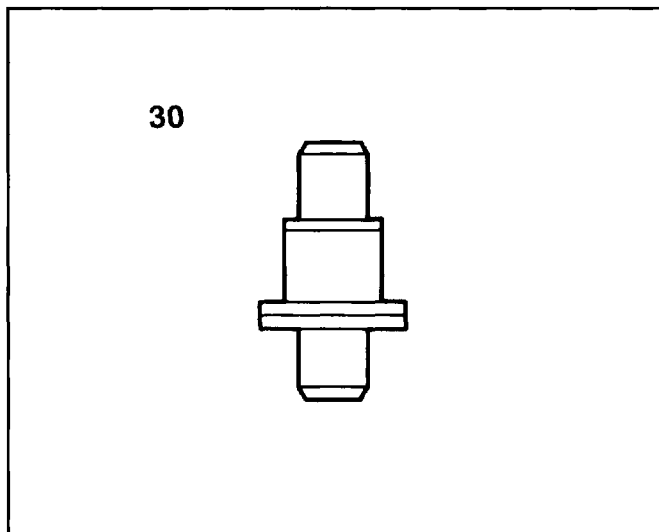


MA45200 Series

Silicon Abrupt Junction Tuning Varactors



Description

The MA45200 series of silicon abrupt junction tuning varactors has been designed to obtain the highest Q possible. Each device in this series has a high density silicon dioxide passivation which results in exceptionally low leakage currents and low post tuning drift. These silicon abrupt junction tuning varactors, which have a high Q, also exhibit large capacitance changes with bias voltages. The capacitance change is approximately equal to the square root of the voltage. The MA45200 series diodes are available in a number of ceramic packages as well as in chip form.

Features

- HIGH Q
- LOW LEAKAGE
- AVAILABLE IN CHIP FORM
- AVAILABLE IN CERAMIC PACKAGES
- CUSTOM DESIGNS AVAILABLE
- LOW POST TUNING DRIFT
- FREQUENCY RANGE VHF — Ku-BAND
- CAN BE SCREENED TO TX, TXV SPECIFICATIONS

Applications

The MA45200 series of silicon tuning diodes is ideally suited for frequency tuning applications through Ku band. These devices are designed for use in solid state electronic tuning of transistor, Gunn and IMPATT oscillators.

Specifications @ $T_A = 25^\circ\text{C}$ **30 Volt Silicon Abrupt Junction Tuning Varactors****Nominal Characteristics**

Model ¹ Number	Minimum ⁶ V_b (Volts)	Total ^{2,7} Capacitance (pF)	Minimum ^{3,7} Capacitance Ratio C_{t0}/C_{tyb}	Minimum ⁴ "Q"	Frequency Range (GHz)	Available ^{1,7} Case Style (Chip)
MA45225	30	0.5	2.7	5500	10-12	132
MA45226	30	0.6	2.9	5500	9-11	132
MA45227	30	0.8	2.9	5000	8-10	132
MA45228	30	1.0	3.0	4800	7-9	132
MA45229	30	1.2	3.2	4800	6-8	132
MA45230	30	1.5	3.3	4500	6-8	132
MA45231	30	1.8	3.5	4000	5-7	132
MA45232	30	2.2	3.6	4000	5-7	132
MA45233	30	2.7	3.7	4000	4-6	132
MA45234	30	3.3	3.7	3500	4-6	132
MA45235	30	3.9	3.8	3500	3-5	132
MA45236	30	4.7	3.8	3000	2-4	132
MA45237	30	5.6	3.9	3000	2-4	132
MA45238	30	6.8	3.9	3000	2-4	132
MA45239	30	8.2	3.9	2700	1-2	132
MA45240	30	10.0	4.0	2500	1-2	132
MA45241	30	12.0	4.0	2200	.5-1.0	132
MA45242	30	15.0	4.0	2000	.5-1.0	132

