MC100EL1648

5V ECL Voltage Controlled Oscillator

The MC100EL1648 is a voltage controlled oscillator that requires an external parallel tank circuit consisting of the inductor (L) and capacitor (C). A varactor diode may be incorporated into the tank circuit to provide a voltage variable input for the oscillator (VCO). This device may also be used in many other applications requiring a fixed frequency clock.

The MC100EL1648 is ideal in applications requiring a local oscillator, systems that include electronic test equipment, and digital high–speed telecommunications.

The MC100EL1648 is based on the VCO circuit topology of the MC1648. The MC100EL1648 uses advanced bipolar process technology which results in a design which can operate at an extended frequency range.

The ECL output circuitry of the MC100EL1648 is not a traditional open emitter output structure and instead has an on–chip termination emitter resistor, R_E, with a nominal value of 510 ohms. This facilitates direct ac–coupling of the output signal into a transmission line. Because of this output configuration, an external pull–down resistor is not required to provide the output with a dc current path. This output is intended to drive one ECL load (3.0 pF). If the user needs to fanout the signal, an ECL buffer such as the EL16 (EL11, EL14) type Line Receiver/Driver should be used.

NOTE: The MC100EL1648 is NOT useable as a crystal oscillator.

- Typical Operating Frequency Up to 1100 MHz
- Low–Power 19 mA at 5.0 Vdc Power Supply
- Phase Noise –90 dBc/Hz at 25 kHz Typical
- PECL Mode Operating Range: V_{CC} = 5.0 V with V_{EE} = 0 V
- NECL Mode Operating Range: V_{CC} = 0 V with V_{EE} = –5.2 V
- Input Capacitance = 6.0 pF (TYP)
- ESD Protection: >2 KV HBM, >100 V MM
- Meets or Exceeds JEDEC Spec EIA/JESD78 IC Latchup Test
- Moisture Sensitivity Level 1
  For Additional Information, see Application Note AND8003/D
- Flammability Rating: UL–94 code V–0 @ 1/8”,
  Oxygen Index 28 to 34
- Transistor Count = 11 devices

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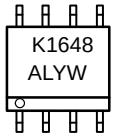
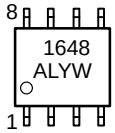
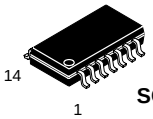
MARKING DIAGRAMS*

SO–8
D SUFFIX
CASE 751

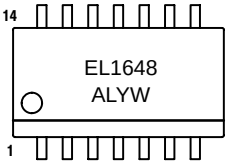


TSSOP–8
DT SUFFIX
CASE 948R





SOIC EIAJ–14
M SUFFIX
CASE 965

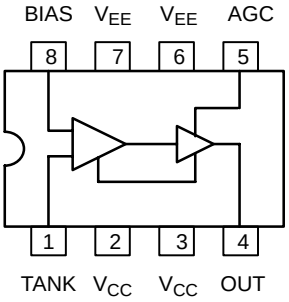


K = MC100
A = Assembly Location
L = Wafer Lot
Y = Year
W = Work Week

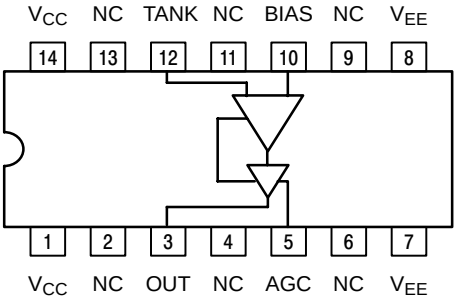
*For additional information, see Application Note AND8002/D

ORDERING INFORMATION

Device	Package	Shipping
MC100EL1648D	SO–8	98 Units / Rail
MC100EL1648DR2	SO–8	2500 Units / Reel
MC100EL1648DT	TSSOP–8	98 Units / Rail
MC100EL1648DTR2	TSSOP–8	2500 / Reel
MC100EL1648M	SOIC EIAJ–14	50 Units / Rail
MC100EL1648MEL	SOIC EIAJ–14	2500 Units / Reel



8 Lead



14 Lead

Warning: All V_{CC} and V_{EE} pins must be externally connected to Power Supply to guarantee proper operation.

Figure 1. Pinout Assignments

PIN DESCRIPTION

PIN	FUNCTION	8 LD	14 LD
BIAS	OSC Input Reference Voltage	8	10
TANK	OSC Input Voltage	1	12
AGC	Automatic Gain Control Input	5	5
OUT	ECL Output	4	3
V_{CC}	Positive Supply	2, 3	1, 14
V_{EE}	Negative Supply	6, 7	7, 8
NC	No Connect		2, 4, 7, 9, 11, 13

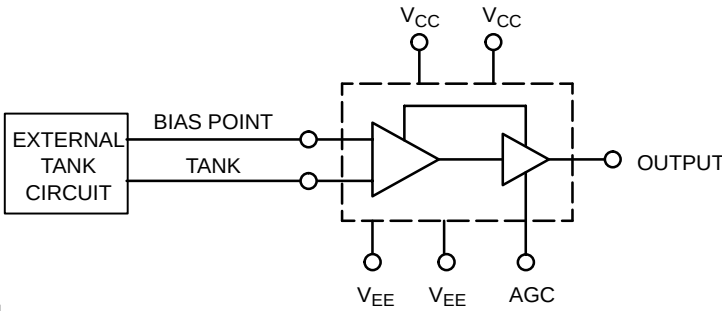


Figure 2. Logic Diagram

MAXIMUM RATINGS (Note 1.)

