Weekend VHF/UHF Power Amplifier

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The Weekend VHF/UHF Transceiver has been well accepted across the world. It can be found on all continents except in Africa. Also myself enjoy using it virtually every day on local VHF/UHF chats mostly via repeaters. Why mostly via repeaters? Well it's rather obvious: Weekend Radio has only 1W output on primary band and only few mW on "secondary" band. So it you have bought UHF version of Weekend Radio it would have 1W on UHF and few mW on VHF band.

Just a quick explanation what I meant with "primary and secondary" band. As such I have by a pure luck found out that DRA818V which is VHF module also transmits and receives at UHF band with slightly limited Rx and less than mW of Tx power. It's virtually same with DRA818U – UHF module, with slightly limited Rx and few mW of Tx power. So those few mW are sufficient for local chats via repeaters, but for any longer distance contacts it's just too low power. Also 1W is not a "brilliant" power for long distance contacts, but it does cover most of FM contacts. The idea that we had in mind was to increase those few mW to at least 1W also on (in chosen example) VHF band. As such we'd have a nice radio that is dual band with 1W output power on both bands VHF & UHF.

Realization

With that idea in mind we started to investigate possibilities to make such an amplifier. We have tested a simple single transistor amplifier which actually worked quite well, it was simple to built, but unfortunately it's output power was rather low. So we searched for other solutions and found simple & effective solution in RF Power Modules, that are mostly made by Mitsubishi and Toshiba. These RF Power Modules are ready to be used with only few external components, they deliver declared power and are rather cheap with respect of what we get for that money.

We have made a prototype to prove the concept and then made a simple PCB, that includes RX/TX switching circuit and possible connection to our AVR microcontroller in case that you want to control RX/TX relay with the main AVR chip.

Realization with M67748L

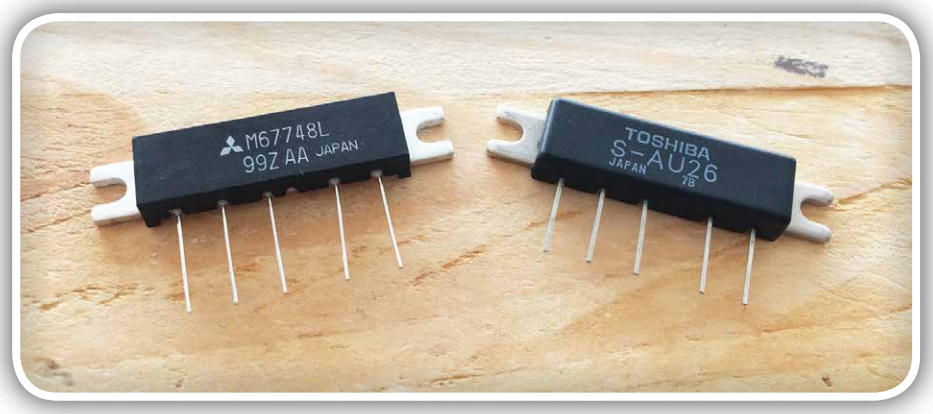
M67748L is a hybrid power amplifier manufactured by Mitsubishi semiconductors.

It's key performances are:

- Max 15V power supply
- Max RF input: 40 mW
- Max RF output: 10 Watt

It's enclosed in an enclosure with embedded

heat sink that can be screwed to larger heat sink. See internal diagram and dimensions at Fig. 1.



Simplicity of power amplifier designed by any Mitsubishi RF power module is a key factor for success of a project that is built by either novice or experienced HAM operator. Namely all the tricky circuits that may cause problems like oscillations and other strange behavior are factory trimmed and sealed in the power pack. All what it's needed for a normal operation of such a power amplifier block are few external components like blocking capacitors and RF chokes.

With our circuit are some specifics. Namely M67748L has max. allowed RF input power limitation to 40 mW. That is not a problem on VHF band, because we get out of DRA818U module less than 1 mW output. But it's a completely different ball game on UHF band where DRA818U delivers full 1W of power which will damage M67748L power module if we by mistake change band from VHF to UHF and hit PTT button. So we have to somehow prevent that this happens.

Luckily we have few I/O pins free on our ATmega328 MCU, so we can spend one pin that will enable our PA. On Fig. 2 see schematics of Weekend VHF PA, where you will notice the connector CON2 to which AVR pin connects.

