APPLICATION NOTE

LZY-1

ULTRA-LINEAR RF AMPLIFIER

20 MHz - 512 MHz
25 WATTS MIN., 1 dB COMPRESSION
(50 WATTS TYP., MAX. OUTPUT)

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LZY-1

1.0 GENERAL DESCRIPTION

The LZY-1 is a low cost, rugged, versatile, 43 dB Typ. gain, broadband, Class A Linear RF Power Amplifier Module designed to operate linearly over the 20 MHz to 512 MHz frequency band. The LZY-1 features low compression and low harmonic distortion at 25 watts, which make it ideally suited to a wide variety of applications.

The conservative electrical and thermal design and careful attention to semiconductor ratings insures continued years of service in both the laboratory and many commercial and semi-hostile military environments.

The workmanship, quality, and attention to protective features along with selection of components to COTS (commercial off-the-shelf) guidelines, further enhance applicability and long MTTF.

The unit electrical performance is specified at +26 VDC but will operate without damage over the +22 VDC to +30 VDC range.

The LZY-1 is supplied with its own high thermal efficiency heat sink and ball bearing cooling fan for immediate use and reliable operation.

For applications where the heat sink / fan assembly presents a difficult physical fit, the RF linear amplifier module may be removed and operated safely with alternative heat sink / cooling methods if the guidelines in paragraph 7.0 are followed. Operation of the amplifier module without proper heat sinking is not recommended and violates the warranty.

Protective features such as Input Overdrive, Reverse Polarity, Transient Protection and Thermal Overload with automatic reset are included. A separate shut-off terminal is provided for remote amplifier on/off control.

The LZY-1 was designed to satisfy a range of broad, and narrow-band multitone or single frequency applications for original equipment, production test and laboratory equipment uses.

2.0 ELECTRICAL PERFORMANCE SPECIFICATIONS

The Electrical Performance Specifications and limits are listed in Table 1.

Typical broadband small and large signal gain and return loss responses are shown in Figures 1 and 2.

Comparison of the curves and gain data at the measurement points illustrates the dynamic linearity of the LZY-1 across the frequency range.

Electrical Performance Specifications and Limits for LZY-1

MODEL NO.	FREQ. MHz f_L f_U	GAIN, dB Min.	GAIN, dB Flatness Max.	POWER, dBm Min. Output (1 dB Comp.)	POWER, dBm Max. Output (Typ.)	POWER, dBm Max. Input (no damage)	DYNAMIC RANGE NF dB Typ.	DYNAMIC RANGE IP3 dBm Typ.	INPUT VSWR In	DC POWER Volt V.	DC POWER Max Current (A)	Case Style Note B	CONNECTION	Price $ Qty (1-9)
LZY-1	20 - 512	39	±1.5	+44	+47	+10	8.6*	54	2.0:1	+26	7.3**	BT412	--	1995.00

features

- saturated power 50W typ.
- high power with low distortion, -32 dBc typ. harmonics at 20 watts
- wide bandwidth, 20 - 512 MHz, useful 10 - 525 MHz
- high gain, 42 dB typ.
- unconditionally stable
- self protected against excessive drive, high case temp., reverse polarity and shorting/ unshorting transients at dc input
- electronic shutoff by grounding the shut-off terminal, reduces output by 50 dB. Open circuiting terminal restores full power
- cool operation with integral fan, 15° C typ. rise
- graceful degradation, +20 to +30V DC

NOTES:
* 80-512 MHz, at 20 MHz 11.6 dB typ.
** At 25W output; includes fan
1. Absolute max. dc voltage: +30V
2. Operating air-ambient temp. for specified performance: -10°C to 50°C
3. Max. storage temp.: -55°C to 100°C
C. Prices and specifications subject to change without notice.

