

RDC-19220/2S

16-BIT MONOLITHIC TRACKING RESOLVER-TO-DIGITAL CONVERTER



DESCRIPTION

The RDC-19220/2S is a low-cost versatile state-of-the-art 16-bit monolithic Resolver-to-Digital Converter. This single chip converter offers programmable features such as resolution, bandwidth and velocity output scaling.

Resolution programming allows selection of 10, 12, 14, or 16 bits, with accuracies to 2.3 minutes. This feature combines the high tracking rate of a 10-bit converter with the precision and low-speed velocity resolution of a 16-bit converter in one package.

The internal Synthesized Reference section eliminates errors due to quadrature voltage. Previously, a 6 degree phase shift caused problems for a 16-bit converter. The synthesized reference capability ensures operation with a phase shift up to 45 degrees.

The velocity output (VEL) from the RDC-19220/2S, which can be used to replace a tachometer, is a 4 V signal referenced to ground. The full-scale value of VEL is set by the user with a single resistor.

The RDC-19220/2S converter is available with operating temperature ranges of 0° to +70°C, -40° to +85°C, and -55° to +125°C.

APPLICATIONS

The low cost, small size, high accuracy, and versatile performance of the RDC-19220/2S converter makes it ideal for use in modern high performance industrial control systems. Typical applications include motor control, radar antenna positioning, machine tool control, robotics, and process control.



Data Device Corporation
105 Wilbur Place
Bohemia, New York 11716
631-567-5600 Fax: 631-567-7358
www.ddc-web.com

Make sure the next
Card you purchase
has...



FEATURES

- Accuracy up to 2.3 Arc Minutes
- Internal Synthesized Reference
- +5 Volt Only Option
- Programmable:
 - Resolution: 10-, 12-, 14-, or 16-Bit
 - Bandwidth
 - Tracking Rate
- Differential Resolver Input Mode
- Velocity Output Eliminates Tachometer
- Built-In-Test (BIT) Output, No 180° Hangup
- -55° to +125°C Operating Temperature

FOR MORE INFORMATION CONTACT:

Technical Support:
1-800-DDC-5757 ext. 7382



FIGURE 1. RDC-19220/2S BLOCK DIAGRAM

TABLE 1. RDC-19220/2S SPECIFICATIONS

These specifications apply over the rated power supply, temperature, and reference frequency ranges; 15% signal amplitude variation & 10% harmonic distortion.

PARAMETER	UNIT	VALUE																																				
RESOLUTION	Bits	10, 12, 14, or 16 (notes 1 & 2)																																				
FREQUENCY RANGE	Hz	47-1k(note 4) 1k - 4k 4k - 10k																																				
ACCURACY -XX2	Min	4 +1 LSB 4 +1 LSB 5 +1 LSB																																				
-XX3 (NOTE 3)	Min	2 +1 LSB 2 +1 LSB 3 +1 LSB																																				
REPEATABILITY	LSB	± 1 ± 1 ± 2																																				
DIFFERENTIAL LINEARITY	LSB	± 1 ± 1 ± 2																																				
REFERENCE		(+REF, -REF)																																				
Type		Differential																																				
Voltage: differential	V	±10 max																																				
single ended	V	±5 max																																				
overload	V	±25 continuous 100 transient																																				
Frequency	Hz	DC to 10,000																																				
Input Impedance	Ohm	10M min //20 pf																																				
SIGNAL INPUT		(+S, -S, SIN, +C, -C, COS)																																				
Type		Resolver, differential, groundbased																																				
Voltage: operating	Vrms	2 ±15%																																				
overload	V	±25 continuous																																				
Input Impedance	Ohm	10M min //10 pf.																																				
REFERENCE		(note 5)																																				
±Sig/Ref Phase Shift	deg	45 max from 400 Hz to 10 kHz																																				
DIGITAL INPUT/OUTPUT																																						
Logic Type		TTL/CMOS compatible																																				
Inputs		Logic 0 = 0.8 V max. Logic 1 = 2.0 V min. Loading=10 µA max P.U. current source to +5 V //5 pF max. CMOS transient protected																																				
Inhibit ($\overline{\text{INH}}$)		Logic 0 inhibits; Data stable within 0.1 µS																																				
Enable Bits 1 to 8 ($\overline{\text{EM}}$)		Logic 0 enables; Data stable within 150 nS																																				
Enable Bits 9 to 16 ($\overline{\text{EL}}$)		Logic 1 = High Impedance Data High Z within 100 nS																																				
Resolution and Mode Control (A & B) (see notes 1 and 2)		<table border="1"> <thead> <tr> <th>Mode</th> <th>B</th> <th>A</th> <th>Resolution</th> </tr> </thead> <tbody> <tr> <td>Resolver</td> <td>0</td> <td>0</td> <td>10 bits</td> </tr> <tr> <td>"</td> <td>0</td> <td>1</td> <td>12 bits</td> </tr> <tr> <td>"</td> <td>1</td> <td>0</td> <td>14 bits</td> </tr> <tr> <td>"</td> <td>1</td> <td>1</td> <td>16 bits</td> </tr> <tr> <td>LVDT</td> <td>-5 V</td> <td>0</td> <td>8 bits</td> </tr> <tr> <td>"</td> <td>0</td> <td>-5 V</td> <td>10 bits</td> </tr> <tr> <td>"</td> <td>1</td> <td>-5 V</td> <td>12 bits</td> </tr> <tr> <td>"</td> <td>-5 V</td> <td>-5 V</td> <td>14 bits</td> </tr> </tbody> </table>	Mode	B	A	Resolution	Resolver	0	0	10 bits	"	0	1	12 bits	"	1	0	14 bits	"	1	1	16 bits	LVDT	-5 V	0	8 bits	"	0	-5 V	10 bits	"	1	-5 V	12 bits	"	-5 V	-5 V	14 bits
Mode	B	A	Resolution																																			
Resolver	0	0	10 bits																																			
"	0	1	12 bits																																			
"	1	0	14 bits																																			
"	1	1	16 bits																																			
LVDT	-5 V	0	8 bits																																			
"	0	-5 V	10 bits																																			
"	1	-5 V	12 bits																																			
"	-5 V	-5 V	14 bits																																			
Outputs																																						
Parallel Data (1-16)		10, 12, 14 or 16 parallel lines; natural binary angle positive logic (see note 2)																																				
Converter Busy (CB)		0.25 to 0.75 µs positive pulse leading edge initiates counter update.																																				
Built-in-Test ($\overline{\text{BIT}}$)		Logic 0 for $\overline{\text{BIT}}$ condition. ±100 LSBs of error with a filter of 500 µS total, Loss-of-Signal (LOS) less than 500 mV, or Loss-of-Reference (LOR) less than 500 mV.																																				

Notes: 1. Unused data bits are set to logic "0."
2. In LVDT mode, bit 16 is LSB for 14-bit resolution or bit 12 is LSB for 10-bit resolution
3. Accuracy in LVDT mode is 0.15% + 1 LSB of full scale.
4. If the frequency is between 47Hz and 1kHz, then there may be 1 LSB of jitter at quadrant boundaries.
5. The maximum phase shift tolerance will degrade linearly from 45 degrees at 400 Hz to 30 degrees at 60 Hz.

TABLE 1. RDC-19220/2S SPECIFICATIONS (CONT.)

PARAMETER	UNIT	VALUE
DIGITAL INPUT/OUTPUT		
Outputs (continued)		
Drive Capability		50 pF+ Logic 0; 1 TTL load, 1.6 mA at 0.4 V max. Logic 1; 10 TTL loads, -0.4 mA at 2.8 V min Logic 0; 100 mV max driving CMOS Logic 1; +5 V supply minus 100 mV min driving CMOS High Z; 10 uA //5 pF max
DYNAMIC CHARACTERISTICS		(at maximum bandwidth)
Resolution	bits	10 12 14 16
Tracking Rate-min(note 6)	rps	1152 288 72 18
Bandwidth(Closed Loop) Max	Hz	1200 1200 600 300
Ka	1/sec ²	5.7M 5.7M 1.4M 360k
A1	1/sec	19.5 19.5 4.9 1.2
A2	1/sec	295k 295k 295k 295k
A	1/sec	2400 2400 1200 600
B	1/sec	1200 1200 600 300
Acceleration (1 LSB lag)	deg/s ²	2M 500k 30k 2k
Settling Time(179° step)	msec	2 8 20 50
VELOCITY CHARACTERISTICS		
Polarity		Positive for increasing angle
Voltage Range(Full Scale)	V	±4 (at nominal ps)
Scale Factor Error	%	10 typ 20 max
Scale Factor TC	PPMC	100 typ 200 max
Reversal Error	%	0.75 typ 1.3 max
Linearity	%	0.25 typ 0.50 max
Zero Offset	mV	5 typ 10 max
Zero Offset TC	µV/C	15 typ 30 max
Load	kΩ	8 max
Noise	Vp/V	1 typ 0.125 min, 2 max
POWER SUPPLIES		(note 6 and 7)
Nominal Voltage	V	+5 -5
Voltage Range	%	±5 ±5
Max Volt. w/o Damage	V	+7 -7
Current	mA	14 typ, 22 max (each)
TEMPERATURE RANGE		
Operating		
-30X	°C	0 to +70
-20X	°C	-40 to +85
-10X	°C	-55 to +125
Storage		
-30X or -20X	°C	-65 to +150
-10X	°C	-65 to +150
THERMAL RESISTANCE		
Junction to Case, θjc		
40 Pin DDIP (Plastic)	°C/W	92.4
40 Pin DDIP (Ceramic)	°C/W	4.6
44 Pin J-Lead (Plastic)	°C/W	72.6
44 Pin J-Lead (Ceramic)	°C/W	2.4
PHYSICAL CHARACTERISTICS		
Size: 40-pin DDIP	in(mm)	2.0 x 0.6 x 0.2 (50.8 x 15.24 x 5.08)
44-pin J-lead	in(mm)	0.690 square (17.526)
Weight:		Plastic Ceramic
40-pin DDIP	oz (g)	0.21 (5.95) 0.24 (6.80)
44-pin J-lead	oz (g)	0.08 (2.27) 0.064 (1.84)

Notes: 6. See text, General Setup Considerations.
(cont.) 7. When using internally generated -5V the internal -5V charge pump when measured at the converter pin, may be as low as -20% (or -4V).

