IR9331/IR9331N V/F Converter

Description

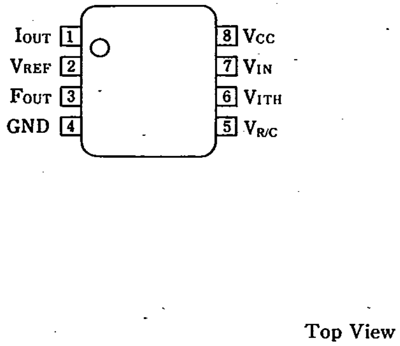
The IR9331/IR9331N is a voltage-to-frequency converters ideally suited for use in simple low-cost circuits for A/D conversion, precision F/V conversion, longterm intergration, linear frequency modulation or demodulation, and many other functions.

Features

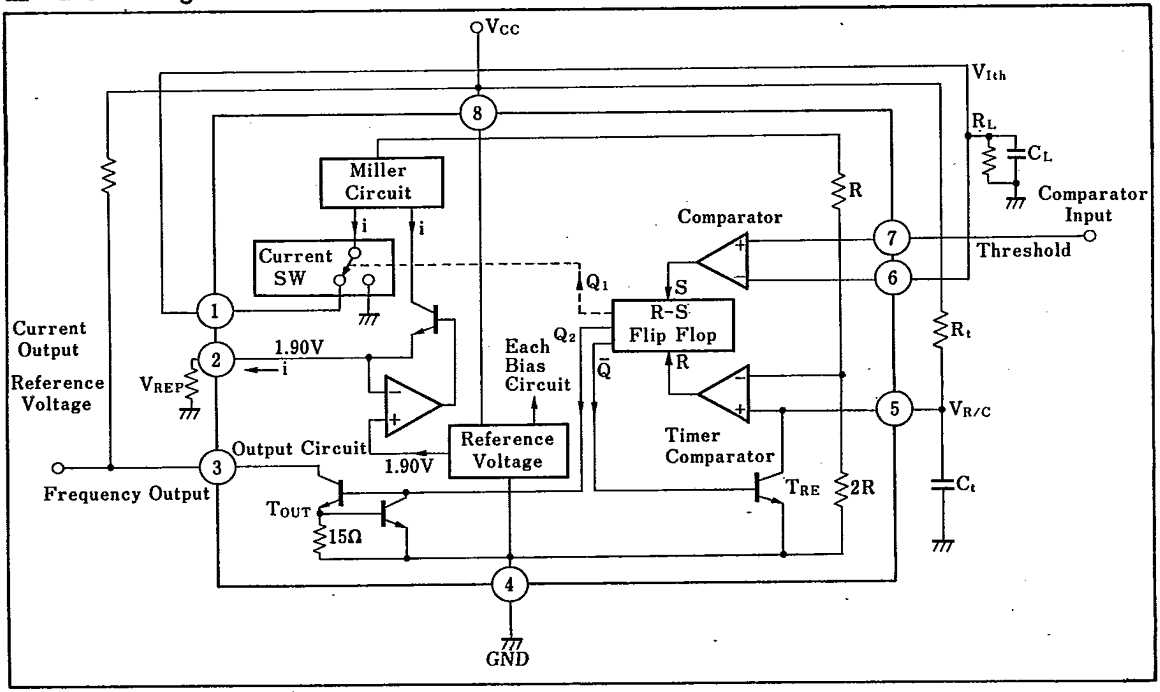
1. Guaranteed linearity 0.01%FS (MAX.)
2. Excellent temperature stability ±30ppm/℃ (TYP.)
3. Wide dynamic range 100dB at 10kHz FS* (MIN.)
4. Wide range of FS frequency 1～100kHz
5. Wide range of supply voltage 4～40V
6. 8-pin dual-in-line package (IR9331)
   8-pin small-outline package (IR9331N)

* FS: Full Scale

Pin connections



Block Diagram



Absolute Maximum Ratings

(Ta=25℃)

Parameter	Symbol	Condition		Rating	Unit
Supply voltage	V_{CC}			40	V
Input voltage	$V_{R/C}$			−0.2~V_{CC}	V
	V_{Ith}				
	V_{IN}				
Output short-circuit time	t_{SG}	to GND		Infinity	s
	t_{SV}	to V_{CC}, short-circuit 30mA(TYP.)		Infinity	
Power dissipation	P_D	Ta≦25℃	IR9331	500	mW
			IR9331N	450	
P_D derating ratio	ΔP_D/℃	Ta>25℃	IR9331N	4.5	mW/℃
Operating temperature	T_{opr}			−10~+70	℃
Storage temperature	T_{stg}			−55~+150	℃

