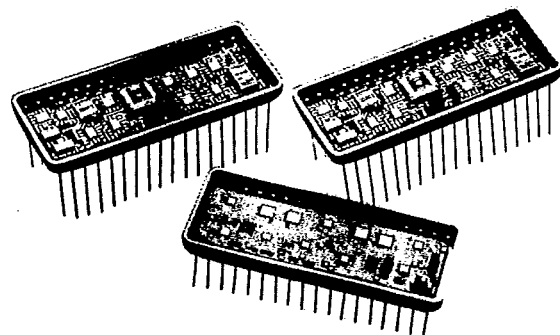


HYBRID TWO-SPEED TRACKING CONVERTER

Resolution to 20 Bits; Any Speed Ratio



FEATURES

- **THREE STANDARD HYBRID MODULES PLUS DISCRETE COMPONENTS WIRED BY CUSTOMER TO DETERMINE SPEED RATIO AND RESOLUTION**

DESCRIPTION

The HSDC-360 is an application of the hybrid control transformer and data processor modules in the HSDC-14 to form a two-speed tracking converter. A circuit diagram with a list of discrete components is provided so that a crossover detector and other required circuit elements can be added to two standard hybrid control transformer modules and one standard data processor module. The additional components and their interconnections determine the speed ratio and resolution of the converter. The circuit for a 1 and 36 speed converter with 16 bit output is described in the data sheet; circuit diagrams for other speed ratios and resolutions will be supplied on request.

The HSDC-360 has most of the characteristics listed in the description of the HSDC-14, including ratiometric conversion, phase sensitive detection, broadband inputs, and DC analog velocity output. The power supply voltage ranges are the same, and the -15V power supply can also be eliminated with a trade-off reduction in the maximum tracking rate.

The accuracy of the HSDC-360 depends on the speed ratio and resolution, and on whether standard or high-accuracy control transformers are used. For a 16 bit, 1 and 36 speed converter the accuracy can be as high as ± 1.2 LSB, including the ± 1 LSB quantizing error.

APPLICATIONS

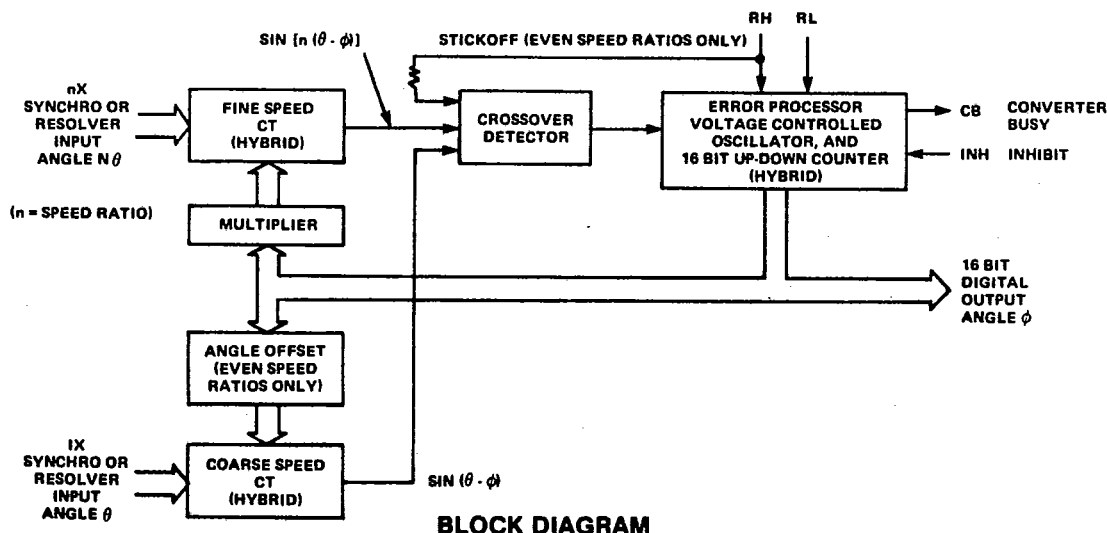
The HSDC-360 may be used wherever analog angle data from a two-speed synchro or resolver system must be converted rapidly and accurately to digital form for transmission, storage, or analysis. Because of the small size, low weight, low power requirement, and high MTBF of its hybrid components, the HSDC-360 is well suited for remotely located and hard to access equipment. All hybrid modules are processed to MIL-STD-883 (burn-in is optional), and can be used in the most stringent industrial and military ground or avionics applications. Designed for printed circuit board mounting by standard techniques, the HSDC-14 can be readily incorporated into other equipment for computer control.

