

V/F Converter

IR9331/IR9331N

T-73-13-03

IR9331/IR9331N V/F Converter

Description

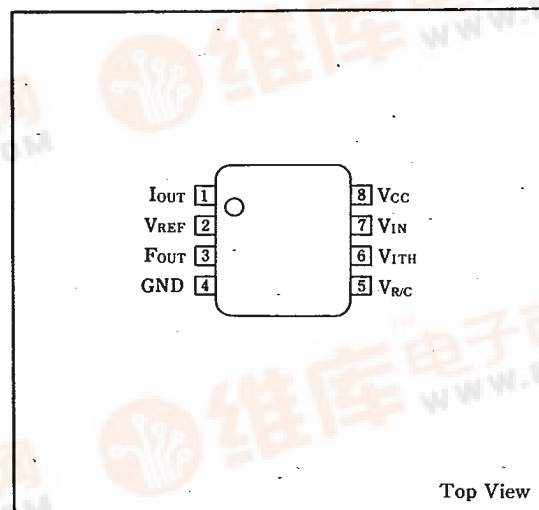
The IR9331/IR9331N is a voltage-to-frequency converters ideally suited for use in simple low-cost circuits for A/D conversion, precision F/V conversion, longterm intergration, linear frequency modulation or demodulation, and many other functions.

Features

1. Guaranteed linearity 0.01%FS (MAX.)
2. Excellent temperature stability $\pm 30\text{ppm}/^\circ\text{C}$ (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)

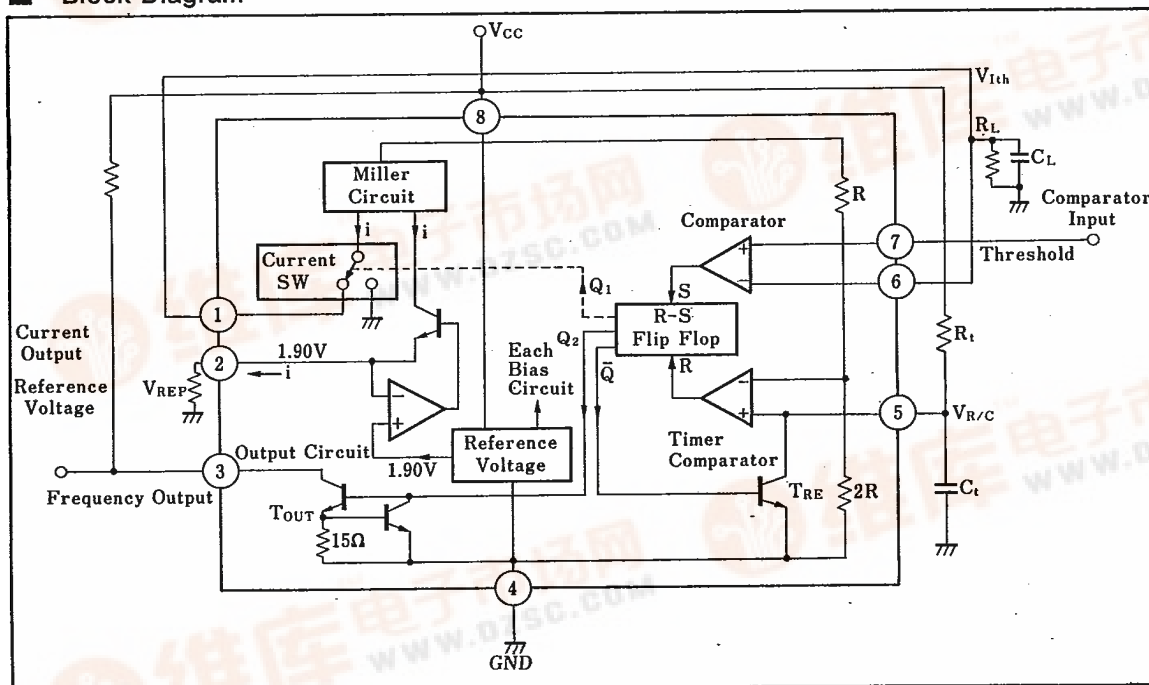
* FS: Full Scale

Pin connections



Top View

Block Diagram



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Absolute Maximum Ratings

(Ta=25°C)

