7 VA DIGITAL-TO-SYNCHRO CONVERTER

DESCRIPTION

With 16-bit resolution and up to ±2 minute accuracy, the DSC-10510 $^{\circledM}$ is a high power digital-to-synchro converter capable of driving multiple Control Transformer (CT), Control Differential Transmitter (CDX) and Torque Receiver (TR) loads up to 7 VA.

The DSC-10510 contains a high accuracy D/R converter, a triple power amplifier stage, a walk-around circuit (to prevent torque receiver hangups), and thermal and over-current protection circuits. The hybrid is protected against over-loads, load transients, over-temperature, loss of reference, and power amplifier or DC power supply shutdown.

Microprocessor compatibility is provided through a 16-bit/2-byte double-buffered input latch. Data input is natural binary angle in TTL compatible parallel positive logic format.

Packaged in a 40-pin TDIP, the DSC-10510 features a power stage that may be driven by either a standard ±15 VDC supply or by a pulsating reference supply when used with an optional power transformer. When powered by the reference source, heat dissipation is reduced by 50%.

APPLICATIONS

The DSC-10510 can be used where digitized shaft angle data must be converted to an analog format for driving CTs, CDXs, and TRs loads. With its double buffered input latches, the DSC-10510 easily interfaces with microprocessor based systems such as flight simulators, flight instrumentation, fire control systems, and flight data computers.

FEATURES

- **7 VA Drive Capability for CT, CDX, or TR Loads**
- **Double Buffered Transparent Input Latch**
- **16-Bit Resolution**
- **Up to 2 Minute Accuracy**
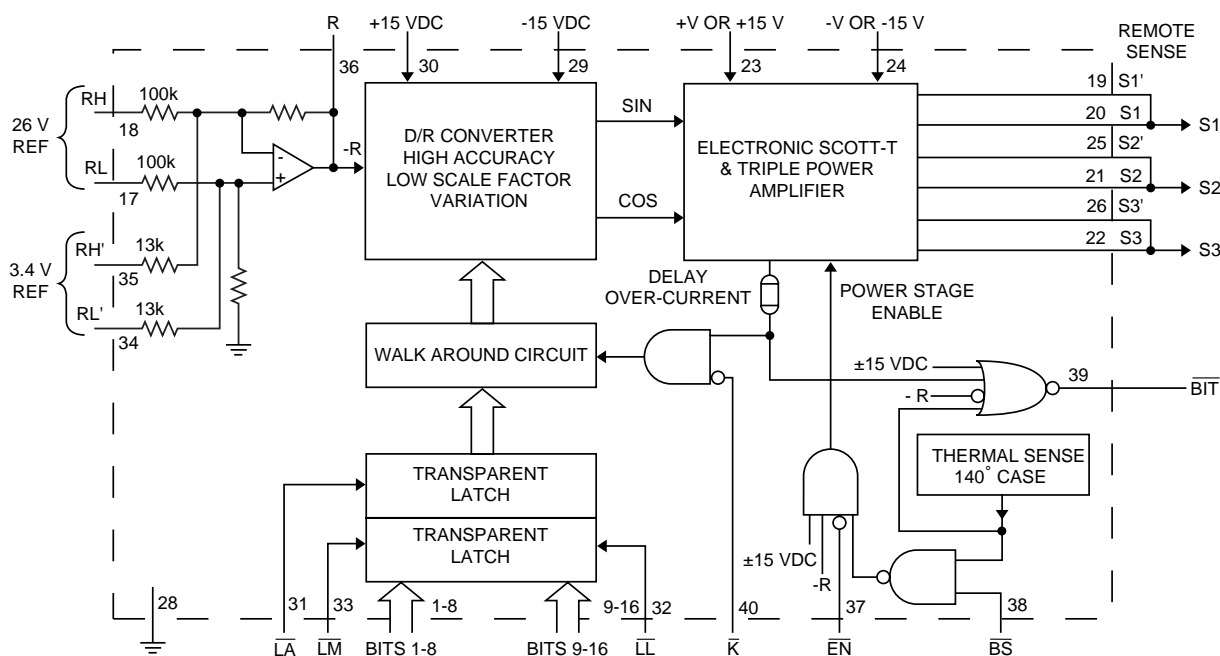- **Power Amplifier Uses Pulsating or DC Supplies**
- **Built-In-Test ($\overline{BIT}$) Output**

