1N5461A,B,C (SILICON)
thru
1N5476A,B,C

VVC —▶|⊢

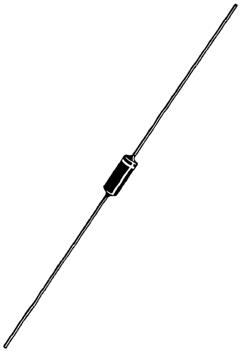
SILICON EPICAP DIODES

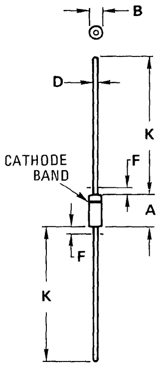
. . . a PREMIUM line of epitaxial, passivated, abrupt-junction tuning diodes for critical and sophisticated frequency control applications through the UHF range.

- High Q at High Frequencies
- Guaranteed High Capacitance Tuning Range
- Excellent Unit-to-Unit Uniformity
- Guaranteed Temperature Coefficient
- Capacitance Tolerances – 10%, 5.0%, and 2.0%
- Complete Typical Design Curves

VOLTAGE-VARIABLE CAPACITANCE DIODES

6.8 – 100 pF
30 VOLTS





DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.84	7.62	0.230	0.300
B	2.16	2.72	0.085	0.107
D	0.46	0.56	0.018	0.022
F	–	1.27	–	0.050
K	25.40	–	1.000	–

All JEDEC dimensions and notes apply

CASE 51-02
DO-7

**MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	30	Volts
Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	400 2.67	mW mW/°C
Operating Junction Temperature Range	T_J	+175	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

**Indicates JEDEC Registered Data.

****ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

Characteristic—All Types	Test Conditions	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage	I_R = 10 μAdc	BV_R	30	—	—	Vdc
Reverse Voltage Leakage Current	V_R = 25 Vdc, T_A = 25°C V_R = 25 Vdc, T_A = 150°C	I_R	— —	— —	0.02 20	μAdc
Series Inductance	f = 250 MHz, lead length ≈1/16″	L_S	—	4.0	10	nH
Case Capacitance	f = 1.0 MHz, lead length ≈ 1/16″	C_C	0.1	0.17	0.25	pF
Diode Capacitance Temperature Coefficient (Note 6)	V_R = 4.0 Vdc, f = 1.0 MHz	TC_c	—	300	400	ppm/°C

Device	C_T, Diode Capacitance* V_R = 4.0 Vdc, f = 1.0 MHz pF			TR, Tuning Ratio C_2/C_{30} f = 1.0 MHz		Q, Figure of Merit V_R = 4.0 Vdc f = 50 MHz
	Min (Nom −10%)	Nom	Max (Nom +10%)	Min	Max	Min
1N5461A	6.1	6.8	7.5	2.7	3.1	600
1N5462A	7.4	8.2	9.0	2.8	3.1	600
1N5463A	9.0	10.0	11.0	2.8	3.1	550
1N5464A	10.8	12.0	13.2	2.8	3.1	550
1N5465A	13.5	15.0	16.5	2.8	3.1	550
1N5466A	16.2	18.0	19.8	2.9	3.1	500
1N5467A	18.0	20.0	22.0	2.9	3.1	500
1N5468A	19.8	22.0	24.2	2.9	3.2	500
1N5469A	24.3	27.0	29.7	2.9	3.2	500
1N5470A	29.7	33.0	36.3	2.9	3.2	500
1N5471A	35.1	39.0	42.9	2.9	3.2	450
1N5472A	42.3	47.0	51.7	2.9	3.2	400
1N5473A	50.4	56.0	61.6	2.9	3.3	300
1N5474A	61.2	68.0	74.8	2.9	3.3	250
1N5475A	73.8	82.0	90.2	2.9	3.3	225
1N5476A	90.0	100.0	110.0	2.9	3.3	200

*To order devices with C_T Nom ±5.0% or ±2.0% add Suffix B or C respectively.