- **SIGNAL AND REF. INPUTS:**
Internal solid state isolation or external isolation transformers
All common synchro and resolver L-L voltage levels and frequencies

- **LOGIC:**
TTL and CMOS compatible
Up to 20 bit parallel binary angle output
Converter Busy and Inhibit

- **POWER REQUIRED:**
 $\pm 15V$ DC and logic voltage supply

*Patented



SPECIFICATIONS
T-71-35-03

Apply over reference amplitude, temperature, and power supply ranges; 10% signal amplitude variation; and up to 10% harmonic distortion in the reference.

PARAMETER	VALUE	PARAMETER	VALUE
RESOLUTION	16 to 20 bits	60 Hz TRANSFORMERS	
ACCURACY Depends on Speed Ratio, Resolution and Whether Option "a" (± 2 min) Is Used Accuracy For 1:36 Speed Ratio and 16 Bit Resolution	± 4 min (or 2 min) speed ratio ± 0.9 LSB ± 0.45 min with standard CT ± 0.39 min with high accuracy CT	Reference Transformer (Optional for Both Solid State and Voltage Follower Input Options)	
SPEED RATIO	Any speed ratio can be accommodated by an appropriate multiplier and angle offset made with discrete components. Consult factory for circuit diagram.	Carrier Frequency Range	47 – 440 Hz
SIGNAL AND REFERENCE INPUT		Input Voltage Range	80 – 138V rms; 115V rms nominal
SOLID STATE BUFFER INPUT (HSCT AND HRCT UNITS)		Input Impedance	600 K Ω min, resistive
Carrier Frequency Range	47 – 1000 Hz	Input Common Mode Voltage	± 500 V rms, transformer isolated
Synchro and Resolver Input Characteristics		Output Description	+R (in phase with RH-RL) and -R (in phase with RL-RH) derived from op-amps. Short circuit proof. 3.0V nominal riding on DC reference V. Output voltage level tracks input level.
Voltage Options and Minimum Input Impedance (Balanced)		Output Voltage	4 mA typ, 7 mA max from +15V supplies.
		Power Required	
		Signal Transformer	
		Carrier Frequency Range	47 – 440 Hz
		Input Voltage Range	10 – 100V rms; L-L 90V rms L-L nominal
		Input Impedance	148 K Ω min L-L balanced resistive
		Input Common Mode Voltage	± 500 V rms, transformer isolated
		Output Description	Resolver output $\pm$ sine ($\pm S$) and $\pm$ cosine ($-C$) derived from op-amps. Short circuit proof 1.0V rms nominal riding on DC reference V. Output voltage level tracks input level.
		Output Voltage	4 mA type 7 mA max from +15V supply
		Power Required	
		DIGITAL INPUT/OUTPUT	
		Logic Type	TTL/DTL/CMOS compatible, depending on logic supply voltage
		Outputs	
		14 Parallel Data Bits	Natural binary angle positive logic
		Converter Busy (CB)	1.5 – 3 μ s positive pulse, leading edge initiates counter update
		Drive Capability	2 or 4 standard TTL loads
		Inhibit Input (INH)	$Z_{IN} > 80$ K Ω pull-up resistor to V_M (V_M = logic supply voltage or ± 15 supply voltage. See Interconnection Diagrams.)
		ANALOG OUTPUTS	
		Internal D.C. Ref. (V)	+3.9 VDC nominal
		AC Error Voltage (θ)	0.38 mV rms per LSB of error
		DC Error Voltage (E)	± 1 VDC per $\pm$ LSB of error
		DC Velocity Voltage ($\dot{\theta}$)	
		For 16 Bit Resolution	+1.0V DC per $+112^\circ$ /sec at 400 Hz
		For Higher Resolutions	+1.0V DC per $+28^\circ$ /sec at 60 Hz
			Scales according to number of bits. At 400 HZ for instance, a 1.0V DC θ output corresponds to 28 $^\circ$ /sec at 16 bits and 7 $^\circ$ /sec at 20 bits.
		DYNAMIC CHARACTERISTICS	
		Input Rate For Full Accuracy	
		For 16 Bit Resolution	
		At 400 Hz	0 to ± 2.5 rps min
		At 60 Hz	0 to ± 0.625 rps min
		For Higher Resolutions	Maximum input rate scales according to number of bits: 1/4 at 18 bits, and 1/16 at 20 bits.
		Velocity Constant	$K_V = \infty$ (No limitation with Type II servo loop)
		Acceleration Constant	
		At 400 Hz	$K_a = 58,000$ sec $^{-2}$ nominal
		At 60 Hz	$K_a = 3,600$ sec $^{-2}$ nominal
		Settling Time	
		For Normal Tracking	No lag error up to specified input rates
		For 179 $^\circ$ Step Change with 1:36 Speed Ratio	
		At 400 Hz	270 msec typ to 1 LSB
		At 60 Hz	350 msec max to final value
		For 179 $^\circ$ Step Change With Other Speed Ratio	1080 msec typ to 1 LSB
			1400 msec max to final value
			Consult factory. Depends on slew rate and small signal settling time.
VOLTAGE FOLLOWER INPUT (FOR HXCT UNITS)			
Carrier Frequency Range	47 – 1000 Hz		
Voltage Range			
$-V_S = 0$ V	1V rms nominal; 1.15V max; 0.1V min		
$V_L = +6.2$ and $-V_S = -7$ V	3V rms nominal; 3.5V max; 0.1V min		
Max Voltage Without Damage	15V rms continuous		
Input Impedance	100V peak transient		
	$Z_{IN} > 10$ M Ω (transient protected voltage follower)		
TRANSFORMER CHARACTERISTICS (FOR HXCT UNITS)			
400 Hz TRANSFORMERS			
Reference Transformer (Optional for Both Solid State and Transformer Input Options)			
Carrier Frequency Range	Option 4 = 360 – 1000 Hz		
Voltage Range	18 – 130V		
Input Impedance	40 K Ω min		
Breakdown Voltage to GND	1200V peak		
Signal Transformer			
Carrier Frequency Range	Option 4 = 360 – 1000 Hz		
Minimum Input Impedances (Balanced)			
	Synchro Z_{IN} (Z_{50})	Resolver Z_{IN}	
90V L-L (Option 4H)	180 K Ω	100 K Ω	
26V L-L (Option 4M)	—	30 K Ω	
11.8V L-L (Option 4L)	20 K Ω	30 K Ω	
Breakdown Voltage to GND	700V peak		