FIGURE 1. DSC-10510 BLOCK DIAGRAM

TABLE 1. DSC-10510 SPECIFICATIONS		
PARAMETER	VALUE	DESCRIPTION
RESOLUTION	16 bits	Bit 1 = MSB, Bit 16 = LSB
ACCURACY	±2 or 4 minutes	
DIFFERENTIAL LINEARITY	1 LSB max in the 16th bit	
OUTPUT SETTLING TIME	40 µs max	For any digital input step change (passive loads).
DIGITAL INPUT/ OUTPUT		
Logic Type Digital Inputs	Logic 0 = 0.8 V max Logic 1 = 2.0 V min	TTL/CMOS compatible All inputs except $\overline{K}$ (Kick pin 40).
Loading	20 µA max to GND //5pf max 20 µA max to + 5V //5 pf max	Bits 1-16, $\overline{BS}$, and $\overline{EN}$.
$\overline{K}$	20 µA max	$\overline{LL}$, $\overline{LM}$, and $\overline{LA}$ (CMOS transient protected) Ground to enable Kick circuit, open to disable; pulls self up to +15 V.
Digital Outputs $\overline{BIT}$		Logic 0 for $\overline{BIT}$ condition (see BIT pin function)
Drive Capability	Logic 0 = 1 TTL Load Logic 1 = 10 TTL Loads	1.6 mA at 0.4 V max 0.4 mA at 2.8 V min
REFERENCE INPUT		
Type	26 Vrms differential 3.4 Vrms differential	RH-RL RH' -RL'
Max Voltage w/o Damage	72.8 Vrms for RH-RL 9.52 Vrms for RH'-RL'	
Frequency	DC to 1 kHz	
Input Impedance Single Ended	100k Ohms ±0.5% 13k Ohms ±0.5%	RH-RL RH'-RL'
Differential	200k Ohms ±0.5% 26k Ohms ±0.5%	RH-RL RH'-RL'

TABLE 1. DSC-10510 SPECIFICATIONS (contd)			
PARAMETER	VALUE		DESCRIPTION
SYNCHRO OUTPUT			
Voltage L-L	11.8 Vrms ±0.5% for nom Ref V		
Scale Factor Variation	±0.1% max		Simultaneous amplitude variation on all output lines as a function of digital angle.
Current CT, CDX or TR Load	700 mA rms max 7 VA max		
DC Offset	±15 mV max		Each line to ground. Varies with angle.
Protection			Output protected from over-current, voltage feedback transient, and over tempera-ture, loss of reference, loss of power amplifier, and loss of ±DC supply voltage.
POWER SUPPLY CHARACTERISTICS			
Nominal Voltage	±15 V	±V	
Voltage Range	±5%,	20 V peak max 3 V above output min	
Max Voltage w/o Damage	18 V	25 V	
Current	25 mA max	load dependent	
TEMPERATURE RANGES			
Operating Case -3XX	0°C to +70°C		
-1XX	-55°C to +125°C		
Storage	-65°C to +150°C		
PHYSICAL CHARACTERISTICS			
Size	2.0 x 1.1 x 0.2 inches (50.8 x 27.9 x 5.1 mm)		40 Pin Triple DIP
Weight	0.9 oz (25.5 g)		

INTRODUCTION

SYSTEM CONSIDERATIONS:

Power Surge at Turn On

When power is initially applied, the output power stages can go on fully before all the supplies stabilize. When multiple D/S con-verters with substantial loads are present, the heavy load can cause the system power supply to have difficulty coming up and indeed may even shut down. It is best to be sure that the power can handle the turn-on surge or to stagger the D/S turn-ons so that the supply can handle it. Typically, the surge will be twice the max rated draw of the converter.

Torque Load Management

When multiple torque loads (TR) are being driven the above problems are exacerbated by the high power levels involved and power supply fold back problems are common unless the stag-ger technique is used. Also, allow time for the load to stabilize. On turn-on it is not likely that all the output loads will be at the same angle as the D/S output. As the angular difference increases so does the power draw until the difference is 180

degrees. At this point the load impedance drops to Zss and cur-rent draw is at maximum.

