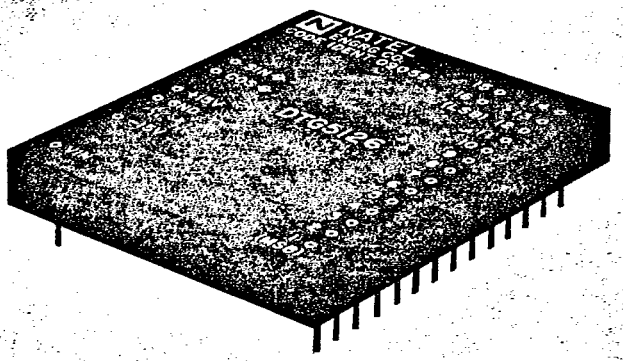
NATEL DTG5126

Digital Trigonometric (Vector) Generator 16-bit Four-Quadrant Multiplying SIN/COS DAC

Features

- **2 arc-minute accuracy**
- **16-bit resolution**
- **0.03% radius accuracy** (independent sin/cos accuracy)
- **Low offset** (suitable for dc application)
- **Very low temperature coefficient**
- **4 quadrant sin/cos conversion**
- **Internal voltage reference option**
- **Buffered reference input**
- **TTL/CMOS compatible**
- **Requires only ±15-V power supplies**
- **Priced at $345/USA price** (DTG 5126-160S)



Applications

PPI display
Axis rotation
Simulators
Vector resolution
Low distortion oscillator
Digital-to-resolver (synchro) converter
Precision phase modulation

Description

The DTG5126 is a versatile 4-quadrant multiplying digital-to-sin/cos converter. The converter accepts a digital input of up to 16 bits (CMOS or TTL compatible) and multiplies it with an analog voltage to generate trigonometric functions $V_{IN} \cdot \sin\theta$ and $V_{IN} \cdot \cos\theta$. V_{IN} is the analog input voltage and θ is the digital input angle. The external analog voltage can be an ac or dc reference with an amplitude of ±10 V peak.

The analog input is buffered through an operational amplifier to minimize loading of the input signal. The digital input switching thresholds are internally derived, thereby making it unnecessary to use a +5 V-dc logic supply.

The 5126 requires ±15 V-dc power supplies for its operation. Reverse polarity protection is provided for +15 V and -15 V supplies. In addition internal decoupling capacitors are used for the power lines. The outputs are short-circuit proof. Accidental shorting from the outputs to either power line or ground will not damage the converter.

Internal Reference Voltage

For applications requiring a fixed dc reference, the model 5126 is available with an internal dc reference source of either +5 V-dc or +10 V-dc. The outputs from the converter are 5 $\sin\theta$, 5 $\cos\theta$ or 10 $\sin\theta$, 10 $\cos\theta$ depending upon the option selected.

Accuracy

Model DTG5126 offers an angular accuracy of 2 arc-minutes. The exceptional high accuracy is achieved by a unique design approach that uses buffer amplifier circuits to eliminate the effect of analog switch resistance instead of requiring special compensating circuits. In addition, the converter offers a very low offset and excellent temperature characteristics that allow it to be used for applications requiring a dc or saw-tooth reference input.

Vector Accuracy

One of the outstanding features of the DTG5126 is its radius accuracy of ±0.03% which makes it an ideal choice for applications requiring independent true sine and cosine functions. Coordinate conversion and PPI (sweep) displays are examples of applications where the DTG 5126 would be an ideal choice.

Resolution

For applications requiring resolution of less than 16-bits the unused LSBs must be connected to ground. For existing designs, the appropriate option may be selected (see ordering information) and the unused bits will be internally grounded and unused LSB input pins will be removed. Accuracy of the outputs is not affected by reducing the resolution of the converter. All other specifications remain the same.

Theory of Operation

The operation of the Model 5126 is illustrated in the functional block diagram of figure 1. Either external reference voltage (ac or dc) or an optional internal reference voltage (5 or 10 V-dc) is buffered through an operational amplifier. Digital inputs are applied to a level shifter before processing.

The digital input code is natural binary angle. The two most significant bits (Bit 1 = 180°, Bit 2 = 90°) determine the quadrant information. Bits 3 through 16, containing angular information together with buffered reference voltage, are applied to two function generators. The operation of the function generators is very similar to a 4-quadrant multiplying DAC. Like a conventional DAC, the 5126 uses resistive ladder networks and solid state switching to control the attenuation of the reference voltage. The ladder networks, however, are designed to attenuate the input reference proportional to the sine and cosine of the digital input angle.
A unique approach is used in the design of ladder networks to obtain high accuracy in the sine and cosine generation so that they can be used as independently accurate functions. The outputs of function generators are then applied to a quadrant select network to obtain true sin θ and cos θ outputs.