Parameter	Symbol	Condition	Rating	Unit
Supply voltage	V_{CC}		40	V
Input voltage	$V_{R/C}$		$-0.2 \sim V_{CC}$	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	$T_a \leq 25^\circ\text{C}$	IR9331 500	mW
			IR9331N 450	
P_D derating ratio	$\Delta P_D/^\circ\text{C}$	$T_a > 25^\circ\text{C}$	IR9331N 4.5	mW/°C
Operating temperature	T_{opr}		$-10 \sim +70$	°C
Storage temperature	T_{stg}		$-55 \sim +150$	°C

Electrical Characteristics

(V_{CC}=15V, Ta=25°C, Test circuit 1)

Parameter	Symbol	Condition	MIN.	TYP.	MAX.	Unit
VFC non linearity error *2	NL_b	$4.5V \leq V_{CC} \leq 20V$		± 0.003	± 0.01	%FS
	NL_b'	$T_{opr}(-10 \sim 70^\circ\text{C})$		± 0.006	± 0.02	
	NL_a	$V_{CC}=15V, f_{OUT}$ Test circuit 2*1		± 0.10	± 0.30	
Scale factor (gain)	SF	$V_{IN} = -10V, R_S = 14k\Omega$	0.90	1.00	1.10	kHz/V
Gain temperature coefficient	αSF	$4.5V \leq V_{CC} \leq 20V, T_{opr}(-10 \sim +70^\circ\text{C})$		± 30		ppm/°C
Gain-power supply stability	SVR	$4.5V \leq V_{CC} \leq 10V$		0.01	0.15	%/V
	SVR'	$10V \leq V_{CC} \leq 40V$		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}	$T_{opr}(-10 \sim +70^\circ\text{C})$		± 4	± 14	
Bias current	I_B			-80	-300	nA
Offset current	I_{IO}			± 8	± 100	nA
In-phase input range	V_{ICM}	$T_{opr}(-10 \sim +70^\circ\text{C})$	-0.2		$V_{CC}-2.0$	V

Timer (terminal 5)

Timer threshold voltage	V_{Ith}		0.63	0.667	0.70	($\times V_{CC}$)V
Input bias current	I_{I5}	$V_{CC}=15V, 0V \leq V_5 \leq 9.9V$		± 10		nA
	I_{I5}'	$V_{CC}=15V, V_5=10V$		200	1,000	
Saturation voltage (reset)	V_{SAT5}	$I=5mA$		0.22	0.5	V

Power supply source (terminal 1)

Output current	I_{OUT}	$R_S=14k\Omega, V_1=0V$	116	136	156	μA
I_{OUT} -Voltage fluctuation	I_{OV}	$0V \leq V_1 \leq 10V$		0.7	1.5	μA
OFF-state leakage current	I_{OFF}			0.02	10.0	nA
	I_{OFF}'	$T_a=70^\circ\text{C}$		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	αV_{REF}			± 60		ppm/°C
Time drift	αV_{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

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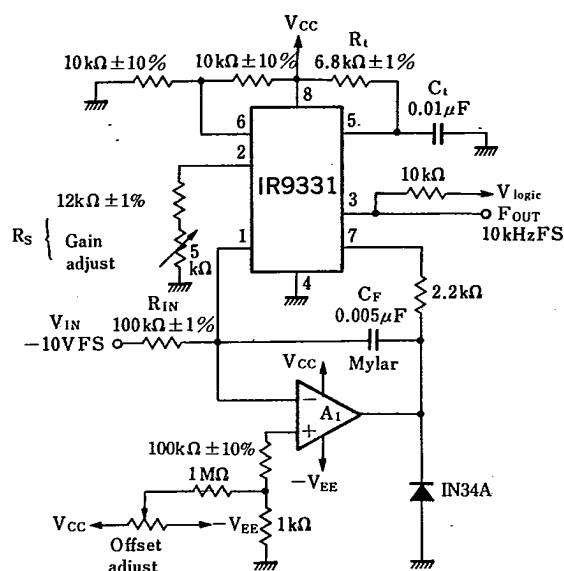
IR9331/IR9331N

