1N5149 (SILICON)
1N5150

The RF Line

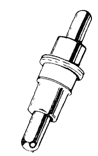
SILICON HIGH FREQUENCY STEP-RECOVERY POWER VARACTORS

. . . designed for 100 MHz to 2 GHz harmonic-generation applications with output power to 25 Watts at 1 GHz.

- Specified f_{in} = 0.5 GHz, f_{out} = 1.0 GHz Characteristics –
  Input Power = 20 W – 1N5149
  = 37 W – 1N5150
  Output Power = 11 W – 1N5149
  = 24 W – 1N5150
  Efficiency = 55% – 1N5149
  = 65% – 1N5150
- Characterized with Doubling, Tripling and Quadrupling Curves
- 100% Functionally Tested as a Doubler @ 1.0 GHz

24 W – 1 GHz – 1N5150
11 W – 1 GHz – 1N5149

STEP-RECOVERY POWER VARACTOR DIODES



MAXIMUM RATINGS

Rating	Symbol	1N5149	1N5150	Unit
Reverse Voltage	V_R	80		Volts
Forward Current	I_F	1.0		Amp
RF Power Input	P_{in}	25	40	Watts
Total Device Dissipation @ T_A = 75°C Derate above 75°C	P_D	10 0.08	14 0.11	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

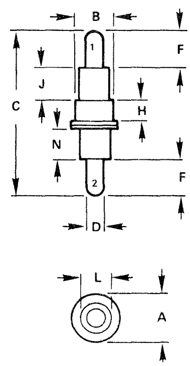
Characteristic	Symbol	1N5150 Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	9.0	°C/W

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

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	BV_R	80	90	–	Vdc
Reverse Current (V_R = 70 Vdc) (V_R = 70 Vdc, T_A = 150°C)	I_R	 – –	 – –	 2.0 100	μAdc
Diode Capacitance (V_R = 6.0 Vdc, f = 1.0 MHz)	C_T	5.0	11.5	20	pF
Figure of Merit (V_R = 6.0 Vdc, f = 50 MHz)	Q	–	800	–	–

FUNCTIONAL TEST (Figure 3)

Characteristic	Symbol	Min	Typ	Max	Unit
RF Power Output (P_{in} = 20 W, f_{in} = 0.5 GHz, f_{out} = 1.0 GHz) 1N5149 (P_{in} = 37 W, f_{in} = 0.5 GHz, f_{out} = 1.0 GHz) 1N5150	P_{out}	 11 24	 – 25	 – –	Watts
Doubler Efficiency (P_{in} = 20 W, f_{in} = 0.5 GHz, f_{out} = 1.0 GHz) 1N5149 (P_{in} = 37 W, f_{in} = 0.5 GHz, f_{out} = 1.0 GHz) 1N5150	η	 55 65	 – 68	 – –	%



STYLE 1:
PIN 1 CATHODE
2. ANODE

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.72	6.22	0.225	0.245
B	4.70	4.95	0.185	0.195
C	19.18	20.19	0.755	0.795
D	2.24	2.49	0.088	0.098
F	4.57	4.83	0.180	0.190
H	2.29	2.54	0.090	0.100
J	3.68	4.06	0.145	0.160
L	3.94	4.19	0.155	0.165
N	3.18	3.43	0.125	0.135

CASE 47-01

OUTPUT POWER versus OUTPUT FREQUENCY

1N5149

FIGURE 1A – DOUBLING (X2)

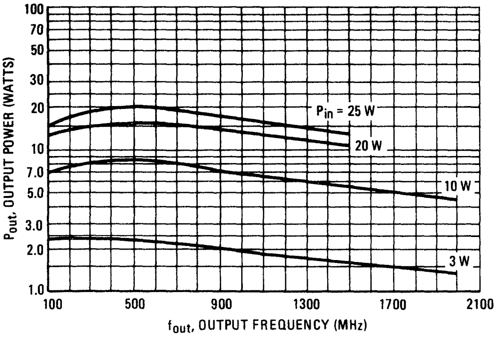


FIGURE 1B – TRIPLING (X3)

