ADC100
Precision 22 Bit
Integrating A/D Converter



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FEATURES

- **22-BIT RESOLUTION**
- **±10.48 INPUT RANGE**
- **1ppm/°C MAX. SCALE FACTOR ERROR**
- **2 ppm MAX. LINEARITY ERROR**
- **AUTO ZERO**
- **BUS COMPATIBLE**
- **INTERNAL CLOCK and REFERENCE**
- **LOW POWER CONSUMPTION (0.4 WATTS)**

APPLICATIONS

- **TEST EQUIPMENT**
- **DATA ACQUISITION**
- **SCIENTIFIC INSTRUMENTS**
- **MEDICAL INSTRUMENTS**
- **SEISMOLOGICAL EQUIPMENT**
- **ROBOTIC SYSTEMS**
- **WEIGHING SYSTEMS**

DESCRIPTION

ADC100 is a high performance 22-bit A/D converter based on a patented architecture which provides outstanding performance (accuracy) comparable to the best digital meters. The ADC100 is available in two operating temperature ranges, -25°C to +85°C and -55°C to +125°C. "M" versions are screened for high reliability and quality.

ADC100 offers 3 ppm max. linearity error and 1ppm/°C max. scale factor error over the military temperature range. It also has excellent offset stability at 2 ppm max. which the user can auto zero if desired.

Type	Temperature Operating Range	Max. Scale Factor Deviation
ADC100C	-25°C to +85°C	60ppm
ADC100CA	-25°C to +85°C	30ppm
ADC100M	-55°C to +125°C	100ppm

ADC100's compatibility with popular microcomputer buses increases its ease of application in smart systems. An on-board microprocessor controls all internal functions of the ADC100. Thaler designers have minimized external connections to greatly reduce the problem often encountered when applying ADC's.

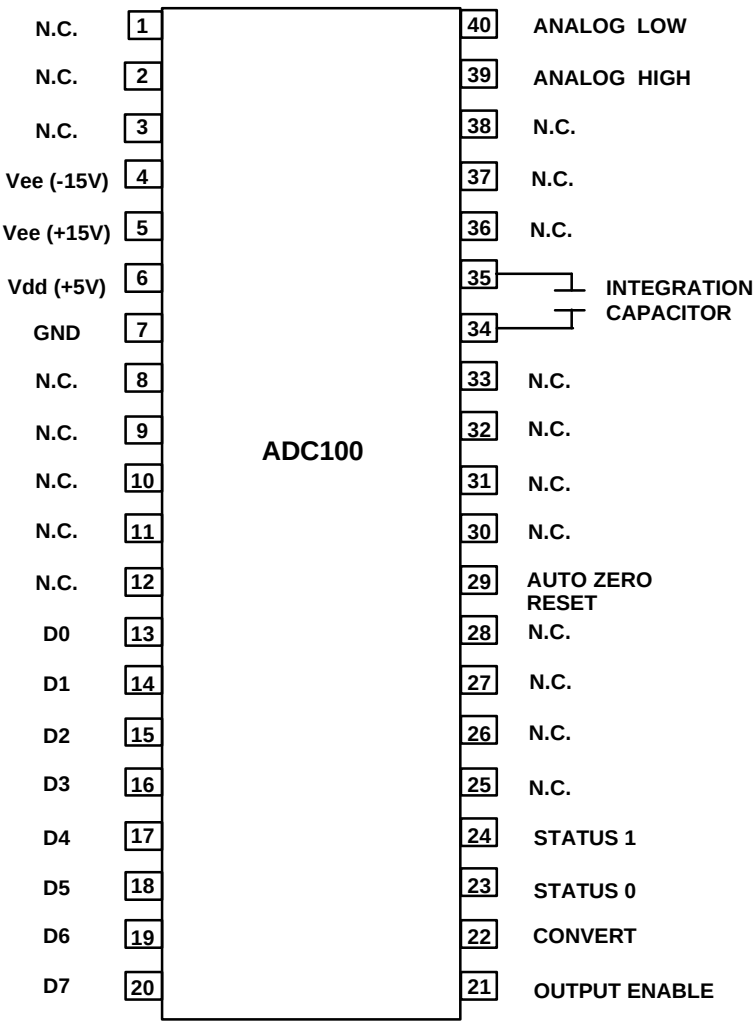
Operating from ±15VDC and a +5VDC power supply, ADC100 is packaged in a hermetically sealed 40-pin ceramic DIP package. Precision test equipment, scientific and medical instruments, and data acquisition systems are primary application areas for the unusually high resolution and accuracy of this ADC.