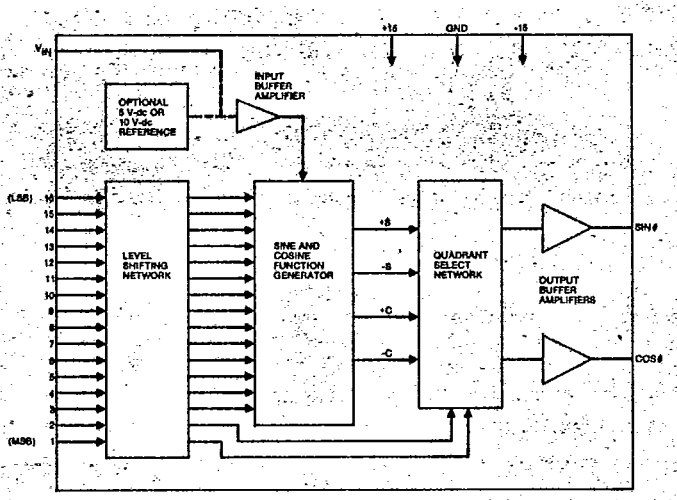
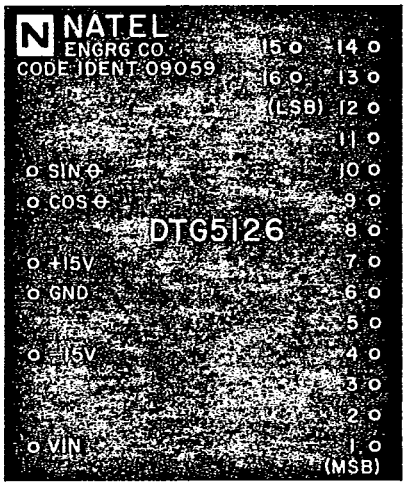


FIGURE 1 Block Diagram Model DTG5126

Pin Designations



1-16	Digital Angle Input 1 is MSB = 180 degrees 16 is LSB = 0.0055 degree
V_{IN}	Analog Reference Input (No connection for internal reference option)
+15 V, -15 V	Supply Voltages
GND	Power Supply Ground Digital Ground Analog Signal Ground
SIN θ , COS θ	Output Analog Signals

Specifications

PARAMETER	VALUE
Digital Input (θ)	TTL/CMOS Compatible (0.1 TTL Load)
Resolution	16 bits (0.33 arc-minutes) MSB = 180°, LSB = 0.0055°
Analog Input (V_{IN})	0 to ± 10 V peak ac or dc
Frequency Input Impedance	dc to 10 kHz 5 MΩ minimum
Analog Outputs	$V_{IN} \cdot \sin\theta$, $V_{IN} \cdot \cos\theta$
Internal Ref. Voltage (option -1) Internal Ref. Voltage (option -2) Angular accuracy Radius accuracy Output scaling accuracy Scale TEMPCO (Ext. Reference) Scale TEMPCO (Int. Reference) Output impedance Zero offset Offset drift	5 Sin θ , 5 Cos θ 10 Sin θ , 10 Cos θ ±2 arc-minutes ±0.03% ±0.03% 5 PPM/°C of FSR 15 PPM/°C of FSR 100 mΩ 2.5 mV 25 μV/°C
Dynamic Characteristics (settling time)	
Analog step Input (10 V step) Digital step Input (90°) Slew - rate	10 μsec to 0.1% 10 μsec to 0.1% 2.5 V/ μsec
Power Supplies	Reverse Voltage Protected
Supply Voltages Supply Currents Supply Rejection	±15 V-dc ±10% ±30 mA maximum 80 dB typical
Physical Characteristics	
Size Weight	3.125 x 2.625 x .42 inch (79.4 x 66.7 x 10.7mm) 3 oz (85 grams) Typical

Absolute Maximum Ratings

Reference Input ..... $-V_S$ to $+V_S$
Power Supply Voltages ($\pm V_S$) ..... ±18 V-dc
Digital Inputs ..... -0.3 V-dc to 7 V-dc
Storage temperature ..... -55° C to +135° C

Applications Using DTG5126

ACP to PPI Waveform Generator

Figure 3 shows how the DTG5126 may be applied to radar antenna systems using incremental shaft encoders. The encoder input provides Angle Change Pulses (ACPs) that are converted to sine/cosine dc signals suitable for rotating the sweep on a PPI-type display. An Azimuth Reference (or North Reference) pulse input is usually available to insure that errors due to spurious noise on the ACP line are not accumulated in the conversion process. In most such applications 4096 ACPs represent 360 degrees of azimuth rotation. If your application requires different scaling contact a Natel Applications Engineer.

