

μ A4151 • μ A7151

VOLTAGE-TO-FREQUENCY CONVERTER

FAIRCHILD LINEAR INTEGRATED CIRCUITS

DESCRIPTION — The μ A4151 is a monolithic building block used to convert dc voltage to digital pulses. The frequency of the output pulses is proportional to the dc input voltage.

The μ A4151 consists of a voltage comparator, a monostable multivibrator and a precision switched current source (see block diagram).

The μ A7151 is the same device as the μ A4151 with a high performance operational amplifier on the same chip. The single supply op amp conditions the input signal and provides a significant improvement in system performance.

- **SINGLE SUPPLY (+8 V_{DC} TO +30 V_{DC})**
- **LINEARITY TO $\pm 0.05\%$**
- **PROGRAMMABLE SCALE FACTOR**
- **PULSE OUTPUT COMPATIBLE WITH ANY LOGIC FORM**
- **TEMPERATURE STABILITY TYPICALLY ± 100 ppm/°C**
- **HIGH NOISE REJECTION**
- **EASILY TRANSMITTABLE OUTPUT**
- **SIMPLE FULL-SCALE TRIM**
- **SINGLE-ENDED INPUT, REFERENCED TO GROUND**
- **ALSO PROVIDES FREQUENCY-TO-VOLTAGE CONVERSION**
- **HIGH PERFORMANCE OP AMP INCLUDED IN μ A7151**

ABSOLUTE MAXIMUM RATINGS

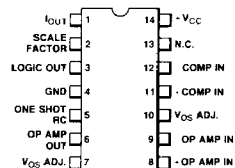
| | |
|---|----------------------------|
| Supply Voltage | 32 V |
| Internal Power Dissipation | 670 mW |
| Input Voltage (Comparator) | -0.2 V to +V _{CC} |
| Input Voltage (Op Amp) | -0.2 V to +V _{CC} |
| Logic Out Shorted-to-Ground | continuous |
| Op Amp Out Shorted-to-Ground | continuous |
| Op Amp Input Common Mode Voltage Range | +13 V to -V _S |
| Op Amp Output Voltage Range, R _L = 10 k Ω | +2 V to +13 V |
| Operating Temperature Range | 0°C to +70°C |
| Storage Temperature Range | -65°C to +150°C |
| Pin Temperatures | |
| Molded DIP (Soldering, 10 s) | 260°C |
| Hermetic DIP (Soldering, 60 s) | 300°C |

CONNECTION DIAGRAMS

14-PIN DIP

(TOP VIEW)

PACKAGE OUTLINES 6A 9A
PACKAGE CODES D P



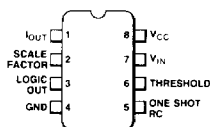
ORDER INFORMATION

| TYPE | PART NO. |
|-------------|---------------|
| μ A7151 | μ A7151PC |

8-PIN MINI DIP

(TOP VIEW)

PACKAGE OUTLINES 9T
PACKAGE CODES T



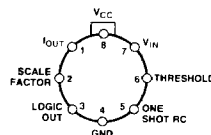
ORDER INFORMATION

| TYPE | PART NO. |
|-------------|---------------|
| μ A4151 | μ A4151TC |

8-PIN METAL CAN

(TOP VIEW)

PACKAGE OUTLINE 5S
PACKAGE CODE H



ORDER INFORMATION

| TYPE | PART NO. |
|-------------|---------------|
| μ A4151 | μ A4151HC |

FAIRCHILD • μ A4151 • μ A7151

ELECTRICAL CHARACTERISTICS: $V_{CC} = +15\text{ V}$, $T_A = 25^\circ\text{C}$ unless otherwise specified.

The following specs apply to the Converter Section only.

