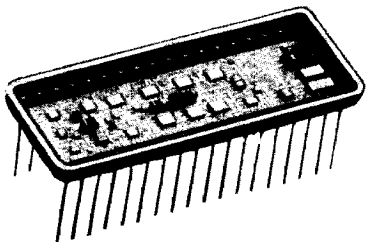


10 BIT HYBRID S/D AND R/D CONVERTER
Low Power, Hi Rel, Single 36 Pin DDIP

Replaced by HSDC 8915 for new designs

FEATURES

- *ONE HYBRID MODULE CONTAINS COMPLETE 10 BIT S/D OR R/D CONVERTER*
- *ACCURACY: ±21 minutes*
- *SIGNAL AND REF INPUTS:*
  Internal solid state isolation or external isolation transformers
  All common L-L levels and frequencies
- *LOGIC:*
  TTL and CMOS compatible
  10 bit parallel binary angle
  Converter Busy and Inhibit
- *POWER REQUIRED:*
  +15V DC and logic voltage supply

DESCRIPTION

A direct outgrowth of DDC's well-established Type II servo loop tracking converter technology, the HSDC-10 is accurate to ±21 minutes (±1 LSB in 10 bits). This accuracy, which includes quantizing error, is maintained under all static and dynamic conditions at speeds up to ±100 rps at 400 Hz (20 rps at 60 Hz). The accuracy is not affected by carrier amplitude variation because the conversion is ratiometric. Phase sensitive detection in the error loop rejects quadrature and noise. Adjustments and calibrations are never required.

The HSDC-10 accepts broadband inputs: 360 to 1000 Hz, or 47 to 1000 Hz. Separate input isolation transformers will seldom be required because the solid state signal and reference inputs are true differential with high AC and DC common mode rejection. The angular velocity of the synchro or resolver is indicated by a DC analog voltage output.

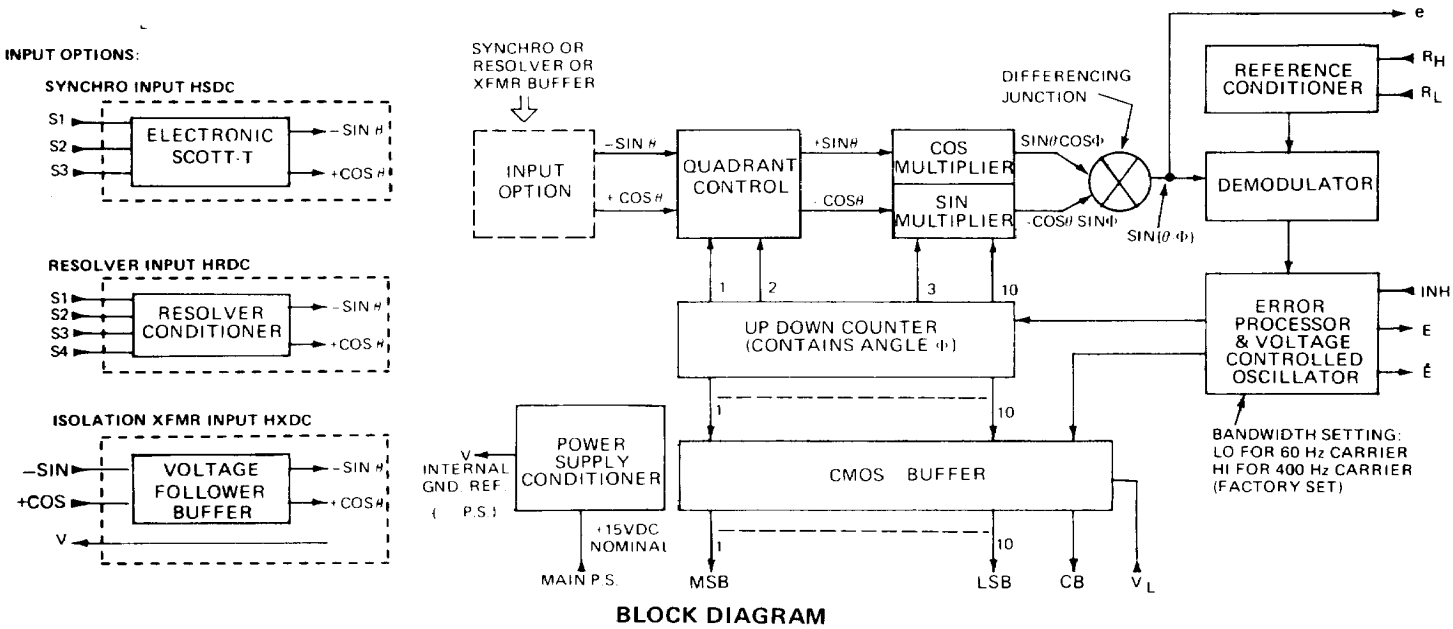
Fewer components and CMOS logic with low power consumption result in a significant improvement in reliability over former units. Predicted MTBF values are as high as 1.6 million hours.

