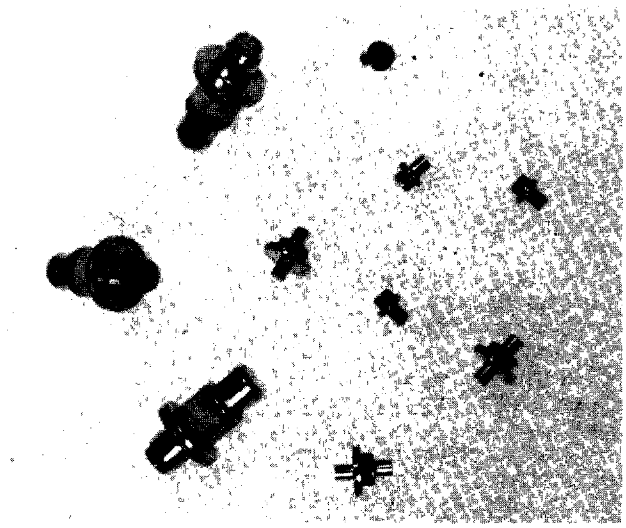
GaAs Multiplier Diodes for Millimeter Waves

Features

- Efficient Multiplication to 94 GHz
- Millimeter Wave Packages
- High Reliability and Space Qualified



Description

Alpha offers a line of Gallium Arsenide multiplier varactors specifically designed for low order multiplication at high output frequencies. These varactors are diffused junction epitaxial devices (mesa structure). The circuit designer can take advantage of the diode's high capacitance swing to generate the needed harmonics in doubler and tripler circuits.

These diodes may be used to double, triple, or quadruple the frequency output of Gunn or FET oscillators to produce outputs from 20 GHz to 90 GHz. Alpha's Advanced Technology Group has successfully used them to fabricate millimeter wave phase shifters, modulators and upconverters as well as multiplier signal sources.

The diodes are offered in the 023 outline for application up to 35 GHz output, the 067 outline for application up to 60 GHz output (the 067 outline has the same interior dimensions as the 082 but has a cathode prong to permit good heat sinking), and the 290 outline which has been used in doubling to 94 GHz and tripling to 130 GHz.

Burn-In

A special variation of this diode family is the only space-qualified, high reliability varactor available today and is used on the ESA European satellite program.

All GaAs varactors are subjected to burn-in screening prior to final measurements: typical burn-in for $C_{JO} = 0.3$ pF is: 60 Hz, $I_P = 30$ mA, $V_P = 2.5$ V (50 ohm series resistor) at 100°C, 16 hours.

MTTF Determination

Alpha has added new oven equipment which is used to perform step-stress tests on various diodes. Properly designed test programs can be used to make a mean time to failure (MTTF) determination at normal application temperatures from step-stress testing measurements performed at higher temperatures.

The testing procedure consists of electrically stressing a sample quantity of diodes taken from a known lot at two elevated temperatures for a time period sufficient to produce 50% failures at each temperature. The failure rate (where "failure" carries a definition assigned by the investigator, a specific parameter, for instance, can be chosen and considered to have failed when it changes by some fixed percentage) obeys the equation of Ahrennius:

$$f = Fo(e^{-E/KT})$$

where f = failure rate at temperature T.
Fo = is a constant.
E = activation energy for the processes involved in the specific parameter change.
T = absolute temperature.
K = Boltzmann's constant.

The failure rate f, is 0.5/time period (required at the elevated temperature for 50% failure). The value of MTTF is 1/f. One can calculate E from a two temperature measurement of MTTF at high temperatures and calculate MTTF at another temperature.

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The advantage of using high temperatures for diode stressing is that failure can be caused to occur rapidly (in a week or less), so a rapid determination can be made. Alpha has recently completed testing GaAs varactor multiplier diodes using these high temperature ovens. The testing was carried out in the range 225°C to 290°C. The ovens are nitrogen gas flushed and are capable of reaching 325°C. Diode test blocks are specially constructed to withstand high temperatures:

1. Contact springs are a special stainless steel alloy so tension is retained at temperature.

2. Vespel insulation is used for mounting contact springs.

3. Surfaces used to contact the diodes are .005 inch gold discs which are eutectic alloyed to the spring and test block surfaces. These discs will withstand high temperatures better than thinner gold plating.

4. Electrical leads are woven glass insulated.

Tests performed on GaAs varactor multipliers at three temperatures show that log MTTF-vs-1/T data points are properly linear and that extrapolated MTTF at 125°C is 20 million hours (2283 years) for the particular electrical stress applied (60 Hz and 10ma peak current).

