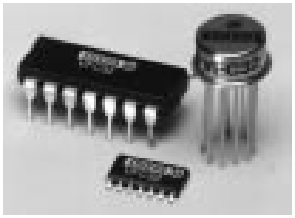
BURR - BROWN®



VFC32

Voltage-to-Frequency and Frequency-to-Voltage CONVERTER

FEATURES

- OPERATION UP TO 500kHz
- EXCELLENT LINEARITY
  ±0.01% max at 10kHz FS
  ±0.05% max at 100kHz FS
- V/F OR F/V CONVERSION
- MONOTONIC
- VOLTAGE OR CURRENT INPUT

APPLICATIONS

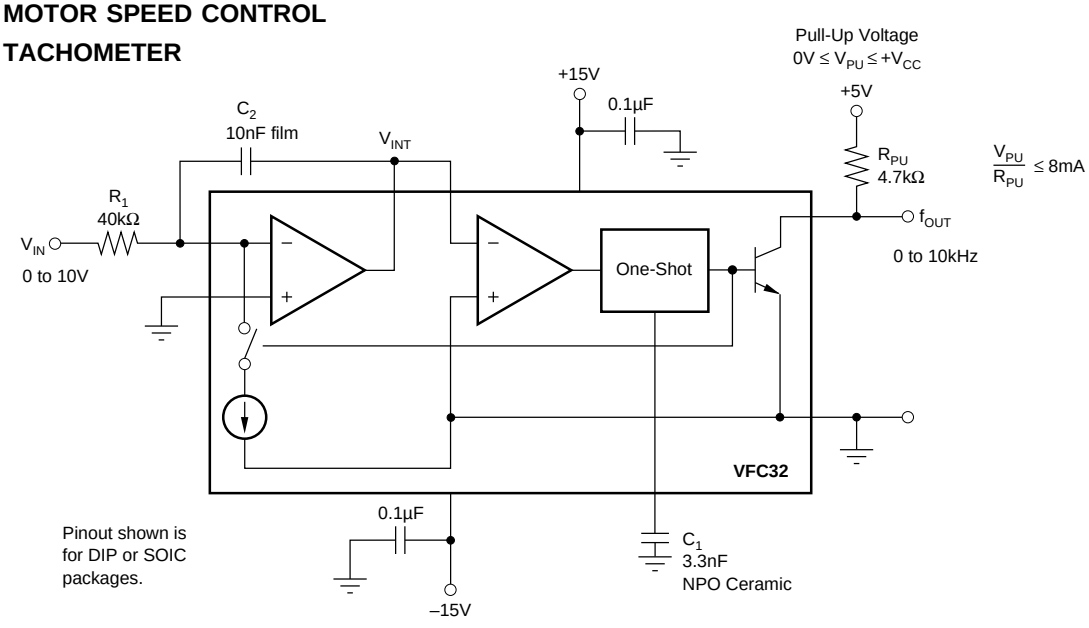
- INTEGRATING A/D CONVERTER
- SERIAL FREQUENCY OUTPUT
- ISOLATED DATA TRANSMISSION
- FM ANALOG SIGNAL MOD/DEMOD
- MOTOR SPEED CONTROL
- TACHOMETER

DESCRIPTION

The VFC32 voltage-to-frequency converter provides an output frequency accurately proportional to its input voltage. The digital open-collector frequency output is compatible with all common logic families. Its integrating input characteristics give the VFC32 excellent noise immunity and low nonlinearity.

Full-scale output frequency is determined by an external capacitor and resistor and can be scaled over a wide range. The VFC32 can also be configured as a frequency-to-voltage converter.

The VFC32 is available in 14-pin plastic DIP, SO-14 surface-mount, and metal TO-100 packages. Commercial, industrial, and military temperature range models are available.



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PDS-372F Printed in U.S.A. September, 1993

SPECIFICATIONS

At T_A = +25°C and V_{CC} = ±15V, unless otherwise noted.

