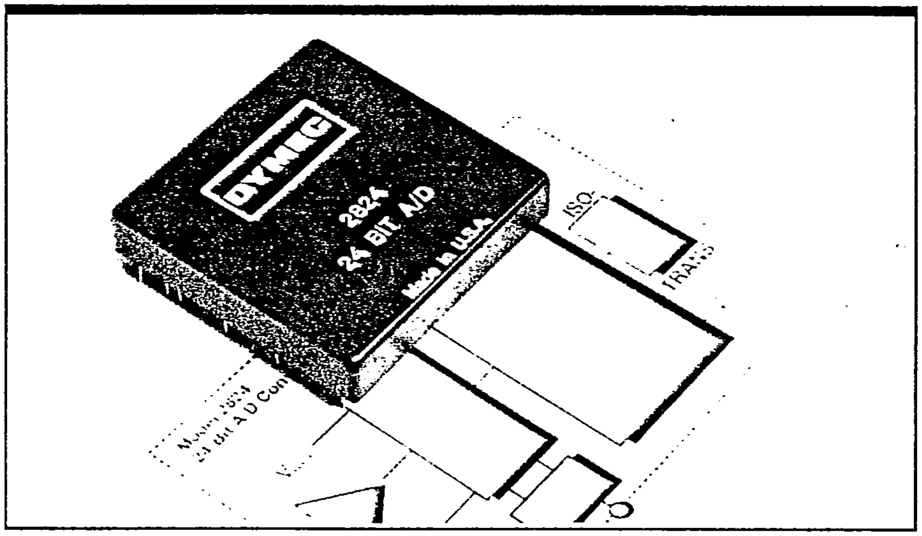
DYMEC

MODEL:

T-51-10-90

2824

24-Bit INSTRUMENTATION A/D CONVERTER



Description

The **Model 2824** is the analog front-end of a voltage-to-frequency converter-based A/D that allows measurements to be made with sensitivities down to 1μV/ count or better, over the entire range of the A/D. This level of performance allows extremely wide dynamic range A/D converters to be implemented that produce meaningful data at 23⁺ bits of equivalent sensitivity. For the first time, the performance of the most sensitive instruments can be obtained from an A/D Converter subsystem, with all the painstaking analog design already completed.

Contained within the 3.25" x 2.0" fully-shielded metal case of the 2824 are: 1) a low noise instrumentation amplifier with programmable gains of 1 and 10, 2) a precision 10MHz full scale V/F converter, and 3) an internal, optically isolated multiplexer to select either the amplifier output, an internal reference or internal ground, for performing automated calibration. The shield of the input coax cable can be driven by internal guard circuitry to reduce interference on the signal leads.The frequency output of the V/F converter and the digital control lines are isolated from the remainder of the circuitry, allowing the entire analog front-end to be *completely* isolated from the rest of the system. This guarantees complete freedom from ground loops and digital noise in the analog section, two absolute requirements if sensitivity of 10μVolts or better is to be achieved.

Used with the **DYMEC Model 5024** 24-bit, 50MHz Counter/Timer IC, a complete A/D converter subsystem can be designed which supports both frequency counting and period averaging measurement techniques, that are switchable "on-the-fly". Software control of gain, calibration, measurement mode and counting intervals are all easily implemented in a memory-mapped I/O configuration.

Features

- <10μV Sensitivity Across the Entire Range at 10 Samples Per Second
- Programmable Sampling Rate
- 24-Bit Resolution
- Instrumentation Amplifier with Active Driven Guard
- Programmable Gains
- Completely Isolated Analog Front-End
- Automated Calibration

Applications

- Analytical Instruments
- Chromatography I/0 Boards
- Test and Measurement Systems

Specifications (All Specifications Guaranteed at 25°C Unless Otherwise Noted)

ANALOG INPUT (Mux Code: B_1=1, B_0=1)

Input Range
-1.11V to +10V; Gain = 1
-0.111V to +1.0V; Gain = 10
Overrange
+5% max.
Configuration
Differential
Differential Impedance
100 MΩ, typical
Common Mode Voltage Range
±10V
CMRR (@ 60Hz)
70dB minimum, 90dB typical
Offset Error
±5kHz maximum; Gain =1; trimmable to zero
±7kHz maximum; Gain = 10; trimmable to zero
Gain Error
0.5% maximum; Gain =1; trimmable to zero
0.8% maximum; Gain = 10; trimmable to zero

CALIBRATION INPUT

Full Scale (Mux Code: B_1=1, B_0=0)
Full Scale Error
0.1% maximum; relative to 10MHz
Offset (Mux Code: B_1=0, B_0=1)
Offset Error
0.5% maximum; relative to F_{OUT} with V_{IN}=0V

TRANSFER CHARACTERISTICS

Quantization Error
None
Full Scale Frequency
10MHz ±0.8%
Integral Non-linearity
±0.05% FS, ±0.05% of Input
Differential Non-Linearity
<0.1ppm
Transfer Function
$F_{OUT} = [((V_{IN} \times Gain) \times 9MHz) \div 10V] + 1MHz$;
for Gain=1, V_{IN} max = 10V
for Gain=10, V_{IN} max = 1V

STABILITY

Gain Temperature Coefficient
±125ppm FS/°C max.
Offset Temperature Coefficient
±25µv/°C typical, ±50µV/°C maximum; Gain =1.