Electrical Characteristics

(V_{CC}=15V, Ta=25℃, Test circuit 1)

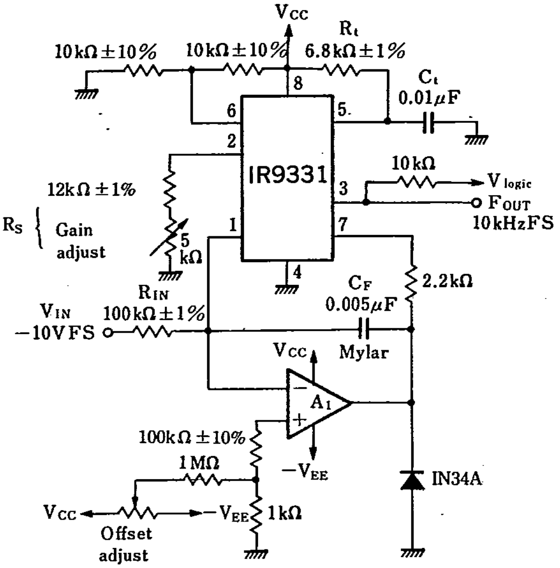
Parameter	Symbol	Condition	MIN.	TYP.	MAX.	Unit
VFC non linearity error*2	NL_b	4.5V≦V_{CC}≦20V		±0.003	±0.01	%FS
	NL_b'	T_{opr}(−10~70℃)		±0.006	±0.02	
	NL_a	V_{CC}=15V, f_{OUT} Test circuit 2*1		±0.10	±0.30	
Scale factor (gain)	SF	V_{IN}=−10V, R_S=14kΩ	0.90	1.00	1.10	kHz/V
Gain temperature coefficient	α SF	4.5V≦V_{CC}≦20V T_{opr}(−10~+70℃)		±30		ppm/℃
Gain-power supply stability	SVR	4.5V≦V_{CC}≦10V		0.01	0.15	%/V
	SVR′	10V≦V_{CC}≦40V		0.006	0.06	
Full scale frequency	F_{FS}	V_{IN}=−10V	10.0			kHz
Over range frequency	F_{over}	V_{IN}=−11V	10			%
Input comparator (terminal 6 and 7)						
Offset voltage	V_{IO1}			±3	±10	mV
	V_{IO2}	T_{opr}(−10~+70℃)		±4	±14	
Bias current	I_B			−80	−300	nA
Offset current	I_{IO}			±8	±100	nA
In-phase input range	V_{ICM}	T_{opr}(−10~+70℃)	−0.2		V_{CC}−2.0	V
Timer (terminal 5)						
Timer threshold voltage	V_{th}		0.63	0.667	0.70	(×V_{CC})V
Input bias current	I_{15}	V_{CC}=15V, 0V≦V_5≦9.9V		±10		nA
	I_{15}'	V_{CC}=15V, V_5=10V		200	1,000	
Saturation voltage (reset)	V_{SAT5}	I=5mA		0.22	0.5	V
Power supply source (terminal 1)						
Output current	I_{OUT}	R_S=14kΩ, V_1=0V	116	136	156	μA
I_{OUT}-Voltage fluctuation	I_{OV}	0V≦V_1≦10V		0.7	1.5	μA
OFF-state leakage current	I_{OFF}			0.02	10.0	nA
	I_{OFF}'	Ta=70℃		2.0	50.0	
Operating current range	I_{opr}			10~500		μA
Reference voltage (terminal 2)						
Reference voltage	V_{REF}		1.70	1.89	2.08	V_{DC}
Temperature coefficient	α V_{REF}			±60		ppm/℃
Time drift	α V_{REF}	1,000 hours		±0.1		%
Logic output (Terminal 3)						
Saturation voltage	V_{SAT3}	I=5mA		0.15	0.50	V
	$V_{SAT3'}$	I=3mA		0.10	0.40	
OFF-state leakage current	I_{OFF3}			0.05	1.0	μA

Parameter	Symbol	Condition	MIN.	TYP.	MAX.	Unit
Supply current (terminal 8)						
Supply current	I_{CC}	$V_{CC}=5V$	1.5	3.0	6.0	mA
	I_{CC}'	$V_{CC}=40V$	2.0	4.0	8.0	