PARAMETER	CONDITIONS	VFC32KP, KU MIN	VFC32KP, KU TYP	VFC32KP, KU MAX	VFC32BM MIN	VFC32BM TYP	VFC32BM MAX	VFC32SM MIN	VFC32SM TYP	VFC32SM MAX	UNITS
INPUT (V/F CONVERTER)	$F_{OUT} = V_{IN}/7.5\ R_1\ C_1$										
Voltage Range[1]											
Positive Input		>0		+0.25mA x R_1	*		*	*		*	V
Negative Input		>0		–10	*		*	*		*	V
Current Range[1]		>0		+0.25	*		*	*		*	mA
Bias Current											
Inverting Input			20	100		*	*		*	*	nA
Noninverting Input			100	250		*	*		*	*	nA
Offset Voltage[2]			1	4		*	*		*	*	mV
Differential Impedance		300 || 10	650 || 10		*	*		*	*		kΩ || pF
Common-mode Impedance		300 || 3	500 || 3		*	*		*	*		MΩ || pF
INPUT (F/V CONVERTER)	$V_{OUT} = 7.5\ R_1\ C_1\ F_{IN}$										
Impedance		50 || 10	150 || 10		*	*		*	*		kΩ || pF
Logic “1”			+1.0		*		*	*		*	V
Logic “0”			–0.05		*		*	*		*	V
Pulse-width Range		0.1		150k/F_{MAX}	*		*	*		*	µs
ACCURACY											
Linearity Error[3]	0.01Hz ≤ Oper Freq ≤ 10kHz		±0.005	±0.010[4]		*	*		*	*	% of FSR[5]
	0.1Hz ≤ Oper Freq ≤ 100kHz		±0.025	±0.05		*	*		*	*	% of FSR
	0.5Hz ≤ Oper Freq ≤ 500kHz		±0.05			*			*		% of FSR
Offset Error Input Offset Votlage[2]			1	4		*	*		*	*	mV
Offset Drift[6]			±3			*			*		ppm of FSR/°C
Gain Error[2]			5			*			*		% of FSR
Gain Drift[6]	f = 10kHz		±75			±50	±100		±70	±150	ppm/°C
Full Scale Drift (offset drift and gain drift)[6, 7]	f = 10kHz		±75			±50	±100		±70	±150	ppm of FSR/°C
Power Supply Sensitivity	f = DC, ±V_{CC} = 12VDC to 18VDC			±0.015			*			*	% of FSR/%
OUTPUT (V/F CONVERTER) (open collector output)											
Voltage, Logic “0”	I_{SINK} = 8mA	0	0.2	0.4	*	*	*	*	*	*	V
Leakage Current, Logic “1”	V_O = 15V		0.01	1.0		*	*		*	*	µA
Voltage, Logic “1”	External Pull-up Resistor Required (see Figure 4)			V_{PU}			*			*	V
Pulse Width	For Best Linearity		0.25/F_{MAX}			*			*		s
Fall Time	I_{OUT} = 5mA, C_{LOAD} = 500pF			400			*			*	ns
OUTPUT (F/V CONVERTER)	V_{OUT}										
Voltage	I_O ≤ 7mA	0 to +10			*			*			V
Current	V_O ≤ 7VDC	+10			*			*			mA
Impedance	Closed Loop			1			*			*	Ω
Capacitive Load	Without Oscillation			100			*			*	pF
DYNAMIC RESPONSE											
Full Scale Frequency				500[8]	*			*			kHz
Dynamic Range		6			*			*			decades
Settling Time	(V/F) to Specified Linearity for a Full Scale Input Step		[9]			*			*		
Overload Recovery	< 50% Overload		[9]			*			*		
POWER SUPPLY											
Rated Voltage			±15								V
Voltage Range		±11		±20					*		V
Quiescent Current			±5.5	±6.0		*	*		*		mA
TEMPERATURE RANGE											
Specification		0		+70	–25		+85	–55		+125	°C
Operating		–25		+85	–55		+125	–55		+125	°C
Storage		–25		+85	–65		+150	–65		+150	°C

* Specification the same as VFC32KP.

NOTES: (1) A 25% duty cycle (0.25mA input current) is recommended for best linearity. (2) Adjustable to zero. See Offset and Gain Adjustment section. (3) Linearity error is specified at any operating frequency from the straight line intersecting 90% of full scale frequency and 0.1% of full scale frequency. See Discussion of Specifications section. Above 200kHz, it is recommended all grades be operated below +85°C. (4) ±0.015% of FSR for negative inputs shown in Figure 5. Positive inputs are shown in Figure 1. (5) FSR = Full Scale Range (corresponds to full scale frequency and full scale input voltage). (6) Exclusive of external components' drift. (7) Positive drift is defined to be increasing frequency with increasing temperature. (8) For operations above 200kHz up to 500kHz, see Discussion of Specifications and Installation and Operation sections. (9) One pulse of new frequency plus 1µs.

ABSOLUTE MAXIMUM RATINGS

Supply Voltage	±22V
Output Sink Current (F_{OUT})	50mA
Output Current (V_{OUT})	+20mA
Input Voltage, –Input	±Supply
Input Voltage, +Input	±Supply
Comparator Input	±Supply
Storage Temperature Range:	
VFC32BM, SM	–65°C to +150°C
VFC32KP, KU	–25°C to +85°C

PACKAGE INFORMATION

MODEL	PACKAGE	PACKAGE DRAWING NUMBER(1)
VFC32KP	14-Pin Plastic DIP	010
VFC32BM	TO-100 Metal	007
VFC32SM	TO-100 Metal	007
VFC32KU	SO-14 SOIC	235

NOTE: (1) For detailed drawing and dimension table, please see end of data sheet, or Appendix D of Burr-Brown IC Data Book.