Power Supply Rejection Ratio
+5V
300ppm/1% change in supply voltage; maximum
+15V
20ppm/1% change in supply voltage; maximum
-15V
500ppm/1% change in supply voltage; maximum
Warm up Time
≤15 minutes to specified accuracy
Noise
Refer to Figure 2 (plot of standard deviation)

DIGITAL INPUT/OUTPUT

Digital Inputs — Opto-isolated
I_{H}= 1mA typical; V_H>4V
I_L= 10µA typical; V_L<0.2V
Digital Outputs —Isolated
HC/TTL Compatible; will drive 3 LSTTL loads
Pulse Width
Negative true, 50ns±15ns
Isolation Voltage
1,000V dc

POWER REQUIREMENTS

Analog Power Inputs
+15V, ±3% (+Vs)
30mA typical, 40mA maximum
-15V, ±3% (-Vs)
25mA typical, 35mA maximum
+5V, ±5% (+Vcc)
90mA typical, 110mA maximum
Digital Power Input
+5V, ±5% (V+)
5mA typical, 15mA maximum

ENVIRONMENTAL AND MECHANICAL

Operating Temperature Range
0°C to +70°C
Storage Temperature Range
-55°C to +125°C
Relative Humidity
0 to 85% non-condensing up to +40°C
Dimensions
2.0" x 3.25" x 0.4"
(50.8x82.6x10.1mm)
Six-sided metal enclosure

GLOSSARY OF TERMS

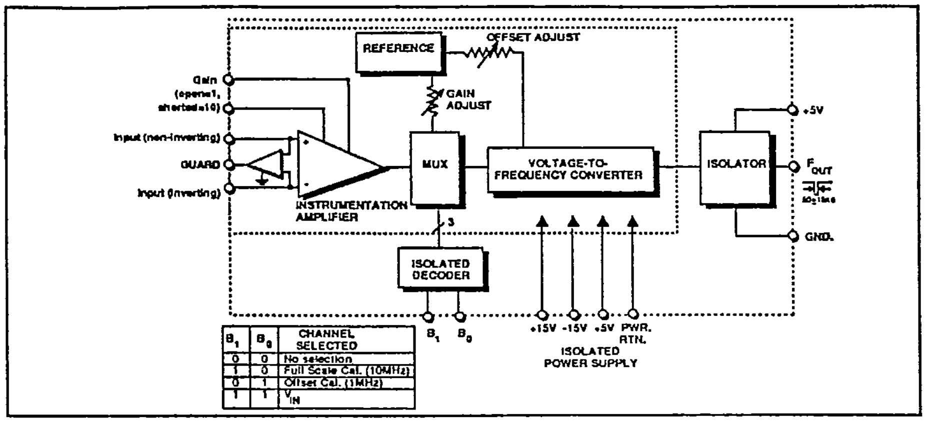
Counts — the incremental bits that comprise the data; what the computer/ user operates on; i.e., one million *counts* —» 1ppm

Frequency — the output pulse train of the V/F converter; i.e., the V/F output *frequency* (in MHz)

Gate Time — the time interval over which the V/F output frequency pulses are counted; i.e., a 10MHz full scale V/F will output 1million pulses in a 100ms *gate time*

Period — 1/frequency (inverse of frequency)

Resolution — smallest increment that information can be broken into; i.e. in an SAR-type A/D, *resolution* is equal to one LSB ($1/2^{n-1}$); with a V/F-based converter, resolution is *one count*



B_1	B_0	CHANNEL SELECTED
0	0	No selection
1	0	Full Scale Cal. (10MHz)
0	1	Offset Cal. (1MHz)
1	1	V_{IN}

Figure 1. Block Diagram

Sensitivity — minimum recognizable change in input per count (bit); = volts per count or volts per LSB; i.e., a 10V full scale V/F, with a 10MHz full scale frequency, with a gate time of 100ms, will output 1 Million counts; 10V/1 Million counts = 10µV/count *sensitivity*; another way to look at sensitivity is that a 16-bit A/D has 65,535 codes (counts) or 152µV per LSB sensitivity

Using the 2824

ZERO ISN'T NECESSARILY ZERO!