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	

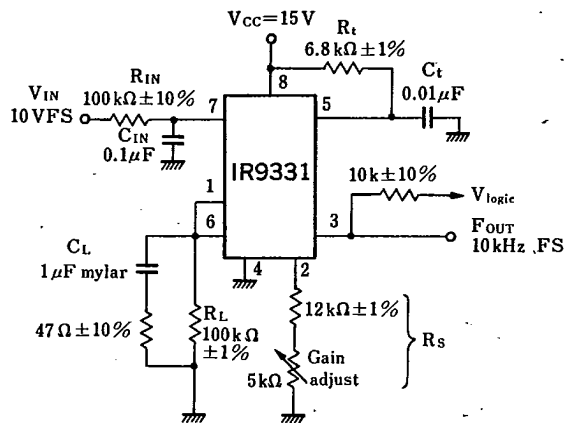
*1 $f_{OUT}=10Hz\sim 11kHz$, this test alone is to be performed on test circuit 2.*2 Non-linearity error is defined as the deviation from $V_{IN} \times (10kHz/-10V_{DC})$ at $f_{OUT}=1Hz\sim 11kHz$.
(Full scale adjustment at 10kHz, zero adjustment at 10kHz)

Test Circuit

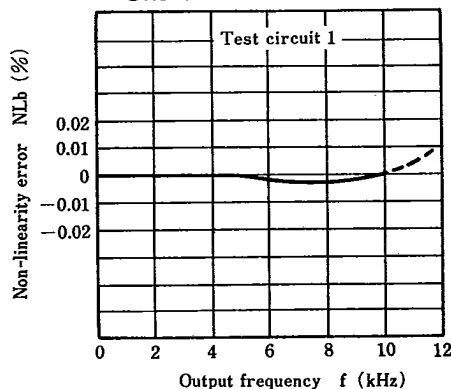
- (1) Test circuit (Precision V/F conversion circuit) (2) Test circuit 2 (Simple V/F conversion circuit)



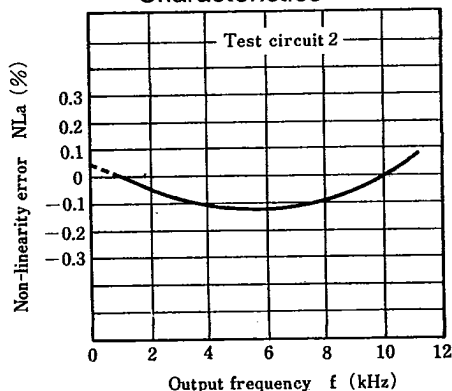
A1 : Use an operational amplifier that satisfies the following conditions:
Input offset voltage below 1mV
Input offset current below 2nA

Electrical Characteristics Curves (Unless otherwise specified, $V_{CC}=15V$, $T_a=25^\circ C$)

