5090A

DATA AND SPECIFICATIONS
DESCRIPTION AND INSTRUCTIONS

T-73-41

Optical Electronics Incorporated

POLAR-TO-CARTESIAN COORDINATE CONVERTER

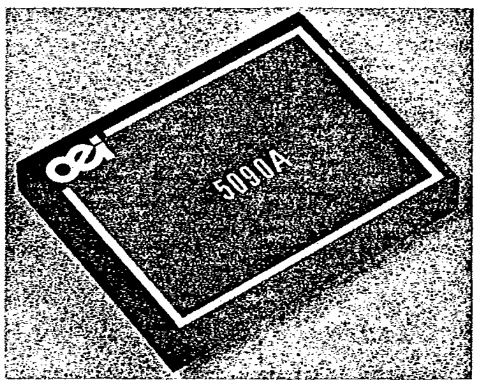
FEATURES
- R sin Θ, R cosine Θ
- FREQUENCY RESPONSE: DC-300KHz
- SLEW RATE: 3.0V/μsec
- OUTPUT: ±10V, ±10mA

APPLICATIONS
- WELL DRILLING EQUIPMENT
- SERVO SYSTEM
- FUNCTION GENERATION

DESCRIPTION
The 5090A is one of a series of devices designed by OEI for image manipulation. This one will translate from a polar coordinate system to a cartesian system. Every point of the input function is translated such that an angle, Θ, and a radius, R appear converted to R sin Θ and R cos Θ. In operation, the voltage representing the angle is converted to two voltages which then represent the sine or cosine of the angle. These voltages are fed, together with the voltage representing the radius R, to separate analog multipliers. These, then, multiply the two functions to arrive at the voltages representing R sin and R cos at their respective outputs.

Included in the device are two stable voltage references at +10V and -10V which enable the designer a ±10mA reference drive current. The radius information can be connected to either source which will provide the possibility of setting the R sin Θ and R cos Θ function to their maximum level of ±10V.

The phase or angular input determines not only the position, but also the rate of speed at the output. For instance, to obtain a true sine or cosine representation at the output, the angular information must be applied to the input in a linear form. This can be a triangle or a sawtooth with linear slopes. The sign on the voltage representing the radius determines whether the



output is in the positive or negative portion of a circle, i.e. positive voltage will allow a sweep in the +180° arc, a negative voltage will give the same sweep in the -180° arc. If the phase voltage cycles from 0 to +10V, then the complete 180° arc will be swept. If this voltage is less than 10 volts, an angle corresponding to 18° per volt will be available at the output. If the output were connected to the vertical and horizontal inputs of a CRT display respectively, the beam would describe a full circle, or, with phase voltages of less than ±10V, a partial circle. The radius of the circle is dependent on the voltage representing R

SPECIFICATIONS

ELECTRICAL

Specifications at T_A = +25°C, V_{CC} = ±15VDC unless otherwise noted.

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MODEL		5090A			
PARAMETER	**CONDITION**	**MIN**	**TYP**	**MAX**	**UNITS**
TRANSFER FUNCTION					
		Eoc = Rcos θ Eos = Rsin θ −180°<θ< 180°			
RATED OUTPUT					
Voltage Current Output Resistance	Io = ±10mA, R_L = 1KΩ Vo = ±10V, R_L = 1KΩ	±10 ±10		 1	V mA Ω
DYANMIC RESPONSE					
Trignometric Functions Small Signal Bandwidth Multiplier Small Signal Bandwidth Trignometric Functions Large Signal Bandwidth Multiplier Large Signal Bandwidth Output Slewing Rate		300 1 30 50 3.0			KHz MHz KHz KHz V/µsec
REFERENCE VOLTAGE					
			±10.0		V
INPUT OFFSET VOLTAGE					
Input Offset Voltage-R Input Input Offset Voltage Drift Output Offset Voltage Output Offset Temperature Coefficient Power Supply Sensitivity				±20 ±1 ±20 ±2 ±25	mV mV/°C mV mV/°C mV/V
ERROR					
Sine Error Cosine Error Multiplication Error Total Error			 0.3	0.3 0.3 0.5 0.5	% % % %
INPUT					
Angle θ Resistance Angle θ Voltage Range Radius Resistance Radius Voltage Range[2] Maximum Voltage Without Damage		100 ±10 3 ±10 $\pm V_S$			MΩ V MΩ V V
INPUT VOLTAGE RANGE					
θ Input R Input	Linear Operation	±10 ±10			V V
POWER SUPPLY					
Rated Voltage Current, Quiescent		±14	±15	±18 ±80	V mA
TEMPERATURE RANGE					
Operating Range Storage Range Thermal Resistance of Module Quiescent Temperature Rise		-55 -65		+85 +100 10 13	°C °C °C/W °C Above Ambient