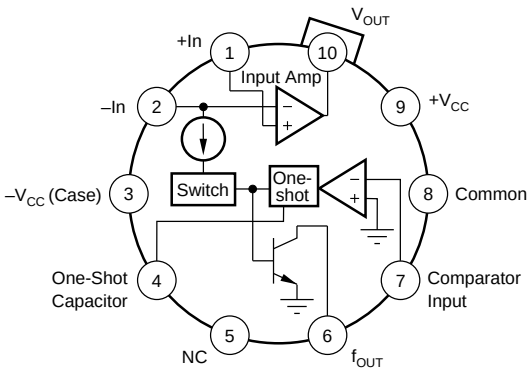
ORDERING INFORMATION

MODEL	PACKAGE	TEMPERATURE RANGE
VFC32KP	14-Pin Plastic DIP	0°C to 70°C
VFC32BM	TO-100 Metal	–25°C to +85°C
VFC32SM	TO-100 Metal	–55°C to +125°C
VFC32KU	SO-14 SOIC	0°C to +70°C

PIN CONFIGURATIONS

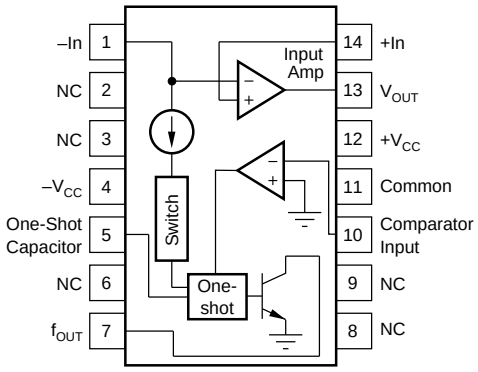
Top View

M Package
(TO-100)



NC = no internal connection
External connection permitted.

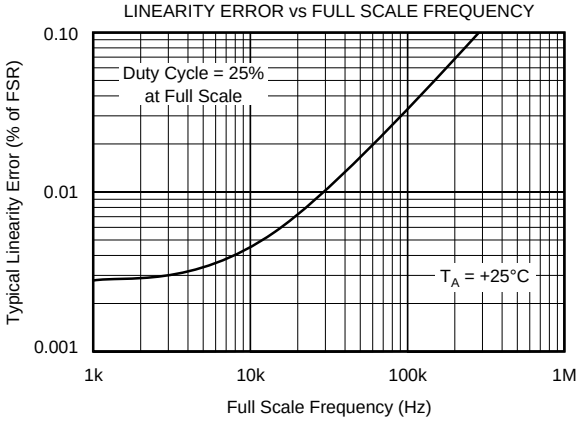
P Package
U Package
(Epoxy Dual-in-line)



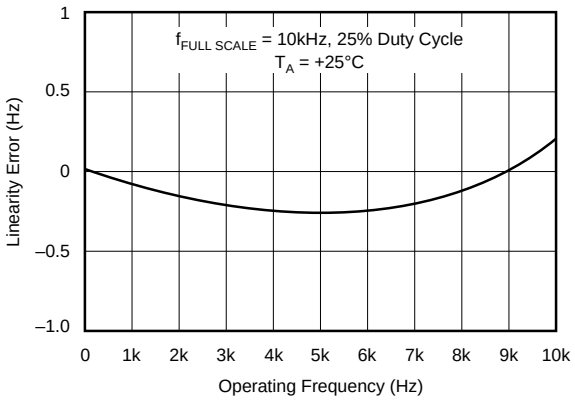
TYPICAL PERFORMANCE CURVES

At T_A = +25°C and V_{CC} = ±15V, unless otherwise noted.

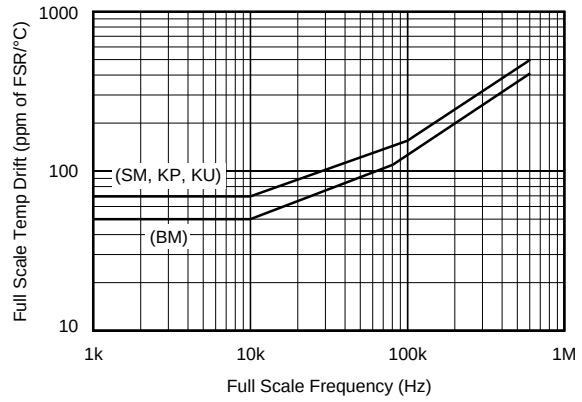
LINEARITY ERROR vs FULL SCALE FREQUENCY



LINEARITY ERROR vs OPERATING FREQUENCY



FULL SCALE DRIFT vs FULL SCALE FREQUENCY



APPLICATION INFORMATION

Figure 1 shows the basic connection diagram for frequency-to-voltage conversion. R_1 sets the input voltage range. For a 10V full-scale input, a 40kΩ input resistor is recommended. Other input voltage ranges can be achieved by changing the value of R_1.

$$R_1 = \frac{V_{FS}}{0.25mA} \quad (1)$$

R_1 should be a metal film type for good stability. Manufacturing tolerances can produce approximately ±10% variation in output frequency. Full-scale output frequency can be trimmed by adjusting the value of R_1—see Figure 3.