APPLICATIONS

The HSDC-10 converters are ideal for remotely located and hard to access equipment where very low power requirements, unusually small size, and high MTBF are critical. Standard units are processed to MIL-STD-883.

These hybrids are well-suited to the most stringent and severe industrial or military ground and avionics applications. In conjunction with other devices, they are readily adapted for closed loop control. Designed for printed circuit board mounting by standard techniques, the HSDC-10 is easily incorporated by the OEM user.

The HSDC-10 Series can be used as a direct replacement for encapsulated S/D converter modules. A PC board mounted option is pin for pin compatible with standard S/D sockets.



BLOCK DIAGRAM

TECHNICAL INFORMATION

INTRODUCTION

The HSDC-10 Series are available either as a single hybrid module containing a complete converter with a solid state input, or as a combination of a hybrid converter module and separate signal and reference isolation transformers. As a standard option, both versions can be mounted on a PC board with a pinout identical to that of standard modular S/D converters. All styles accept a wide variety of synchro or resolver inputs, and have a 10 bit parallel data output, a Converter Busy and Inhibit for computer interfacing, and a DC analog velocity output.

As shown in the HSDC-10 block diagram, there are three types of inputs: an electronic Scott T for direct synchro input (HSDC); a signal conditioner for direct resolver input (HRDC); and a voltage buffer for either synchro or resolver isolation transformers (HXDC). Depending on the reference frequency and line voltage, there are actually three HSDC, three HRDC, or two HXDC input options. One of the eight options must be specified for each hybrid converter. An external signal isolation transformer is required for the HXDC input. Reference isolation transformers are optional for all three types of input.

When testing or evaluating the converter, it is advisable to limit the power supply currents as follows:

SUPPLY	CURRENT LIMIT
+15 VDC	20 mA
V_L	2 mA + Digital Output Load at Logic 1

INPUT SIGNALS

The solid state signal and reference inputs are true differential inputs with high AC and DC common mode rejection, so that separate isolation transformers will seldom be required. Input impedance is maintained with power off. The recurrent AC peak + DC common mode voltage range should not exceed the following values:

INPUT	COMMON MODE MAXIMUM	MAX TRANSIENT PEAK VOLTAGE
11.8V L-L	60V	150V
26 V L-L	60V	150V
90 V L-L	182V	350V
Reference	210V	1000V

90V line-to-line systems generally have voltage transients which exceed the 350V specification listed above. These transients can destroy the thin film input resistor network in the hybrid. Therefore, 90V L-L solid state input modules should always be protected by installing voltage suppressors as shown below.

SPECIFICATIONS

Over reference amplitude, temperature, and power supply ranges; 10% signal amplitude variations; and up to 10% harmonic distortion in the reference.