With this pin we will disable relay to turn on our PA in case that we're working on UHF band. **Please note that you need to make modification of current SW to perform this.**

Detail description

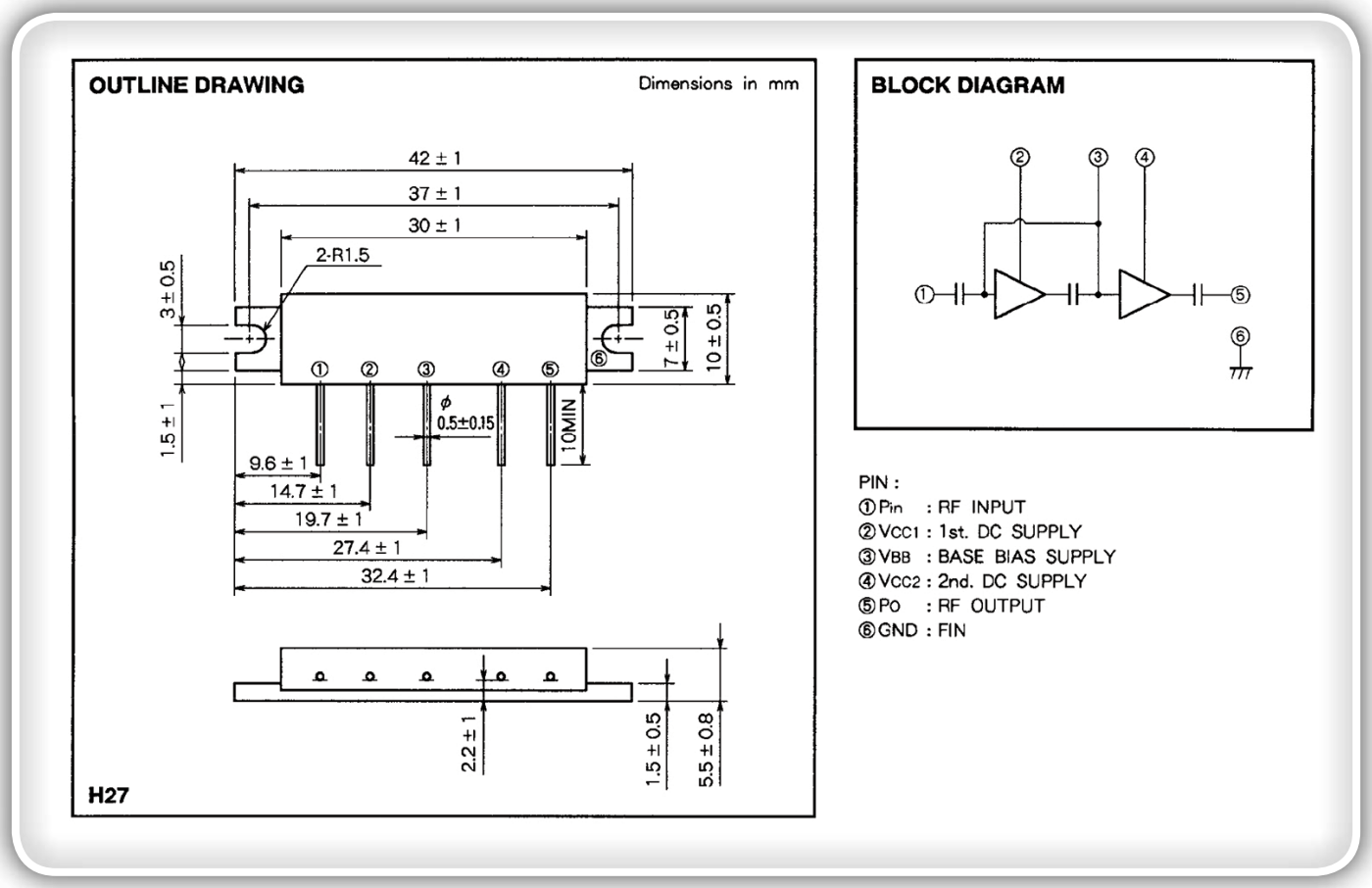


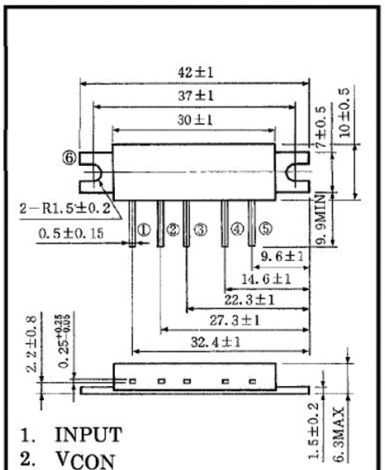
Figure 1: Internal diagram and dimensions of M67748L