The full-scale output frequency is determined by C_1. Values shown in Figure 1 are for a full-scale output frequency of 10kHz. Values for other full-scale frequencies can be read from Figure 2. Any variation in C_1—tolerance, temperature drift, aging—directly affect the output frequency. Ceramic NPO or silver-mica types are a good choice.

For full-scale frequencies above 200kHz, use larger capacitor values as indicated in Figure 2, with R_1 = 20kΩ.

The value of the integrating capacitor, C_2, does not directly influence the output frequency, but its value must be chosen within certain bounds. Values chosen from Figure 2 produce approximately 2.5Vp-p integrator voltage waveform. If C_2's value is made too low, the integrator output voltage can exceed its linear output swing, resulting in a nonlinear response. Using C_2 values larger than shown in Figure 2 is acceptable.

Accuracy or temperature stability of C_2 is not critical because its value does not directly affect the output frequency. For best linearity, however, C_2 should have low leakage and low dielectric absorption. Polycarbonate and other film capacitors are generally excellent. Many ceramic types are adequate, but some low-voltage ceramic capacitor types may degrade nonlinearity. Electrolytic types are not recommended.

FREQUENCY OUTPUT PIN

The frequency output terminal is an open-collector logic output. A pull-up resistor is usually connected to a 5V logic supply to create standard logic-level pulses. It can, however, be connected to any power supply up to $+V_{CC}$. Output pulses have a constant duration and positive-going during the one-shot period. Current flowing in the open-collector output transistor returns through the Common terminal. This terminal should be connected to logic ground.

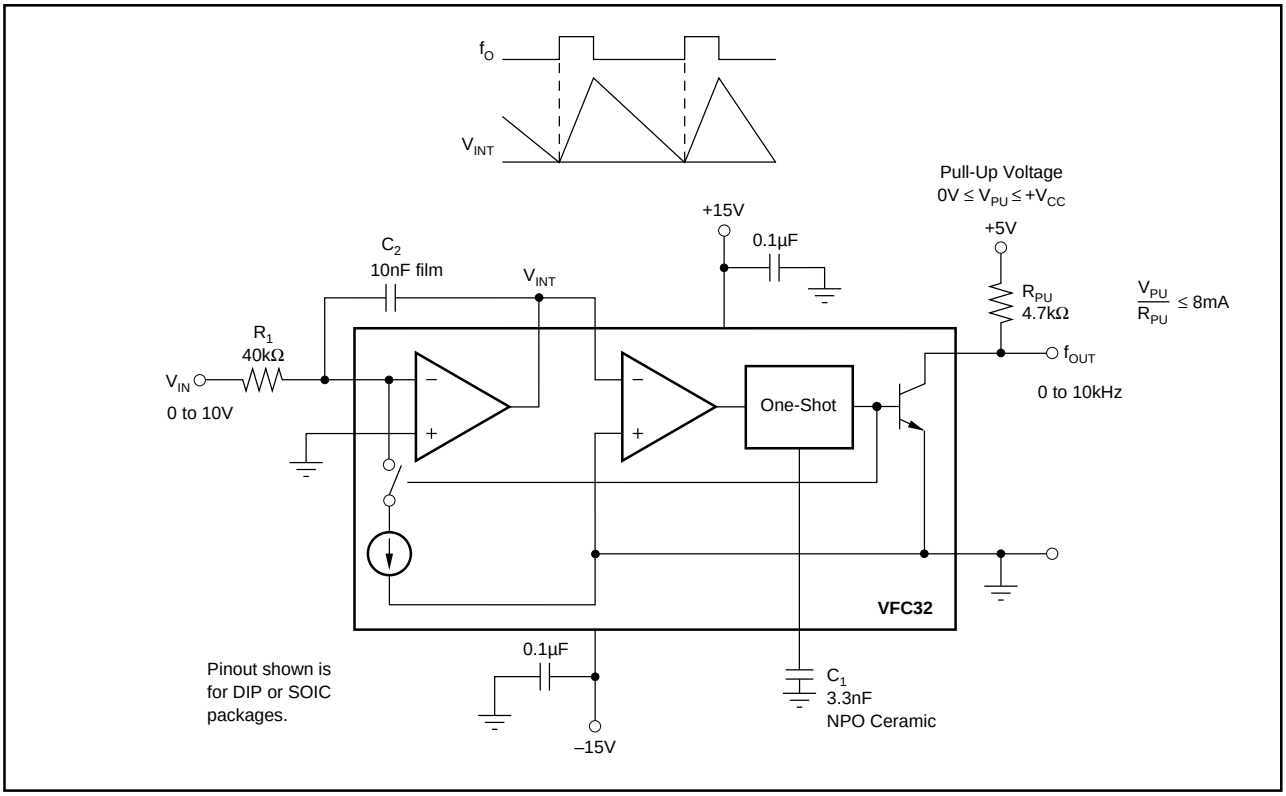


FIGURE 1. Voltage-to-Frequency Converter Circuit.