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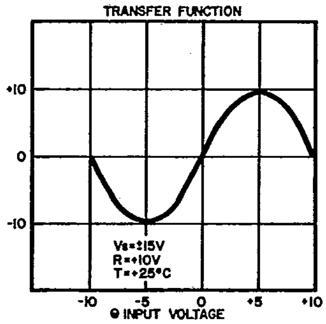
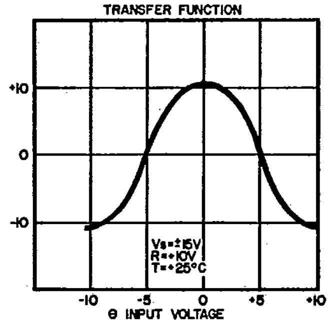
5090A
TYPICAL PERFORMANCE CURVES
(T_A = +25°C, V_{CC} = ±15VDC unless otherwise noted)





and would, at 10 volts, have a diameter representing 20 volts.

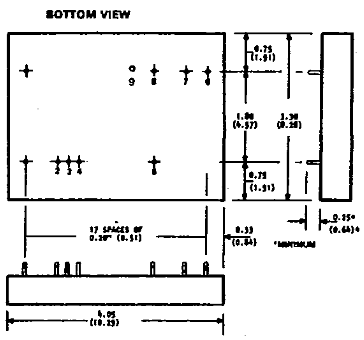
The frequency response limitation of the device is 30V/μs, therefore, transitions from DC to 500kHz can easily be accommodated.

The 5090A introduces only a very small error into any conversion. Sine and cosine errors are a maximum of ±0.3% of full scale. The maximum multiplication error is 0.5% of full scale and the total maximum error is also only ±0.5% of full scale with a ±0.3% typical. Input R-voltage and output offset voltages are ±20mV maximum. The input resistances for angle and radius are 100M ohm and 3M ohm minimum, respectively. These resistances provide a lot of freedom in designing with the devices without undue loading of preceding circuitry. The output load current at ±10 volts output voltage is ±10mA and provides good drive capability without additional buffers.

The power supply is internally compensated and no external compensation capacitors are needed.

The 5090A can be used wherever magnitude and angle need translation to cartesian coordinates of any point in the four quadrants. Applications such as laser steering for scribing, printer/plotter systems, and turret positioning come to mind, and the device is also useful as a function generator.

MECHANICAL DESCRIPTION: The 5090A uses an epoxy encapsulant and is enclosed in a glass-fiber-filled diallyl-phthalate case. Its pins are goldplated per MIL-G-45204, type 2, Class 2. They are 0.040 inches (0.102 cm) in diameter.



Dimensions in inches and (centimeters).