S-AU26

MAXIMUM RATINGS (Tc = 25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
DC Supply Voltage	V_{CC}	16	V
DC Supply Voltage	V_{CON}	16	V
DC Supply Voltage	V_{BB}	5.5	V
Input Power	Pi	30	mW
Output Power	Po	10	W
Total Current	I_T	2	A
Operating Case Temperature Range	Tc(opr)	−30~100	°C
Storage Temperature Range	T_{stg}	−40~110	°C

Unit in mm



1. INPUT
2. V_{CON}
3. V_{BB}
4. V_{CC}
5. OUTPUT
6. GROUND (FLANGE)

JEDEC	—
EIAJ	—
TOSHIBA	5-31A

Weight : 5.4g

Figure 1a: Internal diagram and dimensions of S-AU 26

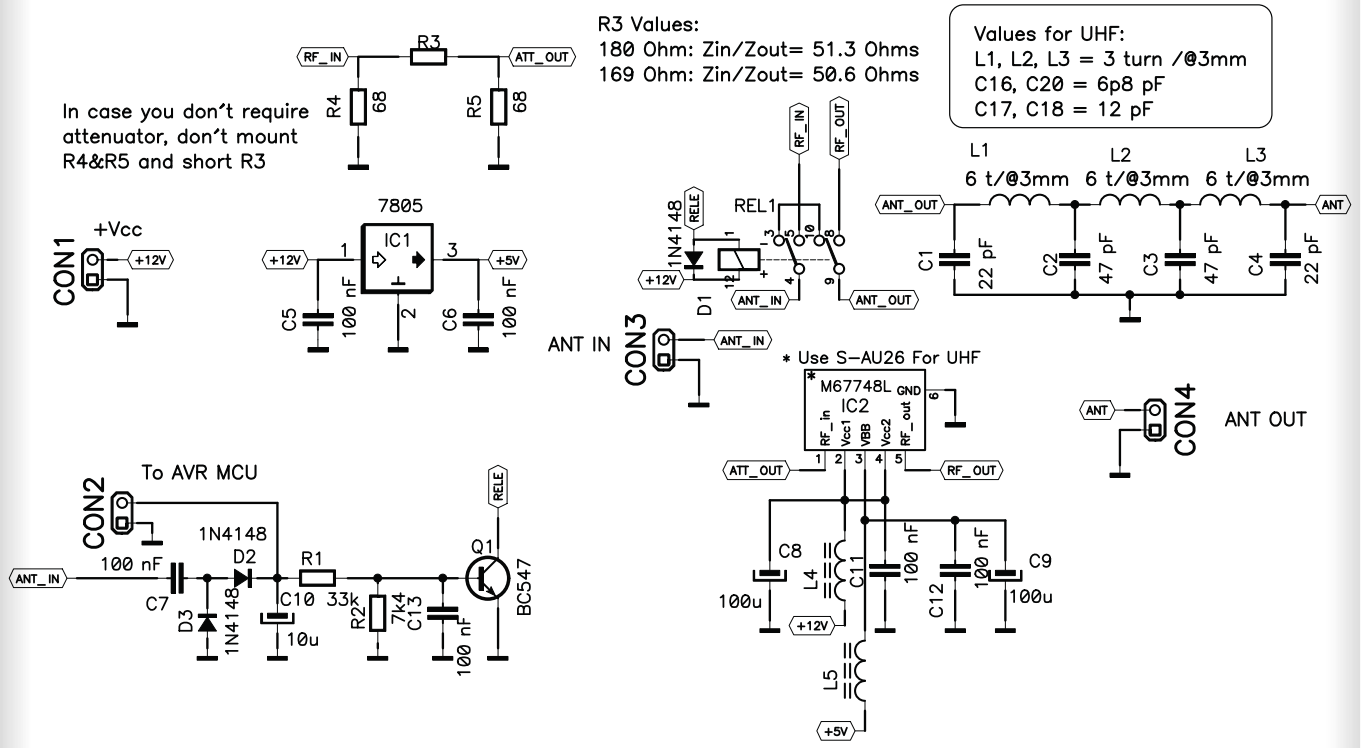


Figure 2: Schematic diagram of Weekend VHF/UHF Power Amplifier

Schematic diagram can be seen on Fig. 2 and as you see it was broken to few parts.
You will see on Fig. 2 the 5V regulator (IC1) and it's components, relay switch around transistor Q1, attenuator (R3, R4, R5), circuit around Power Amplifier (PA) module and output filter.

