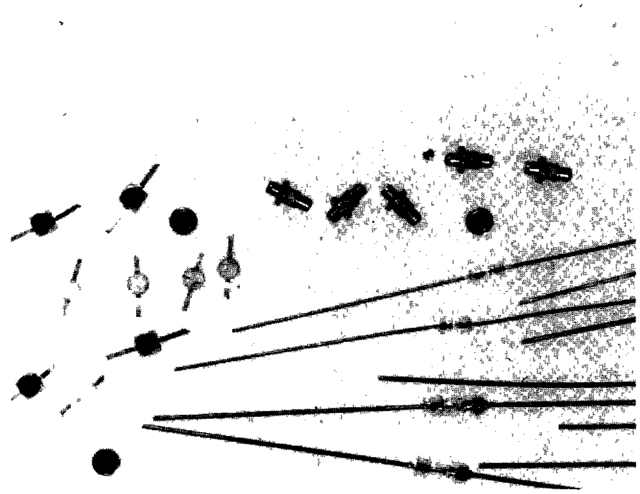
Low Power PIN Switching and Attenuator Diodes

Features

- Optimized for Each Type of Application
- Low Lifetime, Low Resistance for Small Current Drain Switches
- Longer Lifetime, Low Resistance for Medium Power
- Low Lifetime, High Resistance for Attenuators and Modulators
- Long Lifetime for Very Low Frequency Attenuators and Switches



Description

These diodes are supplied in chip or packaged form for all types of low-loss applications in stripline, microstrip, coaxial, and waveguide circuits. They are silicon oxide-passivated for highest reliability and are also available in hermetically sealed metal-ceramic and glass packages for use in extreme environmental conditions.

Diode Types

There are four basic types of RF switching applications, and Alpha offers diodes optimized for each type. In all of the products, control of doping profile assures low loss even at zero bias. Diodes with either PIN or NIP polarity are generally available in all types upon request.

Fast Switching: Diodes for these applications have thin I-regions and low lifetime. Switching speed is under 5 ns, and the diodes have low series resistance at low bias current, offering a steep isolation versus bias characteristic. Suitable for 0.1 to 26 GHz at low power.

Slower Switching: These diodes have moderately thick I-regions and longer lifetime. They also have a steep isolation curve, but switch in 20 to 100 ns and can be used with low distortion at power levels to +30 dBm.

High Speed Modulators and Attenuators: These are low lifetime, thick I-region diodes with gradual isolation curves, making them more suitable for continuously variable attenuators. Low lifetime makes them ideal for switches or attenuators with high modulation rates.

Low Frequency Attenuators and Switches: For these applications, Alpha has developed thick I- region, long lifetime diodes. Minority carrier lifetime to 10 microseconds makes them suitable down to 100 MHz. They are also suitable for higher power applications.

Applications

The table of specifications lists the microwave characteristics of the basic semiconductor chips. The circuit designer may use these data, with the package parasitic characteristics, in modeling the diode in the particular circuit environment. "PIN Diode Basics" are presented in Application Note 80200 at the end of this section.

Diode Design Trade-Offs

Diode Design Rates	Fast Switching or High Modulation Rates	Low Capacitance	Low Forward Loss	Low Reverse Loss	Low Thermal Impedance	High Power
Lifetime	Low	-	High	-	-	High
I Layer Width	Thin	Thick	Thin	-	Thick	Thick

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The measurement of diode loss (R_p) and series resistance (R_s) can be made on both packaged diodes (the diode is used as the terminating impedance on a 50 ohm slotted line) and on chips (in microstrip circuitry). If you buy packaged diodes, the parameters will be 100 percent tested; if you buy chips, the voltage breakdown and junction capacitance will be 100 percent tested. The microwave parameters will be determined from a sample evaluation from each wafer, packaged. Wafer identity and evaluation sample data can be provided. It is easy to describe and explain PIN chip performance in microstrip MIC and the following deals with such circuits.