PARAMETER	VALUE
RESOLUTION	10 bits
ACCURACY	±21 minutes (Max)

SOLID STATE BUFFER INPUT (HSDC OR HRDC UNITS)

Frequency Ranges			
4 (400 Hz)	360 – 1000 Hz		
6 (60 Hz)	47 – 1000 Hz		
Reference Input			
Voltage Range	4 – 130V rms		
Input Impedance	300 KΩ min, single ended		
	600 KΩ min, differential		
Common Mode Range	DC common mode plus recurrent AC peak ÷ 210 max		
Synchro and Resolver Input Characteristics			
Voltage Ranges and Min Z_{IN} (Balanced)			
	Z_{IN} Line to Line	Z_{IN}, Each Line to GND	
Synchro (HSDC)			
90V L-L (Options 4H or 6H)	130 KΩ	85 KΩ	
11.8V L-L (Option 4L)	17.5 KΩ	11.5 KΩ	
	Z_{IN} Single Ended	Z_{IN} Differential	Z_{IN}, Each Line to GND
Resolver (HRDC)			
90V L-L (Option 4H)	175 KΩ	350 KΩ	175 KΩ
26V L-L (Option 4M)	50 KΩ	100 KΩ	50 KΩ
11.8V L-L (Option 4L)	23 KΩ	46 KΩ	23 KΩ
Common Mode Ranges			
For 90V L-L Input	182V max }	DC common mode	
For 26V and 11.8V Input	60V max }	plus recurrent AC peak	

VOLTAGE FOLLOWER INPUT (FOR TRANSFORMERS HXDC UNITS)

Carrier Frequency Range	47 – 1000 Hz
Reference Input Characteristics	
Voltage Range	4 – 130V rms
Input Impedance	300 KΩ min, single ended
	600 KΩ min, differential
Common Mode Range	DC common mode plus recurrent AC peak – 210V max
Sin/Cos Signal Input Characteristics	
Voltage Range	1V nominal, 1.15V max
Max Voltage Without Damage	15V rms continuous; 100V peak transient
Input Impedance	Z_{IN} 10 MΩ (transient protected voltage follower)

TRANSFORMER CHARACTERISTICS

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 KΩ 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_{SO})	Resolver Z_{IN}
90V L-L (Option 4H)	180 KΩ	100 KΩ
26V L-L (Option 4M)		30 KΩ
11.8V L-L (Option 4L)	20 KΩ	30 KΩ
Breakdown Voltage to GND	700V peak	

60 Hz TRANSFORMERS

Reference Transformer (Optional for Both Solid State and Voltage Follower Input Options)

Carrier Frequency Range	47 – 440 Hz
Input Voltage Range	80 – 138V rms; 115V rms nominal
Input Impedance	600 KΩ min, resistive
Input Common Mode Voltage	±500V rms, transformer isolated
Output Description	+R (in phase with RH-RL) and –R (in phase with RL-RH) derived from op-amps. Short circuit proof.
Output Voltage	3.0V nominal riding on ground reference V. Output voltage level tracks input level.
Power Required	4 mA typ, 7 mA max from +15V supplies.

SPECIFICATIONS

Over reference amplitude, temperature, and power supply ranges; 10% signal amplitude variations; and up to 10% harmonic distortion in the reference.