There is not much to say about each of these parts except the attenuator. Namely this attenuator can serve more purposes.

If you look at datasheet of the PA module M67748L you will see that it's designed for use in the VHF frequency band, it's max. input power is 20 mW and output power is 7 Watt at 12.5V power supply.

This makes this PA module ideal for our purpose: we will drive this module with few mW that we get out of DRA818U UHF module and output power will be aprox. 1 Watt.

Attenuator variants

Well in just described use of PA module we don't need attenuator because DRA818U - UHF module delivers only few mW of output power on VHF band. This is great news, because we can drive PA module directly. In this case we can omit R4 and R5 while R3 should be replaced with a short wire.

There is however another possibility of M67748L usage: we can drive it with 1 Watt that we get from DRA818V VHF module and PA module would then deliver >7 Watt at VHF band. We can do that with our Weekend radio providing that we have built in DRA818V - VHF version. In this case we must make sure that attenuator is included on the PCB. On the schematic diagram on Fig. 2 can be seen variants of R3 values. If you can buy 169 Ohm resistor it would be great because in this case Zin/Zout are close to 50 Ohms. If 169 Ohms resistor cannot be obtained then use 180 Ohms resistor with slight impedance mismatch.

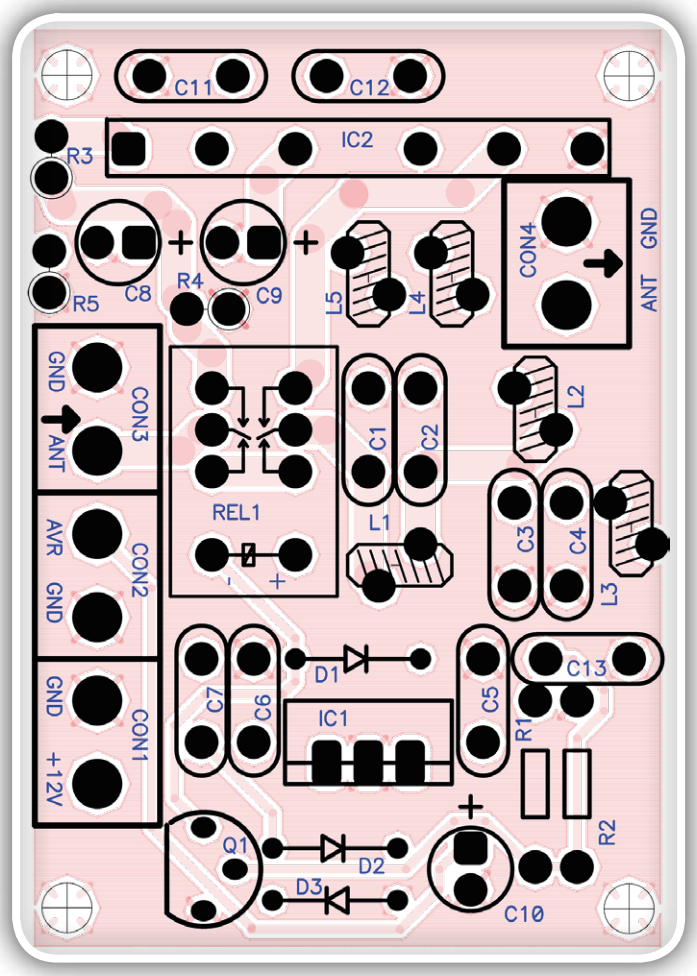
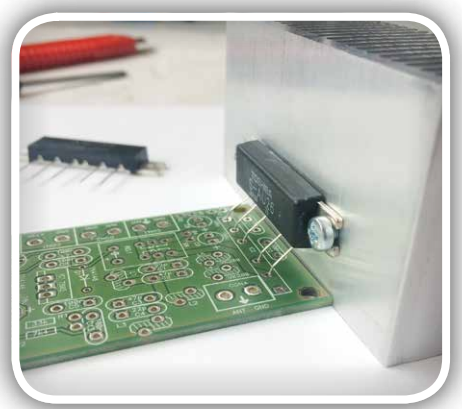