THEORY OF OPERATION

The RDC-19220/2S series of converter is a single CMOS custom monolithic chip. It is implemented using mixed signal CMOS technology which merges precision analog circuitry with digital logic to form a complete high-performance tracking resolver-to-digital converter. For user flexibility and convenience, the converter bandwidth, dynamics, and velocity scaling are externally set with passive components.

FIGURE 1 is the RDC-19220/2S Functional Block Diagram. The converter operates with ± 5 V DC power supplies. Analog signals are referenced to analog ground, which is at ground potential. The converter is made up of two main sections; a converter and a digital interface. The converter front-end consists of sine and cosine differential input amplifiers. These inputs are protected to ± 25 V with 2 k Ω resistors and diode clamps to the ± 5 V DC supplies. These amplifiers feed the high accuracy Control Transformer (CT). Its other input is the 16-bit digital angle ϕ . Its output is an analog error angle, or difference angle, between the two inputs. The CT performs the ratiometric trigonometric computation of $\text{SIN}\theta\text{COS}\phi - \text{COS}\theta\text{SIN}\phi = \text{SIN}(\theta-\phi)$ using amplifiers, switches, logic and capacitors in precision ratios.

Note: The transfer function of the CT is normally trigonometric, but in LVDT mode the transfer function is triangular (linear) and could thereby convert any linear transducer output.

The converter accuracy is limited by the precision of the computing elements in the CT. In this converter ratioed capacitors are used in the CT, instead of the more conventional precision ratioed resistors. Capacitors used as computing elements with op-amps need to be sampled to eliminate voltage drifting. Therefore, the circuits are sampled at a high rate (70 kHz) to eliminate this drifting and at the same time to cancel out the op-amp offsets.

The error processing is performed using the industry standard technique for type II tracking R/D converters. The DC error is integrated yielding a velocity voltage which in turn drives a voltage-controlled oscillator (VCO). This VCO is an incremental integrator (constant voltage input to position rate output) which, together with the velocity integrator, forms a type II servo feed-

back loop. A lead in the frequency response is introduced to stabilize the loop and a lag at higher frequency is introduced to reduce the gain and ripple at the carrier frequency and above. The settings of the various error processor gains and break frequencies are done with external resistors and capacitors so that the converter loop dynamics can be easily controlled by the user.

TRANSFER FUNCTION AND BODE PLOT

The dynamic performance of the converter can be determined from its Transfer Function Block Diagrams and its Bode Plots (open and closed loop). These are shown in FIGURES 2, 3, and 4.

The open loop transfer function is as follows:

$$\text{Open Loop Transfer Function} = \frac{A^2 \left(\frac{s}{B} + 1 \right)}{s^2 \left(\frac{s}{10B} + 1 \right)}$$

where: A is the gain coefficient
 $A^2 = A_1 A_2$
 B is the frequency of lead compensation

The components of gain coefficient are error gradient, integrator gain, and VCO gain. These can be broken down as follows:

- Error Gradient = 0.011 volts per LSB (CT+Error Amp+Demod with 2 V_{rms} input)
- Integrator gain = $\frac{C_s F_s}{1.1 C_{BW}}$ volts per second per volt
- VCO Gain = $\frac{1}{1.25 R_V C_{VCO}}$ LSBs per second per volt

where: $C_s = 10$ pF
 $F_s = 70$ kHz when $R_s = 30$ k Ω
 $F_s = 100$ kHz when $R_s = 20$ k Ω
 $F_s = 125$ kHz when $R_s = 15$ k Ω
 $C_{VCO} = 50$ pF

R_V , R_B , and C_{BW} are selected by the user to set velocity scaling and bandwidth.

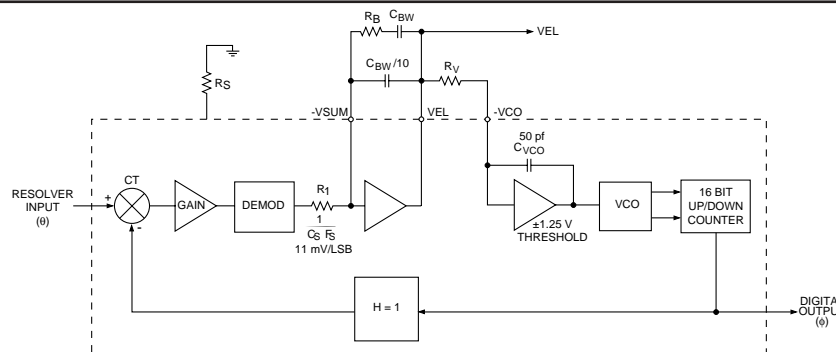


FIGURE 2. TRANSFER FUNCTION BLOCK DIAGRAM #1

GENERAL SETUP CONDITIONS

DDC has external component selection software which considers all the criteria below and, in a simple fashion, asks the key parameters (carrier frequency, resolution, bandwidth, and tracking rate) to derive the external component values.

The following recommendations should be considered when installing the RDC-19220/2S R/D converter:

1) When setting the bandwidth (BW) and Tracking Rate (TR) (selecting five external components), the system requirements need to be considered. For the greatest noise immunity, select the minimum BW and TR the system will allow.

2) Power supplies are $\pm 5V$ DC. For lowest noise performance it is recommended that a $0.1\mu F$ or larger cap be connected from each supply to ground near the converter package.

3) Resolver inputs and velocity output are referenced to AGND. This pin should be connected to GND near the converter package. Digital currents flowing through ground will not disturb the analog signals.

4) The \overline{BIT} output, which is active low, is activated by an error of approximately 100 LSBs. During normal operation, for step inputs or on power up, a large error can exist.

5) Setup of bandwidth and velocity scaling for the optimized critically damped case should proceed as follows:

- Select the desired f_{BW} (closed loop), based on overall system dynamics.

- Select $f_{carrier} \geq 3.5 f_{BW}$

- Compute $R_V = 55 \text{ k}\Omega \times \frac{\left\{ \begin{array}{l} \text{For the converter max tracking rate value,} \\ \text{see the row indicated in TABLE 3.} \end{array} \right\}}{\text{Application max rate}}$

- Compute $C_{BW} \text{ (pF)} = \frac{3.2 \times F_S \text{ (Hz)} \times 10^8}{R_V \times (f_{BW})^2}$

- Where $F_S = 70 \text{ kHz}$ for $R_S = 30 \text{ k}\Omega$
 100 kHz for $R_S = 20 \text{ k}\Omega$
 125 kHz for $R_S = 15 \text{ k}\Omega$

- Compute $R_B = \frac{0.9}{C_{BW} \times f_{BW}}$

- Compute $\frac{C_{BW}}{10}$

6) Selecting a f_{BW} that is too low relative to the maximum application tracking rate can create a spin-around condition in which the converter never settles. The relationship to insure against spin-around is as follows (TABLE 2.):

RPS (MAX)/BW	RESOLUTION
1	10
0.50	12
0.25	14
0.125	16

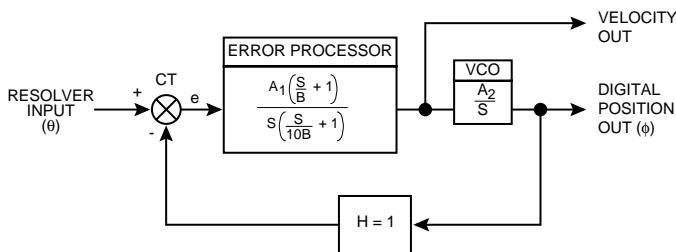


FIGURE 3. TRANSFER FUNCTION BLOCK DIAGRAM #2

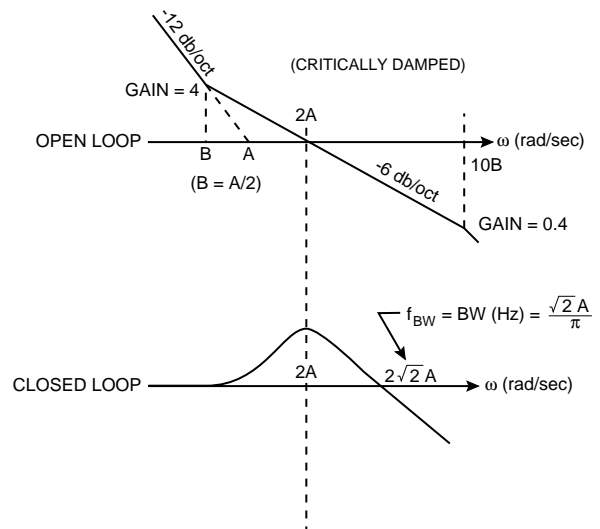


FIGURE 4. BODE PLOTS

7) RDC-19222 package only:

When using the built-in -5 V inverter: connect as shown.

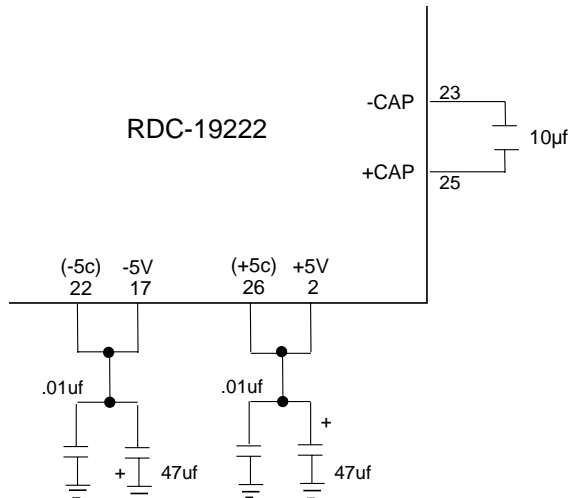


FIGURE 5. -5V BUILT-IN INVERTER

The current drain from the +5 V supply doubles. No external -5 V supply is needed. The power supply 47µf caps shown may be substituted with 10µf caps if the P/S lines are clean (min noise).

When using the built-in -5 V inverter, the maximum tracking rate should be scaled for a velocity output of 3.5 V max. Use the following equation to determine tracking rate used in the formula on page 5:

$$\frac{TR \text{ (required)} \times (4.0)}{(3.5)} = \text{Tracking rate used in calculation}$$

Note: When using the highest BW and Tracking Rates, use of the -5 V inverter is not recommended.

HIGHER TRACKING RATES AND CARRIER FREQUENCIES

Tracking rate (nominally 4 V) is limited by two factors: velocity voltage saturation and maximum internal clock rate (nominally 1,333,333 Hz). An understanding of their interaction is essential to extending performance.

