VFQ-1, VFQ-2, VFQ-3
Low Cost, Monolithic V/F Converters

FEATURES

- **10 kHz to 100 kHz FS**
- **0.01% Maximum linearity at 10 kHz (VFQ-2)**
- **Single- or dual-supply operation**
- **Open collector output**
- **Pulse and square wave outputs**
- **Operates as V/F or F/V**

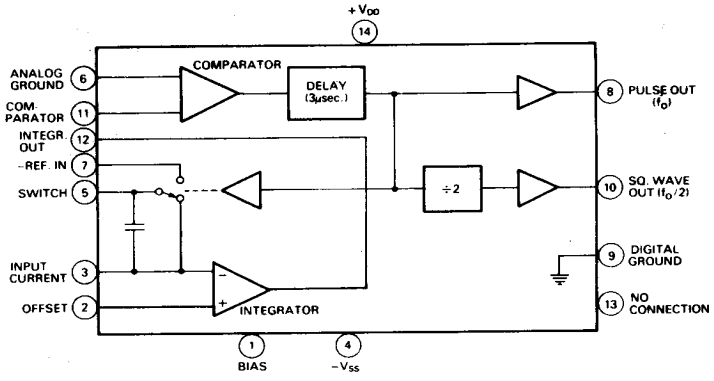
GENERAL DESCRIPTION

DATEL's VFQ series is a family of low-cost, monolithic voltage-to-frequency converters combining bipolar and CMOS technologies. These devices accept a positive analog input current and produce an output pulse train with a frequency linearly proportional to an input current. The full-scale output pulse rate can be set from 10 kHz to 100 kHz by means of two external capacitors.

Linearities are specified for both 10 kHz and 100 kHz full-scale outputs. The maximum linearity, at 10 kHz, of the VFQ-1 is 0.05%, while the VFQ-2 has a maximum of 0.01%, and the VFQ-3 has a 0.25% maximum. The linearity holds over the full output range of zero to full scale.

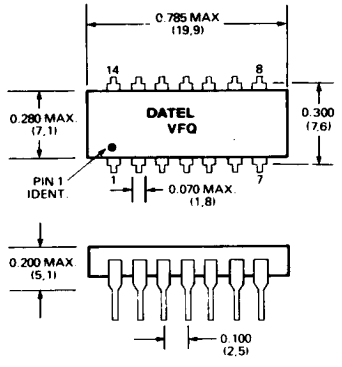
The internal circuitry of these converters includes an operational integrator, a comparator, digital delay circuit, single-pole double-throw electronic switch, a start circuit, a divide by two circuit, and two output driver circuits. Operation is based on the well-known charge balancing integrator principle. The two outputs are open collector NPN which can sink up to 10 mA and give a logical high output up to +18 volts. In normal operation these devices require only five external components and a reference. If the zeroing adjustment is used, a trimming potentiometer and two more resistors are required. The VFQ series can be operated from dual ±4 to ±7.5V supplies or from a single +10V to +15V supply. They may also be operated as frequency-to-voltage converters.

Each model is available in a 14-pin Plastic DIP for 0°C to +70°C operation, with the VFQ-1 also available in a 14-pin Ceramic DIP for −25°C to +85°C operation.

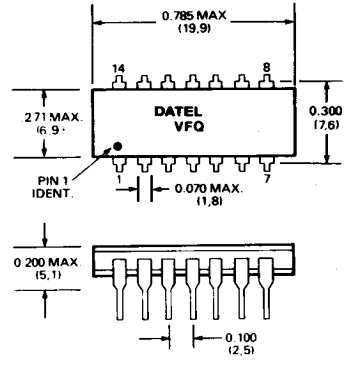


MECHANICAL DIMENSIONS
INCHES (MM)

PLASTIC PACKAGE



CERAMIC PACKAGE



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ABSOLUTE MAXIMUM RATINGS	VFQ-1	VFQ-2	VFQ-3
Supply Voltage, pin 4 to pin 14	18 Volts	*	*
Input Current, pin 3	±10 mA	*	*
Output Voltage, pins 8 to 10	+25 Volts	*	*
Reference (pin 7) to $-V_{ss}$	±1.5 Volts	*	*

FUNCTIONAL SPECIFICATIONS

Typical at 25°C, ±5V supplies, −5V ref., unless otherwise noted.