**Indicates JEDEC Registered Data.

PARAMETER TEST METHODS

1. **L_S, Series Inductance**

   L_S is measured on a shorted package at 250 MHz using an impedance bridge (Boonton Radio Model 250A RX Meter or equivalent).

2. **C_C, Case Capacitance**

   C_C is measured on an open package at 1.0 MHz using a capacitance bridge (Boonton Electronics Model 75A or equivalent).

3. **C_T, Diode Capacitance**

   (C_T = C_C + C_J). C_T is measured at 1.0 MHz using a capacitance bridge (Boonton Electronics Model 75A or equivalent).

4. **TR, Tuning Ratio**

   TR is the ratio of C_T measured at 2.0 Vdc divided by C_T measured at 30 Vdc.

5. **Q, Figure of Merit**

   Q is calculated by taking the G and C readings of an admittance bridge at the specified frequency and substituting in the following equations:

   $$Q = \frac{2\pi fC}{G}$$

   (Boonton Electronics Model 33AS8 or equivalent).

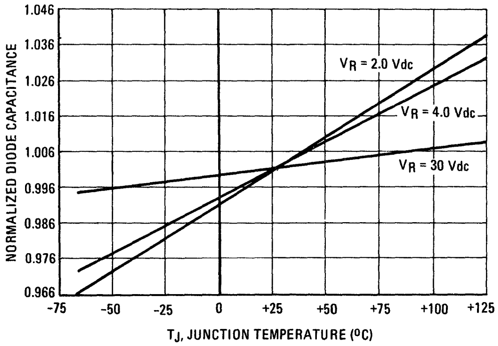
6. **TC_c, Diode Capacitance Temperature Coefficient**

   TC_c is guaranteed by comparing C_T at V_R = 4.0 Vdc, f = 1.0 MHz, T_A = −65°C with C_T at V_R = 4.0 Vdc, f = 1.0 MHz, T_A = +85°C in the following equation, which defines TC_c:

   $$TC_c = \left| \frac{C_T(+85^\circ C) - C_T(-65^\circ C)}{85 + 65} \right| \frac{10^6}{C_T(25^\circ C)}$$

   Accuracy limited by C_T measurement to ±0.1 pF.

