limit frequency (f_{CL})	–3dB each Note that f_{CH}/f_{CL} limits are imposed.
Band elimination filter	Center frequency	

●Partial modification to standard filters and customized filters

Partial modification to standard filters is available as listed below. Custom making on filters is also available by special order. Contact us for further information.

- Supply voltage of +24V is modified to ±15V.
- Wide-band pass filter is rendered with different attenuation characteristics between high pass and low pass.
- Q of band elimination filters is set at any number other than 5.

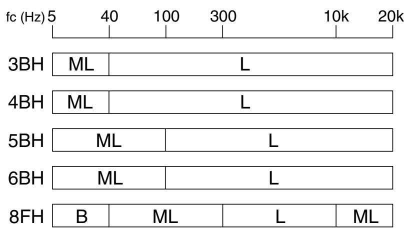
■*High pass filters*

Model	DV-3BH	DV-4BH	DV-5BH	DV-6BH	DV-8FH
Order	3	4	5	6	8
Rolloff	18dB/oct	24dB/oct	30dB/oct	36dB/oct	75dB/oct
Attenuation characteristics	Butterworth				NF polar*1
Cut-off frequency range	5Hz to 20kHz				
Cut-off frequency accuracy (25°C)	±2% (100Hz≤fc<10kHz),±3% (20Hz≤fc<100Hz, 10kHz≤fc<20kHz) ±5% (5Hz≤fc<20Hz)				
Maximum input voltage (Vrms)	3.0				2.5 (fc≤3kHz) 2.0 (3kHz<fc)
Input impedance	Min. 50kΩ				
Output impedance	Max. 100Ω				
Load impedance	Min. 10kΩ				
Pass-band gain	0dB±0.5dB				0dB±1dB*1
Distortion (2Vrms)	Max. 0.5%				
Noise	Max. 140μVrms (10Hz to 500kHz BW)				
Supply voltage	±24V				
Quiescent current (typ)	10mA (fc≤5kHz) 12mA (5kHz<fc)		12mA (fc≤3kHz) 15mA (3kHz<fc)		15mA (fc≤3kHz) 25mA (3kHz<fc)
Operating temperature	Range: 0 to 50°C				

Note: The following specifications are applied unless otherwise specified: 23±5°C

*1. Response hill rolloff: Min. 55dB Pass-band ripple: Max. ±1dB

●Dimensions

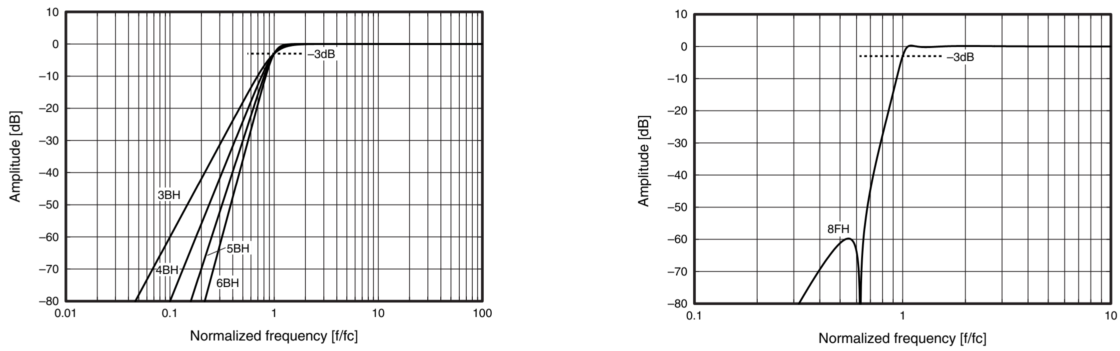


Type	Dimensions (mm)
L	30.8×53.7×18.4
ML	40.8×70.8×20.2
B	53.0×53.0×100.0

Note 1: Dimensions are determined with protrusions such as a connect pin excluded.

Note 2: Type B is applicable to US sockets, and all DV series filters are to be made with Type B.

Characteristics

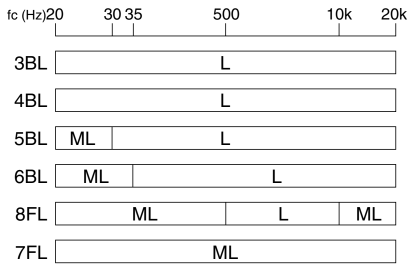


■*Low pass filters*

▼AC-coupled filters (DV-7FL excluded)

Model	DV-3BL	DV-4BL	DV-5BL	DV-6BL	DV-8FL	DV-7FL
Order	3	4	5	6	8	7
Rolloff	18dB/oct	24dB/oct	30dB/oct	36dB/oct	75dB/oct	260dB/oct
Attenuation characteristics	Butterworth				NF polar	Elliptic
Response hill rolloff	–				Min. 55dB	Min. 48dB
Cut-off frequency range	20Hz to 20kHz					
Cut-off frequency accuracy	±2% (100Hz≤fc≤10kHz), ±3% (20Hz≤fc<100Hz, 10kHz<fc≤20kHz)					±3%
Maximum input voltage (Vrms)	3.0				2.5 (fc≤3kHz) 2.0 (3kHz<fc)	7.0 (fc≤10kHz) 3.0 (10kHz<fc)
Input impedance	Min. 50kΩ					
Output impedance	Max. 100Ω					
Load impedance	Min. 10kΩ					
Pass-band gain	0dB±0.5dB				$0dB^{+0dB}_{-3dB}$	0dB±0.5dB
Pass-band ripple	–				Max. ±1dB	Max. ±1dB
Distortion (2Vrms)	Max. 0.5%					Max. 0.1%
Noise	Max. 140µVrms (10Hz to 500kHz BW)					
Supply voltage	+24V					±15V
Quiescent current (typ)	12mA				20mA	±20mA
Operating temperature	Range: 0 to 50°C					

●Dimensions



Type	Dimensions (mm)
L	30.8×53.7×18.4
ML	40.8×70.8×20.2
B	53.0×53.0×100.0

Note 1: Dimensions are determined with protrusions such as a connect pin excluded.

Note 2: Type B is applicable to US sockets, and all DV series filters are to be made with Type B.

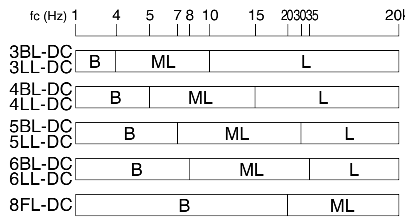
▼DC-coupled filters

Model[*1]	3BL-DC 3LL-DC	4BL-DC 4LL-DC	5BL-DC 5LL-DC	6BL-DC 6LL-DC	8FL-DC	7FL
Cut-off frequency range	1Hz to 20kHz				5Hz to 20kHz	See above
Attenuation characteristics	BL: Butterworth LL: Bessel				NF polar	
Maximum input voltage (Vrms)	7.0 (fc≤10kHz) 3.0 (10kHz<fc≤20kHz)				2.5	
Supply voltage	±15V					
Quiescent current (typ)	±12mA				±18mA	
Offset voltage	±5mV (23±5°C), 100µV/°C (typ)					

Note: The following specifications are applied unless otherwise specified: 23±5°C

*1: Be sure to assign “DV-” to the beginning of a model name for order. (E.g.: 3BL-DC→DV-3BL-DC)
Other specifications are in conformity with AC-coupled filters.

●Dimensions

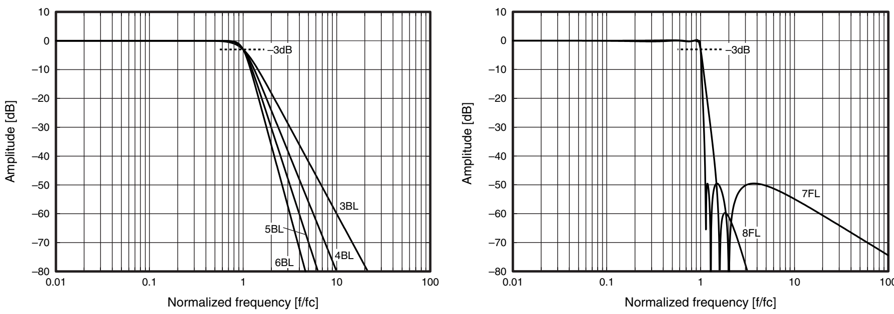


Type	Dimensions (mm)
L	30.8×53.7×18.4
ML	40.8×70.8×20.2
B	53.0×53.0×100.0

Note 1: Dimensions are determined with protrusions such as a connect pin excluded.

Note 2: Type B is applicable to US sockets, and all DV series filters are to be made with Type B.

Characteristics



■Band pass filters

▼Narrow band pass filters (Specifications of model, center frequency (fo), and selectivity (Q) are required for order.)

Model	DV-2BP	DV-3BP	DV-4BP	DV-5BP	DV-6BP
Order	4 (2-pole pair)	6 (3-pole pair)	8 (4-pole pair)	10 (5-pole pair)	12 (6-pole pair)
Rolloff	12dB/oct BW	18dB/oct BW	24dB/oct BW	30dB/oct BW	36dB/oct BW
Center frequency range	40Hz to 20kHz		40Hz to 10kHz		
Center frequency accuracy	±1% (25±5°C), ±2% (0 to 50°C)				
Q	1 to 10 (Error: ±10%)				
Maximum input voltage	7Vrms				
Input impedance	Min. 50kΩ				
Output impedance	Max. 100Ω				
Load impedance	Min. 10kΩ				
Pass-band gain	0dB±1dB				
Distortion	Max. 0.1% (1Vrms)				
Noise	Max. 140μVrms (10Hz to 500kHz BW)				
Supply voltage	±15V				
Quiescent current (typ)	±12mA	±20mA	±24mA	±32mA	±40mA
Operating temperature	Range: 0 to +50°C				
Type	Type L	Type ML	Type NL		

IEC (IEC-225)-compliant 1/3/oct, 1/2/oct, and 1/oct filters adhere to 4.3, 2.9, 1.4 of selectivity (Q) each in 3BP type.

▼Wide band pass filters (Specifications of model, lower limit frequency (f_{CL}), and upper limit frequency (f_{CH}) are required for order.)

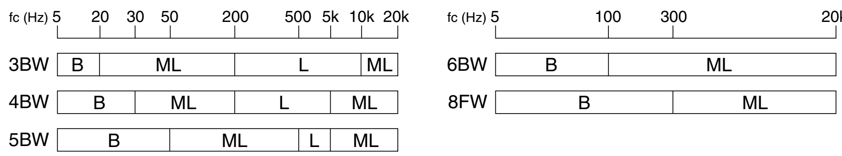
Model	DV-3BW	DV-4BW	DV-5BW	DV-6BW	DV-8FW
Order	6 (3-pole pair)	8 (4-pole pair)	10 (5-pole pair)	12 (6-pole pair)	16 (8-pole pair)
Rolloff	18dB/oct	24dB/oct	30dB/oct	36dB/oct	75dB/oct
Attenuation characteristics	Butterworth				NF polar*2
Cut-off frequency range	5Hz to 20kHz				
Minimum bandwidth*1	4.0	3.0	2.5	2.0	2.0
Center frequency accuracy	±3% (20Hz≤f_{CL}, f_{CH}≤10kHz), ±5% (5Hz≤f_{CL}, f_{CH}<20Hz or 10kHz< f_{CL}, f_{CH}≤20kHz)				
Maximum input voltage (Vrms)	3.0				2.5 (f_{CH}≤3kHz), 2.0 (f_{CH}<3kHz)
Input impedance	Min. 50kΩ				
Output impedance	Max. 100Ω				
Load impedance	Min. 10kΩ				
Pass-band gain	Max. 0dB±1dB				0dB (+0dB, –4dB)
Distortion	Max. 0.5% (2Vrms)				
Noise	Max. 140μVrms (10Hz to 500kHz BW)				
Supply voltage	±24V				
Quiescent current (typ)	15mA (f_{CH}≤5kHz), 20mA (5kHz<f_{CH})		20mA (f_{CH}≤3kHz), 25mA (3kHz<f_{CH})		30mA (f_{CH}≤3kHz), 40mA (3kHz<f_{CH})
Operating temperature	Range: 0 to +50°C				

Note: The following specifications are applied unless otherwise specified: 23±5°C

*1: f_{CH}/f_{CL}

*2: Response hill rolloff: Min. 55dB Pass-band ripple: ±1dB

●Dimensions



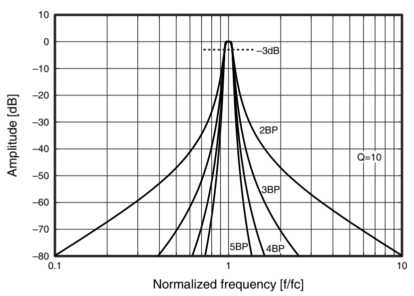
Type	Dimensions (mm)
L	30.8×53.7×18.4
ML	40.8×70.8×20.2
B	53.0×53.0×100.0

Note 1: Dimensions are determined with protrusions such as a connect pin excluded.

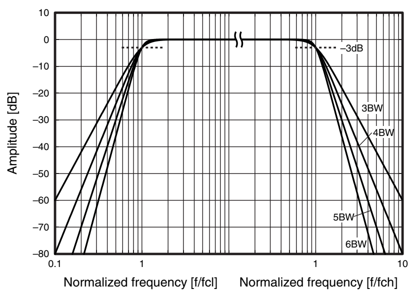
Note 2: Type B is applicable to US sockets, and all DV series filters are to be made with Type B.

Characteristics

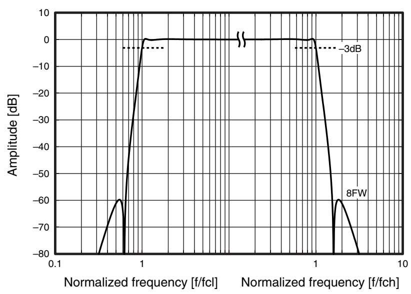
Narrow-band pass filters



Wide-band pass filters



Wide-band pass filters



Filters

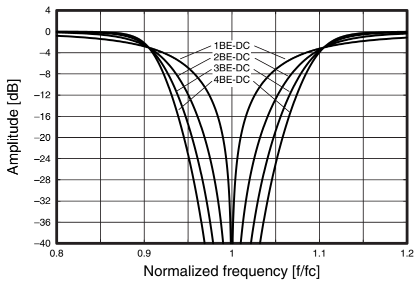
■Band elimination filters

(Specifications of model and center frequency (fo) are required for order.)

Model		DV-1BE-DC	DV-2BE-DC	DV-3BE-DC	DV-4BE-DC
Order		2 (1-pole pair)	4 (2-pole pair)	6 (3-pole pair)	8 (4-pole pair)
Rolloff	Specified fo	Min. 26dB	Min. 40dB	Min. 60dB	Min. 70dB
	Measured fo	Min. 40dB	Min. 60dB	Min. 72dB	
Center frequency range		40Hz to 10kHz			
Center frequency accuracy		±1% (0 to 50°C)			
Q		5 (±10%)			
Maximum input voltage		7Vrms			
Input impedance		Min. 50kΩ			
Output impedance		Max. 100Ω			
Load impedance		Min. 10kΩ			
Pass-band gain		0dB±0.5dB, Max. –1dB at 30kHz for upper limit frequency			
Distortion		Max. 0.1% (7Vrms)			
Noise		Max. 140µVrms (10Hz to 500kHz)		Max. 240µVrms (10Hz to 500kHz)	
Supply voltage		±15V			
Quiescent current (typ)		±12mA	±20mA	±32mA	±40mA
Operating temperature		Range: 0 to +50°C			
Dimensions		40.8 × 70.8 × 20.2mm, Type ML		53.0 × 53.0 × 100.0mm, Type B	

Note: The following specifications are applied unless otherwise specified: 23±5°C

Characteristics



■Precautions for use

●DC voltage is applied to the input/output terminals in 24-volt filters and ±15-volt modified filters, which requires the interruption of DC voltage with a capacitor to use the relevant filters. The capacitor capacity is derived from the following equation with min. 10kΩ of load applied. The proper polarity of the capacitor (see the following figure) and withstand pressure should be assured.

A. Low pass filters

Note that the lower limit (f_L) of the pass band is determined.

$$C_{IN} = \frac{32}{f_L}\ (\mu F) \quad C_{OUT} = 5 \times C_{IN}\ (\mu F)$$

A reduction in f_L level is limited to 0.1dB if the above value is assigned, and 12dB/oct is obtained for the reduced rolloff.

B. High pass filters

Cut-off frequency determined by the capacitor should be 1/20 of f_c at the maximum. The following equation is used to obtain the value.

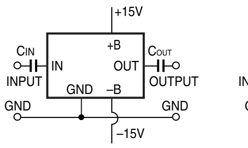
$$C_{IN} = \frac{64}{f_L}\ (\mu F) \quad C_{OUT} = 5 \times C_{IN}\ (\mu F)$$

High pass frequency characteristics: Max. 1MHz at output of 2Vrms

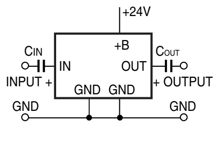
C. Band pass filters

The equation at “B. High pass filters” is also applied to derive wide band pass filters (with f_{CL} and f_{CH} specified).

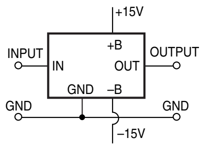
●Be sure to use a stable power that is small in ripple and noise. Potential degradation in filter characteristics and distortion and potential reduction in the maximum input level may be concerned if the voltage that is out of the specifications (Max. 2mVp-p for ±15V filters, and Max. 0.5mVp-p for +24V filters and ±15V modified filters) is applied.



±15V modified filters (non-polar capacitor used)

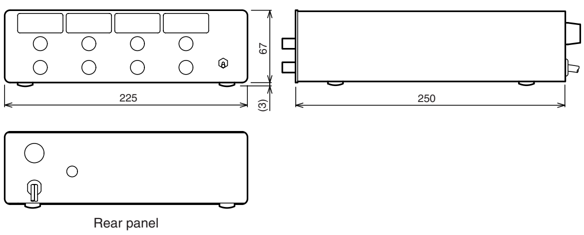


+24V filters



+15V filters

■Multichannel filter DV-04/04B



This case, which is outfitted with DC power for DV filter drive, is designed to use DV filters on the desktop. It is capable of storing up to 4 DV filters*. DV-04 is designed for Types L/ML/NL, and DV-04B supports Type B (±15V, DC-coupled filters). CF series filters (see Page 36) can also be embedded in DV-04 with the use of the CF/DV conversion adapter.
* The maximum quiescent current may impose limits on the number of filters to be stored.

Available filters	Max. 4 DV filters*, Types L/ML/NL, CF series (CF/DV conversion adapter used): DV-04 for Type B: DV-04B
Max. quiescent current	40mA/1 channel: (DV-04) 140mA/4 channels: (DV-04B)
I/O terminals	BNC-R
Supply voltage	AC100V ±10% 50/60Hz
Dimensions	225 (W)×67(H)×250(D)mm (protrusion not included)

A multichannel filter with DC power supply is also available by special order. Contact us for further information.

Fixed Frequency Filter

CF series

CF series filters are semi-custom-designed fixed frequency filters that allow customers to select desirable characteristics from our various existing standard filter characteristics. These filters can be customized to your specifications including the cut-off frequency, center frequency, and selectivity (Q), which requires no external components. Customization is also enabled in accordance with the relevant characteristics plot and transfer functions other than filter characteristics.
Not only the prominent downsizing but the weight reduction of filters has been actualized by capitalizing on surface mount technology, as compared with the current DV series filters.
CF series filters can also be embedded in DV-04 (see Page 35) with the use of the CF/DV conversion adapter. Integration of CF series filters carrying 40mA or more of quiescent current is disabled due to limits on the DV-04 current capacity.

■CF series model and order specifications

■Model

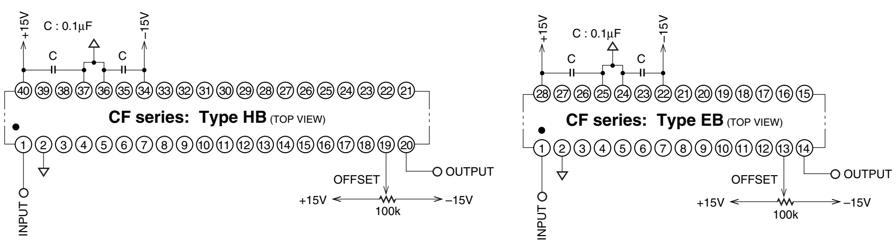
CF—a b c—d—e Hz—Q f—g

- a: Order ("2" for 2-pole)
- b: Attenuation characteristics: B: Butterworth, C: Chebyshev[*1], L: Bessel, F: Elliptic
- c: Filter characteristics: H: High pass, L: Low pass, P: Band pass, E: Band elimination
- d: Type: EB or HB
- e: Cut-off frequency or center frequency
- f: Value (Band pass filter only) = Center frequency / Bandwidth
- g: Amplitude characteristics: A, B, or C (Elliptic filter only)

*1 Not standard characteristics.

Absolute maximum rating	Supply voltage (±Vs) ±18V Input voltage ±Vs
Input characteristics	Input impedance: Min. 50kΩ Maximum input voltage: ±10V (linear)
Output characteristics	Output impedance: Max. 100Ω Maximum output voltage: ±10V (in the pass band) Load resistance: Min. 10kΩ
DC offset voltage	Max. ±5mV
DC offset adjustment	Enabled
Supply voltage	±15V (±5 to ±18V)
Temperature/humidity range	Operation: –20°C to 70°C, 10 to 95%RH Storage: –30°C to 80°C, 10 to 80%RH

Basic connection diagram

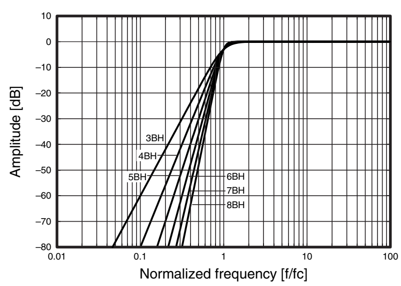


■High pass filters

●Butterworth

Model		CF-3BH	CF-4BH	CF-5BH	CF-6BH	CF-7BH	CF-8BH
Order		3	4	5	6	7	8
Rolloff		18dB/oct	24dB/oct	30dB/oct	36dB/oct	42dB/oct	48dB/oct
Attenuation characteristics		Butterworth					
Cut-off frequency range		1Hz to 50kHz					
Cut-off frequency accuracy		±2% (23±5°C)					
Pass-band gain		0dB±0.5dB					
Maximum input voltage		±10V					
Distortion (7Vrms)		0.01% (typ)					
Noise		Max. 140μVrms (10Hz to 500kHz BW)					
Quiescent current (typ)	fc<20kHz	±8mA		±12mA		±16mA	
	20kHz≥fc	±16mA		±24mA		±32mA	
Type		Type EB: 10Hz to 50kHz, Type HB: 1Hz to 50kHz					

Characteristics



●Elliptic

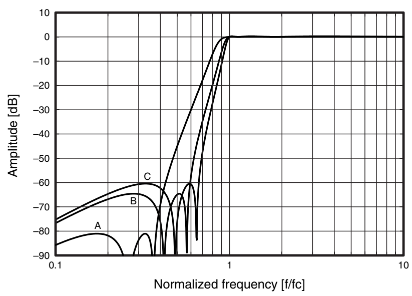
Model	CF-6FH			CF-7FH			CF-8FH		
Amplitude characteristics	Type A	Type B	Type C	Type A	Type B	Type C	Type A	Type B	Type C
Order	6			7			8		
Rolloff (equivalent)	60dB/oct	80dB/oct	100dB/oct	84dB/oct	128dB/oct	260dB/oct	135dB/oct	100dB/oct	274dB/oct
Filter characteristic	Elliptic								
Cut-off frequency range*1	10Hz to 50kHz								
Ripple: 100kHz to 1.1fc	±0.3dB	±0.5dB	±0.7dB	±0.3dB	±0.5dB	±0.7dB	±0.5dB	±0.3dB	±0.7dB
Ripple: 1.1fc to fc	±0.7dB	±1.0dB	±1.2dB	±0.7dB	±1.0dB	±1.2dB	±1.0dB	±0.7dB	±1.2dB
Attenuation characteristics	80dB (typ) 0.38fc	60dB (typ) 0.58fc	60dB (typ) 0.66fc	82dB (typ) 0.51fc	62dB (typ) 0.71fc	50dB (typ) 0.87fc	86dB (typ) 0.64fc	100dB (typ) 0.50fc	64dB (typ) 0.85fc
Low frequency attenuation (DC to 0.1fc)	76dB	56dB	55dB	77dB	57dB	45dB	80dB	95dB	59dB
Pass-band gain	0±0.5dB								
Distortion (7Vrms)	0.01% (typ)								
Noise	Max. 140μVrms (fc<20kHz), Max. 240μVrms (fc≥20kHz) in the 10Hz to 500kHz BW								
Quiescent current (typ): fc<20kHz	±24mA			±32mA			±32mA		
Quiescent current (typ): 20kHz≤fc	±40mA			±48mA*2			±48mA*2		
Type	Type HB or Type EB			Type HB					

Note: The following specifications are applied unless otherwise specified: 23±5°C, Vs = ±15V

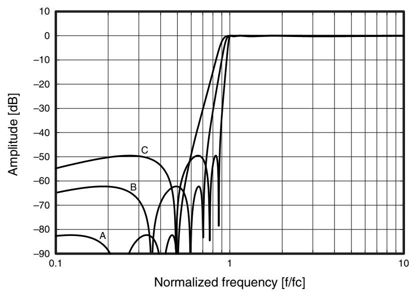
*1. fc = A point passing 0dB (applied to simultaneous Chebyshev filters only) *2. Integration into DV-04 is disabled due to excessive quiescent current.

Characteristics

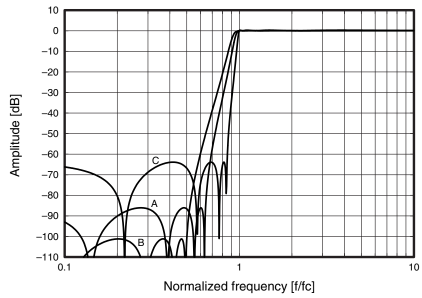
CF-6FH



CF-7FH



CF-8FH

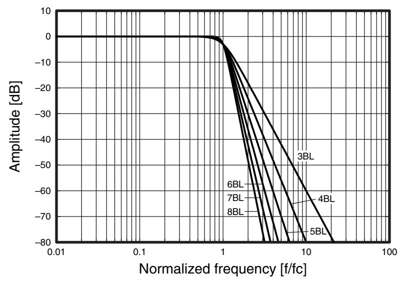


■*Low pass filters*

●Butterworth

Model		CF-3BL	CF-4BL	CF-5BL	CF-6BL	CF-7BL	CF-8BL
Order		3	4	5	6	7	8
Rolloff		18dB/oct	24dB/oct	30dB/oct	36dB/oct	42dB/oct	48dB/oct
Attenuation characteristics		Butterworth					
Cut-off frequency range		1Hz to 1MHz					
Cut-off frequency accuracy		±2%					
Pass-band gain		0dB±0.5dB					
Maximum input voltage		±10V					
Distortion (7Vrms)		0.01% (typ), fc≤100kHz					
Noise	1Hz≤fc≤100kHz	Max. 100μVrms (10Hz to 500kHz BW)					
	100kHz<fc	Max. 400μVrms (10Hz to 20MHz BW)					
Quiescent current (typ)	fc<20kHz	±12mA		±12mA (Type HB), ±16mA (Type EB)		±16mA	
	20kHz≤fc	±24mA		±24mA (Type HB), ±32mA (Type EB)		±32mA	
Type		Type EB: 10Hz to 1MHz, Type HB: 1Hz to 100kHz					

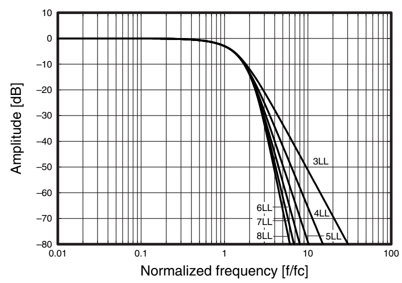
Characteristics



●Bessel

Model		CF-3LL	CF-4LL	CF-5LL	CF-6LL	CF-7LL	CF-8LL
Order		3	4	5	6	7	8
Attenuation characteristics		Bessel					
Cut-off frequency range		1Hz to 1MHz					
Cut-off frequency accuracy		±2%					
Pass-band gain		0dB±0.5dB					
Maximum input voltage		±10V					
Distortion (7Vrms)		0.01% (typ), fc≤100kHz					
Noise	1Hz≤fc≤100kHz	Max. 100μVrms (10Hz to 500kHz BW)					
	100kHz<fc	Max. 400μVrms (10Hz to 20MHz BW)					
Quiescent current (typ)	fc<20kHz	±12mA		±12mA (Type HB), ±16mA (Type EB)		±16mA	
	20kHz≤fc	±24mA		±24mA (Type HB), ±32mA (Type EB)		±32mA	
Type		Type EB: 10Hz to 1MHz, Type HB: 1Hz to 100kHz					

Characteristics



●Elliptic

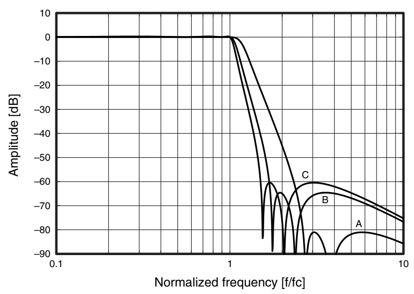
*fc: A point passing 0dB

Model		CF-6FL			CF-7FL			CF-8FL		
Amplitude characteristics		Type A	Type B	Type C	Type A	Type B	Type C	Type A	Type B	Type C
Order		6			7			8		
Rolloff (equivalent)		60dB/oct	80dB/oct	100dB/oct	84dB/oct	128dB/oct	260dB/oct	135dB/oct	100dB/oct	274dB/oct
Filter characteristic		Elliptic								
Cut-off frequency range		10Hz to 1MHz					10Hz to 100kHz	10Hz to 1MHz	10Hz to 100kHz	
Ripple	DC to 0.9fc	±0.3dB	±0.5dB	±0.7dB	±0.3dB	±0.5dB	±0.7dB	±0.5dB	±0.3dB	±0.7dB
	0.9fc to fc	±0.7dB	±1.0dB	±1.2dB	±0.7dB	±1.0dB	±1.2dB	±1.0dB	±0.7dB	±1.2dB
Attenuation characteristics		80dB (typ) 2.64fc	60dB (typ) 1.71fc	60dB (typ) 1.51fc	82dB (typ) 1.96fc	62dB (typ) 1.40fc	50dB (typ) 1.15fc	86dB (typ) 1.56fc	100dB (typ) 2.00fc	64dB (typ) 1.175fc
High frequency attenuation	fc≤100kHz	Min. 76dB*1	Min. 56dB*1	Min. 55dB*1	Min. 77dB*1	Min. 57dB*1	Min. 45dB*1	Min. 80dB*1	Min. 86dB*1	Min. 59dB*1
	fc>100kHz	Min. 64dB*2	Min. 56dB*2	Min. 55dB*2	Min. 60dB*2	Min. 54dB*2	–	Min. 60dB*2	–	–
Pass-band gain		0±0.5dB								
Distortion (7Vrms)		0.01% (typ), fc≤100kHz								
Noise		Max. 100μVrms (fc<50kHz), Max. 200μVrms (50kHz≤fc≤100kHz) (10Hz to 500kHz BW) Max. 700μVrms (100kHz<fc≤1MHz) (10Hz to 20MHz BW)								
Quiescent current (typ)	fc<20kHz	±24mA	±24mA	±24mA	±32mA	±32mA	±32mA	±32mA	±32mA	±32mA
	20kHz≤fc≤100kHz	±40mA	±40mA	±40mA	±48mA*3	±48mA*3	±48mA*3	±48mA*3	±48mA*3	±48mA*3
	100kHz<fc≤1MHz	±45mA*3	±45mA*3	±45mA*3	±50mA*3	±50mA*3	–	±50mA*3	–	–
Type		Type EB (fc 10Hz to 100kHz), Type HB (fc 10Hz to 1MHz)			Type HB					

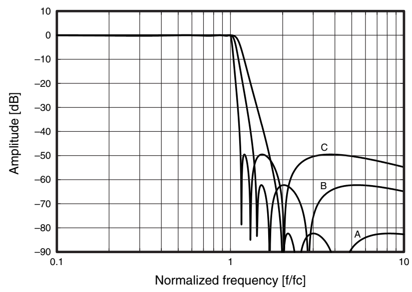
*1. Frequency range: 10fc to 1MHz *2. Frequency range: 2MHz to 10MHz *3. Integration into DV-04 is disabled due to excessive quiescent current.

