digital to synchro converter
25 va 12 bit
series 192A600

GENERAL DATA

The 192A600 series is a high power, 25VA, low cost, 12 bit digital to synchro converter. It was designed specifically to drive multiple torque receivers in training simulators and remote indicators.

Twelve bit natural binary angle data is converted to 3-wire synchro data. Worst case accuracy into a torque receiver load is ±21 minutes which reduces to ±10 minutes into a passive, balanced load of a control transformer.

The series 192A600 is a pin-for-pin replacement for DDC models TD100. All models incorporate a heat-sink-mounted thermal sensor which provides a power driver shutdown for any over-temperature condition. This makes the 192A600 virtually blowout-proof under any overload, short-circuit or stalled rotor condition. An override is provided for cases where operation must continue in spite of over-temperature.

The converters also feature an input register, provisions for shutting down output stage, and the synchro output and reference input are transient protected against the inductive kickback at turn-off of the TR.

All units are completely trimmed and adjustment-free, allowing absolute interchangeability. Reliability is assured by the use of high grade components rigidly encapsulated and electrically stressed to the lowest possible levels.

FEATURES:

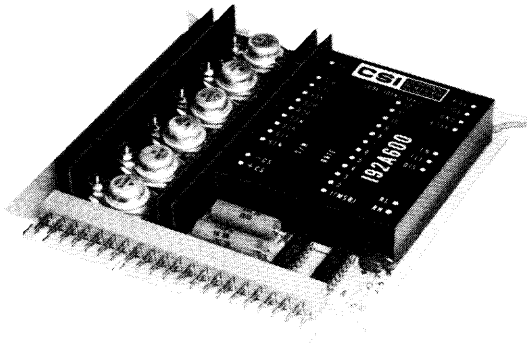
- ☐ TTL compatible
- ☐ Short-circuit and overload protected
- ☐ Thermal shutdown
- ☐ High power output
- ☐ 12 bit resolution
- ☐ Drives TR and CT loads
- ☐ Transient protected
- ☐ Cyclic L-L variations of only 2%
- ☐ ±21 minute accuracy into TR loads

ELECTRICAL SPECIFICATIONS:

Parameter	Value
☐ Accuracy(1)	TR Load: ±21 minutes Passive (CT) load: ±10 minutes
☐ Resolution	12 bits (.088°), 1 std. TTL unit load
☐ Coding	Parallel Natural Binary Angle
☐ Logic(2)	Positive Logic, TTL compatible
☐ Output(3) (5)	3 wire synchro, 25VA
192A601	11.8V L-L, 400Hz SS ISOL
192A602	11.8V L-L, 400Hz XFMR ISOL
192A603	90V L-L, 400Hz XFMR ISOL
192A604	90V L-L, 50-400Hz XFMR ISOL
☐ Reference Input(4)	26Vrms @ 260K Ω SS differential 115Vrms @ 1MΩ SS differential
☐ Output Impedance	(L-L) Z_{out}
192A601	Effectively 0 Ω
192A602	1.2 Ω
192A603	50 Ω
192A604	100 Ω
☐ Control Inputs/Outputs	
Enable (EN)	"1" or open: thermal cutout overridden "0" or gnd: thermal cutout operates automatically

APPLICATIONS

OPERATIONAL FLIGHT TRAINERS - SIMULATORS - COMPUTER INPUT/OUTPUT SYSTEMS.



Parameter	Value		
Disable (DIS)	"1" or open: power stage shutdown "0" or gnd: normal operation		
Fault (FLT)	"1" indicates power stage shutdown "0" indicates power stage operating		
Strobe in	Positive edge trigger, 2 std. TTL unit loads		
Thermal Sensor Trip Point	+105°C		
☐ Power Required			
Volts DC	+15	-15	+5
Amperes	.050 + load	.065 + load	.125
Regulation (%)	5	5	5
☐ Temperature Range			
Operating	0° to 70°C -55°C to + 85°C		
Storage	-55°C to +125°C		
☐ Size	5.26" x 5.38" x 0.8" P.C. card		

NOTES:

(1) Accuracy applies for:
- (a) ±5% variation in power supply voltages
- (b) ±10% reference amplitude and frequency variation
- (c) 10% reference harmonic distortion
- (d) Any balanced load from no load to full load
- (e) Over operating temperature range

(2) The input register is a 74174 Hex D Type flip-flop.

(3) The series 192A600 has a nominal 3A peak current limiting per leg.

(4) Two pin-outs exist for the DDC model TD-100. The early versions did not incorporate a reference input on pins 29 and 30. CSI can supply its 192A600 to be pin compatible with these early versions; contact factory.