By incorporating the chip and the required bonding wire into the transmission line, rather than as shunt elements onto the line, parasitic inductance is almost totally eliminated, and multi-octave performance is achieved.

Consider Figure 1 which shows three chips mounted in a 50 ohm microstrip line. The bonding wires are selected, length and size, in conjunction with the capacitance of the chip to form a low-pass L-C filter section. The characteristic impedance of this section approximates 50 ohms and the electrical length (phase shift) is low enough to provide better than 1.5 VSWR through 18 GHz. Figure 2 shows typical VSWR curves for single diode sections with different chip capacitance values. Chip spacing L_1 and L_2 are varied to provide broadband matching and isolation characteristics and are typically 0.1 wavelength at X-band. Figure 3 shows isolation as a function of diode spacing for a pair of PIN chips.

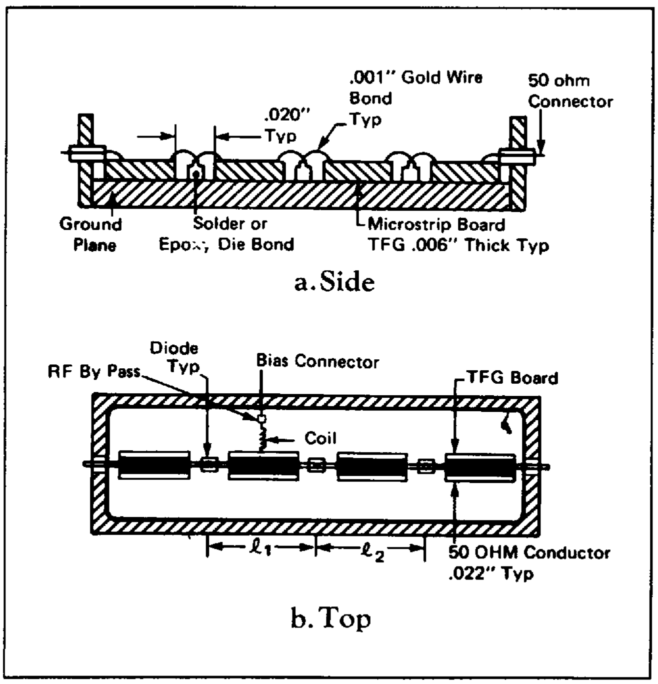

Figure 1. Typical Microstrip Design

Series resistance and isolation for single chips, in a SPST configuration, are shown in Figure 4. Diode insertion loss is caused by a complex dielectric constant and is minimized by optimum control of I-region resistivity and profile. It is characterized as a shunt (parallel) resistance, Rp, which is tabulated for each diode type. This loss is maximum at zero bias. For thicker I-regions, loss can be reduced significantly by application of reverse bias of a few volts. Figure 5 presents Rp data on a few of the diodes. The tabulated data on each type at 3 GHz and zero bias, can be used together with Figure 5 to estimate small signal loss for any diode under various conditions.