Pulsating Power Supplies

D/S and D/R converters have been designed to operate their output power stages with pulsating power to reduce power dis-sipation and power demand from regulated supplies. FIGURES 2 and 3 illustrate this technique. Essentially the power output stage is only supplied with enough instantaneous voltage to be able to drive the required instantaneous signal level. Since the output signal is required to be in phase with the AC reference, the AC reference can be full wave rectified and applied to the push-pull output drivers. The supply voltage will then be just a few volts more than the signal being output and internal power dissipation is minimized.

Thermal Considerations

Power dissipation in D/S and D/R circuits are dependent on the load, whether active (TR) or passive (CT or CDX) and the power supply, whether DC or pulsating. With inductive loads we must bear in mind that virtually all the power consumed will

have to be dissipated in the output amplifiers. This sometimes requires considerable care in heat sinking.

Example:

For illustrative purposes let us make some thermal calculations using the DSC-10510's specifications. The DSC-10510 has a 7 VA drive capability for CT, CDX, or TR loads.

Let us take the simplest case first: **Passive Inductive Load and ±15 Volt DC power stage supplies (as shown in FIGURE 2).** The power dissipated in the power stage can be calculated by taking the integral of the instantaneous current multiplied by the voltage difference from the DC supply that supplies the current and instantaneous output voltage over one cycle of the reference. For an inductive load this is a rather tedious calculation. Instead let us take the difference between the power input from the DC supplies minus the power delivered to the load. A real synchro load is highly inductive with a Q of 4-6; therefore, let's assume that it is purely reactive. The power out, then, is 0 Watts. As a worst case we will also assume the load is the full 7 VA, the converter's rated load. The VA delivered to the load is independent of the angle but the voltage across the synchro varies with the angle from a high of 11.8 Volts line-to-line (L-L) to a low of 10.2 V L-L. The maximum current therefore is 7VA/10.2 V = 0.68 A rms. The output is L-L push-pull, that is, all the current flows from the positive supply out to the load and back to the negative supply. The power input is the DC voltage times the average current or 30 V x (0.68 A x 0.635/0.707) [avg/rms] = 18.32 Watts. The power dissipated by the output driver stage is over 18 Watts shared by the six power transistors. Since one synchro line supplies all the current while the other two share it equally, one will dissipate 2/3 of the power and other two will each dissipate 1/3. There are 2 transistors per power stage so each of the two transistors dissipates 1/3 of the power and the other transistors dissipate 1/6 of the power. This results in a maximum power in any one transistor of 1/3 x 18.32 W = 6.04 Watts. The heat rise from the junction to the outside of the package, assuming a thermal impedance of 4°C per watt = 24.16°C. At an operating case temperature of 125°C the maximum junction temperature will be 149.16°C.

The other extreme condition to consider is when the output voltage is 11.8. The current then will be 0.42 A and the power will be 30 x (0.42A x 0.635/0.707) = 11.32 Watts. A similar calculation will show the maximum power per transistor to be 2.3 Watts. Much less than the other extreme.

For **Pulsating Supplies**, the analysis is much more difficult. Theoretical calculations, for a purely reactive load with DC supplies equal to the output voltage peak vs. pulsating supplies with a supply voltage equal to the output voltage yield **an exact halving of the power dissipated.** At light loads the pulsating supplies approximate DC supplies and at heavy loads, which is the worst case, they approximate a pulsating supply as shown in FIGURE 4. Advantages of the pulsating supply technique are:

- Reduced load on the regulated ±15 VDC supplies
- Halving of the total power
- Simplified power dissipation management

ACTIVE LOAD

Active load – that is torque receivers – make it more difficult to calculate power dissipation. The load is composed of an active part and a passive part. FIGURE 5 illustrates the equivalent two wire circuit. At null that is when torque receiver's shaft rotates to the angle that minimizes the current in R2, the power dissipated is at its lowest. The typical ratio of Zso/Zss = 4.3. For the maximum specified load of Zss = 2 ohm, the Zso = 2 x 4.3 = 8.6 ohms. Also, the typical ratio of R2/R1= 2. In a synchro systems with a torque transmitter driving a torque receiver, the actual line impedances are as shown in FIGURE 6. The torque transmitter and torque receiver are electrically identical, hence the total line impedance is double that of FIGURE 5. The torque system is designed to operate that way. The higher the total line impedances, the lower the current flow at null and the lower the power dissipation. It is recommended that with torque loads, discrete resistors be used as shown in FIGURES 7 and 8.

