

# 3GHz 1Kw High Power Amplifier

**Model AM84-3S4-50-60R**

## Operating Instructions



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This document describes a Solid State High Power Amplifier (HPA), intended for use as drive amplifiers for high power Klystron tubes used in particle beam accelerator.

The amplifier is a GaAs FET unit biased in class A, with a TTL control pulse used to switch the GaAs transistors. The amplifier on/off rise & fall times specified will indicate the limits of the amplifier in terms of the maximum repetition rate/duty cycle that can be supported. Provided that the rise & fall times are taken into account when determining duty, the amplifier will reproduce the input signal characteristic at its output with the minimum of distortion, when the TTL control and RF input signals are correctly synchronised. Thus the PA will be in a "class A" state for the duration of the RF pulse, but otherwise in a standby state. Therefore, since achieving fast amplifier rise & fall times minimises the active cycle (ie, typical overall active cycle = Pulse width + 10uS), this design will allow for the most efficient, and practical management of power and heat generation.

## 2 Technical Specification

### 2.1 Electrical

Frequency of Operation	2.998GHz +/-30MHz
Peak Output Power	+59.5dBm min, +60dBm typ @ 1% duty
Absolute max average output (limited)	+50dBm (100w). See note 1
Input Power	+10dBm nom
Absolute max input power	+20dBm max
Input Signal Characteristic	Pulsed
Pulse Repetition Rate	10Hz nom. See note 2
Pulse Duration	10uS nom. See note 2
RF Rise/fall Times	100nS typ See note 4
Non-Harmonic Spurious Output	-60dBc min
Input Return Loss	14dB min
Output Return Loss	18dB typ
System Power Supply	AC Mains 110V 1 phase 3.4kVA peak. See note 2
RF Input Interface	N type Female
RF Output Interface	N type Female
Pulse Control Rise time (0-100% RF)	5uS max. See note 3
Pulse Control Fall Time (100-0% RF)	5uS max
TTL control signal	TTL HIGH = amplifier ON

### NOTES

POWER OUTPUT RATINGS ARE SPECIFIED AT THE ABOVE STATED DUTY CYCLES.

- 1 Protection against excessive duty cycle is incorporated, and prevents operation above 10% duty
- 2 The primary power input demand will be a function of the duty cycle.
- 3 The pulse control rise & fall times (0-100%) are based on a CW RF input signal, with amplifier pulse modulation accomplished by switching the TTL pulse control signal from low-high (leading edge) and from high-low (trailing edge).
- 4 The RF rise/fall times are based on pulsed RF input, with virtually zero rise/fall time applied when the amplifier has stabilised in class A in response to TTL pulse-control signal.
- 5 The TTL pulse control line is AC coupled to prevent accidental application of CW RF input signals.

### 2.2 Signal Interfaces

RF Input	N type female panel jack
RF Output	N type female panel jack
TTL Enable	BNC female panel jack
TTL Pulse control	BNC female panel jack

Dimensions (LWH)	19" x 4U x 550mm. Rack or bench top style chassis
Weight	25Kg

## 2.4 Front Panel Controls & Indicators

Main power keyswitch	Initialises unit & activates cooling system.
PSU status indicator	Displays status of AC/DC convertors.
RF status indicator	Shows presence of RF at output port
TTL status indicator	Shows presence of TTL-high enable signal
Reflected power indicator	Shows reflected power in excess of 200W
Over temperature indicator	Shows amplifier shut-down due to over temp.
Output Power Meter	Digital LED meter reading peak forward output power in watts

## 2.5 Protection Features

Output power limiter	Amplifier is shut down if average RF output power exceeds 10% duty.
Reverse Power Protection	Integral output isolator provides full power mismatch protection at duty cycles up to 10%. Automatic shut down if reverse power exceeds 100w average. (only possible in event of failure of output power limiter)
Over temperature protection	Monitors power module temperature, with automatic over temp shut-down (with front panel indication) and auto reset.
Remote status indication	A two-state output is provided in the form of a pair of normally-closed dry relay contacts. The output is conductive (20 mA maximum current ) when the internal conditions required for normal operation of the amplifier have been satisfied. Failure of any condition, or the activation of a self-protective feature (excess reverse <b>RF</b> power or over-temperature) causes the contacts to open . The contacts are two screw-type terminals of a barrier terminal strip (back panel).

