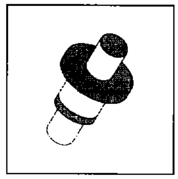
Alpha

Limiter Diodes

CLA3131, CLA3132, CLA3133, CLA3134, CLA3135 Series

Features

- Low Loss
- 4 kW Coarse Limiters
- 200 Watt Midrange Limiters
- 10 mW Clean–Up Limiters



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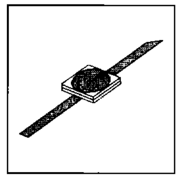

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Description

Alpha has pioneered the microwave limiter diode. Because all phases of manufacturing, from design through epitaxy to the finished device, are specifically tailored to this application, Alpha limiters have lower loss, greater bandwidth and faster turn–on time than equivalent competitive diodes.

Alpha's series of thin base limiter diodes will provide passive receiver protection over the entire range of frequencies from 100 MHz to beyond 30 GHz.

These diodes are PIN silicon devices with a thin intrinsic region, typically 2 microns for the CLA3131 and 3134, 4 microns for the CLA3132 and 3135, and 15 microns for the CLA3133 series. They operate as a power dependent variable resistance, through mechanisms of charge injection and storage, similar to rectification, when used in microwave circuitry as shown in Figure 1. The different "I" region thicknesses and capacitances provide variable threshold and leakage power levels and power handling capability. The CLA3133 series, which can handle incident pulses of up to 4 kW for 1 ms, are used as "coarse" prelimiters, with the thinner diodes used as clean–up or "fine" limiters to reduce the leakage power to as low as 10 mW for protecting the most sensitive receivers.

Chip Dimensions

Model Number	DOT Diameter (Typ.)		Suggested Chip Style
	Inches	mm	
CLA3131–01	0.0015	0.04	149–801
CLA3131–02	0.0025	0.06	149–801
CLA3131–03	0.0035	0.09	149–801
CLA3132–01	0.002	0.05	149–801
CLA3132–02	0.003	0.75	149–801
CLA3132–03	0.0045	0.11	149–801
CLA3133–01	0.003	0.75	149–801
CLA3133–02	0.004	0.10	149–801
CLA3133–03	0.005	0.12	149–801
CLA3134–01	0.0012	0.02	150–806
CLA3134–02	0.0015	0.04	150–806
CLA3135–01	0.0015	0.04	150–806
CLA3135–02	0.0025	0.06	150–801

At receive signal levels these diodes behave at low capacitances even at zero bias. Loss of 0.3 dB at 18 GHz is typical.

In addition to the passive operation as shown in Figure 1, the diodes can be used as quasi–active limiters (Figure 2), with a schottky barrier detector diode providing DC current to the PIN, and as active PIN switches for STC modes (see Figure 3), while simultaneously providing the passive limiting mode.

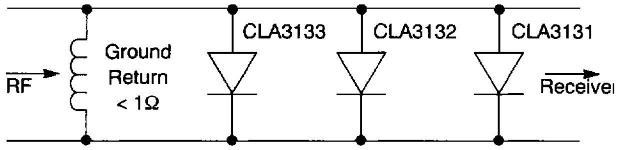

Figure 1. Cascaded Limiter Design

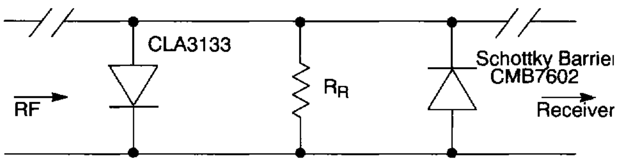

Figure 2. Quasi–Active Limiter

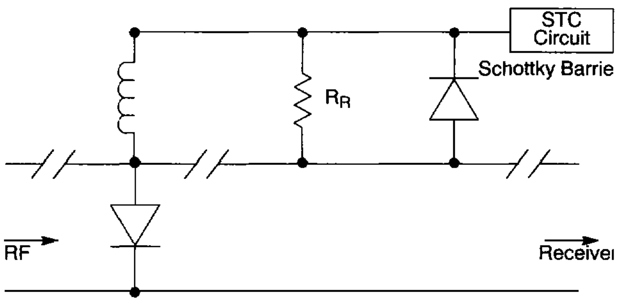

Figure 3. Limiter/STC Dual Function

The CLA3131 and 3132 limiter diodes are constructed in a passivated flat–chip configuration and are available in a basic chip form or encapsulated in a variety of Alpha glass or ceramic packages, a few of which are shown.