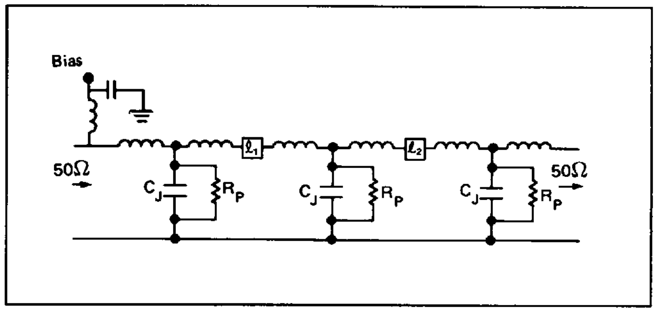

Figure 1b. Zero or Reverse Bias Equivalent Circuit

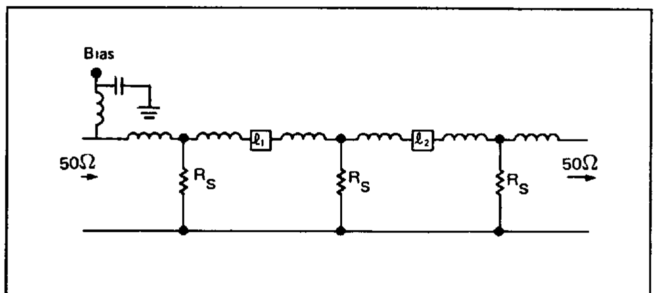

Figure 1c. Forward Bias Equivalent Circuit

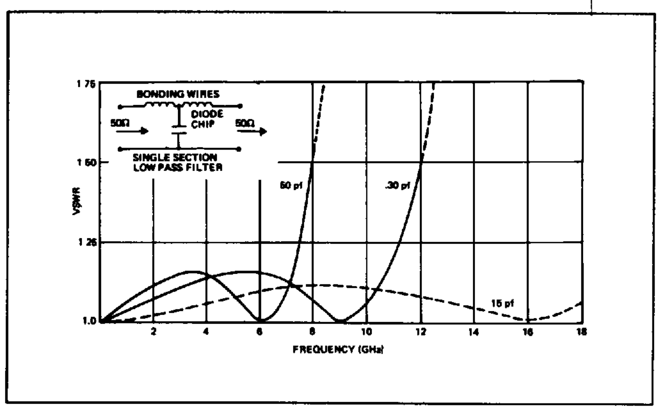

Figure 2. Typical VSWR for Low Pass Filters

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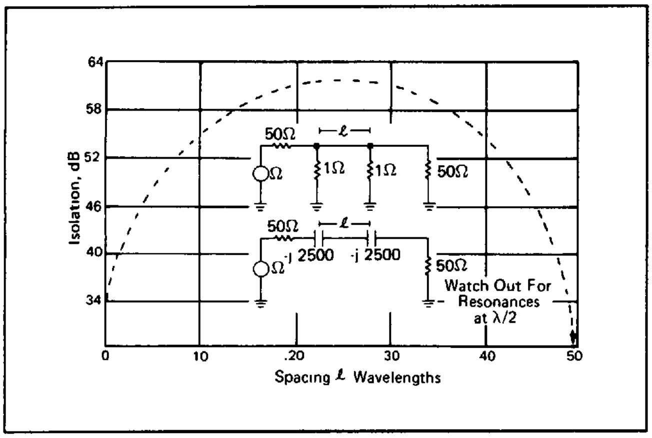

Figure 3. Isolation as a Function of PIN Diode Spacing

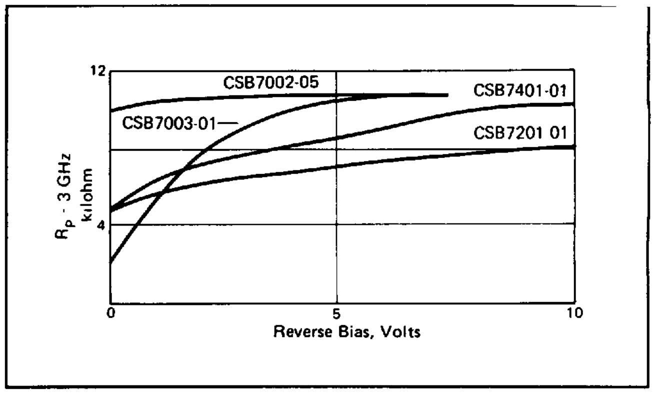

Figure 5. Parallel Resistance vs. Bias

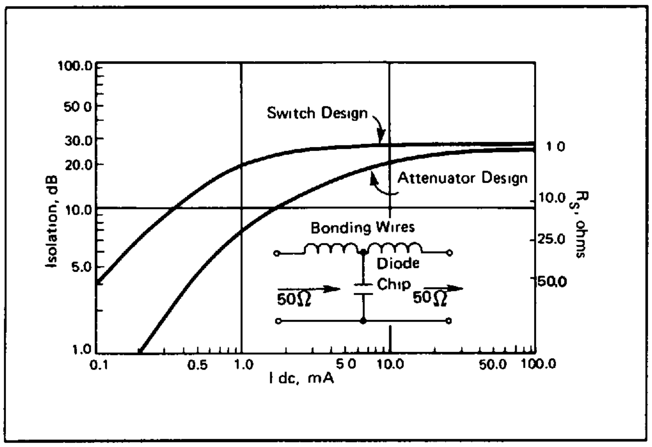

Figure 4. General Curves of Isolation and R_s vs. Bias for Attenuator and Switch Designs.