The General Setup Considerations section makes note of the selection of R_v for the desired velocity scaling. R_v is the input resistor to an inverting integrator with a 50 pF nominal feedback capacitor. When it integrates to -1.25 V, the converter counts up 1 LSB and when it integrates to +1.25 V, the converter counts down 1 LSB. When a count is taken, a charge is dumped on the capacitor such that the voltage on it changes 1.25 V in a direction to bring it to 0 V. The output counts per second per volt input is therefore:

$$\frac{1}{(R_v \times 50 \text{ pF} \times 1.25)}$$

As an example:

Calculate R_v for the maximum counting rate, at a VEL voltage of 4 V.

For a 12-bit converter there are 2¹² or 4096 counts per rotation. 1,333,333/4096 = 325 rotations per second or 333,333 counts per second per volt.

$$R_v = \frac{1}{(333,333 \times 50 \text{ pF} \times 1.25)} = 48\text{k Ohms}$$

The maximum rate capability of the RDC-19220/2S is set by R_S.

When R_S = 30 kHz it is nominally 1,333,333 counts/second, which equates to 325 rps (rotations per second). This is the absolute maximum; it is recommended to only run at < 90% of this rate (as given in TABLE 3), therefore the minimum R_v will be limited to 55 kOhms.

TABLE 3. MAX TRACKING RATE (MIN) IN RPS					
R _C	R _S	RESOLUTION			
		10	12	14	16
30k or open*	30 k	1152	288	72	18

Depending on the resolution, select one of the values from this row, for use in converter max tracking rate formula. (See previous page for formula.)

Carrier frequency is shown in TABLE 4.

TABLE 4. CARRIER FREQUENCY (MAX) IN KHZ					
R _C	R _S	RESOLUTION			
		10	12	14	16
30k or open*	30 k	10	10	5	5

*The use of a high quality thin-film resistor will provide better temperature stability than leaving open.

TABLE 5. TRANSFORMERS

P/N	TYPE	FREQUENCY (HZ)*	IN (VRMS)*	OUT (VRMS)**	ANGLE ACCURACY***	LENGTH (IN)	WIDTH (IN)	HEIGHT (IN)	FIGURE NUMBER
52034	S - R	400	11.8	2	1	0.81	0.61	0.3	6A
52035	S - R	400	90	2	1	0.81	0.61	0.3	6A
52036	R - R	400	11.8	2	1	0.81	0.61	0.3	6B
52037	R - R	400	26	2	1	0.81	0.61	0.3	6B
52038	R - R	400	90	2	1	0.81	0.61	0.3	6B
B-426	Reference	400	115	3.4	N/A	0.81	0.61	0.32	6C
52039	Synchro	60	90	2	1	1.1	1.14	.42	6D
24133	Reference	60	115	3/6 ****	N/A	1.125	1.125	.42	6D

* $\pm 10\%$ Frequency (Hz) and Line-to-Line input voltage (Vrms) tolerances
 ** 2 Vrms Output Magnitudes are $-2 \text{ Vrms} \pm 0.5\%$ full scale
 *** Angle Accuracy (Max Minutes)
 **** 3 Vrms to ground or 6 Vrms differential ($\pm 3\%$ full scale)
 Dimensions are for each individual main and teaser
 60 Hz Synchro transformers are active (requires $\pm 15 \text{ Vdc}$ power supplies)
 400 Hz transformer temperature range: -55°C to $+125^\circ\text{C}$
 60 Hz transformer temperature ranges: -55°C to $+125^\circ\text{C}$, 0 to $+70^\circ\text{C}$

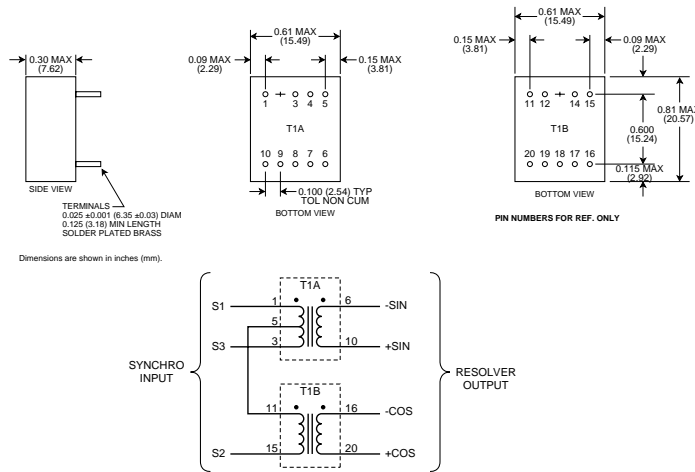


FIGURE 6A. TRANSFORMER LAYOUT AND SCHEMATIC (SYNCHRO INPUT - 52034/52035)

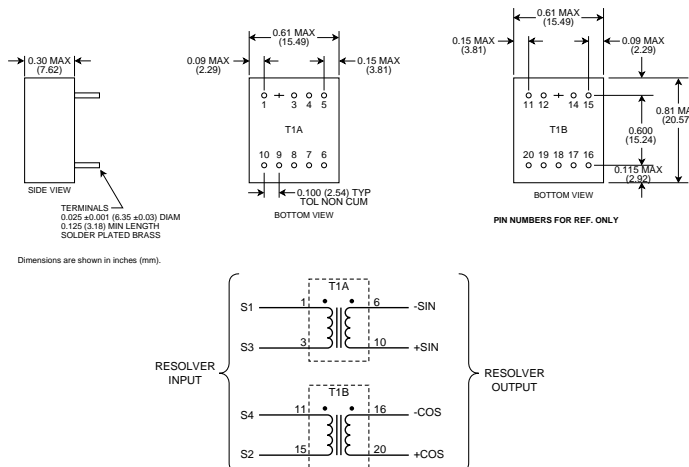
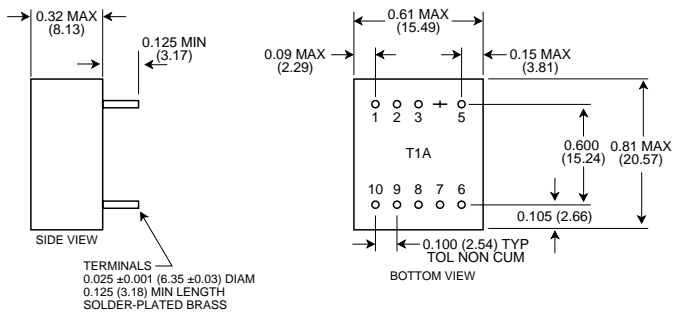


FIGURE 6B. TRANSFORMER LAYOUT AND SCHEMATIC (RESOLVER INPUT - 52036/52037/52038)



Dimensions are shown in inches (mm).

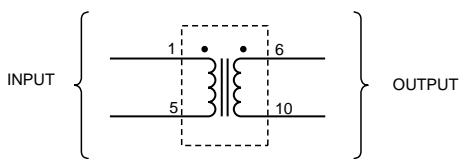
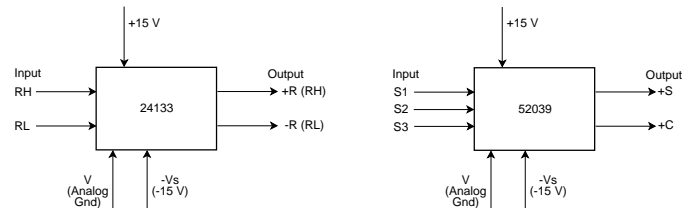
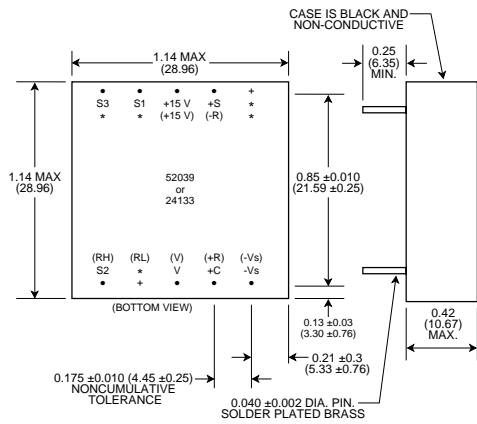


FIGURE 6C. TRANSFORMER LAYOUT AND SCHEMATIC (REFERENCE INPUT - B-426)



The mechanical outline is the same for the synchro input transformer (52039) and the reference input transformer (24133), except for the pins. Pins for the reference transformer are shown in parenthesis (). An asterisk * indicates that the pin is omitted.

FIGURE 6D. 60 HZ SYNCHRO AND REFERENCE TRANSFORMER DIAGRAMS (SYNCHRO INPUT - 52039 / REFERENCE INPUT - 24133)