With 0.0000V at the input to an SAR-type A/D, the output data will represent zero, plus counts representing any system noise that may be present. Since the output frequency of a V/F is linearly proportional to the input voltage, with 0.000V input, the output frequency will be very nearly 0Hz, which can be difficult to calibrate precisely. It is possible to apply an offset to a V/F converter such that a large number of counts represents zero, thus allowing the zero point, or base line to be determined very precisely.

The V/F of the 2824 has a built-in offset applied such that the output frequency is 1MHz for a 0.000V input. The output frequency increases to 10MHz at a full scale voltage input of 10V. This accounts for the analog input specifications of -1.11V to +10V (-0.111V to +1.0V with a gain of 10).

CHOOSING THE GATE TIME (CONVERSION TIME)

V/F conversion allows for the selection of gate time as a trade-off with sensitivity to achieve the desired system performance. The *gate time* can be changed "on the fly" using the 2824/5024 combination. With the 2824, the offset frequency is 1MHz and full scale is 10MHz.

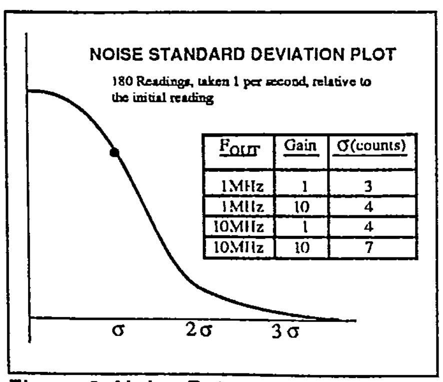
The sensitivity is calculated by determining the number of counts between zero and full scale, which is a function of the *gate time*. For a one second gate time, zero volts in equals 1Million counts, and full scale is 10Million counts. The span is therefore 10-1Million counts or 9Million counts. 10V full scale ÷ 9Million counts yields a sensitivity of 1.1µV/count. (See Figure 4.) Sensitivity is then:

$$\frac{\Delta V}{\Delta C} = \frac{V_{FS}}{\left[\frac{F_{FS}}{\text{Gate Time}} - \frac{F_{OS}}{\text{Gate Time}}\right]}$$

MEASUREMENT TECHNIQUE AND SENSITIVITY

From the specifications, you can see that the transfer function of the V/F is linear (see Figure 3); the output frequency of the V/F increases linearly with increasing input voltage. When the resulting output pulses are counted over a fixed interval, the measurement technique is commonly referred to as *frequency counting* or *frequency metering*. This technique provides a fixed sensitivity (ΔV/ΔC) throughout the transfer curve; the full scale input voltage divided by the full scale number of counts yields the sensitivity of so many volts/count. This sensitivity may be adequate near the upper end of the input range, but it may be desirable to have increased sensitivity near zero. This can be achieved by using the inverse measurement technique, that of *period averaging* (Figure 3).

If frequency metering is a linear function, *f*, the inverse is period averaging, which is the non-linear, asymptotic curve, 1/*f*. In the period averaging technique, a fixed,



F_{OUT}	Gain	σ(counts)
1MHz	1	3
1MHz	10	4
10MHz	1	4
10MHz	10	7

Figure 2. Noise Data

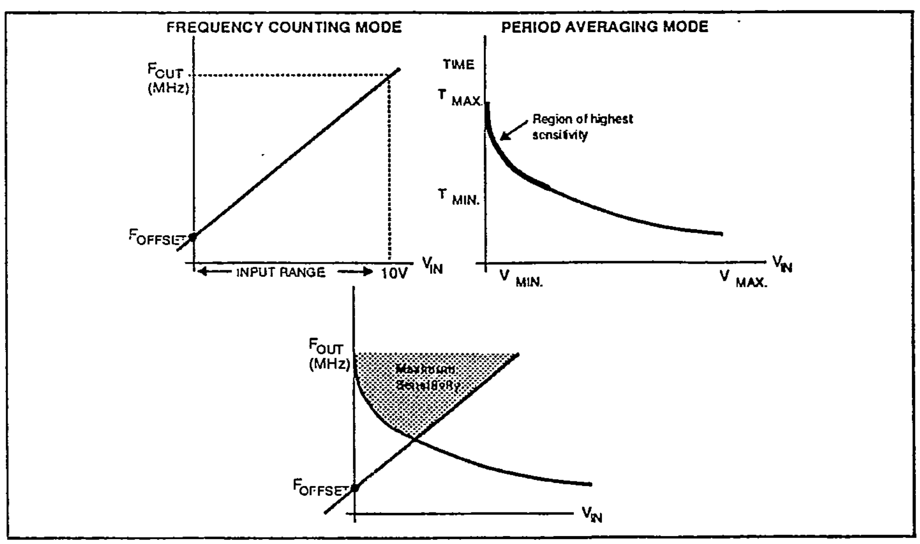
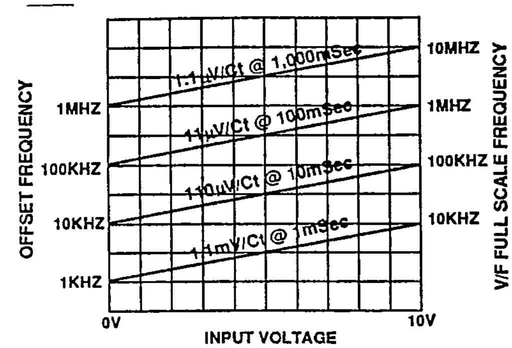