| CHARACTERISTICS | CONDITIONS | MIN | TYP | MAX | UNITS |
|--|---|-------------------|--------------------|--------------------|-----------------------|
| Supply Current | $8.0\text{ V} \leq V_{CC} \leq 15\text{ V}$ $15\text{ V} \leq V_{CC} \leq 22\text{ V}$ $22\text{ V} \leq V_{CC} \leq 30\text{ V}$ | 3.0 3.0 3.0 | 4.5 5.5 6.5 | 7.0 8.5 10.5 | mA |
| Conversion Accuracy | | | | | |
| Scale Factor | Figure 2, $V_1 = 10\text{ V}$, $R_S = 14\text{ k}\Omega$ | 0.90 | 1.0 | 1.10 | kHz/V |
| Drift with Temperature | Figure 2, $V_1 = 10\text{ V}$ | | ± 100 | | ppm/ $^\circ\text{C}$ |
| Drift with V_{CC} | Figure 2, $8.0\text{ V} \leq V_{CC} \leq 18\text{ V}$, $V_1 = 1.0\text{ V}$ | | 0.2 | 1.0 | %/V |
| Input Comparator | | | | | |
| Offset Voltage | | | 5.0 | 10 | mV |
| Offset Current | | | ± 50 | ± 100 | nA |
| Input Bias Current | | | -100 | -300 | nA |
| Common Mode Range (Note 1) | | 0 | 0 to $V_{CC}-2$ | $V_{CC}-3.0$ | V |
| One-Shot | | | | | |
| Threshold Voltage, Pin 5 | | 0.63 | 0.667 | 0.70 | $\times V_{CC}$ |
| Input Bias Current, Pin 5 | | | -100 | -500 | nA |
| Reset V_{sat} | Pin 5, $I = 2.2\text{ mA}$ | | 0.15 | 0.50 | V |
| Current Source | | | | | |
| Output Current ($V_S = 14\text{ k}\Omega$) | Pin 1, Figure 1, $V = 0$ | | 138.7 | | μA |
| Change with Voltage | Pin 1, $V = 0\text{ V}$ to $V = 10\text{ V}$ | | 1.0 | 2.5 | μA |
| Off Leakage | Pin 1, $V = 0\text{ V}$ | | 1.0 | 50 | nA |
| Reference Voltage | Pin 2, Figure 1 | 1.70 | 1.9 | 2.08 | V |
| Logic Output | | | | | |
| V_{sat} | Pin 3, $I = 3.0\text{ mA}$ | | 0.15 | 0.50 | V |
| V_{sat} | Pin 3, $I = 2.0\text{ mA}$ | | 0.10 | 0.35 | V |
| Off Leakage | | | 0.1 | 1.0 | μA |

NOTE 1: Input common mode range includes ground.

μ A7151 Op-Amp

ELECTRICAL CHARACTERISTICS: $V_S = +15\text{ V}$ and ground $T_A = 25^\circ\text{C}$ unless otherwise specified.

| CHARACTERISTICS | MIN | TYP | MAX | UNITS |
|--|-----|-----|------|------------------|
| Input Offset Voltage | | 2.0 | 5.0 | mV |
| Input Offset Current | | 10 | 50 | nA |
| Input Bias Current | | -50 | -250 | nA |
| Input Impedance | | 1.0 | | M Ω |
| Common Mode Rejection Ratio | 70 | 90 | | dB |
| Large Signal Voltage Gain, $R_L = 10\text{ k}$ | 50 | 200 | | V/mV |
| Slew Rate | | 0.6 | | V/ μs |
| Power Supply Rejection Ratio | | 15 | 100 | $\mu\text{V/V}$ |
| Output Short Circuit Current | 10 | | 40 | mA |

CIRCUIT DESCRIPTION

The $\mu A7151$ consists of five circuit blocks as shown in Figure 1. The blocks may be connected in a variety of ways to construct voltage-to-frequency converters (VFC), frequency-to-voltage converters (FVC), or other circuit functions. The circuit blocks are:

1. A differential input comparator featuring very high gain, low offsets, and a common mode range which includes ground.
2. A one-shot multivibrator with the time constant set by an external RC ($T = 1.1RC$) connected to the RC terminal, triggered by the output of the comparator being high.
3. A precision switched current source that is turned on to the value of I_{REF} when the one-shot is on and goes to zero when the one-shot is off. The current I_{REF} is set by an external R_S , connected from the scale factor terminal-to-ground and is equal to the reference voltage divided by R_S and is optimized when set to $138 \mu A$.
4. An open collector output that provides a buffered output from the one-shot.
5. An operational amplifier whose common mode range includes ground and has offset null capability. The op amp has high gain, low offset voltage, low input currents, good PSRR and CMRR, and low drift.

PRINCIPLE OF OPERATION**Voltage to Frequency Conversion (VFC)**

As a voltage to frequency converter the $\mu A7151/4151$ can be connected in several configurations depending on the input voltage, required accuracy, and response time. In all the applications we will see that the input voltage is converted to a current and the circuit will turn the switched current source on at the rate necessary so that the average current from the current source is equal to the input current. As the input voltage (and current) increases, the current source must turn on more often, and the output frequency increases.

SELECTING COMPONENTS FOR THE VFC

Voltage-to-frequency converters can be used for full scale voltages of 100 mV or greater and full scale frequencies of 1 Hz to 100 kHz. Input voltages in excess of $V_{CC} +$ can be accommodated with appropriate resistor dividers to attenuate the voltages. The following components selection guidelines should be used.