Symbol	Parameter	Condition 1	Condition 2	Rating	Units
V_{CC}	Power Supply PECL Mode	V_{EE} = 0 V		7 to 0	V
V_{EE}	Power Supply NECL Mode	V_{CC} = 0 V		–7 to 0	V
V_I	PECL Mode Input Voltage NECL Mode Input Voltage	V_{EE} = 0 V V_{CC} = 0 V	$V_I \leq V_{CC}$ $V_I \geq V_{EE}$	6 to 0 –6 to 0	V V
I_{out}	Output Current	Continuous Surge		50 100	mA mA
TA	Operating Temperature Range			–40 to +85	°C
T_{stg}	Storage Temperature Range			–65 to +150	°C
θ_{JA}	Thermal Resistance (Junction to Ambient)	0 LFPM 500 LFPM	8 SOIC 8 SOIC	190 130	°C/W °C/W
θ_{JC}	Thermal Resistance (Junction to Case)	std bd	8 SOIC	41 to 44	°C/W
θ_{JA}	Thermal Resistance (Junction to Ambient)	0 LFPM 500 LFPM	8 TSSOP 8 TSSOP	185 140	°C/W °C/W
θ_{JC}	Thermal Resistance (Junction to Case)	std bd	8 TSSOP	41 to 44	°C/W
θ_{JA}	Thermal Resistance (Junction to Ambient)	0 LFPM 500 LFPM	14 SOIC 14 SOIC	150 110	°C/W °C/W
θ_{JC}	Thermal Resistance (Junction to Case)	std bd	14 SOIC	41 to 44	°C/W
T_{sol}	Wave Solder	<2 to 3 sec @ 248°C		265	°C

1. Maximum Ratings are those values beyond which device damage may occur.

PECL DC CHARACTERISTICS V_{CC} = 5.0 V; V_{EE} = 0.0 V +0.8 / –0.5 V (Note 2.)

		–30°C			25°C			85°C			
Symbol	**Characteristic**	**Min**	**Typ**	**Max**	**Min**	**Typ**	**Max**	**Min**	**Typ**	**Max**	**Unit**
I_{EE}	Power Supply Current	13	19	25	13	19	25	13	19	25	mA
V_{OH}	Output HIGH Voltage (Note 3.)	3950	4170	4610	3950	4170	4610	3950	4170	4610	mV
V_{OL}	Output LOW Voltage (Note 3.)	3040	3410	3600	3040	3410	3600	3040	3410	3600	mV
AGC	Automatic Gain Control Input	1690		1980	1690		1980	1690		1980	mV
V_{BIAS}	Bias Voltage (Note 4.)	1650		1800	1650		1800	1650		1800	mV
V_{PP}	Peak–to–Peak Tank Voltage		TBD			TBD			TBD		mV

NOTE: Devices are designed to meet the DC specifications shown in the above table, after thermal equilibrium has been established. The circuit is in a test socket or mounted on a printed circuit board and transverse air flow greater than 500 lfpm is maintained.

2. Output parameters vary 1:1 with V_{CC}.
3. 1.0 MΩ impedance.
4. This measurement guarantees the dc potential at the bias point for purposes of incorporating a varactor tuning diode at this point.

NECL DC CHARACTERISTICS V_{CC} = 0.0 V; V_{EE} = –5.0 V +0.8 / –0.5 V (Note 5.)

		–30°C			25°C			85°C			
Symbol	**Characteristic**	**Min**	**Typ**	**Max**	**Min**	**Typ**	**Max**	**Min**	**Typ**	**Max**	**Unit**
I_{EE}	Power Supply Current	13	19	25	13	19	25	13	19	25	mA
V_{OH}	Output HIGH Voltage (Note 6.)	–1050	–830	–399	–1050	–830	–399	–1050	–830	–399	mV
V_{OL}	Output LOW Voltage (Note 6.)	–1960	–1590	–1400	–1960	–1590	–1400	–1960	–1590	–1400	mV
AGC	Automatic Gain Control Input	–3310		–3020	–3310		–3020	–3310		–3020	mV
V_{BIAS}	Bias Voltage (Note 7.)	–3350		–3200	–3350		–3200	–3350		–3200	mV
V_{PP}	Peak–to–Peak Tank Voltage		TBD			TBD			TBD		mV

NOTE: Devices are designed to meet the DC specifications shown in the above table, after thermal equilibrium has been established. The circuit is in a test socket or mounted on a printed circuit board and transverse air flow greater than 500 lfpm is maintained.

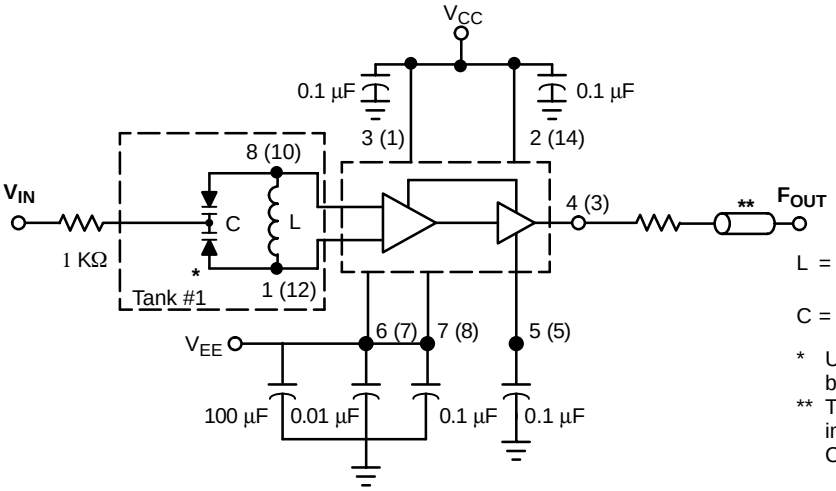
5. Output parameters vary 1:1 with V_{CC}.
6. 1.0 MΩ impedance.
7. This measurement guarantees the dc potential at the bias point for purposes of incorporating a varactor tuning diode at this point.

AC CHARACTERISTICS V_{CC} = 0.0 V; V_{EE} = 5.0 (+0.8 / –0.5 V) or V_{CC} = 5.0 V; V_{EE} = 0 V (Note 8.)