45 Volt Silicon Abrupt Junction Tuning Varactors**Nominal Characteristics**

Model ¹ Number	Minimum ⁶ V_b (Volts)	Total ^{2,7} Capacitance (pF)	Minimum ^{3,7} Capacitance Ratio C_{t0}/C_{tyb}	Minimum ⁴ "Q"	Frequency Range (GHz)	Available ^{1,7} Case Style (Chip)
MA45245	45	0.5	3.3	4000	9-11	132
MA45246	45	0.6	3.7	4000	8-10	132
MA45247	45	0.8	3.9	3800	5-7	132
MA45248	45	1.0	4.0	3500	5-7	132
MA45249	45	1.2	4.2	3500	4-6	132
MA45250	45	1.5	4.4	3300	4-6	132
MA45251	45	1.8	4.6	3000	3-5	132
MA45252	45	2.2	4.8	2700	3-5	132
MA45253	45	2.7	5.5	2700	2-3	132
MA45254	45	3.3	5.2	2400	2-3	132
MA45255	45	3.9	5.3	2200	1.5-2.5	132
MA45256	45	4.7	5.4	2000	1.0-1.5	132
MA45257	45	5.6	5.4	2000	1.0-1.5	132
MA45258	45	6.8	5.4	1800	1.0-1.5	132
MA45259	45	8.2	5.4	1700	1.0-1.5	132

NOTES

- Case style 30 is the standard enclosure for this series. On special order, these devices are also available in other case styles including 31, 94, 96, 108, and in chip form. To order the MA45200 series in chip form or other case styles, add the designated available case number as a suffix to the model number, i.e., MA45229-132 is a chip or MA45229-96 is in the 96 case style.
- Total capacitance is measured at 1 MHz and -4 volts. The standard capacitance is $\pm 10\%$. A tighter tolerance $\pm 5\%$ may be obtained, at an additional cost, by adding the suffix "A" to the basic model number.
- The total capacitance ratio will vary with different packages due to differences in package parasitic capacitance.

- Diode Q at -4 volts is determined at 1.0 GHz and extrapolated to 50 MHz by:

$$Q_{-4} = \frac{1}{2\pi f C_{j-4} R_s}$$

- Reverse leakage current is measured at 80% of the minimum breakdown voltage and will be 20 nanoamperes maximum.
- Reverse leakage is 10 microamperes maximum at minimum breakdown voltage.
- The total capacitance and capacitance ratios shown are for diodes housed in case style 30. Other cases and chip styles will result in slightly different values.

Specifications @ $T_A = 25^\circ\text{C}$ (Cont'd)**60 Volt Silicon Abrupt Junction Tuning Varactors****Nominal Characteristics**

Model ¹ Number	Minimum ⁶ V_b (Volts)	Total ^{2,7} Capacitance (pF)	Minimum ^{3,7} Capacitance Ratio C_{t0}/C_{tvb}	Minimum ⁴ “Q”	Frequency Range (GHz)	Available ^{1,7} Case Style (Chip)
MA45260	60	0.6	4.5	2500	4-6	132
MA45261	60	0.8	4.5	2300	4-6	132
MA45262	60	1.0	4.8	2200	4-6	132
MA45263	60	1.2	5.2	2000	2-4	132
MA45264	60	1.5	5.6	1800	2-4	132
MA45265	60	1.8	5.9	1800	2-4	132
MA45266	60	2.2	6.0	1700	1.5-2.0	132
MA45267	60	2.7	6.2	1700	1.5-3.0	132
MA45268	60	3.3	6.3	1600	1.5-3.0	132
MA45269	60	3.9	6.4	1500	1.0-2.0	132
MA45270	60	4.7	6.5	1400	1.0-2.0	132
MA45271	60	5.6	6.5	1400	1.0-2.0	132
MA45272	60	6.8	6.5	1200	0.5-1.0	132
MA45273	60	8.2	6.8	1200	0.5-1.0	132
MA45274	60	10.0	7.0	1000	0.5-1.0	132
MA45275	60	12.0	7.0	1000	0.5-1.0	131
MA45276	60	15.0	7.2	900	0.25-0.50	131
MA45277	60	18.0	7.2	900	0.25-0.50	131
MA45278	60	22.0	7.4	800	0.25-0.50	131
MA45279	60	27.0	7.4	800	0.10-0.25	131
MA45280	60	33.0	7.4	700	0.10-0.25	131