Environmental Capability

Thermal Shock .... -195.8°C to +100°C
Centrifuge .... 20,000 G
Gross Leak Test .... 10^{-5}-cc/sec
Fine Leak Test .... 10^{-8}-cc/sec
High Temperature Storage .... 200°C

Performance Data

Typical doubler performance is as follows:

Package	F_{out} (GHz)	P_{out} (mW)	%	C_{JO} (Typ.)	V_B
023-001 067-001 082-001	20	200	50	0.5	35
067-001 082-001 290-001	40	150	40	0.3	25
290-001	80	40	25	0.15	15

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Electrical Characteristics

Package Outline: 023-001

V_B(1)(min)	10 Volts				20 Volts			30 Volts		40 Volts	
C_{J0}(2)(pF)	0.3-0.35	0.3-0.45	0.3-0.6	0.6-1.0	0.3-0.45	0.45-0.6	0.6-1.0	0.3-0.6	0.6-1.0	0.3-0.6	0.6 1.0
P_T(3)(max)	200mW	250mW	250mW	300mW	250mW	300mW	350mW	300mW	400mW	350mW	400mW
F_{c-6}(4)(GHz)											
200			D5244-06	D5244-06		D5245-06	D5255-06	D5246-06	D5256-06	D5249-06	D5259-06
250			D5244-12	D5244-12		D5245-12	D5255-12	D5246-12	D5256-12	D5249-12	
300			D5244-18	D5244-18		D5245-18	D5255-18	D5246-18		D5249-18	
350			D5244-24			D5245-24		D5246-24		D5249-24	
400			D5244-30			D5245-30		D5246-30			
450		D5244-36			D5245-36						
500		D5244-42									
550	D5244-48										

Package Outline: 067-001

V_B(1)(min)	10 Volts				20 Volts			30 Volts		40 Volts	
C_{J0}(2)(pF)	0.3-0.35	0.3-0.45	0.30-.6	0.6-1.0	0.3-0.45	0.45-0.6	0.6-1.0	0.3-0.6	0.6-1.0	0.3-0.6	0.6 1.0
P_T(3)(max)	200mW	250mW	250Mw	300mW	250mW	300mW	350mW	300mW	400mW	350mW	400mW
F_{c-6}(4)(GHz)											
200			D5002-06	D5005-06		D5006-06	D5007-06	D5008-06	D5009-06	D5018-06	D5019-06
250			D5002-12	D5005-12		D5006-12	D5007-12	D5008-12	D5009-12	D5018-12	
300			D5002-18	D5005-18		D5006-18	D5007-18	D5008-18		D5018-18	
350			D5002-24			D5006-24		D5008-24		D5018-24	
400			D5002-30			D5006-30		D5008-30			
450		D5002-36			D5006-36						
500		D5002-42									
550	D5002-48										

Package Outline: 290-001

V_B(1)(min)	10 Volts			20 Volts			30 Volts		
C_{J0}(2)(pF)	0.1-0.2	0.2-0.3	0.3-0.6	0.1-0.2	0.2-0.3	0.3-0.6	0.1-0.2	0.2-0.3	0.3-0.6
P_T(3)(max)	150Mw	200mW	250mW	200mW	250mW	300mW	200mW	250mW	300mW
F_{c-6}(4)(GHz)									
400	DVF4559-01	DVF4559-05	DVF4559-11	DVF4559-21	DVF4559-25	DVF4559-31	DVF4559-41	DVF4559-44	DVF4559-51
450	DVF4559-02	DVF4559-06		DVF4559-22	DVF4559-26		DVF4559-42		
500	DVF4559-03	DVF4559-07		DVF4559-23			DVF4559-43		
550	DVF4559-04			DVF4559-24					

Notes:

1. Breakdown Voltage (V_B) is measured at 10 microamps reverse current.
2. Total Capacitance is measured at 1 MHz and 0 bias. Junction Capacitance (C_J) is calculated by subtracting the typical package capacitance from the total capacitance.
   Self resonant frequency may be calculated from Where L is the series inductance. $F_o = \frac{1}{2\pi\sqrt{LC_J}}$
   Series resistance may be calculated from $R_S = \frac{1}{2\pi F_c C_J}$
3. P_T(max) is maximum dissipated power at room temperature for the average capacitance range. At maximum dissipated power, junction temperature is 175°C.
4. Frequency Cutoff (F_c) of the diodes is measured by the Houlding technique. Deloach measurements are available and are utilized for characterizing low capacitance diodes. See GaAs Parametric Amplifier Varactor data sheet for Technical Note on Frequency Cutoff Measurement.