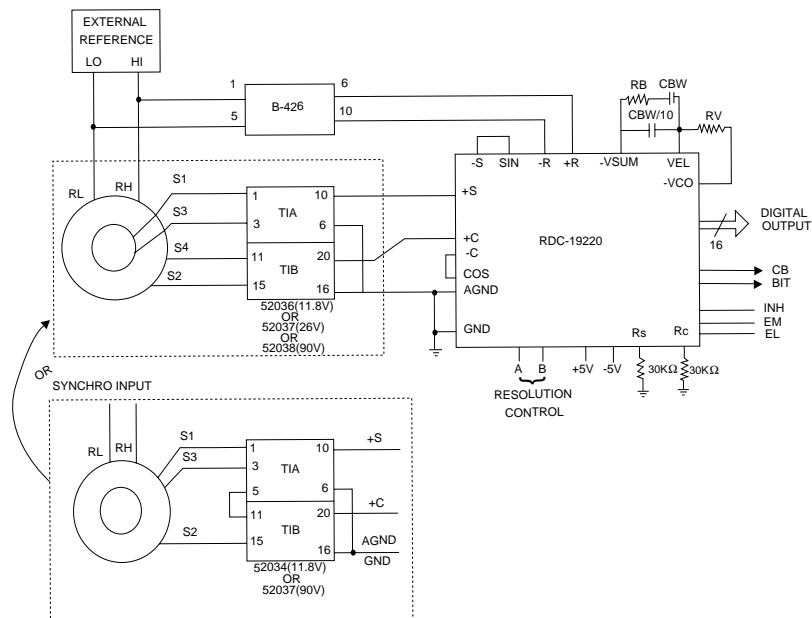


FIGURE 7. TYPICAL TRANSFORMER CONNECTIONS

TYPICAL INPUTS

FIGURES 8 through 10 illustrate typical input configurations

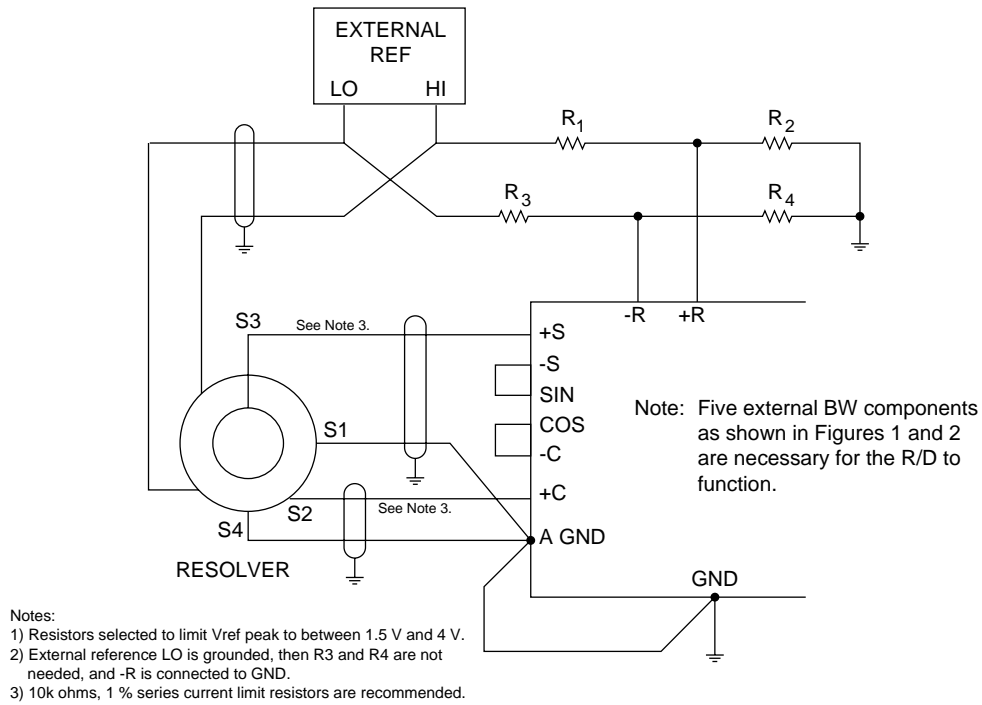
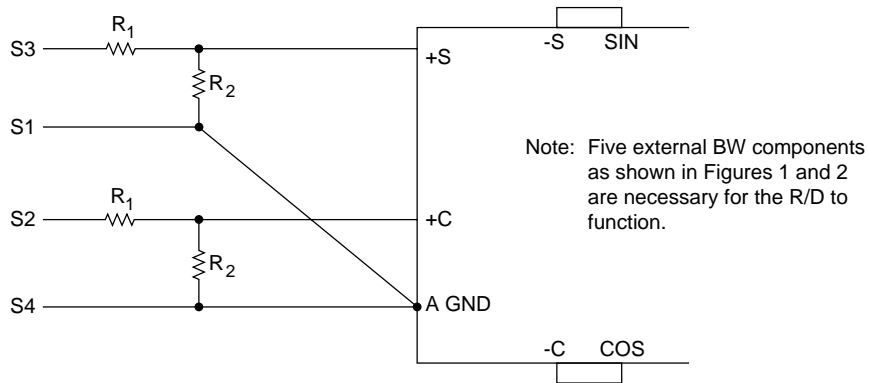


FIGURE 8. TYPICAL CONNECTIONS, 2 VOLT RESOLVER, DIRECT INPUT

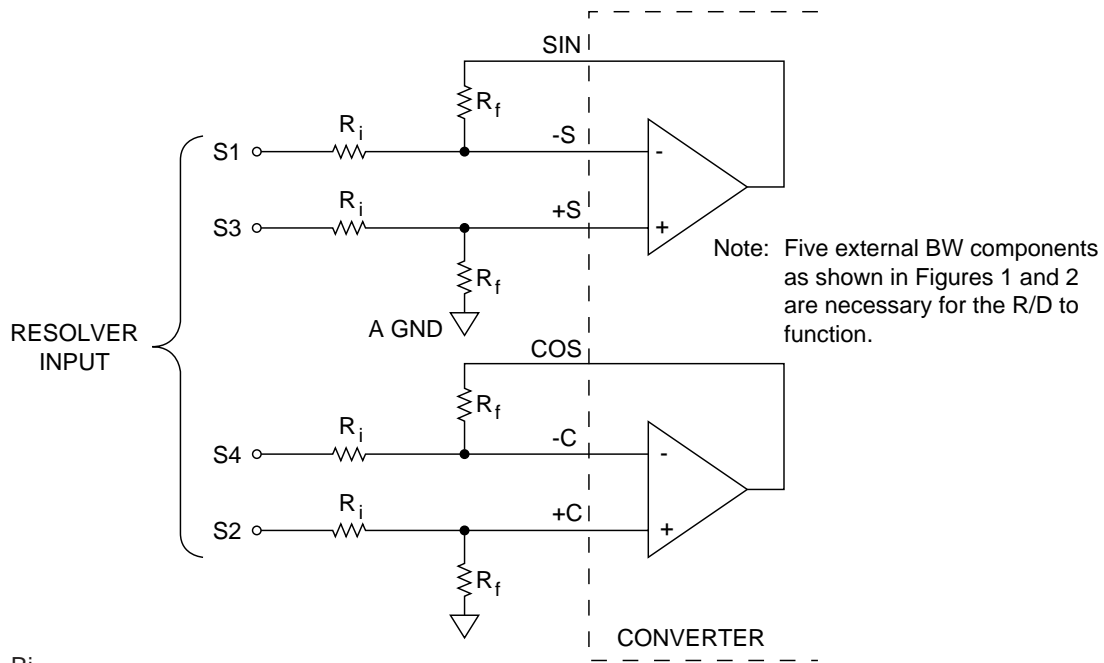


$$\frac{R_2}{R_1 + R_2} = \frac{2}{X \text{ Volt}}$$

R1 + R2 should not load the Resolver too much; it is recommended that R2 = 10k.

R1 + R2 Ratio Errors will result in Angular Errors,
2 cycle, 0.1% Ratio Error = 0.029° Peak Error.

FIGURE 9. TYPICAL CONNECTIONS, X-VOLT RESOLVER, DIRECT INPUT

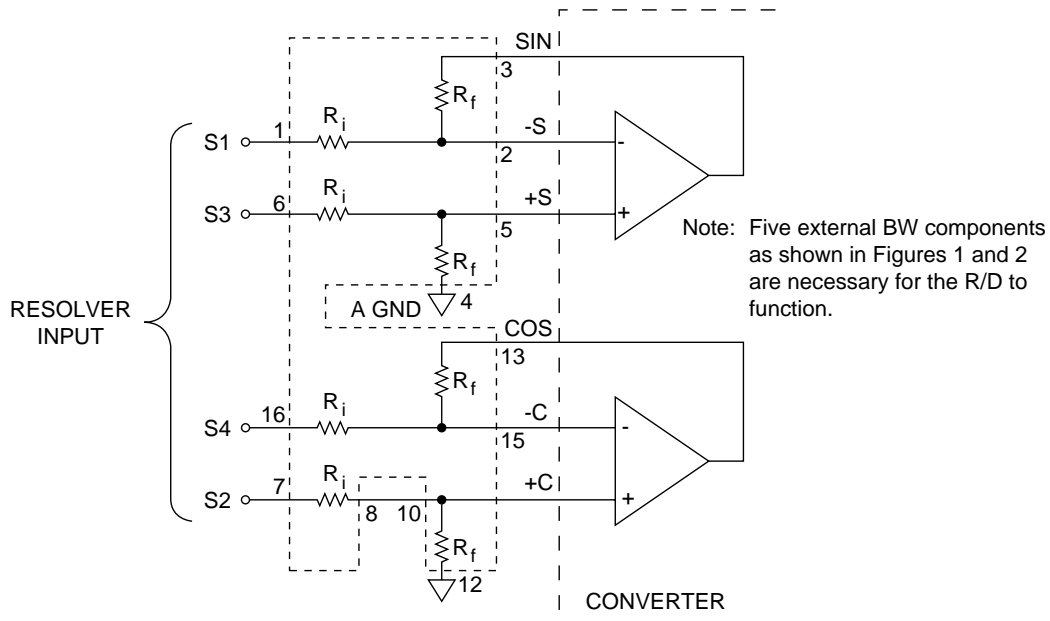


$$\frac{R_i}{R_f} \times 2 V_{rms} = \text{Resolver L-L rms voltage}$$

$$R_f \geq 6 \text{ k}\Omega$$

S1 and S3, S2 and S4, and RH and RL should be ideally twisted shielded, with the shield tied to AGND at the converter.

FIGURE 10A. DIFFERENTIAL RESOLVER INPUT



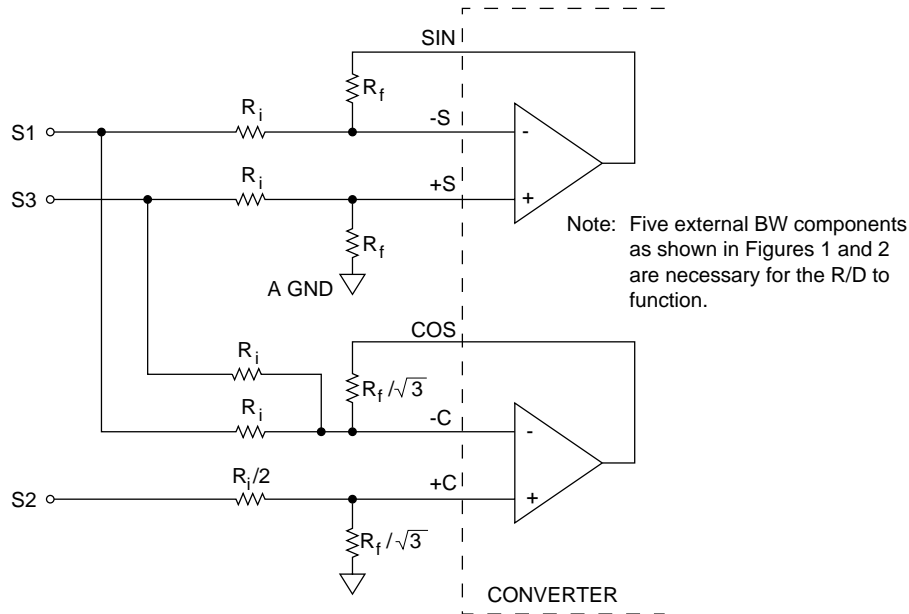
S1 and S3, S2 and S4, and RH and RL should be ideally twisted shielded, with the shield tied to AGND at the converter.