(5) For transformer isolated versions, external transformers are supplied.

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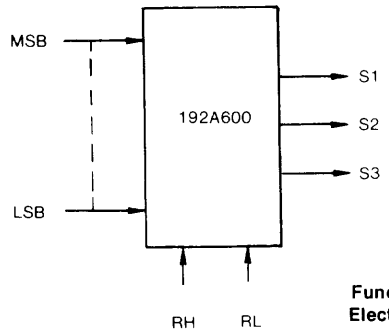
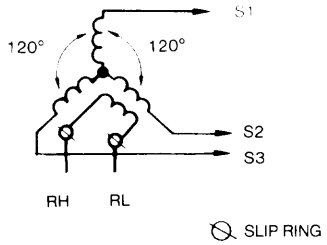
APPLICATION INFORMATION:

The 192A600 series of digital to synchro converters are intended to provide the transformation of digital angle data to 3 wire synchro signals in order to drive torque receivers (TR) or control transformers (CT) synchros. The functional equivalency is shown below:

Digital Θ to Synchro Converter



Mechanical Θ to Synchro Generator



Functional Equivalency of 192A600 to Electromechanical Synchro Generator

Figure I

Analog Reference Input (RH-RL)

The synchro system reference must be connected to the RH and RL inputs of the converter. The output signals are derived from (and are proportional to) the applied reference. Any distortion present on the reference will appear in the output signals.

Analog Output

The analog output signals from the 192A600 are described in the following equations:

$E_{S1\text{-}S3} = KE_{RH\text{-}RL} \text{ SIN } \Theta$

$E_{S3\text{-}S2} = KE_{RH\text{-}RL} \text{ SIN } (\Theta + 120°)$

$E_{S2\text{-}S1} = KE_{RH\text{-}RL} \text{ SIN } (\Theta + 240°)$

Amplitude Variation

It is important to note that K in the above equations has the form NR. N is the transformation ratio of the converter, i.e. 26/11.8, and R varies between 1.01 and .98 every 11.25°. In all synchro/servo systems scale factor variation is not a source of error. But in other applications where the sines and cosines are used independently, one must determine whether the scale factor variation will be a source of error.

Transients

Minor transients occur each time the input data angle changes. The transient duration is approximately 100 microseconds and usually does not cause any appreciable error since the bandwidth of the driven servo filters out these transients.

Driving Torque Receivers

The output amplifiers of the 192A600 are short circuit and thermally protected, and capable of driving the following loads:

192A600 Maximum Load Capabilities

Model	Output	Max Load (Z_{SS})
192A601	11.8V 400Hz	1 Ω
192A602	11.8V 400Hz	1 Ω
192A603	90V 400Hz	50 Ω
192A604	90V 50-400Hz	100 Ω

Z_{SS} can be obtained from the synchro manufacturers specification data sheet. If Z_{SS} is not specified, it can be approximated from the specified rotor and stator resistance as follows:

26/11.8V synchro $Z_{SS} \cong$ stator res. + .21 (rotor res.)

115/90V synchro $Z_{SS} \cong$ stator res. + .61 (rotor res.)

In the null condition, when the D/S output angle equals the Torque Receiver shaft angle, no circulating currents will flow in the stator windings. This is because the voltage produced by the transformer action of the receiver exactly balances the voltage produced by the transformer action of the D/S converter. The 192A600 uses multipliers which deviate from the sine and cosine laws by 2% but retain angular accuracy because the ratio $\frac{\text{sine}}{\text{cosine}}$ = tangent is correct. This magnitude variation means that in the null condition the effective scale factor variation will permit currents to flow. This deviation does reflect a VA requirement in the null condition but it is not of sufficient magnitude to cause concern.

In order to determine the power required for an off null condition the following equation can be used:

$$\Delta VA = \frac{V_{LL}^2 \, 2 \sin \frac{\Theta}{2}}{Z_{SS} + Z_{out}}$$

Where: V_{LL} = maximum stator line to line voltage

Θ = the off null angle

Z_{SS} = stator impedance with rotor shorted

Z_{out} = line to line D/S output impedance

For large initial angular offsets, the current limit of the 192A-600 will restrict the current and hence the maximum torque.

In addition to transformation variations, the 192A600 differs from the normal synchro control transmitter in that its output angle can change 180° in less than 100 μseconds. This may cause a hang-up condition when driving a torque receiver or servo. The cause for this possible hang-up is that in any synchro system there is a false null 180° opposed from the true null, and the 192A600 can change the angle so fast that the servo cannot respond. If there were a finite error signal, the servo would drive away from it and back to the true null; but since the error voltage is zero, there is no loop correction signal. To avoid the possibility of this hang-up condition, the software which determines how the digital input angle changes should never allow 180° steps to occur.