90 Volt Silicon Abrupt Junction Tuning Varactors**Nominal Characteristics**

Model ¹ Number	Minimum ⁶ V_b (Volts)	Total ^{2,7} Capacitance (pF)	Minimum ^{3,7} Capacitance Ratio C_{t0}/C_{tvb}	Minimum ⁴ “Q”	Frequency Range (GHz)	Available ^{1,7} Case Style (Chip)
MA45290	90	1.0	6.0	1500	2.0-4.0	132
MA45291	90	1.2	6.5	1200	2.0-4.0	132
MA45292	90	1.5	7.0	1100	2.0-4.0	132
MA45293	90	1.8	7.3	1000	2.0-4.0	132
MA45294	90	2.2	7.5	900	1.5-3.0	132
MA45295	90	2.7	7.8	900	1.5-3.0	132
MA45296	90	3.3	8.0	800	1.0-2.0	132
MA45297	90	3.9	8.3	800	1.0-2.0	132
MA45298	90	4.7	8.5	700	1.0-2.0	132
MA45299	90	5.6	8.8	600	0.5-1.0	132

See notes on previous page.

MAXIMUM RATINGS

Reverse Voltage	Same as rated breakdown V_b
Operating Temperature	-65°C to +150°C
Storage Temperature	-65°C to +200°C
Temperature Coefficient	300 ppm/°C at -4 Volts
Power Dissipation	$C_j = 1.0$ pF max. @100mW
(derate linearly to zero at 150°C)	$C_j = 1.0$ pF min. @200mW

ENVIRONMENTAL PERFORMANCE

All tuning varactors in the MA45200 series are capable of meeting the performance tests dictated by the methods and procedures of the latest revisions of MIL-S-19500, MIL-STD-202 and MIL-STD-750 which specify mechanical, electrical, thermal and other environmental tests common to semiconductor products.

HIGH RELIABILITY PARTS

All diodes in the MA45200 series may be screened to TX, TXV specification.