## 3.0 Operating Instructions

### 3.1 Prior to Use

#### **IT IS STRONGLY RECOMMENDED THAT SECTION 5 (SAFETY) IS READ PRIOR TO USING THIS EQUIPMENT**

The AM84 amplifier is supplied with a pair of keys for the front panel keyswitch, and a line power cord.

Ensure that the front air intake and rear exhaust areas are not obstructed. Reduced airflow may result in overheating and possible reduction in life of the amplifier. There may also be an increase in fan noise or frequency.

Connect AC supply to line connector.  
Connect RF input & RF output.

#### **ENSURE LOAD RATING IS ADEQUATE FOR THE INTENDED POWER OUTPUT. THIS CAN BE UP TO 1000W.**

Connect the TTL enable control line to the rear panel "TTL Enable" BNC port.  
Connect the TTL pulse control line to the rear panel "TTL Pulse Control" BNC port.

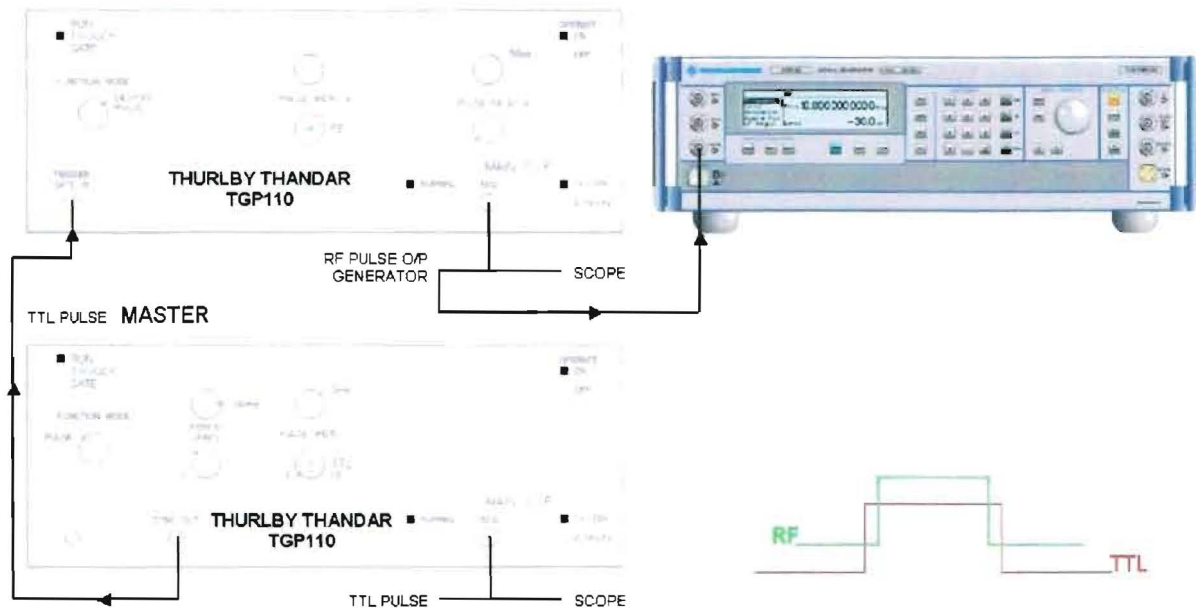
*Ensure that these connections are not transposed – this will not damage the amplifier but will result in unsatisfactory performance*

For SMR20 specifications & function refer to the operating manual or to online information at:

[http://www2.rohde-schwarz.com/file\\_3894/smr\\_20-40%20e03.pdf](http://www2.rohde-schwarz.com/file_3894/smr_20-40%20e03.pdf)

METHOD 1: TRIGGERING 2 PULSE HATS USING 2 GENERATORS  
METHOD 2: OMIT MASTER

INNER RF HAT **SLAVE**



1): Simple method using two external pulse generators:

Use the SMR20 as a "dumb" RF pulse generator. It generates an RF pulse when commanded by an external TTL pulse generator - *It doesn't do anything else*. If the input pulse from the TTL generator is 10uS, so will be the RF pulse from the SMR20

With this method, you need *two* external synchronised pulse generators (recommended Thurlby-Thandar TGP110). The first, "master" unit sets the prf, and the TTL pulse width to be fed to the amplifier's "pulse control" TTL. It also triggers the second, "slave" unit, which is used to set the RF pulse width, and to command the R&S to generate the RF pulse when connected to the "pulse" socket (see p.4.10). (It can also trigger a scope).

