24-23cm RF Power Amplifier

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Revision Number

This document is for use with printed circuit board version 0.0h.

23-24cm Power Amplifier Overview

This circuit features a two stage liner RF amplifier that is designed for operation in the 1240 to 1300MHz range. A SXA-389BZ wide band GaAs amplifier with a P1dB of over 23dBm provides the power needed to drive a Mitsubishi RA18H1213 18 watt power amplifier module.

Features:

- Wide input power supply voltage range 10 to 15 volts
- Low standby current typically less than 5 mA.
- High gain two stage amplifier with moderate output power
    - 0 to +10dBm input for full output depending on power module gain setting
    - Pout 1dB of 42-43dBm and max Pout of about 44dBm at 1300 MHz, and a couple dB higher at 1240 MHz.
- Input PI attenuator can be used to optimize input level for best overall gain
    - Can be set for optimum Pout with inputs up to +20dBm
- Switched DC supply provides power to devices such as Tx/Rx relay during transmit
    - Up to 2A through a 0.2 ohm p-channel switch
    - Controlled switching times with relays in mind prevents hot switching when used without a sequencer
- Thermostatically controlled fan switch
    - Conserves battery power, fan is active only when heatsink temperature exceeds threshold
- Over temperature shutdown
- PTT active input is designed to be driven by an open collector or open drain switch.
- On board envelope modulation detector enables output power monitoring

Hardware Circuit Description

Printed Circuit Board

The following description refers to components shown in the '24-23cm PA Schematic V0.0h.pdf' document. External component connections to the PCB are detailed in the '24-34cm PA_I-P for PCB V0.0h.pdf' document.

Input Power Supply Connections

Pad P1, Vin, and the ground area around screw 5, provide areas for a direct solder connection to high current power supply leads. All other connections to the printed circuit board are made through connectors. D7 is an idiot diode used to protect the circuitry in case the power leads are reversed. An external 10 Amp fuse must be used in series with the positive supply lead for this circuit to work properly. C23 is an RF bypass capacitor. D4 an on board green LED is turned on through R22 when Vin is applied. D4 and the Tx indicator LED D3 are used primarily during test and debug. They can be removed after testing to minimize standby current consumption. R18 through P4 pin 3 supplies an off-board power supply indicator LED. The external LED's anode connects to P4 pin 3 and cathode to ground.

PTT and Switched Vin

The PTT components create a time controlled Switched Vin (SwVin) designed to prevent hot switching of an RF coaxial relay powered by SwVin. Q2 and Q5 are the key components. When

the PTT line is high (receive state) Q2 which provides supply voltage to the internal regulator and the SwVin port is off and Q5 which controls the bias voltage on the amplifier module U3 is on. When the PTT line goes low (transmit), Q5 turns off and Q2 on. When transitioning from receive to transmit (PTT low) the voltage rise time on the RA18H1213G module VBIAS pin is fairly slow because the power supply regulator, its filter capacitors, and C20 on the VBIAS line must reach about 2.5 volts before any substantial RF power can be generated by the module. A relay powered by SwVin will change state before RF power is present at the contacts. With the components shown the relay switches typically when VBIAS is about a volt and the total turn on time is about 100mS. Faster turn-on times are possible by reducing the value of C20, but make sure the VBIAS voltage is never more than 2.5V when the relay switches. Higher VBIAS voltages won't guarantee that the RF output power is low. When the PTT input is high (receive) Q5 an N-channel switch is held on by Vin through R28 and D9. When the PTT line goes low (transmit) there is insufficient voltage to keep the 6.8V zener D9 on so Q5 turns off and is kept off by R29. This releases the module VBIAS line to enable the RF output. At the same time Q2 a P-channel FET switch provides power to all components attached to the SwVin buss. This includes the first stage RF amplifier and the VBIAS pin on the RA18H1213G. When the PTT input goes high to end the transmit state Q5 turns on immediately removing VBIAS from the module shutting off the RF. Q2 on the other hand turns off more slowly as C19 charges to Vin through R17 holding the gate of Q2 on. This keeps the relay in the transmit state for about 5 ms after Q5 grounds VBIAS insuring the RF is off. D1 and D2 isolate the two PTT timing functions and also act as polarity guards to prevent high voltages on the PTT line from damaging on board components. C22 is an RF bypass capacitor. The PTT line is designed to be driven by an open collector or open drain switch. The PTT input is fairly high impedance. Switching the input to ground won't take more than 0.5mA and the PTT voltage during transmit should not be more than 1 volt to ground. The switch connected to the PTT line must support an off voltage of at least Vin. The SwVin output P5 will supply over 1A at close to Vin. But note that it's an open drain configuration fed from Q2, and Q2 is not protected against short circuits to ground. So make sure that P5 is never shorted to ground or Q2 will attempt to source several amps before destroying itself thermally.