PARAMETER	VALUE
Signal Transformer	
Carrier Frequency Range	47 – 440 Hz
Input Voltage Range	10 – 100V rms L-L; 90V rms L-L nominal
Input Impedance	148 KΩ min L-L balanced resistive
Input Common Mode Voltage	±500V rms, transformer isolated
Output Description	Resolver output, + sine (+S) and – cosine (–C) derived from op-amps. Short circuit proof.
Output Voltage	1.0V rms nominal riding on ground reference V. Output voltage level tracks input level.
Power Required	4 mA typ, 7 mA max from ±15V supply.
DIGITAL INPUT/OUTPUT	
Logic Type	TTL/DTL/CMOS compatible, depending on V_L
Outputs	
10 Parallel Data Bits	Natural binary angle; positive logic
Converter Busy (CB)	2 to 4μs positive pulse; leading edge initiates update.
Drive Capability	4 standard TTL loads
Inhibit Input (INH)	Z_{IN} = 80 KΩ pull-up resistor to V_L Logic 1 allows tracking Logic 0/1 threshold = 0.27V_L ± 10%
ANALOG OUTPUTS	
Internal D.C. Refence (V)	½ positive power supply voltage (7.5 VDC nominal)
AC Error Voltage (e)	60 mv amplitude per LSB of error
DC Error Voltage (E)	–1 VDC per +LSB of error
DC Velocity Voltage (Ė)	+1 VDC per +23 rps at 400 Hz +1 VDC per +4.6 rps at 60 Hz
DYNAMIC CHARACTERISTICS	
Input Rate for Full Accuracy	
400 Hz Versions	0 to ±100 rps min at +15 VDC P.S.
60 Hz Versions	0 to ±20 rps min at +15 VDC P.S.
Velocity Constant	K_V = ∞ (Type II servo loop)
Acceleration Constant	
400 Hz Versions	K_a = 200,000 sec^{-2} min
60 Hz Versions	K_a = 10,000 sec^{-2} min
Settling Time	
For Normal Tracking	No lag error up to specified input rates
For 179° Step Change	
400 Hz Versions	To 1 LSB: 25 ms typ To Final Value: 65 ms max
60 Hz Versions	To 1 LSB: 140 ms typ To Final Value: 160 ms typ; 200 ms max
TEMPERATURE RANGE	
Operating	
-1 Option	–55°C to +125°C
-3 Option	0°C to +70°C
Storage	–55°C to +135°C

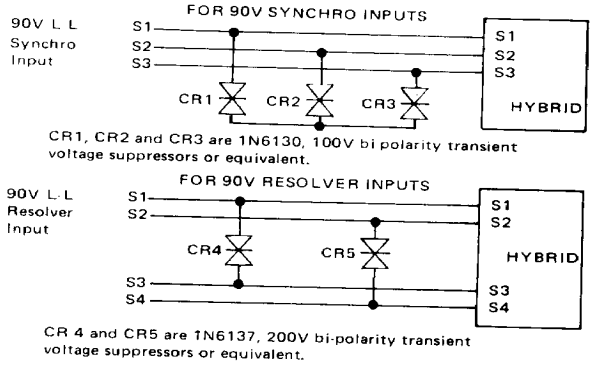
POWER SUPPLIES

	+15 VDC	Logic Supply V_L
Voltage Range	+11 to 16.5V	+4.5V to +15 supply voltage
Max Voltage Without Damage	0 to +18V	0 to +18V
Current or Impedance	15 mA max*	Z_{IN} = 10 KΩ min

*Does not include current required by active 60 Hz transformers.

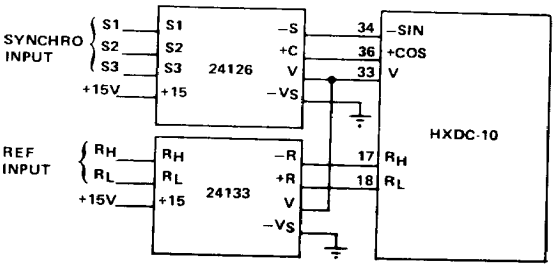
PHYSICAL CHARACTERISTICS

Converter Module	
Type	36 pin double DIP
Size	0.78 x 1.9 x 0.21 inch (2.0 x 4.8 x 0.53 cm)
Weight	0.85 oz typ (24 g)
400 Hz Transformer Modules	
Type	Encapsulated module. Signal input uses 2 modules (T1A and T2B). Ref input uses 1 module (T2).
Size	0.8 x 0.6 x 0.3 inch (2 x 1.5 x 0.8 cm)
Weight	0.4 oz max (11 g)
60 Hz Transformer Modules	
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)
P.C. Board Mounted Units	
Size	See Outline Drawing
Weight	
Without Transformers	1.4 oz max (40 g)
With 400 Hz Transformers	2.54 oz max (72 g)