MAXIMUM RATING SPECIFICATIONS — ADC100

MODEL	ADC100		
PARAMETER	**MIN**	**MAX**	**UNITS**
TEMPERATURE			
Operating	-55	125	°C
Storage	0	160	°C
POWER SUPPLY			
V_{CC}	+14	+16	VDC
V_{EE}	-14	-16	VDC
V_{DD}	+4	+6	VDC
INPUTS			
Analog Inputs	V_{EE}	V_{CC}	
Digital Inputs	0	V_{DD}	

EXTERNAL CONNECTIONS

(TOP VIEW)



NOTES:

1. **Power Supply Decoupling**
   The ADC100 has internal 0.1µF decoupling capacitors for all power supply inputs. The internal decoupling capacitors are adequate for applications with relatively short power supply leads (approx. 5") or if additional capacitors are located on a circuit board. For applications with long power supply leads an external capacitor of 10 mF on the +/- 15V inputs and 33 mF on the +5V input is recommended.

2. **Ground**
   The ground connection (pin 7) should be made as solid as possible since ground noise can result in a loss of accuracy. Use of a ground plane is a good approach to maintain the full accuracy of the ADC100.

3. **External Components**
   A 0.68 µF polystyrene integration capacitor must be connected to pins 34 and 35 with a lead length not exceeding 2".

4. **Analog Inputs**
   In order to avoid differential noise pickup it is recommended to use parallel adjacent lines for the analog inputs (pins 39, 40) on PC boards and shielded lines outside of the PC connections.

ELECTRICAL SPECIFICATIONS

(Vps = +/- 15V, + 5V, T = 25 Deg. C.)

ADC100

MODEL	ADC100C			ADC100CA			ADC100M			
PARAMETER	**MIN**	**TYP**	**MAX**	**MIN**	**TYP**	**MAX**	**MIN**	**TYP**	**MAX**	
ACCURACY										
Resolution		22			*			*		Bits
Input Equivalent Noise		1			*			*		µV
Offset without Auto Zero			4			2			*	ppm
Offset with Auto Zero			1			0.5			*	ppm
Full Scale			100			50			*	ppm
Noise (.1-10Hz) @ 10V		6			*			*		µVpp
Nonlinearity			3			2			*	ppm
Normal Mode Rejection [1]	60			*			*			dB
TEMPERATURE STABILITY										
Offset			0.2			0.1			*	ppm/° C
Full Scale			1.0			0.5			*	ppm/° C
TIME STABILITY										
Offset		.1			*			*		ppm/month
Full Scale [2]		2			*			*		ppm/24 hrs.
ERROR ALL SOURCES										
24 hrs, +/- 1 Deg. C Amb.			.0007, 2			.0005, 2			*	%, +/- Counts
90 days, +/- 5 Deg. C Amb.			.0010, 2			.0008, 2			*	%, +/- Counts
1 year, +/- 5 Deg. C Amb.			.0015, 2			.0013, 2			*	%, +/- Counts
CONVERSION TIME			320			*			*	ms
WARM-UP TIME			5			*			*	minutes
POWER SUPPLY REJECTION										
+/- 15 VDC	80			*			*			dB
5 VDC	80			*			*			dB
ANALOG INPUT CHARACTERISTICS										
Input Range	-10.485760		10.485755	*		*	*		*	V
Bias Current		1.2	3		*			*		nA
Input Impedance		200			*			*		GΩ
POWER SUPPLY VOLTAGES										
+15 V	14.5	15	15.5	*	*	*	*	*	*	V
-15 V	14.5	15	15.5	*	*	*	*	*	*	V
5 v	4.5	5	5.5	*	*	*	*	*	*	V
POWER SUPPLY CURRENTS										
+15 V		23			*			*		mA
-15 V		24			*			*		mA
5 v		42			*			*		mA
DIGITAL INPUTS										
Low			0.8			*			*	V
High	4.0			*			*			V
DIGITAL OUTPUTS										
Low			0.8			*			*	V
High	4.0			*			*			V
AUTO ZERO INPUT										
Low			0.8			*			*	V
High	4.0			*			*			V
CONVERT INPUT										
Low			0.8			*			*	V
High	4.0			*			*			V
TEMPERATURE RANGE	-25		85	*		*	-55		125	°C