*The "Master" sets the TTL duration. The "Slave" sets the RF pulse duration, and triggers the R&S generator.*

Use the following settings for a duty cycle of 0.01%% at 10Hz prf, referring to p. 4.15, on the SMR20:

Pulse Mod Source:	Off (This turns off SMR20 <i>internal</i> pulse gen).
Pulse Mod Polarity:	Normal
Pulse Generator Settings:	Irrelevant, you're not using it.

Turning to the two pulse generators, the Master TGP110 has the following settings:

Function/Mode :	Run/Pulse
Period:	100mS (for a prf of 10Hz)
Pulse width:	20uS (symmetrically 10uS longer than the RF pulse).
Pulse Delay:	Irrelevant, you're not using it.
Normal/Complement:	Select Normal
Amplitude:	5V



Function/Mode:	Triggered/Delayed Pulse
Period:	N/A
Pulse width:	10uS (for 0.01% Duty cycle).
Pulse Delay:	5uS (approx gap between the TTL and the RF Pulse).
Normal/Complement:	Select Normal
Amplitude	5V.

2): Advanced method using a single external pulse generator:

Assuming that the R&S is fitted with the SMR-B14 option (p.4.10). Use the R&S as a triggered, time-delayed pulse generator. In this method, you only need *one* external pulse generator, which again sets the prf and the TTL "pulse control" signal. This is the master, not the R&S. It is applied to the "pulse" socket of the SMR20. (p.4.16).

Turning to the SMR20 and referring to p.4.15:

Pulse Mod Source	On (This activates R&S internal pulse gen).
Pulse Mod Polarity	Normal
Pulse Generator Settings:	
Pulse Period	100mS
Pulse Width	10uS (0.01% duty).
Pulse Delay	5uS (approx gap between TTL command and the pulse output).
Double Pulse state	Off

A "trigger delay" may need to be located in another menu and set to zero, or adjusted appropriately.

*The master generator has the same settings as the master in the Simple Method above.*

### 3.2.2 TTL & RF Pulse Timing

*Note that the amplifier is not yet activated at this stage*

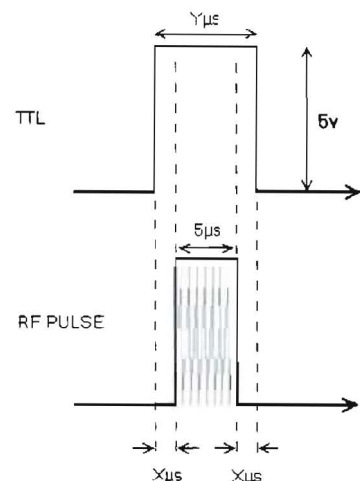
Connect RF input and RF output connectors. Ensure that the output load and cable rating is adequate for the intended power output which may exceed 1000w. Ensure that the maximum RF input level does not exceed +20dBm. **Excessive overdrive will result in permanent damage to the amplifier.**

The RF pulse to be amplified must be synchronised with the TTL pulse control signal. (note that the port is AC coupled – a permanent TTL High will NOT result in any RF output).

*The pulse control rise & fall times must be taken into account – the RF pulse input must be delayed by at least 5uS from the TTL pulse control pulse for the amplifier to operate correctly.*

A typical timing sequence for a 5uS pulse is shown below:

XuS = 5uS (Rise), 5uS (Fall)  
YuS = 15uS



### 3.2.1 System Start Up

Switch line supply ON via front panel keyswitch. “MAINS POWER” LED will illuminate, indicating line power is now applied. Cooling fans will be heard to start internally.

Pressing the “AMPLIFIER ENABLE” switch will activate the RF amplifier, and the green lens will illuminate.