NOTE: If either the AC input of the 192A600 or the reference input to the TR is removed, heavy currents will circulate.

Thermal Cutout Operation

Thermal protection embodied in the 192A600 consists of a tempsistor mounted on the heat-sink of the power driver which controls a cutout on the power stages. The trip point for this cutout is +105°C on the heat-sink fins.

Operation of the thermal cutout is enabled or can be over-ridden with the Enable (EN) line (pin 28) and Disable (DIS) line (pin 24). For normal automatic thermal cutout, EN (pin 28) must be tied to ground or logic "0". A logic "1" will over ride the cutout and keep the power drivers energized despite a continued overload condition. When the cutout is over-ridden, the FLT on pin 25 will return to logic "0".

The Disable (DIS) function, pin 24, is provided to enable the user to cut out the power drivers at any time regardless of EN or FLT condition. A logic "1" or open will shut down the power stage and a logic "0" or ground will permit normal operation. Thus, the FLT line can be used to sense overload and either allow the cutout to continue or, should conditions warrant, initiate an over-ride command to the EN line and force continued operation and possible damage.

If it is desired to override the shutdown under certain conditions, the FLT output can be used to trip a latch to control the EN input. Do not connect FLT directly to the EN input for this results in oscilations since the FLT signal does not latch.

Driving Control Transformers

The 192A600 can also drive passive loads such as control transformers, and with improved accuracy of ±10 minutes. The load parameter for these devices is Z_{SO} (stator impedance with rotor open circuited). Control transformers are highly inductive, with a reasonable Q; therefore it is possible to resonate this load by placing three capacitors of the proper value across the synchro output in a delta configuration. By turning the load, you can raise the effective load impedance, and thereby drive many more loads in parallel. Note that high grade capacitors are necessary, and that they must be able to withstand the full AC output voltage. The formula for determining the capacitor size is given below:

$$C = \frac{X'_{LSO}}{6\pi f[(R'_{SO})^2 + (X'_{LSO})^2]}$$

Where: C = Tuning capacitor in farads in delta connection.

X'_{LSO} = Reactive component of impedance of one stator winding leg with rotor open circuit

F = Frequency in Hz

R'_{SO} = Resistive component of impedance of one stator winding leg with rotor open circuit

Note: $Z'_{SO} = \frac{2}{3}(Z_{SO})$

Z_{SO} = Stator winding impedance with rotor open circuit

Power Supplies

When fully loaded, the 192A600 draws pulsating current due to the class AB driver amplifiers. The ±15V power supplies must be capable of peaks without current-limiting.

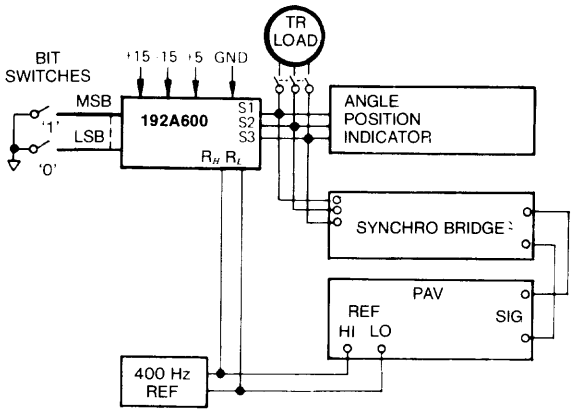
CAUTION: APPLICATION OF REVERSE POLARITY OF ANY ONE OF THE THREE POWER SUPPLY INPUTS WILL CAUSE CATASTROPHIC FAILURE.

Digital Data Connections

The input register of the 192A600 (74174 HEX D flip-flops) will accept 12 bits (or less) of digital angle data. The digital angle input data is strobed in on the positive-going edge of the strobe pulse. For fewer than 12 bits, ground the unused input bit pins. Inputs are DTL/TTL/LSTTL compatible requiring 1 unit load of drive capability.

TESTING

For accuracy in testing the 192A600, the equipment shown in figure 2 is needed. Set in any angle by the use of the bit switches and adjust the synchro bridge for a null as read on the phase-angle voltmeter. The error is equal to the angle read by the bridge subtracted from the theoretical angle. A table of angles versus bits is given in figure 3.