		–40°C			25°C			85°C			
Symbol	**Characteristic**	**Min**	**Typ**	**Max**	**Min**	**Typ**	**Max**	**Min**	**Typ**	**Max**	**Unit**
$\mathscr{L}$ (f)	CSR @ 25 kHz Offset, 1.0 Hz BW		–90			–90			–90		dBc/Hz
$\mathscr{L}$ (f)	CSR @ 1.0 MHz Offset, 1.0 Hz BW		–120			–120			–120		dBc/Hz
SNR	Signal to Noise Ratio from Carrier		40			40			40		dB
F_{sts}	Frequency Stability (Supply Drift)		3.6			3.6			3.6		kHz/mV
F_{stt}	Frequency Stability (Thermal Drift)		0.1			0.1			0.1		kHz/°C
Hz	Second Harmonic from Carrier		–25			–25			–25		dBc
V_{dc}	Output Duty Cycle					50					%
f_{max}	(Note 1)		1.1			1.1			1.1		GHz

8. Frequency variation over temperature is a direct function of the ΔC/Δ Temperature and ΔL/Δ Temperature.

GENERIC TEST CIRCUITS: Bypass to Supply Opposite GND

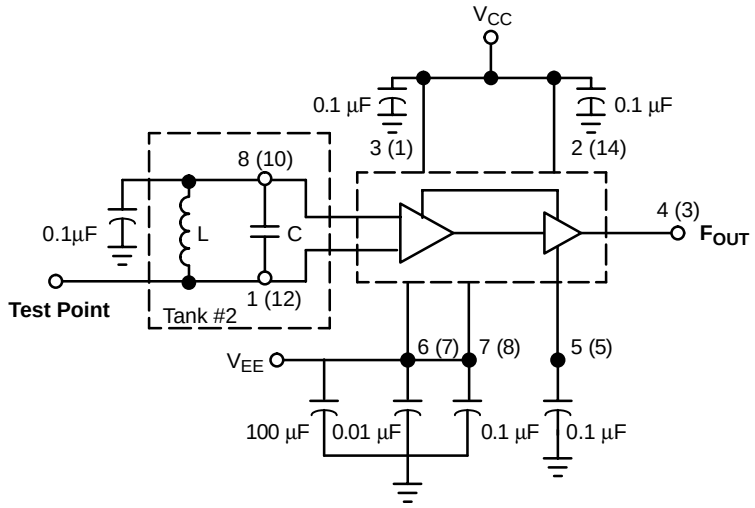


L = Micro Metal torroid #T20–22, 8 turns #30 Enameled Copper wire (@ 40 nH)
C = MMBV609

* Use high impedance probe (>1.0 Megohm must be used).
** The 1200 ohm resistor and the scope termination impedance constitute a 25:1 attenuator probe. Coax shall be CT–070–50 or equivalent.

8 pin (14 pin) Lead Package

Tank Circuit Option #1, Varactor Diode



L = Micro Metal torroid #T20–22, 8 turns #30 Enameled Copper wire (@ 40 nH)
C = 3.0–35pF Variable Capacitance (@ 10 pF)

Note 1 Capacitor for tank may be variable type. (See Tank Circuit #3.)
Note 2 Use high impedance probe (> 1 MΩ).

8 pin (14 pin) Lead Package

Tank Circuit Option #2, Fixed LC

Figure 3. Typical Test Circuit with Alternate Tank Circuits

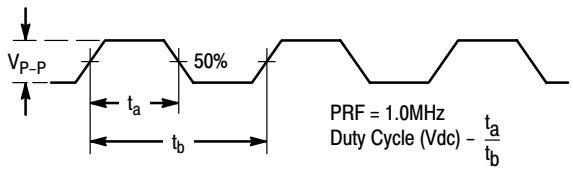


Figure 4. Output Waveform

OPERATION THEORY

Figure 5 illustrates the simplified circuit schematic for the MC100EL1648. The oscillator incorporates positive feedback by coupling the base of transistor Q6 to the collector of Q7. An automatic gain control (AGC) is incorporated to limit the current through the emitter–coupled pair of transistors (Q7 and Q6) and allow optimum frequency response of the oscillator. In order to maintain the high quality factor (Q) on the oscillator, and provide high spectral purity at the output, transistor Q4 is used to translate the oscillator signal to the output differential pair Q2 and Q3. Figure 14 indicates the high spectral purity of the oscillator output (pin 4 on 8–pin SOIC). Transistors Q2 and Q3, in conjunction with output transistor Q1, provide a highly buffered output that produces a square wave. The typical output waveform can be seen in Figure 4. The bias drive for the oscillator and output buffer is provided by Q9 and Q11 transistors. In order to minimize current, the output circuit is realized as an emitter–follower buffer with an on chip pull–down resistor R_E.