*1 $f_{OUT}=10Hz\sim11kHz$, this test alone is to be performed on test circuit 2.
*2 Non-linearity error is defined as the deviation from $V_{IN}\times(10kHz/-10V_{DC})$ at $f_{OUT}=1Hz\sim11kHz$.
(Full scale adjustment at 10kHz, zero adjustment at 10kHz)

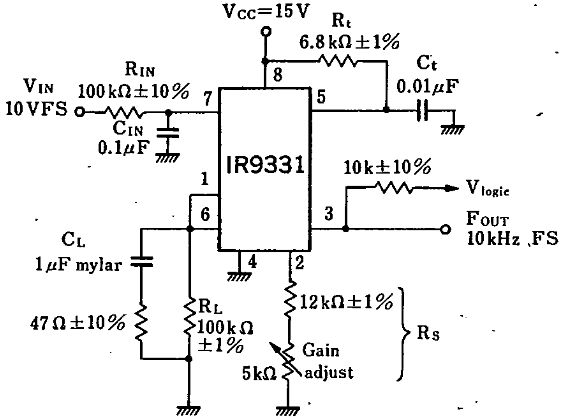
■ Test Circuit

(1) Test circuit (Precision V/F conversion circuit)



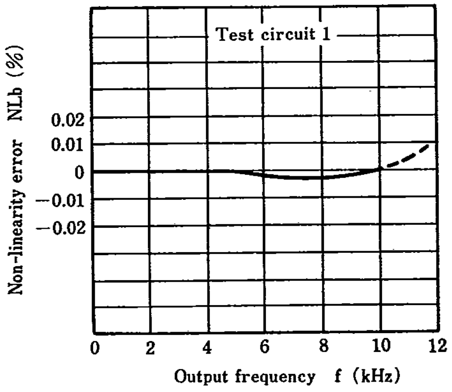
A1 : Use an operational amplifier that satisfies the following conditions:
Input offset voltage below 1mV
Input offset current below 2nA

(2) Test circuit 2 (Simple V/F conversion circuit)

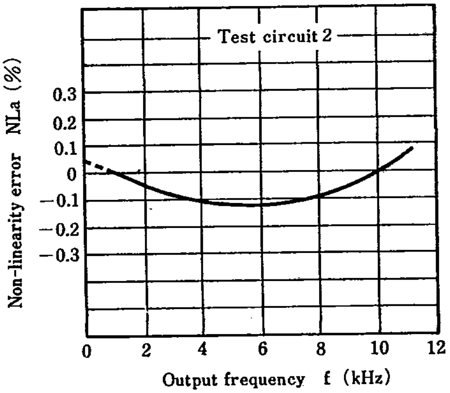


■ Electrical Characteristics Curves (Unless otherwise specified, $V_{CC}=15V$, $Ta=25°C$)

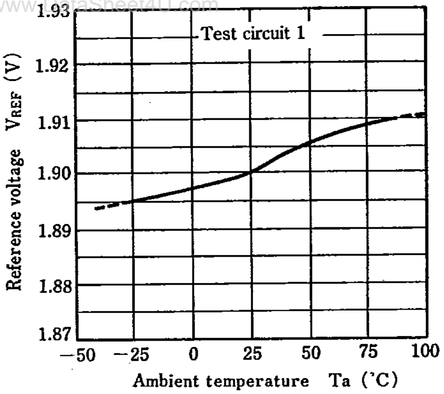
Non-linearity error—Output frequency Characteristics



Non-linearity error—Output frequency Characteristics



Reference voltage—Ambient temperature Characteristics



Description of Operation

The IR9331 is organized mainly as an input comparator, R-S flip-flop, timer comparator, current supply, current switch 1.9V reference voltage supply and output circuit. To briefly explain the circuit operation, the feed-back of this circuit is organized in supply, current switch 1.9V reference voltage supply and output circuit. To briefly explain the circuit V_{IN} is higher, C_L will be discharged through R_L in a relatively short time to settle for a lower frequency. That is to say that it operates as a highly accurate loose coupling oscillator that produces frequencies linearly in proportion to the input voltage.