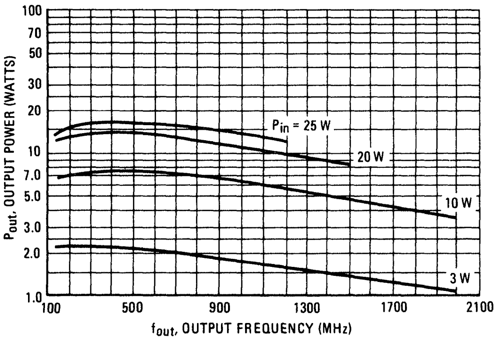
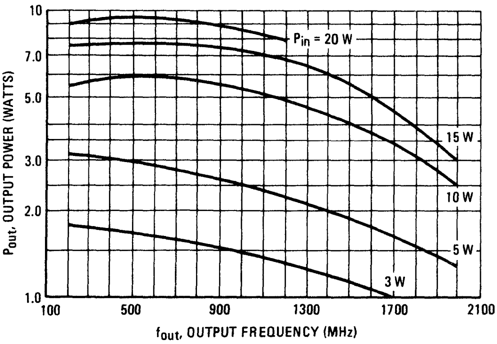


FIGURE 1C – QUADRUPLING (X4)



1N5150

FIGURE 2A – DOUBLING (X2)

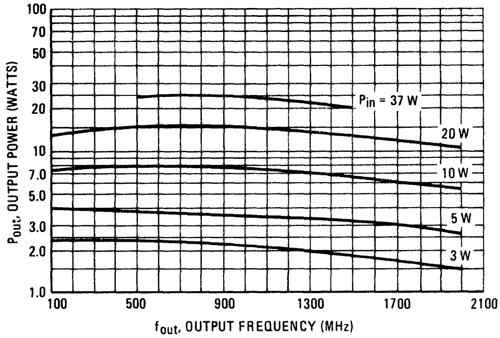


FIGURE 2B – TRIPLING (X3)

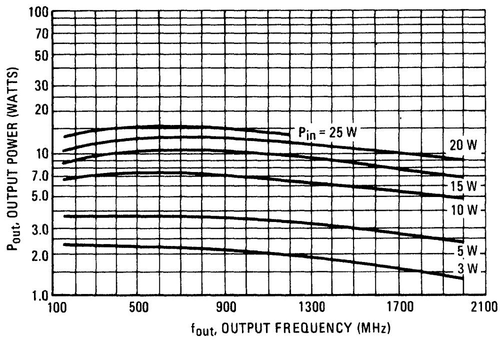


FIGURE 2C – QUADRUPLING (X4)

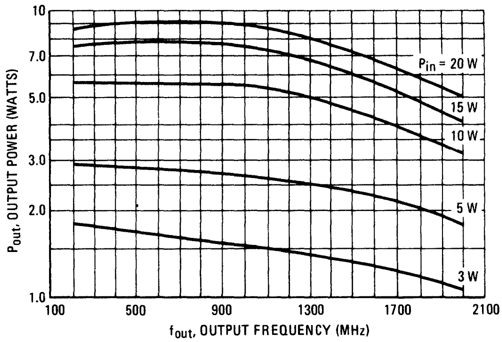
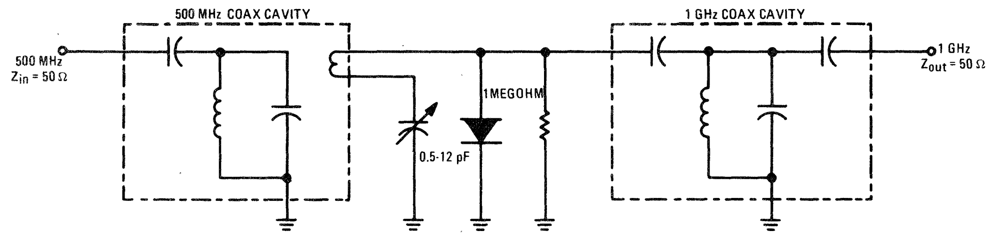
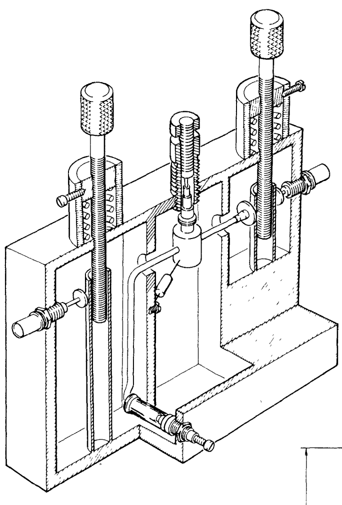
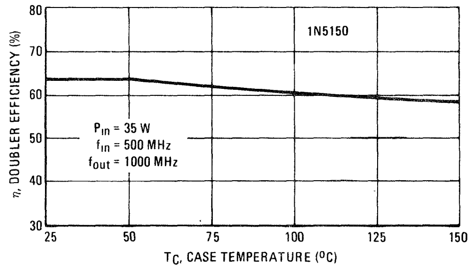
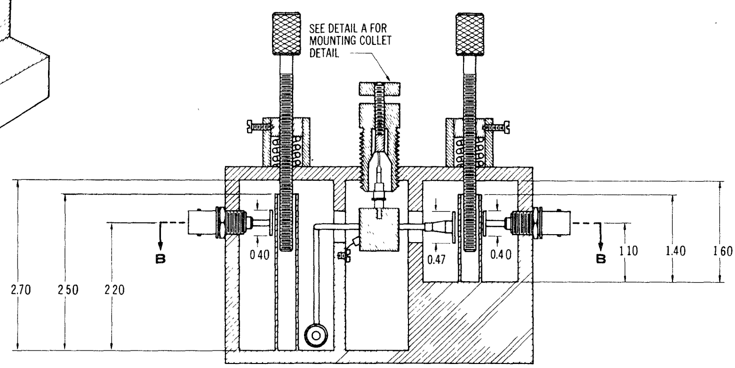