Non-linearity error—Output frequency
Characteristics

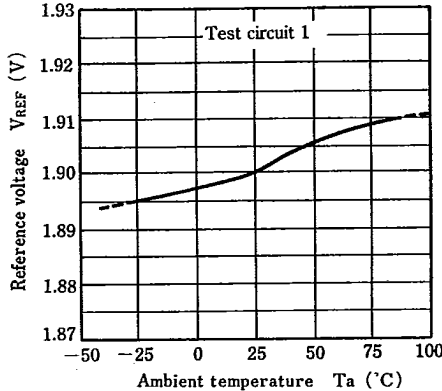


Non-linearity error—Output frequency
Characteristics

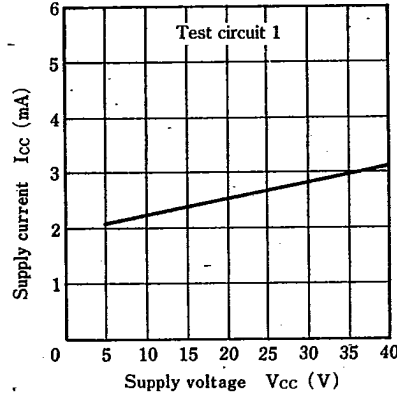


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Reference voltage—Ambient temperature Characteristics



Supply current—Supply voltage 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_{1th} (terminal 6) becomes as satisfies $V_{1th} < V_{IN}$. The input comparator compares V_{1th} 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 $\bar{Q}$ 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 $1.1R_t C_t$ ($1.1 = \ln 0.333...$)

Even if the timer comparator generate reset output, the F.F will remain set so long as $V_{1th} \leq V_{IN}$, in which it will continue being charged 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 repetition of this cycle above over and over again in a second is the frequency as defined.

How to work out the output frequency

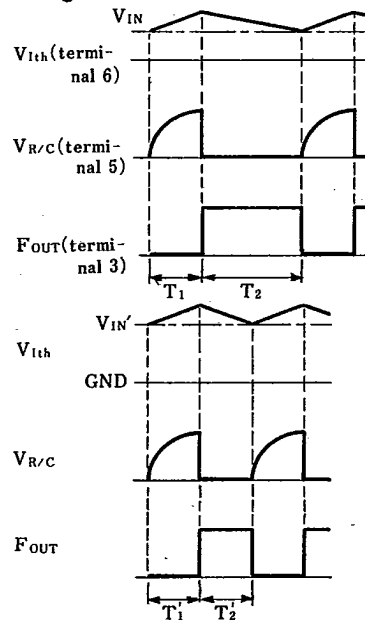
$$f_{OUT} = \frac{1}{T_1 + T_2}, \quad i = V_{REF}/R_S$$

$$T_1 = -R_t C_t \ln(1/3) \approx 1.1 R_t C_t \quad \text{Charging time for } C_L$$