Recommended Chip Style

Model Number	Chip Style
CSB7002-01	150-801
CSB7002-02	150-801
CSB7002-03	150-801
CSB7002-04	150-802
CSB7002-05	150-806
CSB7002-06	150-801
CSB7002-07	150-801
CSB7003-01	150-801
CSB7003-02	150-801
CSB7003-03	150-801
CSB7003-04	150-802
CSB7401-01	149-801
CSB7401-02	149-801
CSB7401-03	149-802
CSB7201-01	149-802
CSB7201-02	149-802
CSB7201-03	149-802

Other chip styles may be available upon request.

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Specifications

The diodes listed are representative of a standard product line. Diodes with different or more stringent specifications are available on request. In particular, the variation of series resistance with current can be tailored to meet almost any need. To assist the circuit designer, some of the trade-offs involved in switching diode design are listed on page 3-31.

Table 1.

RF Applications	Model Number	Min[1] V_b (Volts)	C_{J50}[2]	Max[3] R_{100mA} (ohms)	Typ[3] R_{1mA} (ohms)	T_s[4] Typ (ns)	T_L[5] Typ (ns)	R_P[6] Typ (k ohms)	θcw[7] (Typ)
Fast Switching	CSB7002-01	80	.03-.08	1.8	8.0	5	50	3.0	80
	CSB7002-02	80	.08-.13	1.5	2.5	5	80	1.5	60
	CSB7002-03	80	.13-.23	1.2	2.5	5	80	1.5	40
	CSB7002-04	80	.23-.33	1.0	2.0	5	100	1.0	40
Lowest Loss	CSB7002-05	25	.03-.08*	1.5	3.0	5	20	10	100
	CSB7002-06	25	.08-.13*	1.2	2.5	5	20	10	80
	CSB7002-07	25	.13-.23*	1.2	2.5	5	20	10	60
Slower Switching	CSB7003-01	100	.03-.08	1.5	2.5	20	150	2	80
	CSB7003-02	100	.08-.13	1.2	2.5	20	200	2	60
	CSB7003-03	100	.13-.23	0.9	2.5	20	250	2	40
	CSB7003-04	100	.23-.33	0.8	2.5	20	300	1	40
High Speed Attenuator	CSB7401-01	100	.10 max	1.4	15	5	50	5	80
	CSB7401-02	100	.10-.15	1.2	10	5	80	5	60
	CSB7401-03	100	.15-.25	1.0	10	5	100	5	50
Low Frequency Attenuator	CSB7201-01	200	.10 max	1.4	50	20	750	3	50
	CSB7201-02	200	.20 max	1.2	30	20	800	3	40
	CSB7201-03	200	.50 max	0.7	20	-	1000	2	30

Ordering Information

Add six-digit package or chip style designation to model number. **EXAMPLE:** CSB7002-01-023-001

Notes:

1. V_b is measured at 10μA
2. C_j is measured at 1 MHz at -50V bias; * - 6 Volts.
3. R_s is measured at 500 MHz.
4. T_s is the RF switching time from 90% to 10% and 10% to 90% transmission. The bias conditions are +10 mA/-10 Volts.
5. T_L is the minority carrier lifetime measured with I_f = 10 mA, I_r = 6 mA, recovering to -3 mA.
6. Diode dissipative loss can be represented as a shunt resistance across the junction capacitance. Data presented for 3.0 GHz, zero bias.
7. Typical cw thermal impedance in package 023-001.
8. Some of these parts are available in NIP polarity.