CONNECTIONS FOR VOLTAGE TRANSIENT SUPPRESSORS

The 60 Hz signal and reference transformers 24126 and 24133 are active devices with op-amp outputs, and require connections to the power supplies as shown below. Active devices are provided because passive transformers require considerably more volume at 60 Hz than at 400 Hz.



CONNECTIONS FOR 60 Hz SYNCHRO AND REFERENCE TRANSFORMERS

ANALOG OUTPUTS

The analog outputs are V, e, E, and Ė. V is an internal D.C. Reference, 7.5 VDC nominal, and is equal to half the main power supply voltage. The outputs e, E, and Ė ride on the D.C. reference voltage V, and should be measured with respect to V. All three outputs can swing ±5 volts with respect to V.

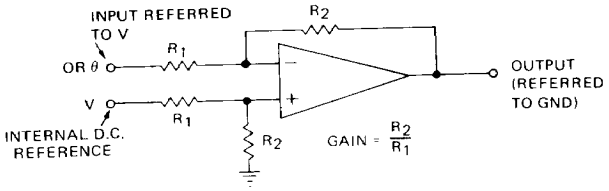
As indicated in the block diagram, e is the AC error voltage, sin $(\theta - \Phi)$ cos ωt. The amplitude of e is 60 mv rms per LSB of error.

E is a DC voltage proportional to the error $(\theta - \Phi)$ near the null point, with –1 VDC output per +LSB of error.

Ė is a DC voltage proportional to the angular velocity $d\theta/dt = d\Phi/dt$. A +1 VDC output corresponds to +23 rps for 400 Hz units, and +4.6 rps for 60 Hz units.

Maximum loading for each analog output is 1 mA. Outputs e, E, and Ė are not required for normal operation of the converter; V is used as reference ground with the external transformer option HXDC.

The following figure shows a difference circuit which may be used to reference the analog outputs with respect to normal ground instead of the internal D.C. reference V.

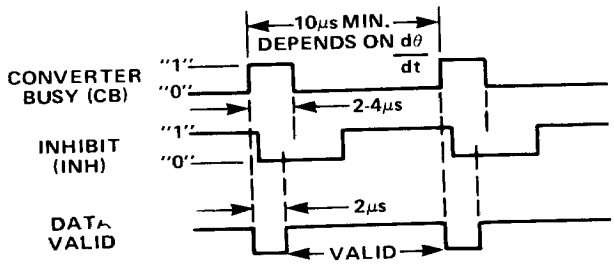


DIFFERENCE CIRCUIT FOR ANALOG OUTPUTS

TIMING

The diagram below shows the timing waveforms of the converter. Whenever an input angle change occurs, the converter changes the digital angle in steps of 1 LSB, and generates a converter busy pulse (CB). The output data change is initiated by the leading edge of the CB pulse. The output becomes stable in less than 2μs, even though the CB pulse may last longer.

The inhibit logic input INH may be used to stop the tracking process and hold the digital output constant during read-out. Extra CB pulses will not occur if the input angle changes while the counter is locked by the INH. The converter will ignore an inhibit command applied during the "busy" interval until that interval is over. A simple method of interfacing to a computer is to (a) apply the inhibit, (b) wait 2μs, (c) transfer the data, and (d) release the inhibit.



TIMING DIAGRAM

DYNAMIC PERFORMANCE

A Type II servo loop ($K_V = \infty$) and very high acceleration constants give the HSDC-10 superior dynamic performance, as listed in the specifications. If the power supply voltage is not the +15 VDC nominal value, the specified input rates for full accuracy will increase or decrease in proportion to the fractional change in voltage.