Table 1: Electrical Specifications, -10°C to +50°C Ambient Temperature

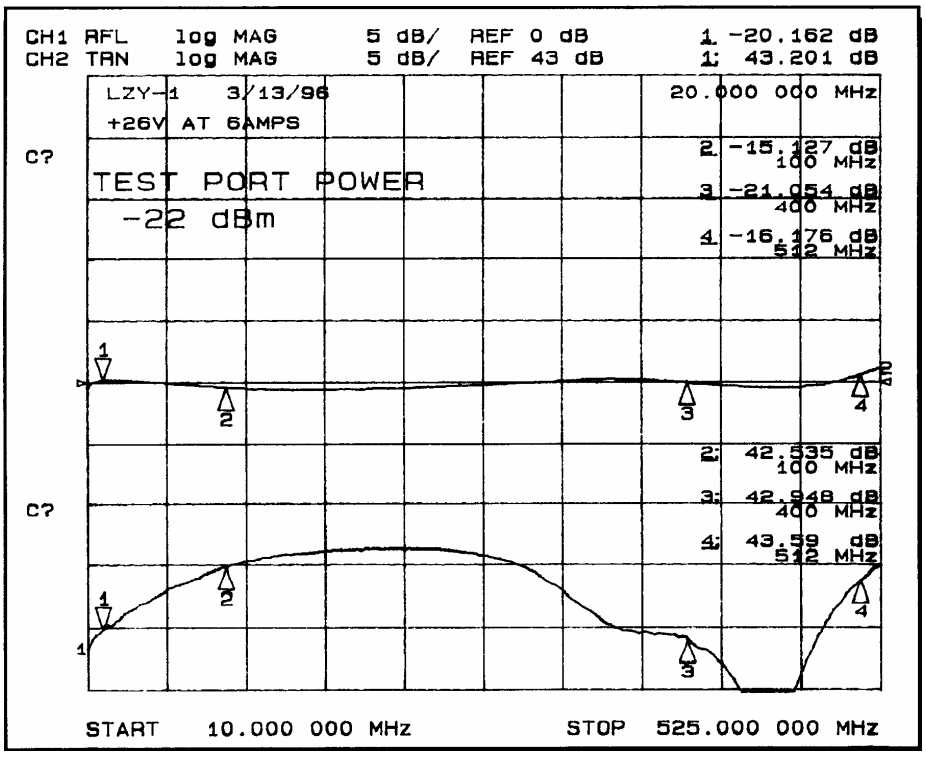


Figure a: Small Signal Response @ -22 dBm P_{IN}

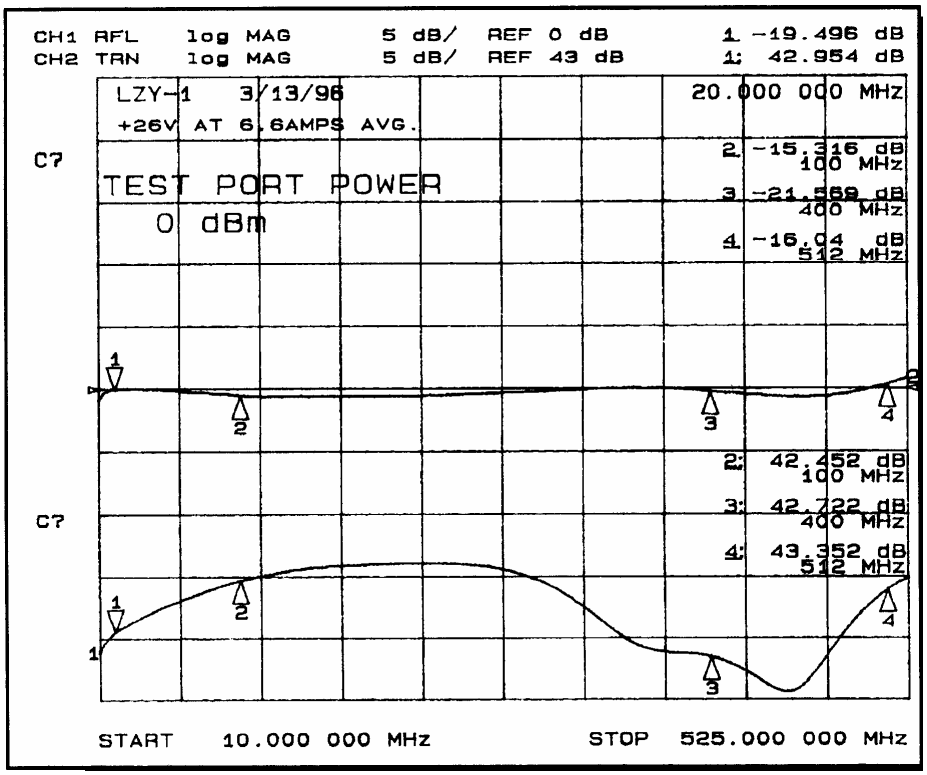


Figure 2: Large Signal Response @ 0 dBm P_{IN}