Some display applications require dc sine and cosine voltages to be modulated by a ramp signal proportional to sweep length. These applications are accomodated by DTG5126 with external reference option.

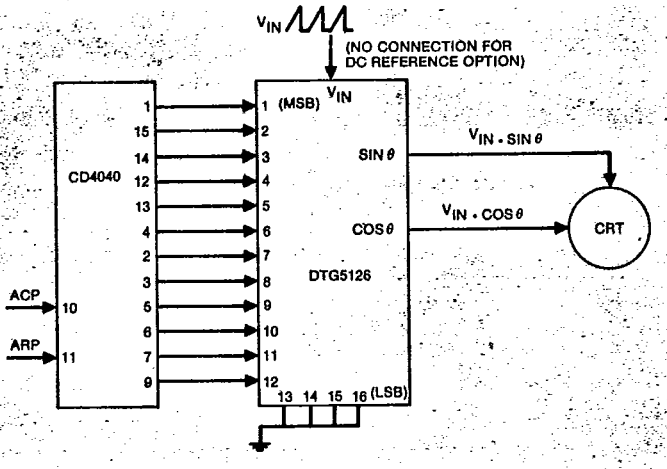


FIGURE 3 PPI Waveform Generation Using DTG5126

Coordinate Conversion and Transformation

Many aircraft, space vehicles, ships and other moving platforms require the information generated in one coordinate system to be transformed into another coordinate system. For example, the position of a satellite launch vehicle is initially measured by a ground tracking station in polar coordinates. To "HAND-OFF" position information to another tracking site, transformation to rectangular coordinates is required. The transformation of coordinates shown in figure 4 is easily accomplished by using two DTG5126 (figure 5) to implement the transformation equations:

$$X = R \cdot \cos\phi \cdot \cos\theta$$
$$Y = R \cdot \cos\phi \cdot \sin\theta$$
$$Z = R \cdot \sin\phi$$

The input voltage, R, corresponds to the system tracking range. Digital angles θ and ϕ are the tracking system Azimuth and Elevation respectively.

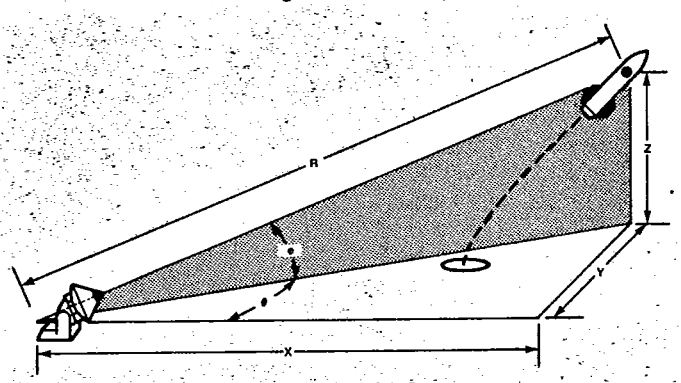


FIGURE 4 Polar to Rectangular Coordinates Transformation

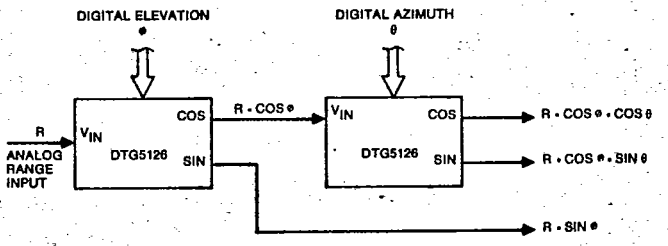


FIGURE 5 3-Dimensional Polar-to-Rectangular Conversion

Two-dimensional coordinate transformation. In the missile application of figure 6, components of velocity measured with an inertial navigator must be transformed into components relative to the roll pitch axis of the vehicle. This transformation is implemented by using two DTG5126s connected as shown in figure 7. Inertial velocity components obtained from the inertial navigator are applied to the reference inputs of two 5126s. The resulting components are summed in two external operational amplifiers, the outputs of each operational amplifier represent the velocity components in the Roll, Pitch coordinate system (often referred to as the "Body Coordinate System").