ORDERING INFORMATION

1. Converters may be ordered as follows. Note that:
   (a) For HXDC options which are not board mounted, a reference and a transducer transformer must be ordered separately from part 2 below.
   (b) For HXDC options which are board mounted (BM or BMV options) transformers mounted on the board are included with the part number and should not be ordered from part 2.

HSDC – 10 – 4H – 3 – BM – RT – 883B

- Options:
  - Blank = No options
  - BM = Converter and transformers (if any) mounted on PC board. Board pinouts are the same as those on a standard modular S/D converter.
  - BMV = Same as BM except board has two extra pins for DC analog velocity output.
  - ST or RT = Synchro Xfmr or Resolver Xfmr. For board mounted 400 Hz HXDC versions only. Specifying ST or RT Indicates whether the board mounted T1 Xfmr should be synchro or resolver.
  - 883-B = Hybrids conform to MIL-STD-883, DDC procedures. If 883B is not specified, pre-burn in test and burn in are not included.
- Temperature Range (Operating):
  - 3 = 0°C to +70°C
  - 1 = -55°C to +125°C
- Frequency and Voltage Levels:
  - 4 = 360 to 1000Hz (400Hz)
  - 6 = 47 to 1000Hz (60Hz)
  - H = 115V Reference, 90V L-L Signal
  - M = 26V Reference, 26V L-L Signal
  - L = 26V Reference, 11.8V L-L Signal

  Available Options are:
  Synchro (HSDC): 4H, 4L, 6H
  Resolver (HRDC): 4H, 4M, 4L

  If input is HXDC and converter is not board mounted, specify 4 or 6 only and omit H, M, or L. Voltage level in this case is determined by Xfmrs ordered separately from part 2 below.
- Resolution = 10 bits
- Input Type:
  - HSDC or HRDC = Synchro or Resolver input with solid state input buffer. No ref or transducer Xfmrs are required.
  - HXDC = Voltage follower buffer. Requires external signal conditioner such as an isolation transformer.

2 400 Hz and 60 Hz transformers may be ordered by part number (P/N) as follows:

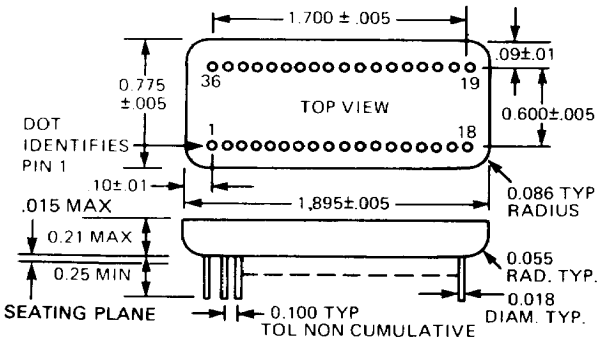
Type	Frequency	Ref Voltage	L-L Voltage	Part Numbers: Ref Xfmr	Part Numbers: Signal Xfmr
Synchro	400 Hz	115V	90V	21049	21045*
Synchro	400 Hz	26V	11.8V	21049	21044*
Resolver	400 Hz	115V	90V	21049	21048*
Resolver	400 Hz	26V	26V	21049	21047*
Resolver	400 Hz	26V	11.8V	21049	21046*
Synchro	60 Hz	115V	90V	24133-1† -3†	24126-1† -3†

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

†-1 and -3 indicate operating temperature, and range available (see ordering information)

HYBRID MODULE DIAGRAMS

1. MECHANICAL OUTLINE (36 PIN DOUBLE DIP)



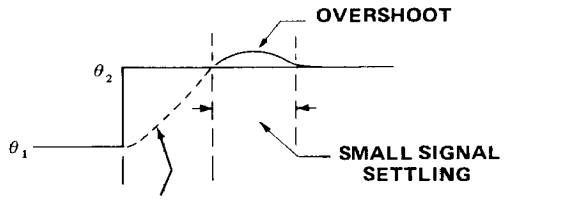
PACKAGE IS KOVAR WITH ELECTROLESS NICKEL PLATING
PINS ARE KOVAR WITH GOLD PLATING: (50 μ INCH MIN).
CASE IS ELECTRICALLY FLOATING