INPUTS			
Input Current Range	0 to 10 µA	*	*
Input Current Overrange, max.	+50 µA	*	*
Input Offset Voltage, max.[1]	±50 mV	±50 mV	±100 mV
Reference Input	Negative Voltage Within ±1.5V of negative supply		
OUTPUTS			
Type Outputs	Open Collector NPN		
Pulse Output, pin 8	Negative Going, 3 µsec. pulses at f_o		
Square Wave Output, pin 10	Square Wave at $f_o/2$		
Output Logic Levels	V_{OUT} ("0") ≤ +0.4V at −10 mA V_{OUT} ("1") = $+V_{DD}$		
PERFORMANCE			
Linearity, 10 kHz Full-Scale, max.	0.05%	0.01%	0.25%
Linearity, 100 kHz Full-Scale, max.	0.25%	0.08%	0.5%
Gain Tempco, max.	40 ppm/°C	40 ppm/°C	100 ppm/°C
Zero Tempco, max.	50 µV/°C	50 µV/°C	100 µV/°C
Full Scale Accuracy, before trim	±10%	*	*
Output Settling Time, 0.01%	2 Pulses of New Frequency		
SPECIFICATIONS AS F/V			
Nonlinearity, max.[2]	0.05%	0.02%	0.25%
Input Frequency Range	10 Hz to 100 kHz	*	*
Input Voltage, min.	±0.4V	*	*
Input Voltage, max.	−2V to $+V_{DD}$	*	*
Input Pulse Width, Negative pulse, min.	0.5 µsec.	*	*
Input Pulse Width, Positive pulse, min.	5.0 µsec.	*	*
Output Voltage Range[3]	0V to ($+V_{DD}$ − 1)	*	*
Output Load, min.	2 kΩ		
POWER REQUIREMENTS			
Positive Supply (pin 14)	+4.0V to +7.5V		
Negative Supply (pin 4)	−4.0V to −7.5V		
Quiescent Current, max.[4] VFQ-1C, 2C	±4 mA		
VFQ-1R	±6 mA		
VFQ-3C	±10 mA		
PHYSICAL/ENVIRONMENTAL			
Operating Temperature Range:			
Suffix C	0 °C to +70°C		
Suffix R	−25°C to +85°C		
Storage Temperature Range	−65°C to +150°C		
Package, C Suffix	14 pin Plastic DIP		
Package, R Suffix	14 pin Ceramic DIP		

*Specifications same as VFQ-1.

FOOTNOTES:

1. Before Trimming, I_{IN} = 0.
2. 10 Hz to 100 kHz
3. $R_L \geq 2$ kΩ
4. $V_{IN} = -0.1V$

TECHNICAL NOTES

1. To calibrate the VFQ as a V/F converter, connect as shown in the diagrams. Connect a precision voltage source (such as DATEL DVC-8500) to the input resistor. Connect a 5 digit counter, with time base set to one second, to the output (pin 8).

   Zero. Set the voltage reference to +0.01V and adjust the zero adjust potentiometer for an output frequency of 10 Hz (for 10 kHz FS) or 100 Hz (for 100 kHz FS).

   Gain. Assuming the 10V FS input, set the voltage reference to +10.000V and trim the value of R1 to give an output frequency of 10,000 Hz (for 10 kHz FS) or 100,000 Hz (for 100 kHz FS).

2. The two outputs (pins 8 and 10) are open collector NPN transistors for easy interfacing to a variety of standard logic circuits. A pull-up resistor must be used as shown in the diagrams. The resistor may be tied to any voltage up to +18V, which can be separate from +Vdd.

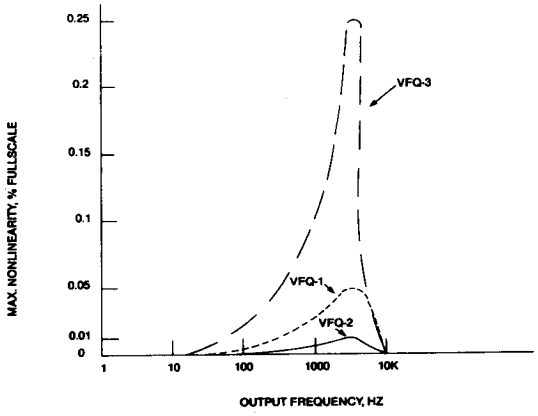
3. Note that the negative reference voltage must be within ±1.5V of the negative supply ($-V_{SS}$). For a given full-scale output frequency the value of C_2 is dependent on the negative reference voltage.