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HSDC-360*

TECHNICAL INFORMATION

T-71-35-03

INTRODUCTION

The applications information for the HSDC-360 has much in common with that for the HSDC-14, since the same control transformer and data processor modules are used. The HSDC-14 data sheet will be referenced frequently to avoid repeating information and diagrams.

The block diagram shows the main components of the HSDC-360. The multiplier, angle offset, stickoff resistor, and crossover detector are composed of discrete components.

The operation of a two-speed S/D is essentially the same as a single speed except there are two control transformers (CT) which generate two error voltages. These two CTs are fed by a common up-down counter with the counter data multiplied by the speed ratio for the fine speed CT.

Assuming an off-null condition, as when the system is first energized, the crossover detector feeds the coarse (1X) CT error signal output to the demodulator and error processor. The converter seeks a null as it would for a single speed S/D. As null is approached (to within 2.5° nominally) the coarse CT output drops below a preset threshold and the crossover detector then switches the fine speed CT error signal into the demodulator and error processor. Since the counter angle θ is multiplied by the speed ratio, the gradient of the fine speed CT is n times the coarse (1X) CT output. The servo loop then is able to seek an even finer null, using the fine speed CT error signal. The converter will continue to use the fine error signal for continuous tracking, switching back to the coarse signal only when the coarse error exceeds the crossover threshold. An angle offset and stickoff voltage are introduced in the coarse channel for even speed ratios in order to eliminate the false stable nulls which can occur when the fine and coarse speed angles are simultaneously at 180° .