2. PIN CONNECTION TABLE

PIN	FUNCTION	PIN	FUNCTION	
1	Ground	19	Inhibit (INH)	
2	+15VDC	20	N.C.	
3	V (Internal D.C. Ref.)	21	Bit 10 (LSB)	
4	e	22	Bit 9	
5	N.C.	23	Bit 8	
6	N.C.	24	Bit 7	
7	N.C.	25	Bit 6	
8	N.C.	26	Bit 5	
9	N.C.	27	Bit 4	
10	N.C.	28	Bit 3	
11	N.C.	29	Bit 2	
12	N.C.	30	Bit 1 (MSB)	
13	Ê	31	Converter Busy (CB)	
14	N.C.	32	V_L	
15	Ê			
16	N.C		HSDC HRDC	HXDC
17	R_H	33	S3	V (Internal Ref.)
18	R_L	34	S1	– SIN
		35	S4 (Resolver Only)	N.C.
		36	S2	+ COS

NOTE: To insure proper operation V must not be connected to PIN 1.

So long as the maximum tracking rate (100 rps at 400 Hz and 20 rps at 60 Hz) is not exceeded, there will be no lag in the converter output. If a step input occurs, as is likely when the power is initially turned on, the response will be critically damped. Figure 8 shows the response to a step input. After initial slewing at the maximum tracking rate of the converter, there is one overshoot which is inherent to a Type II servo. The overshoot settling to final value is a function of the small signal settling time.



RESPONSE TO A STEP INPUT

The nominal open loop transfer functions for the HSDC-10 are

$$\text{For 60 Hz:}\quad G = \frac{103^2\left(\frac{S}{50}+1\right)}{S^2\left(\frac{S}{500}+1\right)} \qquad \text{For 400 Hz:}\quad G = \frac{515^2\left(\frac{S}{260}+1\right)}{S^2\left(\frac{S}{2600}+1\right)}$$

RELIABILITY

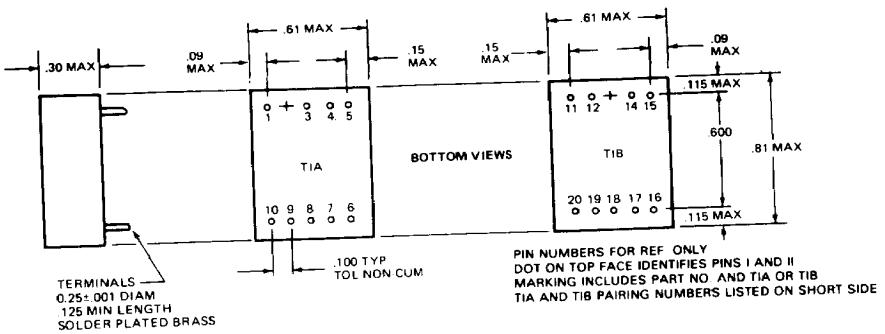
The use of MSI and thin film resistor networks, as well as careful thermal design, results in very high MTBF values. Summaries of MTBF calculations are available on request.

All DDC hybrids are built in accordance with requirements of MIL-STD-883 and are screened as shown in our Processing Flow Chart. This screening is based on the requirements of Method 5004/5008 except for burn in, which is optional. To specify pre-burn in tests and burn in, add 883B to the part number. The computed MTBF value for MIL-STD-883B processing (including burn in) is 1,625,000 hours, Ground Fixed, at 25°C.