FIGURE 3 – HARMONIC DOUBLER EFFICIENCY TEST CIRCUIT

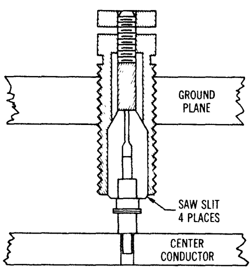




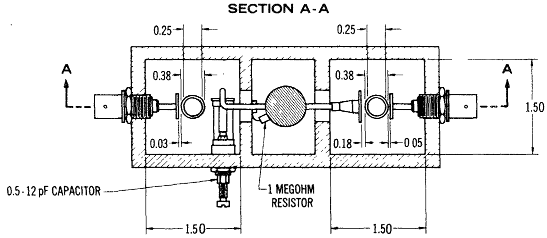




SECTION A-A



DETAIL A



SECTION B-B

FIGURE 4 – LINEARITY CHARACTERISTIC WITHOUT RETUNING

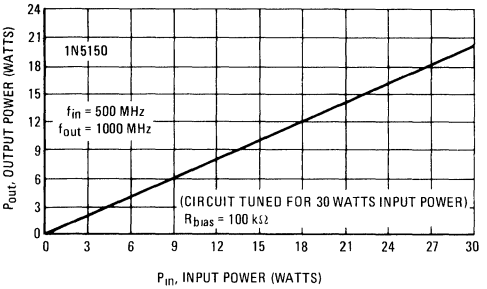
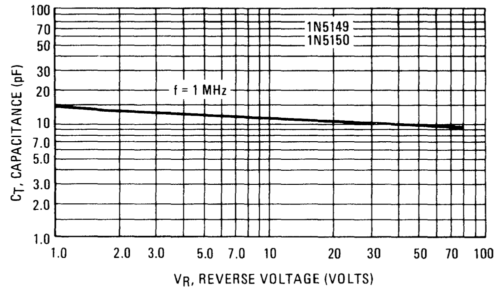


FIGURE 5 – CAPACITANCE versus REVERSE VOLTAGE



APPLICATION NOTE

VARACTOR CHARACTERISTICS

The 1N5149 and 1N5150 varactors are designed for RF power inputs up to 25 watts and 40 watts respectively. These devices exhibit high multiplication efficiency at output frequencies as low as 0.1 GHz and as high as 2.0 GHz. Power handling capability is stressed in device construction, but high efficiency is maintained with power inputs as low as 3 watts. At output frequencies below 600 MHz, where input power beyond the capability of these devices is needed, the 1N4386 and 1N4387 varactors are recommended.

The 1N5149 and 1N5150 power varactors are epitaxial-passivated, diffused-junction varactors with a unique impurity profile. The significance of the impurity profile is the enhancement of snap-off in the current waveform, due to the fast recovery of stored minority carriers after a forward-voltage surge. Dependence upon nonlinearity rather than capacity variation with reverse voltage results in high efficiency at high power levels and considerably less distortion of multiplied amplitude-modulated signals.