MODULE INTERCONNECTIONS

A circuit diagram and list of components for a 16 bit 1:36 speed converter are given to illustrate the most common resolution and speed ratio. Interconnection layout is not critical. The analog outputs are derived from op-amps, have low output impedance, and are short circuit proof.

The output drive capability can be either 2 or 4 standard TTL loads as indicated in the Notes. The penalty for 4 TTL load capability is that the Inhibit input, which is internally connected to V_M by an 80 K Ω pull-up resistor, will be referenced to the +15V supply rather than to the logic supply voltage.

SIGNAL AND REFERENCE INPUTS AND TRANSFORMERS

All information listed under this section heading in the HSDC-14 data applies. Note especially the protective voltage suppressors that must be installed on all 90V L-L solid state input modules to prevent voltage transients from destroying the input resistor networks.

LOGIC INPUTS AND OUTPUTS

Logic outputs consist of 16 to 20 parallel data bits and a Converter Busy (CB). These outputs are short circuit proof to ground or to positive voltages as high as V_L .

Information about the Inhibit (INH) is given in the corresponding section of the HSDC-14 data.

ANALOG OUTPUTS

The analog outputs are V , e , E , and θ . V is an internal D.C. ground, +3.9V DC nominal, and is used as reference ground with the voltage follower buffer input option (HXDC). The other analog outputs, which ride on the D.C. reference V , are not used externally in normal operation.

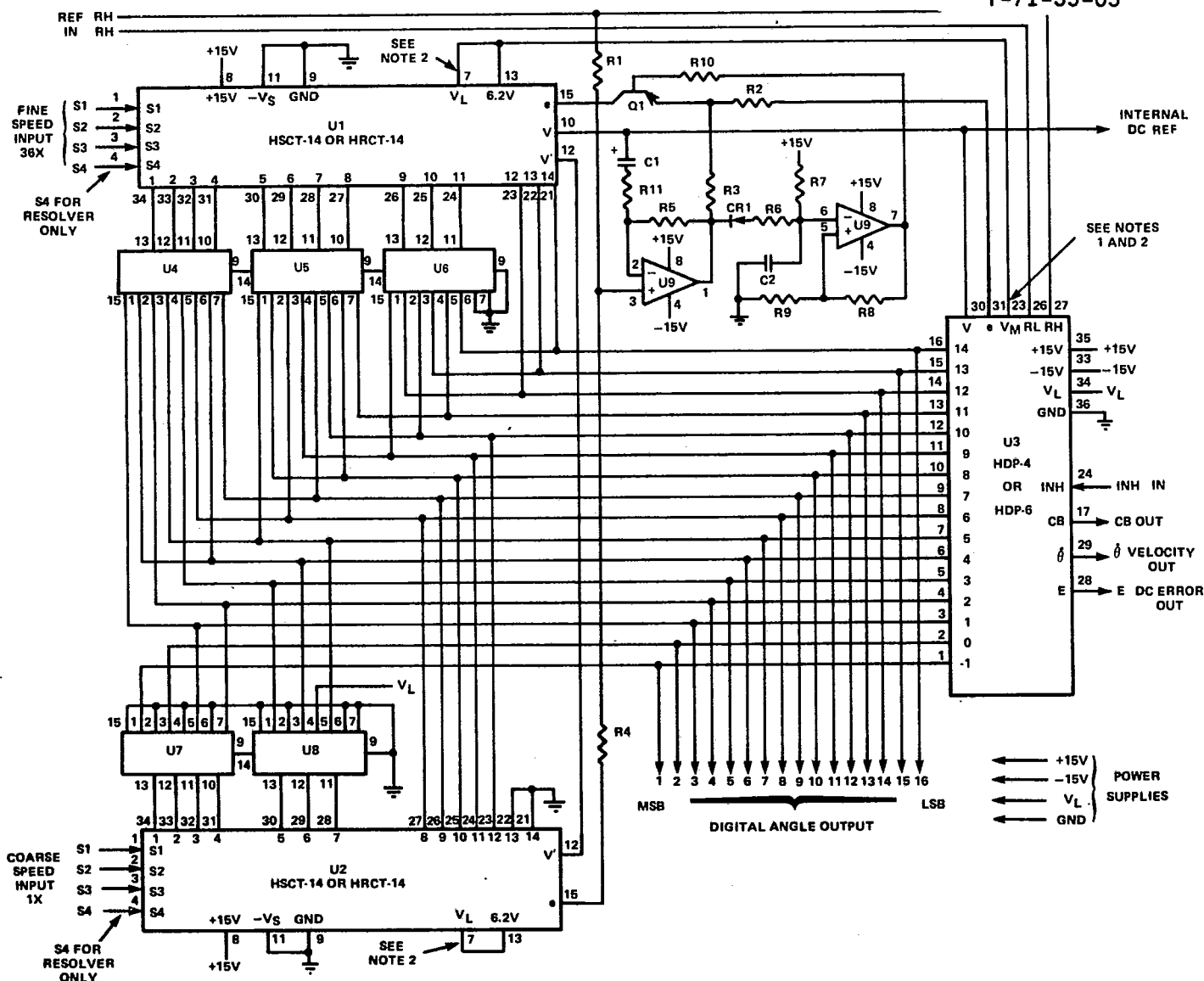
The HSDC-14 data sheet describes the characteristics of the analog outputs e , E , and θ . The only difference for the HSDC-360 is the scaling for the velocity output $\dot{\theta}$. This scaling is given in the HSDC-360 specifications table.