Characteristics

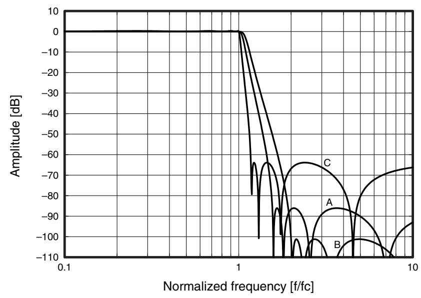
CF-6FL



CF-7FL



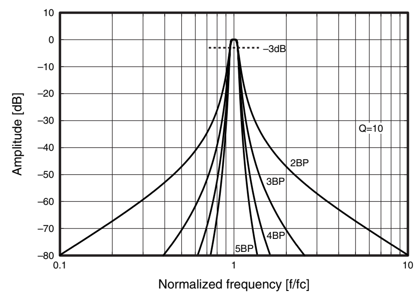
CF-8FL



■*Band pass filters*

Model		CF-2BP	CF-3BP	CF-4BP	CF-5BP	CF-6BP
Order		4 (2-pole pair)	6 (3-pole pair)	8 (4-pole pair)	10 (5-pole pair)	12 (6-pole pair)
Attenuation characteristics		12dB/oct BW	18dB/oct BW	24dB/oct BW	30dB/oct BW	36dB/oct BW
Center frequency range		1Hz to 100kHz				
Center frequency accuracy		±1% (23±5°C)				
Q		1 to 10 (Accuracy: ±5%)				
Pass-band gain		0dB±0.5dB				
Maximum input voltage		±10V				
Distortion (7Vrms)		0.01% (typ)				
Noise		Max. 100μVrms (fc<50kHz), Max. 200μVrms (fc≥50kHz) 10Hz to 500kHz BW				
Quiescent current (typ)	fc<20kHz	±12mA	±16mA	±24mA	±28mA	±32mA
	20kHz≤fc	±24mA	±32mA	±48mA*3	±56mA*3	±64mA*3
Type		Type EB	Type HB			

Characteristics

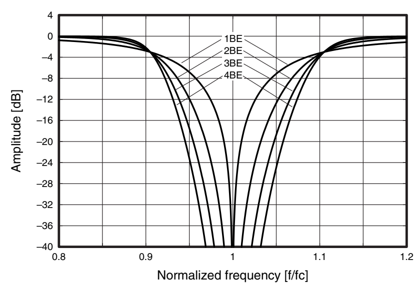


■*Band elimination filters*

Model		CF-1BE	CF-2BE	CF-3BE	CF-4BE
Order		2 (1-pole pair)	4 (2-pole pair)	6 (3-pole pair)	8 (4-pole pair)
Rolloff	Specified fo	Min. 26dB	Min. 40dB	Min. 60dB	Min. 70dB
	Measured fo	Min. 40dB	Min. 60dB	Min. 72dB	
Center frequency range		1Hz to 50kHz			
Center frequency accuracy		±1% (23±5°C)			
Q		5 (Accuracy: ±5%)			
Pass-band gain		0dB±0.5dB			
Maximum input voltage		±10V			
Distortion (7Vrms)		0.01% (typ)			
Noise		Max. 140μVrms (10Hz to 500kHz BW)		Max. 240μVrms (10Hz to 500kHz BW)	
Quiescent current (typ)	fc<20kHz	±8mA	±16mA	±24mA	±32mA
	20kHz≤fc	±16mA	±32mA	±48mA*3	±64mA*3
Type		Type EB	Type HB		

*3. Integration into DV-04 is disabled due to excessive quiescent current.

Characteristics



Customization is also enabled in accordance with the relevant characteristics plot and transfer functions if no intended characteristics are observed in standard filter characteristics or no specific model is provided.

Band Elimination Filter

SD-1BE

SD-1BE filter is a low-powered hybrid IC 1-pole pair band elimination filter. Mode selection is available under digital control, FILT mode or THRU mode. FILT mode can be placed at 50Hz or 60Hz of center frequency, and the rolloff is controlled to remain 24dB or more even if ±1% is shifted from center frequency.
The offset voltage is internally adjusted to 10mV or lower in both THRU and FILT modes.
The downsizing has been achieved to actualize a 20-pin single-inline package (SIP).

▼Absolute maximum ratings

Model	Band elimination filter
Order	1-pole pair
Mode	FILT mode, THRU mode
Setting	TTL or C-MOS, negative logic Pulled up to +5V at 100kΩ

▼Transfer characteristics (FILT mode)

Center frequency (fo)	50Hz or 60Hz
Setting	TTL or C-MOS, negative logic Pulled up to +5V at 100kΩ
Q	2.0 (fo=50Hz), 2.4 (fo=60Hz)
Maximum attenuation	Min. 24dB (fo±1%)

▼FILT/THRU mode common characteristics

Pass-band gain	0±0.3dB (0.1fo)
Upper limit frequency	50kHz, Max. 0±1dB (small signal)

▼I/O characteristics

Input impedance	Max. 60kΩ ±5%
Max. input voltage (linear)	±10V
Output impedance	Max. 50Ω ±5%
Max. output voltage (linear)	±10V
Offset voltage	Max. ±10mV (Zero adjustment available)
Noise	140µVrms typ (BW: 10Hz to 500kHz)
Distortion	Max. 0.01% (at 1kHz, ±3V applied)

▼Others

Supply voltage (Vs), Quiescent current		±5 to ±16V	±0.7mA (typ) –1.0mA (typ)
		±5V	+300µA (typ)
Temperature/ humidity range	**Operation**	–10°C to 60°C, 10 to 90%RH	
	Storage	–20°C to 70°C, 10 to 80%RH	
Dimensions		51.5 × 14.0 × 4.0mm, Type S20	

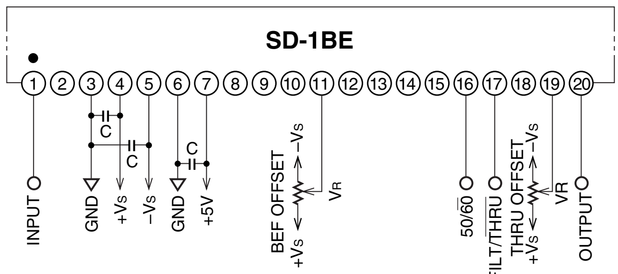
Note: The following specifications are applied unless otherwise specified: 23±5°C, ±15V, +5V of power

■*Controlling*

	50/$\overline{60}$	FILT/$\overline{\text{THRU}}$
0	50Hz	FILT
1	60Hz	THRU

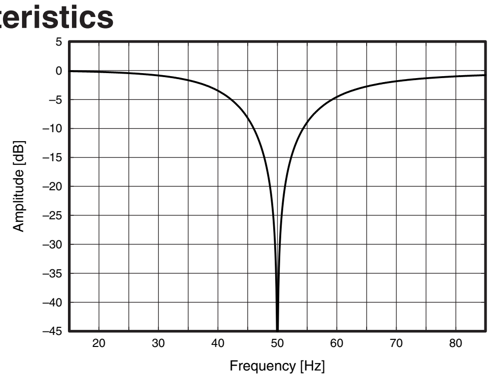
0: Open or +5V
1: 0V

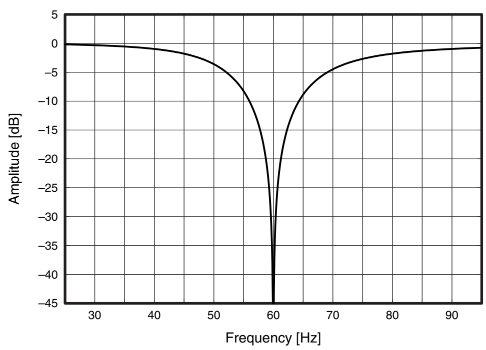
Basic connection diagram



GND: Pins 3 and 6 are internally shorted.
VR : 10kΩ to 100kΩ
C : 0.1µF (cer)

Characteristics





200B/S Band Pass Filter

CF-4FPA

CF-4FPA filter is a band pass filter designed for a 200B/S modem. This filter possesses frequencies falling into the following six types: 800, 1200, 1600, 2000, 2400, and 2800Hz. The downsizing has been achieved to actualize a 40-pin dual-inline package in dimensions of 54.4 × 33.7 × 6.5mm.

▼Absolute maximum ratings

Supply voltage (±Vs)	±18V
Input voltage	±Vs

▼Filter characteristics

Filter characteristics	4-pole Elliptic BPF

▼Center frequency (fo)

Center frequency	800, 1200, 1600, 2000, 2400, 2800Hz (nominal value)

▼Pass-band characteristics

Gain	0±1dB (fo)
Pass-band ripple	0±1dB (fo±100Hz, fo=0dB)

▼Attenuation

Attenuation	Min. 15dB (fo±200Hz) Min. 45dB (fo±300Hz)

▼Distortion

Distortion	Max. 0.1% (3Vrms applied)

▼Input characteristics

Impedance	Min. 50kΩ
Maximum voltage	±10V
Maximum voltage	Same as supply voltage

▼Output characteristics

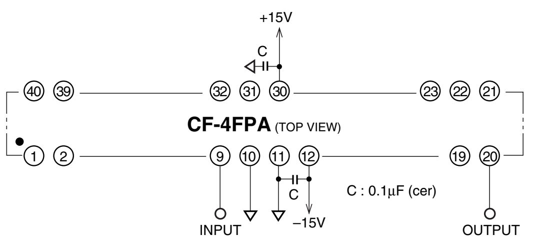
Impedance	Max. 100Ω
Load resistance	Min. 10kΩ
Max. output voltage	±10V
Noise	Max. 140μVrms (BW: 10Hz to 500kHz)
Offset voltage	±20mV (typ)

▼Others

Supply voltage		±15V (±5 to ±16.5V operational)
Quiescent current		±28mA (typ) (Max. ±42mA)
Temperature/ humidity range	Operation	–20°C to 70°C, 10 to 95%RH
	Storage	–30°C to 80°C, 10 to 80%RH
Dimensions		54.4 × 33.7 × 6.5mm, Type H

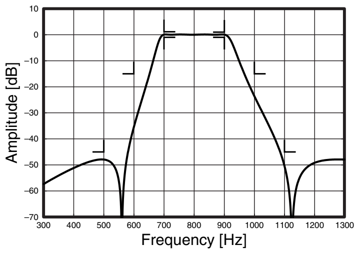
Note: The following specifications are applied unless otherwise specified: 23±5°C, Vs = ±15V

Basic connection diagram

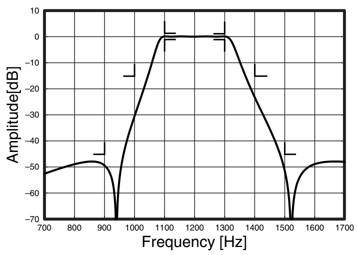


Characteristics

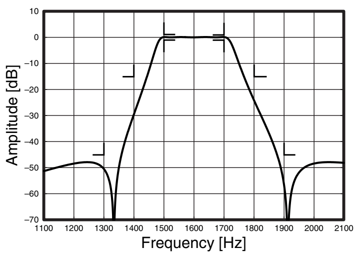
Frequency characteristics



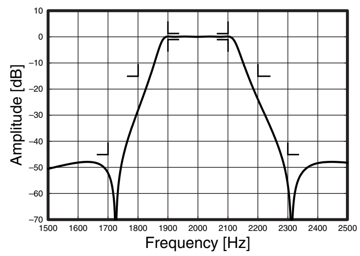
CF-4FPA 800Hz



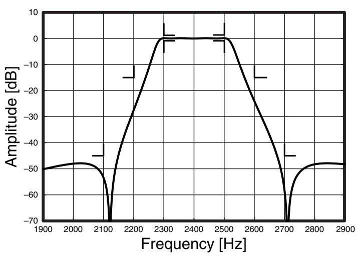
CF-4FPA 1200Hz



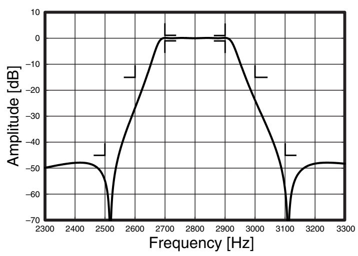
CF-4FPA 1600Hz



CF-4FPA 2000Hz

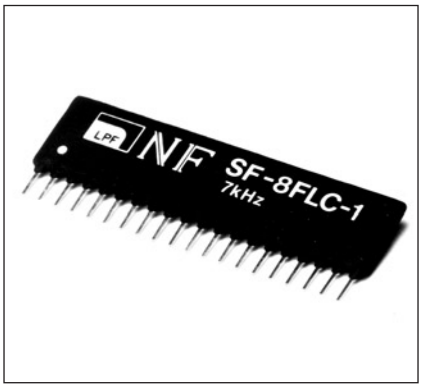


CF-4FPA 2400Hz



CF-4FPA 2800Hz

Low Pass Filter for Wide Band Speech Signals



SF-8FLC-1 *compliant with CCITT Rec.G.722*

SF-8FLC-1 filter is a low pass filter intended for anti-aliasing of terminal equipment in a 64kbit/sec of wideband transmission network. This filter possesses steep attenuation characteristics such as -25dB at 8kHz, –50dB at 9kHz, and –70dB at 14kHz despite 7kHz of cut-off frequency.
Not only the prominent downsizing but the weight reduction of the filter has been realized to achieve a 20-pin single-inline package in dimensions of 51.5 × 14.0 × 5.5mm.

▼Filter characteristics

Filter characteristics	Compliant with CCITT Rec.G.722.
Pass-band gain	±0.5dB (1kHz, 10kΩ of load)
Amplitude characteristics (1kHz = 0dB)	+0/–1.5dB (50Hz), ±0.5dB (100Hz), +0.5dB (6.4kHz), +0.5/–1.5dB (7kHz), Max. –25dB (8kHz), Max. –50dB (9kHz), Max. –70dB (14kHz)
Fixed delay	Max. 2ms (minimum pass band)
Group delay response	Max. 1ms (50Hz), Max. 500µs (100Hz), Max. 125µs (200Hz), Max. 125µs (4kHz), Max. 500µs (6.4kHz), Max. 1ms (7kHz) (Fixed delay = 0s)

▼Input characteristics

Input impedance	Min. 50kΩ
Maximum voltage	±10V

▼Output characteristics

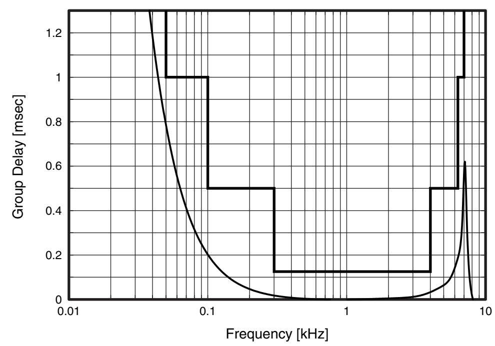
Output impedance	Max. 100Ω
Max. output voltage	±10V
Load impedance	Max. 10kΩ
Noise	Max. 140µVrms (BW: 10Hz to 500kHz)
Offset voltage	±30mV (typ)

▼Others

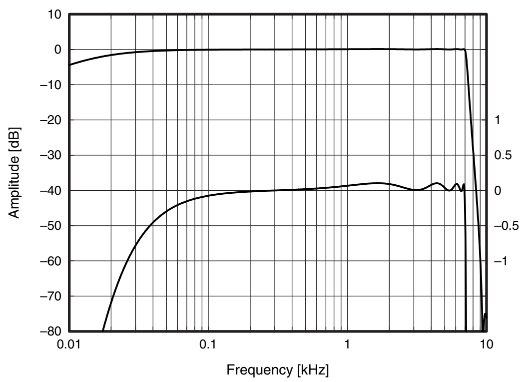
Supply voltage/current		±15V ±10%, ±32mA (typ)
Temperature/ humidity range	**Operation**	–20°C to 70°C, 10 to 95%RH
	Storage	–30°C to 80°C, 10 to 80%RH
Dimensions		51.5 × 14.0 × 5.5mm, Type S20

Note: The following specifications are applied unless otherwise specified: 23±5°C, Vs = ±15V

Characteristics

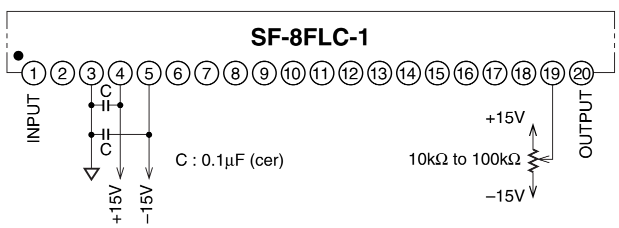


Measured group delay response



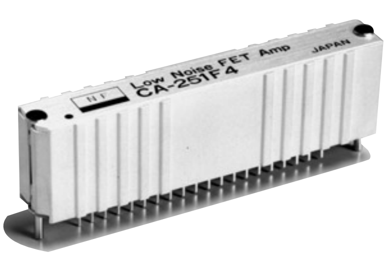
Measured frequency response

Basic connection diagram



Low Noise Amplifier

CA-251F4



CA-251F4 amplifier is a low noise amplifier allocated with bandwidth of DC to 10MHz. With substantially low noise maintained, outstanding DC characteristics and frequency characteristics have been actualized through the adoption of the noise reduction circuit that is the application of the negative feedback technology. Our original 6-surface-shielded single-inline package is a great contributor to the implementation of high precision signal processing and high density mounting. CA-251F4 is powered by ±15V, and its gain is 40dB.

▼Absolute maximum ratings

Supply voltage (±Vs)	±16.5V
Signal input voltage	±1V, ±0.5V (with no power supplied)
Offset input voltage	±Vs

▼Input

Input form	DC coupling, unbalanced single ended input
Input impedance	1MΩ ±5% (DC, Pins ① and ② connected, Shunt capacitance: 55pF (typ))
Linear maximum input voltage	±100mV (at 1kHz)
Input bias current	±30pA (typ)
Input voltage noise density	Max. 1.8nV/√Hz (at 10kHz, short-circuit in input terminal) 1.4nV/√Hz (typ) (at 10kHz, short-circuit in input terminal)
Input current noise density	150fA/√Hz (typ) (at 1kHz)
Input offset voltage	±50μV (typ) (short-circuit in input terminal) Zero adjustment available with an external trimmer potentiometer.
Input DC drift	±2μV/°C (typ) (short-circuit input terminal) 0 to 40°C

▼Output

Output form	DC coupling, unbalanced single ended output
Maximum output voltage	±10V (at 1kHz, load resistance≥1kΩ)
Maximum output current	±10mA
Slew rate	110V/μs (typ)
Output impedance	50Ω ±5% (DC)

▼Amplifier

Voltage gain	40±0.2dB (at 1kHz)
Voltage gain frequency characteristics	DC to 10MHz (+0.5/–3dB)
I/O phase	In-phase
Harmonics distortion	0.006% (typ) (at 1kHz, ±10V output)

▼Power supply

Recommended power supply voltage range	±15V±1V
Quiescent current	±30mA, ±25mA (typ)

▼Environment

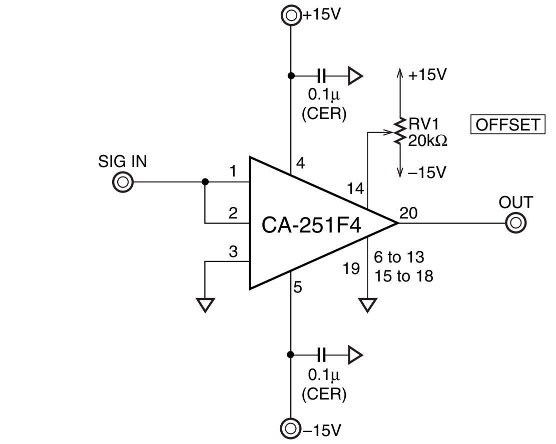
Specified temperature range		23±5°C
Temperature/ humidity range	**Operation**	–20°C to 70°C, 10 to 90%RH
	Storage	–30°C to 80°C, 10 to 80%RH

▼Dimensions

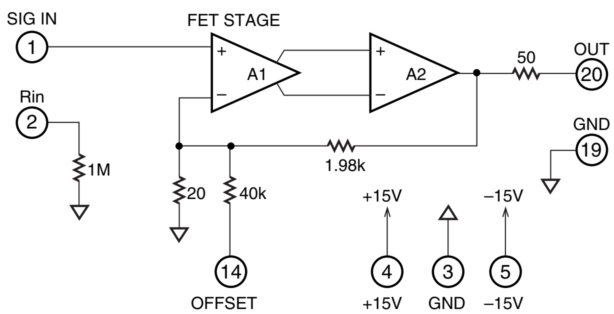
Type	Type SS20 (20-pin shielded SIP)
Dimensions	67 × 10.5 × 20mm (protrusion not included)
Weight (NET)	Approx. 20g

Note: The following specifications are applied unless otherwise specified: 23±5°C, Supply voltage: ±15V, Load resistance: 1MΩ

Basic connection diagram

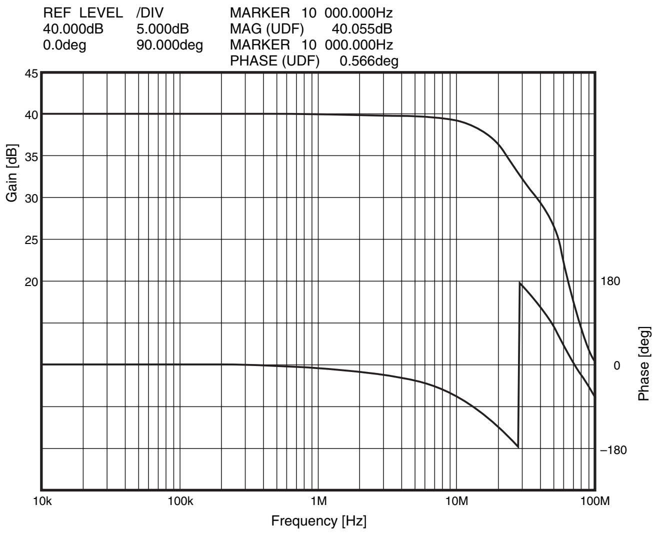


Block diagram

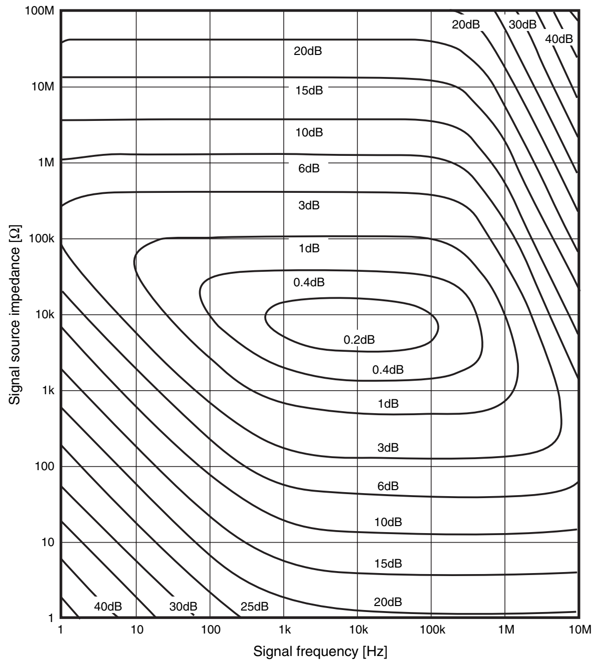


Characteristics

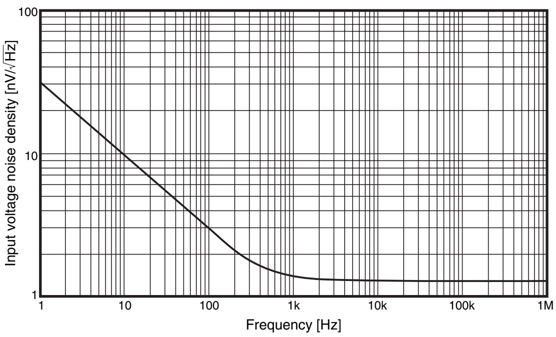
Frequency



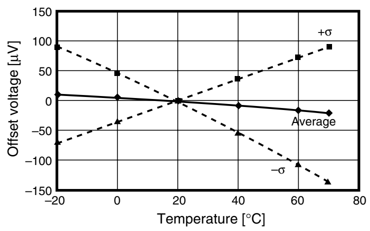
Noise Figure



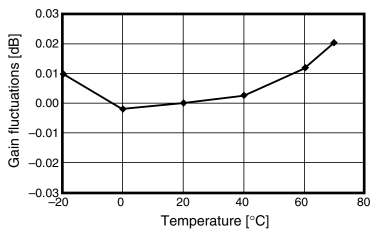
Input voltage noise density



Offset drift



Gain drift

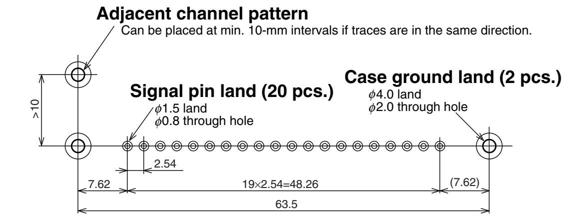


■Notes

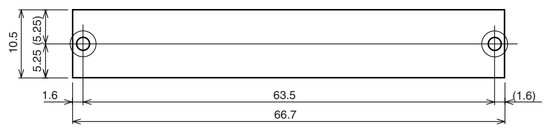
Proper connection between the case ground and the GND potential should always be assured. No sufficient shielding effect is produced if disregarded.

No signal traces should be assigned on the maximum visible outline of the component mounting surface. Possible contact between the metal case and the board is observed around the maximum visible outline, which triggers the establishment of a short circuit between the signal and case. A ground plane pattern is recommended to incorporate into the maximum visible outline and the inside of the case to enhance shielding effect.

- The maximum input voltage is ±0.5V when the module is not in action (no power being supplied). Potential damage to the module may be concerned if the maximum voltage is violated. If a voltage of ±0.5V or more is input, a protective circuit is inserted into the input terminal.
- The maximum input amplitude is ±1V when the module is in action. If signal amplitude of ±1V or more is input, a protective circuit is inserted into the input terminal.
- The series regulator type power supply is required to ensure low noise. Switching noise lies in the switching regulator type power supply such as a DC-DC converter, which impairs low noise in the module.



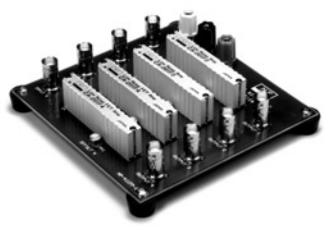
Pattern dimensions



Maximum outer dimensions

Evaluation board

A module-mounted evaluation board is available for easy evaluation of this module. Contact us for further information.



Low Noise FET Differential Amplifier

CA-451F4

CA-451F4 amplifier is a FET input low noise differential amplifier, which ensures not only 2.5nV/√Hz of input voltage noise density but ×100 voltage gain. With substantially low noise maintained, outstanding DC characteristics (2μV/°C) and frequency characteristics (DC to 10MHz) have been actualized through the adoption of the noise reduction circuit that is the application of the negative feedback technology. FET input is incorporated into CA-451F4 amplifier, which delivers low noise characteristics up to high signal source impedance (100kΩ). Our original 6-surface-shielded 20-pin single-inline package is a great contributor to the implementation of high precision signal processing and high density mounting.

▼Absolute maximum ratings

Supply voltage (±Vs)		±16.5V
Signal input voltage	**Differential input**	±1V, ±0.7V (with no power supplied)
	Common mode input	±Vs, ±0.7V (with no power supplied)
Offset input voltage		±Vs

▼Input

Input form	DC coupling, differential input
Differential input impedance	2GΩ (typ) (DC, single ended) Shunt capacitance: 22pF (typ)
Common mode input impedance	1GΩ (typ) (DC) Shunt capacitance: 44pF (typ)
Linear maximum differential input voltage	±100mV (at 1kHz)
Linear maximum common mode input voltage	±5V (at 1kHz)
Input bias current	±50pA (typ)
Input offset current	±10pA (typ)
CMRR (RTI)	110dB (at 60Hz) 70dB (typ) (at 1MHz)
Input voltage noise density	Max. 3nV/√Hz (at 10kHz) 2.5nV/√Hz (typ) (at 10kHz)
Input current noise density	100fA/√Hz (typ) (at 1kHz)
Input offset voltage	±50μV (typ) (short-circuit in input terminal) Zero adjustment available with an external trimmer potentiometer.
Input DC drift	±2μV/°C (typ) (short-circuit in input terminal) 0 to 40°C

▼Output

Output form	DC coupling, single ended output
Maximum output voltage	±10V (at 1kHz, load resistance≥1kΩ)
Maximum output current	±10mA
Slew rate	110V/μs (typ)
Output impedance	50Ω±5% (DC)

▼Amplifier

Voltage gain	40±0.2dB (at 1kHz)
Voltage gain frequency characteristics	DC to 10MHz (+0.5/–3dB)
Harmonics distortion	0.008% (typ) (at 1kHz, ±1V output)

▼Power supply

Recommended power supply voltage range	±15V±1V
Quiescent current	±40mA, ±32mA (typ)

▼Environment

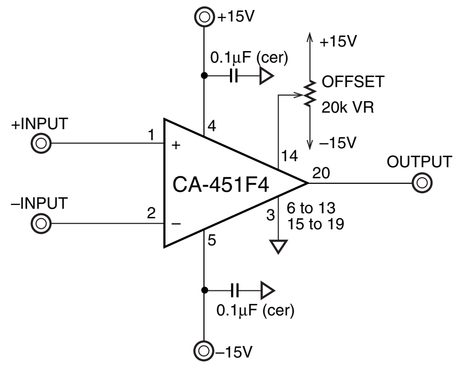
Temperature/ humidity range	**Operation**	–20°C to 70°C, 10 to 90%RH
	Storage	–30°C to 80°C, 10 to 80%RH

▼Dimensions

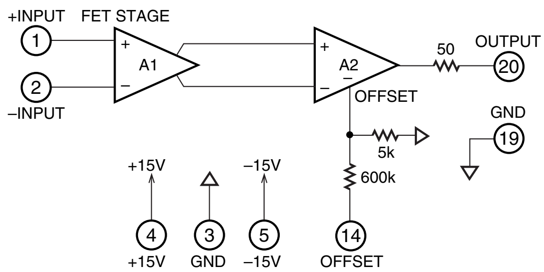
Type	Type SS20 (20-pin shielded SIP)
Dimensions	67 × 10.5 × 20mm (protrusion not included)
Weight (NET)	Approx. 20g

Note: The following specifications are applied unless otherwise specified: 23±5°C, Supply voltage: ±15V, Load resistance: 1MΩ

Basic connection diagram



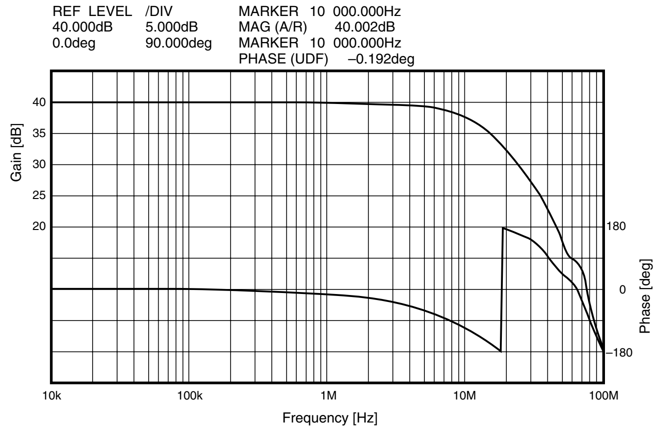
Block diagram



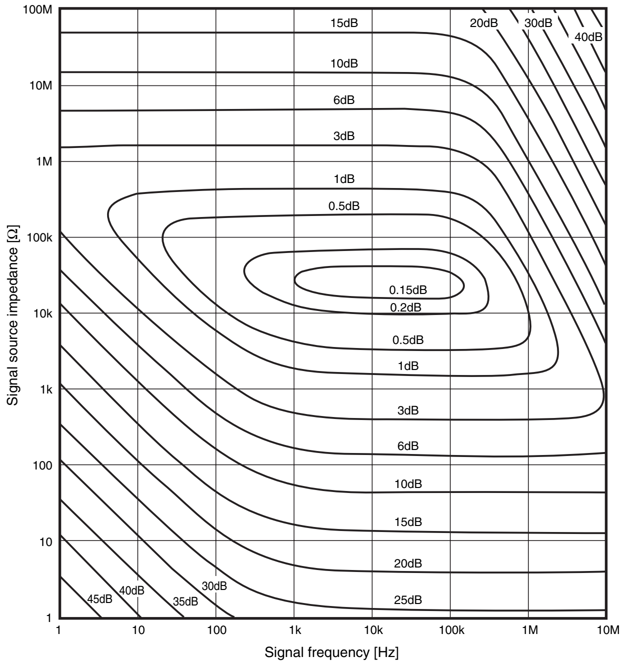
Amplifiers

Characteristics

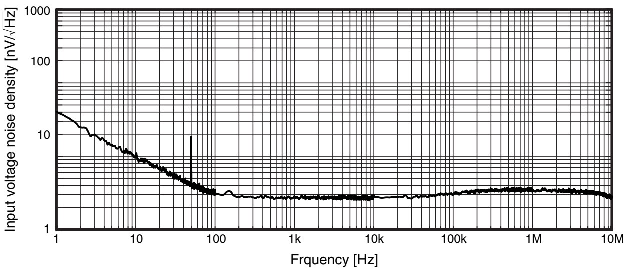
Frequency



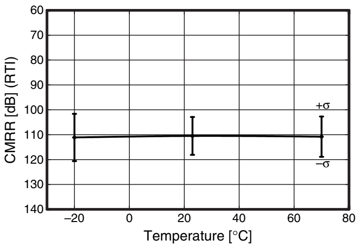
Noise figure



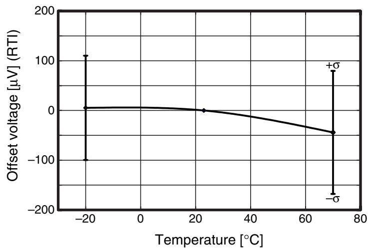
Input voltage noise density



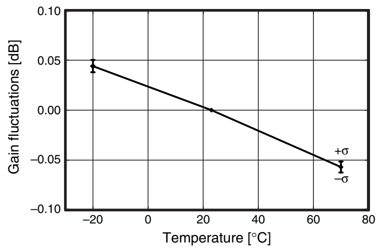
CMRR drift



Offset drift



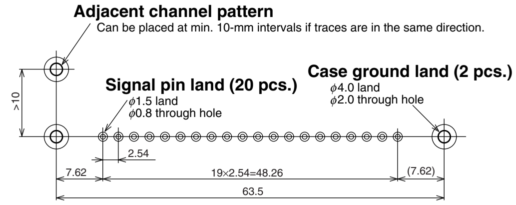
Gain drift



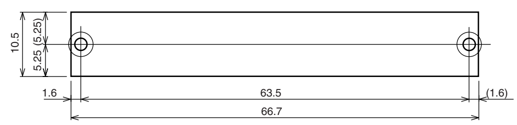
■Notes

Proper connection between the case ground and the GND potential should always be assured. No sufficient shielding effect is produced if disregarded.
No signal traces should be assigned on the maximum visible outline of the component mounting surface. Possible contact between the metal case and the board is observed around the maximum visible outline, which triggers the establishment of a short circuit between the signal and case. A ground plane pattern is recommended to incorporate into the maximum visible outline and the inside of the case to enhance shielding effect.