For DDC-49530: $R_i = 70.8 \text{ k}\Omega$, 11.8 V input, synchro or resolver.

For DDC-49590: $R_i = 270 \text{ k}\Omega$, 90 V input, synchro or resolver.

Maximum addition error is 1 LSB.

FIGURE 10B. DIFFERENTIAL RESOLVER INPUT, USING DDC-49530 (11.8 V) OR DDC-49590 (90 V)

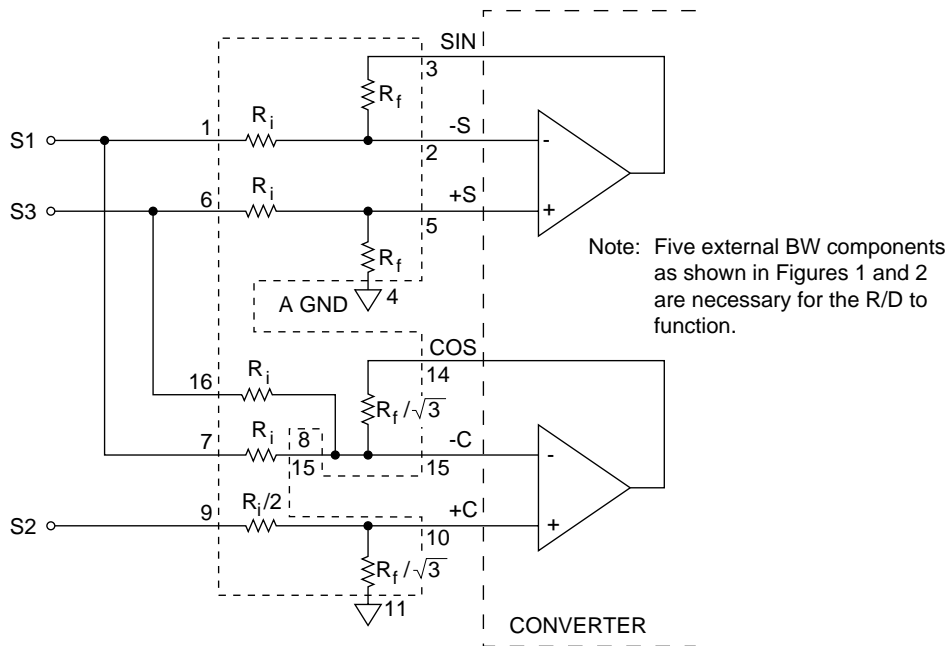


$$\frac{R_i}{R_f} \times 2 V_{rms} = \text{Resolver L-L rms voltage}$$

$$R_f \geq 6 \text{ k}\Omega$$

S1, S2, and S3 should be triple twisted shielded; RH and RL should be twisted shielded. In both cases the shield should be tied to AGND at the converter.

FIGURE 10C. SYNCHRO INPUT



S1, S2, and S3 should be triple twisted shielded; RH and RL should be twisted shielded. In both cases the shield should be tied to AGND at the converter.

90 V input = DDC-49590: $R_i = 270 \text{ k}\Omega$, 90 V input, synchro or resolver.

11.8 V input = DDC-49530: $R_i = 70.8 \text{ k}\Omega$, 11.8 V input, synchro or resolver.

Maximum addition error is 1 LSB.

FIGURE 10D. SYNCHRO INPUT, USING DDC-49530 (11.8 V) OR DDC-49590 (90 V)

DC INPUTS

As noted in TABLE 1 the RDC-19220/2S will accept DC inputs. It is necessary to set the REF input to DC by tying +REF to +5 V and -REF to GND or -5 V. (With DC inputs, the BIT output is not valid.)

VELOCITY TRIMMING

RDC-19220/2S specifications for velocity scaling, reversal error, and offset are contained in TABLE 1. Velocity scaling and offset are externally trimmable for applications requiring tighter specifications than those available from the standard unit. FIGURE 11 shows the setup for trimming these parameters with external potentiometers. It should also be noted that when the resolution is changed, VEL Scaling is also changed. Since the VEL output is from an integrator with capacitor feedback, the VEL voltage cannot change instantaneously. Therefore, when changing resolution while moving, there will be a transient with a magnitude proportional to the velocity and a duration determined by the converter bandwidth.

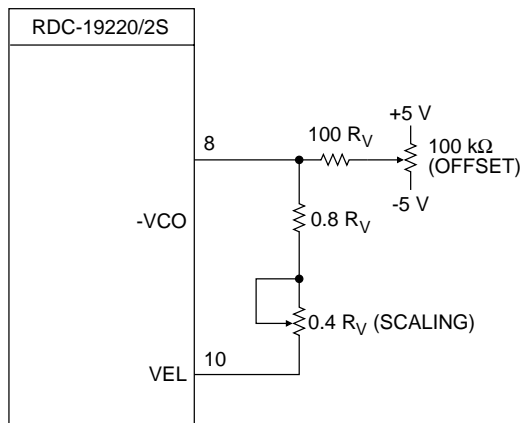


FIGURE 11. VELOCITY TRIMMING

SYNTHESIZED REFERENCE

The synthesized reference section of the RDC-19220/2S eliminates errors caused by quadrature voltage which is due to a phase shift between the reference and the signal lines. Quadrature voltages in a resolver or synchro are by definition the resulting 90° fundamental signal in the nulled out error voltage (e) in the converter. Due to the inductive nature of synchros and resolvers, their signals lead the reference signal (RH and RL) by about 6°.

When an uncompensated reference signal is used to demodulate the control transformer's output, quadrature voltages are not completely eliminated. As shown in FIGURE 1, the converter synthesizes its own $\text{COS}(\omega t + \alpha)$ reference signal from the $\text{SIN } \theta$ $\text{COS}(\omega t + \alpha)$, $\text{COS } \theta - \text{COS}(\omega t + \theta)$ signal inputs and from the

$\text{COS}\omega t$ reference input. The phase angle of the synthesized reference is determined by the signal input. The reference input is used to choose between the +180° and -180° phases. The synthesized reference will always be exactly in phase with the signal input, and quadrature errors will therefore be reduced. The synthesized reference circuit also eliminates the 180° false error null hang up.

Due to the inductive nature of resolvers, the output signals typically lead the reference by 6°, and a 6° phase shift will cause problems for a 2.3 arc minute accuracy converter. A synthesized reference will always be exactly in phase with the signal input.

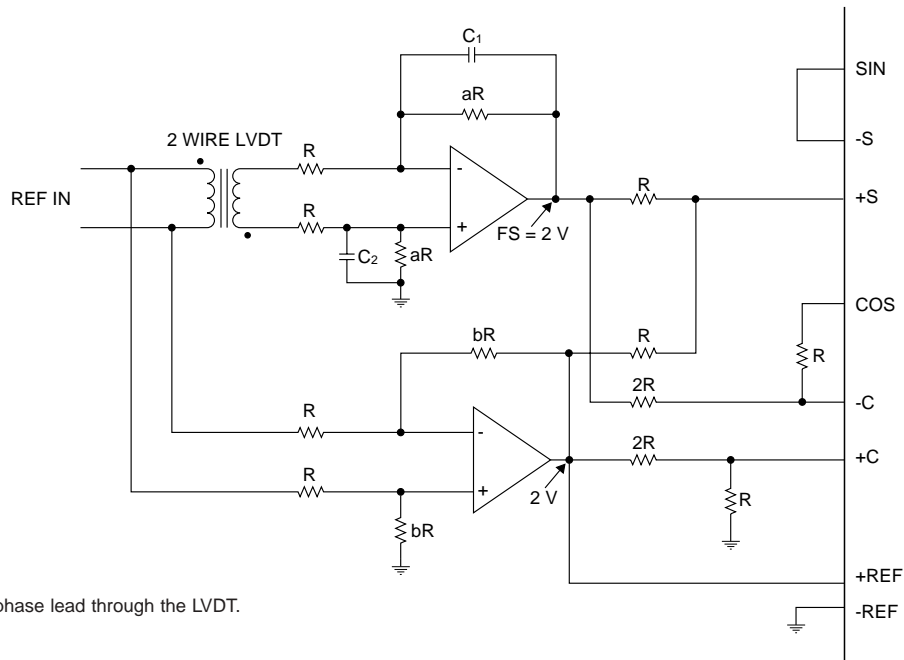
LVDT (LINEAR VARIABLE DIFFERENTIAL TRANSFORMER) MODE

As shown in TABLE 1 the RDC-19220/2S unit can be made to operate as a LVDT-to-digital converter by connecting Resolution Control inputs A and B to "0," "1," or the -5 volt supply. In this mode the RDC-19220/2S functions as a ratiometric tracking linear converter. When linear AC inputs are applied from an LVDT the converter operates over one quarter of its range. This results in two less bits of resolution for LVDT mode than are provided in resolver mode.

The LVDT output signals will need to be scaled to be compatible with the converter input. FIGURE 12B is a schematic of an input scaling circuit applicable to 3-wire LVDTs. The value of the scaling constant "a" is selected to provide an input of 2 V_{rms} at full stroke of the LVDT. The value of scaling constant "b" is selected to provide an input of 1 V_{rms} at null of the LVDT. Suggested components for implementing the input scaling circuit are a quad op-amp, such as a 4741 type, and precision thin-film resistors of 0.1% tolerance. FIGURE 12A illustrates a 2-wire LVDT configuration.

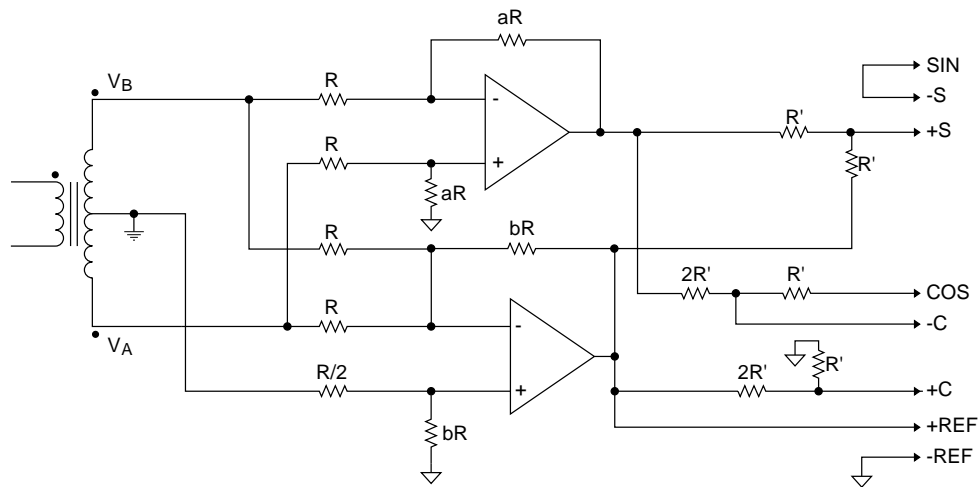
Data output of the RDC-19220/2S is Binary Coded in LVDT mode. The most negative stroke of the LVDT is represented by ALL ZEROS and the most positive stroke of the LVDT is represented by ALL ONES. The most significant 2 bits (2 MSBs) may be used as overrange indicators. Positive overrange is indicated by code "01" and negative overrange is indicated by code "11" (see TABLE 6).