PIN CONNECTIONS
1 +Vs
2 +10VR
3 (-) IN
4 −10VR
5 A-IN
6 -Vs
7 A-O
8 B-IN
9 B-O
10 COMMON

APPLICATIONS

The 5090A is an analog device that is designed for rapid translation from a polar coordinate system to a cartesian system. Any point in the polar system, which is described by the phase angle Θ and a radius R, can quickly be described by the X and Y coordinates R sin Θ and R cos Θ in any of the four quadrants. These functions could, of course, be performed by a digital system, but the ease of application and the fact that no software need be developed, add to the attractiveness of this device. As can be seen from the functional block diagram in Figure 1, the 5090A consists of two pairs of parts that operate on two input voltages. These voltages represent the angle Θ and the radius R. The voltage representing the angle could come from a direction indicator a rotating system might provide. The voltage simulating R could be picked off from a linear potentiometer.

The phase voltage is first translated into two voltages of a sine and a cosine function. These, in turn, are applied to two independent multipliers.

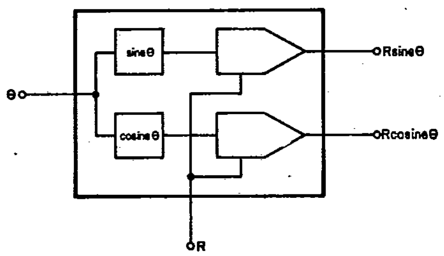


FIGURE 1: FUNCTIONAL BLOCK DIAGRAM

The voltage for the magnitude R is applied to the two multipliers to give the two output voltages their relative magnitudes. Voltages representing R sin Θ and R cos Θ are then available at the output. In addition, the sine and cosine of the input angle are also available at the device.

These kinds of translations have been available from electromechanical devices, such as potentiometers with especially shaped resistance paths for a long time. However, being basically mechanical in nature, they have the speed limitations inherent in this kind of mechanization. Also, mechanical devices wear, a consideration not applicable to electronic parts. Since this device is capable of coordinate translation to 500kHz, it outperforms any mechanical device easily. Furthermore, the 5090A can operate with negative voltage values, which is not possible with potentiometers with any reasonable effort. (It should be noted that operation with negative voltages, though possible, is not guaranteed for the 5090A.)

Figure 2 shows the basic connections to the device. The input voltages for the angle Θ and the radius R are applied to pins 3 and 5, respectively. The internal voltage reference sources of +10V and -10V appear on pins 2 and 4, respectively. These two voltage references can be used in application of the 5090A or for other reference voltages that might be necessary in the system.

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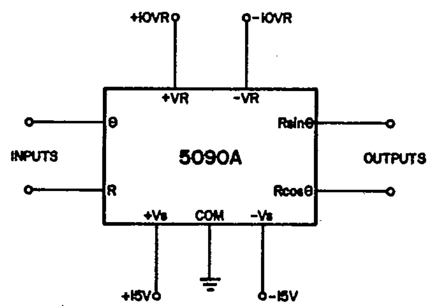

Remember the +VR and -VR pins are voltage sources and provide ±10 volt references for use throughout the system.

FIGURE 2: BASIC CONNECTIONS

The R input can be connected to either one of these reference voltages. This will enable the user to set the outputs of R sin Θ and R cos Θ to their maximum of +10V or -10V. The phase input determines position and also the speed or rate of information at the output of the device, depending on the input frequency. To obtain R sin Θ or R cos Θ, the phase input should be a linearly rising and falling triangular wave. The sign of the phase voltage determines the sign of the output. In other words, a voltage rise of 0 to +10V describes the positive +180°. Conversely, a negative going input describes the −180° of the angle. Thus a voltage varying between the maximum ±10V input would describe a circle of 20V diameter. If the voltage is less than the ±10V allowed, only a portion or segment of the circle is described. For example, a triangular wave of ±5V peak-to-peak would describe a half moon. The input voltage need not be triangular in shape. A ramp, spanning the required peak voltages, would do fine. However, the designer must remember to provide an extremely rapid flyback to prevent "ghosting". Typically, the 5090A can be found in radar displays where a translation of antenna rotation and distance to an object can better be seen in cartesian coordinates. This is particularly true for map overlays. The entertainment industry uses it for laser displays where the output of the two complementary functions of sine and cosine can be combined in a variety of ways. Also, the 5090A's can be combined with two operational amplifiers to construct a coordinate rotator as shown in Figure 3.