4. Note the minimum-maximum waveform requirements for the input when using the VFQ as a frequency-to-voltage converter. See "Input Waveform Limits" diagram. The minimum ±0.4V must be observed as well as the minimum widths for both positive and negative going portions of the waveform. If the input waveform exceeds the maximum amplitude limits, an input resistor and back-to-back clamping diodes should be used as shown in the connection diagram.

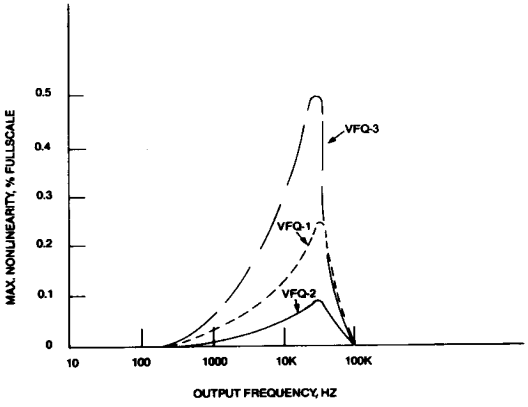
5. For F/V operation, the input signal must cross through zero in order to trip the comparator. In order to overcome the hysteresis the amplitude must be greater than ±200 mV. If only a unipolar input signal (F_{in}) is available, it is recommended that either an offset circuit using resistors be used or that the signal be coupled in via a capacitor.

PERFORMANCE CHARACTERISTICS

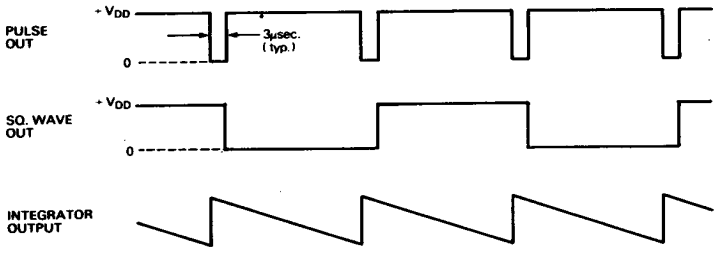
MAX. NONLINEARITY – 10 KHZ FULLSCALE

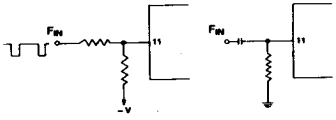


MAX. NONLINEARITY – 100 KHZ FULLSCALE



OUTPUT WAVEFORMS





NOTE:
For F/V operation, if only a unipolar input signal is available, an offset circuit using resistors should be used or the signal should be capacitor coupled.

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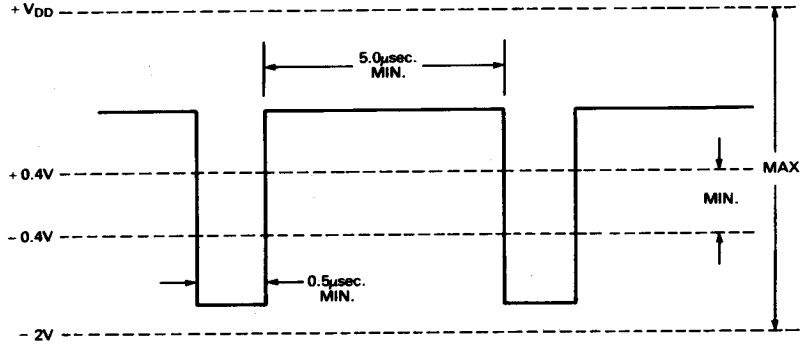
INPUT WAVEFORM LIMITS (F/V CONVERTER)