FREQUENCY-TO-VOLTAGE CONVERSION

Figure 4 shows the VFC32 connected as a frequency-to-voltage converter. The capacitive-coupled input network C_3, R_6 and R_7 allow standard 5V logic levels to trigger the comparator input. The comparator triggers the one-shot on the falling edge of the frequency input pulses. Threshold voltage of the comparator is approximately –0.7V. For frequency input waveforms less than 5V logic levels, the R_6/R_7 voltage divider can be adjusted to a lower voltage to assure that the comparator is triggered.

The value of C_1 is chosen from Figure 2 according to the full-scale input frequency. C_2 smooths the output voltage waveform. Larger values of C_2 reduce the ripple in the output voltage. Smaller values of C_2 allow the output voltage to settle faster in response to a change in input frequency. Resistor R_1 can be trimmed to achieve the desired output voltage at the full-scale input frequency.

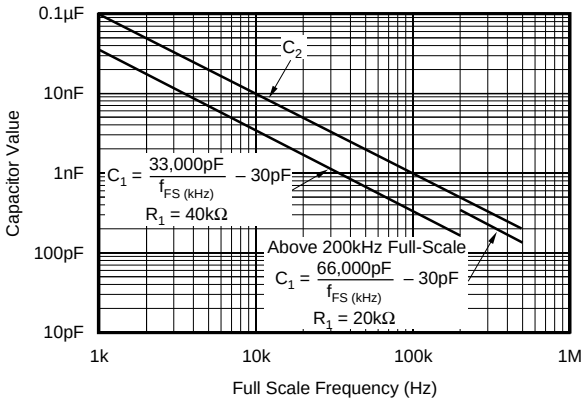


FIGURE 2. Capacitor Value Selection.

PRINCIPLES OF OPERATION

The VFC32 operates on a principle of charge balance. The signal input current is equal to V_{IN}/R_1. This current is integrated by input op amp and C_2, producing a downward ramping integrator output voltage. When the integrator output ramps to the threshold of the comparator, the one-shot is triggered. The 1mA reference current is switched to the integrator input during the one-shot period, causing the integrator output ramp upward. After the one-shot period, the integrator again ramps downward.

The oscillation process forces a long-term balance of charge (or average current) between the input signal current and the reference current. The equation for charge balance is:

$$I_{IN} = I_{R(AVERAGE)} \tag{2}$$

$$\frac{V_{IN}}{R_1} = f_O t_{OS}(1mA) \tag{3}$$

Where:

f_O is the output frequency

t_{OS} is the one-shot period, equal to

$$t_{OS} = 7500\ C_1\ (\text{Farads}) \tag{4}$$

The values suggested for R_1 and C_1 are chosen to produce a 25% duty cycle at full-scale frequency output. For full-scale frequencies above 200kHz, the recommended values produce a 50% duty cycle.