MA45200 Series — Silicon Abrupt Junction Tuning Varactors

Typical Performance Curves

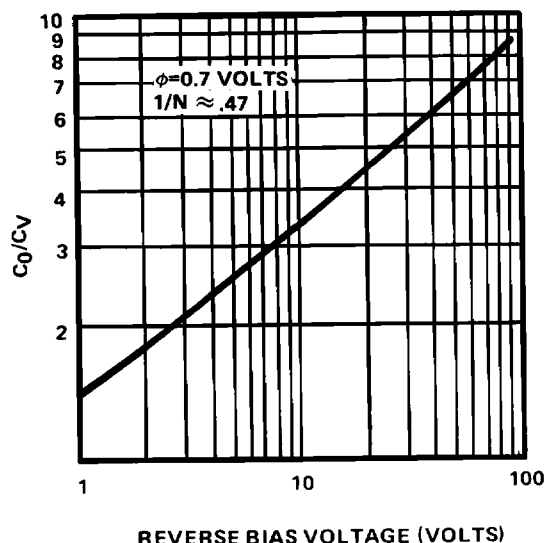


FIGURE 1. Typical Capacitance Change Ratios for Silicon Tuning Varactor Chips

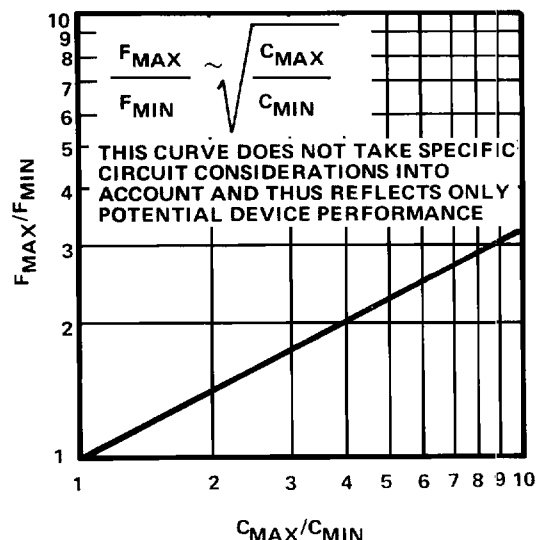


FIGURE 2. Frequency Tuning Ratio as a Function of Capacitance Change Ratio

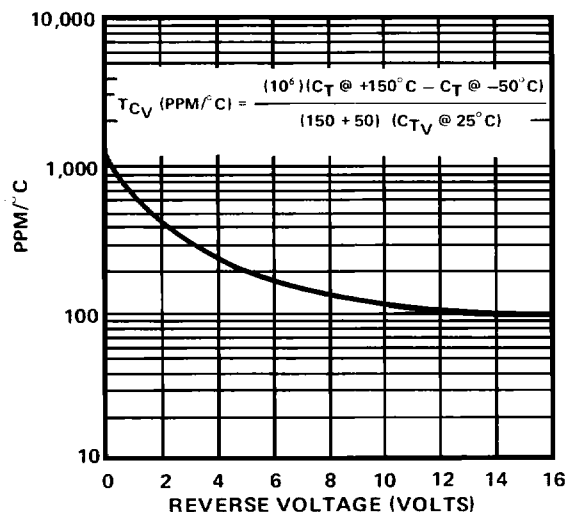


FIGURE 3. Typical Temperature Coefficient of Silicon Varactors

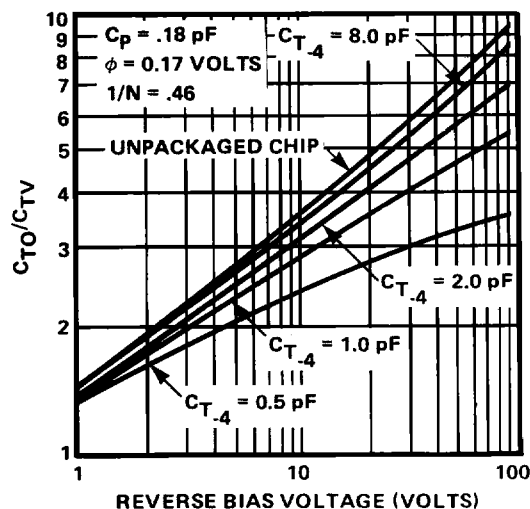


FIGURE 4. Typical Capacitance Change Ratios for Silicon Tuning Varactors in Case Styles 30, 31 & 108

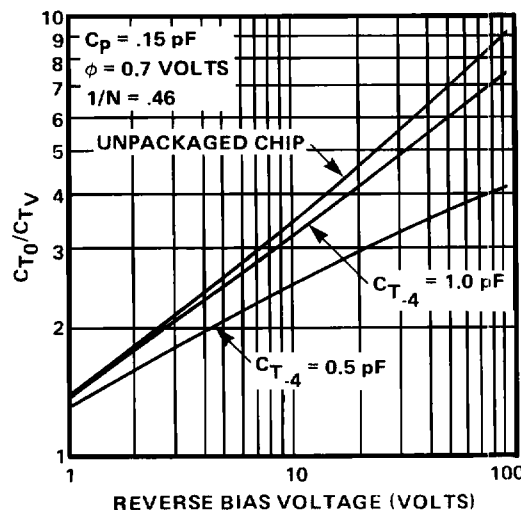


FIGURE 5. Typical Capacitance Change Ratios for Silicon Tuning Varactors in Case Styles 94 and 96

Application Notes

Capacitance Change Ratio

The capacitance change between any two reverse bias voltages for a silicon abrupt junction tuning varactors in chip form is given by:

$$(1) \quad \frac{C_{jV_1}}{C_{jV_2}} = \left(\frac{V_2 + \theta}{V_1 + \theta} \right)^\gamma$$

where:

- C_{jV_1} = Junction capacitance at reverse voltage (V_1)
- C_{jV_2} = Junction capacitance at reverse voltage (V_2)
- θ = Contact potential (0.7 volts for silicon)
- V_1 = Reverse bias voltage at point 1
- V_2 = Reverse bias voltage at point 2
- γ = Gamma (exponential of the C-V curve)
- $\gamma \cong .47$ for MA45200 series

The junction capacitance ratio for a chip, between zero volts and any reverse bias voltage (V) simplifies to:

$$(2) \quad C_{j0}/C_{jV} = 1 + \frac{V}{\theta}^\gamma$$

The diode capacitance ratio given in Equation 1 diminishes when the semiconductor chip is enclosed in a hermetic package. The amount of decrease depends on the value of case capacitance (C_p) and its relative magnitude with respect to the chip junction capacitance (C_j). The total

capacitance (C_T) of the packaged diode at any reverse voltage (V) is given by:

$$(3) \quad C_{TV} = C_p + C_{jV}$$

The total capacitance tuning ratio from zero to any reverse bias voltage is shown in Figures 1 and 2 and for all the standard tuning diode packages as a function of reverse bias and total capacitance at -4 volts (C_{T-4}). From these plots, the total capacitance ratio between any two voltage levels can be obtained by dividing (C_{T0}/C_{TV_2}) by (C_{T0}/C_{TV_1}) to yield (C_{jV_1}/C_{jV_2}). Figures 1 and 2 show the typical total capacitance vs ($V_R + \theta$) for each device in this series. For a more in-depth discussion on capacitance change ratio see M/A-COM Semiconductor Products Inc., SPI-MISER article, "Tuning Varactor Diode Selection Guide," 1986.