- The maximum input voltage is ±0.5V when the module is not in action (no power being supplied). Potential damage to the module may be concerned if the maximum voltage is violated. If a voltage of ±0.5V or more is input, a protective circuit is inserted into the input terminal.
- The maximum input amplitude is ±1V when the module is in action. If signal amplitude of ±1V or more is input, a protective circuit is inserted into the input terminal.
- The series regulator type power supply is required to ensure low noise. Switching noise lies in the switching regulator type power supply such as a DC-DC converter, which impairs low noise in the module.



Pattern dimensions



Maximum outer dimensions

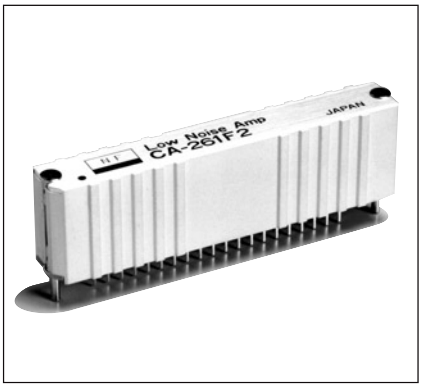
Evaluation board

A module-mounted evaluation board is available for easy evaluation of this module. Contact us for further information.

Amplifiers

Low Noise Amplifier

CA-261F2



CA-261F2 amplifier is a low noise amplifier allocated with bandwidth of DC to 10MHz. With substantially low noise maintained, outstanding DC characteristics and frequency characteristics have been actualized through the adoption of the noise reduction circuit that is the application of the negative feedback technology. Our original 6-surface-shielded single inline package is a great contributor to the implementation of high precision signal processing and high density mounting. CA-261F2 is powered by ±15V, and its gain is 40dB.

▼Absolute maximum ratings

Supply voltage (±Vs)	±16.5V
Signal input voltage	±1V, ±0.5V (with no power supplied)
Offset input voltage	±Vs

▼Input

Input form	DC coupling, unbalanced single ended input
Input impedance	100kΩ ±5% (DC, Pins ① and ② connected, Shunt capacitance: 80pF (typ))
Linear maximum input voltage	±100mV (at 1kHz)
Input bias current	±20nA (typ)
Input voltage noise density	Max. 0.9nV/√Hz (at 1kHz, short-circuit in input terminal) 0.8nV/√Hz (at 1kHz, short-circuit in input terminal)
Input current noise density	1.5pA/√Hz (typ) (at 10kHz)
Input offset voltage	±20µV (typ) (short-circuit in input terminal) Zero adjustment available with an external trimmer potentiometer.
Input DC drift	±0.3µV/°C (typ) (short-circuit input terminal) 0 to 40°C

▼Output

Output form	DC coupling, unbalanced single ended output
Maximum output voltage	±10V (at 1kHz, load resistance≥1kΩ)
Maximum output current	Min. ±10mA
Slew rate	10V/µs (typ)
Output impedance	50Ω ±5% (DC)

▼Amplifier

Voltage gain	40±0.2dB (at 1kHz)
Voltage gain frequency characteristics	DC to 200kHz (+0.5/–3dB)
I/O phase	In-phase
Harmonics distortion	0.006% (typ) (at 1kHz, ±10V output)

▼Power supply

Recommended power supply voltage range	±15V±1V
Quiescent current	Max. ±30mA, ±22mA (typ)

▼Environment

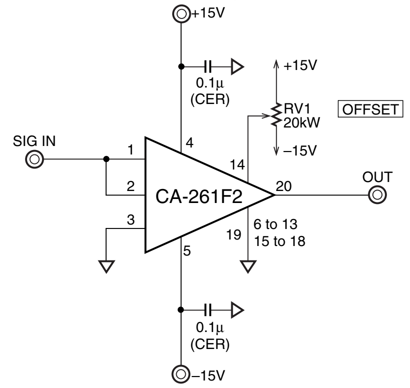
Specified temperature range		23±5°C
Temperature/ humidity range	**Operation**	–20°C to 70°C, 10 to 90%RH
	Storage	–30°C to 80°C, 10 to 80%RH

▼Dimensions

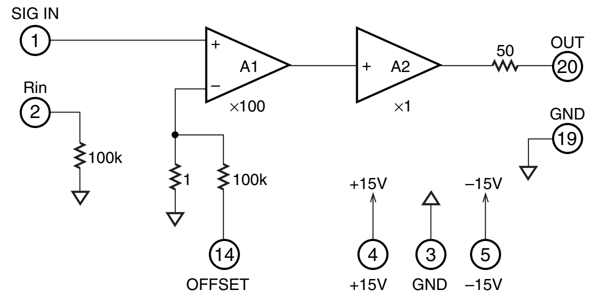
Type	Type SS20 (20-pin shielded SIP)
Dimensions	67 × 10.5 × 20mm (protrusion not included)
Weight (NET)	Approx. 20g

Note: The following specifications are applied unless otherwise specified: 23±5°C, Supply voltage: ±15V, Load resistance: 1MΩ

Basic connection diagram



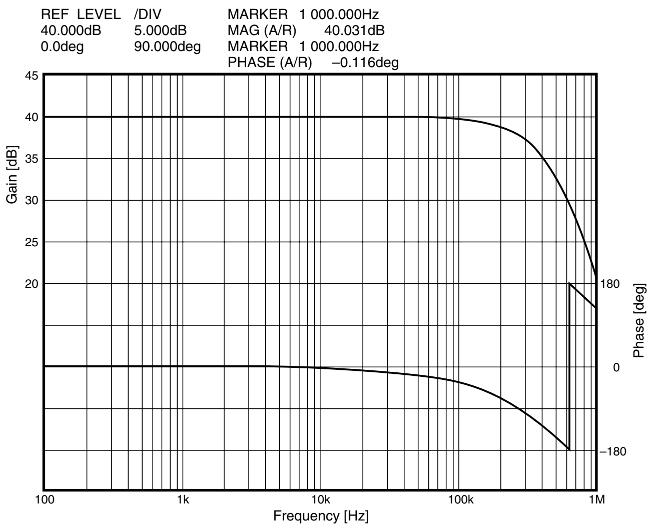
Block diagram



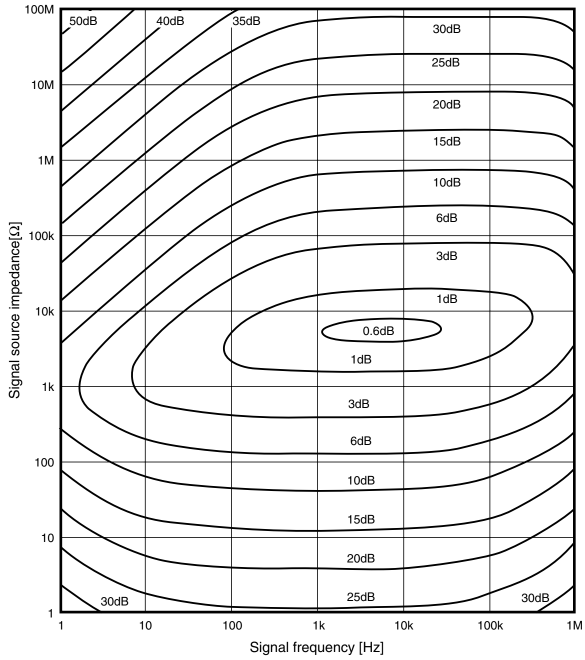
Amplifiers

Characteristics

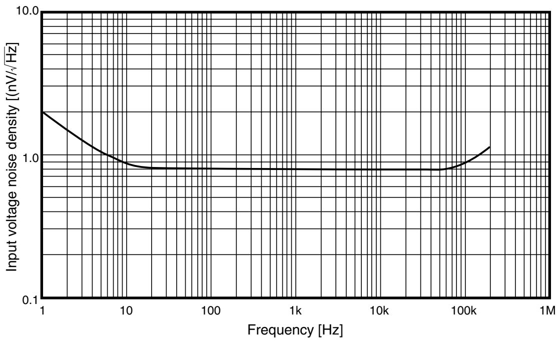
Frequency



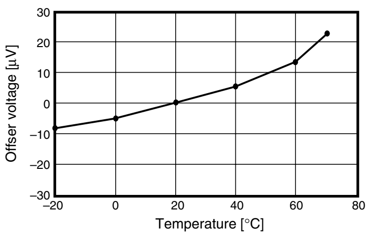
Noise figure



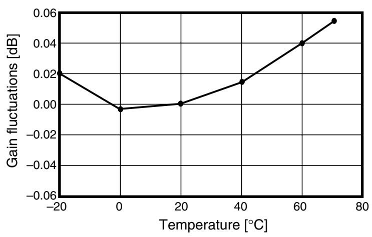
Input voltage noise density



Offset drift



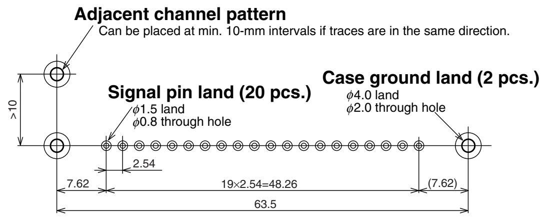
Gain drift



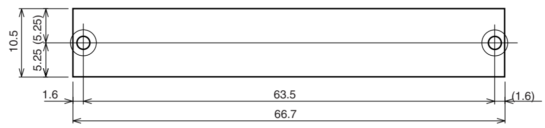
■Notes

Proper connection between the case ground and the GND potential should always be assured. No sufficient shielding effect is produced if disregarded.
No signal traces should be assigned on the maximum visible outline of the component mounting surface. Possible contact between the metal case and the board is observed around the maximum visible outline, which triggers the establishment of a short circuit between the signal and case. A ground plane pattern is recommended to incorporate into the maximum visible outline and the inside of the case to enhance shielding effect.

- The maximum input voltage is ±0.5V when the module is not in action (no power being supplied). Potential damage to the module may be concerned if the maximum voltage is violated. If a voltage of ±0.5V or more is input, a protective circuit is inserted into the input terminal.
- The maximum input amplitude is ±1V when the module is in action. If signal amplitude of ±1V or more is input, a protective circuit is inserted into the input terminal.
- The series regulator type power supply is required to ensure low noise. Switching noise lies in the switching regulator type power supply such as a DC-DC converter, which impairs low noise in the module.



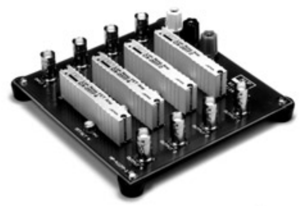
Pattern dimensions



Maximum outer dimensions

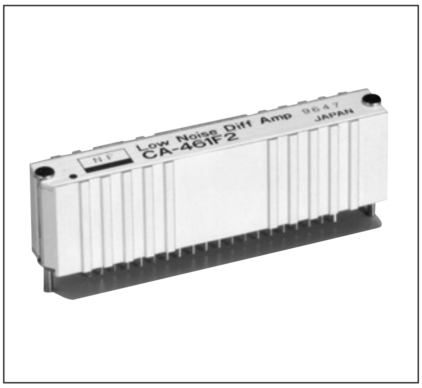
Evaluation board

A module-mounted evaluation board is available for easy evaluation of this module. Contact us for further information.



Low Noise Differential Amplifier

CA-461F2



CA-461F2 amplifier is a low noise differential amplifier, which ensures not only 1.5nV/√Hz of input voltage noise density but ×100 voltage gain.
With substantially low noise maintained, outstanding DC characteristics (0.3μ/°C) and frequency characteristics (DC to 200kHz) have been actualized through the adoption of the noise reduction circuit that is the application of the negative feedback technology.
Bipolar input is incorporated into CA-461F2 amplifier, which delivers low noise characteristics up to low signal source impedance (500Ω or less).
Our original 6-surface-shielded 20-pin single-inline package is a great contributor to the implementation of high precision signal processing and high density mounting.

▼Absolute maximum ratings

Supply voltage (±Vs)		±16.5V
Signal input voltage	Differential input	±1V, ±0.7V (with no power supplied)
	Common mode input	±Vs, ±0.7V (with no power supplied)
Offset input voltage		±Vs

▼Input

Input form	DC coupling, balanced differential input
Differential input impedance	100kΩ, Max. 5% (DC, single ended) Shunt capacitance: 80pF (typ)
Common mode input impedance	500kΩ (typ) (DC) Shunt capacitance: 130pF (typ)
Linear maximum differential input voltage	±100mV (at 1kHz)
Linear maximum common mode input voltage	±10V (at 1kHz)
Input bias current	±30nA (typ)
Input offset current	±7nA (typ)
CMRR (RTI)	Min. 100dB, 120dB (typ) (at 60Hz)
Input voltage noise density	Max. 1.8nV/√Hz (at 1kHz, short circuit in input terminal) 1.5nV/√Hz (typ) (at 1kHz, short circuit in input terminal)
Input current noise density	2.5pA/√Hz (typ) (at 10kHz)
Input offset voltage	±40μV (typ) (short-circuit in input terminal) Zero adjustment available with an external trimmer potentiometer.
Input DC drift	±0.3μV/°C (typ) (short-circuit in input terminal) 0 to 40°C

▼Output

Output form	Unbalanced single ended output
Maximum output voltage	±10V (at 1kHz, load resistance≥1kΩ)
Maximum output current	±10mA
Slew rate	10V/μs (typ)
Output impedance	50Ω ±5% (DC)

▼Amplifier

Voltage gain	40±0.2dB (at 1kHz)
Voltage gain frequency characteristics	DC to 200kHz (+0.5/–3dB)
Harmonics distortion	0.006% (typ) (at 1kHz, ±10V output)

▼Power supply

Recommended power supply voltage range	±15V±1V
Quiescent current	±30mA, ±22mA (typ)

▼Environment

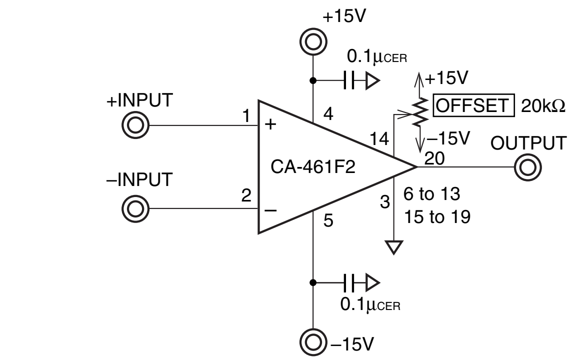
Temperature/ humidity range	Operation	–20°C to 70°C, 10 to 90%RH
	Storage	–30°C to 80°C, 10 to 80%RH

▼Dimensions

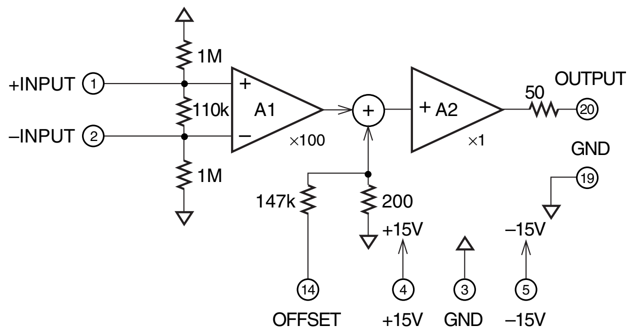
Type	Type SS20 (20-pin shielded SIP)
Dimensions	67 × 10.5 × 20mm (protrusion not included)
Weight (NET)	Approx. 20g

Note: The following specifications are applied unless otherwise specified: 23±5°C, Supply voltage: ±15V, Load resistance: 1MΩ

Basic connection diagram

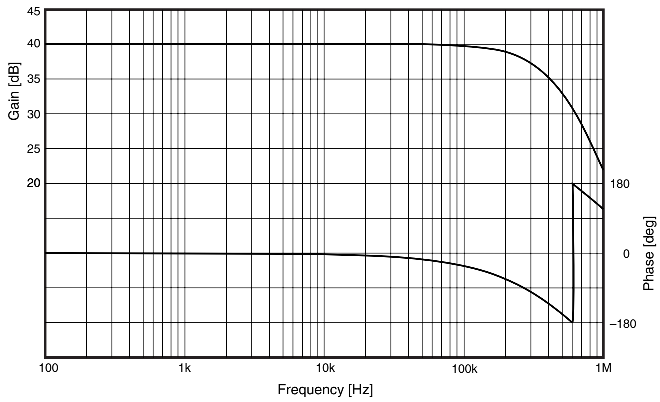


Block diagram

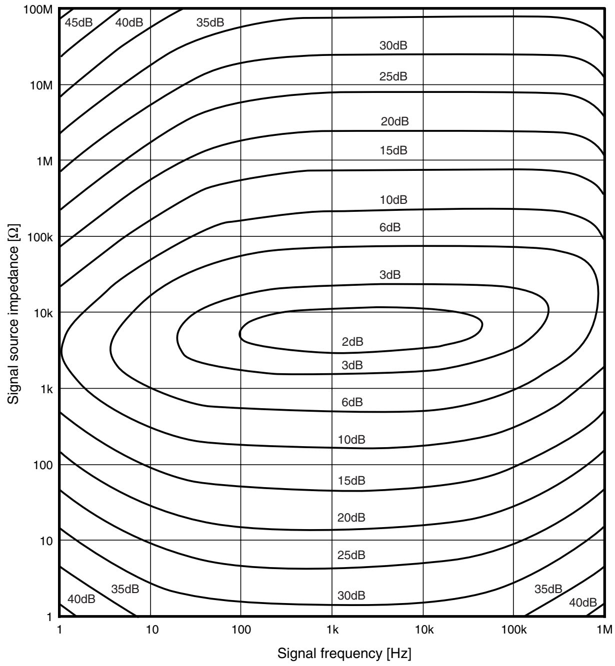


Characteristics

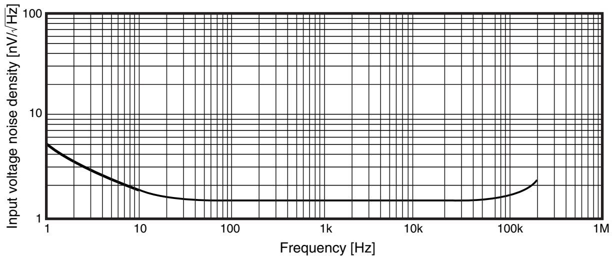
Frequency



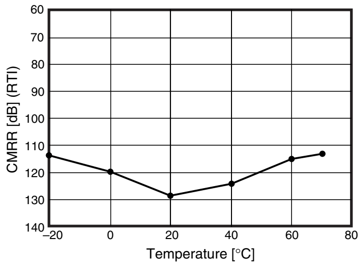
Noise figure



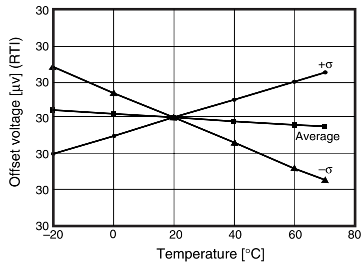
Input voltage noise density



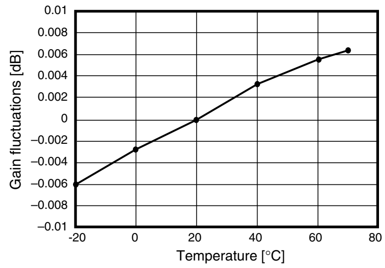
CMRR drift



Offset drift



Gain drift

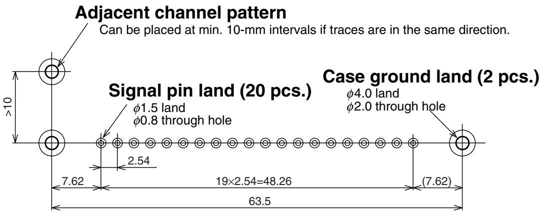


■*Notes*

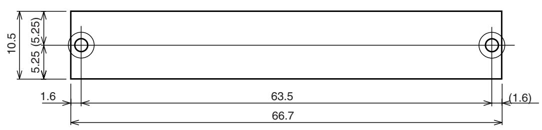
Proper connection between the case ground and the GND potential should always be assured. No sufficient shielding effect is produced if disregarded.

No signal traces should be assigned on the maximum visible outline of the component mounting surface. Possible contact between the metal case and the board is observed around the maximum visible outline, which triggers the establishment of a short circuit between the signal and case. A ground plane pattern is recommended to incorporate into the maximum visible outline and the inside of the case to enhance shielding effect.

- The maximum input voltage is ±0.5V when the module is not in action (no power being supplied). Potential damage to the module may be concerned if the maximum voltage is violated. If a voltage of ±0.5V or more is input, a protective circuit is inserted into the input terminal.
- The maximum input amplitude is ±1V when the module is in action. If signal amplitude of ±1V or more is input, a protective circuit is inserted into the input terminal.
- The series regulator type power supply is required to ensure low noise. Switching noise lies in the switching regulator type power supply such as a DC-DC converter, which impairs low noise in the module.



Pattern dimentions



Maximum outer dimensions

Evaluation board

A module-mounted evaluation board is available for easy evaluation of this module. Contact us for further information.

Differential Amplifier

CA-406L2

CA-406L2 amplifier is a low noise differential amplifier capable of logical setting of gains (×1 to ×100) in accordance with 1-, 2-, or 5-sequence. Frequency characteristics are expressed in a flat response till 50kHz. A gain accuracy is limited to 0.1% (typ), and a superior common mode rejection ratio of 100dB (typ) is assured.
Gain setting is completed by controlling the 6 control terminals (1, 2, 5, 10, ×1, ×10) according to TTL or CMOS negative logic.
CA-406L2 amplifier is a 20-pin single-inline package, which enables high density mounting.

▼Absolute maximum ratings

Supply voltage (±Vs)	±18V
Signal input voltage	±Vs
Control voltage	+5.5V, –0.5V

▼Gain

Gain	1, 2, 5, 10, 20, 50, ×100
Accuracy	±0.1% (typ)

▼Input characteristics

Input form	Differential input
Impedance	$3\times10^{10}\Omega$//8pF (typ) (for differential and common input)
Common mode voltage	±10V
Common mode rejection ratio	Min. 90dB (DC to 60Hz: G = 100)
Offset voltage	±2mV (typ) (RTI, G = 100, input grounding)
Offset drift	±25µV/°C (typ) (RTI, G = 100, input grounding)
Voltage noise density	27nV/$\sqrt{\text{Hz}}$ (typ) (RTI, G = 100, input grounding)

▼Frequency characteristics

±3dB flat (small signal)	Min. DC to 200kHz
±1% flat (small signal)	DC to 50kHz (typ)
Full power bandwidth	DC to 100kHz (typ)
Slew rate	20V/µs (typ)

▼Output characteristics

Maximum voltage	±10V
Maximum current	±5mA
Impedance	Max. 5kΩ
Load resistance	Min. 2kΩ

▼Control characteristics

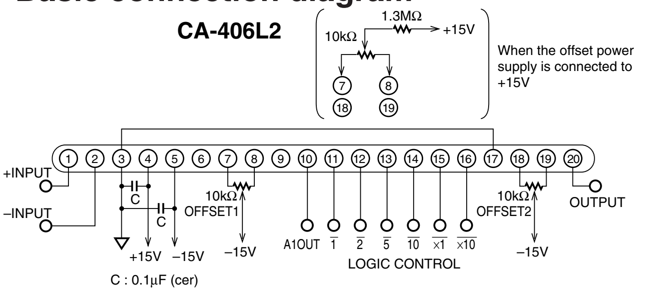
Control line	1, 2, 5, 10, ×1, ×10
Level	TTL or CMOS negative logic
Level input process	Pulled up to +5V (internal) at 100kΩ

▼Others

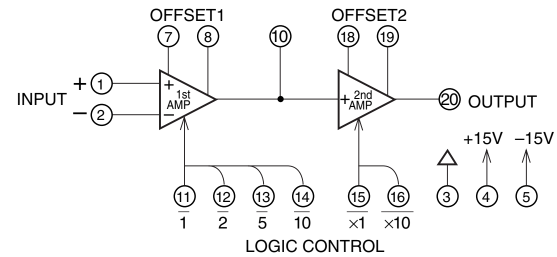
Supply voltage		±15V (±14 to 16V)
Quiescent current		+15mA, –12mA (typ)
Temperature/ humidity range	**Operation**	–20°C to 70°C, 10 to 95%RH
	Storage	–30°C to 80°C, 10 to 80%RH
Dimensions		51.5 × 14 × 6.5mm, Type S20

Note: The following specifications are applied unless otherwise specified: 23±5°C, Vs = ±15V

Basic connection diagram

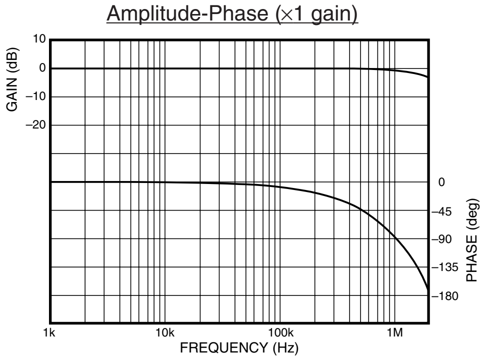


Block diagram

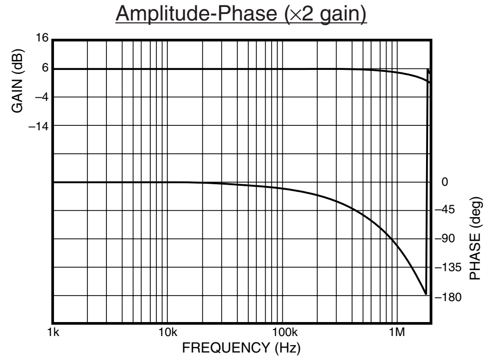


Characteristics

Amplitude-Phase (×1 gain)



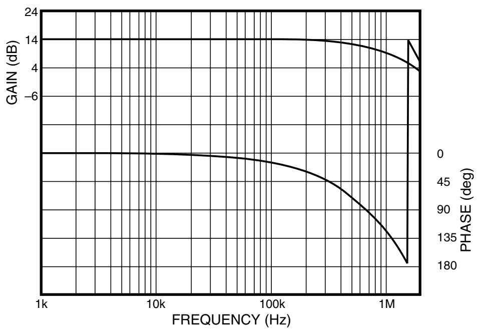
Amplitude-Phase (×2 gain)



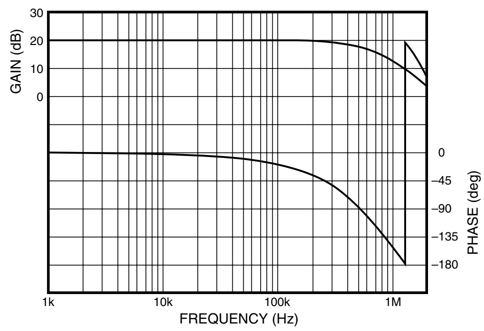
Amplifiers

Characteristics

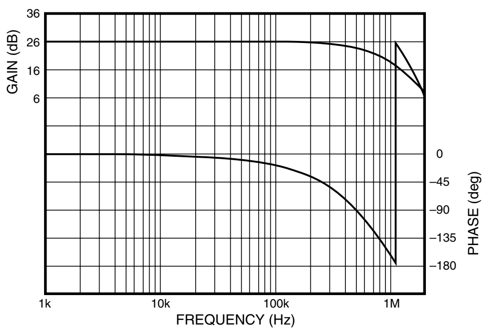
Amplitude-Phase (×5 gain)



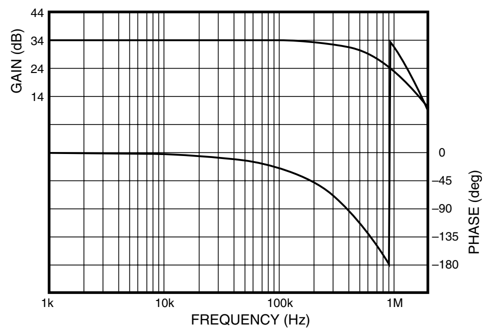
Amplitude-Phase (×10 gain)



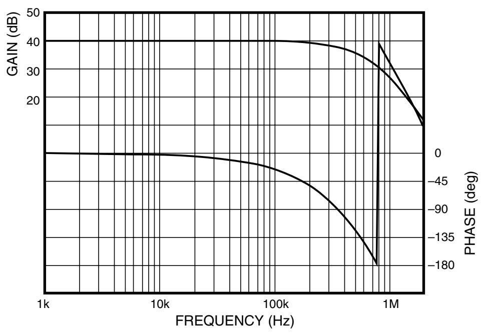
Amplitude-Phase (×20 gain)



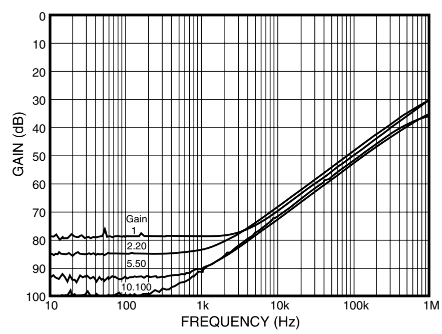
Amplitude-Phase (×50 gain)



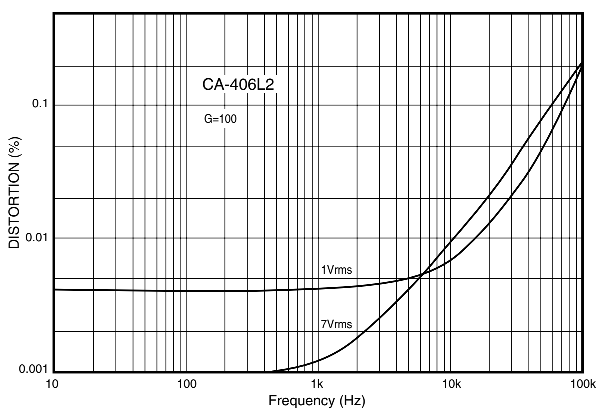
Amplitude-Phase (×100 gain)



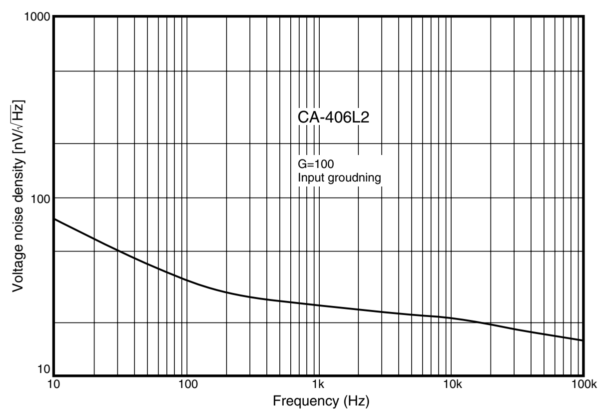
Common mode rejection ratio (CMRR)



Harmonics distortion



Input voltage noise density



Programmable Gain Amplifier

CA-206L2

CA-206L2 amplifier is a low noise DC amplifier capable of logical setting of gains (×1 to ×100) in accordance with 1-, 2-, or 5-sequence. Frequency characteristics are expressed in a flat response till 100kHz. A gain error is limited to 0.1% (typ) that denotes high accuracy. Gain setting is completed by controlling the 6 control terminals (1, 2, 5, 10, ×1, ×10) according to TTL or CMOS IC negative logic.
Easy gain setting with the use of 3-bit binary signal or binary code switch is assured if the amplifier is connected with the binary latch adapter CA-903N. The latch function enables direct connection to CPU. CA-206L2/CA-903N amplifiers are 20-pin single inline package, which enables high density mounting.