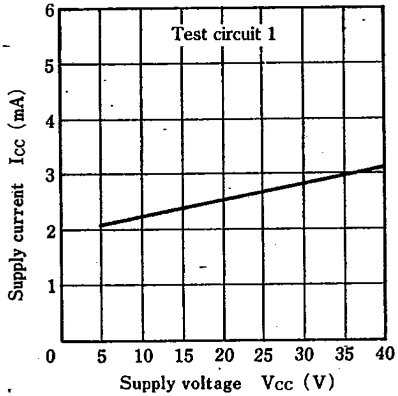
Following is a detailed description.

Suppose that the voltage V_{Ith} (terminal 6) becomes as satisfies $V_{Ith} < V_{IN}$. The input comparator compares V_{Ith} and V_{IN} to set the R-S flip-flop. The Q_1 output of F.F closes the current switch and starts charging C_L with the current i. At the same time the Q_2 output turns on the frequency output transistor (T_{OUT}) while the $\overline{Q}$ turns off the reset transistor (T_{RE}). From this moment on C_T will continue to get charged logarithmically toward V_{CC}. When the voltage of C_T has come up to 2/3 V_{CC}, the timer comparator applies reset output to F.F. The time taken so far is about $1.1R_tC_t$ ($1.1 = \ln 0.333...$)

Even if the timer comparator generate reset output, the F.F will remain set so long as $V_{1th} \leqq V_{IN}$, in which it will continue being charaged well beyond 2/3 V_{CC} until it gets to the state where $V_{1th} > V_{IN}$. This condition arises on power-up or when an excessively higher signal gets in to have the output frequency 0. It will, however, go back to normal if V_{IN} restores within the operating range.

F.F will not be reset until the reset output is produced and a condition is reached as satisfies V_{1th} V_{IN}. The current switch opens to have C_L start discharging (until it reaches a point where V_{1th} V_{IN}. Simultaneously with the resetting of F.F, T_{RE} turns on to have C_T discharge itself. Also T_{OUT} turns off. The number of the repetion of this cycle above over and over again in a second is the frequency as defined.

Supply current—Supply voltage Characteristics



How to work out the output frequency

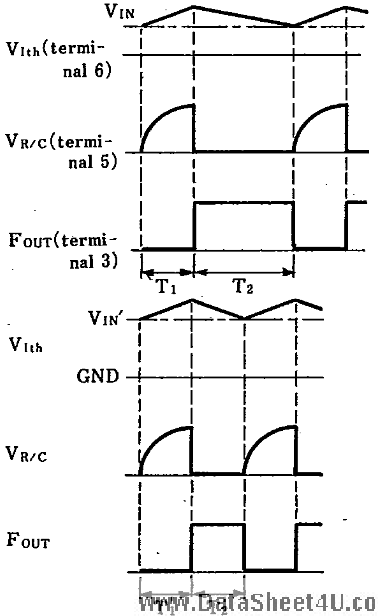
$$f_{OUT} = \frac{1}{T_1 + T_2}, \quad i = V_{REF}/R_S$$

$$T_1 = -R_tC_t\ln(1/3) \fallingdotseq 1.1R_tC_t \text{ Charging time for } C_L$$