Varactor Q

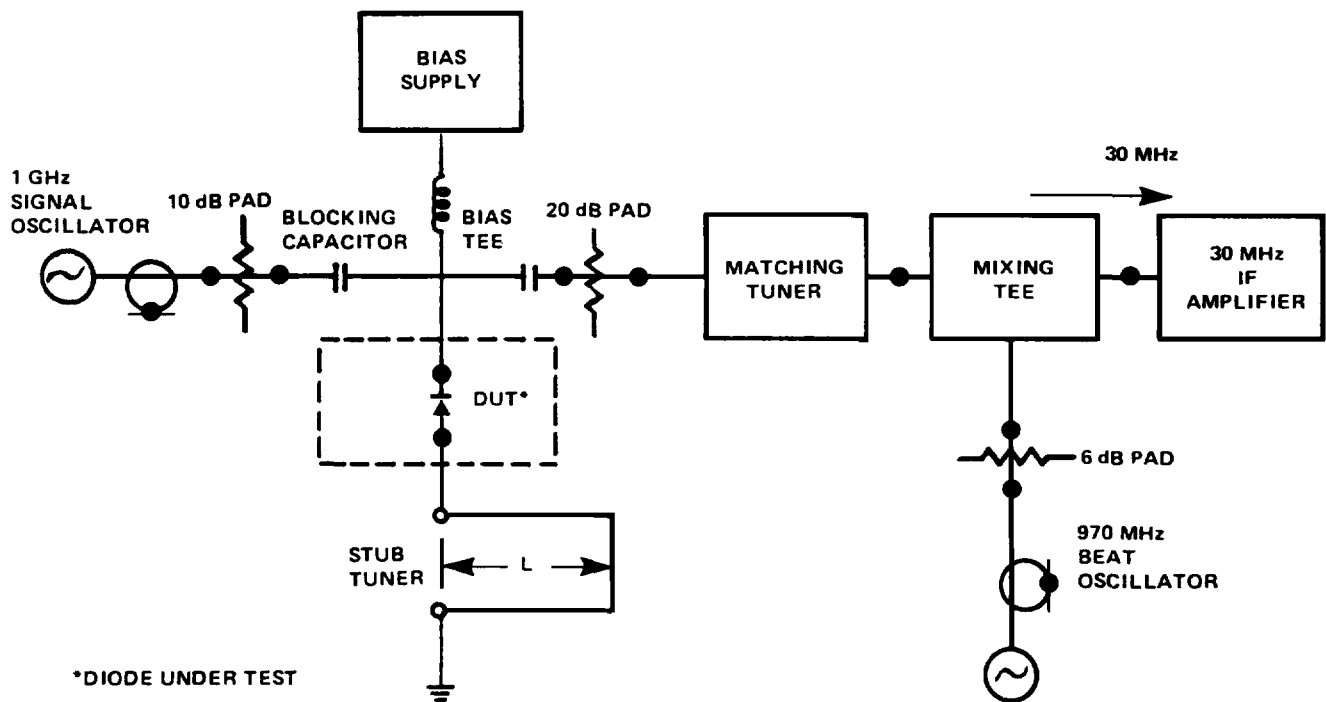
The Q of tuning varactors is historically given at a frequency of 50 MHz and a reverse bias voltage of -4 volts. This is determined by using the 1 GHz series resistance and a 1 MHz capacitance measure, Q @ 50 MHz is:

$$Q_{50 \text{ MHz}} = \frac{3183}{(R_s - 4)(C_j - 4)}$$

where:

- R_s = series resistance (ohms) measured at -4 volts
- $C_j - 4$ = junction capacitance at -4 volts (pF).