▼Absolute maximum ratings

Supply voltage (±Vs)	±18V
Signal input voltage	±Vs
Control voltage	+5.5V, –0.5V

▼Gain

Gain (G)	1, 2, 5, 10, 20, 50, ×100 Error: ±0.1% (typ), Max. ±0.4% (1kHz)
Setting	6 control terminals (1, 2, 5, 10, ×1, ×10) used

▼Input characteristics

Input form	Unbalanced
Input impedance	1MΩ ±2% (1kHz)
Max. input voltage (linear)	±10V (G = 1)
Offset voltage	±1mV (typ) (RTI, G = 100, input grounding) Offset voltages of the input/output amplifiers: Adjustable with external trimmer potentiometer (2 pcs.).
Offset drift	±20µV/°C (typ) (RTI, G = 100, input grounding)
Voltage noise density	7nV/√Hz (typ) (RTI, G = 100, input grounding)

▼Frequency characteristics

±3dB flat (small signal)	Min. DC to 500kHz
±1% flat (small signal)	DC to 100kHz (typ)
Full power bandwidth	DC to 100kHz (typ)
Slew rate	10V/µs (typ)

▼Output characteristics

Maximum output	Voltage: ±10V, Current: ±5mA
Load resistance	Min. 2kΩ
Output impedance	Max. 5kΩ

▼Control characteristics

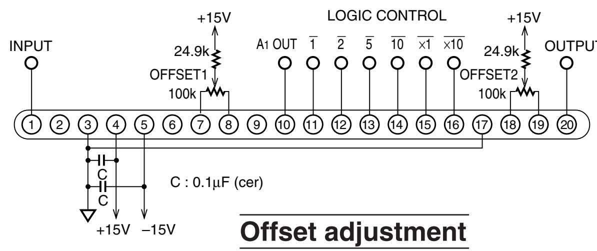
Control line	1, 2, 5, 10, ×1, ×10
Level	TTL or CMOS negative logic
Level input process	Pulled up to +5V (internal) at 100kΩ

▼Others

Supply voltage		±15V (±14 to 16V)
Quiescent current		+15mA (typ), –20mA (max)
Temperature/ humidity range	Operation	–20°C to 70°C, 10 to 95%RH
	Storage	–30°C to 80°C, 10 to 80%RH
Dimensions		51.5 × 14 × 6.5mm, Type S20

Note: The following specifications are applied unless otherwise specified: 23±5°C, Vs = ±15V

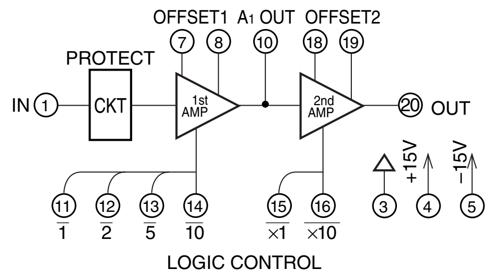
Basic connection diagram



Offset adjustment

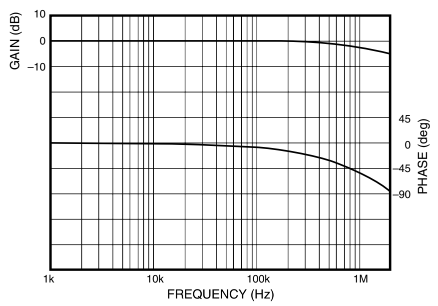
Establish a ground for INPUT, and obtain a gain of 100.
Adjust OFFSET1 to obtain 0V of A1OUT.
Adjust OFFSET2 to obtain 0V of OUTPUT.

Block diagram

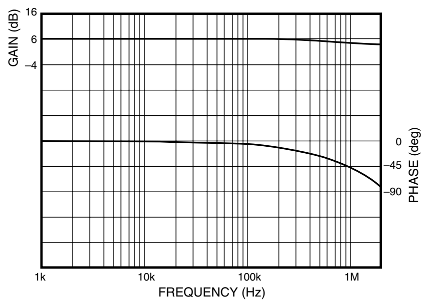


Characteristics

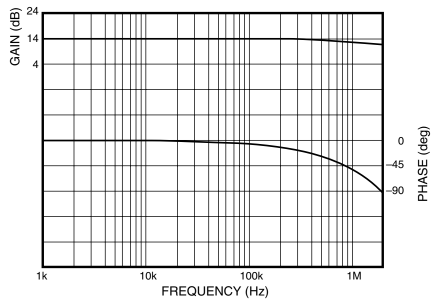
Amplitude-Phase (×1 gain)



Amplitude-Phase (×2 gain)

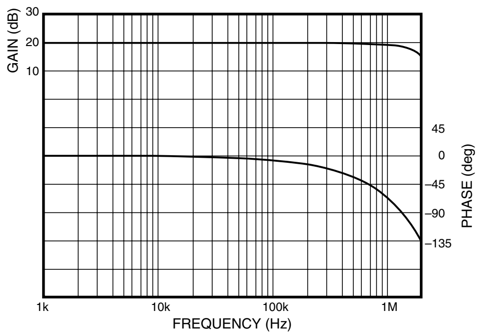


Amplitude-Phase (×5 gain)

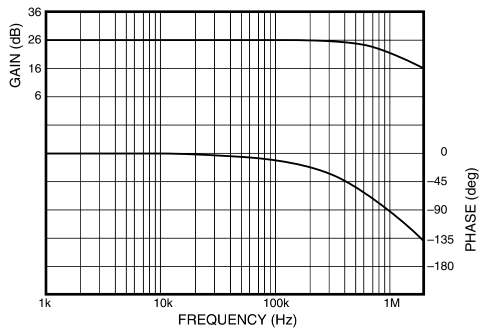


Characteristics

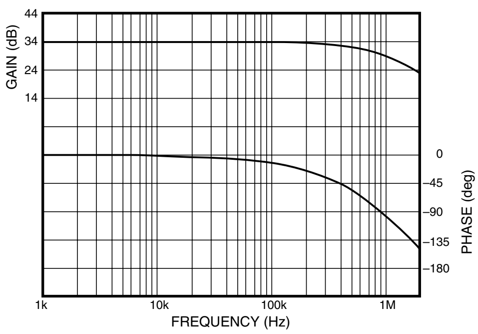
Amplitude-Phase (×10 gain)



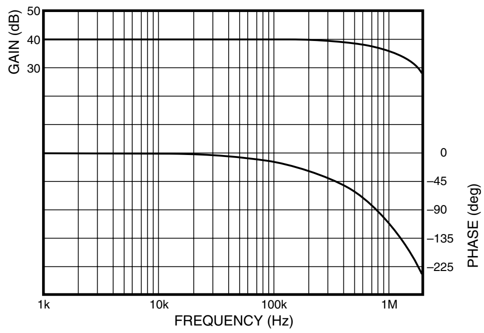
Amplitude-Phase (×20 gain)



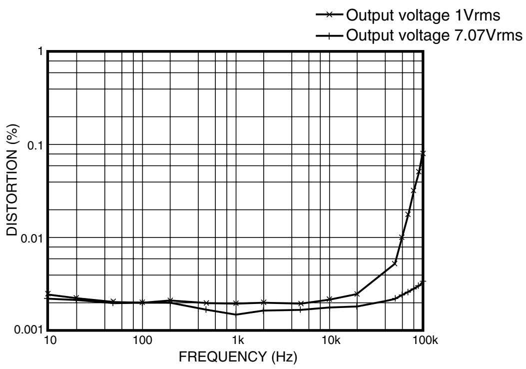
Amplitude-Phase (×50 gain)



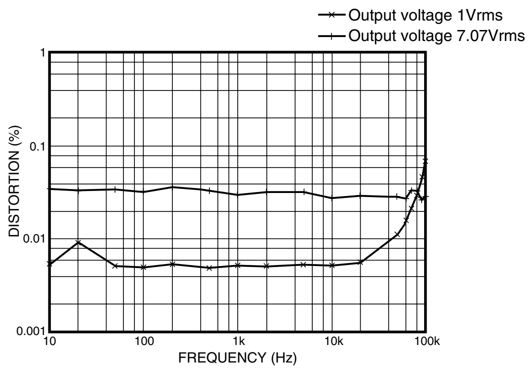
Amplitude-Phase (×100 gain)



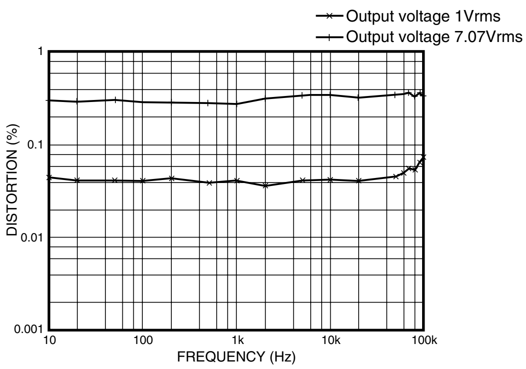
Distortion (×1 gain)



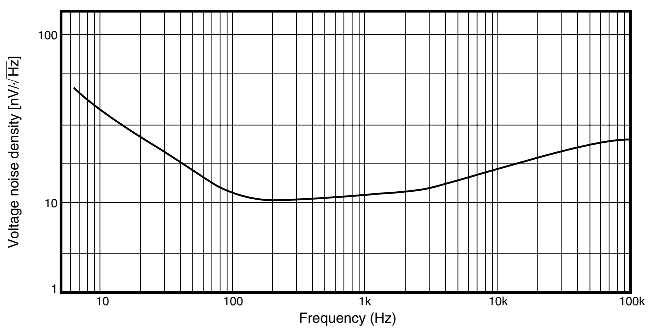
Distortion (×10 gain)



Distortion (×100 gain)



Input voltage noise density (×100 gain)



Amplifiers

Binary Latch Adapter

CA-903N

CA-903N adapter is endowed with outstanding features including gain setting by binary code that is available if connected to CA-206L2 programmable gain amplifier or CA-406L2 differential amplifier. This adapter is also capable of actuating the latch function.
Gain setting binary code input becomes valid if the latch control input terminal is open or set at +5V, which allows gain setting by the negative logic level signal. Latch control input needs to be set at 0V to exert the latch function, which enables data on gain setting binary code input to be latched at the edge of 0V.
Connection with CA-206L2 and CA-406L2 amplifiers is established with the same-numbered pins (8 pcs.), and the power is supplied.

▼Absolute maximum ratings

Supply voltage (±Vs)	+5.5V
Control voltage	+5.5V, –0.5V

▼I/O characteristics (truth table)

Gain	Input				Output						Function
	G	C	B	A	1	2	5	10	×1	×10	–
1	H	H	H	H	L	H	H	H	L	H	–
2	H	H	H	L	H	L	H	H	L	H	–
5	H	H	L	H	H	H	L	H	L	H	–
10	H	H	L	L	H	H	H	L	L	H	–
20	H	L	H	H	H	L	H	H	H	L	–
50	H	L	H	L	H	H	L	H	H	L	–
100	H	L	L	H	H	H	H	L	H	L	–
100	H	L	L	L	H	H	H	L	H	L	–
	L	×	×	×	Data is latched at the falling edge of G.						Latch

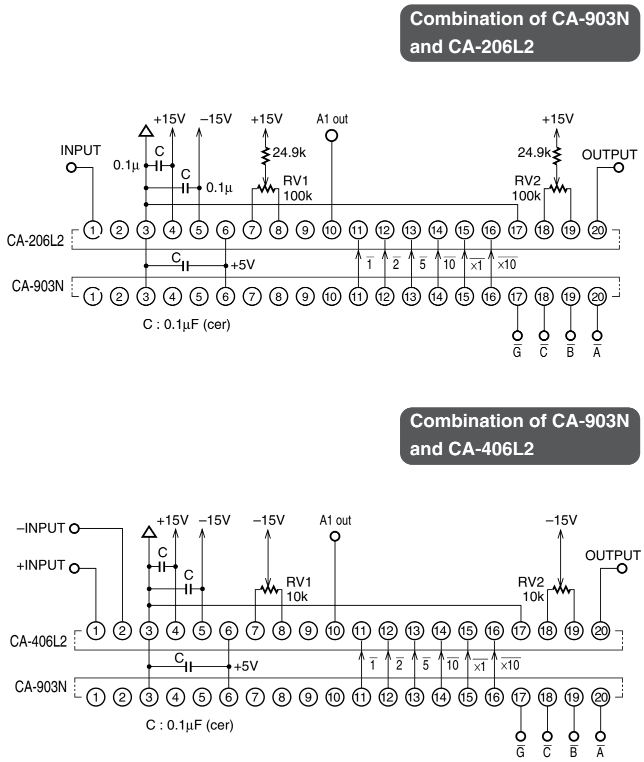
Level	TTL or CMOS negative logic
Level input process	Pulled up to +5V (internal) at 100kΩ
Latch function	A variation in control input make its presence at the output if Trigger terminal ⑰ is open or set at "Hi". If the terminal is set at "Lo", data on control input at the falling edge is latched.

▼Others

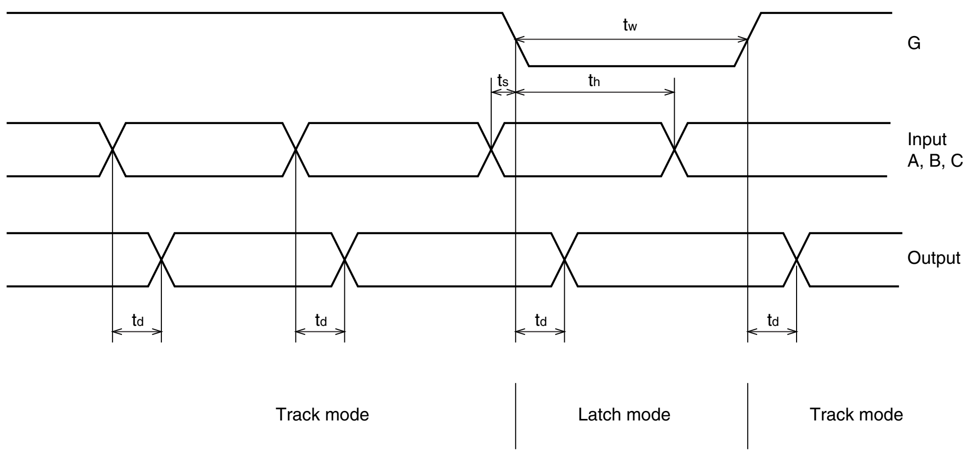
Supply voltage		+5V ±10%
Quiescent current		150µA (typ), 1mA (max)
Temperature/ humidity range	**Operation**	–20°C to 70°C, 10 to 95%RH
	Storage	–30°C to 80°C, 10 to 80%RH
Dimensions		51.5 × 14 × 4.0mm, Type S20

Note: The following specifications are applied unless otherwise specified: 23±5°C, Vs = ±15V

Basic connection diagram



■*Control signal timing chart*



td:	Setup delay time:	Max. 850ns
ts:	Min. setup time:	50ns
th:	Min. hold time:	50ns
tw:	Min. pulse duration:	150ns

High Speed Inverting Amplifier

CA-102R3

CA-102R3 amplifier is designed for inverting amplification that is capable of gain setting with the external resistors (2 pcs.). 10MHz at –3dB, 1MHz at full power, and 200V/µs of slew rate are obtained in frequency of small signal if a gain is "1". The maximum output voltage is ±10V, and the maximum output current is 10mA. This amplifier is suited to be used as an adder to produce an attenuation pole for the configuration of an elliptic filter that is the application of DT-208D series filters. CA-102R3 amplifier has the advantage of superior frequency characteristics and compact size that expands a wide range of applications.

▼Amplification characteristics

Gain	Gained with external resistors (2 pcs.). (R_{IN}, R_{NF}) $GAIN = \frac{R_{NF}}{R_{IN}}$
Frequency characteristics	Full power: DC to 1MHz Small signal: DC to 10MHz (±3dB)
Slew rate	200V/µs (typ)

▼Input characteristics

Impedance	R_{IN}
Max. input voltage	±10V

▼Output characteristics

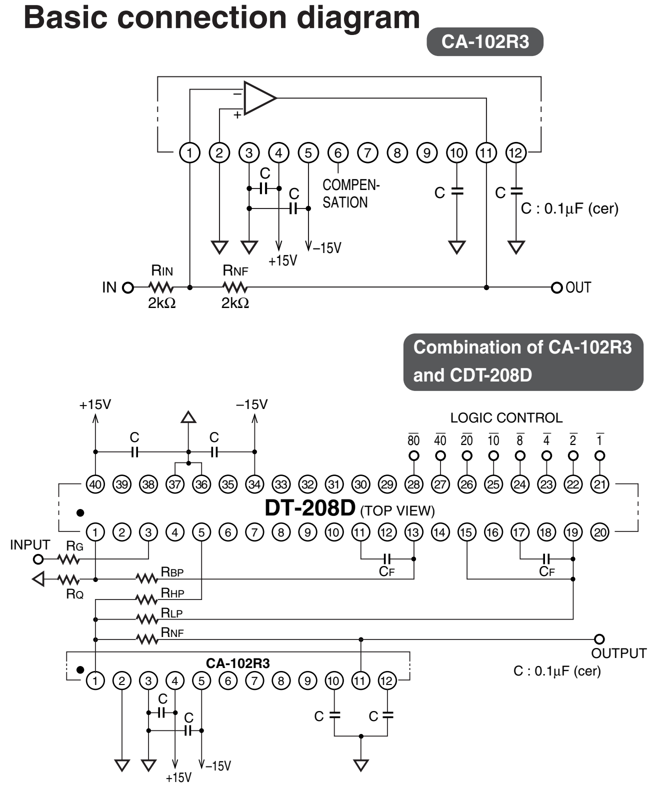
Impedance	Max. 5Ω
Max. output voltage	±10V
Max. output current	±10mA
Offset voltage	±7mV (typ)

▼Others

Supply voltage		±15V (±14 to 16V)
Quiescent current		±20mA (typ)
Temperature/ humidity range	**Operation**	–20°C to 70°C, 10 to 95%RH
	Storage	–30°C to 80°C, 10 to 80%RH
Dimensions		32 × 13.3 × 4.0mm, Type S12

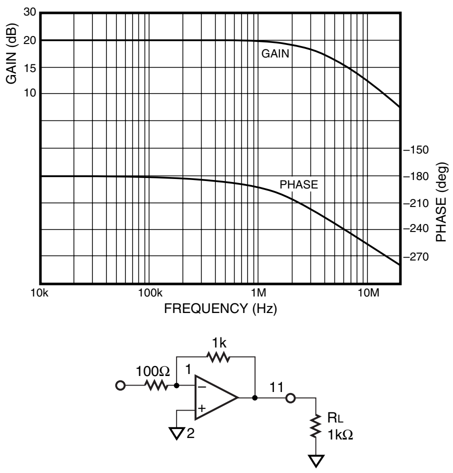
Note: The following specifications are applied unless otherwise specified: 23±5°C, Vs = ±15V, R_{IN} = 2kΩ, R_{NF} = 2kΩ

Basic connection diagram

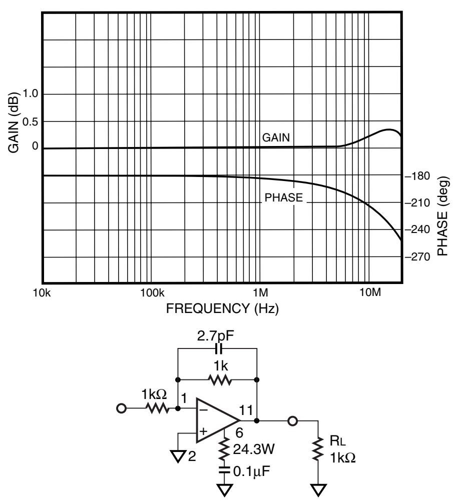


Characteristics

Amplitude-Phase (×20 gain)



Amplitude-Phase (0dB gain)



Low Noise Amplifier

SA-220F5 SA-230F5 SA-430F5 SA-200F3 SA-400F3

SA-230F5

SA series amplifiers are preamplifiers for submicro-signal detection, which have been developed to assure noise reduction never before accomplished. 5 types of SA series amplifiers, which vary by a frequency band, input form, and input impedance, are available. Not only the dedicated power supply but the sensor control power supply is offered for outstanding noise reduction.
SA series amplifiers have actualized low noise featuring the following items through the adoption of our original circuit that is the application of the negative feedback technology: 50Ω of input impedance, 0.6dB of noise figure (SA-230F5), 0.5nV/√Hz of input voltage noise at 100kΩ (SA-200F3), and 200fA/√Hz of input voltage noise at 1MΩ (SA-220F5).

Model	SA-220F5 Low noise FET amplifier	SA-230F5 Low noise amplifier	SA-430F5 Low noise differential amplifier
Frequency band (typ)	300Hz to 100MHz	400Hz to 140MHz	400Hz to 110MHz
▼Input			
Input form	AC coupling, unbalanced single ended input (SMA connector)	AC coupling, unbalanced single ended input (SMA connector)	AC coupling, balanced differential input (2 SMA connectors)
Input impedance	1MΩ ±5% (5kHz) Shunt capacitance: 57pF (typ)	50Ω ±5% (100kHz)	Differential input: 50Ω ±5% (100kHz) Common mode input: 530Ω typ (100kHz)
Maximum input voltage (burnout voltage)	±1.0V	±1.0V	±2.0V (differential input/common input)
CMRR (RTI)	– –	– –	Min. 80dB (100kHz) 90dB typ (100kHz), 80dB typ (10MHz)
Input voltage noise density (short-circuit in input terminal)	Max. 0.7nV/√Hz (100kHz) 0.5nV/√Hz typ (10k to 1MHz)	Max. 0.35nV/√Hz (100kHz) 0.25nV/√Hz typ (10k to 1MHz)	Max. 0.45nV/√Hz (100kHz) 0.35nV/√Hz typ (10k to 1MHz)
Input noise current density	200fA/√Hz typ (100kHz)	5.0pA/√Hz typ (100kHz)	7.0pA/√Hz typ (100kHz)
Noise figure (50Ω)	–	Max. 0.7dB, 0.6dB typ (10MHz) Max. 1.0dB, 0.8dB typ (100MHz)	Max. 1.25dB, 1.10dB typ (10MHz) Max. 1.75dB, 1.40dB typ (100MHz)
▼Output characteristics			
Maximum output voltage	2Vp-p (1kHz to 20MHz, load resistance: 50Ω)	2Vp-p (1kHz to 20MHz, load resistance: 50Ω)	2Vp-p (1kHz to 20MHz, load resistance: 50Ω)
Output impedance	50Ω ±5% (100kHz)	50Ω ±5% (100kHz)	50Ω ±5% (100kHz)
▼Amplifier			
Voltage gain	46±0.5dB (1MHz, load resistance: 50Ω)	46±0.5dB (1MHz, load resistance: 50Ω)	46±0.5dB (1MHz, load resistance: 50Ω)
Voltage gain frequency characteristics	1kHz to 80MHz +0.5, Max. –3dB 300Hz to 100MHz +0.5, –3dB typ	1kHz to 100MHz +0.5, Max. –3dB 400Hz to 140MHz +0.5, –3dB typ	1kHz to 100MHz +0.5, Max. –3dB 400Hz to 110MHz +0.5, –3dB typ
Intercept point	–	+30dBm typ (68MHz)	+28dBm typ (68MHz)
▼Power supply			
Recommended power supply voltage range	±15V ±5%	+15V ±5%	±15V ±5%
Quiescent current (no signal)	Max. +65mA typ +75mA Max. –10mA typ –15mA	Max. +55mA	Max. +55mA typ +65mA Max. –30mA typ –45mA
▼Environment			
Specified temperature range	23°C±5°C	23°C±5°C	23°C±5°C
Storage temperature/ humidity range	–10°C to 50°C, 10 to 80%RH (no condensation)	–10°C to 50°C, 10 to 80%RH (no condensation)	–10°C to 50°C, 10 to 80%RH (no condensation)
▼Dimensions			
Dimensions	68 × 43 × 28mm (protrusion not included)	68 × 43 × 17.6mm (protrusion not included)	68 × 43 × 28mm (protrusion not included)
Weight (NET)	Approx. 130g	Approx. 90g	Approx. 130g

Note: Power supply: SA-915D1

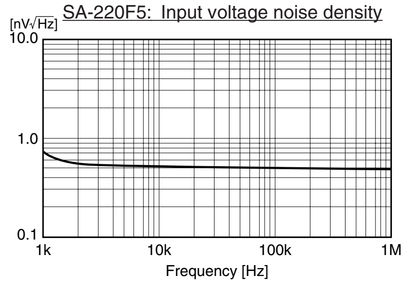
SA-220F5

SA-200F3

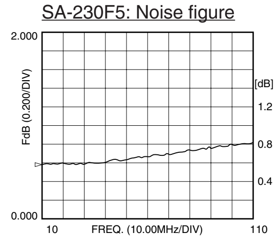
SA-430F5

SA-400F3

SA-220F5: Input voltage noise density



SA-230F5: Noise figure



Amplifiers

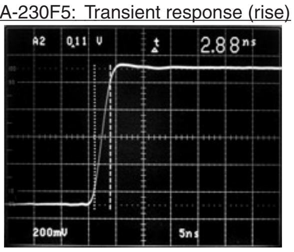
■Main applications

SA series amplifiers are used to foster versatility as sensor head amplifiers or preamplifiers for sensitivity improvement and noise reduction in analyzers and measurement instruments.

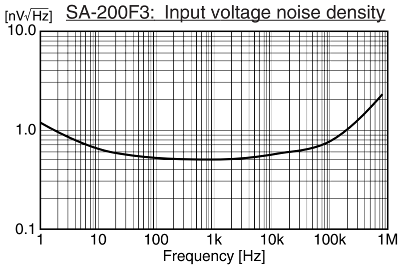
- "MCT <Mercury Cadmium Tellurium> sensor" for infrared detection
- "Superconducting SQUID sensor" for micro-magnet detection
- "High-temperature superconducting Josephson device" for microwave detection
- "Electromagnetic sensor" for MRI systems
- Photodetector such as a photomultiplier and phototransistor

SA-200F3 Low noise amplifier	SA-400F3 Low noise differential amplifier
DC to 800kHz	DC to 700kHz
▼Input	
DC coupling, unbalanced single wire grounded input (SMA connector)	DC coupling, balanced differential input (2 SMA connectors)
Selectable among 1k/ 10k/ 100kΩ ±5% (DC), Shunt capacitance: Max. 150pF	Selectable among 1k/ 10k/ 100kΩ ±5% (DC), Shunt capacitance: Max. 80pF
±0.5V	Differential input: ±0.5V Common input: ±10V
–	Min. 110dB (50Hz) 120dB typ (50Hz), 80dB typ (100kHz)
Max. 0.7nV/$\sqrt{Hz}$ (1kHz) Max. 0.5nV/$\sqrt{Hz}$ (1kHz)	Max. 0.9nV/$\sqrt{Hz}$ (1kHz) Max. 0.75nV/$\sqrt{Hz}$ (1kHz)
2.2pA/$\sqrt{Hz}$ (10kHz)	3.0pA/$\sqrt{Hz}$ (10kHz)
–	–
▼Output characteristics	
±10V (1kHz, load resistance≥1kΩ)	±10V (1kHz, load resistance≥1kΩ)
50Ω ±5% (DC)	50Ω ±5% (DC)
▼Amplifier	
40±0.5dB (1kHz)	40±0.5dB (1kHz)
DC to 800kHz +0.5, –3dB typ	DC to 700kHz +0.5, –3dB typ
–	–
▼Power supply	
±15V ±5%	±15V ±5%
±50mA	±92mA typ ±100mA
▼Environment	
23°C±5°C	23°C±5°C
–10°C to 50°C, 10 to 80%RH (no condensation)	–10°C to 50°C, 10 to 80%RH (no condensation)
▼Dimensions	
68×43×17.6mm (protrusion not included)	68×67×28mm (protrusion not included)
Weight: Approx. 90g	Approx. 180g (heat sink included)

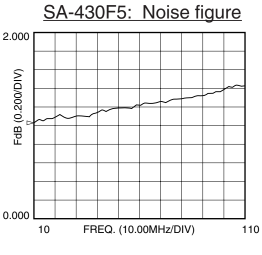
SA-230F5: Transient response (rise)



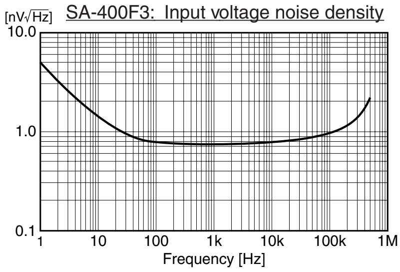
SA-200F3: Input voltage noise density



SA-430F5: Noise figure



SA-400F3: Input voltage noise density



■DC power supply: SA-915D1

SA-915D1 power supply is to supply DC power, which is intended for SA series amplifiers, for reductions in noise and ripple. The innovative way to fight the noise has been taken in this power supply. The combination use of a SA series amplifier and SA-915D1 power supply is suggested to assure outstanding performance.

▼Output

Output form	Mini DIN, 4-pin connector
Output voltage	±15V±3%
Maximum output current	±100mA
Output voltage noise/ripple	Max. 300µVrms (BW: 10Hz to 20MHz)
Output voltage temperature coefficient	500ppm/°C typ

▼Others

Power supply	AC100V±10%, 48Hz to 62Hz Approx. 10VA
Dimensions	120×55×200mm (protrusion not included)
Weight (NET)	Approx. 1.4kg
Operating temperature/ humidity range	0°C to 40°C, 10 to 95%RH (no condensation)
Storage temperature/ humidity range	–0°C to 50°C, 10 to 80%RH (no condensation)

Note: The following specifications are applied unless otherwise specified: 23±5°C, AC100V, Load resistance: 150Ω

■DC bias supply: SA-912S1

SA-912S1 power supply is a bias power supply for sensors that process micro-signals.

This power supply is composed of a dual-redundant regulator, special noise filter circuit, dual transformers, and dual shield chassis, which offers excellent noise reduction.

▼Output

Output form	Mini DIN, 4-pin connector
Output voltage	±12V±3% (no load)
Maximum output current	±100mA
Output voltage noise/ripple	Max. 3µVrms (BW: 10Hz to 1MHz)
Output voltage temperature coefficient	300ppm/°C typ

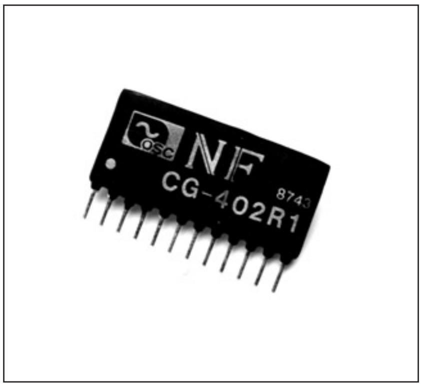
▼Others

Power supply	AC100V±10%, 48Hz to 62Hz Approx. 5VA
Dimensions	120×55×200mm (protrusion not included)
Weight (NET)	Approx. 1.4kg
Operating temperature/ humidity range	0°C to 40°C, 10 to 90%RH (no condensation)
Storage temperature/ humidity range:	–10°C to 50°C, 10 to 80%RH (no condensation)

Note: The following specifications are applied unless otherwise specified: 23±5°C, AC100V, Load resistance: 70Ω

Resistor Tunable Oscillator

CG-402R1/2

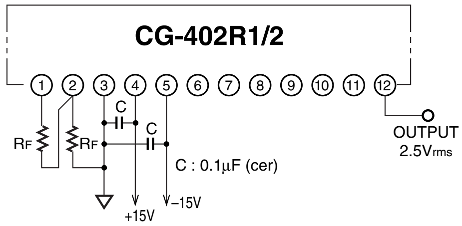


CG-402R series oscillators have achieved reductions in price and size through the simplification of the circuit. Frequencies are allocated with the external resistors (2 pcs.), and CG-402R series oscillators are in 12-pin single-inline package that enhances mounting density.