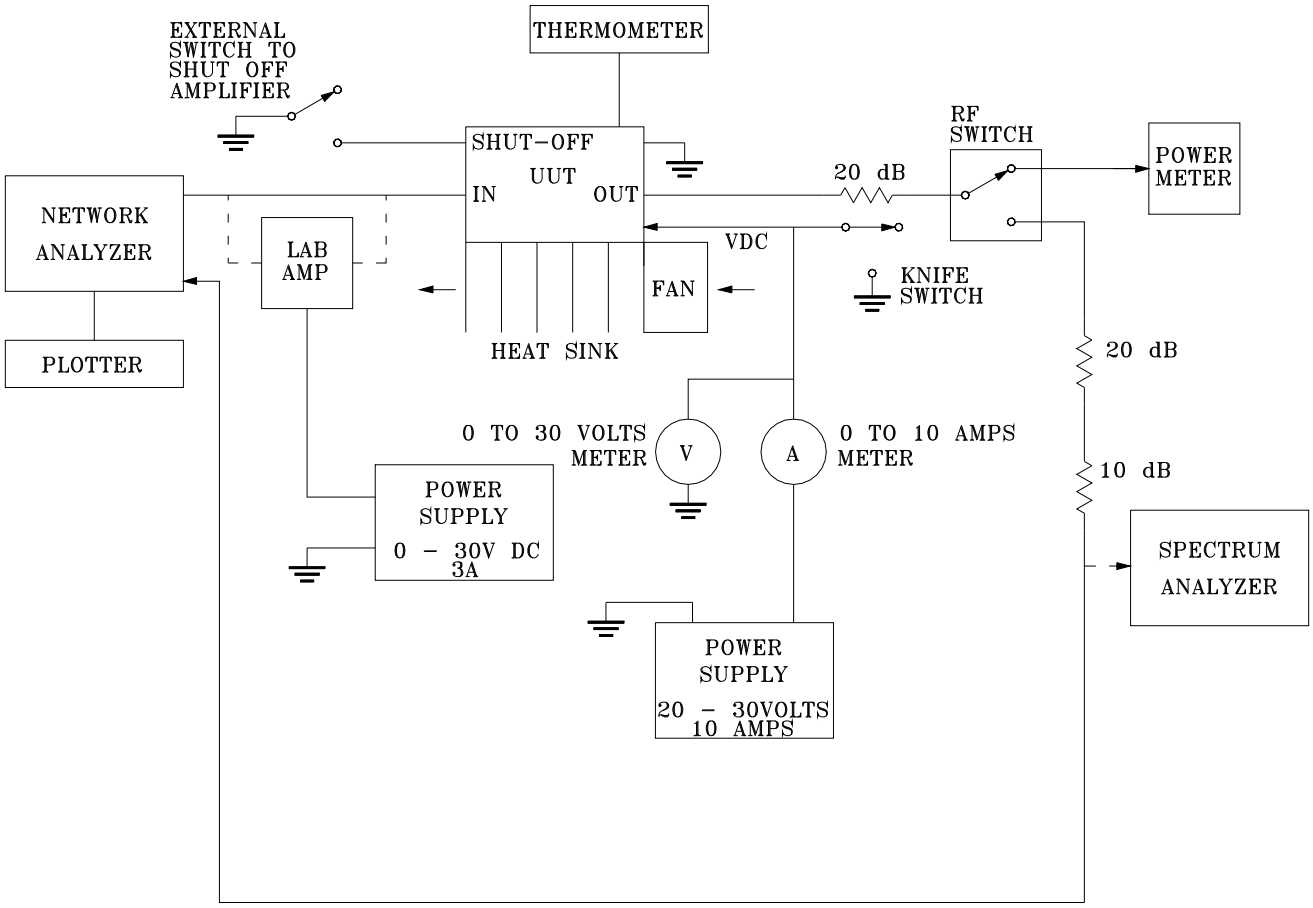


Figure 3: Acceptance Test Procedure Test Setup

3.0 MECHANICAL SPECIFICATIONS

The mechanical outline drawing, mechanical specifications and heat sink mounting details are shown in Figure 4.