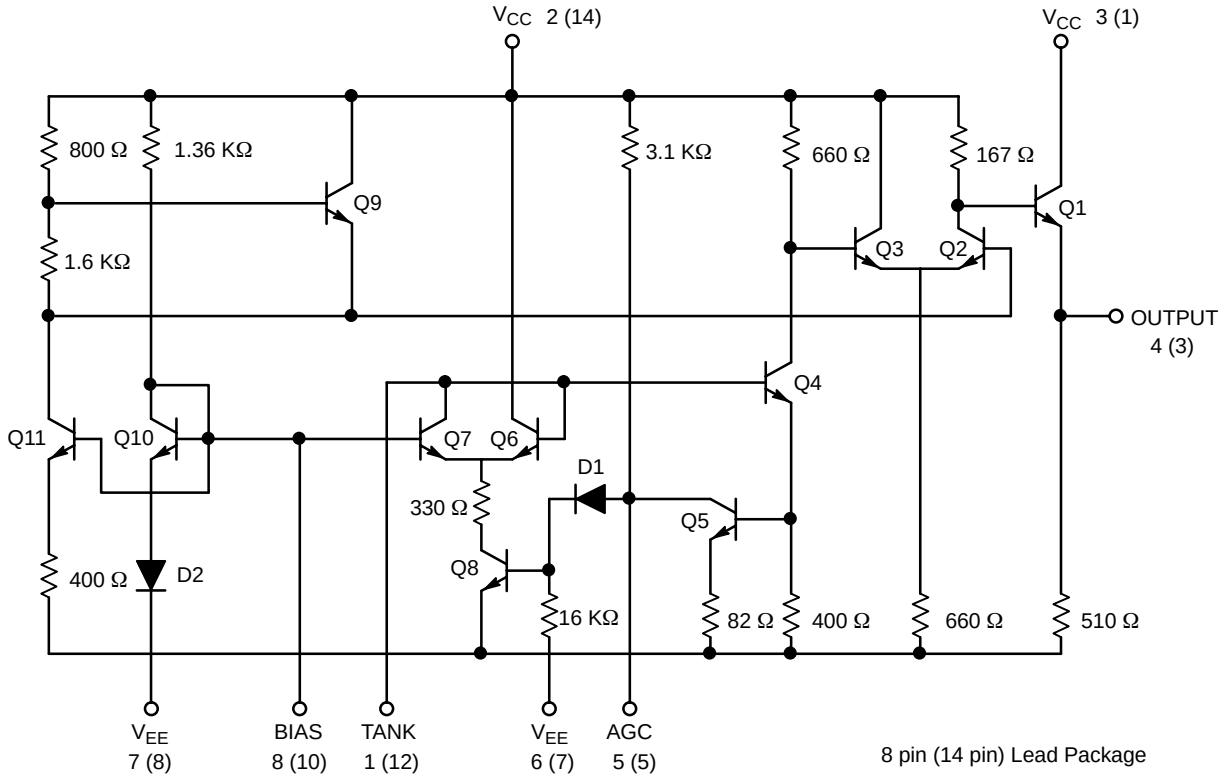


Figure 5. Circuit Schematic

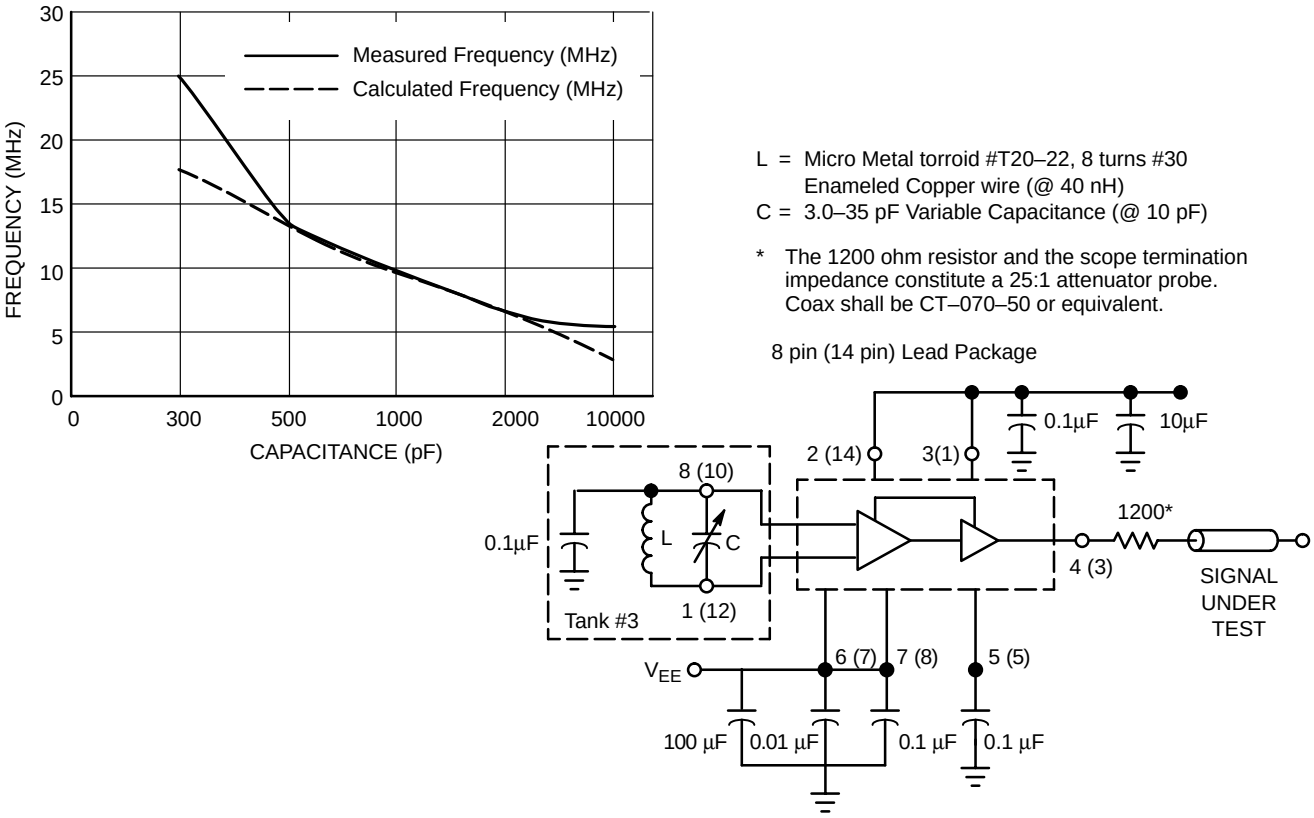


Figure 6. Low Frequency Plot

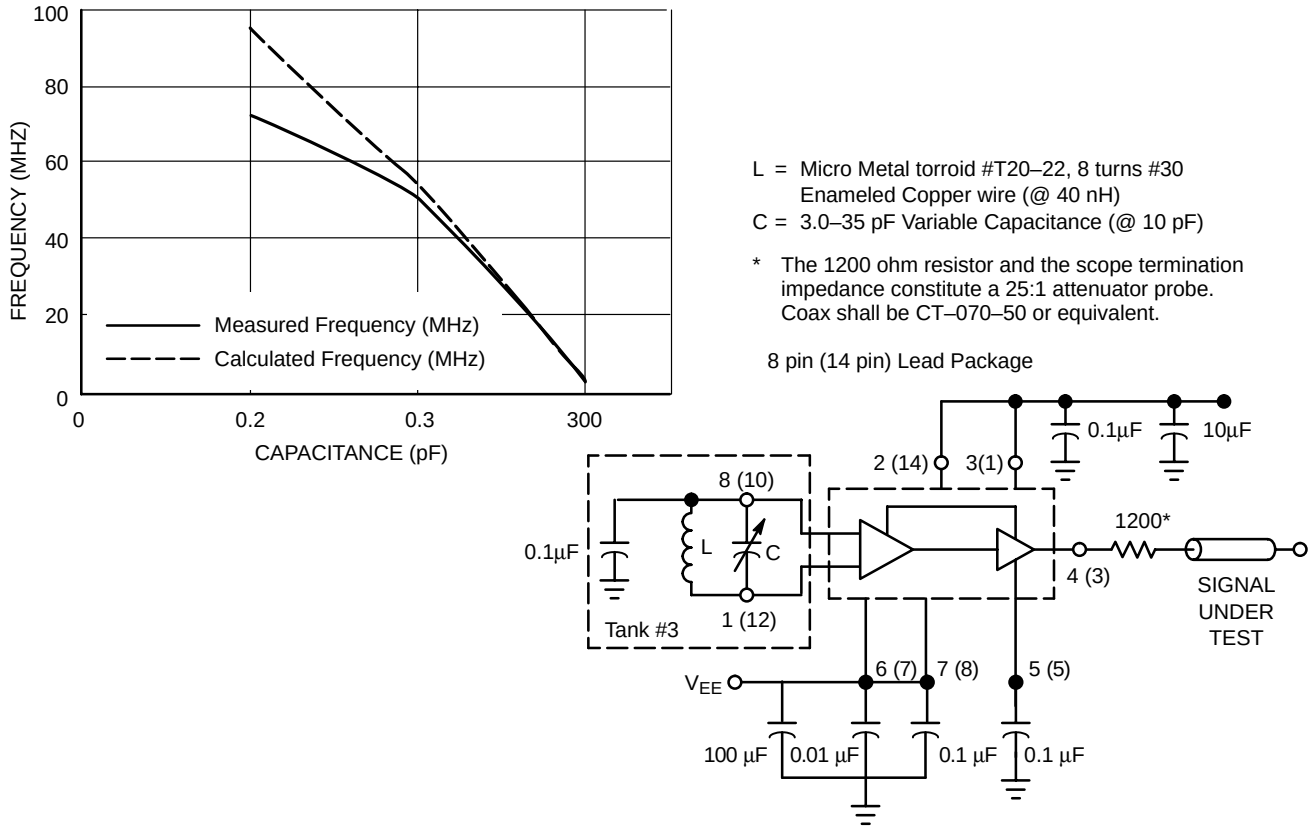
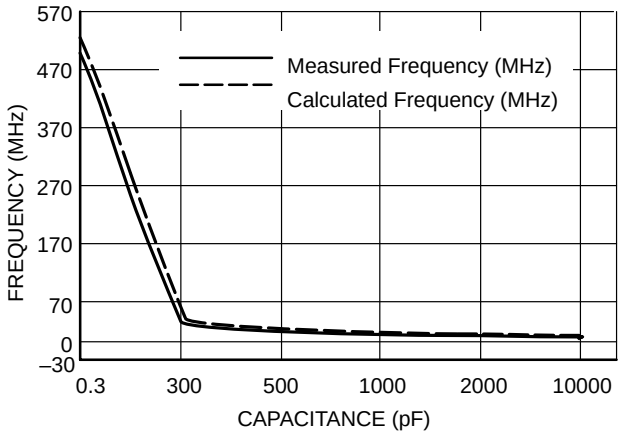
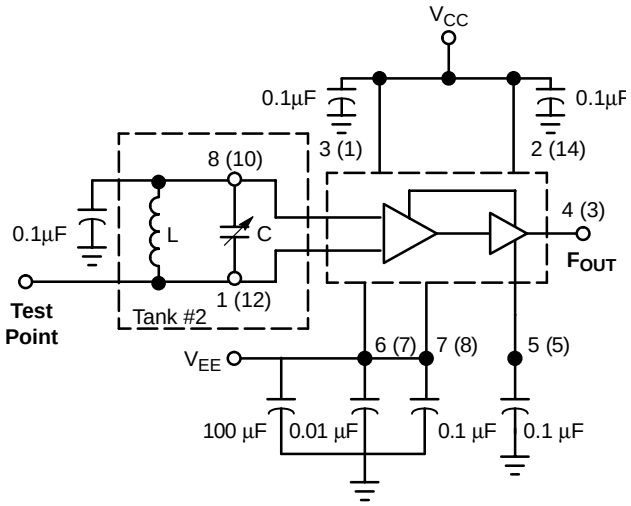


Figure 7. High Frequency Plot

FIXED FREQUENCY MODE

The MC100EL1648 external tank circuit components are used to determine the desired frequency of operation as shown in Figure 8, tank option #2. The tank circuit components have direct impact on the tuning sensitivity, I_{EE}, and phase noise performance. Fixed frequency of the tank circuit is usually realized by an inductor and capacitor (LC network) that contains a high Quality factor (Q). The plotted curve indicates various fixed frequencies obtained with a single inductor and variable capacitor. The Q of the components in the tank circuit has a direct impact on the resulting phase noise of the oscillator. In general, when the Q is high the oscillator will result in lower phase noise.





L = Micro Metal torroid #T20–22, 8 turns #30 Enameled Copper wire (@ 40 nH)
C = 3.0–35 pF Variable Capacitance (@ 10 pF)

Note 1 Capacitor for tank may be variable type. (See Tank Circuit #3.)
Note 2 Use high impedance probe (> 1 MΩ).

8 pin (14 pin) lead package

$Q_L \geq 100$

Figure 8. Fixed Frequency LC Tank

Only high quality surface–mount RF chip capacitors should be used in the tank circuit at high frequencies. These capacitors should have very low dielectric loss (high–Q). At a minimum, the capacitors selected should be operating at 100 MHz below their series resonance point. As the desired frequency of operation increases, the values of the tank capacitor will decrease since the series resonance point is a function of the capacitance value. Typically, the inductor is realized as a surface–mount chip or a wound coil. In addition, the lead inductance and board inductance and capacitance also have an impact on the final operating point. The following equation will help to choose the appropriate values for your tank circuit design.

$$f_0 = \frac{1}{2\pi \sqrt{L_T * C_T}} \qquad \text{eq. 1}$$

Where

L_T = Total Inductance
C_T = Total Capacitance

Figure 9 and Figure 10 represent the ideal curve of inductance/capacitance versus frequency with one known tank component. This helps the designer of the tank circuit to choose desired value of inductor/capacitor component for the wanted frequency. The lead inductance and board inductance and capacitance will also have an impact on the tank component values (inductor and capacitor).