Model		CG-402R1	CG-402R2
Frequency range*1		20Hz to 20kHz	1kHz to 100kHz
Frequency setting		Specified with external resistors (2 pcs.).	
Frequency accuracy*2		±5%, ±2% (typ)	
Frequency stability		±50ppm/°C (typ)	
Output voltage		2.5Vrms±5%*3	
Output voltage stability		100ppm/°C (typ)	
Output impedance		Max. 5Ω	
Load impedance		Min. 2kΩ	
Distortion		Max. 0.1% (200Hz to 10kHz)	
Supply voltage		±15V±10%	
Quiescent current (typ)		±8mA	12mA
Temperature/ humidity range	Operation	–20°C to 70°C, 10 to 95%RH	
	Storage	–30°C to 80°C, 10 to 80%RH	
Dimensions		32×14.0×5.5mm, Type S12	

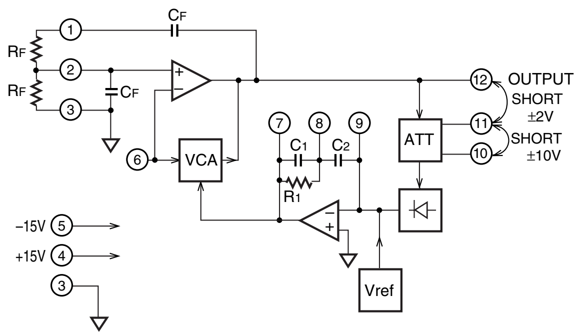
Note: The following specifications are applied unless otherwise specified:
23±5°C, ±15V, R_F = 15.9kΩ
*1. Expansion of the lower frequency is enabled.
*2. Errors of external resistors are excluded.
*3. Available at ±2 to ±10V. Max. output: ±10V, ±5mA
(402R1: 20Hz to 10kHz, 402R2: 1kHz to 50kHz)

Basic connection diagram



Output voltage
Pins ⑩ – ⑪ shorted: ±10V
Pins ⑪ – ⑫ shorted: ±2V

Block diagram



■*Frequency setting*

Equation of external resistor

CG-402R1 $R_F = \frac{15.9\times10^3}{fo}$ (kΩ)

CG-402R2 $R_F = \frac{159\times10^3}{fo}$ (kΩ)

Note: fo: Oscillation frequency
Units: fo in Hz

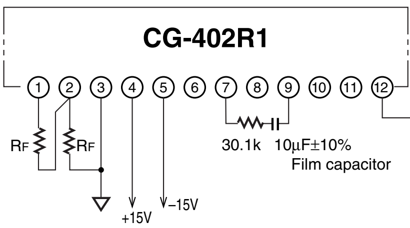
Frequency setting requires 2 external resistors of the same resistance.
Be sure to use resistors with relative tolerance of 1% to ensure optimal internal operation.

■ *Expansion of the lower frequency range (10Hz to 20Hz)*

Equation of external resistor

CG-402R1 $R_F = \frac{15.9\times10^3}{fo}$ (kΩ)

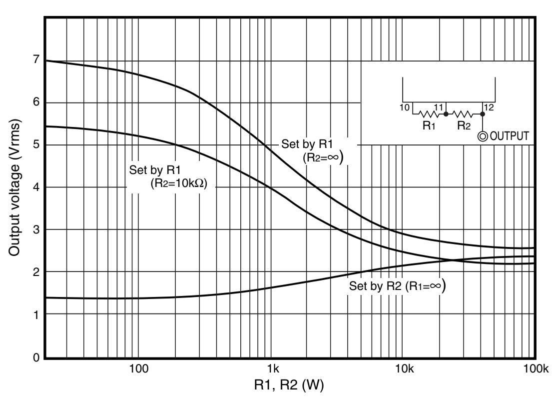
Note: fo: Oscillation frequency
Units: fo in Hz



■*Output voltage setting*

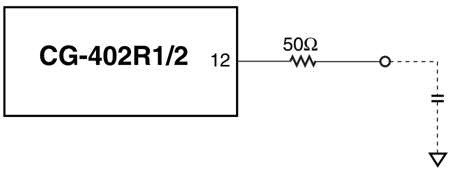
2.5Vrms of output voltage is obtained if Pins ⑩ and ⑪ are open, but output voltage varies as follows: ±10V (approx. 7Vrms) when Pins ⑩-⑪ are shorted and ±2V (approx. 1.4Vrms) when Pins ⑪-⑫ are shorted. An external resistor is required for setting output voltage (1.4 to 7Vrms) other than the above. The graph at the right expresses the standard values of external resistor and output voltage. Adjustment with a variable resistor is required to derive correct voltage.

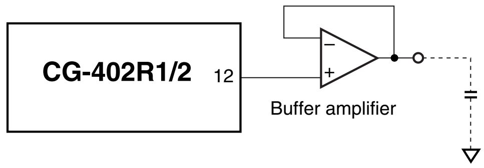
Output voltage setting



■*When load capacity is large*

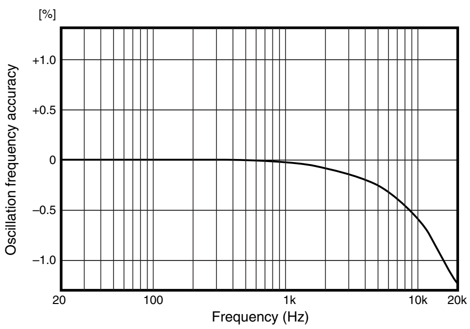
Potential unstable and abnormal oscillation may be concerned if 100pF or more of load capacity is observed. With a coaxial cable or shielding wire put under load, overload capacity is detected in some oscillators a load capacity if the cable or wire reaches a length in excess of 50cm. In the event of the above, a 50Ω-resistor or buffer amplifier needs to be inserted between the relevant oscillator and load.



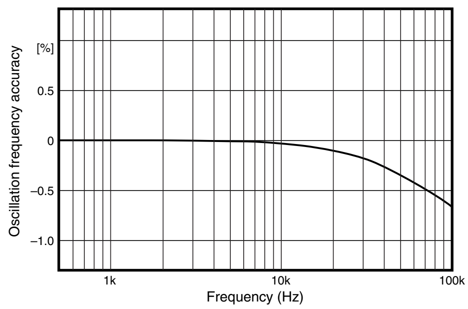


Characteristics

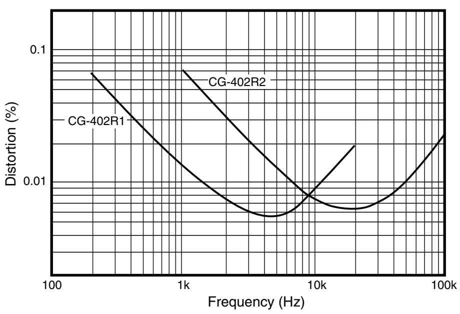
Oscillation frequency accuracy (CG-402R1)



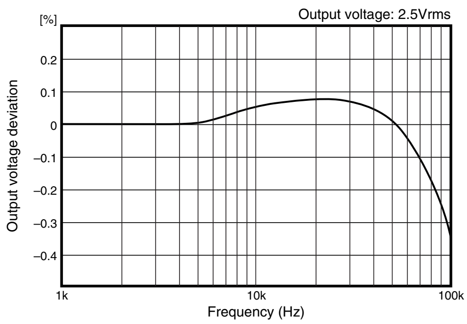
Oscillation frequency accuracy (CG-402R2)



Harmonics distortion - Oscillation frequency



Output voltage - Oscillation frequency



Oscillators

Resistor Tunable Oscillator

CG-202R3

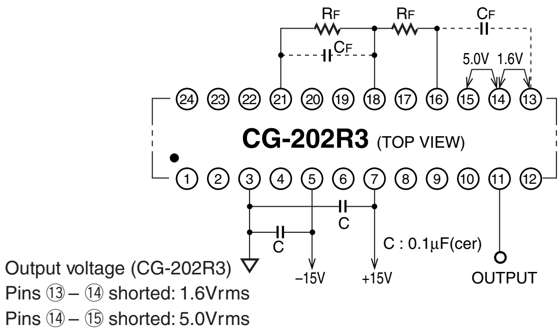
CG-202R3 oscillator is a sine-wave oscillator capable of allocating oscillation frequency in the range of 100kHz to 1MHz. This oscillator not only possesses superior frequency accuracy and output voltage accuracy but also assures stable sine-wave signals. CG-202R3 oscillator is in 24-pin dual-inline package, which enables a low-pass expansion up to 10Hz with the external capacitors and capacitor.

Frequency range[*1]		100kHz to 1MHz
Frequency setting		Specified with external resistors (2 pcs.).
Frequency accuracy[*2]		Max. ±5%, ±2% (typ)
Frequency stability		±50ppm/°C (typ)
Output voltage[*3]		2.5Vrms±3%
Output voltage stability		50ppm/°C (typ)
Output impedance		50Ωtyp
Load impedance		Min. 2kΩ, Max. 100pF
Harmonics level		–50dB (typ)(1MHz) –60dB (typ)(100kHz)
Supply voltage		±15V±10%
Quiescent current (typ)		+30mA/–20mA
Temperature/ humidity range	**Operation**	–20°C to 70°C, 10 to 95%RH
	Storage	–30°C to 80°C, 10 to 80%RH
Dimensions		34.5×18.7×7.9mm, Type KB

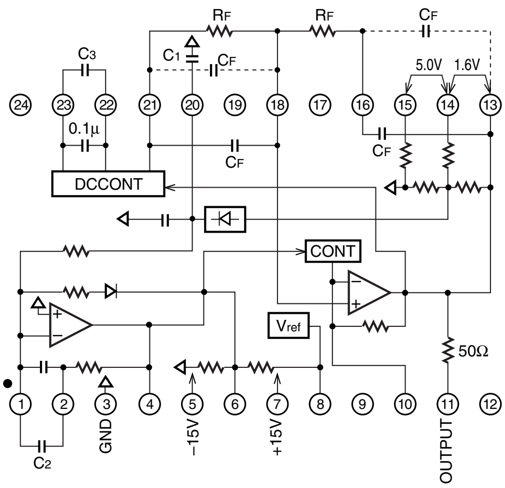
Note: The following specifications are applied unless otherwise specified:
23±5°C, ±15V, R_F = 15.9kΩ

*1. Expansion of the lower frequency is enabled.
*2. Errors of external resistors are excluded.
*3. Available at 1.6 to 5.0Vrms.

Basic connection diagram



Block diagram



Oscillators

■*Frequency setting*

Equation of external resistor

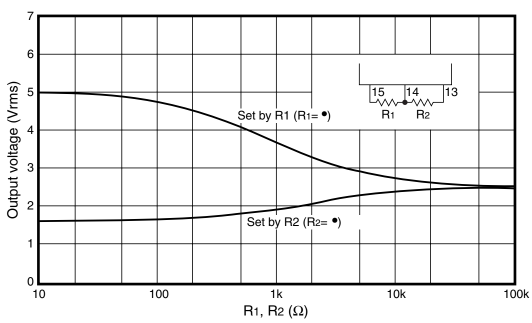
$$R_F = \frac{1.59\times10^6}{fo} \text{ (k}\Omega\text{)} \quad fo : \text{Oscillation frequency [Hz]}$$

Frequency setting requires 2 external resistors of the same resistance.
Little fluctuations in output level are observed if there is an accuracy between the external resistors.
Be sure to use resistors with relative tolerance of 1% to ensure optimal internal operation.

■*Output voltage setting*

2.5Vrms of output voltage is obtained if Pins ⑬, ⑭, and ⑮ are open, but output voltage varies as follows: 1.6Vrms when Pins ⑬-⑭ are shorted and 5Vrms when Pins ⑭-⑮ are shorted. An external resistor is required for setting output voltage (1.4 to 7Vrms) other than the above. The graph at the right expresses the standard values of external resistor and output voltage. Adjustment with a variable resistor is required to derive correct voltage.

Output voltage setting



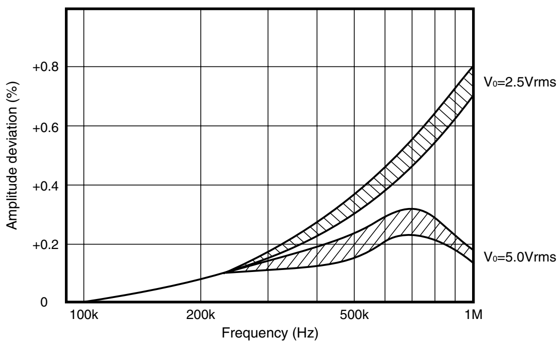
■*Expansion of the lower frequency range*

Frequency range (Hz)	C1 ③–⑳	C2 ①–②	C3 ㉒–㉓	Cf ⑬–⑯ ⑱–㉑	R_F ⑯–⑱ ⑱–㉑
100k – 1M	–	–	–	–	$\frac{1.59\times10^6}{fo}$ (kΩ)
10k – 1M	–	0.2μF	–	–	$\frac{1.59\times10^6}{fo}$ (kΩ)
1k – 100k	0.47μF	2μF	–	–	$\frac{1.59\times10^6}{fo}$ (kΩ)
100 – 10k	4.7μF	20μF	–	900pF	$\frac{1.59\times10^5}{fo}$ (kΩ)
10 – 100	20μF	47μF	1μ	9900pF	$\frac{1.59\times10^4}{fo}$ (kΩ)

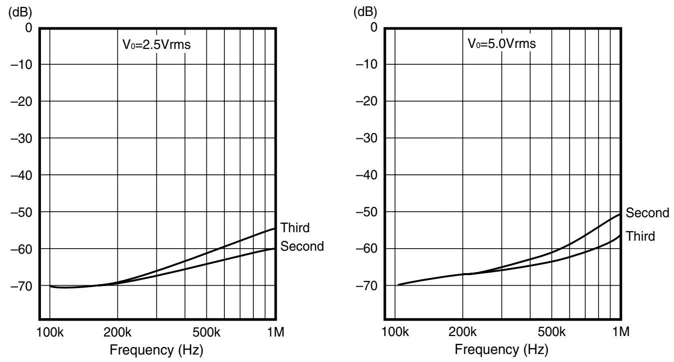
Characteristics

Output voltage - Frequency

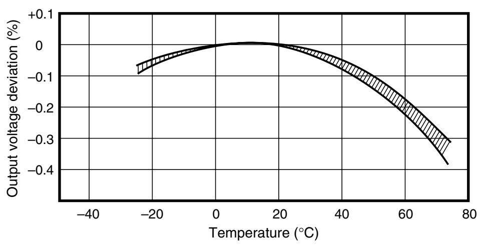
100kHz standard Rl = 1kΩ



Harmonics level

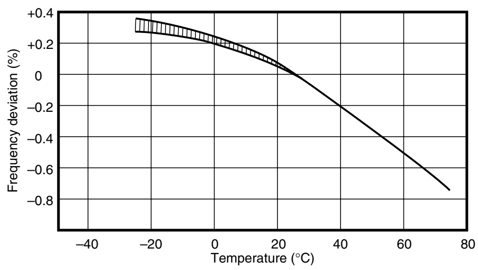


Output voltage - Temperature fo = 100kHz

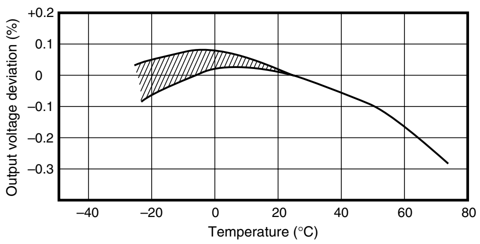


Oscillation frequency - Temperature

fo = 1MHz

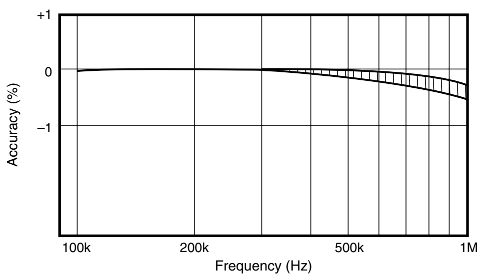


Output voltage - Temperature fo = 1MHz



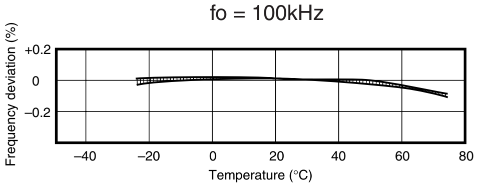
Oscillation frequency accuracy

100kHz standard: R_F: Calculated value



Oscillation frequency - Temperature

fo = 100kHz



Resistor Tunable Oscillator

CG-102R1/2 CG-302R1/2

CG-102/302 series oscillators are sine-wave oscillators capable of allocating oscillation frequency in the 20- to 100kHz range. This oscillator not only possesses superior frequency accuracy and output voltage accuracy but also assures stable sine-wave signals. An additional input terminal is embedded in CG-102/302 series oscillators for output with 90°-phase lag and sync oscillation, which expands applicability. With the use of the external capacitors and capacitor, a low-pass expansion up to 1Hz is enabled.

CG-102 series oscillators are in 24-pin dual-inline package, and CG-302 series oscillators are in 20-pin single-inline package.

Model		CG-102R1	CG-302R1	CG-102R2	CG-302R2
Frequency range[*1]		20Hz to 20kHz		1kHz to 100kHz	
Frequency setting		Specified with external resistors (2 pcs.).			
Frequency accuracy[*2]		Max. ±2%, ±0.5% (typ)			
Frequency stability		±15ppm/°C (typ)		±25ppm/°C (typ)	
Output voltage		2.5Vrms ±0.5%[*3]			
Output voltage stability		50ppm/°C (typ)			
Output impedance		Max. 5Ω			
Load impedance		Min. 2Ω, Max. 100pF			
Distortion		Max. 0.005% (70Hz to 10kHz)		Max. 0.005% (2kHz to 50kHz) Max. 0.01% (50kHz to 100kHz)	
Supply voltage		±15V±10%			
Quiescent current (typ)		+13mA/ –23mA	±13mA	+28mA/ –38mA	±28mA
Temperature/ humidity range	Operation	–20°C to 70°C, 10 to 95%RH			
	Storage	–30°C to 80°C, 10 to 80%RH			
Dimensions		34.5×18.7×7.9mm Type KB 24pin DIP	51.5×14.0×5.5mm Type S20 20pin SIP	34.5×18.7×7.9mm Type KB 24pin DIP	51.5×14.0×5.5mm Type S20 20pin SIP

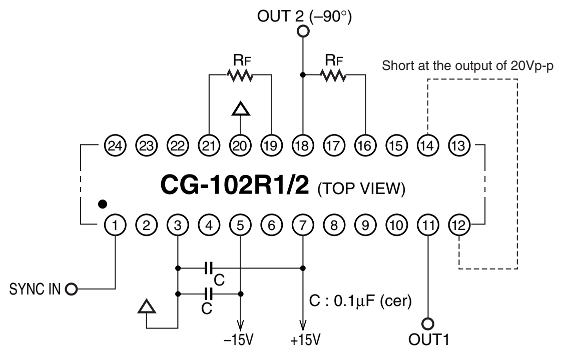
Note: The following specifications are applied unless otherwise specified:
23±5°C, ±15V, RF = 15.9kΩ

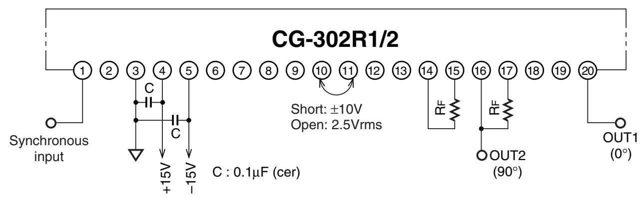
*1. Expansion of the lower frequency is enabled.

*2. Errors of external resistors are excluded.

*3. Available at 0.5 to 20Vp-p. Max. output: ±10V, ±5mA
(CG-102R1/302R1: 20Hz to 10kHz, CG-102R2/302R2:1kHz to 50kHz)

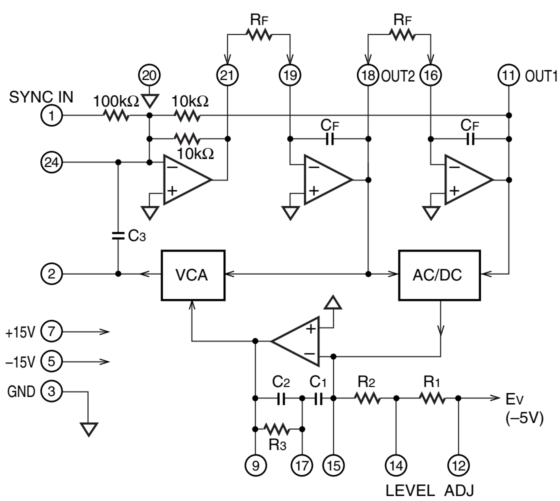
Basic connection diagram



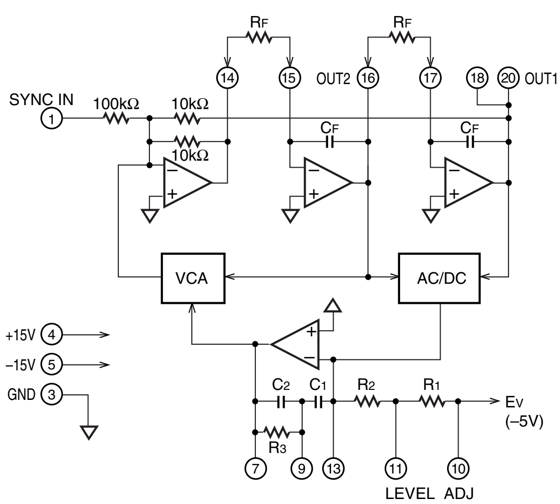


Block diagram

CG-102R1/2



CG-302R1/2



■Frequency setting

Equation of external resistor

CG-102R1
CG-302R1 $R_F = \dfrac{15.9\times10^3}{fo} (k\Omega)$

CG-102R2
CG-302R2 $R_F = \dfrac{159\times10^3}{fo} (k\Omega)$

Note: fo: Oscillation frequency
Units: fo in Hz

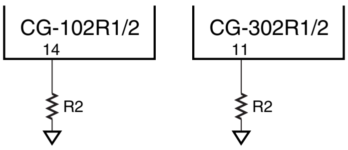
Frequency setting requires 2 external resistors of the same resistance.
An accuracy between the external resistors causes fluctuations in output level.
E.g.: Max. ±0.5% of difference between outputs 1 and 2 if a resistor with tolerance of 1% is used

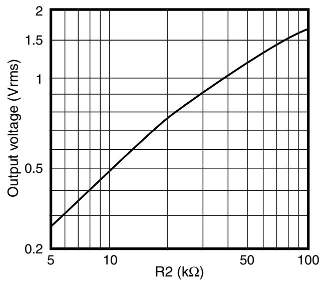
■Output voltage adjustment

CG-102 series oscillators are designed to obtain 20Vp-p of output voltage if Pins ⑫ and ⑭ are shorted, and CG-302 series oscillators are designed to obtain the same voltage if Pins ⑩ and ⑪ are shorted. 2.5Vrms of output voltage is obtained if CG-102/302 oscillators are open.

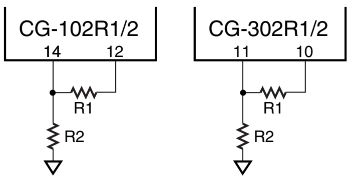
An external resistor is required for setting output voltage other than the above. The graphs as shown below express the standard values of external resistor and output voltage. Adjustment with a variable resistor is required to derive correct voltage.

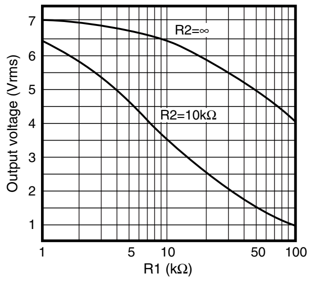
●To set the voltage at 1.5Vrms or less





●To set the voltage at 1.5Vrms or more

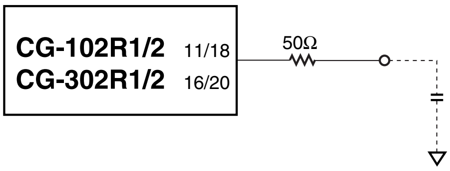


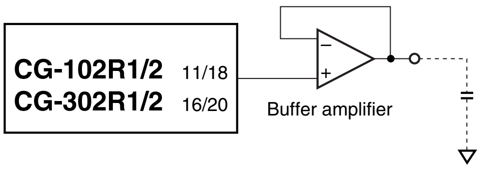


Note: Output voltage: Max. 2.5Vrms if 10kHz or more is allocated to CG-102R1/302R1 and 50kHz or more is allocated to CG-102R2/302R2.

■When load capacity is large

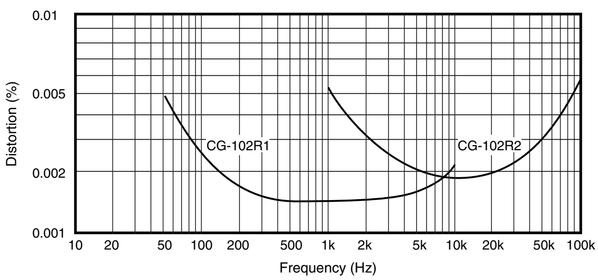
Potential unstable and abnormal oscillation may be concerned if 100pF or more of load capacity is observed. With a coaxial cable or shielding wire put under load, overload capacity is detected in some oscillators a load capacity if the cable or wire reaches a length in excess of 50cm. In the event of the above, a 50Ω-resistor or buffer amplifier needs to be inserted between the relevant oscillator and load.



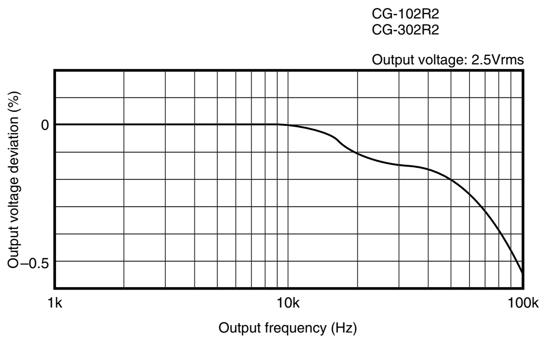


Characteristics

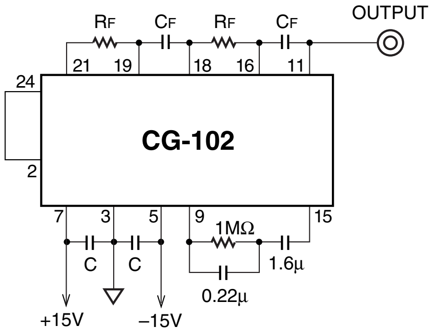
Distortion – Frequency

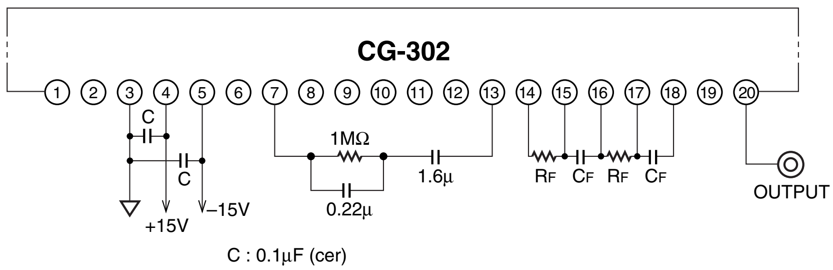


Output voltage deviation - Oscillation frequency



■Expansion of the lower frequency range





Type 1 $R_F = \dfrac{159}{(C_F+0.01)\times fo}$ [kΩ]

Type 2 $R_F = \dfrac{159}{(C_F+0.001)\times fo}$ [kΩ]

C_F : [μF], fo : [Hz]

Note: 1Hz≤fo≤1kHz

800Ω ≤ R_F ≤ 800kΩ

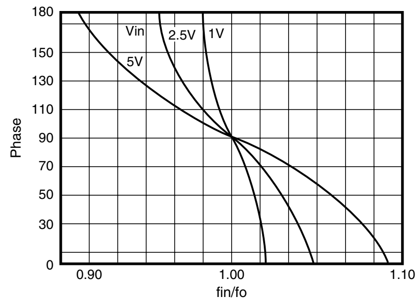
■Sync oscillation

CG-102/302 series oscillators are capable of bringing external synchronization signals into sync with oscillation output produced by the oscillators. The synchronization bandwidth is approx. 1.5%/Vrms.

The frequency of external synchronization signals is to be determined with great accuracy in advance, and then the oscillation frequency is allocated to agree with the frequency of external synchronization signal. Synchronization between the output frequency and external signal frequency is developed if an external signal (1V to 5Vrms) is added to Pin 1.

The graph at the right represents the phase difference between the external signal and oscillation output, besides the external signal level and synchronization band.

Note that potential change in oscillator level and increase in distortion may be concerned depending on the conditions of synchronization.

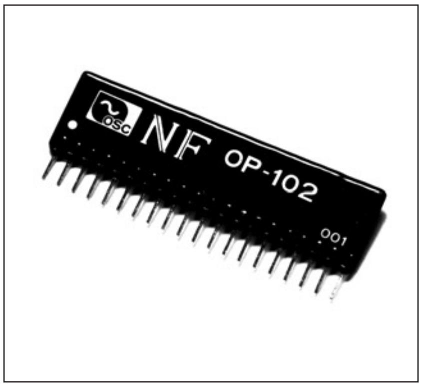


Ratio between sync input signal frequency and oscillation frequency without sync input

Oscillators

Oscillator Adapter

OP-102



OP-102 adapter can be used as a sine-wave oscillator that is capable of setting the frequency by a 3-digit BCD input, in combination with DT-212D series filters.
Performance linked with oscillation frequency (setting method, setting accuracy, temperature coefficient) that DT-212D series filters offer is applied. Performance related to output voltage (accuracy, stability, temperature coefficient), however, is determined by OP-102 adapter. The output voltage has been trimmed to 2.5Vrms±0.5% internally but can be set between 0.5Vrms and 20Vp-p with the use of an external resistor.
The oscillation frequency range is 1Hz to 100kHz. An external capacitor is required if 100Hz or less of frequency is obtained.
OP-102 adapter is powered by ±15V and a 20-pin single-inline package in dimensions of 51.5 × 14.0 × 4.0mm.

▼Absolute maximum ratings

Supply voltage (±Vs)	±18V
Signal input (Pins ⑬ and ⑮)	±Vs

▼Output characteristics

Output voltage	2.5Vrms	20Vp-p
Accuracy	Max. ±0.5%	±0.6% (typ)
Output voltage range	500mVrms to 2.5Vrms ≤100kHz 500mVrms to 20Vp-p ≤50kHz Short in a specified pin (20Vp-p) Set with an external resistor.	
Output resistance	Max. 5Ω (DT-212D)	
Distortion	0.01% (typ)	0.012% (typ)
90° output	Output with 90°-phase lag at frequency same as the main output	

▼Oscillation frequency characteristics (DT-212D)

Frequency range	1Hz to 100kHz An external capacitor required if frequency is 100Hz or less
Frequency accuracy	±0.1% (typ)
Frequency setting	BCD: 3 digits

▼Others

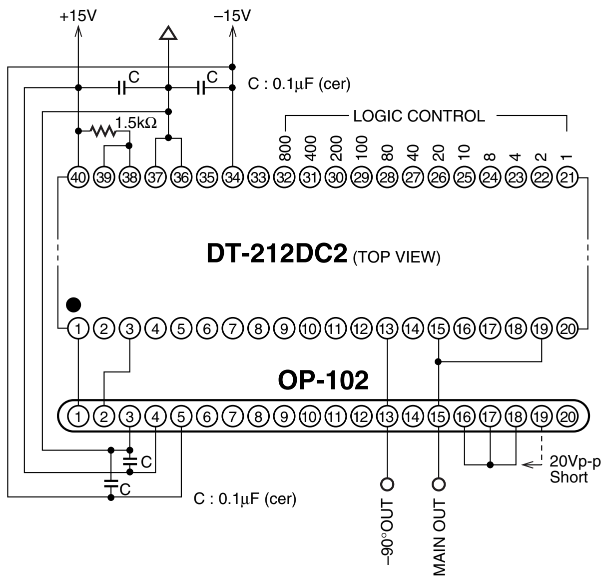
Supply voltage		±15V ±10%
Quiescent current		+15mA, –25mA
Temperature/ humidity range	**Operation**	–20°C to 70°C, 10 to 95%RH
	Storage	–30°C to 80°C, 10 to 80%RH
Dimensions		51.5 × 14.0 × 4.0mm, Type S20

Note: The following specifications are applied unless otherwise specified:
23±5°C, Vs = ±15V, 1kHz, 2.5Vrms

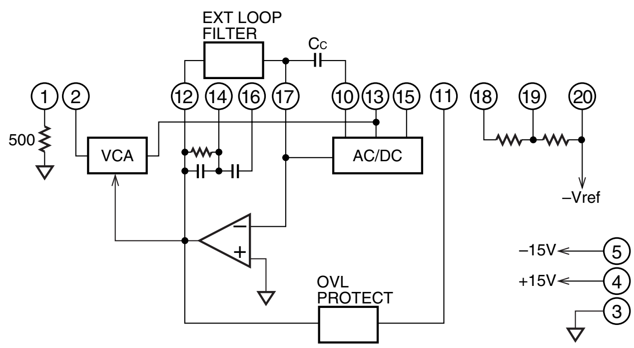
Basic connection diagram

The following diagram represents the basic connection of oscillation at 2.5Vrms with this module connected to the DT-212DC2 filter.