Limiter diodes with lower capacitance values, to 0.08 pF, constructed with a passivated mesa configuration, are available in the CLA3134 and 3135 series. The mesa devices offer low C_J, and therefore broader bandwidth, lower loss, and faster response, at reduced power. These diodes are also available in chip package form, and represent the ultimate in limiter performance, not approached by other manufacturers. The CLA3133 diodes (highest power) are available in both planar and mesa construction.

Figures 4 and 5 illustrate the fundamental structures of diodes mounted in a 50 ohm microstrip circuit. The diode characteristics listed in the table refer to chips mounted in such a circuit. The designer can use these parameters in modeling the chip in any package, provided overall package parasitics are considered. Additional bonding and handling methods are contained in Alpha application notes.

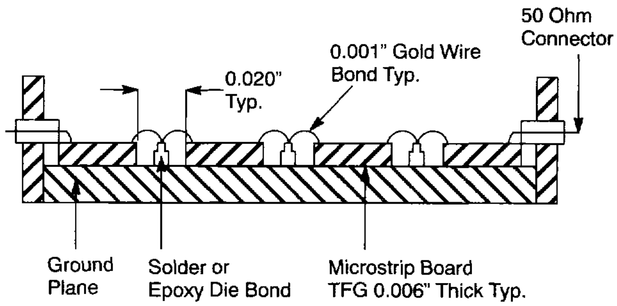

Figure 4. Side View

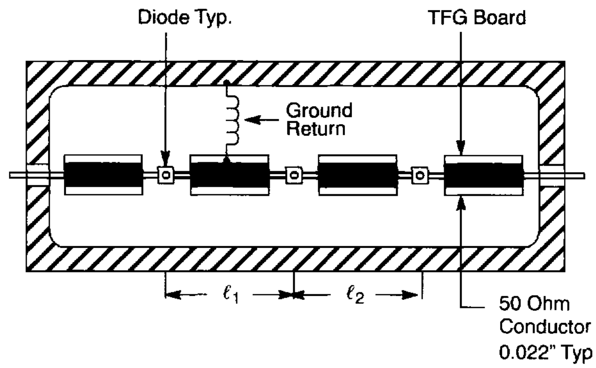

Figure 5. Top View

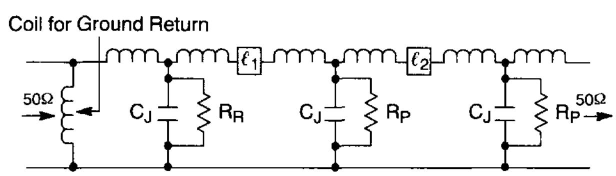

Figure 6. Low Level Equivalent Circuit

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Basic Application

When designing microstrip limiters the bonding wire length and diameter, in conjunction with the chip capacitance, form a low pass filter (see Figure 8). Line lengths of (L_1, and L_2) are varied to provide broadband matching and flat leakage characteristics. Typically, L_1 and L_2 are on the order of 0.1 wavelength. In Figure 1, the CLA3133 chip provides about 20 dB attenuation, reducing a 1 kW input to 10 watts. The CLA3132 reduces this to 100 mW and the CLA3131 to about 20 mW.