VFQ FORMULAS

$$f_{OUT} = \frac{V_{IN}}{R_1} \times \frac{1}{V_{REF}\ C_2}$$

$$R_1 = \frac{V_{IN}\ (max.)}{10\mu A}$$

$82K \leq R_2 \leq 120K$

$3C_2 \leq C_1 \leq 10\ C_2$

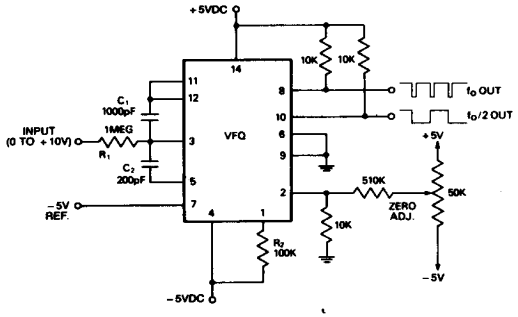
C_1 (optimum) $= 4\ C_2$

F/V CONVERTER
$V_{OUT} = F_{IN}(V_{REF} \times C_2 \times R_1)$

OUTPUT TIME CONSTANT:
$T = R_1\ C_1$

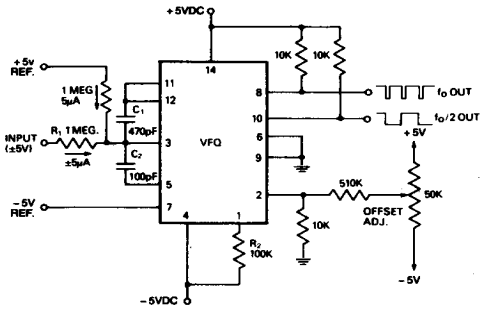
APPLICATION DIAGRAMS

NORMAL CONNECTION—10 kHz FULL SCALE

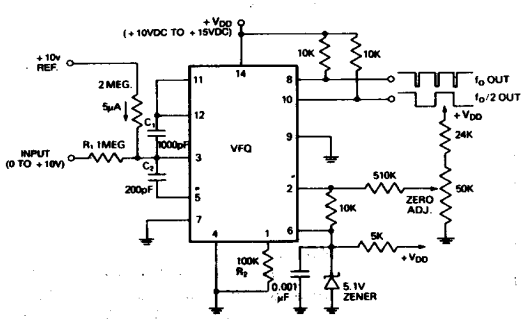


NOTE: FOR 100kHz FULL SCALE, C_1 = 100pF AND C_2 = 20 pF

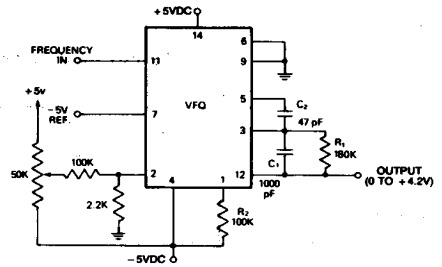
BIPOLAR OPERATION (0 to 20 kHz)



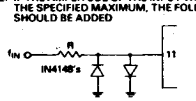
SINGLE SUPPLY OPERATION



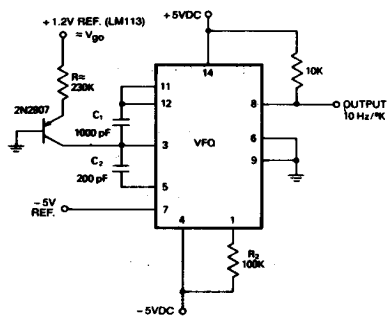
FREQUENCY TO VOLTAGE CONVERTER (0 to 100 kHz INPUT)



NOTE: IF THE AMPLITUDE OF THE INPUT WAVEFORM EXCEEDS THE SPECIFIED MAXIMUM, THE FOLLOWING INPUT CIRCUIT SHOULD BE ADDED



TEMPERATURE TO FREQUENCY CONVERTER



NOTES:
1. V_{go} IS THE EXTRAPOLATED ENERGY-BAND-GAP VOLTAGE FOR SILICON AT 0°K.
2. R IS A STABLE METAL FILM RESISTOR (50 PPM/°C OR BETTER) IT'S EXACT VALUE SHOULD BE FOUND BY ADJUSTING IT TO GIVE AN OUTPUT FREQUENCY OF 10 X °K IN HZ FOR A KNOWN TEMPERATURE SUCH AS 300°K. IT WILL THEN BE CORRECTLY CALIBRATED FOR ALL OTHER TEMPERATURES.
3. WHEN PROPERLY IMPLEMENTED THIS CONVERTER IS ACCURATE TO 1°K.

ORDERING INFORMATION

MODEL NO.	OPERATING TEMP. RANGE	LINEARITY
VFQ-1C	0°C to +70°C	0.05%
VFQ-1R	−25°C to +85°C	0.05%
VFQ-2C	0°C to +70°C	0.01%
VFQ-3C	0°C to +70°C	0.25%

ACCESSORIES

Part Number	Description
TP50K	Trimming Potentiometer