The setting of oscillation frequency requires the utilization of digital signal input from the DT-212DC2 filter.
Input: TTL/CMOS compatible



Block diagram



Expansion of the lower oscillation frequency

Expansion of the lower oscillation frequency is enabled with the external capacitors CEXT (2 pcs.) connected to the DT-212D filter as shown in Figure 3.
CEXT is derived from the following equation.

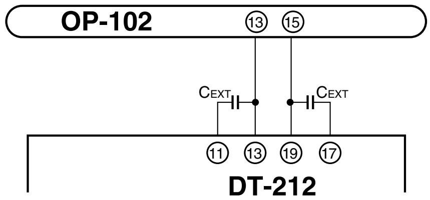
$$C_{EXT}=\frac{5\times10^4}{fo}\ [pF]$$

fo: Oscillation frequency [Hz] when set at 001

The oscillation frequency range and CEXT are listed below.

	Set resolution	CEXT[*1]
100 to 100kHz	100Hz	500pF
10 to 15.99kHz	10Hz	5000pF
1[*1] to 1.599kHz	1Hz	50000pF

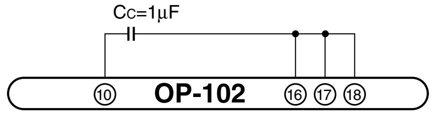
*1. Be sure to use an external loop filter to ensure 1Hz to 10Hz of oscillation if the adapter is used in the 1Hz to 1.599kHz range.
*2. The DT-212DC1 filter is pre-assigned with 50000pF, and the DT-212DC2 filter is pre-assigned with 500pF.



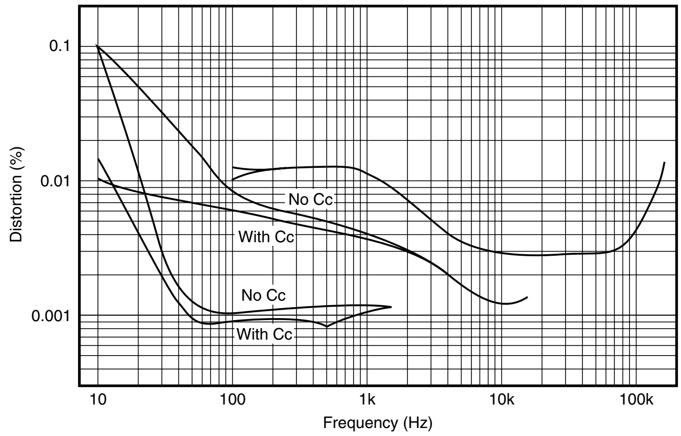
Connected with CEXT

Distortion improvement with external Cc

Distortion is improved by establishing the connection between the external capacitor Cc and OP-102 adapter as shown in Figure 4. No effects are considered if the external capacitors CEXT are switched to use.



Connected with Cc

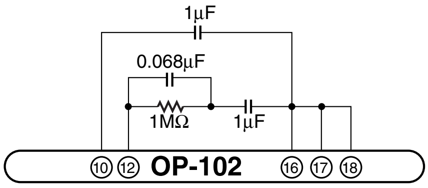


Distortion – Frequency characteristics

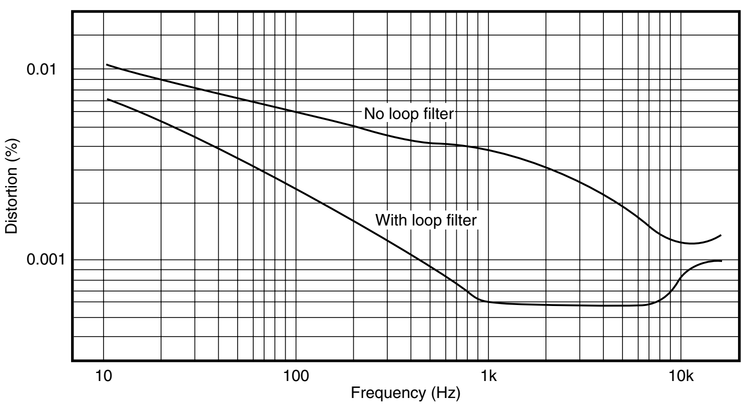
Distortion improvement with external loop filter

Deterioration in distortion is observed upon expansion of the lower oscillation frequency, but the connection with an external component contributes to improvement in distortion.
The oscillation frequency range and circuit example are provided below.

1. 10Hz to 15.99kHz

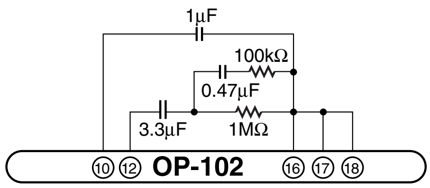


Connected with loop filter

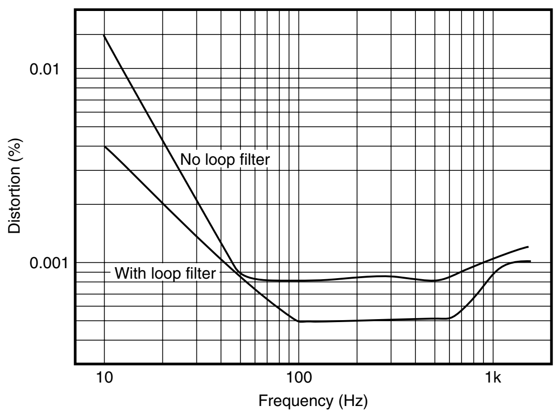


Distortion – Frequency characteristics

2. 1Hz to 1.599kHz



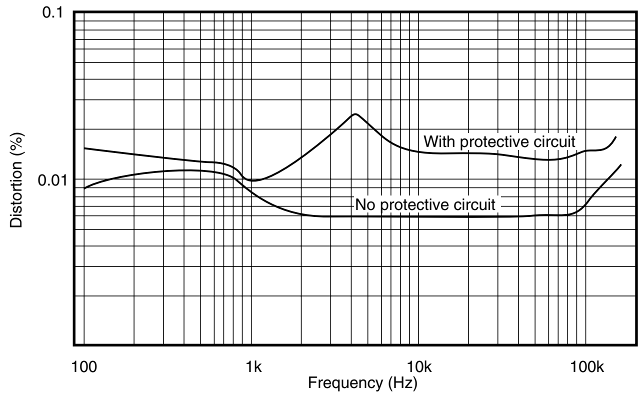
Connected with loop filter



Distortion – Frequency characteristics

■ *Expansion of the lower oscillation frequency*

The upper limit of oscillation frequency for 2.5Vrms of output is 100kHz, and for 20Vp-p is 50kHz. Oscillation up to 159.9kHz for 2.5Vrms and 100kHz for 20Vp-p is enabled through the connection with the protective circuit embedded in the OP-102 adapter.
The protective circuit goes into action when the connection between Pin ⑪ (DT-212D) and Pin ⑪ (OP-102) is established. The above, however, results in deterioration in distortion regardless of the range.



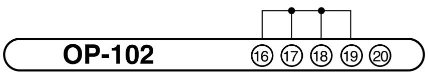
Distortion – Frequency characteristics

■*Output voltage setting*

The setting of output voltage for the OP-102 adapter requires Pins ⑰ to ⑳. The following procedure should be used to vary output voltage.

1. 20Vp-p

The OP-102 adapter is outfitted with a trimmed resistor.
Connect Pins ⑯ to ⑲.



20Vp-p setting

2. 20Vp-p to 500mVrms

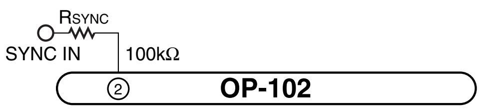
Connect an external resistor as shown below.
The output voltage is derived from the following equation:
R[kΩ]=1111/Vo   Vo: Output voltage [Vrms]

The standard values are provided above. Adjustment through the partial replacement of the resistor with a trimmer potentiometer is required to derive correct voltage.

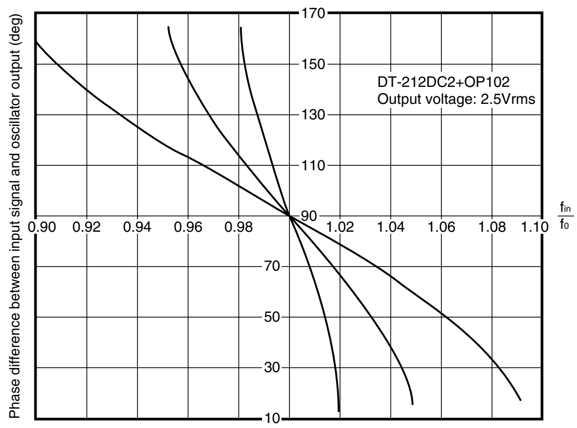
Output voltage adjustment

■*Sync oscillation*

Sync oscillation by external signals is to be ensured if R_{SYNC} is added as shown below.
The frequency range that allows synchronization varies with input voltages.
The most stable synchronization is maintained at 90° in the 0- to 180°- range of synchronization.
If a synchronization input voltage remains the same, the synchronization range can be changed by changing R_{SYNC}. Duplation of the input voltage is equivalent to a reduction of R_{SYNC} by half.
The following represents the standard input voltage of I/O phase difference to a frequency ratio, as parameter.



Connection of synchronization input



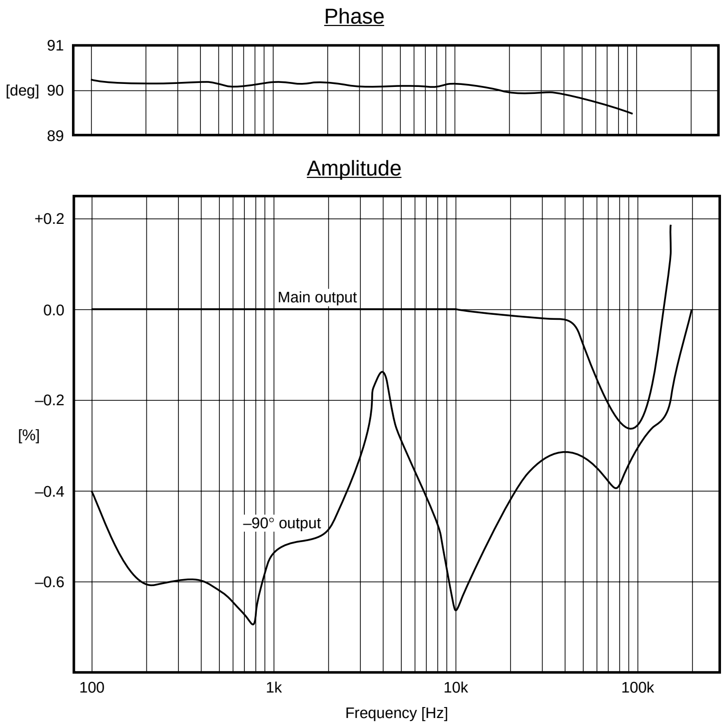
Synchronization input - Phase difference

f_{in} : Sync input signal frequency
f_o : Oscillation frequency without sync input

Oscillators

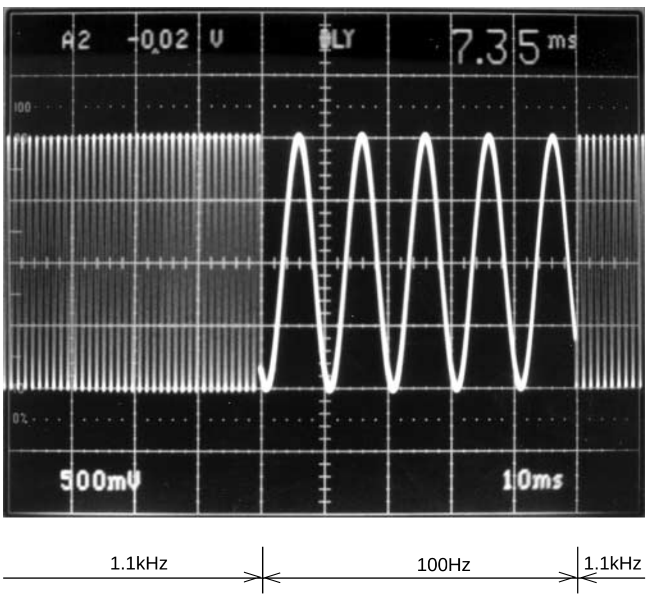
■Amplitude and phase difference of 2-phase output

The OP-102 adapter is rated to deliver 2 types of output as follows: main output (Pin ⑮) and -90° (Pin ⑬). These outputs are equal in oscillation frequency but have slight errors in the output voltage and phase difference.
Examples of errors in amplitude and phase difference at main output and -90° output are provided below.



■Response for oscillation frequency setting

The output response to changes in the oscillation frequency setting is phase-continuous, which causes 300ns typ-delay.



VER : 500mV/div
HOR : 10ms/div

Random Binary Generator

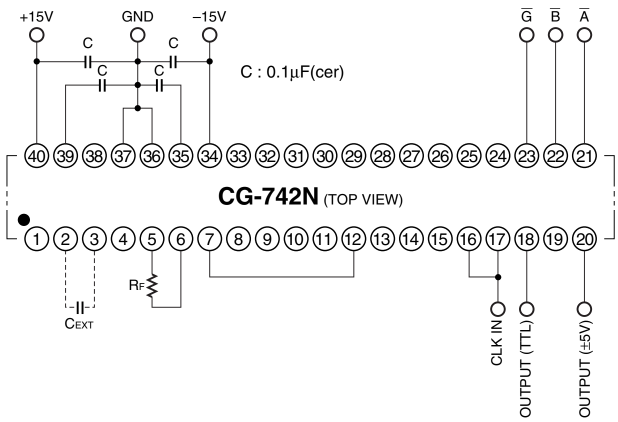
CG-742N

CG-742N generator is a noise generator that produces false random binary signals with high stability.
The original oscillation frequency setting is completed with the external resistor or external clock, and a frequency demultiplier is embedded in the generator to facilitate the noise band-width setting.
The generator is allocated with long periodic noise source through pseudo random M series with the use of a 42-stage shift resistor. The CG-742N generator assures the output falling into TTL level and ±5V for analog process. The initialization of pulse trains to be output is enabled with the use of the reset terminal, which can be applicable to reproducibility.
The filtering of outputs delivered by this generator contributes to the acquisition of power spectrum characteristics up to 100kHz.

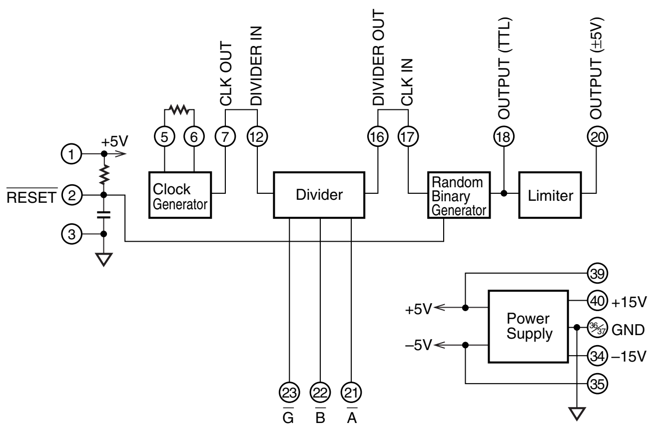
Noise source		Pseudo random M series with a 42-stage shift resistor $\text{Cycle}=\frac{\text{Approx. }4.398\times10^{12}}{fo}[S]$ fo: Clock frequency [Hz] 10.18 day at 5MHz of clock frequency Spectrum intervals 1.136 µHz at 5MHz of clock frequency
Original oscillation frequency		Allocated with the external resistor or TTL-level external clock.
Original oscillation frequency range		0.5M to 5MHz (with external resistor) Max. 5MHz (with external clock)
Frequency demultiplier (bypass enabled)		1/1, 1/10, 1/100, 1/1000 Set with the logic signals (TTL level). Latch function assigned
Output		Random binary output TTL level LSTTL (1 pc.) actuated ±5V (no load) Output impedance: Approx. 100Ω Load resistance: Min. 5kΩ (Max. 1mA) Rise/fall time: Max. 200ns
Power supply		±15V (±11 to ±16V)
Maximum input voltage		②⑫⑰㉑㉒㉓ +5.5V, –0.5
Dimensions		54.4×33.7×9.4mm, Type HA
Temperature/ humidity range	**Operation**	–20°C to +70°C, 10 to 95%RH
	Storage	–30°C to +80°C, 10 to 80%RH

Note: The following specifications are applied unless otherwise specified: 23±5°C, Vs = ±15V

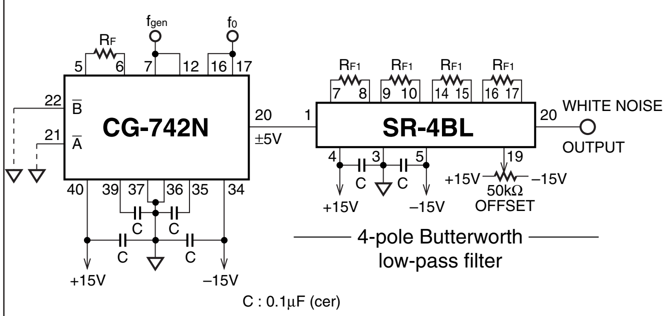
Basic connection diagram 1 (Random binary)



Block diagram



Basic connection diagram 2 (White noise)

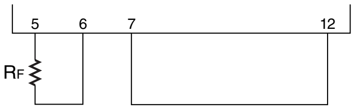


■Usage

1. Oscillator

Either the built-in oscillator or external clock is available for M series drive.

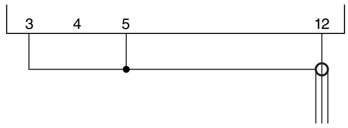
a. When a built-in oscillator is used

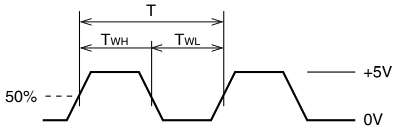


$$f_{gen}=\frac{1}{R_F\times2\times10^{-10}}$$

f_{gen}: Oscillation frequency [Hz]
R_F : Element resistance [Ω]

b. When an external clock is used



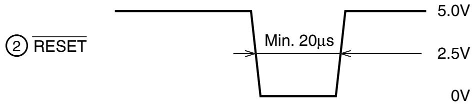


T : Min. 200ns
T_{WH} : Min. 20ns
T_{WL} : Min. 20ns
Duty Any (enabled if 1:1 is not ensured)

c. Reset

Initialization of M series

The initialization of M series takes effect through the addition of pulses to Pin ② with an open collector or setting at 0V by contact signals, as show below. Proper initialization upon supply of the power is assured only if a rise in the supply voltage is at or less 10ms.

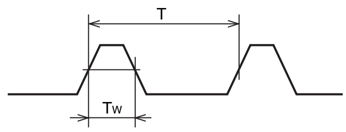


2. Frequency demultiplier

Clock derived from the built-in oscillator or external clock is to be divided with the frequency demultiplier into 1/10, 1/100, and 1/1000. The frequency demultiplier is under control of Pins ㉑ and ㉒ and, the setting is latched by Pin ㉓ signal.
Direct clock input to Pin ⑰ is required if no built-in frequency demultiplier is necessary. Pin ⑫ for frequency demultiplier input is connected to GND.

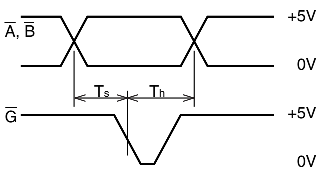
3. M series

Pin ⑰ is designed for clock input.



T : 200ns (Max. 5MHz)
T_W : Min. 20ns

Control signal timing chart



T_s: Min. 13ns
T_h: Min. 5ns

Control codes

G̅	B̅	A̅	
OPEN			×1
H	L	L	×0.001
H	L	H	×0.01
H	H	L	×0.1
H	H	H	×1
Z	×	×	Latch

“H” : +5V
“L” : 0V

4. White noise

Outputs delivered by the CF-742N generator is random binary outputs (±5V-square waves with random cycles), which prompts the CF-742N generator to adopt the amplitude distribution (application of normal analog noise) as Gaussian distribution (normal distribution). Filtering is required to obtain flat frequency characteristics (white noise).
There is a close connection among the following: clock frequency (frequency of Pin ⑰), low-pass filter cut-off frequency, equivalent noise bandwidth determined by filter order, peak factor of analog noise (filter output) and output voltage.
The filter cut-off frequency and clock frequency are derived from the equations shown at right.

a. Set the output voltage Eo [rms]. (Peak factor: Min. 4)
$E_O \leq 1.25V$ E_O : RMS value of output voltage [Vrms]

b. Designate an equivalent noise bandwidth (B) and filter order to obtain filter cut-off frequency (fc).

$$f_C=\frac{B}{k}$$

fc: Filter cut-off frequency [Hz]
B: Equivalent noise bandwidth [Hz]
K: Noise bandwidth coefficient (see table 1)

Table 1: Coefficient of noise bandwidth (Butterworth)

Order	k
1	1.57
2	1.11
3	1.05
4	1.03

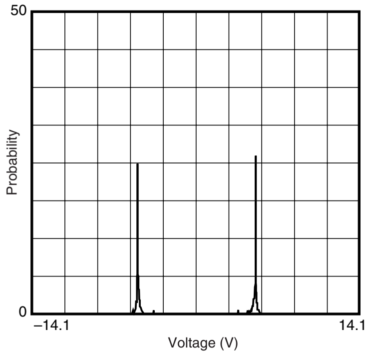
c. Derive a clock frequency (fo) from the cut-off frequency (fc) and output voltage (Eo).

$$f_O=\frac{50B}{E_O^2}$$

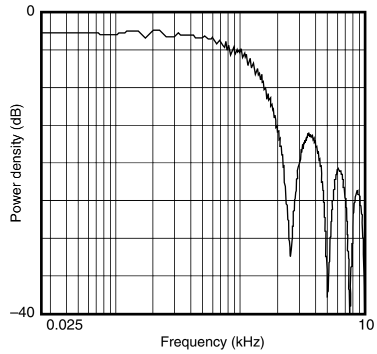
fo. Clock frequency [Hz]

Characteristics

Random binary output probability density

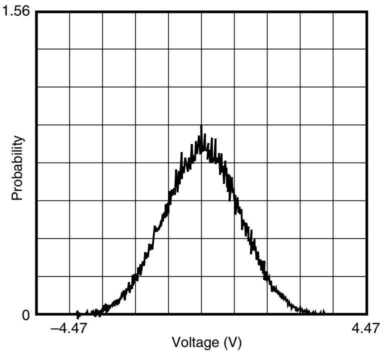


Random binary output power spectrum

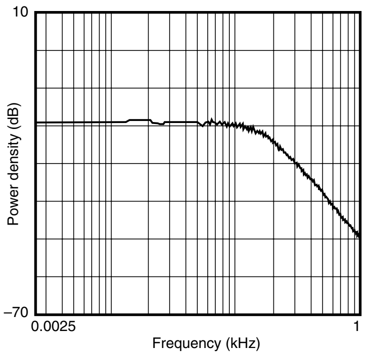


Condition: Clock frequency: 2.5kHz

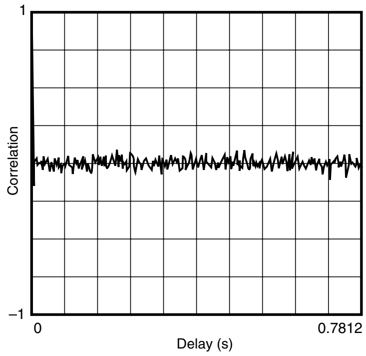
Gaussian distribution output probability density



Gaussian distribution output power spectrum



Gaussian distribution output autocorrelation



Condition: Clock frequency: 10kHz
Low-pass filter equivalent noise bandwidth: 200Hz
(2-pole Butterworth: fc = 180Hz)

■Technical data

Noise output characteristics after filtering

Power spectrum of random binary output is derived from the following equation:

$$P_E(f)=\frac{25}{f_0}[V^2/Hz] \quad \text{.......} (1)$$

fo: Clock frequency of random binary generator

Power spectrum varies along with filtering as shown below.

$$P_{EO}(f)=\frac{25}{f_0}|H(j\omega)|^2 \quad \text{.......} (2)$$

H (j(t)): Filter transfer function

RMS value is determined from the following equation:

$$E_O=\sqrt{\frac{2.25}{f_0}\int_0^{\infty}|H(j\omega)|^2 d\omega} \text{ [rms]} \quad \text{.......} (3)$$

If it is simplified,

$$E_O=\sqrt{\frac{50}{f_0}A^2 B} \text{ [rms]} \quad \text{.......} (4)$$

B: Equivalent noise bandwidth
A: Filter pass-band gain

The equivalent noise bandwidth (B) is defined as follows:

$$B=\frac{1}{A^2}\int_0^{\infty}|H(j\omega)|^2 d\omega \quad \text{.......} (5)$$

The filter order-equivalent noise bandwidth (B) relationship is provided in Table 1.

Flatness of not only noise bandwidth but noise frequency is of importance to use frequency as white noise.

Random binary amplitude characteristics are expressed by the following equation:

$$E(f)=\frac{\sin(\pi f/f_0)}{\pi f/f_0} \quad \text{.......} (6)$$

Amplitude characteristics are obtained as shown in Table 2.

Table 1

Order	B
1	1.57fc
2	1.11fc
3	1.05fc
4	1.03fc

Butterworth characteristics applied

Table 2 Random binary output amplitude characteristics

f/fo	Amplitude [dB]
0.001	–0.00
0.01	–0.00
0.02	–0.01
0.05	–0.04
0.1	–0.14
0.2	–0.58
0.5	–3.92
1	–

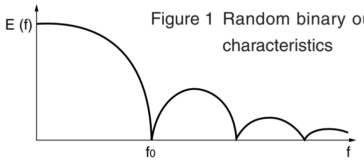


Figure 1 Random binary output amplitude characteristics

Amplitude characteristics of Butterworth low-pass filters are assigned with “1” for a pass-band gain.

$$E_0(f)=\sqrt{\frac{1}{1+(f/f_C)^{2n}}} \quad \text{.......} (7)$$

Amplitude characteristics are obtained as shown in Table 3.

Table 3: Butterworth filter amplitude characteristics

f/fc	Amplitude [dB]			
	1-pole	2-pole	3-pole	4-pole
0.001	–0.00	0.00	0.00	0.00
0.01	–0.00	–0.00	0.00	0.00
0.1	–0.04	–0.00	–0.00	–0.00
0.2	–0.17	–0.01	–0.00	–0.00
0.3	–0.37	–0.04	–0.00	–0.00
0.4	–0.64	–0.10	–0.02	–0.00
0.5	–0.97	–0.26	–0.07	–0.02
0.6	–1.34	–0.53	–0.20	–0.07
0.7	–1.73	–0.93	–0.48	–0.24
0.8	–2.14	–1.49	–1.01	–0.67
0.9	–2.57	–2.19	–1.85	–1.55

The peak factor (P.F.) is defined as follows:

$$P.F.=\frac{E_P}{E_0} \quad \text{.......} (8)$$

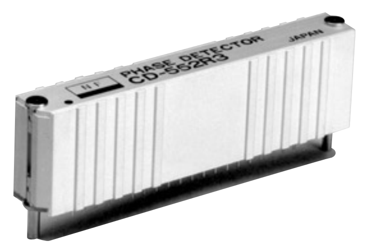
Assign 5 [Vo-p] to peak value (Ep) for the generator, and substitute Eo from Equation (4).

$$P.F.=\frac{5}{\sqrt{\frac{50}{f_0}A^2 B}} \quad \text{.......} (9)$$

To use it as Gaussian random noise, determine Eo to maintain 4 in peak factor.

Phase Detector

CD-552R3 CD-552R4



CD-552R series detectors are an on-board phase detectors possessing frequencies falling within the range of 1kHz to 200kHz for CD-552R3 and frequencies falling within the range of 10kHz to 2MHz for CD-552R4.
The signal system is composed of the phase sensitive detector (PSD), low-pass filter (LPF), and output amplifier. A low-pass expansion of output low-pass filter cut-off frequency is available with the addition of one external resistor, and the gain setting (×1 to ×10) is also enabled. The reference signal system consists of a 0°-90° phase shifter (PAT.P) and 50%-duty circuit (PAT.P), which enables the detection of A sin ϕ or A cos ϕ phase. The phase detection with double frequency is permitted if 2f mode is placed through the connection with the specified pin.
CD-552R series detectors are in a static-shielded 20-pin single inline package.

▼Absolute maximum ratings

Supply voltage (±Vs)	±18V
Signal input voltage	±Vs
Reference signal input voltage	+5.5V, –0.5V
Logic control voltage	+5.5V, –0.5V

▼Signal system

▽Signal input

Model	CD-552R3	CD-552R4
Input impedance	Max. 10kΩ±5% at 1kHz	Max. 2.5kΩ±5% at 10kHz
Linear maximum input voltage	Min. ±10V	
Allowable slew rate	Max. 5V/µs	Max. 130V/µs

▽Phase detector

Detection method	Synchronous rectifying type by square-wave multiplication	
Detection characteristics	Vout=Vin • A • cosϕ Vout: Detection DC output Vin: Input signal (synchronization) A: Gain ϕ: Phase difference between the signal system and reference signal system	
Operating frequency range	1kHz to 200kHz	10kHz to 2MHz
Gain (ϕ=0)	(sine-wave): Pins ⑫ and ⑬ open (sine-wave): Short in Pins ⑫ and ⑬ Selectable in the 1 to 10-Vdc/Vo-p with the external resistor (Pins ⑫ and ⑬)	
Gain accuracy	Max. ±3%	
Phase difference (signal system and reference signal system)	–0.05° (typ) at 1kHz, –8° (typ) at 200kHz	–0.5° (typ) at 10kHz, +13° (typ) at 2MHz

▽Low-pass filter

Order	1-pole (6dB/oct)	
Cut-off frequency	Pins ⑨-⑩ shorted, Low-pass expansion is enabled with an external resistor or capacitor.	Pins ⑨-⑩ shorted, Low-pass expansion is enabled with an external resistor or capacitor.