* Same as ADC100C

Note: 1) 60 Cycle

2) (Max-Min Value) - Noise(.1-10Hz)

THEORY OF OPERATION

In the ADC100 block diagram (see Figure 1), V_{hi} and V_{low} are the inputs. Both are buffered and fed into a differential, voltage controlled, single output current source. This current is added to the reference current at the input of the op amp integrator. The output of the integrator is fed into a Schmitt trigger, which in turn, is fed into the ADC's timing control circuitry. When the integrator output actuates the Schmitt trigger, the timing circuit changes the direction of the reference current source and the integrator begins integrating in the opposite direction. This continues until the Schmitt trigger is actuated again by the integrator and reverses the direction of the reference current.

The equation for integration times are:

$$T_p = \frac{V \times C}{I_{ref} + I_{inp}} \qquad T_m = \frac{V \times C}{-I_{ref} + I_{inp}}$$

V = Voltage
C= Integration Capacitor Value
I_{ref} = Reference Current
I_{inp} = Input Current

Resolving these equations produces:

$$I_{inp} = I_{ref} \frac{T_p - T_m}{T_p + T_m}$$

T_p = Time Positive
T_m = Time Negative

The timing control circuitry governs the counters that measure the integration time in both directions.

The ADC100's on-board microprocessor is used to calculate the results of the integration equation above. It is also used to perform error corrections and to control the built-in-auto-zero function. Note that the mP automatically performs an auto-zero function at start-up, but it is recommended, to achieve maximum accuracy, that an auto-zero be performed again after the ADC100 is fully warmed up.

When the µP detects a convert signal, it lowers the status lines to indicate that the ADC is involved in a conversion. When it detects a change in slope direction, the µP will collect the counts for the integration time. When sufficient counts have been collected, the µP performs the calculations described above.

When the calculations are complete, the µmP places the most significant byte in the output buffer and raises the S_0 flag. When another pulse is placed on the convert line, the middle byte is placed on the output, the S_0 flag is lowered and the S_1 flag raised. When the last pulse is placed in the convert line, the least significant byte is placed in the output buffer and both status flags are high indicating that the ADC100 is ready for another conversion.

Status line summary:

S_1	S_0	
0	0	Conversion in progress.
0	1	Conversion complete. MSB in output.
1	0	Middle byte in output register.
1	1	LSB in output. Ready for next conversion.