TABLE 6. 12-BIT LVDT OUTPUT CODE FOR FIGURE 12B				
LVDT OUTPUT	MSB		LSB	
+ over full travel	01	xxxx	xxxx	xxxx
+ full travel -1 LSB	00	1111	1111	1111
+0.5 travel	00	1100	0000	0000
+1 LSB	00	1000	0000	0001
null	00	1000	0000	0000
- 1 LSB	00	0111	1111	1111
-0.5 travel	00	0100	0000	0000
- full travel	00	0000	0000	0000
- over full travel	11	xxxx	xxxx	xxxx

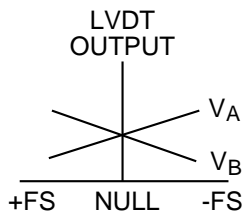


C1 = C2, set for phase lag = phase lead through the LVDT.

FIGURE 12A. 2-WIRE LVDT DIRECT INPUT



- Notes:
1. $R' \geq 10 \text{ k}\Omega$
 2. Consideration for the value of R is LVDT loading.



$$b = \frac{1}{V_{\text{Anull}}} = \frac{1}{V_{\text{Bnull}}}$$

$$a = \frac{2}{(V_A - V_B)_{\text{max}}}$$

$$\text{SIN} = 1 + \frac{a}{2} (V_A - V_B)$$

$$\text{COS} = 1 - \frac{a}{2} (V_A - V_B)$$

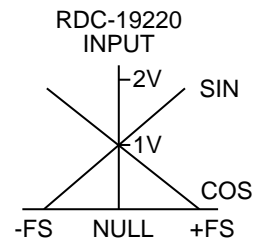


FIGURE 12B. 3-WIRE LVDT SCALING CIRCUIT

INHIBIT, ENABLE, AND CB TIMING

The Inhibit ($\overline{\text{INH}}$) signal is used to freeze the digital output angle in the transparent output data latch while data is being transferred. Application of an inhibit signal does not interfere with the continuous tracking of the converter. As shown in FIGURE 13, angular output data is valid 150 ns maximum after the application of the negative inhibit pulse.

Output angle data is enabled onto the tri-state data bus in two bytes. Enable MSBs ($\overline{\text{EM}}$) is used for the most significant 8 bits and Enable LSBs ($\overline{\text{EL}}$) is used for the least significant 8 bits. As shown in FIGURE 14, output data is valid 150 ns maximum after the application of a negative enable pulse. The tri-state data bus returns to the high impedance state 100 ns maximum after the rising edge of the enable signal.

The Converter Busy (CB) signal indicates that the tracking converter output angle is changing 1 LSB. As shown in FIGURE 15, output data is valid 50 ns maximum after the middle of the CB pulse. The CB pulse width is $1/40 F_s$, which is nominally 375 ns.

BUILT-IN-TEST ($\overline{\text{BIT}}$)

The Built-In-Test output ($\overline{\text{BIT}}$) monitors the level of error from the demodulator. This signal is the difference in the input and output angles and ideally should be zero; if it exceeds approximately 100 LSBs (of the selected resolution) the logic level at $\overline{\text{BIT}}$ will change from a logic 1 to a logic 0.

This condition will occur during a large step and reset after the converter settles out. $\overline{\text{BIT}}$ will also change to logic 0 for an over-velocity condition, because the converter loop cannot maintain input-output or if the converter malfunctions where it cannot maintain the loop at a null. $\overline{\text{BIT}}$ will also be set low for a detected Loss-of-Signal (LOS) and/or a Loss-of-Reference (LOR). The $\overline{\text{BIT}}$ signal may pulse during certain error conditions, i.e., when the converter is in a spin around condition or the signal amplitude is on the threshold of LOS.

LOS will be detected if both sin and cos input voltages are less than 500 mV peak. LOR will be detected if the differential reference voltage is less than 500 mV peak.

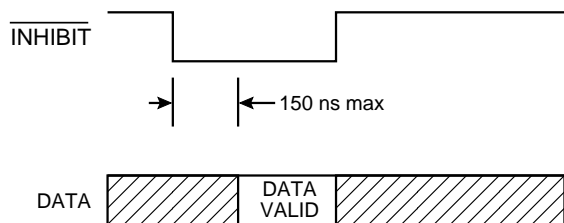


FIGURE 13. INHIBIT TIMING

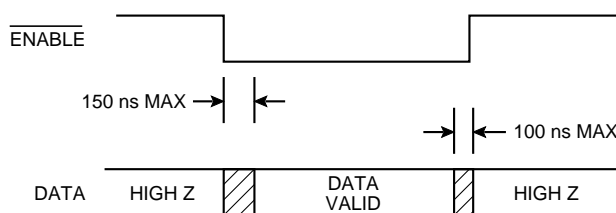


FIGURE 14. ENABLE TIMING

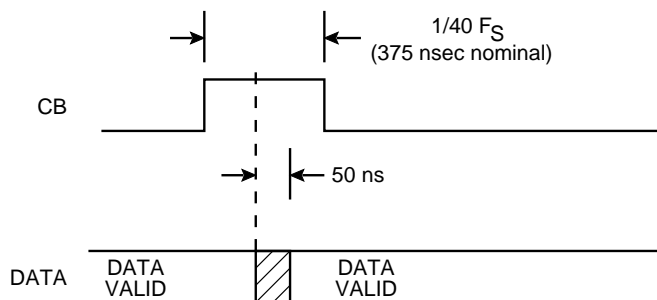


FIGURE 15. CONVERTER BUSY TIMING

PIN OUT FUNCTION TABLES BY MODEL NUMBER

The following tables detail pin out functions by the DDC model number.

The RDC-19220S has differential inputs but requires both ± 5 V power supplies.

The RDC-19222S has differential inputs and can be used with ± 5 V or +5 V only.

TABLE 7. RDC-19220S (40 PIN) PIN OUTS

#	NAME	DESCRIPTION	#	NAME	DESCRIPTION
1	A	Resolution Control	40	+5 V	Power Supply
2	B	Resolution Control	39	$\overline{\text{EL}}$	Enable LSBs
3	$\overline{\text{INH}}$	Inhibit	38	Bit 16	LSB
4	+REF	+Reference Input	37	Bit 8	
5	-REF	-Reference Input	36	Bit 15	
6	-VCO	Neg. VCO Input	35	Bit 7	
7	-VSUM	Vel Sum Point	34	Bit 14	
8	VEL	Velocity Output	33	Bit 6	
9	+C	Signal Input	32	Bit 13	
10	COS	Signal Input	31	Bit 5	
11	-C	Signal Input	30	Bit 12	
12	+S	Signal Input	29	Bit 4	
13	+SIN	Signal Input	28	Bit 11	
14	-S	Signal Input	27	Bit 3	
15	-5 V	Power Supply	26	Bit 10	
16	R_S	Sampling Set	25	Bit 2	
17	R_C	Current Set	24	Bit 9	
18	$\overline{\text{EM}}$	Enable MSBs	23	Bit 1	MSB
19	A GND	Analog Ground	22	CB	Converter Busy
20	GND	Ground	21	$\overline{\text{BIT}}$	Built-In-Test

TABLE 8. RDC-19222S (44-PIN) PIN OUTS

#	NAME	DESCRIPTION	#	NAME	DESCRIPTION
1	$\overline{\text{EL}}$	Enable LSBs	44	BIT 16	LSB
2	+5V	Power Supply (see note)	43	BIT 8	
3	A	Resolution Control	42	Bit 15	
4	B	Resolution Control	41	Bit 7	
5	$\overline{\text{INH}}$	Inhibit	40	Bit 14	
6	+REF	+Reference Input	39	Bit 6	
7	-REF	-Reference Input	38	Bit 13	
8	-VCO	Neg. VCO Input	37	Bit 5	
9	-VSUM	Vel Sum Point	36	Bit 12	
10	VEL	Velocity Output	35	Bit 4	
11	+C	Signal Input	34	Bit 11	
12	COS	Signal Input	33	Bit 3	
13	-C	Signal Input	32	Bit 10	
14	+S	Signal Input	31	Bit 2	
15	SIN	Signal Input	30	Bit 9	
16	-S	Signal Input	29	Bit 1	MSB
17	-5V	Power Supply	28	CB	Converter Busy
18	R_S	Sampling Set	27	$\overline{\text{BIT}}$	Built-in-Test
19	R_C	Current Set	26	+5C (+5V)	Pos. Supply Cap
20	$\overline{\text{EM}}$	Enable MSBs	25	+CAP	Pos. Terminal
21	A GND	Analog Ground	24	GND	Ground
22	-5C (-5V)	Neg. Supply Cap	23	-CAP	Neg. Terminal

Note: When using the built-in -5 V inverter: connect pin 2 to 26, pin 17 to 22, and a 10 $\mu\text{F}/10$ VDC capacitor from pin 23 (negative terminal) to pin 25 (positive terminal). Connect a 47 $\mu\text{F}/10$ VDC capacitor from -5 V to GND. The current drain from the +5 V supply doubles. No external -5 V supply is needed.

DIMENSIONS SHOWN ARE IN INCHES (MM).