A torque load is usually at null. Once the torque receiver nulls at power turn on, the digital commands to the D/S are usually in

NOTES:
  PARTS LIST FOR 400Hz
  D1, D2, D3, D4 = 1N4245
  C1 AND C2 = 47μF, 35V DC CAPACITOR

FIGURE 2. TYPICAL CONNECTION DIAGRAM UTILIZING PULSATING POWER SOURCE

FIGURE 3. PULSATING POWER SUPPLY VOLTAGE WAVEFORMS

smaller angular steps, so the torque system is always at or near null. Large digital steps, load disturbances, a stuck torque receiver or one synchro line open, however, causes an off null condition.

Theoretically, at null the load current could be zero (See FIGURE 9). If Vac = Vab, both in magnitude and phase, then, when "a" was connected to "b," no current would flow. Pick C1 and C2 to match the phase lead of R1 – Zso. In practice this ideal situation is not realized. The input to output transformation ratio of torque receivers are specified at 2% and the turns ratio at 0.4%. The in-phase current flow due to this nominal output voltage (10.2 V) multiplied by the % error (2.4/100) divided by total resistance (4 Ohms) = 61mA. A phase lead mismatch between the torque receiver and the converter of 1 degree results in a quadrature current of 10.2 V x sin 1°/4 Ohms = 44.5 mA. Total current is the phaser sum 61 + 44.5 = 75.5 mA . Power dissipation is 30 VDC x 75.5 mA rms x 0.9 (avg/rms) = 2.04 Watts. Since this is a light load condition, even pulsating supplies would be approximating DC supplies.

The **off null** condition power dissipation is quite different. Real synchros have no current limiting, so that the circuit current would be the current that the circuit conditions demanded. The worst case would be for a 180 degree error between the two synchros as shown in FIGURE 10. For this condition the two equivalent voltage sources would be 10.2 V opposing. The current would be (10.2 x 2) / 4 = 5.1 A in phase. The power dissipated in the converter is the power supplied by the ±15 VDC supplies minus the power delivered to the load. (30 V x 5.1 A x 0.9) - (10.2 V x 5.1 A) = 87.7 Watts for DC supplies. This would require a large power supply and high wattage resistors. The converter output current is usually limited (in the DSC-10510 case to 0.8 A peak). This limits the power supply to more rea-

sonable values but introduces another problem – the torque receiver can hang up in a continuous current limited condition at a false stable null. Fortunately, the DSC-10510 has special circuits that sense this continuous current overload condition and sends a momentary 45° "kick" to the torque receiver thus knocking it off the false null. The torque receiver will then swing to the correct angle and properly null. If the torque receiver is stuck it will, not be able to swing off the over-current condition. In this case the converter will send a $\overline{BIT}$ signal when the case exceeds 140°C. This $\overline{BIT}$ signal can be used to shut down the output power stage.

An additional advantage of using pulsating power supplies is that the loss of reference when driving torque loads is fail safe. The load will pump up the ±V voltage through the power stage clamp diodes and the loss of the reference detector will disable the power stage. The power stage will, therefore, be turned off with the needed power supply voltages. The pulsating power supply diodes will isolate the pumped up pulsating supplies from the reference. If the DC power supplies are to be used for the power stage and there is a possibility of the DC supplies being off while the reference to the torque receiver is on, then the protection circuitry shown in FIGURE 11 is highly recommended.

A remote sense feature is incorporated in DDC's DSC-10510 hybrid digital-to-synchro converter. Rated at 7 VA, it offers accuracies to ±2 minutes of arc at the load. This remote sense feature operates just as other precision sources do. A separate line is run to each leg of the synchro (in addition to the drive line) to sense the voltage actually appearing on the load. This is then used to regulate the output based on load voltage rather than converter output voltage. This feature is very useful in driving heavy passive loads in precision systems.
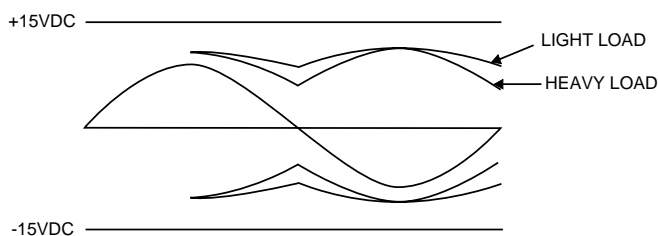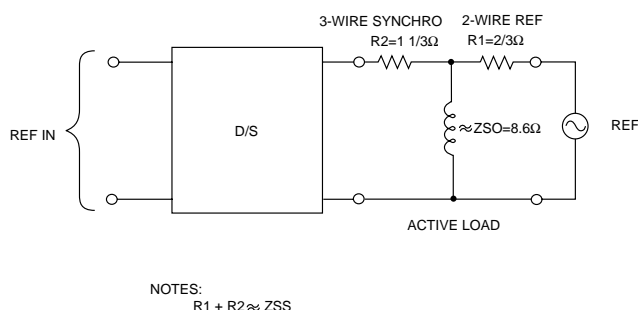