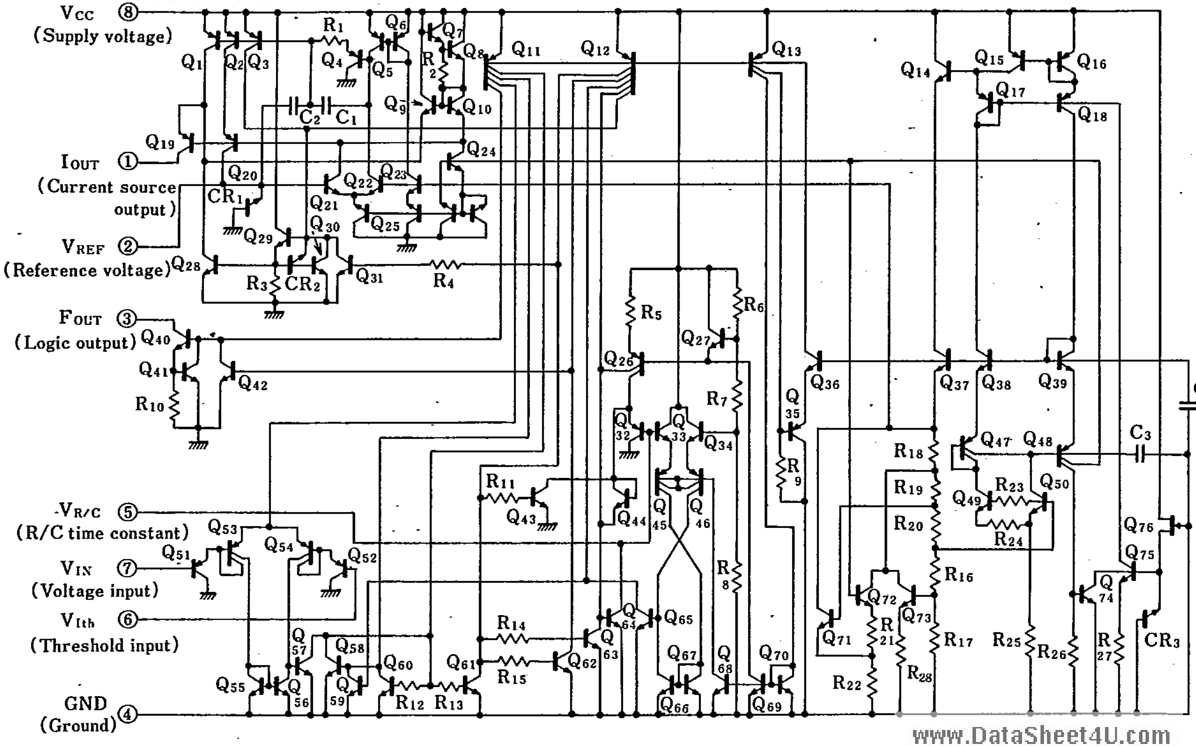
$$T_2 = \frac{(i - V_{IN}/R_L)R_L}{V_{IN}} T_1 \qquad \text{Charging time for } C_L$$

$$f_{OUT} = \frac{V_{IN}}{iR_LT_1} = \frac{V_{IN}}{V_{REF}} \cdot \frac{R_S}{R_L} \cdot \frac{1}{1.1R_tC_t}$$

Timing Chart



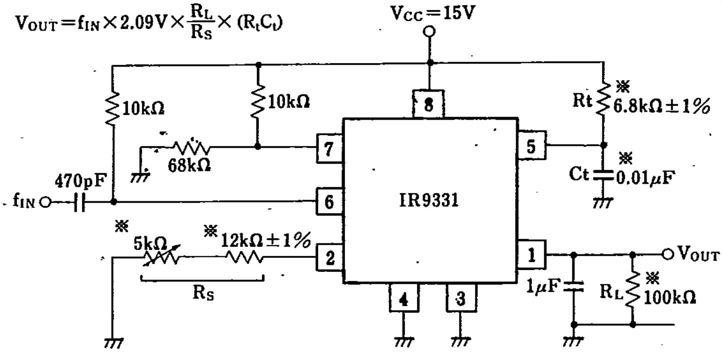
Equipvalent Circuit



Application Circuit Example

(1) Simple F/V conversion

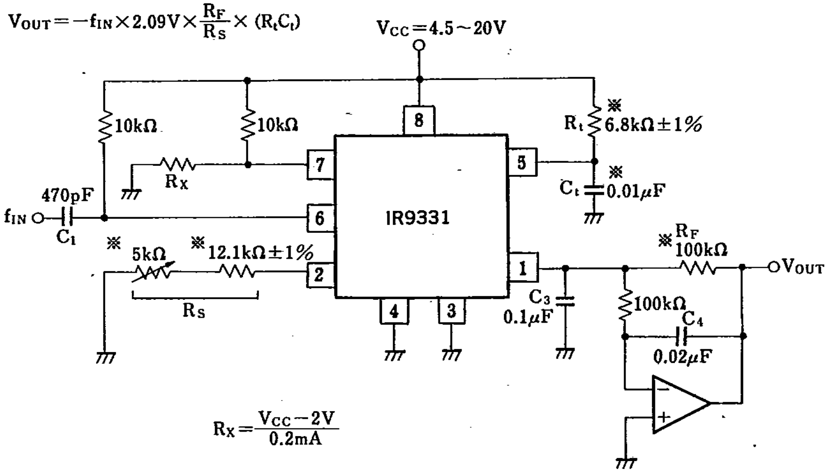
$$V_{OUT} = f_{IN} \times 2.09V \times \frac{R_L}{R_S} \times (R_t C_t)$$