1 GHz R_s MEASUREMENT



*DIODE UNDER TEST

TABLE 1. COMPARISON OF RELATIVE PERFORMANCE OF DIFFERENT TUNING VARACTOR CHARACTERISTICS

Varactor Type	Linear Tuning	Harmonic Content	Q or Loss	Post Tuning Drift Charac.	Settle Time	Temp. Stability	Phase Noise	Residual FM	Normal (Max) Useful Tun. Range (Volts)	Noise Performance When Osc. Is Overdriven	Useful Cap. Change Obtainable (Maximum)
Si Abrupt	Fair	Good	Good	Very-Good	Good	Good-Best	Best	Best	0-60	Good	~6/1
Si Hyperabrupt	Good	Good	Fair	Very-Good	Best	Fair	Fair-Good	Fair-Good	2-20	Good	~12/1 to 15/1
GaAs Abrupt	Fair	Good	Best	Fair	Fair	Best	Good	Good	1-30	Poor	~5/1
GaAs Hyperabrupt	Good-Best	Good	Good	Fair	Fair	Fair	Fair-Good	Fair-Good	2-20	Poor	~6/1 to 12/1

TABLE II. CHOICE OF TUNING VARACTOR BY TYPE OF VOLTAGE CONTROLLED OSCILLATOR

	Silicon Abrupt	Silicon Hyperabrupt	GaAs Abrupt	GaAs Hyperabrupt
ECM VCO With Post Tuning Drift Requirements A) To 10 GHz B) Above 12 GHz	Good Fair	Best Good	Fair Good	Fair Best
Telecommunication Phase Locked Oscillator	Fair	Good	Good	Best
VCOs for Tuned Synthesizers A) Instruments and Telecommunication B) Radar Synthesizers	Best Good	Good — —	— — Best	— — Good
Radar Local Oscillators A) Frequency Agile Radar (Using Synthesizer) B) Frequency Agile Radar (Using Tuned Exciter) C) Marine/Weather Radar Local Oscillator	Good Good Good	Good Best Fair-Good	Good Good Best	Best Very Good Good
Telecommunications Transmitter VCOs	Good	Good	Good	Best
Missile Seeker	Good	Fair	Good	Best
Doppler Radar/Motion Detector VCOs	Good	Good	Good	Best
Instrument VCO	Good	Best	— —	— —
Police Radar Detectors A) 11.5 GHz VCO B) 1 GHz VCO	— — Good	— — Good	Best — —	Good Best

— — Denotes not normal usage for this type of varactor.

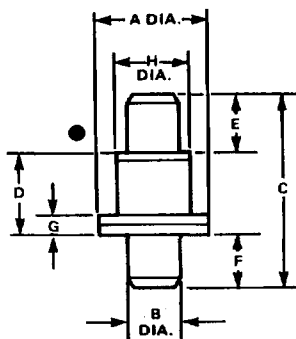
TABLE III.

Suggested Tuning Varactor By Type of VCO					
	Frequency	Silicon Abrupt	Silicon Hyperabrupt	GaAs Abrupt	GaAs Hyperabrupt
ECM VCO With Post Tuning Drift Specification	C X Ku		4ST554 4ST551 —		46580
Telecommunication P.L.O.	L C X	45238 45230 45350	4ST533 4ST554 4ST551	46602	46485 46476 46471
VCO For Tuned Synthesizer	UHF VHF	45350 45355	4ST533 4ST522		
Radar LO A) Frequency Agile Radar Synthesizer B) Tuned Exciter C) Marine/Weather Radar LO	VHF X Ku X	45351 45226 45225 45226	4ST522 4ST551 — 4ST551	46602 46601 46602	46471 46470
Telecommunications Transmitter (VCO)	C X Ku K	45230	4ST554 4ST551 — —	46609 46602 46601 46600	46456 46451 46450-94 46450-94
Missile Seeker	X Ku	45227C 45226C	4ST551 —	46602 46601	46581 46580
Doppler Radar/Motion Detection	X		—	46602	
Instrument VCO	UHF VHF	45350 45355	4ST533 4ST522		
PRD Radar Detector 11 GHz VCO 1 GHz VCO	X L	45346	4ST551 4ST533	46602	46471
UHF/Mobile Radio VCO VHF/Mobile Radio VCO			4ST533 4ST522		