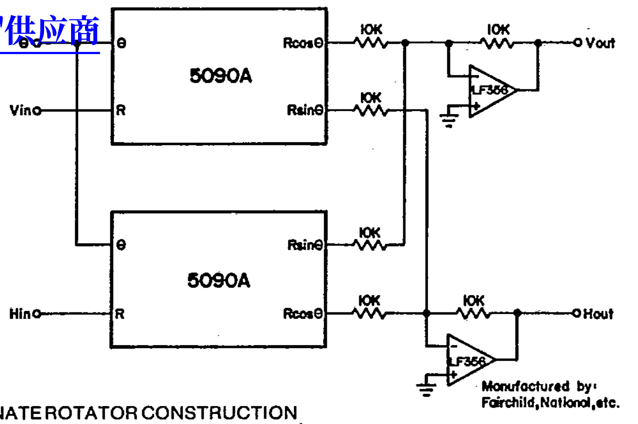

FIGURE 3: COORDINATE ROTATOR CONSTRUCTION

POLAR TO CARTESIAN COORDINATE CONVERTER FOR SERVO SYSTEM

Here, the angle input of the two OEI devices are tied together to provide synchronization on the output. The voltage representing vertical values is fed to the R input of the first 5090A. The horizontal representation is fed to the R input of the second 5090A. The cosine output of one is then combined with the sine output of the other device via 10K ohm resistors. These two new outputs are fed to the inverting input summing nodes of two unity gain operational amplifiers. The respective outputs of these amplifiers will then provide the opposite polarity of the inputs, i.e. the vertical output Vo is equal to the negative -Vin. The operational amplifiers can be used to scale the output by appropriate choice of gain in the leg to be scaled. Thus, either one or both outputs can be made to provide a larger or smaller representation of the input. Imaging systems of all kinds can take advantage of such an arrangement.

Other possible applications are servo systems and shaker systems that operate from sine wave functions such as are required by MIL-STD 781B. For the latter system, the ±30mA drive capability may need additional driver amplifiers, depending on the size of the shaker and weight of the product.

Laser scribers in the production of integrated circuits can also benefit from the translation capabilities of the 5090A. As depicted in Figure 4,

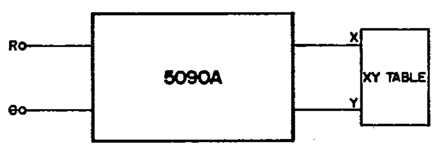

FIGURE 4: LASER SCRIBER FOR INTEGRATED CIRCUITS

either the table with the material to be scribed or the laser mount can be moved in an X-Y coordinate system.

Servo systems for other applications, such as printer/plotter combinations, can also apply the 5090A in a similar manner.

ANGLE MEASUREMENT

Since the 5090A is capable of coordinate translation, it can be used for measurement of angular displacement and can then provide angle and phase relationships in a readily measurable form. An example is shown in Figure 5.

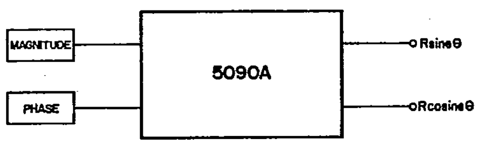

FIGURE 5: ANGULAR DISPLACEMENT

Other useful applications can be obtained with the 5090A as a function generator, shown in Figure 6. Here, the triangular signal is applied to the phase input, whereas the amplitude representation is input at the R pin of the device.

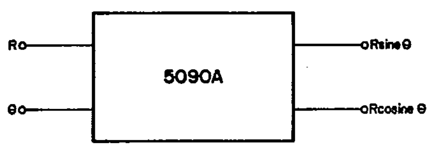

FIGURE 6: FUNCTION GENERATOR

The outputs then represent the sine and cosine which can be used in a variety of applications.