FIGURE 1 — NORMALIZED DIODE CAPACITANCE versus JUNCTION TEMPERATURE



TYPICAL DEVICE PERFORMANCE

FIGURE 2 – DIODE CAPACITANCE versus REVERSE VOLTAGE

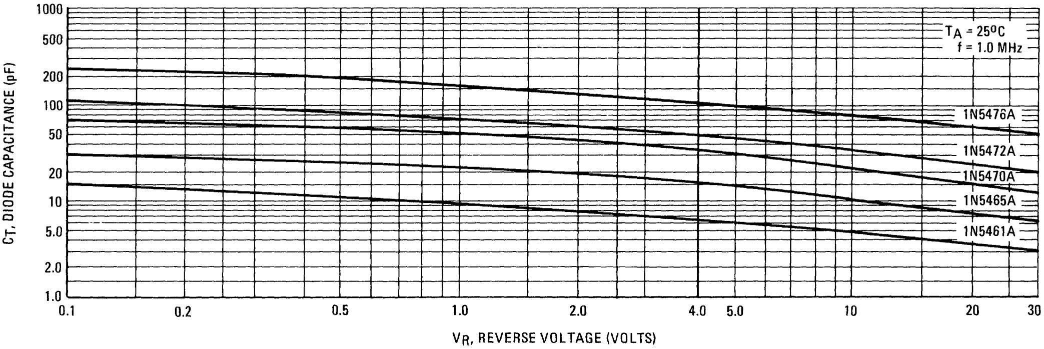


FIGURE 3 – FIGURE OF MERIT versus REVERSE VOLTAGE

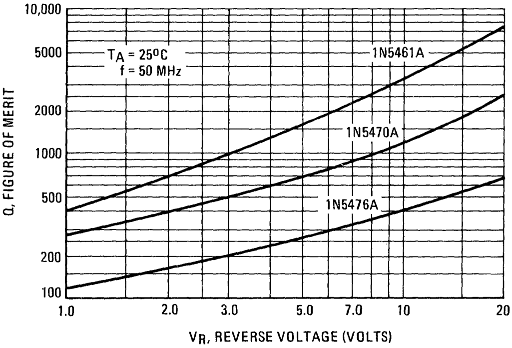


FIGURE 4 – FIGURE OF MERIT versus FREQUENCY

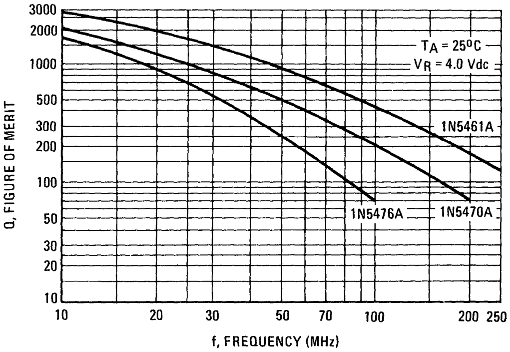


FIGURE 5 – REVERSE CURRENT versus REVERSE BIAS VOLTAGE

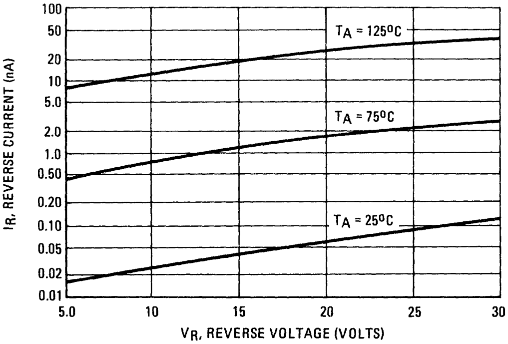
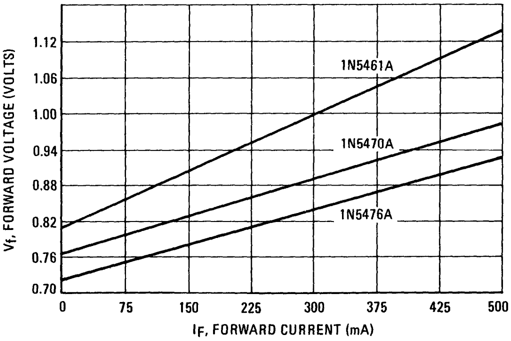


FIGURE 6 – FORWARD VOLTAGE versus FORWARD CURRENT



EPICAP VOLTAGE-VARIABLE CAPACITANCE DIODE DEVICE CONSIDERATIONS

A. Epicap Network Presentation

The equivalent circuit in Figure 7 shows the voltage capacitance and parasitic elements of an EPICAP diode. For design purposes at all but very high and very low frequencies, L_S, R_J, and C_C can be neglected. The simplified equivalent circuit of Figure 8 represents the diode under these conditions.

Definitions:

C_J – Voltage-Variable Junction Capacitance
R_S – Series Resistance (semiconductor bulk, contact, and lead resistance)
C_C – Case Capacitance
L_S – Series Inductance
R_J – Voltage-Variable Junction Resistance (negligible above 100 kHz)

FIGURE 7

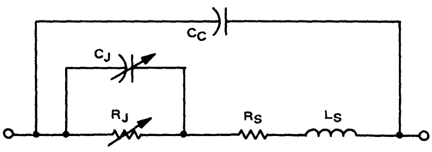


FIGURE 8

B. Epicap Capacitance versus Reverse Bias Voltage

The most important design characteristic of an EPICAP diode is the C_T versus V_R variation as shown in equations 1 and 2. Tuning Ratio, TR, between any two voltage points on curve of equation (2) is determined from equations (3) and (4).