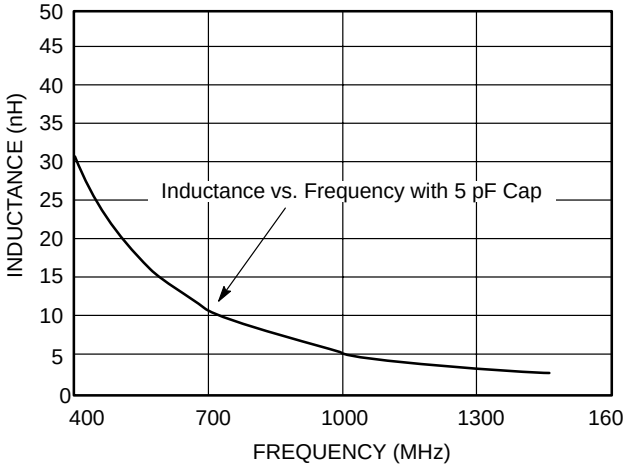


Figure 9. Capacitor Value Known (5 pF)

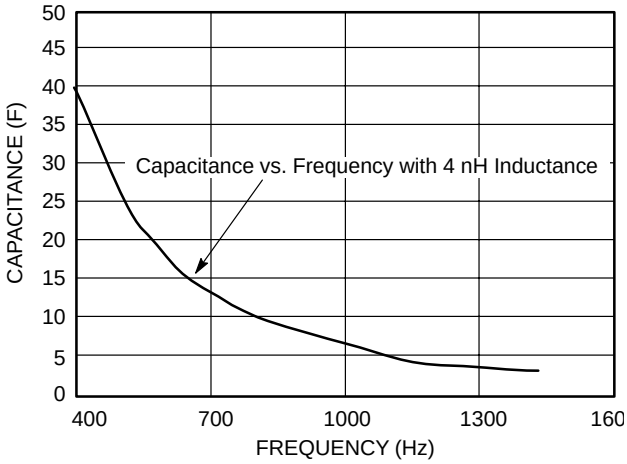
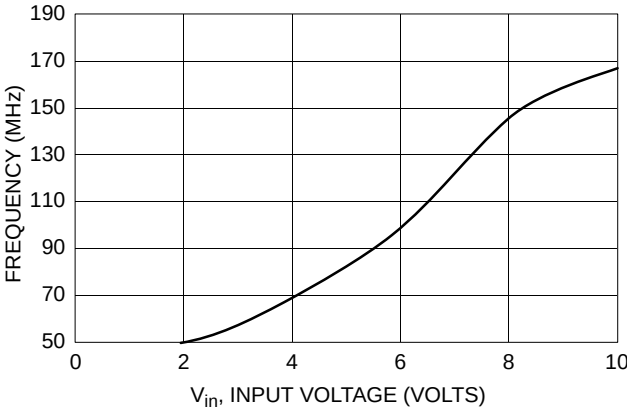


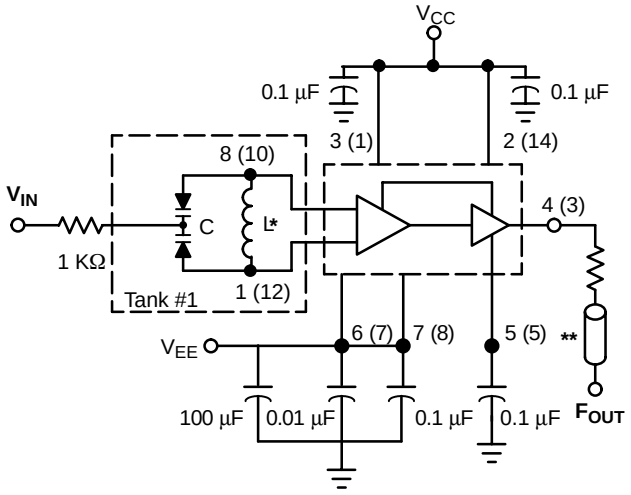
Figure 10. Inductor Value Known (4 nH)

VOLTAGE CONTROLLED MODE

The tank circuit configuration presented in Figure 11, Voltage Controlled Varactor Mode, allows the VCO to be tuned across the full operating voltage of the power supply. Deriving from Figure 6, the tank capacitor, C, is replaced with a varactor diode whose capacitance changes with the voltage applied, thus changing the resonant frequency at which the VCO tank operates as shown in Figure 3, tank option #1. The capacitive component in Equation 1 also needs to include the input capacitance of the device and other circuit and parasitic elements.



Plot 1. Dual Veractor MMBV609, V_{IN} vs. Frequency



* Use high impedance probe (>1.0 Megohm must be used).

** The 1200 ohm resistor and the scope termination impedance constitute a 25:1 attenuator probe. Coax shall be CT–070–50 or equivalent.

L = Micro Metal torroid #T20–22, 8 turns #30 Enameled Copper wire (@ 40 nH)

C = MMBV609

8 pin (14 pin) lead package

Figure 11. Voltage Controlled Varactor Mode

When operating the oscillator in the voltage controlled mode with Tank Circuit #1 (Figure 3), it should be noted that the cathode of the varactor diode (D), pin 8 (for 8 lead package) or pin 10 (for 14 lead package) should be biased at least 1.4 V above V_{EE}.

Typical transfer characteristics employing the capacitance of the varactor diode (plus the input capacitance of the device, about 6.0 pF typical) in the voltage controlled mode is shown in Plot 1, Dual Varactor MMBV609 Vin vs. Frequency. Figure 6, Figure 7, and Figure 8 show the accuracy of the measured frequency with the different variable capacitance values. The 1.0 kΩ resistor in Figure 11 is used to protect the varactor diode during testing. It is not necessary as long as the dc input voltage does not cause the diode to become forward biased. The tuning range of the oscillator in the voltage controlled mode may be calculated as follows:

$$\frac{f_{max}}{f_{min}} = \frac{\sqrt{C_D(max) + C_S}}{\sqrt{C_D(min) + C_S}} \qquad \text{eq. 2}$$

Where

$$f_{min} = \frac{1}{2\pi\sqrt{(L(C_D(max) + C_S)}} \qquad \text{eq. 3}$$

Where

C_S = Shunt Capacitance (input plus external capacitance)

C_D = Varactor Capacitance as a function of bias voltage

Good RF and low–frequency bypassing is necessary on the device power supply pins. Capacitors on the AGC pin and the input varactor trace should be used to bypass the AGC point and the VCO input (varactor diode), guaranteeing only dc levels at these points. For output frequency operation between 1.0 MHz and 50 MHz, a 0.1 µF capacitor is sufficient. At higher frequencies, smaller values of capacitance should be used; at lower frequencies, larger values of capacitance. At high frequencies, the value of bypass capacitors depends directly on the physical layout of the system. All bypassing should be as close to the package pins as possible to minimize unwanted lead inductance. Several different capacitors may be needed to bypass various frequencies.