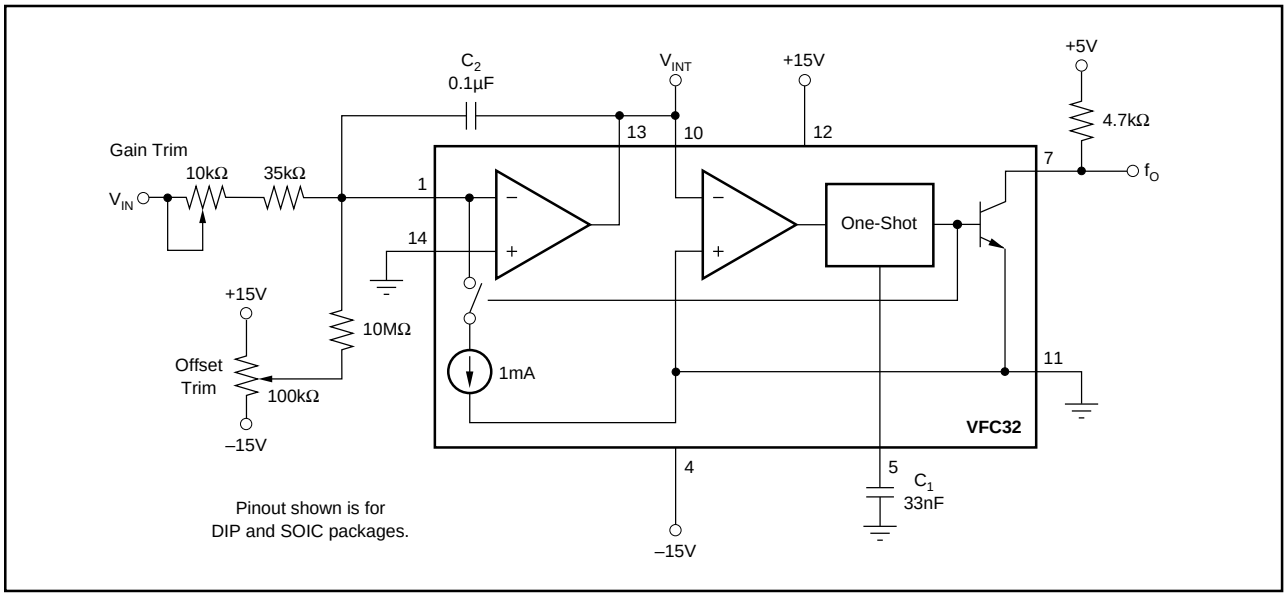


FIGURE 3. Gain and Offset Voltage Trim Circuit.

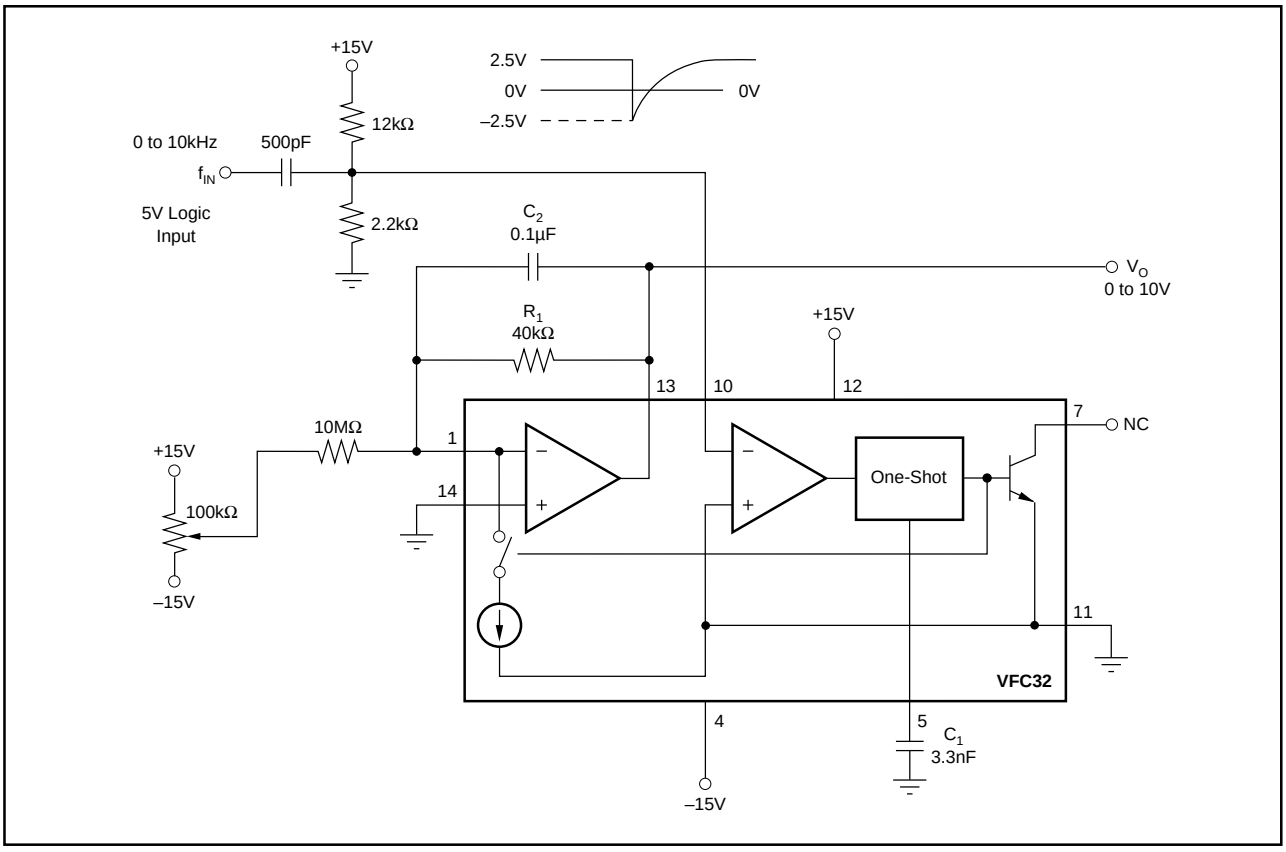


FIGURE 4. Frequency-to-Voltage Converter Circuit.