$$C_T = C_C + C_J \qquad (1)$$

$$C_T = C_C + \frac{C_o}{\left(1 + \frac{V_R}{\phi}\right)^{\gamma}} \qquad (2)$$

$$\text{TR Junction} = \frac{C_{J1}}{C_{J2}} = \left(\frac{V_{R2} + \phi}{V_{R1} + \phi}\right)^{\gamma} \qquad (3)$$

$$\text{TR Diode} = \frac{C_{T1}}{C_{T2}} = \frac{C_{J1} + C_C}{C_{J2} + C_C} \qquad (4)$$

$C_o = C_J$ at $V_R = 0$
V_R = Reverse Bias (Volts)
γ, Diode Power Law, ≈ 0.44
ϕ, Contact Potential, ≈ 0.6 Volt
$C_c \approx 0.17$ pF

C. Epicap Capacitance versus Frequency

Variations in EPICAP effective capacitance, as a function of operating frequency, can be derived from a simplified equivalent circuit similar to that of Figure 7, but neglecting R_S and R_J. The admittance expression for such a circuit is given in equation 5. Examination of equation 5 yields the following information:

At low frequencies, $C_{eq} \approx C_J$; at very high frequencies ($f \approx \infty$) $C_{eq} \approx C_C$.

As frequency is increased from 1.0 MHz, C_{eq} increases until it is maximum at $\omega^2 = 1/L_S C_J$; and as ω^2 is increased from $1/L_S C_J$ toward infinity, C_{eq} increases from a very negative capacitance (inductance) toward $C_{eq} = C_C$, a positive capacitance.

Very simple calculations for C_{eq} at higher frequencies indicate the problems encountered when capacity measurements are made above 1.0 MHz. As ω approaches $\omega_o = 1/\sqrt{L_S C_J}$, small variations in L_S cause extreme variations in measured diode capacitance.

$$Y = j\omega C_{eq} = j\omega C_C + \frac{j\omega C_J}{1 - \omega^2 L_S C_J} \qquad (5)$$

D. EPICAP Figure of Merit (Q) and Cutoff Frequency (f_{co})

The efficiency of EPICAP response to an input frequency is related to the Figure of Merit of the device as defined in equation 6. For very low frequencies, equation 7 applies whereas at high frequencies, where R_J can be neglected, equation 6 may be rewritten into the familiar form of equation 8.

Another useful parameter for EPICAP devices is the cutoff frequency (f_{co}), and is the frequency point where Q is equal to 1. Equation 9 gives this relationship.

$$Q = \frac{X_{Seq}}{R_{Seq}} \qquad (6)$$

$$Q_{Lf} = \frac{\omega C_J R_J^2}{R_J + R_S(1 + \omega^2 C_J^2 R_J^2} \qquad (7)$$

$$Q_{hf} = \frac{1}{\omega R_S C_{eq}} \qquad (8)$$

$$f_{co} = Qf_{max} \quad \frac{1}{2\pi R_S C_{BVR}} \qquad (9)$$

E. Harmonic Generation Using EPICAPS

Efficient harmonic generation is possible with EPICAPS because of their high cutoff frequency and breakdown voltage. Since EPICAP junction capacitance varies inversely with the square root of the breakdown voltage, harmonic generator performance can be accurately predicted from various idealized models. Equation 10 gives the level of maximum input power for the EPICAP and equation 11 gives the relationships governing EPICAP circuit efficiency. In these equations, adequate heat sinking has been assumed.

$$P_{in(max)} = \frac{M(BV_R + \phi)^2}{R_S} \; \frac{f_{in}}{f_{co}} \qquad (10)$$

$M(x2) = 0.0285$; $M(x3) = 0.0241$; $M(x4) = 0.196$

$$\text{Eff} = 1 - N \frac{f_{out}}{f_{co}} \qquad (11)$$

$N(x2) = 20.8$; $N(x3) = 34.8$; $N(x4) = 62.5$

M and N are Constants