VAVEFORM CONDITIONING – SINE OR SQUARE WAVE

The peak–to–peak swing of the tank circuit is set internally by the AGC pin. Since the voltage swing of the tank circuit provides the drive for the output buffer, the AGC potential directly affects the output waveform. If it is desired to have a sine wave at the output of the MC100EL1648, a series resistor is tied from the AGC point to the most negative power potential (ground if positive volt supply is used, –5.2 volts if a negative supply is used) as shown in Figure 12. At frequencies above 100 MHz typical, it may be desirable to increase the tank circuit peak–to–peak voltage in order to shape the signal into a more square waveform at the output of the MC100EL1648. This is accomplished by tying a series resistor (1.0 kΩ minimum) from the AGC to the most positive power potential (+5.0 volts if a positive volt supply is used, ground if a –5.2 volt supply is used). Figure 13 illustrates this principle.

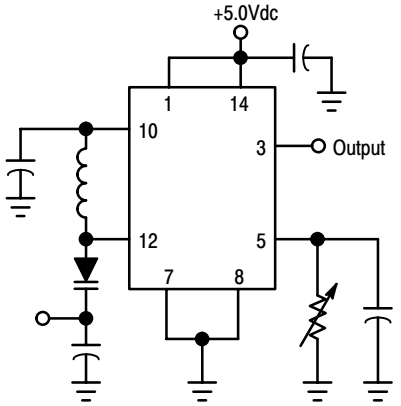


Figure 12. Method of Obtaining a Sine–Wave Output

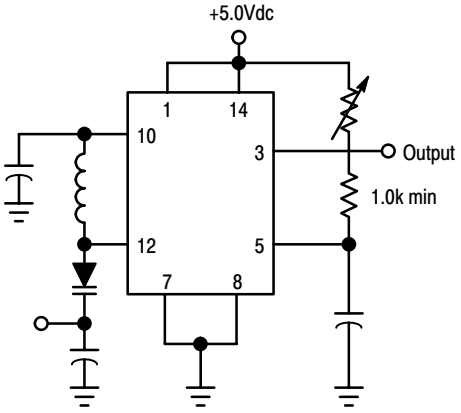


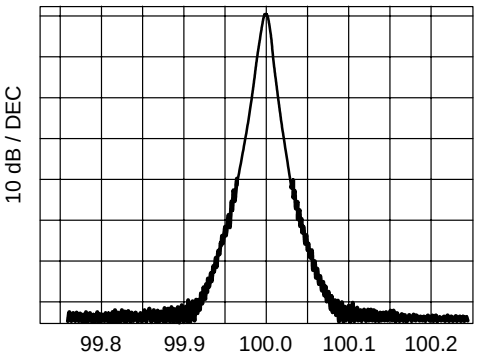
Figure 13. Method of Extending the Useful Range of the MC100EL1648 (Square Wave Output)

SPECTRAL PURITY

TEST VOLTAGE/CURRENT TABLE
(V_{CC} = 0.0V, V_{EE} = –5.2 V)

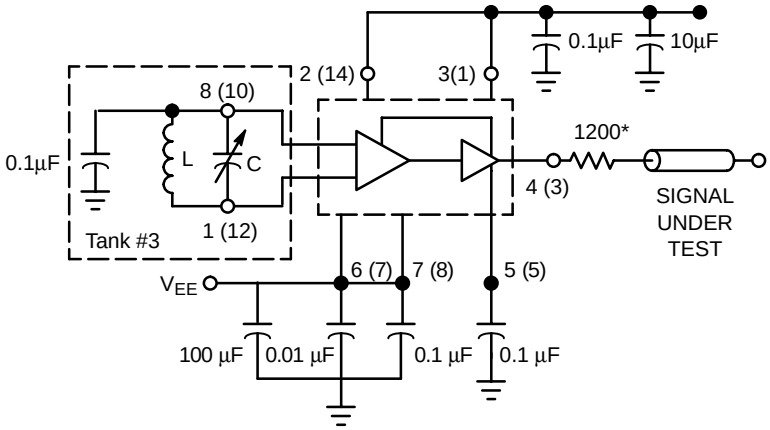
Symbol	Conditions			Units
	–30°C	+25°C	+85°C	
V_{IHmax}	–3.2	–3.35	–3.5	V
V_{ILmin}	–3.7	–3.85	–4.0	V
IL	–5.0	–5.0	–5.0	mA

Note: SOIC “D” package guaranteed –30°C to +70°C only



B.W. = 10 kHz
Center Frequency = 100 MHz
Scan Width = 50 kHz/div
Vertical Scale = 10 dB/div

Spectral Purity



L = Micro Metal torroid #T20–22, 8 turns #30 Enameled Copper wire (@ 40 nH)
C = 3.0–35 pF Variable Capacitance (@ 10 pF)

** The 1200 ohm resistor and the scope termination impedance constitute a 25:1 attenuator probe. Coax shall be CT–070–50 or equivalent.