4.0 ELECTRICAL FEATURES

4.1 OVERDRIVE PROTECTION

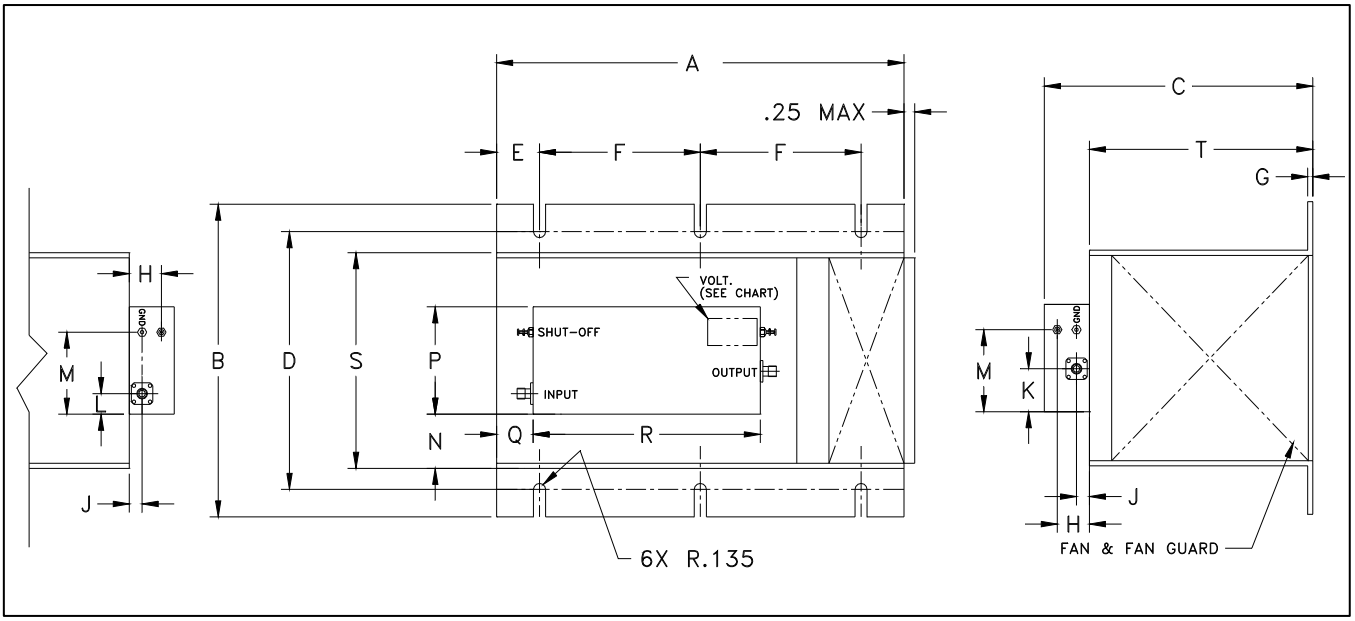
The LZY-1 is designed to operate with input drive levels up to +10 dBm without damage at any frequency in the 20 MHz to 512 MHz range.
The unit contains a factory set control for automatic power output foldback to protect internal components from RF input overdrive damage.

Foldback action takes place when the input drive level causes the output power to exceed a threshold. This threshold can vary from 55 watts to 125 watts depending on the input signal frequency. No damage will occur to the amplifier under any of these output power levels.

At threshold, the output power begins to drop. As input drive level is increased, the output power turns down to a low level, safeguarding the amplifier components.

At input drive levels below the threshold, the overdrive protection circuit is inactive and does not affect amplifier performance. The unit will perform within the limits of the specifications of Table 1.

Mechanical Outline Drawing & Dimensions



Case No.		A	B	C	D	E	F	G	H	J	K	L	M	N	P	Q	R	S	T	wt. grams.	NOTES
BT412	inch	9.50	7.3	6.3	6.00	1.00	3.75	.13	.75	.30	1.00	.48	1.91	1.3	2.50	.9	5.30	5.1	5.2	4000	A8, D17
	mm	241.30	185.42	160.00	152.40	25.40	95.25	3.30	19.05	7.62	25.40	12.18	48.51	33.02	63.50	22.86	134.62	129.54	132.08		

A8. Case material: aluminum alloy. Finish: case irridite. Heat sink: black anodize.
D17. Connectors: Female SMA only.

Figure 4 – Mechanical Outline Drawing

4.2 THERMAL OVERLOAD PROTECTION

The LZY-1 has an automatic built-in thermal shutoff feature. When mounted on the heat sink / fan assembly supplied with the unit, the LZY-1 is a thermally efficient system that meets the performance parameters in Table 1 in ambient environments from 0°C to +50°C.