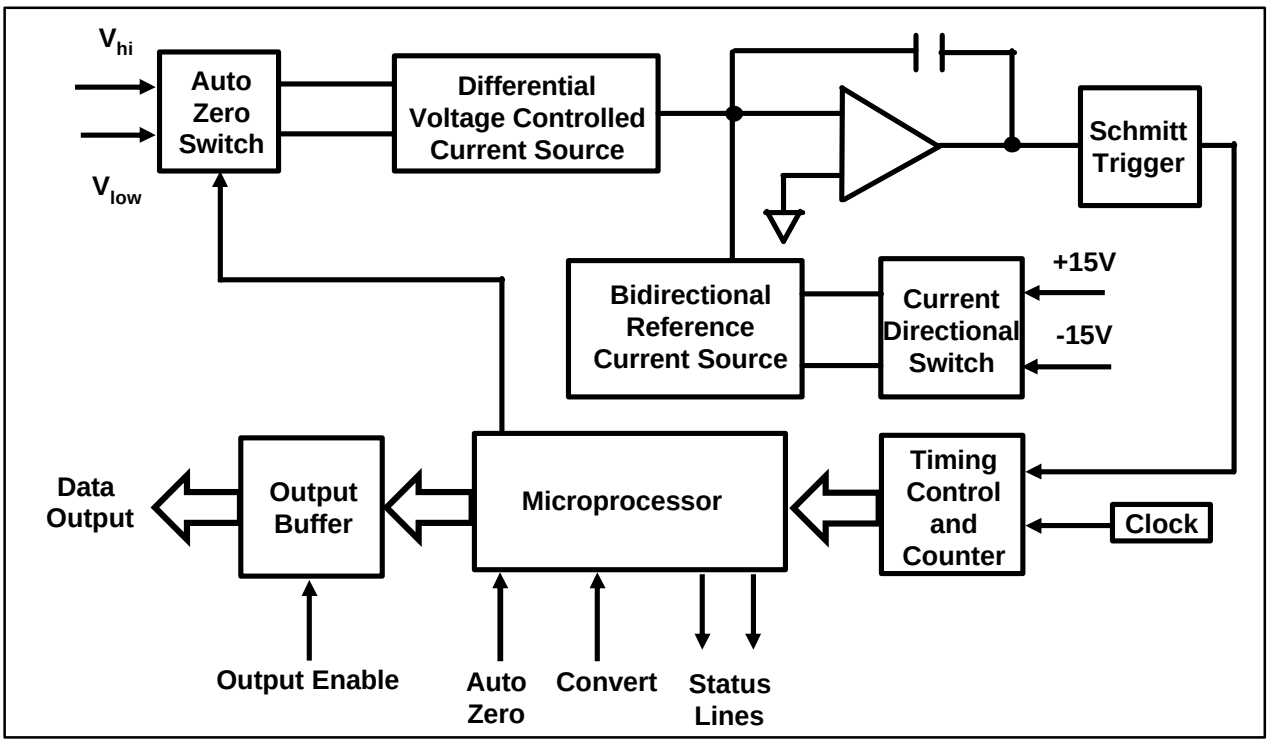


FIGURE 1. BLOCK DIAGRAM

CONNECTING THE ADC100

POWER SUPPLIES

The power supply lines are connected to pins 4-7. Pin 4 is -15V, pin 5 is +15v, pin 6 is +5V and pin 7 is GND.

OUTPUT DATA LINES

The output data is available in byte form on pins 13-20. Pin 20 is the Most Significant Bit and pin 13 the Least Significant Bit. The data lines go to a high impedance state when the Output Enable line is at a logic one level.

OUTPUT ENABLE (PIN 21)

Data is placed on the Output Data Lines by a logic zero on this line.

CONVERT (Pin22)

This line is used to initiate a conversion cycle and to retrieve the output data. The status lines indicate which function will be executed. The first pulse (transition from logic one to logic zero) starts the conversion cycle. Two subsequent pulses are used to place the lower two bytes on the Output Data Lines.

AUTO-ZERO / RESET (Pin 29)

A logic zero on this input will autozero the ADC150-3 by internally connecting the analog high to analog low. Since the µP is reset the status lines S1 and S0 are tristate before going to the low position. The status lines will remain low until the autozero is complete.

INTEGRATION CAPACITOR (Pin 34, 35)

A .68 µF polystyrene capacitor must be connected to these pins. Lead length should be as short as possible and not exceed 2".

ANALOG INPUTS (Pin 39, 40)

Both analog inputs are buffered by op-amps and have a common mode rejection of approximately 80dB. min. To maintain the full accuracy at the ADC it is recommended to keep the input to analog common to less than 0.1VDC.

STATUS LINES (Pins 23, 24)

These lines indicate the present state of the ADC. When the Convert line receives the first pulse in a conversion cycle the Status Lines go to logic zero, indicating that a conversion cycle is in progress. When the conversion is complete the microprocessor places the MSB of the output data in the output buffer and then raises S_0 to a logic one, indicating that the MSB at the output data is available in the output buffer. When the Convert Line is pulsed again the middle byte of the output data is placed in that output buffer and S_1 changes to logic one and S_0 to logic zero. The third pulse places the LSB of the output data in the buffer and both status lines go to the logic one. The converter is now ready for the next conversion cycle.

The table below shows a summary of the status code.