Full-scale : 10kHz
Non-linearity : ±0.06%,

(2) High grade F/V conversion

$$V_{OUT} = -f_{IN} \times 2.09V \times \frac{R_F}{R_S} \times (R_t C_t)$$



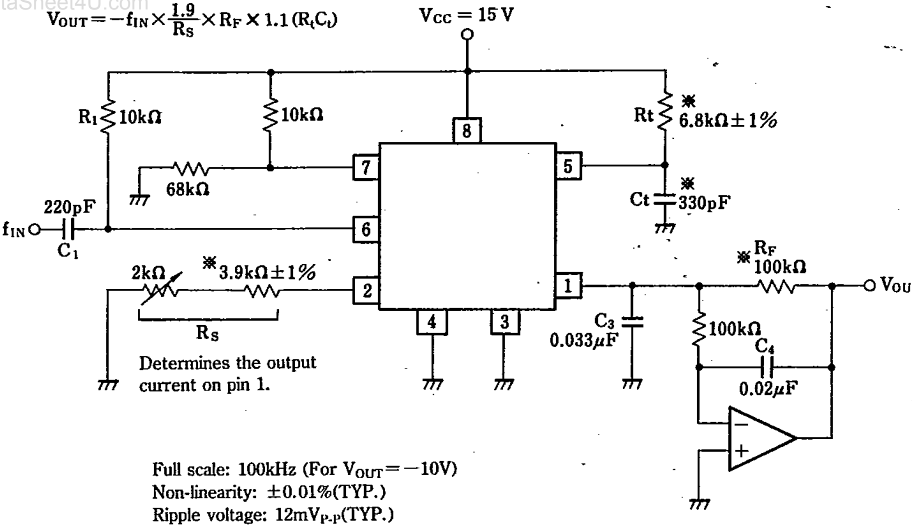
$$R_X = \frac{V_{CC} - 2V}{0.2mA}$$

Full-scale : 10kHz
Non-linearity : ±0.01%

※ Use resistors with reduced coefficient of temperature.

(3) High grade F/V conversion

$$V_{OUT} = -f_{IN} \times \frac{1.9}{R_S} \times R_F \times 1.1\,(R_tC_t)$$

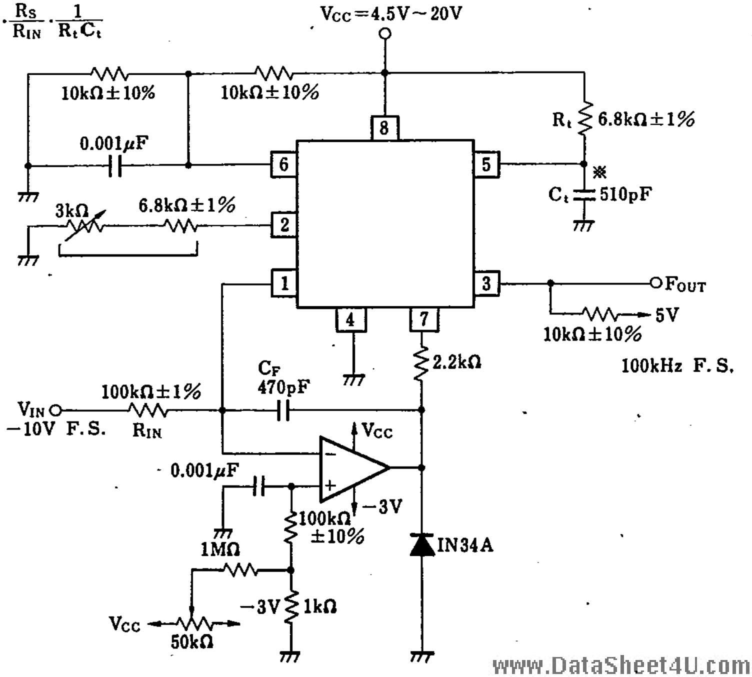


Full scale: 100kHz (For $V_{OUT} = -10V$)
Non-linearity: ±0.01%(TYP.)
Ripple voltage: 12mV$_{P\text{-}P}$(TYP.)

※ Use resistors with reduced coefficient of temperature.

(4) High grade F/V conversion (100kHz full-scale)

$$f_{OUT} = \frac{-V_{IN}}{2.09V} \cdot \frac{R_S}{R_{IN}} \cdot \frac{1}{R_tC_t}$$



※ Use resistors with reduced coefficient of temperature.