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

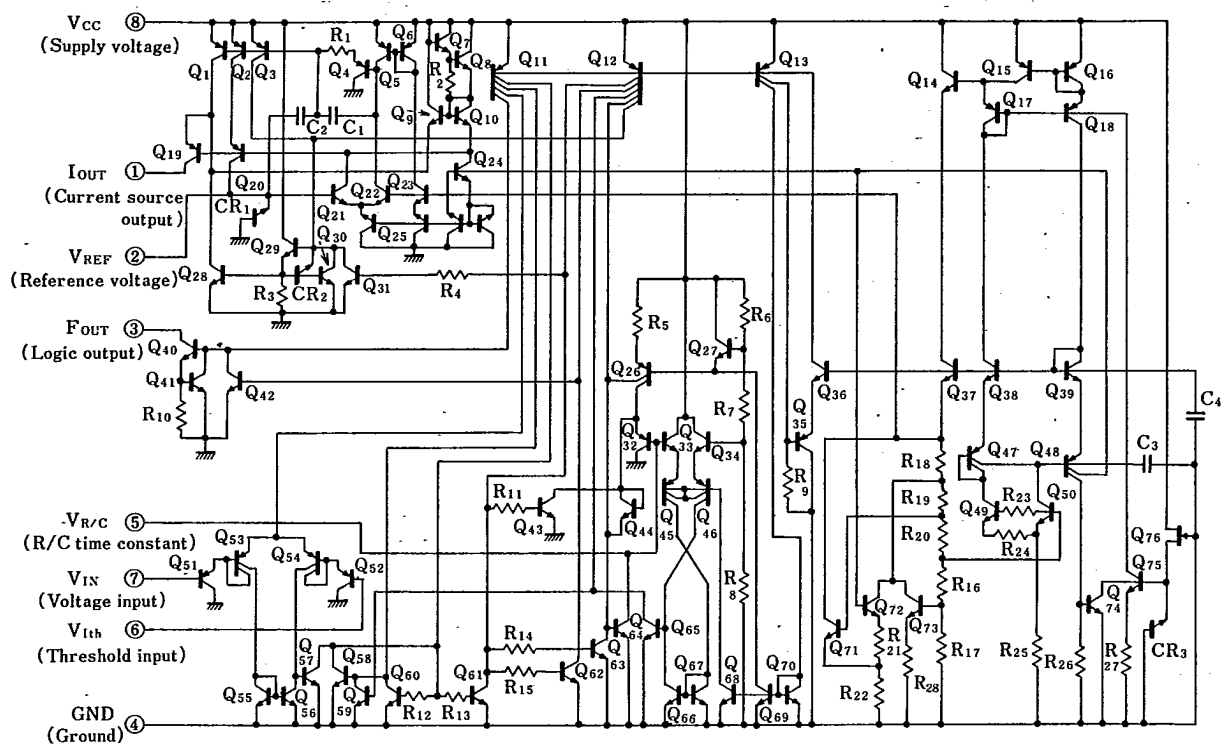
$$f_{OUT} = \frac{V_{IN}}{i R_L T_1} = \frac{V_{IN}}{V_{REF}} \cdot \frac{R_S}{R_L} \cdot \frac{1}{1.1 R_t C_t}$$

Timing Chart



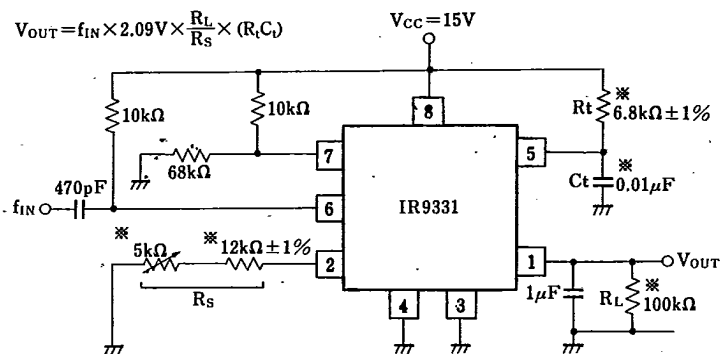
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■ Equivalent Circuit