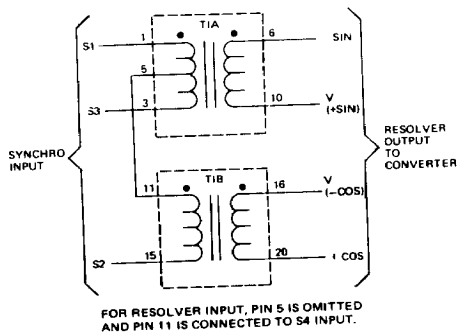
400 Hz SYNCHRO AND RESOLVER TRANSFORMER DIAGRAMS (TIA AND TIB)

EACH TRANSFORMER CONSISTS OF TWO SECTIONS, TIA AND TIB.

1. MECHANICAL OUTLINES



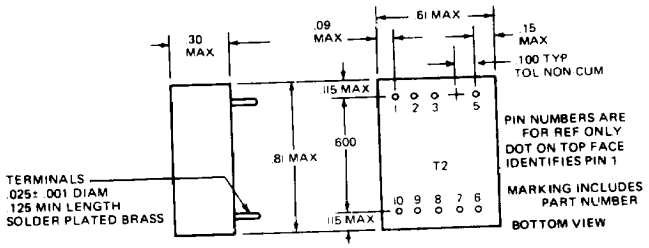
2. SCHEMATIC DIAGRAMS



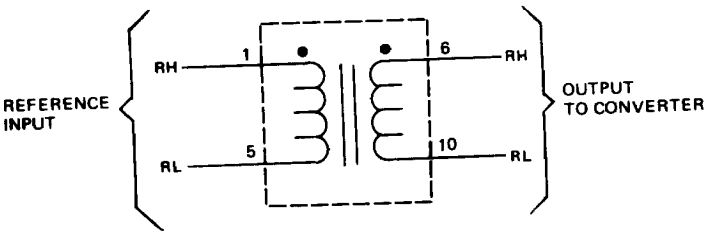
FOR RESOLVER INPUT, PIN 5 IS OMITTED AND PIN 11 IS CONNECTED TO S4 INPUT.

400 Hz REFERENCE TRANSFORMER DIAGRAMS (T2)

1. MECHANICAL OUTLINE



2. SCHEMATIC DIAGRAM



60 Hz SYNCHRO AND REFERENCE TRANSFORMER DIAGRAMS

The mechanical outline is the same for the synchro input transformer (24126) and the reference input transformer (24133), except for the pins. Pins for the reference transformer are shown in parentheses ( ) below. An asterisk * indicates that the pin is omitted.

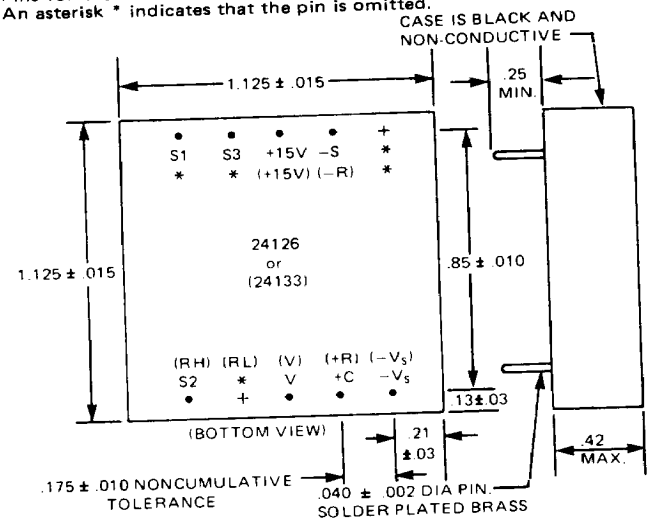


DIAGRAM FOR BOARD MOUNTED UNITS, BM AND BMV

MECHANICAL OUTLINE SHOWING PIN CONNECTIONS
BM UNIT IS PIN FOR PIN COMPATIBLE WITH STANDARD S/D AND R/D CONVERTER SOCKETS