Case Styles

● DENOTES CATHODE NOT TO SCALE

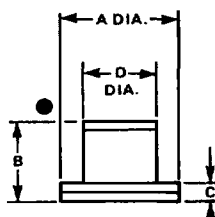
30



DIM.	INCHES		MILLIMETERS	
	MIN.	MAX.	MIN.	MAX.
A	0.119	0.127	3.02	3.22
B	0.060	0.064	1.52	1.63
C	0.205	0.225	5.21	5.72
D	0.085	0.097	2.16	2.46
E	0.060	0.064	1.52	1.63
F	0.060	0.064	1.52	1.63
G	0.016	0.024	0.41	0.61
H	0.079	0.083	2.01	2.11

$C_P = 0.18$ pF Typical
 $L_S = 0.40$ nH Typical

31

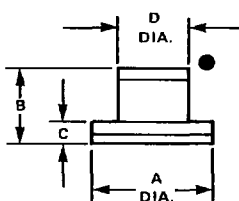


DIM.	INCHES		MILLIMETERS	
	MIN.	MAX.	MIN.	MAX.
A	0.119	0.127	3.02	3.23
B	0.085	0.097	2.16	2.46
C	0.016	0.024	0.41	0.61
D	0.077	0.083	1.96	2.11

$C_P = 0.18$ pF Typical
 $L_S = 0.60$ nH Typical

Case Styles (Cont'd)

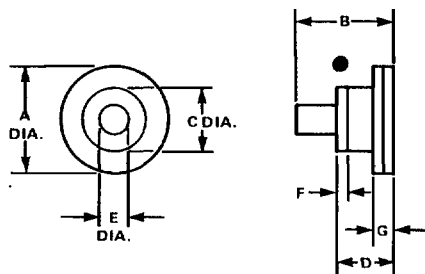
94



DIM.	INCHES		MILLIMETERS	
	MIN.	MAX.	MIN.	MAX.
A	0.078	0.086	1.98	2.18
B	0.040	0.050	1.02	1.27
C	—	0.015	—	0.38
D	0.047	0.053	1.19	1.35

$C_p = 0.15$ pF Typical
 $L_s = 0.17$ nH Typical

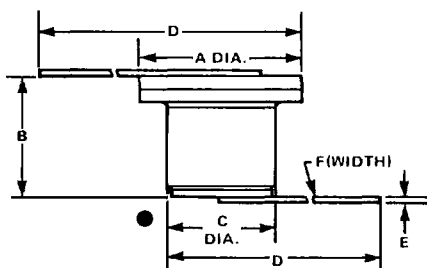
96



DIM.	INCHES		MILLIMETERS	
	MIN.	MAX.	MIN.	MAX.
A	0.078	0.086	1.98	2.18
B	0.070	0.080	1.78	2.03
C	0.047	0.053	1.19	1.35
D	0.040	0.050	1.02	1.27
E	0.024	0.026	0.61	0.66
F	0.004	0.010	0.10	0.25
G	—	0.015	—	0.38

$C_p = 0.15$ pF Typical
 $L_s = 0.17$ nH Typical

108

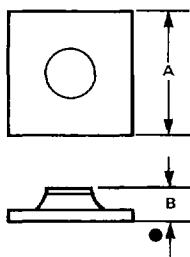


DIM.	INCHES		MILLIMETERS	
	MIN.	MAX.	MIN.	MAX.
A	0.119	0.127	3.02	3.23
B	0.085	0.097	2.16	2.46
C	0.077	0.083	1.96	2.11
D	0.975	1.025	24.77	26.04
E	0.002	0.004	0.05	0.09
F	0.077	0.083	1.96	2.11

$C_p = 0.18$ pF Typical
 $L_s = 0.60$ nH Typical

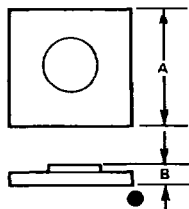
Chip Styles

131



DIM.	INCHES		MILLIMETERS	
	MIN.	MAX.	MIN.	MAX.
A	0.030	0.035	0.76	0.89
B	0.003	0.006	0.08	0.15

132



DIM.	INCHES		MILLIMETERS	
	MIN.	MAX.	MIN.	MAX.
A	0.020	0.024	0.51	0.61
B	0.003	0.006	0.08	0.15