During the rise time of the incident pulse, the diodes behave in the following manner. The CLA3131, due to its thin "I" region, is the first to change to a low impedance. Experiments indicate that the CLA3131 reaches the 10 dB isolation point in about 1 ns and 20 dB in 1.5 ns with an incident power of 10 watts. The CLA3132 takes about 4 ns and the CLA3133 about 50 ns. Consequently, the CLA3131 provides protection during the initial stages of pulse rise time, with the thicker diodes progressively "turning on" as the power increases. With proper spacing (L_1 and L_2), the "on" diodes reflect high impedances to the upstream diodes, reducing the turn–on time for those diodes and ensuring that essentially all of the incident power is reflected by the input diode, preventing burnout of the thinner diodes. At the end of the pulse the process reverses, and the diodes "recover" to the high impedance state; the free charge which was injected in the "I" region by the incident power leaks off through the ground return and additionally is reduced by internal combination. With a ground return, recovery time is on the order of 50 ns. With a high impedance return, for example the circuit of Figure 2, the schottky diodes recovers or 1 "opens" in practically zero time, and internal recombination, on the order of several diode lifetimes, is the only available mechanism for recovery. This recovery time can be long–on the order of 1 μs for the CLA3133 series. The shunt resistor R_r minimizes the problem. One hundred ohms will approximately double the recovery time, compared to a short circuit.

When the schottky diode is directly coupled to the transmission line, in cascade after the coarse limiter, the leakage power will be less than if a zero ohm ground return were used. If the schottky is decoupled too much, the leakage power increases, owing to the high DC impedance of a schottky. Similarly, a 3.0 ohm ground return causes an increase of about 3 dB in leakage power compared to a zero ohm return.