▽Detection output

Output impedance	Max. 50Ω±10% at 1kHz	Max. 50Ω±10% at 10kHz
Linear maximum input voltage	Min. ±10V (DC, Load resistance≥2kΩ)	
Linear maximum input current	Min. ±5mA (DC)	
Offset voltage	Max. ±15mV, ±5mV (typ) Short in input, Gain: 1Vdc/Vo-p	
Offset voltage adjustment	Zero adjustment available with external pre-set resistors. (Pin ⑭)	

▼Reference signal system

▽Reference signal input

Model	CD-552R3	CD-552R4
Input circuit	CMOS Schmitt trigger, pulled up at 100 kΩ Trip point: +3.5V/+1.5V (typ)	
Input voltage	CMOS (0/+5V) level	
Unipolar (1f) mode	A rising or falling edge is regarded as a reference.	
Polarity switch	Pin ⑰ open or +5V: Rising edge regarded as a reference 0V: Falling edge regarded as a reference	
Pulse duration	Min. 50nsec	
Bipolar (2f) mode	Both rising and falling edge are regarded as a reference.	
Mode setting	Connected with the reference signal input (Pin ⑱) and polarity switch input (Pin ⑰).	
Input waveform	Duty: 50%	
Input frequency range	1kHz to 100kHz	10kHz to 1MHz

▽0°-90° phase shifter

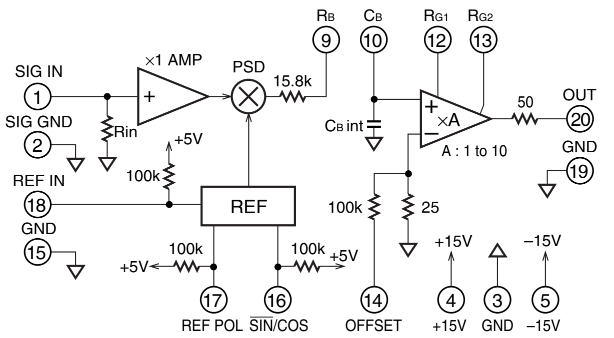
Function	This enables the detection of COS or SIN through a 0°-90° phase shift of reference signal input (Pin ⑱).
0°-90° phase difference	–90±0.5°, –90±0.1° (typ)
Control	Pin ⑯ open or +5V : 0° (COS) 0V : –90° (SIN)
Control input circuit	CMOS Schmitt trigger, pulled up at 100 kΩ

▼Others

Recommended supply voltage		±15V±1V	
Quiescent current		±25mA (max), ±20mA (typ)	±35mA (max), ±26mA (typ)
Specified temperature range		23°C±5°C	
Temperature/ humidity range	**Operation**	–20C° to 70C°, 10 to 90%RH	
	Storage	–30C° to 80C°, 10 to 80%RH	
Dimensions		67×10.5×20mm (protrusion not included) Type SS20 (20-pin shielded SIP)	
Weight (NET)		Approx. 20g	

Note: The following specifications are applied unless otherwise specified:
23±5°C, Supply voltage: ±15V

Block diagram



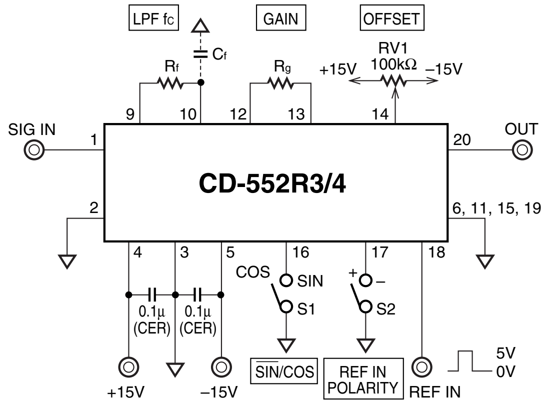
	CD-552R3	CD-552R4
Rin	10k	2.5k
CBint	10000p	1000p

SIN/COS This is used to switch the internal phase shifter between 0° and 90°, which enables the switching of detector input/output between A sin ϕ and A cos ϕ.
[A: Amplitude (o-p) of input signal, ϕ: Phase difference between input signal and reference signal]
HI: A•cosϕ (0°) (specified when the pin is open)
LO: A•sinϕ (90°)

REF POL This is used to switch the reference polarity of reference signals. An edge specified is a reference phase. With the REF POL terminal connected to the REF IN terminal, the phase detection with double frequency is enabled if 50% of duty is assigned to the reference signal.
HI: Rising edge regarded as a reference (specified when the pin is open)
LO: Falling edge regarded as a reference
Connected with REF IN terminal :
Both rising and falling edge regarded as a reference

OFFSET This is used to adjust output DC offset. ±15V is available for input, which allows both terminals of the pre-set resistor to be connected with ±15V input. The sliding terminal is connected to the OFFSET terminal. The signal is transmitted to the REF IN terminal with the SIG IN terminal connected to the ground, which brings the pre-set resistor into action to make offset adjustment.

Basic connection diagram



■Gain setting

CD-552R3/4 detectors are outfitted with the variable-gain output amplifiers (×1 to ×10). The maximum output voltage is set at 10Vo-p that should not be surpassed when setting proper gain for post processor.

$$Rg=\frac{2.9873\times10^{4}}{A-1}-3.3\times10^{3}[\Omega]$$

A: Gain [times (×)]

Example: Set points

Gain	×1	×2	×5	×10
Resistance	∞	26.7kΩ	4.12kΩ	0

■LPF setting

CD-552R3/4 detectors are outfitted with the primary LPF that is capable of setting frequencies of 1kHz (10kHz) or less with the use of the external CR. Proper frequency is to be allocated, allowing for the bandwidth, responsibility, and fluctuation for output signals.

CD-552R3

$$R_f=\frac{1}{2\pi\cdot(1\times10^{-8}+C_f\,[F])\cdot f_C\,[Hz]}-15.9\times10^{3}\ [\Omega]$$

f_C : Cut-off frequency
C_f: External capacitor

Example: Set points

Cut-off frequency (Equivalent noise bandwidth)	1Hz (1.57Hz)	10Hz (15.7Hz)	100Hz (157Hz)	1kHz (1.57kHz)
Resistance	1.43MΩ	1.58MΩ	143kΩ	0
Capacitance	0.1μF	–	–	–

R should remain at 2MΩ or less with the use of the eternal capacitor (Cf). Theory holds that a larger value can be assigned, but potential deterioration in offset, DC drift and noise may be concerned if assigned.

CD-552R4

$$R_f=\frac{1}{2\pi\cdot(1\times10^{-9}+C_f\,[F])\cdot f_C\,[Hz]}-15.9\times10^{3}\ [\Omega]$$

f_C : Cut-off frequency
C_f: External capacitor

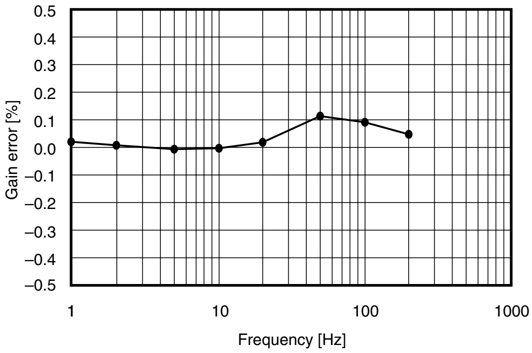
Example: Set points

Cut-off frequency (Equivalent noise bandwidth)	10Hz (15.7Hz)	100Hz (157Hz)	1kHz (1.57kHz)	10kHz (15.7kHz)
Resistance	140kΩ	1.58MΩ	143kΩ	0
Capacitance	0.1μF	–	–	–

Characteristics CD-552R3

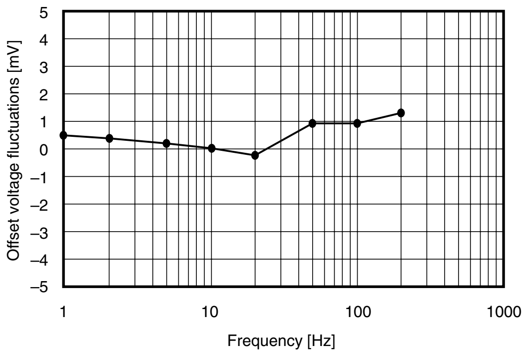
Gain fluctuations

Reference: 10kHz, Gain: ×10

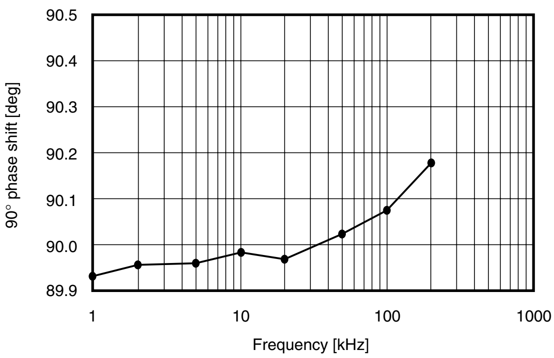


Offset voltage fluctuations

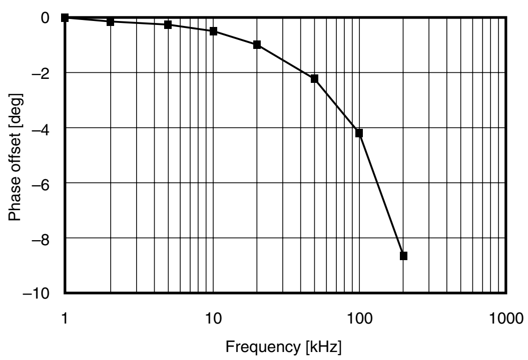
Reference: 10kHz, Gain: ×10



90° phase shift fluctuations



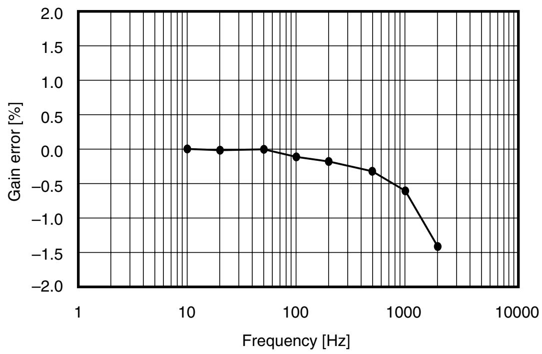
Phase offset



Characteristics CD-552R4

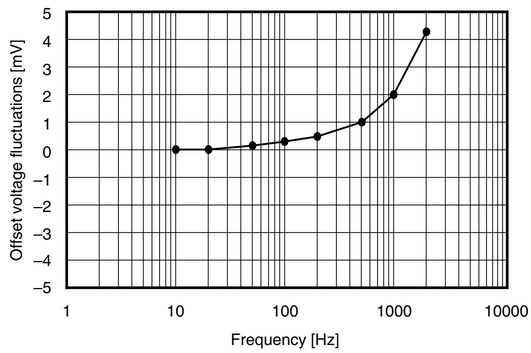
Gain fluctuations

Reference: 10kHz, Gain: ×10

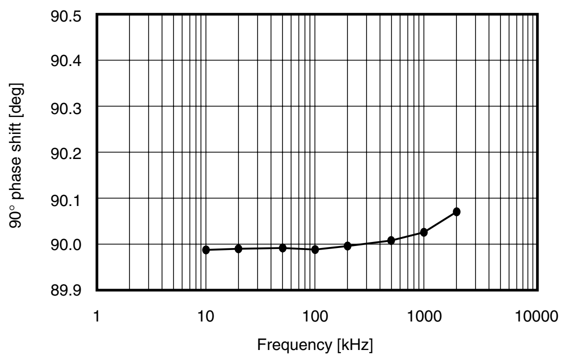


Offset voltage fluctuations

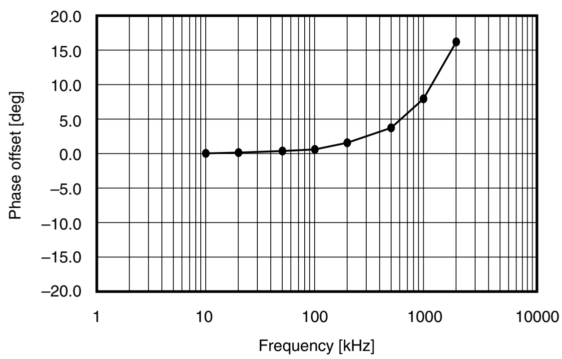
Reference: 10kHz, Gain: ×10



90° phase shift fluctuations

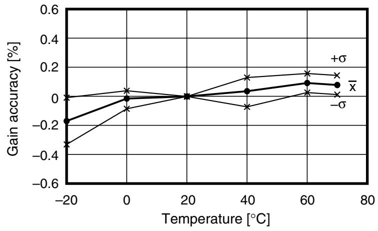


Phase offset

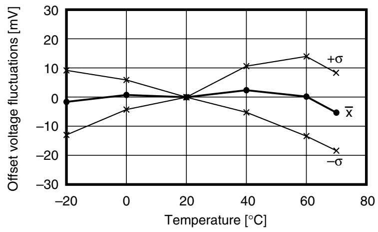


Characteristics CD-552R3

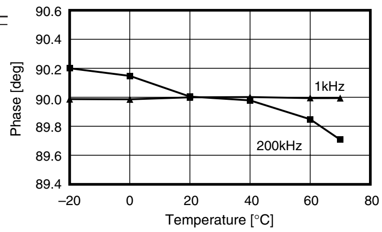
Gain accuracy – Temperature



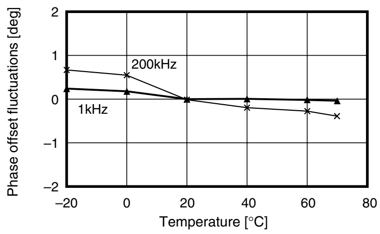
Offset voltage – Temperature



90° phase shift accuracy – Temperature

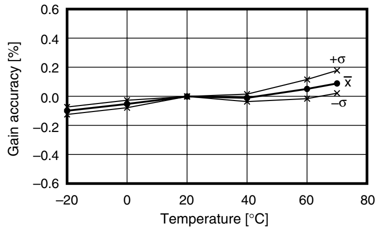


Phase offset – Temperature

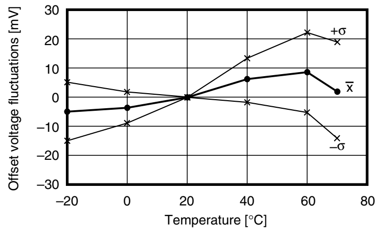


Characteristics CD-552R4

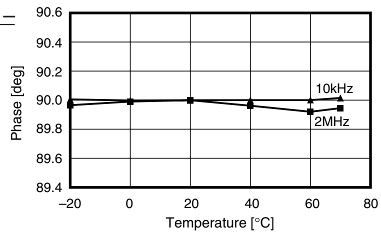
Gain accuracy – Temperature



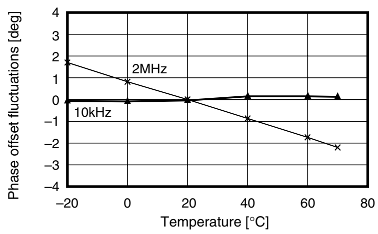
Offset voltage – Temperature



90° phase shift accuracy – Temperature



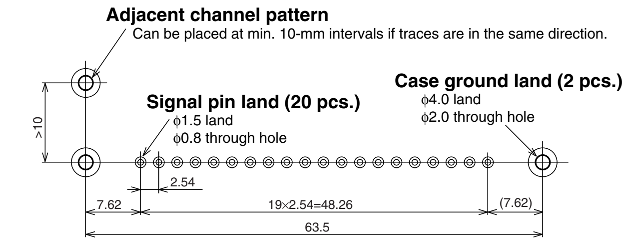
Phase offset – Temperature



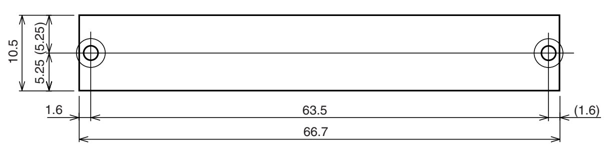
Pattern design

Proper connection between the case ground and the GND potential should always be assured. No sufficient shielding effect is produced if disregarded.

No signal traces should be assigned on the maximum visible outline of the component mounting surface. Possible contact between the metal case and the board is observed around the maximum visible outline, which triggers the establishment of a short circuit between the signal and case. A ground plane pattern is recommended to incorporate into the maximum visible outline and the inside of the case to enhance shielding effect.



Pattern dimensions



Maximum outer dimensions

Phase Detectors

To assure dynamic range and stability

■*Signal pre-processing*

If a sufficient S/N ratio fails to be obtained by the optimization of detector input level or setting of the output amplifier, a filter needs to be inserted in front of the detector to enhance the S/N ratio of input signal.
The filter falls into the four types (low-pass, high-pass, band pass, and band elimination) and becomes a determinant of the following items: asynchronous signal frequency component, amplitude characteristics, filter characteristics, and cut-off frequency.
The band pass filter attenuates all signals other than synchronization signal, which maximizes the improvement of the S/N ratio. Relatively large variations in phase around the center frequency, which may lead to detection accuracy if a phase change is made in response to temperature drift. Phase drift is minimized if low-order (1-pole if possible) Q is assigned.
The low-/high-pass filters attenuate low-/high-pass signals, and offer the smaller improvement of the S/N ratio as compared with the band pass filter. A phase change at a pass band is curbed, which contributes to a smaller detection accuracy attributed to fluctuations in cut-off frequency.
The band elimination provides large attenuation to signals of specified frequencies. An efficient improvement of the S/N ratio is obtained if specified frequency is assigned to the asynchronous signal. The least phase change at a pass band is assured, which minimizes a detection accuracy attributed to fluctuations in cut-off frequency.

■*Input signal level*

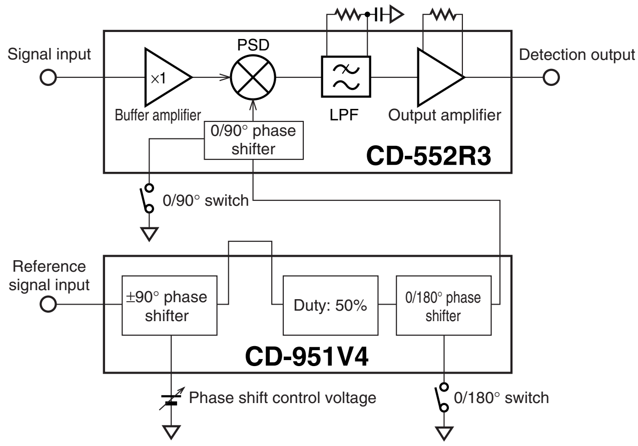
CD-552R3/4 detectors features $10V_{0-p}$ of the maximum input level. A dynamic range can be assured if a large level of synchronization signal is input by maintaining within $10V_{0-p}$. The actual input signal contains both asynchronous and synchronization signals, which requires a decrease in the amplitude of $10V_{0-p}$ or less.
E.g.: $0.1V_{0-p}$ synchronization signal is present in $1V_{0-p}$ signal that is a total of asynchronous and synchronization signals. CD-552R3/4 detectors performs the detection of the signals at 1Vdc of output despite the ×10-post-stage DC amplifier being designated. The allowable input level enables a ×10-amplifier to be inserted in front of the CD-552R3/4 detectors to input the maximum input voltage of $10V_{0-p}$. The detection output obtains 10Vdc when the ×10-post-stage DC amplifier is designated, which allows the obtainment of the maximum output signal.

■*Output amplifier*

The output amplifier is capitalized on to obtain a proper output level if a small detection output remains despite the optimization of input signals. CD-552R3/4 detectors are outfitted with the variable-gain output amplifiers (×1 to ×10). The maximum output voltage is set at $10V_{0-p}$ that should not be surpassed when setting gain to assure proper voltage for post processor.
Note that an increase in DC drift, offset voltage and output noise is considered with an increase in gain.

Phase adjustment

Phase detection with the use of the CD-552R3/4 detectors may require phase adjustment for the optimization of detection sensibility and cancellation of processing phase.
Phase adjustment is conducted in combination with the voltage controlled phase detector CD-951V4. Continuous change in phase shift of the reference signal is enabled through DC voltage.



Evaluation board

A module-mounted evaluation board is available for easy evaluation of this module. Contact us for further information.

Phase Shifter

CD-951V4

CD-951V4 is a 360°-voltage controlled phase shifter in the frequency range of 1kHz to 2MHz, and adopts CMOS-level (0/+5V) square wave for input and output. This is composed of the ±100°-variable voltage controlled phase circuit and 50%-duty circuit (PAT.P) with 0/180° switch. The combination use of the ±100°-phase shifter and 0/180°-selector enables the output of 50%-duty square wave that phase is shifted in the 360° range to the phase shifter input signal.
Double frequency is produced by the 50%-duty input signal if 2f mode is placed through the connection with the specified pin.
CD-951V4 is in a static-shielded 20-pin single-inline package, which is a great contributor to the implementation of high precision signal processing and high density mounting.

▼Absolute maximum ratings

Supply voltage (±Vs)	±18V
Phase control DC input voltage	±Vs
Phase shifter input voltage	+5.5V, –0.5V
Logic control voltage	+5.5V, –0.5V

▼50%-duty output/voltage control phase shifter

▽Setting

Setting	Pins ⑮-⑯ shorted, Pin ⑰ open
I/O characteristics	**50%-duty square wave, which a phase is shifted by voltage control, is output with reference to the edge specified at polarity switch of phase shifter input signal waveform.**

▼Frequency range

Frequency range	1kHz to 2MHz (2 ranges available: 1kHz to 200kHz, 10kHz to 2MHz)
Range switch	Pin ⑫ open or +5V: 1kHz to 200kHz 0V: 10k to 2MHz

▼Phase shifter input characteristics

Input circuit	CMOS Schmitt trigger, pulled up at 100 kΩ
Trip point	+3.5V/+1.5V (typ)
Input voltage	CMOS (0/+5V) level
Unipolar (1f) mode	A rising or falling edge is regarded as a reference.
Polarity switch	Pin ⑬ open or +5V: Rising edge regarded as a reference 0V: Falling edge regarded as a reference
Pulse duration	Min. 50nsc
Bipolar(2f) mode	Both rising and falling edge are regarded as a reference.
Mode setting	Connected with the phase shifter input (Pin ⑭) and polarity switch input (Pin ⑬).
Input waveform	Duty : 50%
Input frequency range	1kHz to 1MHz

▼Voltage control characteristics

Control method	Phase shift is specified in the proportion to phase control DC input voltage.
Input resistance	100kΩ±3% (DC)
Linear maximum input voltage	±5V ≤1MHz
Linear control range	±90°
Voltage control sensitivity	–20°/V (–100°/+5V, 100°/–5V)
Sensitivity accuracy	±1°/V

▽Phase shifter output characteristics

Output circuit	HCMOS output, series resistor at 100Ω
Output voltage	CMOS (0/+5V) level
Duty	50%±0.03% (typ) (at 200kHz) 50%±0.3% (typ) (at 2MHz)
0/180° switch	Pin ⑳ open or +5V : –180°, 0V : 0°
–180° accuracy	–180°±0.02° (typ) (at 200kHz) –180°±0.2° (typ) (at 2MHz)
Phase offset	(1k to 200kHz) –0.6° (typ) (at 1kHz) –4.5° (typ) (at 200kHz) (10kHz to 2MHz) –0.9° (typ) (at 10kHz) –42.0° (typ) (at 2MHz)
Phase offset adjustment	Adjustment available with a 20kΩ-external potentiometer. (Pin ②)
Adjustment range	±5° (typ)

▼Reference voltage

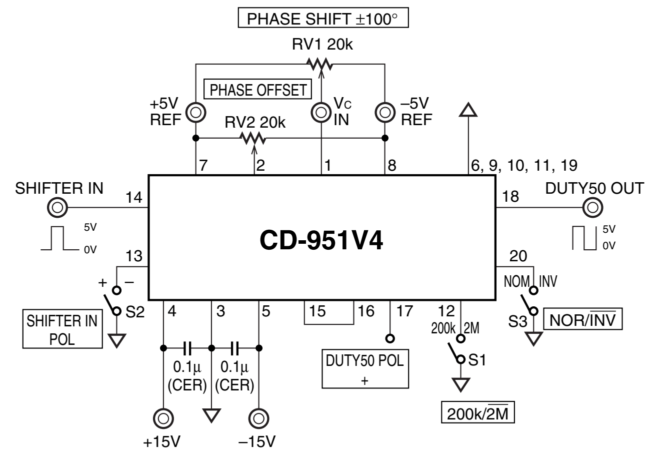
Output voltage/accuracy	Max. ±5V±2%
Temperature stability	50ppm/°C (typ)
Maximum output current	±1mA

▼Others

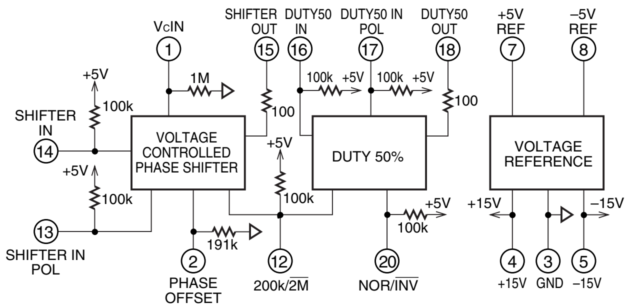
Recommended supply voltage		±15V±1V
Quiescent current		+25mA (max), +18mA (typ) –20mA (max), –12mA (typ)
Temperature/ humidity range	**Operation**	–20C° to 70C°, 10 to 90%RH
	Storage	–30C° to 80C°, 10 to 80%RH
Dimensions		67×10.5×20mm (protrusion not included) Type SS20 (20-pin shielded SIP)
Weight (NET)		Approx. 20g

Note: The following specifications are applied unless otherwise specified: 23±5°C, Supply voltage: ±15V

Basic connection diagram



Block diagram



SHIFTER IN POL — This is used to switch the reference polarity of shifter input. The operation at double frequency, as compared with the reference signal, is actualized through the connection between the SHIFTER IN POL terminal and SHIFTER IN terminal if 50% of duty is assigned to the reference signal.
- HI: Rising edge regarded as a reference (specified when the pin is open)
- LO: Falling edge regarded as a reference
- Connected with SHIFTER IN terminal: Both rising and falling edge regarded as a reference

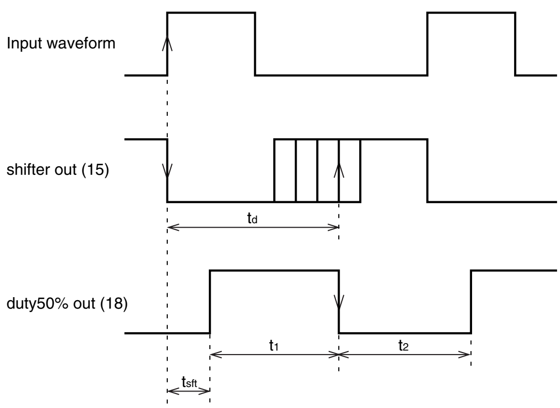
PHASE OFFSET — This is used to cancel phase offset. Zero adjustment of the phase offset for CD-951V4 phase shifter only is enabled in the range of 1kHz to 200kHz. Both terminals of a trimmer potentiometer of 20kΩ min. are connected with ±5V input (Pins ⑥ and ⑦), and the center terminal is connected to the PHASE OFFSET terminal.

200k/2M — This is used to switch the operating frequency range between 1kHz-200kHz and 10kHz-2MHz in response to the used frequency.
- HI: 1kHz to 200kHz (The pin is open)
- LO: 10kHz to 200MHz

NOR/INV — This is used to switch the output phase between 0° and 180°. A 360°-phase shifter is configured in combination with a continuously variable phase shifter (±90°).
- HI: 0° (The pin is open)
- LO: 180°

DUTY50 IN POL — This is used to switch the input polarity of the 50%-duty circuit. “HI” (open) should remain on for normal connection.
- HI: Rising edge regarded as a reference (The pin is open)
- LO: Falling edge regarded as a reference

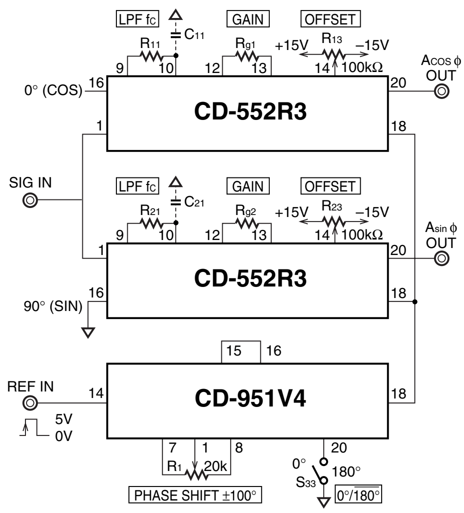
Timing chart



This timing chart presents the operation of the voltage controlled phase shifter CD-951V4.
E.g.: The CD-951V4 phase shifter is set to regard a rising edge of the input signal as a phase reference. This detector produces the signal “LO” (Pin ⑮) for the time proportionate to the control voltage (td) if a rise is observed in the input signal (Pin ⑭).
Waveform shaping (Pin ⑱) is performed to assure 50% in duty (t1 = t2) with reference the rising edge in the obtained signal.
td adjustment allows continuous change in input/output rise time (tsft), which denotes phase change.
The same operating principles* are applied to the phase detector CD-552R3 that has realized 90°-phase shift with high accuracy.

* Patent pending

Usage example **2-phase detector**



This example indicates the adoption of this detector to the 2-phase detector. The cos and sin detection outputs are obtained, which allows amplitude and phase of the synchronization signals to be derived from the relevant vector operation.
The settings of GAIN (×1 to ×10) and LPFfc (max. 1kHz) are available in this detector. Offset adjustment is required as necessary.
Phase adjustment is available by 90°-continuous phase shift (CD-951V4 R1) or 0/180°-switch (S33), which enables 360°-phase change in total.

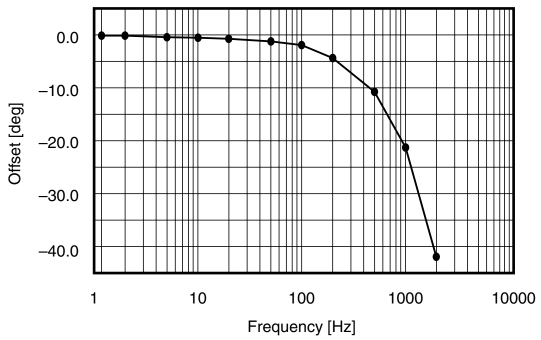
GAIN setting: Short: ×10
Open: ×1

LPFfc setting (same as R21):
Short: 1kHz

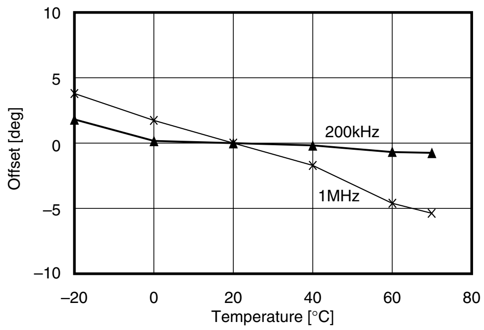
Note: See the CD-552R3/R4 in Page 72 for details in the GAIN setting and LPF setting.

Characteristics

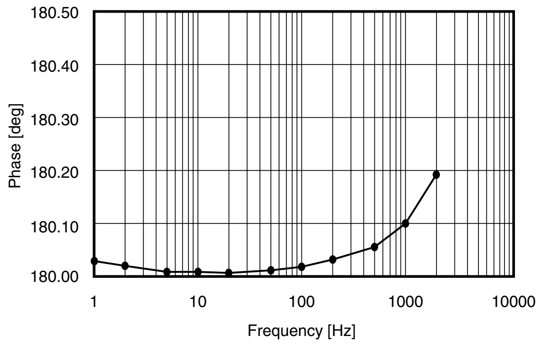
Phase offset



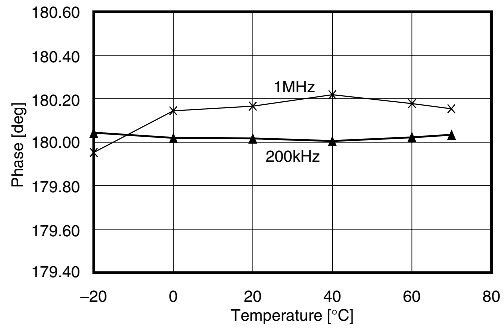
Phase offset - Temperature



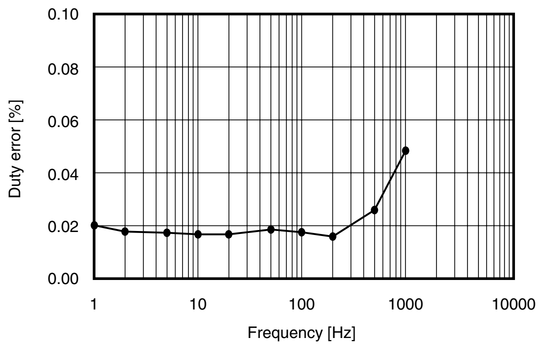
180° phase error



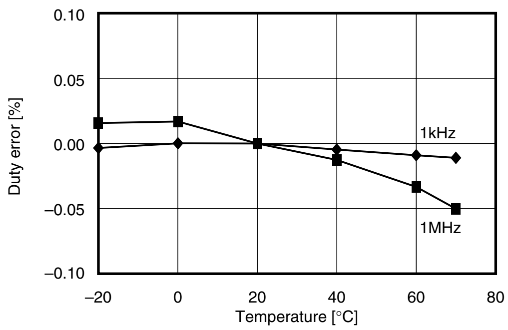
180° phase error - Temperature



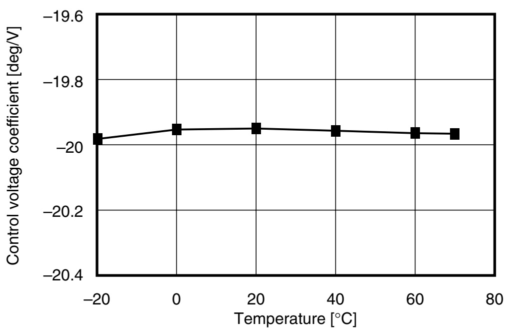
Duty error



Duty error - Temperature



Control voltage coefficient – Temperature



Phase Detector

CD-505R2

CD-505R2 detector is a hybrid phase detector composed of the following units: input differential amplifier, two post amplifiers, band-pass filter, phase shifter, phase detector, and low-pass filter. This detector possessing the frequency range of 10Hz to 10kHz enables the setting of center frequency with the use of the resistors (2 pcs.). Not only gain setting for the post amplifiers with the resistors (2 pcs.) but phase setting with the resistor and trimmer potentiometer is also available.
The reference signal is designed to apply square wave with 1:1 of a duty factor, and the phase shifter assures its phase adjustment in the range of ± 45°. The post amplifier can be utilized as a 90°-phase shifter and inverting amplifier that actualizes ± 360°-adjustment with the combined use of the switch.
The 2-pole low-pass filter (Q = 0.5) is allocated, which facilitates the setting of the equivalent noise bandwidth with the use of resistors and capacitors.