Application Circuit Example

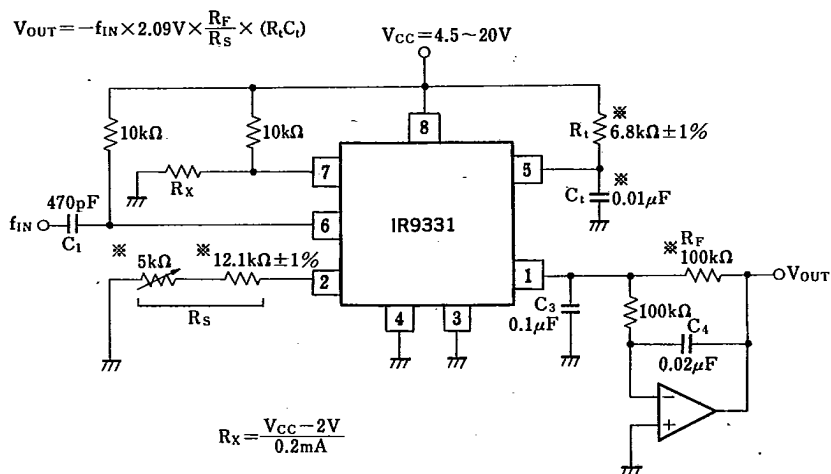
(1) Simple F/V conversion



[Full-scale : 10kHz
Non-linearity : $\pm 0.06\%$,

(2) High grade F/V conversion

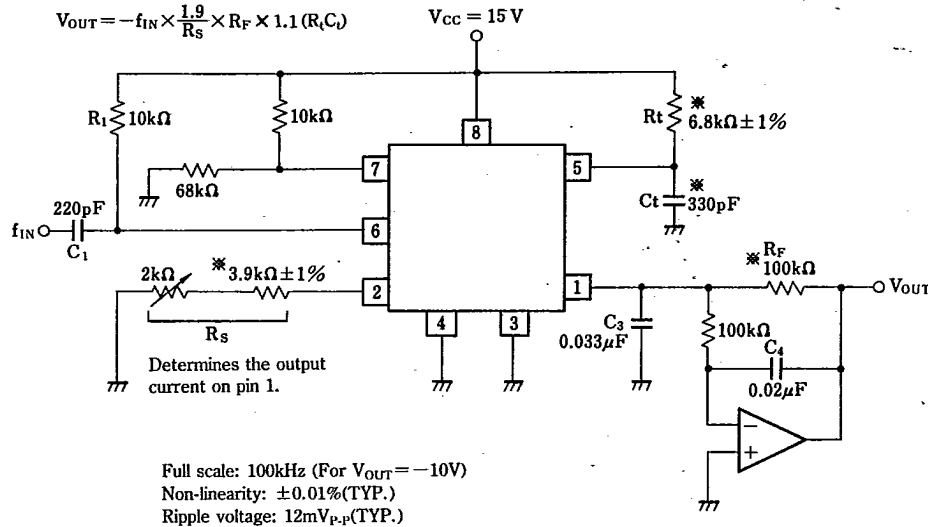
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[Full-scale : 10kHz
Non-linearity : $\pm 0.01\%$

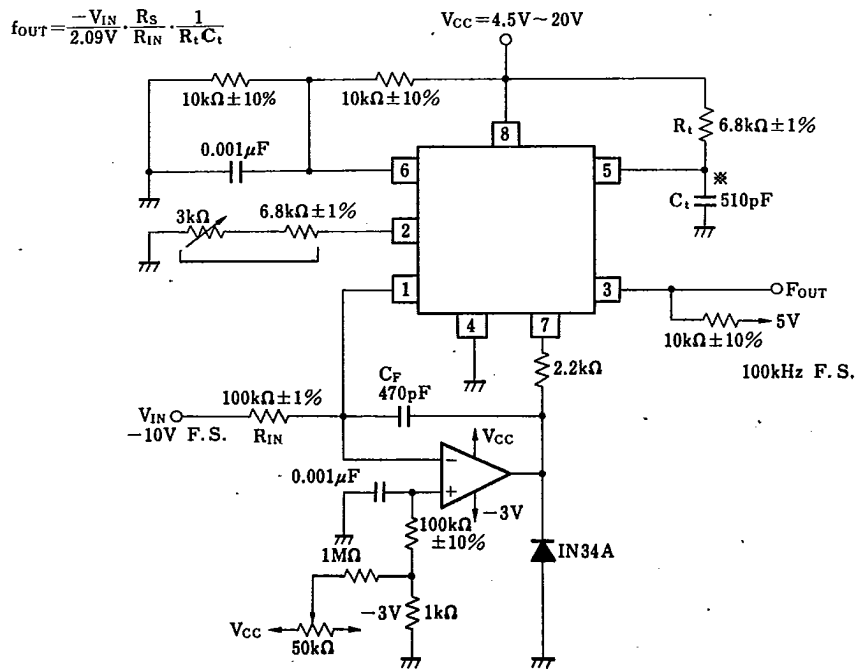
※ Use resistors with reduced coefficient of temperature.

(3) High grade F/V conversion



※ Use resistors with reduced coefficient of temperature.

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



※ Use resistors with reduced coefficient of temperature.