The “RF ON” LED illuminates only when RF output exceeds a nominal 10W. This is intended as a confidence indication only.

The “PSU Status” LED will illuminate indication satisfactory operation of the internal AC-DC convertors.

**Ensure that the maximum RF input level does not exceed +20dBm. Excessive overdrive may result in permanent damage or degradation in performance.**

### 3.2.2 Applying RF Power

The amplifier may now be enabled by the application of a TTL High to the BNC enable port.

The RF pulse to be amplified must be synchronised with the TTL pulse control signal. (note that the port is AC coupled – a permanent TTL High will NOT result in any RF output).

*The pulse control rise & fall times must be taken into account – the RF pulse input must be delayed by at least 5µs from the TTL pulse control pulse for the amplifier to operate correctly.*

High speed pulsing should not be attempted using the TTL Enable control line which is for low frequency system activation only.

### 3.3 Resetting the Amplifier

In the event of a VSWR shut-down as indicated by the RF Power LED extinguishing and VSWR LED illuminating, the cooling fans will continue to operate. First, switch the “AMPLIFIER ENABLE” OFF. Then switch the amplifier OFF at the “MAINS POWER” keyswitch. After a few seconds all indicators will extinguish and the amplifier may be restarted as above.

## 4.0 Maintenance

No maintenance is required in normal operation.

There are no user-serviceable parts within the amplifier. Each amplifier is factory tested and supplied with a set of test results, and some internal layout information. If degradation in performance to below the specified levels occurs, or a failure is suspected, then the complete unit should be returned to the manufacturer together with details of the fault.

**THE CENTRE CONDUCTOR OF THE RF OUTPUT CONNECTOR SHOULD NOT BE TOUCHED WHILST UNIT IS IN OPERATION. UP TO 1000W RF POWER IS PRESENT WHICH PRESENTS A SHOCK HAZARD AND CAN CAUSE BURNS.**

**THIS AMPLIFIER MUST BE GROUNDED.**

**THIS UNIT IS HEAVY - CARE SHOULD BE TAKEN WHEN LIFTING.**

**THE AMPLIFIER MUST BE SUPPORTED AT THE REAR WHEN INSTALLED INTO A RACK OR CABINET. THE SIDE EXTRUSIONS ACCEPT M5 CAPTIVE NUTS. DO NOT SUPPORT THE AMPLIFIER BY THE FRONT PANEL MOUNTING EARS ALONE.**

**CARE MUST BE TAKEN TO PREVENT SMALL OBJECTS FALLING INTO THE UNIT THROUGH THE VENTILATION GRILLES**

**NO PANELS OF THE AMPLIFIER SHOULD BE REMOVED BY THE USER. HAZARDOUS VOLTAGES ARE PRESENT WITHIN THE AMPLIFIER CHASSIS.**