TIMING AND DYNAMIC PERFORMANCE

The discussion and diagrams in the HSDC-14 data sheet concerning timing and dynamic performance apply to the HSDC-360 without modification.

CIRCUIT DIAGRAM FOR 16 BIT, 1:36 SPEED CONVERTER

T-71-35-03



NOTES:

1. Digital output drive capability is normally 2 standard TTL loads. If logic supply $V_L = +5V$ for TTL interface and 4 unit load capability is desired, disconnect pin 23 (V_M) on U3 from 6.2V and connect it to +15V. Note that the Inhibit logic 1 is referred to V_M .
2. If the external logic supply voltage V_L is greater than 6.2V, do not connect pins 7 (V_L) on U1, U2 and pin 23 (V_M) on U3 to 6.2V. Instead, connect these three pins to the external logic supply V_L .
3. If signal isolation transformers are required, use HXCT-14 for U1, U2. See Interconnection Diagram in HSDC-14 data sheet for signal and reference transformer connections.

PARTS LIST:

- U1, U2 = DDC hybrid control Transformers } See ordering information
 U3 = DDC hybrid data processor
 U9 = 4558, dual op-amp
 R1 = Coarse speed stickoff. Value depends on reference voltage level. $R1 = 22\text{ M}\Omega$, 5% for 115V rms ref and $R1 = 5.1\text{ M}\Omega$, 5% for 26V ref.
 U4 - U8 = 4008, CMOS 4-bit adders.
 U4, U5, U6 form 36X multiplier
 U7, U8 form 1X angle offset
 Coarse and fine speed loop gain
 1% Resistors: $R2 = 80.6\text{ K}\Omega$; $R3 = 100\text{ K}\Omega$, $R4 = 10\text{ K}\Omega$;
 $R5 = 750\text{ K}\Omega$; $R11 = 10\text{ K}\Omega$
 $C1 = 10\mu\text{F}$, 6V DC
 Crossover Detector
 5% Resistors: $R6 = 1\text{ K}\Omega$; $R7, R8 = 1\text{ M}\Omega$, $R9 = 200\text{ K}\Omega$,
 $R10 = 30\text{ K}\Omega$
 $C2 = 0.1\mu\text{F}$ ceramic; CR1 - 1N4148
 Crossover Switch
 Q1 = 2N2946