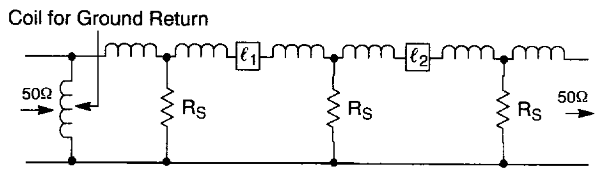

Figure 7. High Power Equivalent Circuit

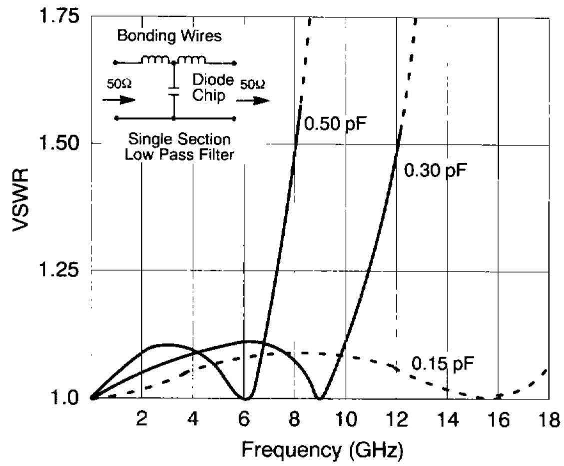

Figure 8. Typical VSWR for Low Pass Filters

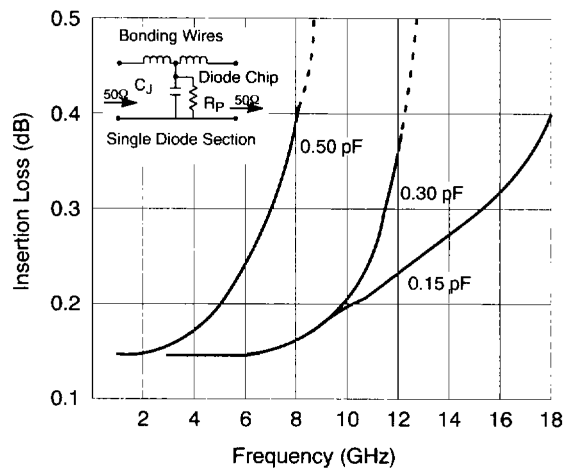

Figure 9. Typical Diode Insertion Loss vs. Frequency

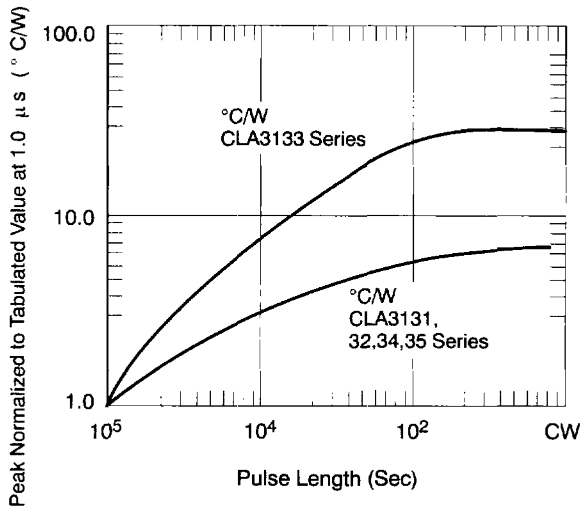

Figure 10. Pulsed Thermal Impedance

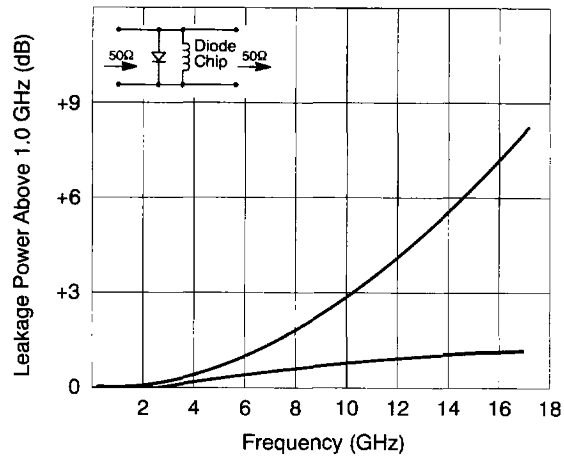

Figure 12. Leakage Power vs. Frequency

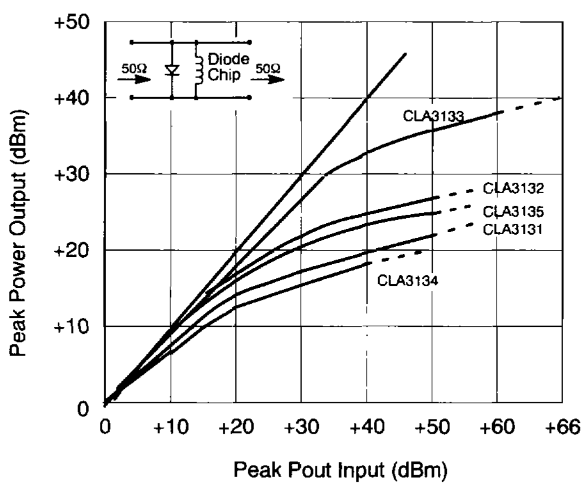

Figure 11. Typical Peak Leakage Power at 1 GHz

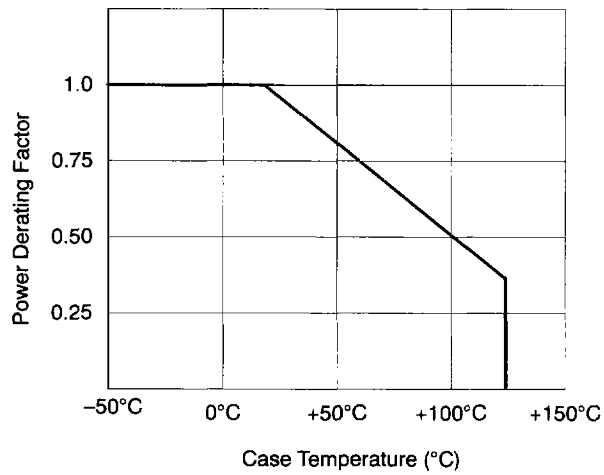

Figure 13. Power Handling Capability vs. Temperature

Ordering Information

The table on the following page shows the part numbers for chip limiter diodes.

Packaged limiter diodes may be specified by adding the package number to the chip number. For example, CLA3131–01–023–001 is the CLA3131–01 in the 023–001 package.

The recommended packages for limiter diodes are shown on page 6–10.