Figure 3. Maximizing Sensitivity



Gate Time	Counts	Span	Sensitivity (FS/Max Cts.)
1 second	1MHz to 10MHz	9MHz	1.1µV/count
100ms	100kHz to 1MHz	900kHz	11 µV/count
10ms	10kHz to 100kHz	90kHz	110 µV/count
1ms	1kHz to 10kHz	9kHz	1.1mV/count

Figure 4. Conversion Time Nomograph

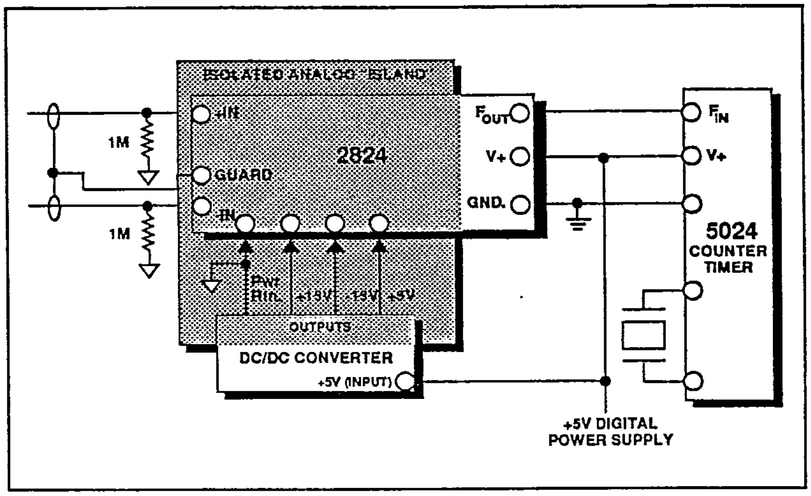
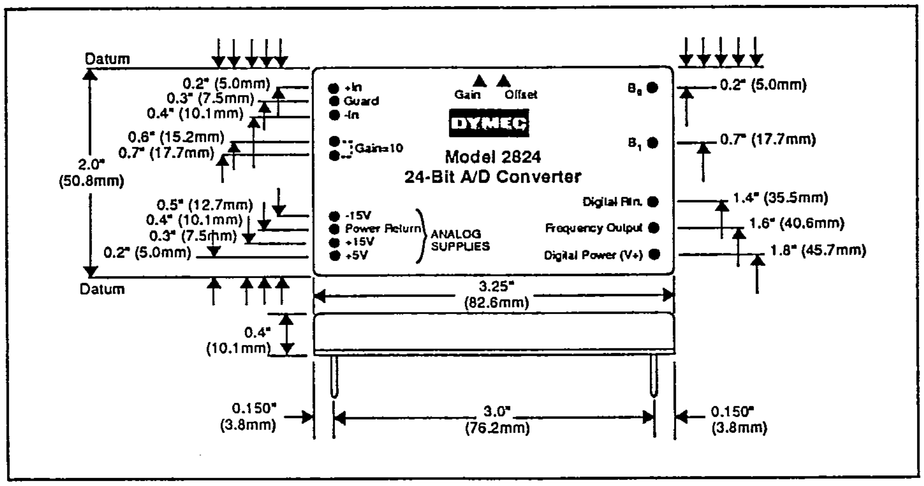


Figure 5. Typical Connection Diagram

Using the 2824 (Continued)

high frequency clock (up to 50MHz with the 5024 Counter/Timer) is counted for a "gate time" whose length is a user-defined number of periods of the V/F output frequency. This provides very high sensitivity measurements at very low signal levels. Either frequency counting or period averaging can be chosen "on the fly" using the 2824/5024 to optimize sensitivity.

Mechanical Dimensions & Pinout



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