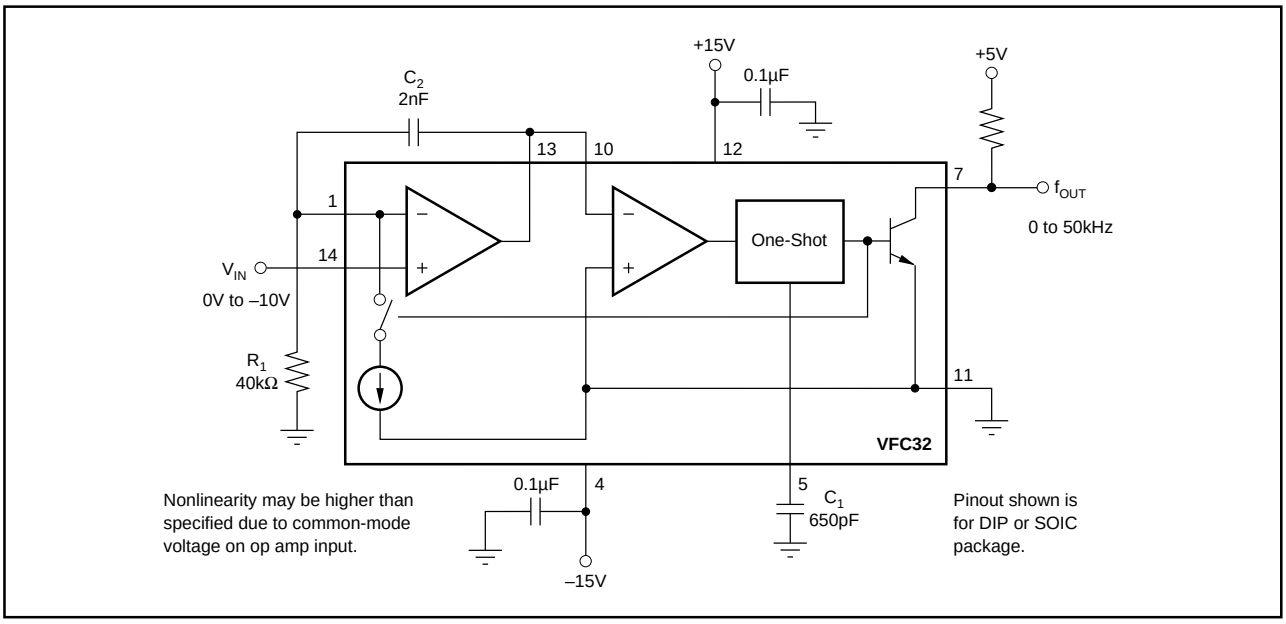
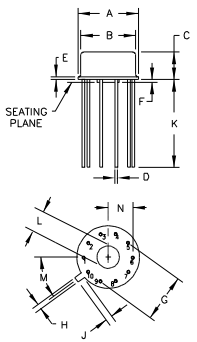


FIGURE 5. V/F Converter—Negative Input Voltage.

PACKAGE DRAWINGS

Package Number 007 - TO-100 Package

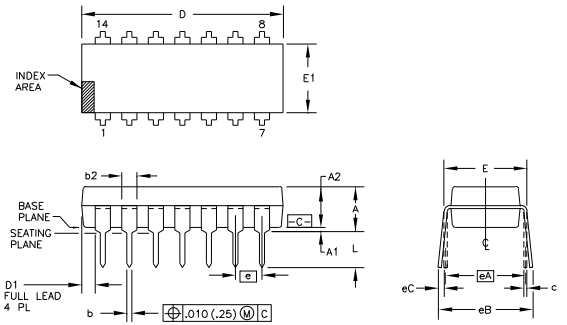


DIM	INCHES		MILLIMETERS		NOTE
	MIN.	MAX.	MIN.	MAX.	
A	.335	.370	8.51	9.40	
B	.305	.335	7.75	8.51	
C	.165	.185	4.19	4.70	
D	.016	.021	0.41	0.53	
E	.010	.040	0.25	1.02	
F	.010	.040	0.25	1.02	
G	.230	BASIC	5.84	BASIC	
H	.028	.034	0.71	0.86	
J	.029	.045	0.74	1.14	
K	.500	--	12.70	--	
L	.120	.160	3.05	4.06	
M	36°	BASIC	36°	BASIC	
N	.110	.120	2.79	3.05	

NOTES:
1. LEADS IN TRUE POSITION WITHIN .010" (0.25mm) R @ MMC AT SEATING PLANE.
2. PIN NUMBERS SHOWN FOR REFERENCE ONLY. NUMBERS MAY NOT BE MARKED ON PACKAGE.