The amplifier is factory mounted on the heat sink using a thin film of thermal grease between the RF module and the heat sink mounting surface. (See paragraph 7.0 for operation without the factory supplied heat sink.)

With the fan operational at +26 VDC, the cooling air velocity is approximately 110 CFM.

The combination of heat sink design and cooling air velocity results in a very efficient thermal resistance (0.08°C/watt) between the mating surfaces. Under these conditions, the amplifier temperature is held to less than 15°C above ambient temperature at 20 watts P_{Out}.

When the temperature of the LZY-1 exceeds +65°C due to any combination of ambient temperature and / or overdrive, a thermal switch will actuate and shut off the amplifier by shutting off bias to all stages. As the amplifier case cools down below 40°C, the thermal switch will reset and restore the amplifier to normal operation.

4.3 REVERSE POLARITY PROTECTION

The LZY-1 is protected against damage from improper connection of the supply voltage by incorporating a diode in series with the positive VDC terminal.

4.4 TRANSIENT PROTECTION

The LZY-1 is protected from damage by DC line transients and accidental shorting at the VDC terminals by a zener protection circuit. This protection circuit is connected to the transistor bias regulator supply and limits (clamps) those transients that would normally pass through the regulator and damage the transistors.

4.5 SHUT-OFF TERMINAL

The LZY-1 has a separate EMI-Filtered shutoff terminal and a corresponding ground terminal for use with an external remote shutoff circuit.

The nominal RF power output of 25 watts is reduced by 50 dB minimum within 20 milliseconds when the shut off terminal is grounded.

When the shutoff terminal is open-circuited, the RF output is restored within 40 milliseconds.

The voltage present at the shutoff terminal (open circuited) is approximately 11 volts. When grounded, the series current is less than 11 mA.

5.0 MECHANICAL FEATURES

5.1 OUTLINE

The outline drawing and dimensional detail are shown in Figure 4.

5.2 HEAT SINK

The LZY-1 heat sink is a high thermal efficiency heat sink that, when used with the 4 inch 110 CFM fan, results in a thermal resistance of 0.08°C/Watt. This number is derived by dividing the case temperature increase of 15°C by the max DC Power of 190 watts (26 volts at 7.3A). (See paragraph 4.2 for other thermal considerations).

5.3 COOLING FAN

The cooling fan is a long life, brushless DC operated 4 inch ball bearing •muffin• fan which delivers 110 CFM air at +26 VDC. The fan is mounted to an optimally designed plenum on the heat sink for minimum air turbulence. The fan is protected by a fan guard.

The DC requirement of the fan, as installed, is 300 mA typical, 400 mA max at +26 VDC.

The fan meets EMI standards per FCC Part 15, Subpart J.

5.4 WEIGHT

The LZY-1 amplifier alone weighs less than 1.14 kg. Total weight with heat sink / fan is under 4.0 kg.

6.0 SUGGESTED APPLICATIONS

The following performance characteristics are those generally expected from the LZY-1 under the conditions stated for each application. The versatility of the LZY-1 ultra-linear amplifier is denoted in each of these applications for AM, FM, Pulse, Multi-Carrier and other signal formats and modulation schemes common to the communications bands which form part of the 20 MHz to 512 MHz frequency spectrum.

The suggested performance is provided to the user as a guideline which makes the LZY-1 ideal for a variety of driver or output amplifiers in many equipments. Specific results may vary under different conditions.

6.1 AM AMPLIFICATION

The LZY-1 can be used to amplify an AM (Amplitude Modulated) carrier to a level of 5 watts (20 watts PEP) with less than 5% AM distortion when modulated at 90%.

6.2 FM AMPLIFICATION

The LZY-1 will typically produce a minimum of 32 watts CW or higher and is limited only by the overdrive threshold limits set by the input signal frequency as described in paragraph 4.1.

6.3 LINEAR PULSE AMPLIFICATION

The LZY-1 is ideal for linear pulse or pulse train amplification to faithfully reproduce a pulse signature to the 20 to 30 watt peak power level. The pulse width and duty cycle is not limited at these power levels because of the Class A amplifier operation.

6.4 MULTI-CARRIER AMPLIFICATION

The LZY-1 when tested with two 5 watt tones (10 watts average) spaced 100 kHz apart at 400 MHz will display an IP_3 minimum of +52 dBm. IMD under these conditions are typically -30 dBc or better.

Other carrier spacing, power levels and number of carriers may change the IMD performance.