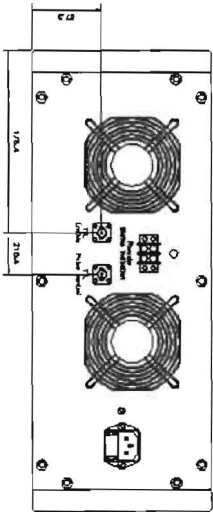
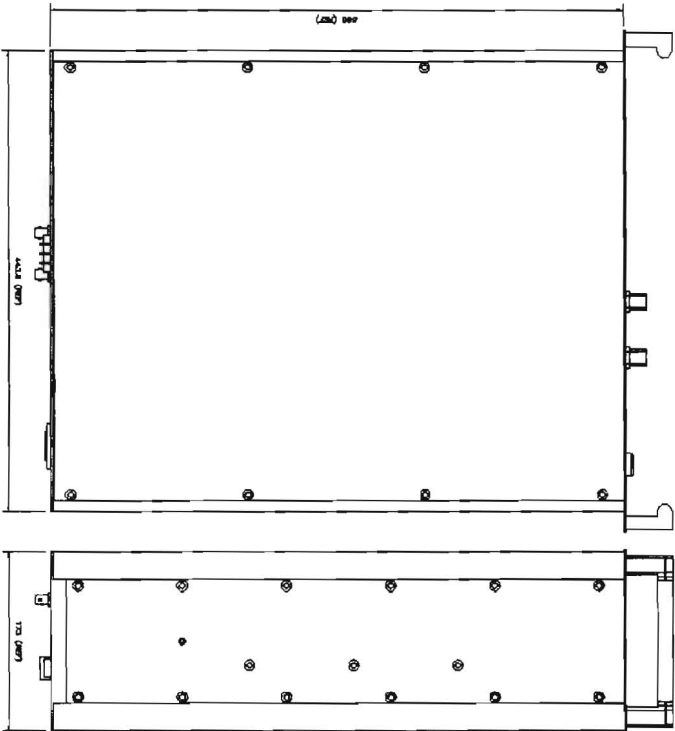
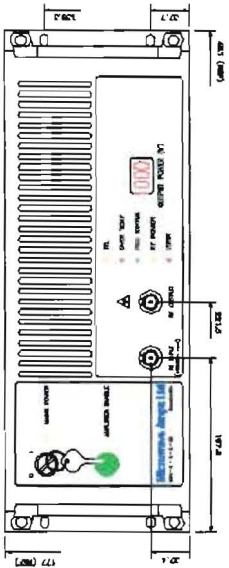
**Line supply is filtered within the amplifier. A fuse of an appropriate rating is fitted to the rear panel. Should this repeatedly fail, the unit should be returned to the manufacturer.**

**Small objects and thin cables etc should be kept away from the rear panel cooling fans which are fitted with finger guards.**

## **6.0 Warranty**

Microwave Amplifiers Ltd warrants for 2 years from date of shipment that the goods supplied will be in full compliance with the agreed specifications and will be free from defects in material and workmanship. Any and all other warranties (except of title) express or implied, relating to fitness for particular purpose, merchantable quality or otherwise are expressly disclaimed. Seller will not be responsible for special or consequential loss or damages. Liability shall be limited to the repair or replacement of defective products subject to the return of the product intact, and un-tampered with by the buyer.





## PRODUCT TEST DATA

Model no : AM84-3S4-50-60R

Ser no : 001

Batch no

6958

Test	Specification	Recorded
Frequency Range	2.968 – 3.028GHz	<u>2.968 – 3.028</u> GHz
RF Input Power	+10dBm nom, +20dBm max	<u>+15</u> dBm
Input Pulse Duration	10uS	<u>10</u> uS
Pulse Repetition Rate	10Hz	<u>10</u> Hz
Rise Time (cw)	5uS	<u>2.5</u> uS
Fall Time (cw)	5uS	<u>4</u> uS
RF Rise/Fall Time	100nS typ	<u>&lt;100</u> nS
Pulsed RF Output Power	+59.5dBm min	<u>59.5</u> dBm
Non Harmonic Spurious Output	-60dBc min	<u>&gt;-65</u> dBc
Forward Power Meter	Power out @ indicated 800w	<u>808</u> W
	Power out @ indicated 400w	<u>392</u> W
Input Return Loss	14dB min	<u>20.1</u> dB
Output Return Loss	18dB min	<u>19.0</u> dB
Over Temperature Protection	Activates at Temp 80C +/-5C	<u>75</u> C

**PRODUCT TEST DATA**

Model no : AM84-3S4-50-60R

Ser no : 001./6958

TTL Control (Enable)	TTL HIGH = amplifier ON	OK/ <del>NOT</del> OK
RF Status Indicator	Illuminates with RF O/P > nom 10w	OK/ <del>NOT</del> OK
TTL Status Indicator	Illuminates with TTL High enable signal	OK/ <del>NOT</del> OK
Reflected Power Indicator	Illuminates if reflected power > nom 200w	OK/ <del>NOT</del> OK
Output Power Limiter	Amplifier disabled with RF O/P > 10% nom	OK/ <del>NOT</del> OK
Over Temperature Indicator	Illuminates with OT activation	OK/ <del>NOT</del> OK
Remote Status Indication Contacts	Contacts open cct with alarm condition	OK/ <del>NOT</del> OK

Tested by :



Date :

27/1/09.

Inspected :



Date :

27/1/09