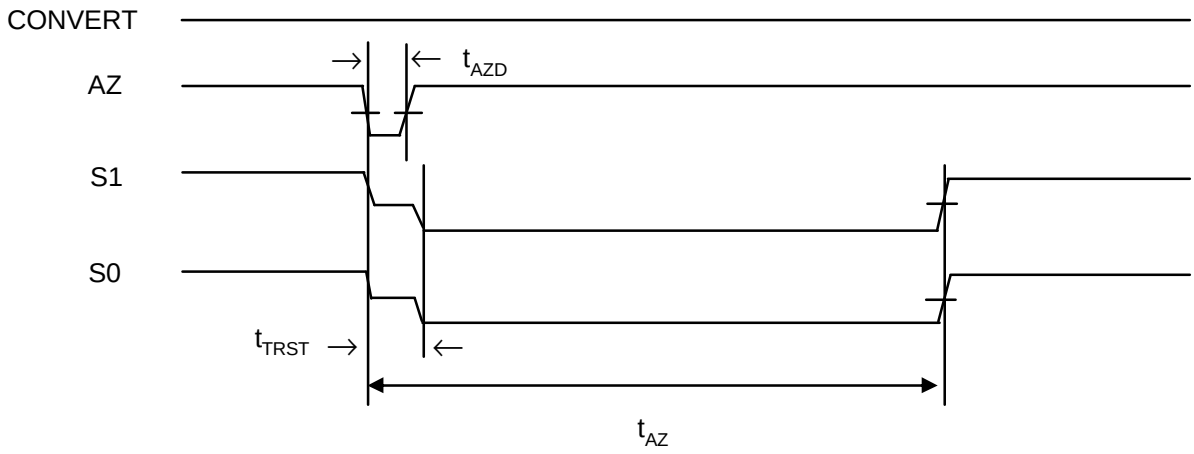
S_1	S_0	
0	0	Conversion in progress.
0	1	Conversion complete. MSB in output.
1	0	Middle byte in output register.
1	1	LSB in output. Ready for next conversion.

OUTPUT DATA REPRESENTATION

The output data is represented in BOB (Bipolar Offset Binary) format. One LSB is scaled to be exactly 5mV. The table below shows the output data codes for zero and plus-minus full scale input voltage.

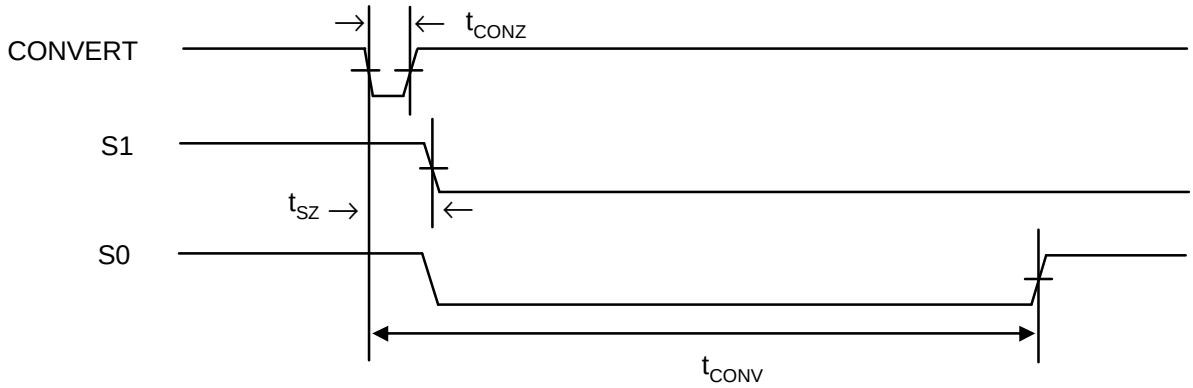
Input Voltage	Output Data		
	High Byte	Middle Byte	Low Byte
-10.485760 V	00	00	00
0.0 V	20	00	00
+10.485755 V	3F	FF	FF

TIMING DIAGRAMS



Symbol	Parameter	Min.	Typ.	Max.	Unit
t_{AZD}	AZ Pulse Width	0.2			µs
t_{TRST}	Tristate Time			30	ms
t_{AZ}	AZ Time			400	ms