Figure 3: Component placement



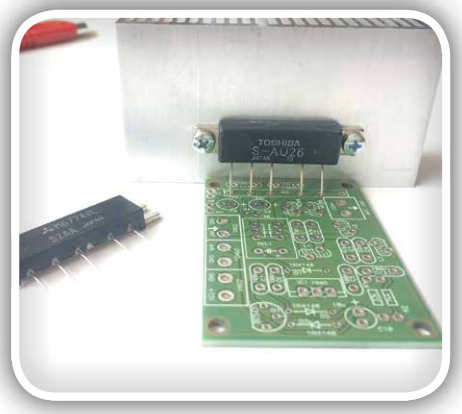


Figure 4: S-AU26 or M67748L mounting

Antenna RX/TX switch

Antenna RX/TX switch circuit is done around Q1. It's well known circuit with one addition. Since Weekend radio is an Open source project builders can program their AVR to turn relay On/Off with the AVR MCU on the Weekend Radio. In this case omit C7, C10, D1 and D2. Sure enough you have to adopt SW within AVR to turn Q1 on/off when on Tx/Rx. Also do not turn relay on when UHF band is in use. This is needed not to overload power module's input with 1W.
If you're pleased with circuit as it is then leave the circuit and SW as designed. But make sure not to transmit with 1 Watt power into Power module without suitable attenuator in between, or else Power module will be destroyed. You have been warned!

Building Instructions

PA is designed on a double side PCB with lot's of ground plane on both sides. I suggest to start assembling PCB with smallest parts like diodes, resistors, ceramic capacitors, electrolytic capacitors, relay, connectors and finally regulator. Follow Figure 3 where components placement can be seen.

The M67748L is mounted the last. Note that one pin – Pin 6 is tab of the M67748L and it should also be connected to the PCB. Before you mount M67748L on the PCB I suggest to tighten it well to a suitable heatsink. When mounting it to a heatsink make sure that you add a flat solder lug for screw, as seen on Fig. 4. Do not use Power module without heatsink because you may damage it!!

To this flat solder lug the GND will be connected from the PCB.

For connecting Antenna input and output terminals you should use 50 Ohms coaxial cable like RG-316 or similar which should have 50 Ohms connector of your preference mounted at it's end.

Make sure that you will configure attenuator according to your power input – see description above.

When all is checked you may connect 12V DC to power terminals, connect your Weekend Radio to CON3 (Ant IN) and your antenna to CON4 (Ant OUT) connectors. For first tests I suggest to use dummy load instead of antenna. If you are using UHF Weekend radio connect it to VHF band select empty channel and press TX for a short time while monitoring current consumption and output power. Current should stay below 4A (between 2-3 A), while output power should be about 1 Watt. If all is assembled well, the Weekend Power Amplifier will work from the first test, because there is no need to adjust it.

IMPORTANT NOTICE: do not load input of Weekend Power Amplifier with more than 20 mW without attenuator! This might destroy hybrid module M67748L.

Make sure that you do not power your Weekend radio PA with voltages higher than 13.8V, because voltages higher than 15V may permanently damage your PA RF module.

There are two possibilities to use Weekend radio PA:

- Use it as a stand-alone PA (in this case use input attenuator)
- Embed it within Weekend radio

Conclusion

Weekend radio is very popular HAM radio project, because it's simple to build, cheap and it has great performances. The only disadvantage of it is that it cannot transmit 1 Watt on both VHF and UHF bands. This is about to be changed with addition of this simple power amplifier, which will rise output of Weekend radio on it's “secondary” band to aprox. 1 Watt.

This project can also be used as a stand alone power amplifier which can deliver 7 Watts if 20 mW are delivered at it's input. If your radio has higher output power you can still use Weekend PA. Namely we have added a simple attenuator which attenuates input power from 1 Watt to less than 20 mW for reliable work of M67748L. So it's ideal companion to all Weekend radio project builders.

Needless to say that instead of M67748L one can use S-AU26 UHF Hybride power module to obtain 7W output at UHF with 1W input. All the circuit remains same except output filter changes as indicated in the schematic diagram.

PCB and KIT are available from: https://www.svet-el.si/english/index.php/shop