The approximate input and output impedances of the varactors, when operated as doublers, triplers (with idler), and quadruplers (with idler), are predicted from the formulas below. These equations are based on computer-determined approximations and tables.[1]

Doubler (High Level Drive)

$$R_{in} \approx \frac{42}{C_{-6}f_{in}} \qquad C_{eff\,in} \approx \frac{C_{min}}{0.5}$$

$$R_{out} \approx \frac{41.5}{C_{-6}f_{in}} \qquad C_{eff\,out} \approx \frac{C_{min}}{0.5}$$

where: R_{in} = the input resistance in ohms
C_{-6} = varactor capacitance in pF at −6 volts
f_{in} = input frequency in GHz
R_{out} = output resistance in ohms
$C_{eff\,in}$ = effective input capacitance in pF
$C_{eff\,out}$ = effective output capacitance in pF
C_{min} = capacitance at voltage breakdown, in pF

Tripler (High Level Drive)

$$R_{in} \approx \frac{55}{C_{-6}f_{in}} \qquad C_{eff\,in} \approx \frac{C_{min}}{0.5}$$

$$R_{out} \approx \frac{20}{C_{-6}f_{in}} \qquad C_{eff\,out} \approx \frac{C_{min}}{0.5}$$

Quadrupler (High Level Drive)

$$R_{in} \approx \frac{55}{C_{-6}f_{in}} \qquad C_{eff\,in} \approx \frac{C_{min}}{0.5}$$

$$R_{out} \approx \frac{20}{C_{-6}f_{in}} \qquad C_{eff\,out} \approx \frac{C_{min}}{0.5}$$

These formulas show values useful for initial circuit design, but they differ from final optimum values in some cases.

GENERAL DESIGN CONSIDERATIONS

In the design of varactor harmonic multipliers, lumped-circuit techniques are useful to the 450-600 MHz range with little performance degradation, provided coil and capacitor unloaded "Q" values of 200 to 300 are maintained.

Coaxial, stripline, or helical-coil resonators are recommended for higher frequencies. Both cavity and broadband filters can be used. Component values are not critical, but excessive inductance or insufficient coupling can reduce efficiency, and insufficient inductance or excessive coupling can cause poor filtering. Simple experimentation with well-constructed, shielded breadboards is generally sufficient to optimize the circuit. An adequate tuning range must be provided to insure input matching over normal varactor parameter variations. Spurious signals between stages should be kept below 30 dB by suitable filter circuits.

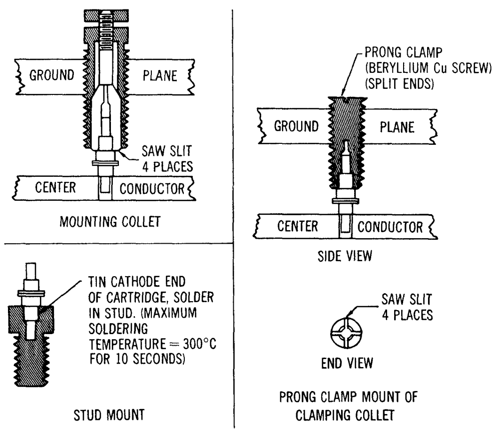
Bias resistors in 500 kohm range give optimum efficiency under self bias. For a linear input-power to output-power relationship, a lower-value bias resistor should be used (approximately 80 kohms). Amplitude-modulated signals can be linearly multiplied with negligible distortion at power-input levels to 30 watts. Figure 4 shows the linearity of the power-output versus power-input relationship without circuit retuning.

For frequency multiplication other than doubling, idler circuits should be used for best efficiencies. One-step, high-order frequency multiplications are possible because of the step-recovery characteristics of these varactors.

VARACTOR MOUNTING

The 1N5149 and 1N5150 varactors are in the cartridge package (designated by the suffix C). This package is well suited for both shunt and series-mounted varactor circuits. Figure 6 shows cross-sectional views of typical mountings. These mountings combine high power-dissipation characteristics with low parasitic impedance.

FIGURE 6 – SUGGESTED MOUNTINGS



[1]C. B. Burckhardt, "Analysis of Varactor Frequency Multipliers for Arbitrary Capacitance Variation and Drive Level", THE BELL SYSTEM TECHNICAL JOURNAL, April, 1965, pp 675-692.