Test Configuration
Figure 2

ANGLE VS. BITS

		Deg/Bit	Min/Bit
MSB	1	180	10,800
	2	90	5,400
	3	45	2,700
	4	22.5	1,350
	5	11.25	675
	6	5.625	338
	7	2.813	168.8
	8	1.406	84.36
	9	0.7031	42.86
	10	0.3516	21.096
	11	0.1758	10.548
	12	0.08799	5.279

Bit Weights Figure 3

Tolerances: .XX = ±.02
.XXX = ±.010

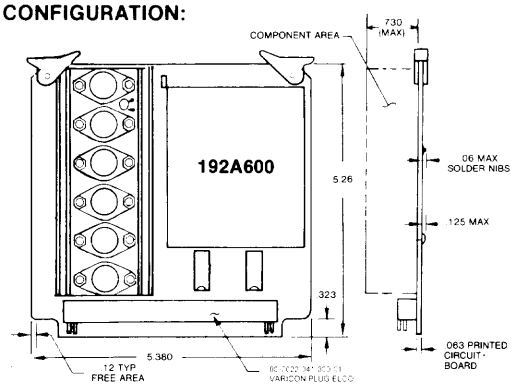
ORDERING INFORMATION:

192A Suffix	Output Voltage	Output Type	Input	Frequency
600†		SS	26V	50-400Hz
601*	11.8V	SS	26V	400Hz
602	11.8V	XFMR ISOL	26V	400Hz
603	90V	XFMR ISOL	115V	400Hz
604	90V	XFMR ISOL	115V	50-60Hz

†Module only
*Without external transformer

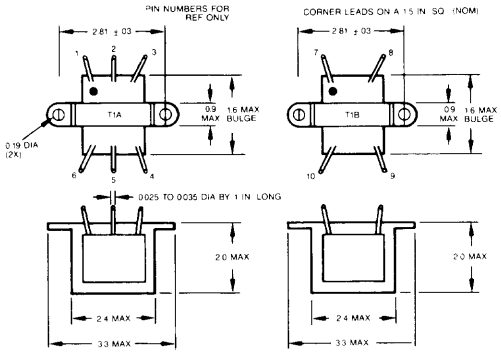
Above part numbers describe commercial temperature devices (0° to +70°C); add suffix ET to part number for extended temperature range (-55°C to +85°C), e.g. 601 ET (-55° to +85°C). Consult factory for part numbers describing additional options.

CONFIGURATION:

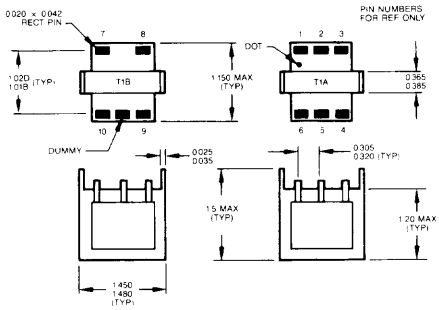


WEIGHT: 13 Oz.

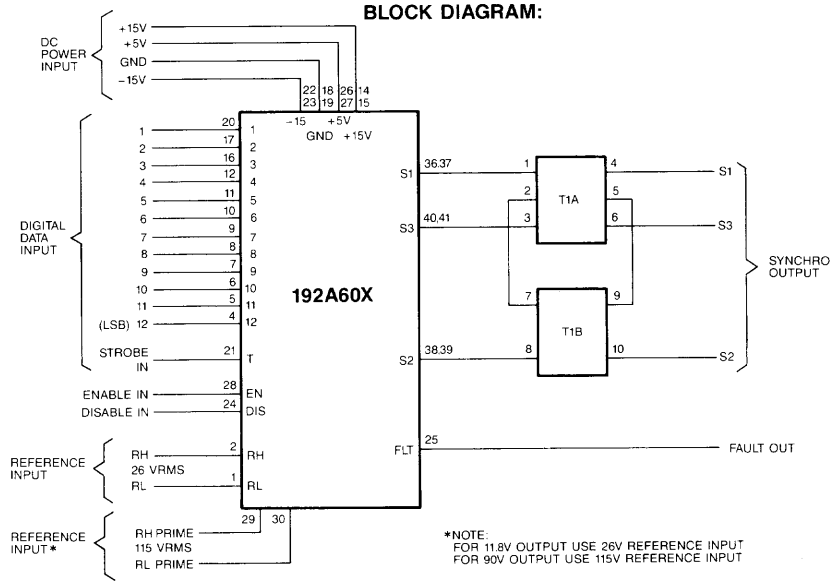
60Hz Transformer



400Hz Transformer



BLOCK DIAGRAM:



*NOTE:
FOR 11.8V OUTPUT USE 26V REFERENCE INPUT
FOR 90V OUTPUT USE 115V REFERENCE INPUT