▼Absolute maximum ratings

Supply voltage (±Vs)	±18V
Signal input voltage	±Vs ①, ③, ⑤, ⑪, ㉝, ㊴
Reference signal input voltage	+5.5V ㉑

▼Input amplifier

Input form	Differential input
Input impedance	Differential input 200kΩ Inverting input 100kΩ Non-inverting input 200kΩ
Gain	×1
Frequency characteristics	DC to 10kHz
Maximum input voltage (linear)	±10V

▼Post amplifier

Gain	×1 to ×100 (2-stage amplifier, ×10×2) Setting : Specified with external resistors (2 pcs.).
I/O phase	In-phase
Frequency characteristics	DC to 10kHz

▼Band pass filter

Characteristics	1-pole pair band pass filter
Q	5
Center frequency (fo) **Setting method**	Range: 10Hz to 10kHz Setting: Specified with external resistors (2 pcs.). R_{BP}≤1.59MΩ Combined use of external capacitor is also available if 100Hz or less is obtained.
Gain	0dB±0.5dB

▼Phase shifter

Frequency range	10Hz to 10kHz
Phase shift	Range: 90°±45° Setting: Specified with an external resistor and a trimmer potentiometer Combined use of an external capacitor is also available if 100Hz or less is obtained.
Gain	×1

▼Phase detector

Frequency range	10Hz to 10kHz
Type	Synchronous detection (with reference signal)
Reference signal	TTL level, Duty factor: 1:1
Input processing (internal)	Pulled down at 100kΩ
Offset	ϕ1/ϕ2 balanced, Output offset adjustment available with an external trimmer potentiometer.

▼Low-pass filter

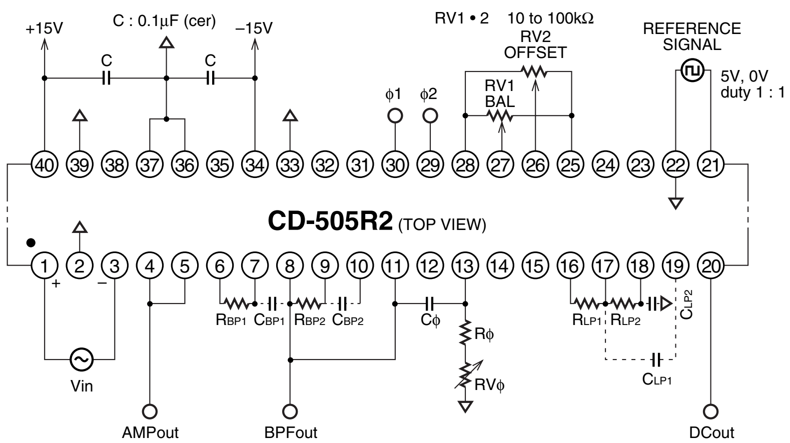
Characteristics	2-pole low-pass filter
Equivalent noise bandwidth	Range: 30Hz to 1kHz (with 2 external resistors) Any setting is available with 2 external resistors (R_{LP}) and 2 capacitors (C_{LP}).

▼Others

Supply voltage		±15V (±14 to ±16V)
Quiescent current		±30mA (typ)
Temperature/ humidity range	**Operation**	–20C° to 70C°, 10 to 95%RH
	Storage	–30C° to 80C°, 10 to 80%RH
Dimensions		54.4×33.7×6.5mm Type H

Note: The following specifications are applied unless otherwise specified: 23±5°C, ±15V

Basic connection diagram



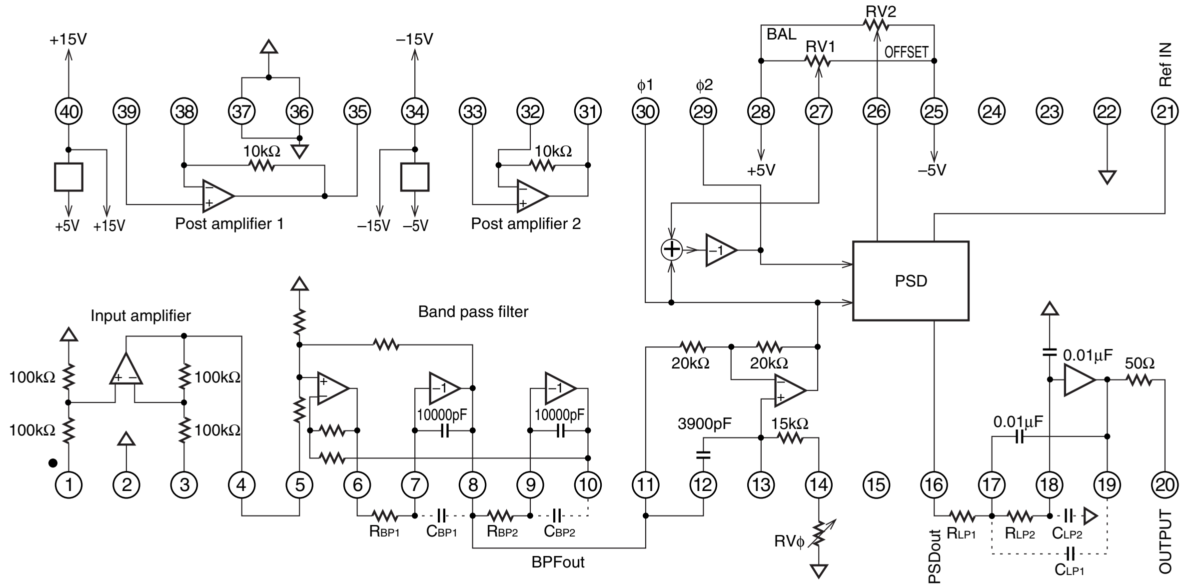
●**Usage example of post amplifier**

1. Signal system amplifier for the detection of micro-input signals
2. Instrumentation amplifier to obtain a large CMRR at high input impedance
3. Phase shifter to assure the 360°-range for phase adjustment

●**Calculation of constant**

1. To determine the center frequency
   ➡Band pass filter: R_{BP}1, 2 (C_{BP}1,2)
2. To determine the phase shift
   ➡Phase shifter: Cϕ, Rϕ, RVϕ
3. To determine the equivalent noise bandwidth
   ➡Low-pass filter: R_{LP}1, 2 (C_{LP}1,2)

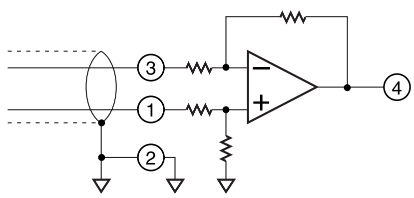
Block diagram



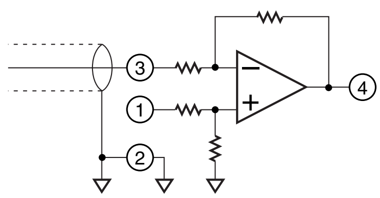
①-④**: Input amplifier**

The input amplifier is a differential amplifier carrying Pin ① for non-inverting input and Pin ② for inverting input.
The basic usage of the input amplifier is shown below.

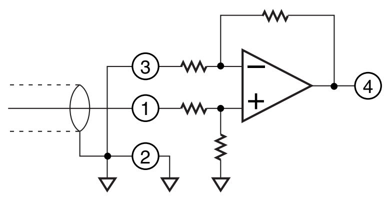
1. Differential amplifier



2. Inverting amplifier



3. Non-inverting amplifier



⑪-⑭**: Phase shifter**

The phase shifter is used to adjust signal system phase in the 90°-range.
Phase adjustment exceeding the above range requires the 360°-phase shifter application.
Signal monitor terminal: Pins ㉙ and ㉚

⑤-⑩**: Band pass filter**

This band pass filter enables the measurement of fundamental waves with harmonics eliminated.
By using external components, it is possible to configure a 1-pole pair band pass filter (Q=5).
This band pass filter is capable of providing an attenuation of 20dB to 3-order harmonics and of 26dB to 5-order harmonics. With R_{BP} used, center frequency adjustment for the band pass filter is performed to keep a phase difference " 0 " or "180°" through a comparison between the input signal and B_{PF} OUT terminal ⑧ signal.

PSD

This is used for the phase detection in 2-phase signals by the reference signal.

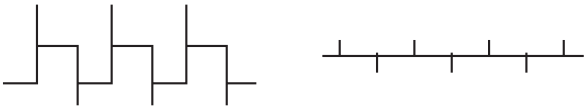
⑯-⑳**: LPF**

This is a low-pass filter capable of determining the equivalent noise bandwidth. The configuration of a 2-pole LPF is enabled with the use of the external resistors (2 pcs.) or the combined use of the external capacitor according to frequency. Some use applications may require the use of a 1-pole pair low-pass filter. See Page 83 for details.

■Offset adjustment

Offset adjustment is required for 2 places.
Use the following procedures for offset adjustment.

1. BALANCE (RV1)
Establish a ground for +/- inputs. The PSD OUT terminal ⑯ is to be monitored at the maximum sensitivity of the oscilloscope. Input the reference signal at the used frequency, and adjust the BALANCE RV1 to minimize p-p of the square wave.



(Before adjustment) (After adjustment)

Oscilloscope waveform

2. OFFSET (RV2)
Use the same steps to connect the DC OUT ⑳ to the DC voltmeter. Adjust the OFFSET volume to obtain "0" in output DC voltage.

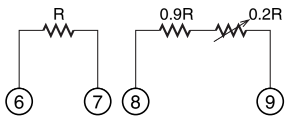
Note: Offset voltage contains frequency characteristics, which requires re-adjustment if a change is made in the signal frequency.

■Band pass filter setting

Table 1: R_{BP} constants

	No C_{BP} used		C_{BP} used	
fo	R_{BP}	C_{BP}	R_{BP}	C_{BP}
10kHz	1.58kΩ	–	–	
1kHz	15.8kΩ	–	–	
100Hz	158kΩ	–	14.3k	0.1μ
10Hz	1.58MΩ	–	143k	0.1μ

fo fine adjustment
Fine adjustment of center frequency requires a trimmer potentiometer to be assigned to either of R_{BP}s as series.



If a frequency is out of the constants listed in Table 1, R_{BP} and C_{BP} need to be derived from the following equations.

fo≥100Hz

$$R_{BP}=\frac{15915}{fo}\ [k\Omega] \qquad fo:[Hz]$$

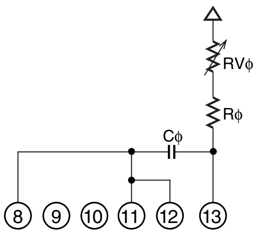
fo<100Hz

$$P_{BP}=\frac{1.5915\times10^{5}}{(0.01+C_{BP})\cdot fo}[\Omega] \qquad fo:[Hz],\ C_{BP}:[\mu F]$$

$$1.59k\Omega\leq R_{BP}\leq1.59M\Omega$$

■Phase shifter setting

1) When any frequency is allocated: 1



Connection diagram 1

$1k\Omega\leq R\phi\leq100k\Omega$
Determine Rϕ and Cϕ from the following equation to agree with the above values.

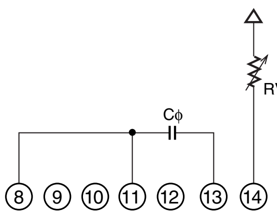
$$R\phi=\frac{1}{2\pi\cdot(C\phi+3.9\times10^{-9})\cdot2.72f}\ [\Omega]$$

f : [Hz]
Cϕ : [F]

Derive RVϕ in accordance with the conditions of the determined Rϕ and RVϕ≥6.67 Rϕ.

E.g.: 400Hz
Cϕ=1700pF
216.1kΩ is derived for Rϕ from the above equation.
RVϕ>174kΩ leads to RVϕ = 200kΩ.

2) When any frequency is allocated: 2



Connection diagram 2

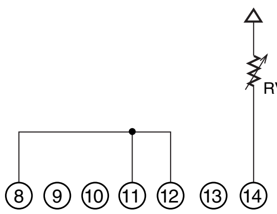
RVϕ=100kΩ

$$C\phi=\frac{1}{2\pi\cdot f\cdot40.8\times10^{3}}[F]$$

f : [Hz]

Determine Cϕ from the following equation.

3) When 1kHz is allocated



Connection diagram 3

If 1kHz is allocated to the used frequency, ±45°-phase shift is enabled with an external potentiometer only.

	Connection diagram 1			Connection diagram 2		Connection diagram 3
	Cϕ	RVϕ	Rϕ	Cϕ	RVϕ	RVϕ
10kHz	–	10k	1.5k	390p	100k	–
1kHz		–		–		100k
100Hz	–	1M	150k	39000p	100k	–
10Hz	39000pF	1M	150k	0.39μ	100k	–

Phase Detectors

■Equivalent noise bandwidth setting

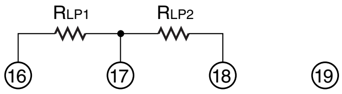
1) When 2-pole low-pass filter is used

Equivalent noise bandwidth	Time constant (TC)	Connection diagram	R_{LP}1, 2	C_{LP}1, 2
100Hz	1.25msec	1	124kΩ	–
30Hz	4.17msec	1	412kΩ	–
10Hz	12.5msec	1	1.24MΩ	–
3Hz	41.7msec	2	41.2kΩ	1μF
1Hz	125msec	2	124kΩ	1μF
0.3Hz	417msec	2	412kΩ	1μF
0.1Hz	1.25sec	2	1.24MΩ	1μF
0.03Hz	4.17sec	2	412kΩ	10μF
0.01Hz	12.5sec	2	1.24MΩ	10μF

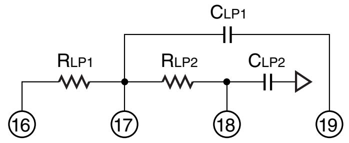
Time constant (TC)=R_{LP} • C_{LP}
Equivalent noise bandwidth=1/8TC

Any R_{LP} and C_{LP} available according to 10kΩ≤R_{LP}≤1.59MΩ.

A settling time for output voltage is 6- to 7-times time constant.



<Figure 1> Equivalent noise bandwidth: 10Hz to 100Hz



<Figure 2> Equivalent noise bandwidth <10Hz

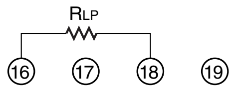
2) When 1-pole low-pass filter is used

Equivalent noise bandwidth	Time constant (TC)	Connection diagram	R_{LP}1, 2	C_{LP}1, 2
100Hz	2.5msec	1	249kΩ	–
30Hz	8.33msec	1	825kΩ	–
10Hz	25msec	2	226kΩ	0.1μF
3Hz	83.3msec	2	750kΩ	0.1μF
1Hz	250msec	2	249kΩ	1μF
0.3Hz	833msec	2	825kΩ	1μF
0.1Hz	2.5sec	2	249kΩ	10μF
0.03Hz	8.33sec	2	825kΩ	10μF
0.01Hz	25.0sec	2	1.13MΩ	22μF

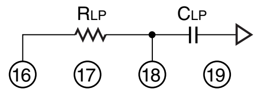
Time constant (TC)=R_{LP} • C_{LP}
Equivalent noise bandwidth=1/4TC

Any R_{LP} and C_{LP} available according to 10k≤ R_{LP}≤1.59MΩ.

A settling time for output voltage is 4- to 5-times time constant.



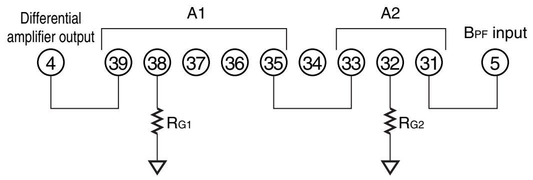
<Figure 1> Equivalent noise bandwidth: 30Hz to 100Hz



<Figure 2> Equivalent noise bandwidth <30Hz

■Application of post amplifier

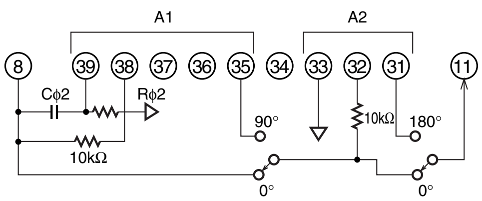
●Signal system amplifier



$$A_1=\frac{R_{G1}+10k}{R_{G1}} \quad A_2=\frac{R_{G2}+10k}{R_{G2}} \quad R_{G1}, R_{G2} : [k\Omega]$$

$A_1, A_2 \le 10$
E.g.: R_{G1}= R_{G2}=1.11kΩ if 10 is assigned to A_1 and A_2

●360°-phase shifter



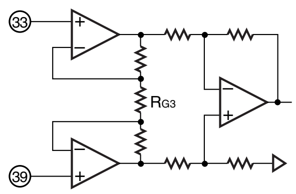
Determine Cϕ2 [F].

$$R\phi_2=\frac{1}{2\pi \cdot f \cdot C\phi_2}\ [\Omega]$$
f : [Hz]

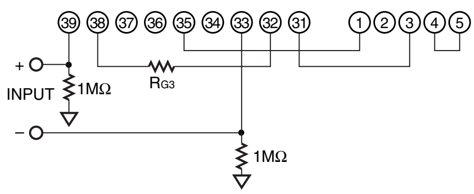
* 1.59k≤Rϕ2≤1.59M

●Instrumentation amplifier

Gain between input and Pin ④

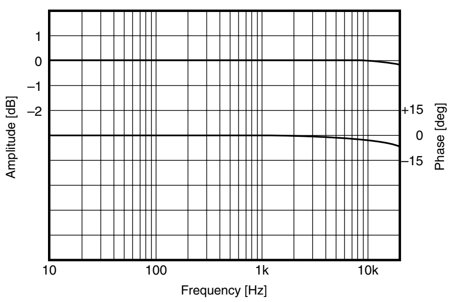


$$\text{Gain}=\frac{R_{G3}+20\times10^3}{R_{G3}} \quad R_{G3} : [\Omega]$$

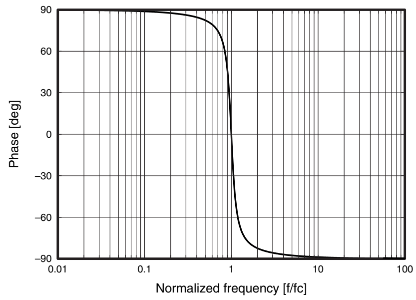


Characteristics

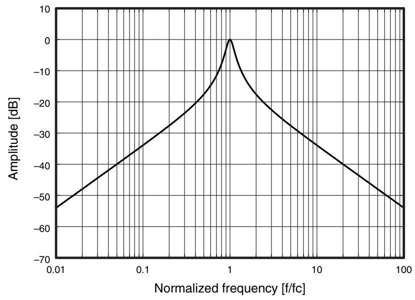
Input differential amplifier – Phase



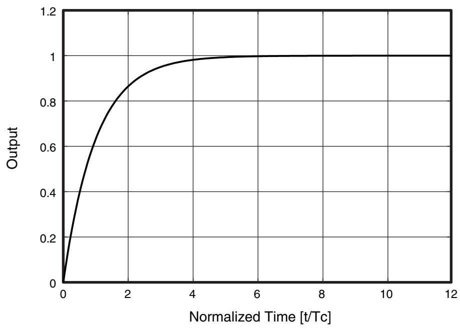
Phase
(Band pass filter, Q = 5)



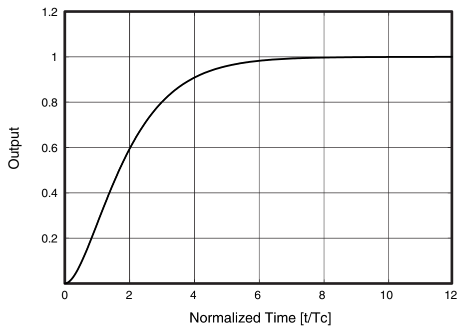
Amplitude
(Band pass filter, Q = 5)



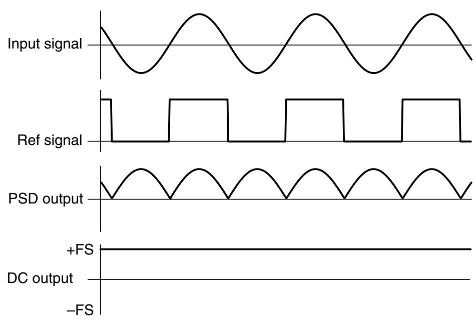
Output step response (1-pole low-pass filter)



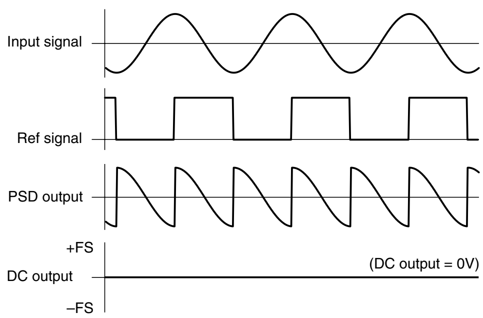
Output step response (2-pole low-pass filter)



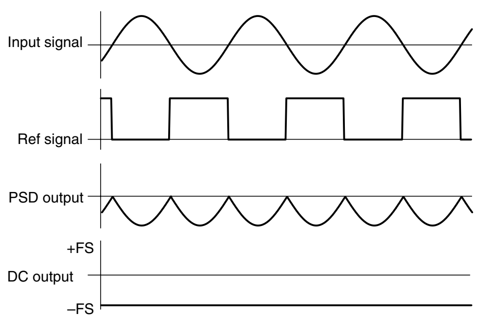
I/O waveform (Phase difference: 0°)



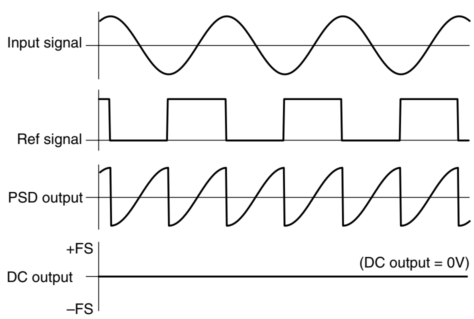
I/O waveform (Phase difference: 90°)



I/O waveform (Phase difference: 180°)

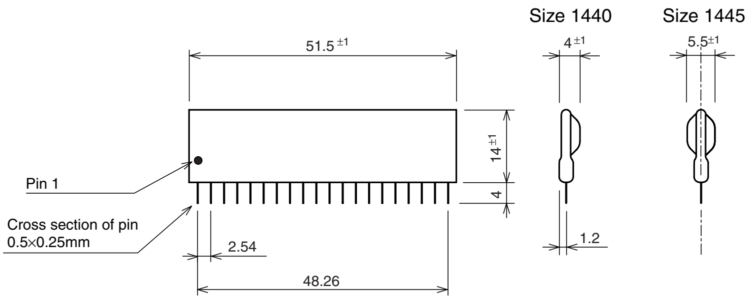


I/O waveform (Phase difference: 270°)

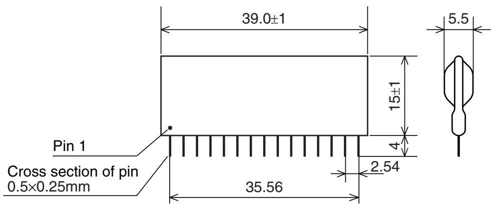


■Single-inline package (SIP)

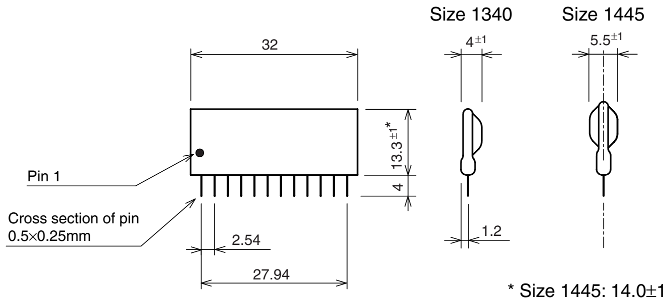
[Type S20]



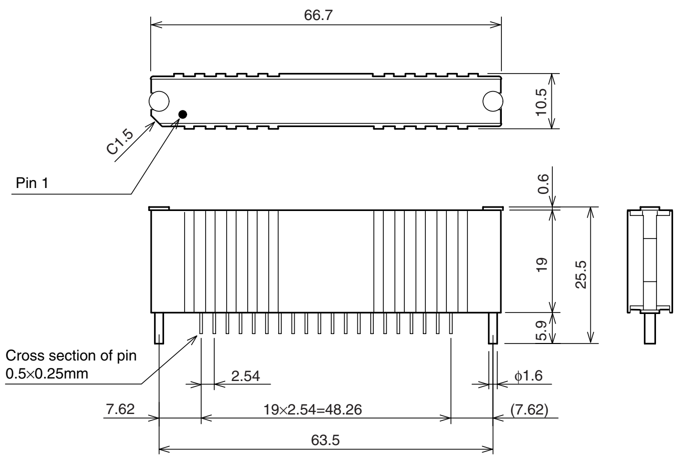
[Type S15]



[Type S12]

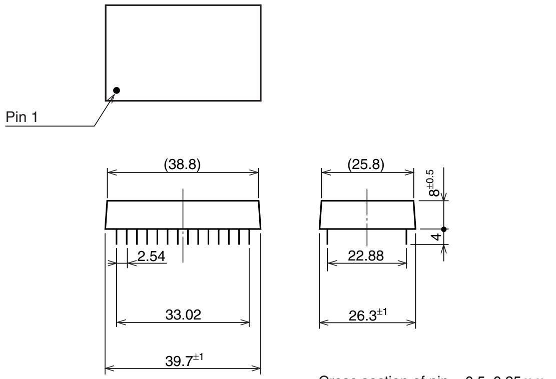


[Type SS20]



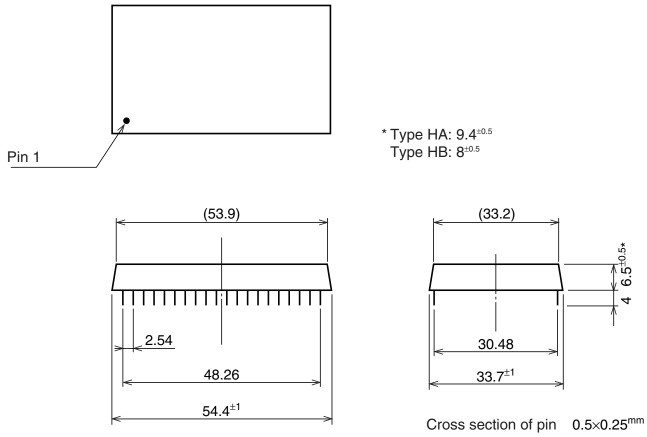
■Dual-inline package (DIP)

[Type EB]



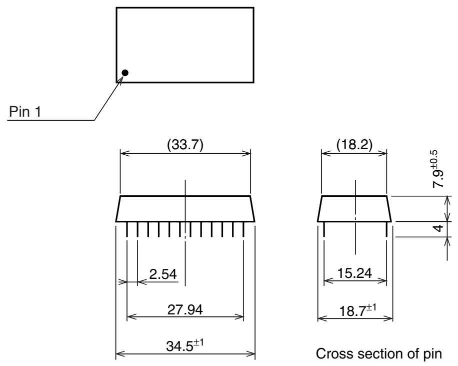
Cross section of pin 0.5×0.25mm

[Type H] [Type HA] [Type HB]



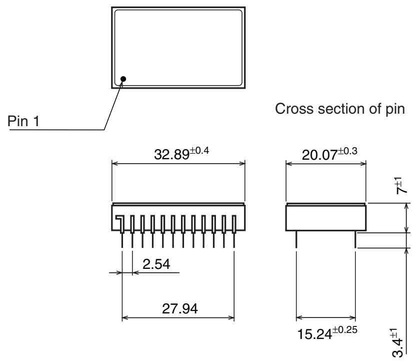
Cross section of pin 0.5×0.25mm

[Type KB]



Cross section of pin 0.5×0.25mm

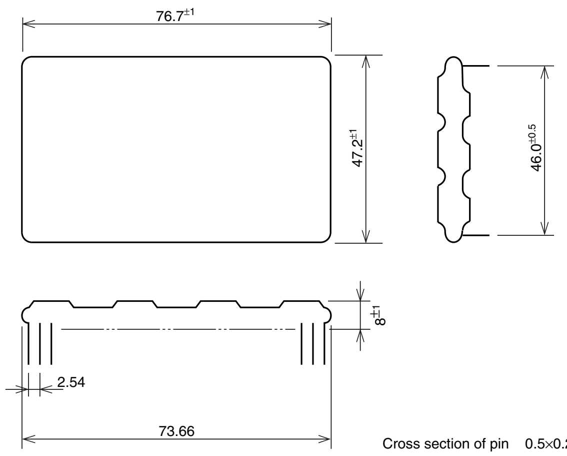
[Type KC]



Cross section of pin 0.46×0.25mm

Material: Body: 90% alumina ceramics (black)
Cover: Kovar (Fe, Ni, Co)
Surface treatment: Gold-plated
Pin: Alloy 42 (Fe, Ni)
Surface treatment: Nickel-plated + Gold-plated

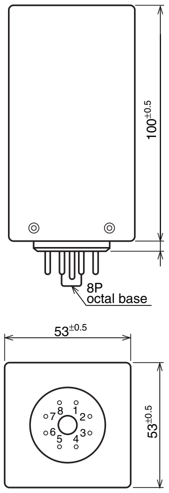
[Type ID]

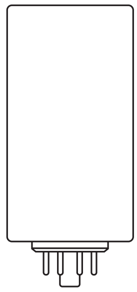


Cross section of pin 0.5×0.25mm

■DV series package (DIP)

[Type B]

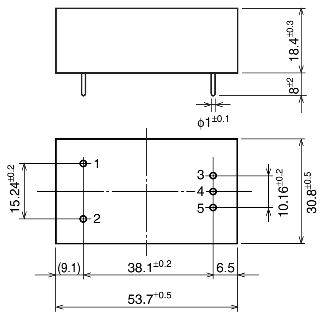


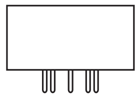


	±15V	–24V
1	+B	+B
2	OUTPUT	OUTPUT
3	–B	GND
4	CASE GND	CASE GND
5	INPUT	INPUT
6	GND	NC
7	NC	NC
8	NC	NC

* US socket-compliant plug

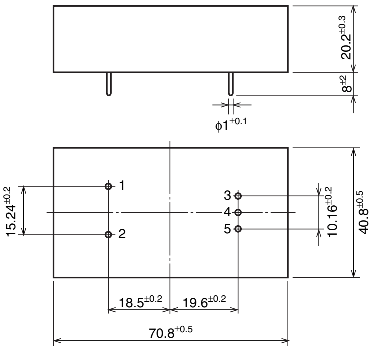
[Type L]

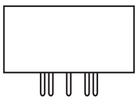




	±15V	+24V
1	INPUT	INPUT
2	GND	GND
3	+B	+B
4	OUTPUT	OUTPUT
5	–B	GND

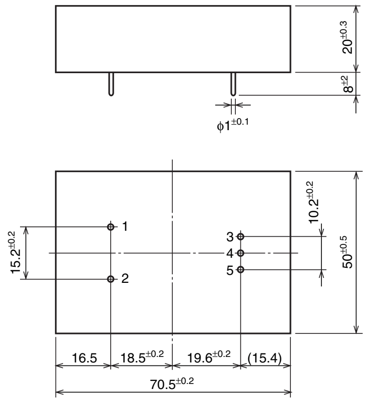
[Type ML]

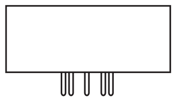




	±15V	+24V
1	INPUT	INPUT
2	GND	GND
3	+B	+B
4	OUTPUT	OUTPUT
5	–B	GND

[Type NL]





	±15V	+24V
1	INPUT	INPUT
2	GND	GND
3	+B	+B
4	OUTPUT	OUTPUT
5	–B	GND

FUNCTION MODULE

DATA BOOK

- The description given in this data book is based on the information as of April 1, 2005.
- Some appearance and specifications may change without notice.
- Please check the latest specifications before purchasing.

NF Corporation

6-3-20 Tsunashima Higashi, Kohoku-ku, Yokohama 223-8508, Japan

NF Corporation

●**Head Office**
6-3-20 Tsunashima Higashi, Kohoku-ku, Yokohama 223-8508, Japan
Phone : +81-45-545-8128 Fax : +81-45-545-8187

●**Shanghai Representative Office**
Room5E, Modern Mansion, 218 Xiangyang South Road, Xuhui District,
Shanghai 200031, China
Phone : +86-21-6473-5735 Fax : +86-21-6415-6576

●**Shenzhen Representative Office**
Room1701, East, Aidi Building, No.5003 Binhe Road, Futian District,
Shenzhen 518045, China
Phone : +86-755-8355-1866 Fax : +86-755-8355-1214

http://www.nfcorp.co.jp/english/index.html

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