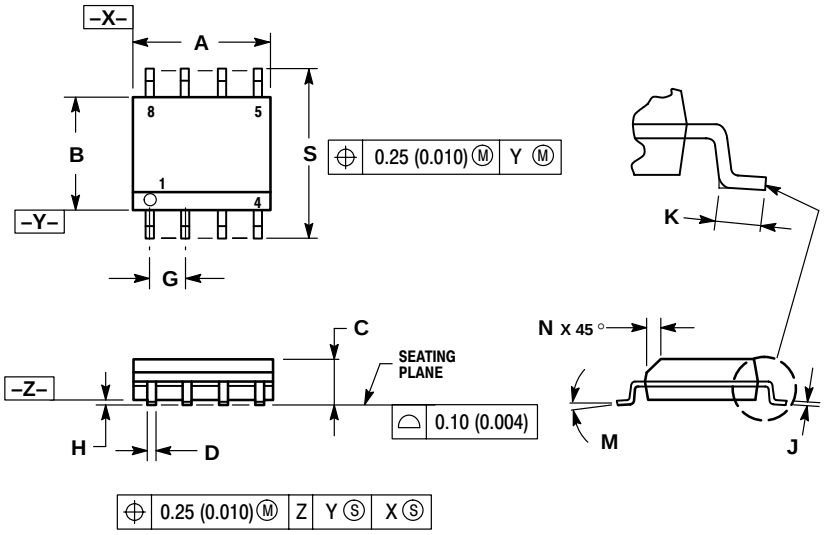
8 pin (14 pin) Lead Package

Spectral Purity Test Circuit

Figure 14. Spectral Purity of Signal Output for 200 MHz Testing

PACKAGE DIMENSIONS

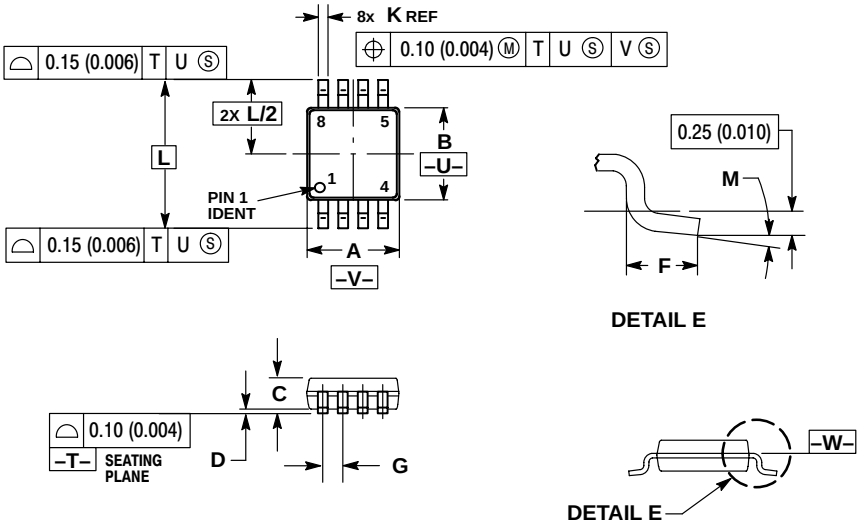
SO–8
D SUFFIX
CASE 751–07
ISSUE W



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSION A AND B DO NOT INCLUDE MOLD PROTRUSION.
4. MAXIMUM MOLD PROTRUSION 0.15 (0.006) PER SIDE.
5. DIMENSION D DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.127 (0.005) TOTAL IN EXCESS OF THE D DIMENSION AT MAXIMUM MATERIAL CONDITION.

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.80	5.00	0.189	0.197
B	3.80	4.00	0.150	0.157
C	1.35	1.75	0.053	0.069
D	0.33	0.51	0.013	0.020
G	1.27 BSC		0.050 BSC	
H	0.10	0.25	0.004	0.010
J	0.19	0.25	0.007	0.010
K	0.40	1.27	0.016	0.050
M	0 °	8 °	0 °	8 °
N	0.25	0.50	0.010	0.020
S	5.80	6.20	0.228	0.244

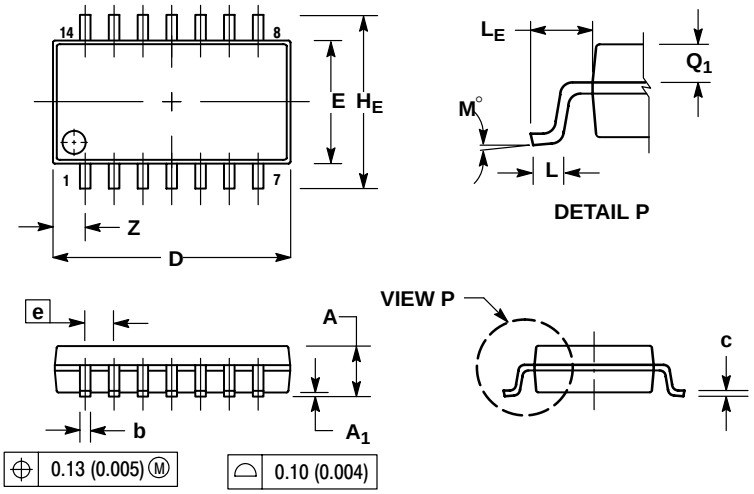
TSSOP–8
DT SUFFIX
CASE 948R–02
ISSUE A



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSION A DOES NOT INCLUDE MOLD FLASH. PROTRUSIONS OR GATE BURRS. MOLD FLASH OR GATE BURRS SHALL NOT EXCEED 0.15 (0.006) PER SIDE.
4. DIMENSION B DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSION. INTERLEAD FLASH OR PROTRUSION SHALL NOT EXCEED 0.25 (0.010) PER SIDE.
5. TERMINAL NUMBERS ARE SHOWN FOR REFERENCE ONLY.
6. DIMENSION A AND B ARE TO BE DETERMINED AT DATUM PLANE –W–.

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	2.90	3.10	0.114	0.122
B	2.90	3.10	0.114	0.122
C	0.80	1.10	0.031	0.043
D	0.05	0.15	0.002	0.006
F	0.40	0.70	0.016	0.028
G	0.65 BSC		0.026 BSC	
K	0.25	0.40	0.010	0.016
L	4.90 BSC		0.193 BSC	
M	0 °	6 °	0 °	6 °

SOIC EIAJ–14
M SUFFIX
CASE 965–01
ISSUE O



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSIONS D AND E DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS AND ARE MEASURED AT THE PARTING LINE. MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED 0.15 (0.006) PER SIDE.
4. TERMINAL NUMBERS ARE SHOWN FOR REFERENCE ONLY.
5. THE LEAD WIDTH DIMENSION (b) DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.08 (0.003) TOTAL IN EXCESS OF THE LEAD WIDTH DIMENSION AT MAXIMUM MATERIAL CONDITION. DAMBAR CANNOT BE LOCATED ON THE LOWER RADIUS OR THE FOOT. MINIMUM SPACE BETWEEN PROTRUSIONS AND ADJACENT LEAD TO BE 0.46 (0.018).

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	---	2.05	---	0.081
A_1	0.05	0.20	0.002	0.008
b	0.35	0.50	0.014	0.020
c	0.18	0.27	0.007	0.011
D	9.90	10.50	0.390	0.413
E	5.10	5.45	0.201	0.215
e	1.27 BSC		0.050 BSC	
H_E	7.40	8.20	0.291	0.323
L	0.50	0.85	0.020	0.033
L_E	1.10	1.50	0.043	0.059
M	0 °	10 °	0 °	10 °
Q_1	0.70	0.90	0.028	0.035
Z	---	1.42	---	0.056

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