FIGURE 4. LOADED WAVEFORMS

FIGURE 6. TORQUE SYSTEM

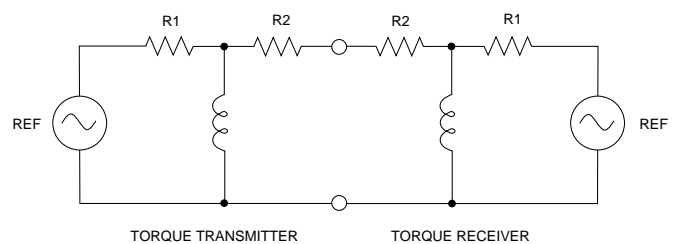NOTES:
R1 + R2 ≈ ZSS

FIGURE 5. EQUIVALENT 2-WIRE CIRCUIT
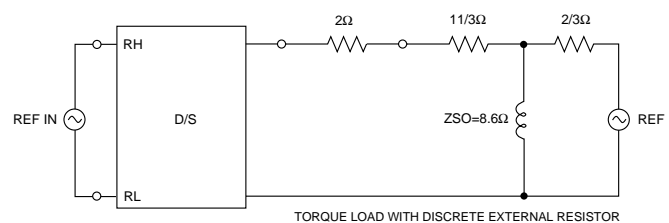

TORQUE LOAD WITH DISCRETE EXTERNAL RESISTOR
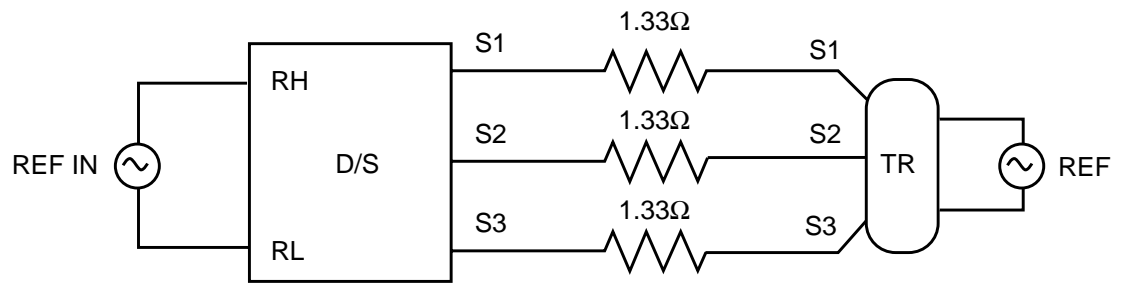
FIGURE 7. D/S EQUIVALENT
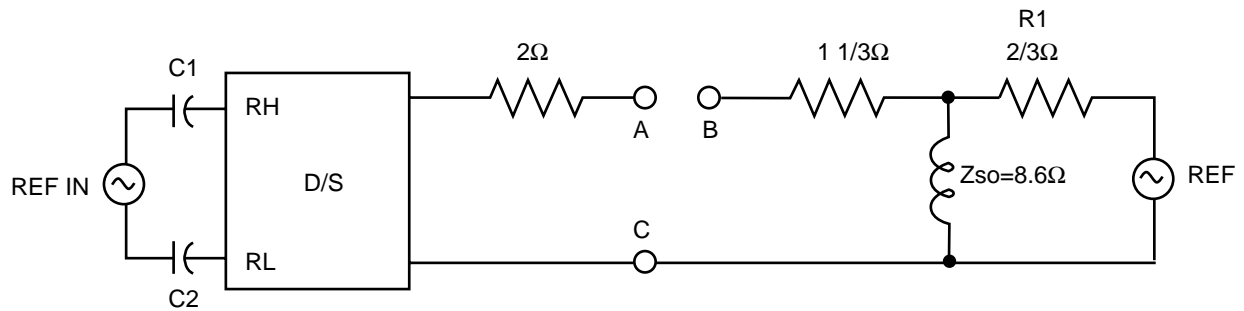
FIGURE 8. D/S – ACTUAL HOOK-UP
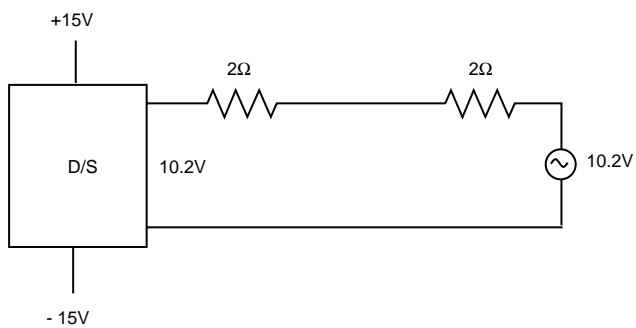