1. R_S should be approximately 14 k Ω to optimize the system performance versus temperature. R_S is normally a 12 k Ω fixed resistor and a 5 k Ω pot to be used to adjust the full scale output frequency. Small variations in R_S have minimal effect on system temperature performance.
 $I_{REF} = V_{REF}/R_S = 1.95 V/R_S$
2. $R_0 C_0$ sets the one-shot pulse width, $T_0 = 1.1 R_0 C_0$. This pulse width must be shorter than the minimum period of the maximum frequency ie, set it equal to .75 ($1/f_0$). Therefore, $R_0 C_0 = .68 (1/f_0)$. Values of R_0 should be between 6.8 k Ω and 680 k Ω and C_0 should be from .001 μF to 1 μF .
3. R_B should be as low as possible for the highest accuracy, (this reduces the effect of current source R_{OUT}) but must be large enough to insure that the current source output is greater than $V_{IN} \max/R_B$. Therefore, choose R_B such that $R_B \sim 1.33 V_{IN} \max/I_0$.
4. C_B for Figure 2 must be chosen to trade-off between accuracy and response time. Larger values of C_B give greater system accuracy but response time is limited by the $R_B C_B$ time constant. A good choice for D_B is $10^{-2}/f_0$.
5. C_1 for Figures 3 and 4 can be selected depending on the output frequency. The smaller C_1 is the faster the system response will be. C_1 must be large enough to limit the amplifier swing. The op amp will swing a voltage set by $I_0 T_0/C_1$, so if the comparator is biased at $2/3 V_{CC} +$ this constrains $C_1 > 3 I_0 T_0/2 V_{CC} +$. A nominal value of $C_1 = 5 \times 10^{-5}/f_0$ meets this requirement.

COMPARISON OF VOLTAGE TO FREQUENCY CIRCUITS

Table I shows a comparison of the three basic circuits set-up for a 0 to 10 V input range and a full scale output of 10 kHz.

FREQUENCY TO VOLTAGE CONVERSION

The $\mu A7151/4151$ can be connected as frequency-to-voltage converter (FVC). This circuit basically works by putting out a current pulse per cycle of input frequency and integrating the current pulses across an output resistor to give an output voltage which is proportional to the average value of I_0 ($I_0 T_0 f_{IN}$).

TABLE I - APPLICATIONS

| | Figure 2 | Figure 3 | Figure 4 |
|------------------|-------------|-------------|------------|
| Linearity | 1.0% | 0.2% | 0.05% |
| Frequency Offset | +10 Hz | 0 | 0 |
| Response Time | 135 μs | 200 μs | 10 μs |
| Input Voltage | + | + | - |
| Single Supply | yes | yes | yes |
| Split Supply | - | - | yes |

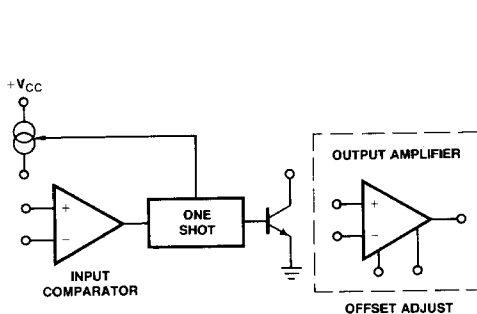


Fig. 1

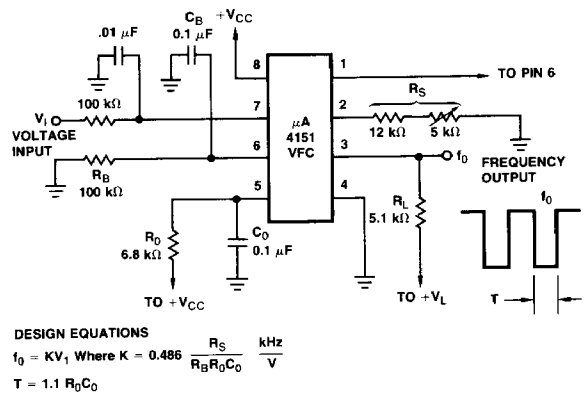


Fig. 2

PRECISION VOLTAGE TO FREQUENCY CONVERTER FOR POSITIVE INPUTS

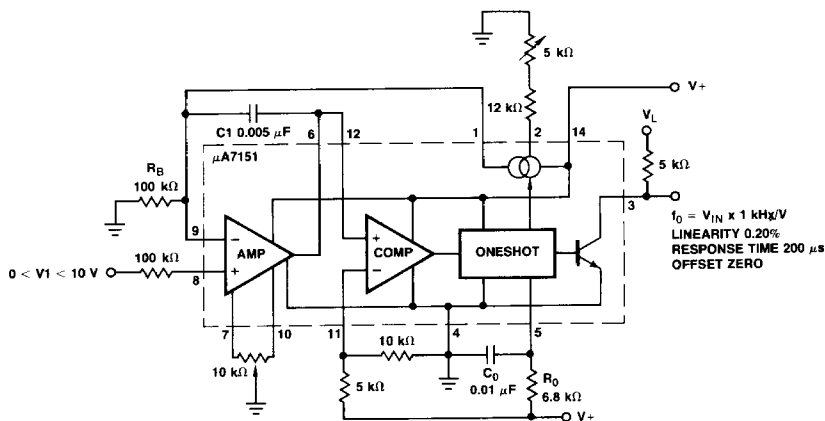


Fig. 3

Fig. 4

Fig. 5

Fig. 6

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