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Electrical Specifications

Part Number	V_B (V)	C_{JO} (pF)	C_{J6} (pF)	R Typical		R_P[2] (Ω)	$Θ_P$[3] (°C/W)	$Θ_{CW}$ (°C/W)	T_L (ns)
	typ	typ	max	@10 mA (Ω)	@1.0 mA (Ω)	typ	typ		typ
CLA3131–01	20–45	0.20	0.15	1.5	5.0	2000	10	100	5
CLA3131–02		0.50	0.30	1.2	4.5	1000	6	80	10
CLA3131–03		0.70	0.50	1.0	4.0	1000	5	55	10
CLA3132–01	45–75	0.20	0.15	1.5	4.0	2000	7	80	10
CLA3132–02		0.50	0.30	1.2	3.5	1000	5	60	15
CLA3132–03		0.70	0.50	1.0	3.0	1000	3	40	20
CLA3133–01	120–180	0.20	0.15*	1.5	3.5	2000	1.2	40	50
CLA3133–02		0.60	0.30*	1.0	3.0	1000	0.5	20	50
CLA3133–03		0.80	0.50*	0.5	3.0	1000	0.3	15	100
CLA3134–01	15–30	0.12	0.10	2.0	4.0	3000	15	120	5
CLA3134–02		0.20	0.15	1.5	3.0	2000	10	80	5
CLA3135–01	30–60	0.12	0.15	2.0	4.0	3000	10	100	7
CLA3135–02		0.20	0.15	1.5	4.0	2000	7	70	7

* –50 Volts

Typical Performance

Part Number	Peak Pin @ 1.0 µsec (dBm)	Threshold[4] (dBm)	Leakage[4] P_{OUT} (dBm)	Insertion Loss[2] (dBm)	CS[5] Power In (W)	Recovery[6] Time, (ns)
	max	typ	typ	typ	max	typ
CLA3131–01	+50	+10	+22	0.1	2	10
CLA3131–02	+53	+10	+24	0.2	3	10
CLA3131–03	+56	+10	+25	0.2	4	10
CLA3132–01	+53	+15	+27	0.1	3	20
CLA3132–02	+56	+15	+29	0.2	4	20
CLA3132–03	+59	+15	+31	0.2	5	20
CLA3133–01	+60	+20	+39	0.1	6	50
CLA3133–02	+63	+20	+41	0.2	10	50
CLA3133–03	+66	+20	+44	0.2	15	100
CLA3134–01	+47	+7	+21	0.1	2	5
CLA3134–02	+50	+7	+24	0.1	3	5
CLA3135–01	+47	+12	+24	0.1	3	10
CLA3135–02	+50	+12	+27	0.1	4	10

1. Series resistance is measured at 500 MHz.
2. Chip loss can be represented as a resistance in shunt with the junction capacitance. R_P is measured at 3 GHz, zero Bias. Figure 9 indicates typical variation with frequency. Loss data shown are for 10 GHz for 0.15 and 0.30 pF chips, 5 GHz for 0.50 pF chips. Reflective loss is shown in Figure 8 and is included. Loss is measured at –10 dBm input.
3. Pulsed thermal impedance is given for a 1 µs pulse. Figure 10 shows typical variation for longer pulse lengths. CW thermal impedance presumes infinite heat sink.
4. Threshold input power produces 1 dB increase in insertion loss. Figure 11 shows typical leakage power curves. Data taken for 1.0 GHz. Figure 12 shows typical variation with frequency. Note especially the roll–off of CLA3133 at higher frequency.
5. Note that CW power and average power are not synonymous. Power ratings are computed in terms of a peak junction temperature of 200°C, for short pulses, an average junction temperature of 125°C, and an ambient of 25°C. Duty factor 0.001 assumed for maximum pulse power input. Figure 13 shows power derating with temperature.
6. Recovery time is measured with ground return (less than 1.0 ohm) to 1 dB excess loss, at 1 GHz.
7. Limiter diodes with higher capacitance and/or higher breakdown voltage for very high power applications are available on request.

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