6.5 TELEVISION CARRIER AMPLIFICATION

The LZY-1 can reproduce video, sound and color burst carriers on a composite TV signal with minimal sync clipping for levels up to 5 watts average.

6.6 BROADBAND 20 MHZ TO 512 MHZ SWEPT SIGNAL

For swept linear applications at 20 watts, the LZY-1 will accept a constant input and produce an output level within ±1.5 dB.

6.7 FEEDFORWARD AMPLIFICATION

The LZY-1 can be used as a main amplifier or error amplifier in a VHF or UHF feedforward application due to its low IMD and relatively flat phase, delay, and amplitude characteristics.

7.0 ALTERNATIVE HEAT SINKING / COOLING

The LZY-1 RF Linear Amplifier electrical specifications in Table 1 are guaranteed when the RF Linear Amplifier module is operated on the factory supplied heat sink and the cooling fan is running.

Physical limitation of certain equipment configurations may require the user to provide alternative methods of heat sinking/cooling.

In these cases, the user can remove the RF Linear Amplifier module from the factory supplied heat sink by disconnecting the wires between the cooling fan and the module then removing the four mounting screws holding the module to the heat sink.

The user must then provide an alternative heat sinking/ heat removal method that provides an equivalent thermal resistance of 0.08°C/Watt to realize the unit electrical performance specified in Table 1. (See Paragraph 4.2 for thermal considerations).

Depending on the approach to cooling, alternative methods may increase or decrease the thermal resistance of that interface resulting in operation of the amplifier at a lower or higher temperature rise above ambient.

A qualified Engineer or Technician should be responsible to design and evaluate the alternative Heat Sinking method.

Failure to provide the proper heat sinking will result in module overheating which in turn will activate the automatic thermal shut down circuit when the module temperature exceeds +65°C.

8.0 QUALITY ASSURANCE PROVISIONS

8.1 ACCEPTANCE TEST PROCEDURE

All LZY-1 amplifier assemblies are subjected to 100% factory RF testing in accordance with a written Acceptance Test Procedure in which RF performance parameters and electrical features are tested and verified. Certificates of compliance are available.

RF performance data is recorded and inspected for conformance within the limits set forth in Table 1.

Currently, each unit is subjected to a DC burn-in test for 72 hours with the input and output ports terminated in 50 ohms. This is a worst case condition for the amplifier since, when terminated, the DC power dissipated in the amplifier circuitry exceeds the amount dissipated when RF power is being generated.

Performance is compared before and after the DC burn-in.

DC burn-in testing will continue at our discretion until sufficient history is generated to reduce or eliminate this test.

8.1.1 Acceptance Test Procedure Test Setup

Figure 3 illustrates the test position set up used to perform acceptance testing on the LZY-1 for the majority of the performance parameters specified in Table 1.

8.1.2 Test Equipment

The test equipment required to perform the acceptance tests is detailed in Table 2. In the event any item of test equipment is unavailable, substitution of equivalent equipment is suggested. All test equipment should be turned on 30 minutes prior to start of test.

DESCRIPTION	MANUFACTURER	MODEL
Ammeter	HP	428B
Digital Multimeter	Fluke	8050A
Digital Thermometer	Omega	650
20 dB Attenuator	Sierra	662A-20
Spectrum Analyzer	Anritsu	MS2601A
Network Analyzer	HP	8753C
Power Meter	HP	435B
Power Meter Sensor	HP	8482H
Power Supply 28V 10 Amps	Various	
Plotter	HP	7470A
Terminations, 50 Ohm, 1/2 Watt	Various	SMA-Male
Switch (A/B)	Various	
Lab Amplifier	Mini-Circuits	MAV-11
Attenuator 10 dB/20 dB (2W)	Various	
Power Supply (0-30V; 3A)	Various	
Switch, Knife, High Current	Various	

Table 2: Acceptance Test Setup Equipment

8.2 WARRANTY

All LZY-1 amplifiers are warranted to be free from defects in material and workmanship for a period of one year from date of shipment. This warranty does not cover the conditions of physical abuse or operation beyond the specification limits delineated in Table 1.

Operation of the RF module without the Heat Sink / Fan assembly supplied or without the cooling fan operative violates the warranty and will result in thermal shutdown when the module temperature exceeds +65°C.

9.0 REFERENCES

LZY-1 specification sheet, Rev A, ED-4276, 02/01/96

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