SPECIFICATIONS		T-71-35-03	
PARAMETER	VALUE	PARAMETER	VALUE
TEMPERATURE RANGES		PHYSICAL CHARACTERISTICS	
Operating		Converter Module and Data Processor Module	
-1 option	-55°C to +125°C	Type	36 pin double DIP
-3 option	0°C to +70°C	Size	0.78 x 1.9 x 0.21 inch (2.0 x 4.8 x 0.53 cm)
Storage	-55°C to +135°C	Weight	1 oz max (28 g)
POWER SUPPLIES		400 Hz Transformer Modules	
Nominal Voltage	+15 VDC -15 VDC Logic Supply	Type	Encapsulated module. Signal input uses 2 modules (T1A and T2B) Ref uses 1 module (T2)
Voltage Range	+11 to +16.5V 0 to -16.5V +4.5V to +15 supply	Size	0.8 x 0.6 x 0.3 inch (2 x 1.5 x 0.8 cm)
Absolute Max Voltage	+18V -18V +18V	Weight	0.4 oz max (11 g)
Current or Impedance	70 mA max* 20 mA max* Z _{IN} - 10 KΩ min	60 Hz Transformer Modules	
*Does not include current required by 60 Hz active transformers.		Type	Encapsulated module. Signal transformer and reference transformer each consist of one such module
		Size	1.125 x 1.125 x 0.42 inch (2.86 x 2.86 x 1.07 cm)
		Weight	0.7 oz max (20 g)

ORDERING INFORMATION

Order two hybrid control transformers and one hybrid data processor. DDC does not supply the discrete components for the angle multiplier, angle offset, and stickoff.

- Order two control transformers as follows. These units operate over the full 47-1000 Hz frequency range. Transformers for HXCT-14 units must be ordered separately as described below.

HSCT-14-H-1-a-883B

Reliability Grade:

883B = Fully compliant with MIL-STD-883.

B = Screened to MIL-STD-883 but without QCI testing.

Blank = Standard DDC procedures.

Accuracy:

Blank = ±4 minutes
a = ±2 minutes

Temperature Range (Operating):

1 = -55°C to +125°C
3 = 0°C to +70°C

Voltage Levels:

- Synchro solid state input (HSCT):

H = 90V L-L
L = 11.8V L-L

- Resolver solid state input (HRCT):

H = 90V L-L
M = 26V L-L
L = 11.8V L-L

- Voltage follower input (HXCT):

Omit voltage level specification.
One HXCT model accepts all normal voltage levels.

Resolution = 14 Bits

Input Type

HSCT = Solid state synchro

HRCT = Solid state resolver

HXCT = Voltage follower buffer. Requires external signal conditioner such as an isolation transformer.

- Order one data processor as follows:

HDP-4-1-883B

Reliability Grade:

883B = Fully compliant with MIL-STD-883

B = Screened to MIL-STD-883 but without QCI testing.

Blank = Standard DDC procedures.

Temperature Range:

1 = -55°C to +125°C
3 = 0°C to +70°C

Carrier Frequency Range:

4 = 360-1000 Hz
6 = 47-1000 Hz

- Isolation transformers for CT modules with voltage follower buffer inputs (HXCT-14) must be ordered separately by part number.

		Part Numbers			
Type	Frequency	Ref. Voltage	L-L Voltage	Ref. Xfmr.	Signal Xfmr.
Synchro	400 Hz	115V	90V	21049	21045*
Synchro	400 Hz	26V	11.8V	21049	21044*
Resolver	400 Hz	115V	90V	21049	21048*
Resolver	400 Hz	26V	26V	21049	21047*
Resolver	400 Hz	26V	11.8V	21049	21046*
Synchro	60 Hz	115V	90V	24133	24126*

*The part number for each 400 Hz synchro or resolver isolation transformer includes two separate modules as shown in the outline drawings.

MECHANICAL OUTLINES

Mechanical outlines, pin assignments, and schematic diagrams for the control transformer and error processor modules and for all transformers are available from the factory.