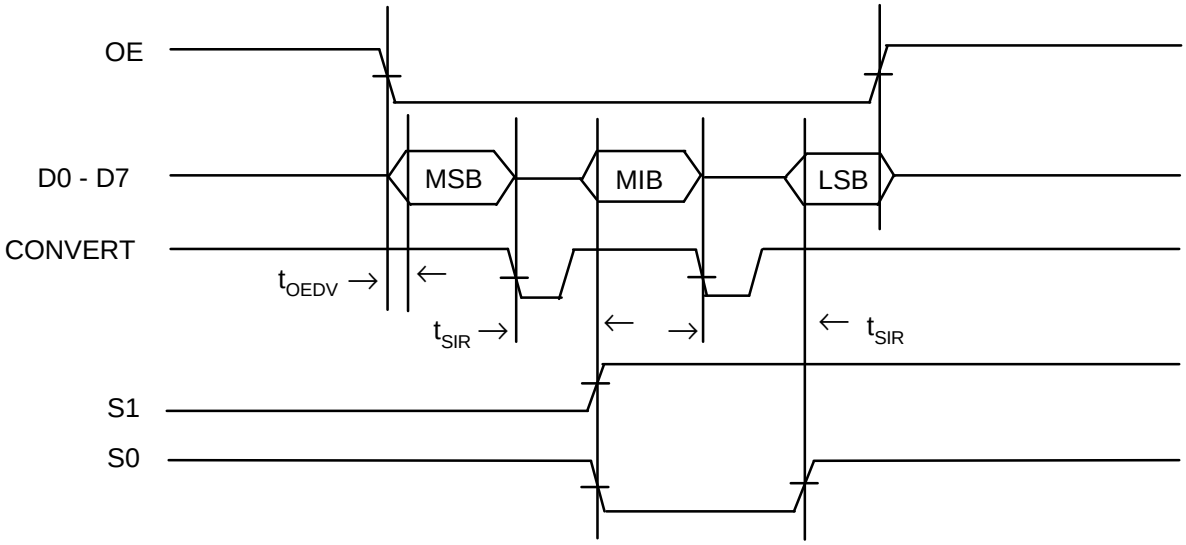
FIGURE 2. AUTO ZERO



Symbol	Parameter	Min.	Typ.	Max.	Unit
t_{CONZ}	Convert Pulse	5.0			µs
t_{SZ}	Status Delay			8.0	µs
t_{CONV}	Convert Time			320	ms

FIGURE 3. CONVERSION

TIMING DIAGRAMS

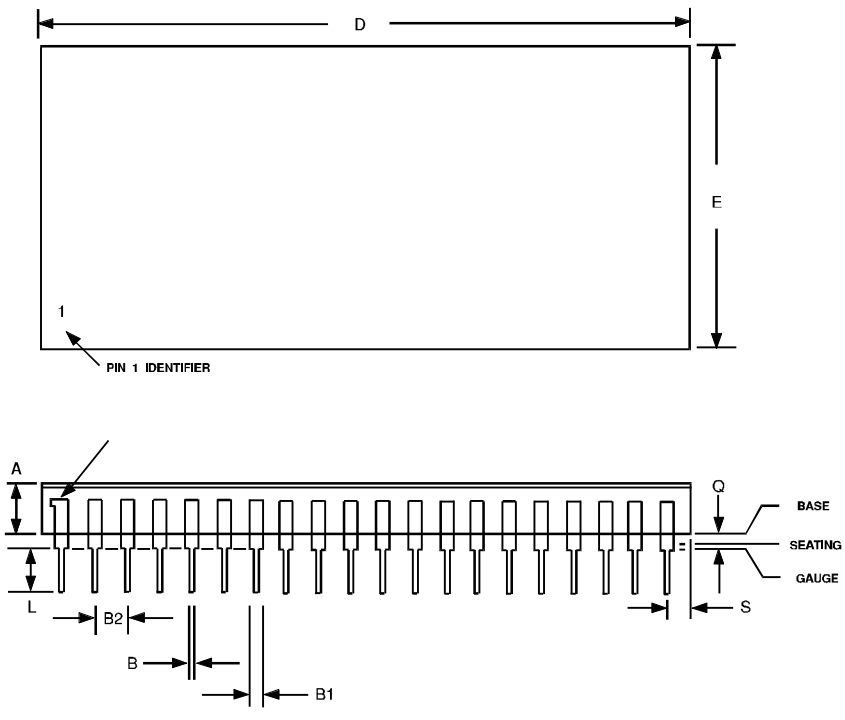


Symbol	Parameter	Min.	Typ.	Max.	Unit
t_{OEDV}	OE Delay			45	ns
t_{SIR}	Status Delay		3.0		µs

FIGURE 4. DATA OUTPUT

40-PIN HYBRID PACKAGE

	INCHES	
DIM	MIN	MAX
E	1.080	1.100
D	2.075	2.115
A	0.155	0.185
L	0.220	0.240
B2	.100 typ	
B	.018 typ	
Q	.015	.035
C	.009	.012
P	.012	.018
G1	.890	.910
B1	.040 typ	



NOTES:
1. GOLD PLATING 60 MICRO INCHES MINIMUM THICKNESS OVER 100 MICRO INCHES NOMINAL THICKNESS OF NICKEL

FIGURE 5. MECHANICAL SPECIFICATIONS