PACKAGE NUMBER: ZZ007 | REV.: A
JEDEC NUMBER: UNKNOWN

Package Number 010 - 14-Pin Plastic, Single-Wide DIP

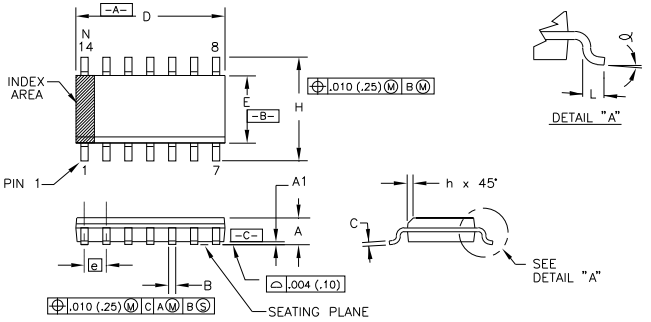


DIM	INCHES		MILLIMETERS		NOTE
	MIN.	MAX.	MIN.	MAX.	
A	--	.210	--	5.33	3
A1	.015	--	0.38	--	3
A2	.115	.195	2.92	4.95	
b	.014	.022	0.36	0.56	
b2	.045	.070	1.14	1.78	9
c	.008	.014	0.20	0.36	
D	.735	.775	18.67	19.69	4
D1	.005	--	0.13	--	4
E	.300	.325	7.62	8.26	5
E1	.240	.280	6.10	7.11	4
e	.100	BASIC	2.54	BASIC	
eA	.300	BASIC	7.63	BASIC	5
eB	--	.430	--	10.92	6
eC	.000	.060	0.00	1.52	6
L	.115	.150	2.92	3.81	3
N	14		14		7

NOTES:
1. ALL DIMENSIONS ARE IN INCHES.
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3. DIMENSIONS A, A1, AND L ARE MEASURED WITH THE PACKAGE SEATED IN JEDEC SEATING PLANE GAUGE GS-3.
4. D, D1, AND E1 DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS. MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED .010 (0.25mm).
5. E AND eA MEASURED WITH THE LEADS CONSTRAINED TO BE PERPENDICULAR TO DATUM -C-.
6. eB AND eC ARE MEASURED AT THE LEAD TIPS WITH THE LEADS UNCONSTRAINED.
7. N IS THE MAXIMUM OF TERMINAL POSITIONS.
8. POINTED OR ROUNDED LEAD TIPS ARE PREFERRED TO EASE INSERTION.
9. b2 MAXIMUM DIMENSION DOES NOT INCLUDE DAMBAR PROTRUSIONS. DAMBAR PROTRUSIONS SHALL NOT EXCEED .010 (0.25mm).
10. DISTANCE BETWEEN LEADS INCLUDING DAMBAR PROTRUSIONS TO BE .005 (0.13mm) MINIMUM.
11. A VISUAL INDEX FEATURE MUST BE LOCATED WITHIN THE CROSS-HATCHED AREA.
12. FOR AUTOMATIC INSERTION, ANY RAISED IRREGULARITY ON THE TOP SURFACE (STEP, MESA, ETC.) SHALL BE SYMMETRICAL ABOUT THE LATERAL AND LONGITUDINAL PACKAGE CENTERLINES.

PACKAGE NUMBER: ZZ010 | REV.: G
JEDEC NUMBER: MS-001-AA

Package Number 235 - 14-Lead SOIC



DIM	INCHES		MILLIMETERS		NOTE
	MIN.	MAX.	MIN.	MAX.	
A	.0532	.0688	1.35	1.75	
A1	.004	.0098	0.10	0.25	
B	.013	.020	0.33	0.51	7
C	.0075	.0098	0.19	0.25	
D	.3367	.3444	8.55	8.75	2
E	.1497	.1574	3.80	4.00	3
e	.050	BASIC	1.27	BASIC	
H	.2284	.244	5.80	6.20	
h	.0099	.0196	0.25	0.50	4
L	.016	.050	0.40	1.27	5
N	14		14		6
α	0°	8°	0°	8°	

NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
2. DIMENSION "D" DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS. MOLD FLASH, PROTRUSIONS AND GATE BURRS SHALL NOT EXCEED .006 IN. (0.15 mm) PER SIDE.
3. DIMENSION "E" DOES NOT INCLUDE INTER-LEAD FLASH OR PROTRUSIONS. INTER-LEAD FLASH AND PROTRUSIONS SHALL NOT EXCEED .010 IN. (0.25 mm) PER SIDE.
4. THE CHAMFER ON THE BODY IS OPTIONAL. IF IT IS NOT PRESENT, A VISUAL INDEX FEATURE MUST BE LOCATED WITHIN THE CROSS-HATCHED AREA.
5. "L" IS THE LENGTH OF TERMINAL FOR SOLDERING TO A SUBSTRATE.
6. "N" IS THE NUMBER OF TERMINAL POSITIONS.
7. THE LEAD WIDTH "B", AS MEASURED .014 IN. (0.36 mm) OR GREATER ABOVE THE SEATING PLANE, SHALL NOT EXCEED A MAXIMUM VALUE OF .024 IN. (0.61 mm).
8. LEAD TO LEAD COPLANARITY SHALL BE LESS THAN .004 IN. (0.10 mm) FROM SEATING PLANE.

PACKAGE NUMBER: ZZ235 | REV.: D
JEDEC NUMBER: MS-012-AB