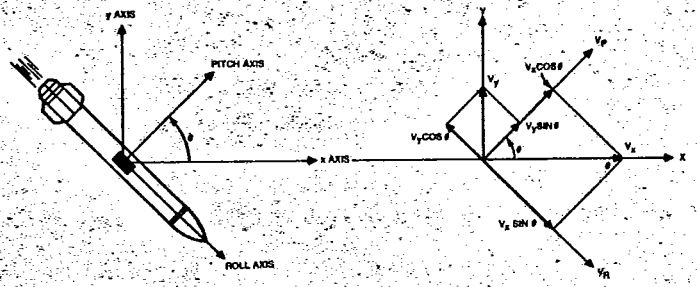


FIGURE 6 x,y-to-Roll, Pitch Coordinate Transformation

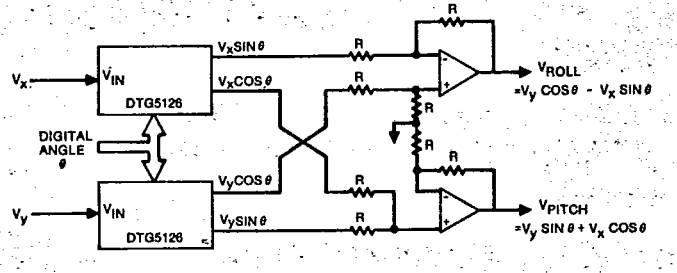
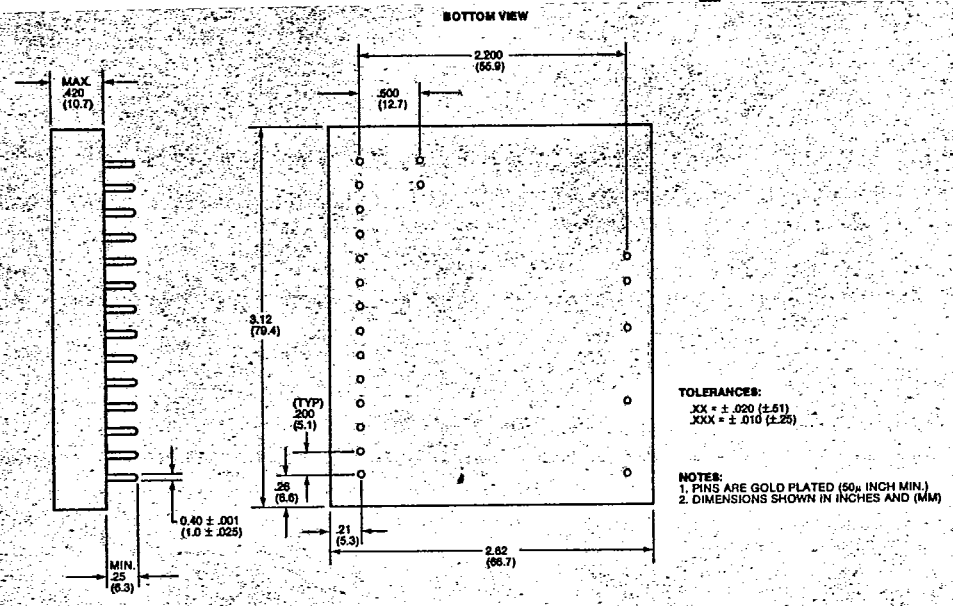


FIGURE 7 2-Dimensional Coordinate Transformation



Mechanical Outline

Ordering Information

DTG5126 — T B R M

Temperature Range
1 = 0° C to +70° C
3 = -55° C to +105° C

MIL Specification
S = Standard
B = MIL-STD 883B
C = MIL-STD 883C

Resolution Bits
6 = 16-bits
4 = 14-bits
2 = 12-bits

Reference
0 = External
1 = +5 V-dc Internal
2 = +10 V-dc Internal

A wide range of other SYNCHRO CONVERSION products and application assistance is available from Natel. Application Notes can be requested when available ..... and Natel's applications engineers are at your disposal for specific problems.

Other Synchro Conversion products available from Natel

36-PIN DDIP HYBRIDS

- 16-bit microprocessor-compatible Digital-to-Synchro/Resolver converter, with double buffered inputs and 1 arc-minute accuracy (HDSR2006).
- 14-bit Digital-to-Synchro/Resolver converter that is pin-compatible with existing designs, with transformation and angular accuracy improvement of a factor of 2 to 4 (HDSR2504).
- 16-bit microprocessor-compatible Synchro/Resolver-to-Digital converter, with 3-state outputs, operating from a single +5-V power supply (HSRD1006)

DISCRETE MODULES AND SYSTEMS

- Two-speed logic combiner with 20-bit, 3-state output, in a 1.3 x 2.6 x .35 inch size (TSL1X36)
- 14 and 16-bit Digital to Synchro/Resolver converters, with internal power amplifiers (5012, 5112, 5116)
- High power Synchro/Resolver Drivers
- 10 to 20-bit single-speed Synchro-to-Digital converters.

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