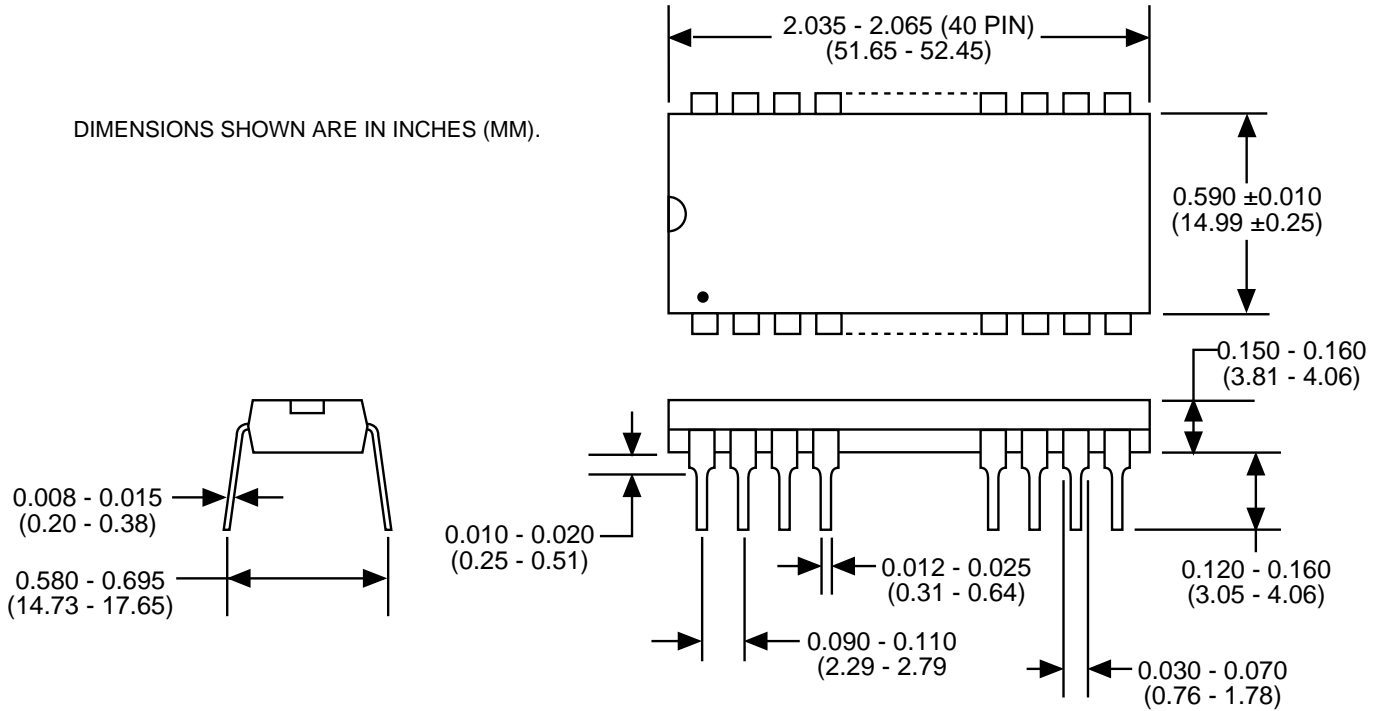
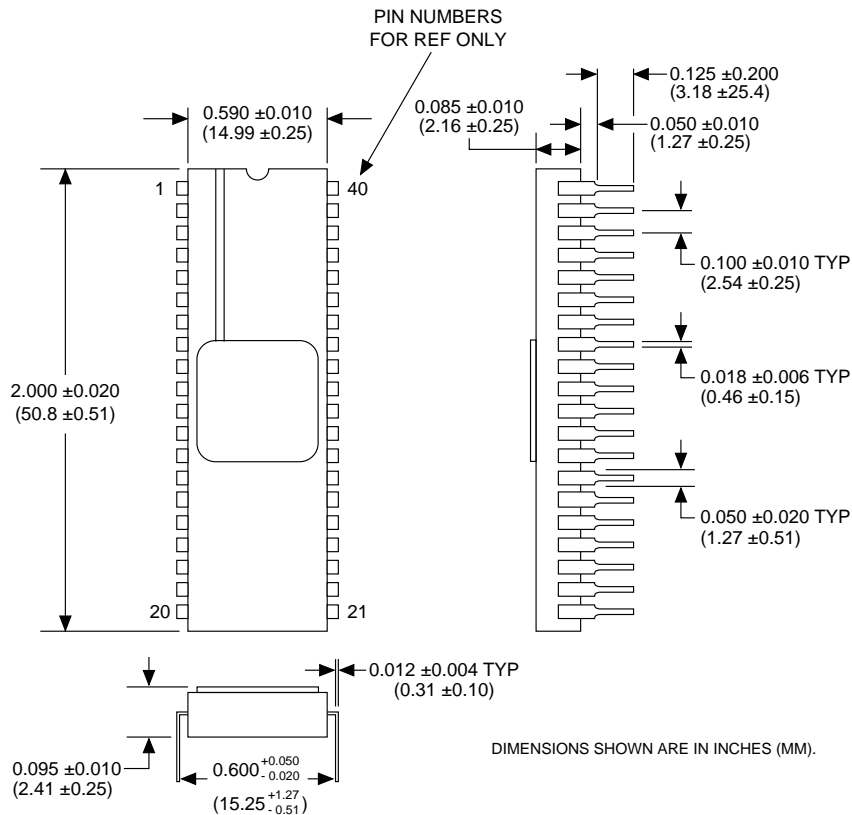


FIGURE 16. RDC-19220S (40-PIN DDIP) PLASTIC PACKAGE MECHANICAL OUTLINE



DIMENSIONS SHOWN ARE IN INCHES (MM).