FIGURE 9. IDEAL NULL CONDITION
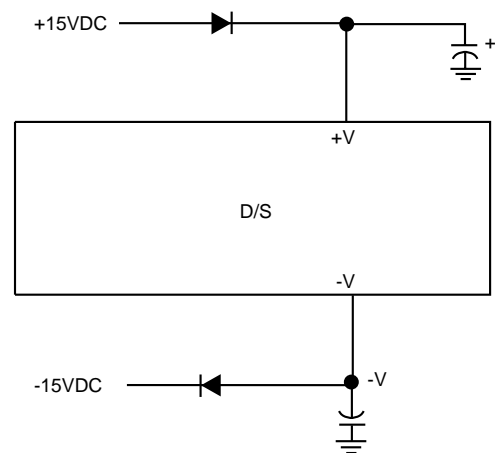

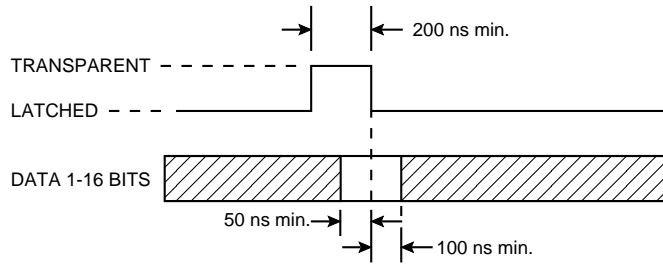**FIGURE 10. WORST CASE 180° ERROR**

FIGURE 11. PROTECTION CIRCUITRY

FIGURE 12. LL, LM, LA TIMING DIAGRAM

TABLE 2. DSC-10510 PIN FUNCTIONS		
PIN	**NAME**	**FUNCTION**
1	D01	Digital Input 01 (MSB) Logic "1" enables.
2	D02	Digital Input 02
3	D03	Digital Input 03
4	D04	Digital Input 04
5	D05	Digital Input 05
6	D06	Digital Input 06
7	D07	Digital Input 07
8	D08	Digital Input 08
9	D09	Digital Input 09
10	D010	Digital Input 10
11	D011	Digital Input 11
12	D012	Digital Input 12
13	D013	Digital Input 13
14	D014	Digital Input 14
15	D015	Digital Input 15
16	D016	Digital Input 16 (LSB)
17	RL	26 Vrms Reference Low Input
18	RH	26 Vrms Reference High Input
19	S1'	Synchro S1 Remote Sense Output
20	S1	Synchro S1 Output
21	S2	Synchro S2 Output.
22	S3	Synchro S3 Output
23	+V	Power Stage +V
24	-V	Power Stage - V
25	S2'	Synchro S2 Remote Sense Output
26	S3'	Synchro S3 Remote Sense Output
27	NC	No connection.
28	GND	Ground
29	-15 V	Power Supply
30	+15 V	Power Supply
31	$\overline{LA}$	2nd Latch All Enable. Input enables dual latch.
32	$\overline{LL}$	1st Latch LSBs Enable. Enables bits 9-16.
33	$\overline{LM}$	1st Latch MSBs Enable. Enables bits 1-8.
34	RL'	3.4 Vrms Reference Low Input
35	RH'	3.4 Vrms Reference High Input
36	-R (TP)	No connection. Factory test point.
37	$\overline{EN}$	Enable. Power stage enable input allows for digital shutdown of power stage. Gives complete control of converter to digital system.
38	$\overline{BS}$	Battle Short Input. Logic 0 overrides over temperature protection.
39	$\overline{BIT}$	Built-In-Test Output. Logic 0 when loss of reference, loss of ±15 VDC supply, case temperature of +140°C, EN input signal, or an output over-current has been detected. Power output stage is turned off unless BS is at 0.
40	$\overline{K}$	Kick. Input used for reducing excessive current flow in torque receiver loads at false null.
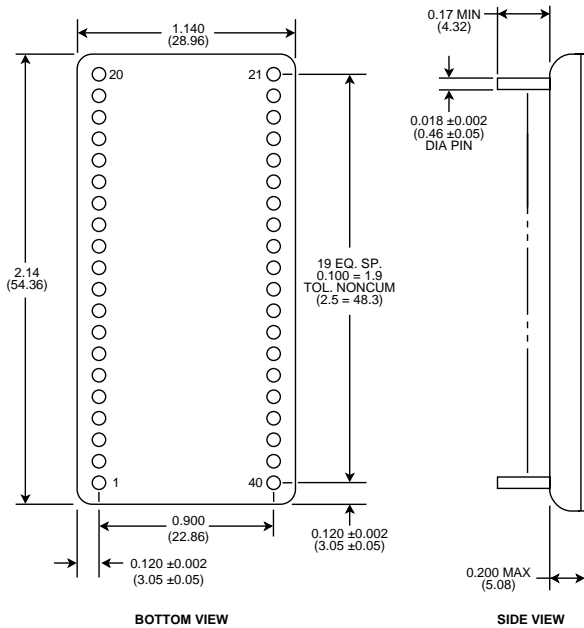
Notes:
1. Dimensions are in inches (millimeters).
2. Lead identification numbers for reference only.
3. Lead cluster shall be centered within ±0.10 of outline dimensions. Lead spacing dimensions apply only at seating plane.
4. Pin material meets solderability requirements of MIL-PRF-38534.

FIGURE 13. DSC-10510 MECHANICAL OUTLINE 40-PIN TDIP

ORDERING INFORMATION

DSC-10510-X X X X

Supplemental Process Requirements:
- S = Pre-Cap Source Inspection
- L = Pull Test
- Q = Pull Test and Pre-Cap Inspection
- Blank = None of the Above

Accuracy:
- 3 = ±4 minutes
- 4 = ±2 minutes

Process Requirements:
- 0 = Standard DDC Processing, no Burn-In (See table below.)
- 1 = MIL-PRF-38534 Compliant
- 2 = B*
- 3 = MIL-PRF-38534 Compliant with PIND Testing
- 4 = MIL-PRF-38534 Compliant with Solder Dip
- 5 = MIL-PRF-38534 Compliant with PIND Testing and Solder Dip
- 6 = B* with PIND Testing
- 7 = B* with Solder Dip
- 8 = B* with PIND Testing and Solder Dip
- 9 = Standard DDC Processing with Solder Dip, no Burn-In (See table below.)

Temperature Grade/Data Requirements:
- 1 = -55°C to +125°C
- 2 = -40°C to +85°C
- 3 = 0°C to +70°C
- 4 = -55°C to +125°C with Variables Test Data
- 5 = -40°C to +85°C with Variables Test Data
- 8 = 0°C to +70°C with Variables Test Data

*Standard DDC Processing with burn-in and full temperature test — see table below.
For DSC-10510 use optional Power Transformer, DDC P/N 42359
For S2 Grounded Applications, use Transformer DDC P/N 42929.

STANDARD DDC PROCESSING		
TEST	**MIL-STD-883**	
	METHOD(S)	**CONDITION(S)**
INSPECTION	2009, 2010, 2017, and 2032	—
SEAL	1014	A and C
TEMPERATURE CYCLE	1010	C
CONSTANT ACCELERATION	2001	A
BURN-IN	1015, Table 1	—

The information in this data sheet is believed to be accurate; however, no responsibility is assumed by Data Device Corporation for its use, and no license or rights are granted by implication or otherwise in connection therewith. Specifications are subject to change without notice.

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