Voltage Regulator

An LDO regulator is used to supply the SXA-389BZ first stage RF amplifier, LM56 thermostat and bias for U3 the RA18H1213G power amplifier. U1 is the adjustable version of the 1117 low dropout regulator. R15 and R16 set the output voltage to 9.00 volts and C21 reduces regulator noise and output ripple. C15 and C16 provide input filtering and RF bypassing for the regulator and C13 and C14 provide output filtering, amplifier stability, and turn on transient voltage overshoot control. As the regulator output is only on when the PTT is active, this output voltage can also be used as an indication that the PA is on and ready to amplify an RF input. R24 and D3 provide an on-board status LED indicator, and R27 which connects to P6 pin3 can be used with an external LED to indicate the amplifier is active. The external LED's anode connects to P6 pin 3 and cathode to ground.

Fan and Over Temperature Control

U4 an LM56 thermostat controls an off-board cooling fan and will shut down the RF power at the over temperature threshold. R12, R13 and R14 set the temperature thresholds to approximately 40 and 65 degrees Celsius. An Excel spreadsheet 'LM56Calculator' is available as part of the project tool suite for those that would like to alter the thresholds. C12 provides supply bypassing for the IC. When the fan temperature threshold is exceeded Output 1 turns on turning on P-channel MOSFET Q1. As the absolute maximum supply voltage for U4 is 12V, D10 provides level shifting between the input supply and regulated 9V output. The drain of Q1 connects to P7 pin 2 and an external fan connects between this pin and ground. Q1 can supply up to 1 Amp for an off-board fan. Like Q2 this open drain configuration isn't protected and shorting its drain to ground when it's on will destroy the device, so make sure that its drain is connected to a valid load. As fans are an inductive load, D8 provides transient protection for Q2. If the over temperature threshold is exceeded, Out2 turns on and goes low turning on Q3. Q3 provides current to drive an external over temperature LED through R26 to P6 pin 1. The over temperature LED anode should be connected to this pin and cathode to ground. The collector of Q3 also turns on Q4 which in turn pulls the junction of R5 and R6 to ground effectively removing VBIAS from U3 and shutting off the RF. There is about a six degree Celsius hysteresis built into the LM56 so if the

over temperature threshold is reached, the PA power won't return until the heatsink has cooled to about 58 C, and the fan will remain on until the heatsink reaches about 34 deg C.

RF Path

R1 to R3 form an input pi attenuator that can be used to set the input power level. If the attenuator isn't used, R1 and R3 are not installed and R2 is a 0 Ohm jumper. If the attenuator is used select values appropriate to maintain the input and output impedance 50 ohms while providing the desired level of attenuation. Several on-line applications are available that will generate values for the three resistors for a desired attenuation while maintaining the correct input and output impedance. A table of resistor values is also provided in the assembly document. U2 is a SXA-389BZ MMIC that provides about 14dB of gain at 1300MHz with a P1 of approximately +24 dBm. C1 is an input DC block. R7 to R9 provide power from the 9V supply limiting the drain current, setting the drain voltage, and also defines the 1dB gain compression point. C9 C10 and C11 provide supply filtering and RF bypassing. L1 couples the DC to the amplifier drain. C18 is a DC blocking capacitor that keeps the DC current out of the RA18H1213G input attenuator.

U3 is a Mitsubishi RA18H1213G amplifier module. It provides a minimum of 18W out for an input drive of about 23 dBm or less depending on the gain as set by VBIAS. R4, R5, and R6 provide an adjustable DC bias for the VBIAS pin. C2, C3 and C4 provide RF bypassing and filtering for VBIAS. D5 prevents the VBIAS voltage from exceeding its six volt limit as R6 is adjusted for the optimum analog bias point. C5 to C8 provide RF bypassing and filtering for the main supply.

An envelope detector consisting of R19, D6, C17, and R20 provides an indication of RF modulation that can be fed to off-board circuitry to provide the user with an indication of the amplifier's RF output.