FIGURE 17. RDC-19220S (40-PIN DDIP) CERAMIC PACKAGE MECHANICAL OUTLINE

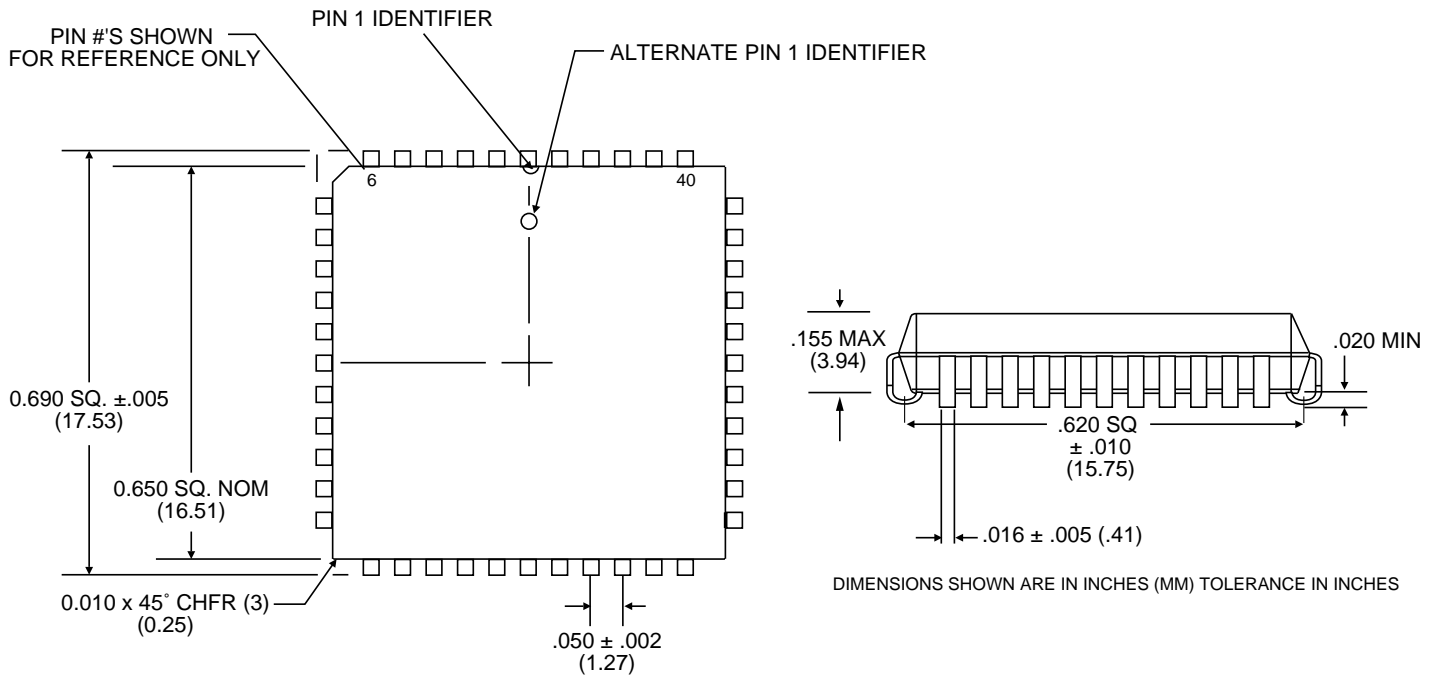


FIGURE 18. RDC-19222S (44-PIN PLASTIC J-LEAD) MECHANICAL OUTLINE

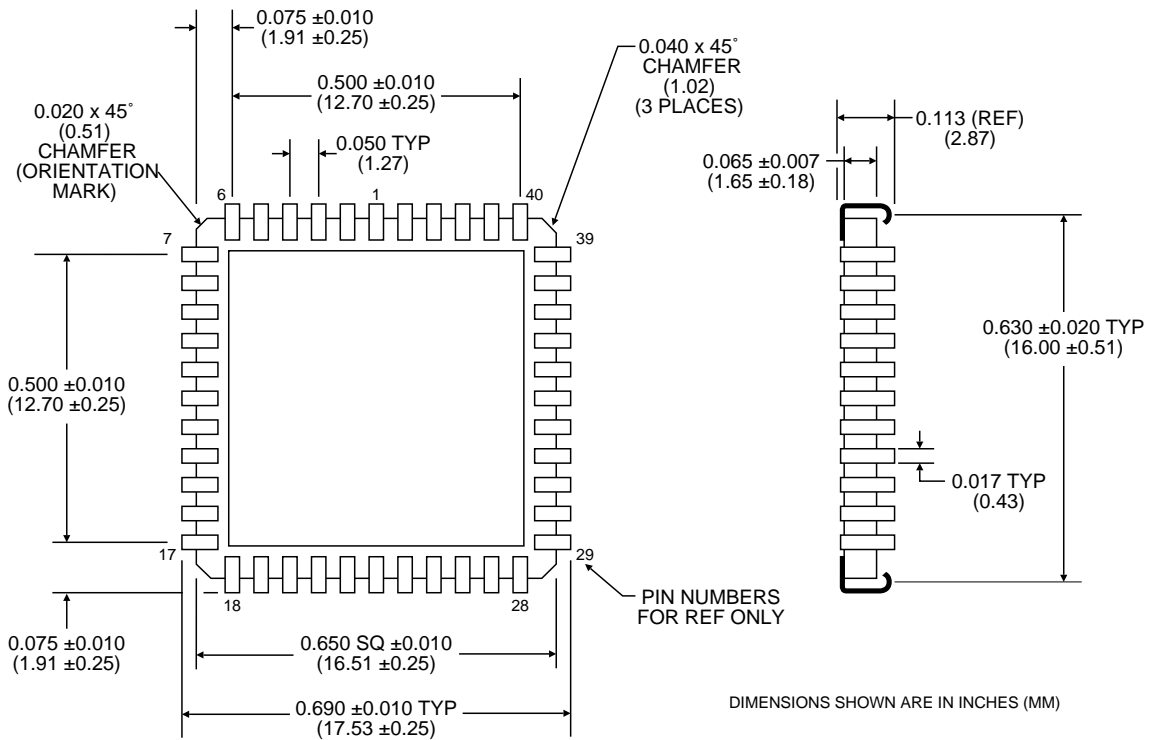


FIGURE 19. RDC-19222S (44-PIN CERAMIC J-LEAD) MECHANICAL OUTLINE

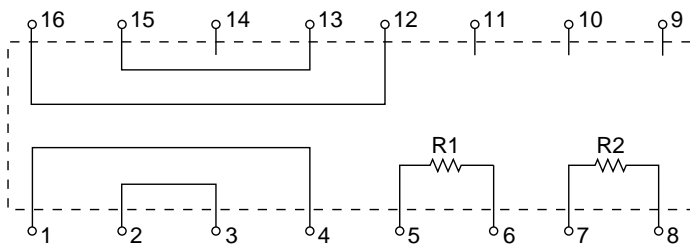


FIGURE 20. (DDC-55688-1) LAYOUT AND RESISTOR VALUES (R1 AND R2 = 10 KΩ 1.0% TOL, ABSOLUTE TC = ±100 PPM MAX)

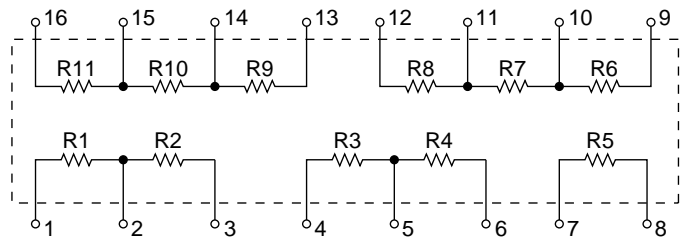
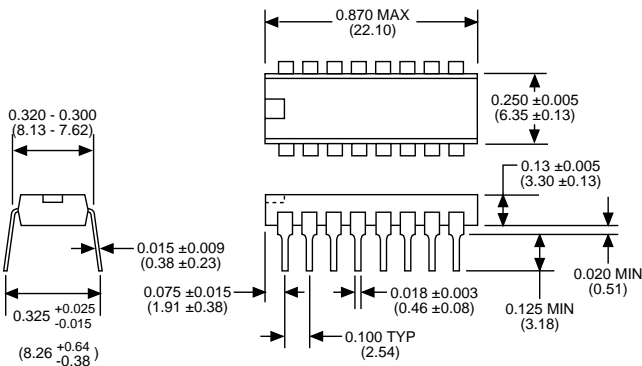


FIGURE 21. (DDC-49530, DDC-49590, DDC-57470) LAYOUT AND RESISTOR VALUES (SEE TABLE 9)

TABLE 9. FRONT-END THIN-FILM RESISTOR NETWORKS (SEE FIGURE 21)

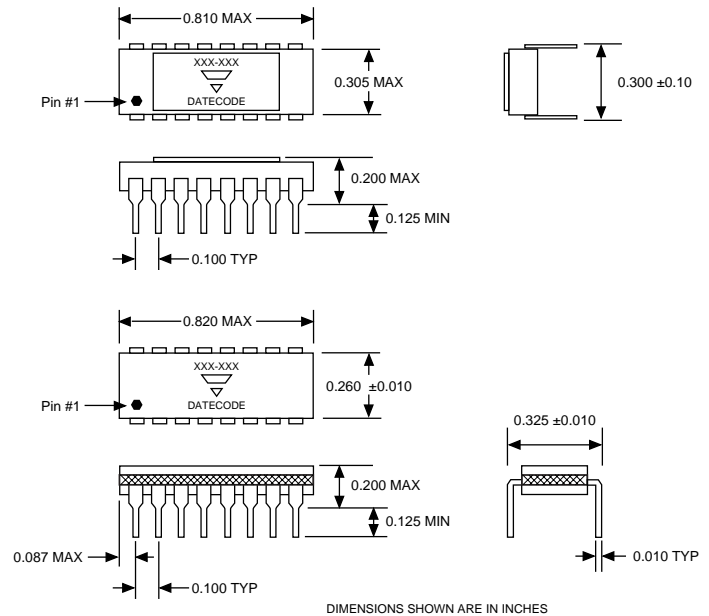
DDC-49530, DDC-57470 RESISTOR VALUES (11.8 V INPUTS)						
SYMBOL	ABS VALUE (Ω)	TOL (%)	REL TO	REL VALUE (Ω)	TOL (%)	TCR (PPM)
R1	70.8 k	0.1				25
R2			R1	12 k	0.02	2
R3			R4	12 k	0.02	2
R4			R1	70.8 k	0.02	2
R5			R1	70.8 k	0.02	2
R6			R1	35.4 k	0.02	2
R7			R6	6.9282 k	0.02	2
R8			R6	5.0718 k	0.02	2
R9			R11	5.0718 k	0.02	2
R10			R11	6.9282 k	0.02	2
R11			R1	70.8 k	0.02	2
DDC-49590 RESISTOR VALUES (90 V INPUTS)						
R1	270 k	0.1				25
R2			R1	6 k	0.02	2
R3			R4	6 k	0.02	2
R4			R1	270 k	0.02	2
R5			R1	270 k	0.02	2
R6			R1	135 k	0.02	2
R7			R6	3.4641 k	0.02	2
R8			R6	2.5359 k	0.02	2
R9			R11	2.5359 k	0.02	2
R10			R11	3.4641 k	0.02	2
R11			R1	270 k	0.02	2



DIMENSIONS SHOWN ARE IN INCHES (MM).

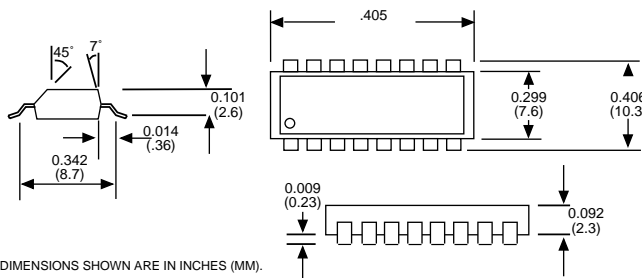
FIGURE 22. 16-PIN THIN-FILM RESISTOR NETWORK DIP MECHANICAL OUTLINE (DDC-49530, DDC-49590*, DDC-55688-1)

*Note: DDC-49590 - alternate ceramic package may be substituted for plastic package depending upon availability (See Figure 24).



DIMENSIONS SHOWN ARE IN INCHES

FIGURE 24. 16-PIN THIN-FILM RESISTOR NETWORK DIP MECHANICAL OUTLINE (ALTERNATE CERAMIC PACKAGE FOR DDC-49590)



DIMENSIONS SHOWN ARE IN INCHES (MM).

FIGURE 23. 16-PIN THIN-FILM RESISTOR NETWORK FLAT-PACK MECHANICAL OUTLINE (DDC-57470)

ORDERING INFORMATION

RDC-1922XS - XXXX

Supplemental Process Requirements:

- T = Tape and Reel
- S = Pre-Cap Source Inspection
- L = Pull Test
- Q = Pre-Cap Source and Pull Test
- K = One Lot Date Code
- W = One Lot Date Code and Pre-Cap Source Inspection
- Y = One Lot Date Code and 100% Pull Test
- Z = One Lot Date Code, Pre-Cap Source Inspection and 100% Pull Test

Accuracy:

- 2 = 4 minutes + 1 LSB
- 3 = 2 minutes + 1 LSB

Process Requirements:

- 0 = Standard DDC Processing, no Burn-In
- 2 = 168 Hour Burn-In at +125°C (-55 to +125°C devices only) **
- 7 = 168 Hour Burn-In at +125°C (-55 to +125°C devices only) plus solder dip **

Temperature Grade:

- 1 = -55 to +125°C
- 2 = -40 to +85°C
- 3 = 0 to +70°C
- 4 = -55 to +125°C with Variables Test Data

Package:

- 0 = 40-Pin DDIP*
- 2 = 44-Pin J-Lead* with +5 Volt-Only Option
- 9 = Screened to Class K, 44-Pin J-Lead ceramic package,
only available in the following options: ** Temperature Grade: #1 or 4
Process Requirements: #2 or 7

*Plastic for -20X and -3XX, ceramic for -1XX and -4XX.

** For RDC-19229 Process Requirement Burn-In will be 320 hours.

Notes: 1) DDC reserves the right to supply ceramic packages in place of plastic packages.
 2) Consult factory for External Component Selection Software.

THIN-FILM RESISTOR NETWORKS: (Operating temperature range: -55 to +125°C)

- DDC-49530 = 11.8 V input, DIP
- DDC-57470 = 11.8 V input, surface mount
- DDC-49590 = 90 V input, DIP
- DDC-55688-1 = 2 V direct, DIP

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.



105 Wilbur Place, Bohemia, New York, U.S.A. 11716-2482

For Technical Support - 1-800-DDC-5757 ext. 7382

Headquarters, N.Y., U.S.A. - Tel: (631) 567-5600, Fax: (631) 567-7358

Southeast, U.S.A. - Tel: (703) 450-7900, Fax: (703) 450-6610

West Coast, U.S.A. - Tel: (714) 895-9777, Fax: (714) 895-4988

United Kingdom - Tel: +44-(0)1635-811140, Fax: +44-(0)1635-32264

Ireland - Tel: +353-21-341065, Fax: +353-21-341568

France - Tel: +33-(0)1-41-16-3424, Fax: +33-(0)1-41-16-3425

Germany - Tel: +49-(0)8141-349-087, Fax: +49-(0)8141-349-089

Japan - Tel: +81-(0)3-3814-7688, Fax: +81-(0)3-3814-7689

World Wide Web - <http://www.ddc-web.com>

