# SDR Splitter/Switcher
# Version 2.0
# John Price – WA2FZW

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# Introduction

This document describes a splitter/switcher that allows simultaneous reception on a normal ham radio transceiver and an SDR (Software Defined Radio). The design is a modified version of a design by Bill Ockert (ND0B) and Paul Newcombe (N2EME).

The switcher that Bill and Paul designed required an external RF splitter to allow simultaneous reception on the transceiver and the SDR; I built the splitter into the unit and made a few other modifications described below.

Paul describes his switcher in this excellent video.

I've been using Bill and Paul's switch box along with an SDRPlay RSPdx SDR several weeks on 6 meter meteor scatter (MSK144 mode) with excellent results. Using SDR Console to operate the SDR, I get many more and stronger decodes on the SDR than on my radio (Yaesu FT-891). I haven't tried the SDR in combination with my 2 meter radio yet (Icom IC-9700).

Another video from Hasan Schiers Jr. (N0AN) describes how to tweak the SDR Console settings for optimum performance.

## Design Considerations

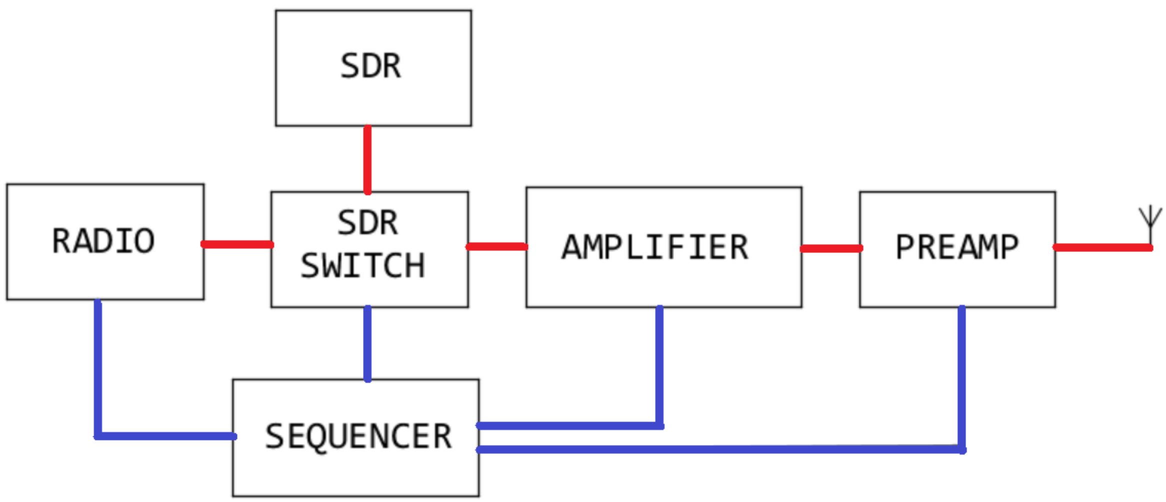
After exchanging several emails with Bill, I decided that I had a few different design considerations than he and Paul had, which is not to imply that there is anything wrong with their design; as I said, it worked fine for me. I simply wanted a device with different design objectives; these are incorporated into this design:

- Bill and Paul's design required an external splitter in order to be able to receive simultaneously on the transceiver and the SDR. I wanted the splitter to be internal and mounted on the PCB.
- Bill and Paul's design relied on an external front-end protection device for the SDR such as the DXE-RG-5000HD available from DxEngineering or cheaper ones on eBay. My design includes a relay contact that grounds the SDR input when transmitting.
- Their design included an RF sensing circuit that could optionally be enabled. Having smoked one of my preamps (fortunately one easily repaired) a couple of times, I don't trust this switching method so I eliminated that circuit.

- Their design also provided outputs to control a preamp (positive control) and to key a linear amplifier. As I use [my processor controlled homebrew sequencer] to perform those functions, I also eliminated these outputs.

### Station Configuration

The following shows how both my 6 meter and 2 meter stations are (or will be) configured:




The red lines are the RF paths and the blue lines are the control lines. In my case, my preamps are capable of handling 1.5KW when switched via voltage (not RF sensing) so they can be placed near the antenna even though I'm running considerable power on both bands.

If you don't have a preamp that can handle that much power, then the preamp can be installed between the SDR switch and the amplifier.

Also note that there is no provision in my setup to use a 'bias-T' arrangement to power the preamps.

You really need a preamp when using the SDR splitter/switch as the splitter introduces a 3+ dB loss to both the radio and SDR when receiving.

I thought of adding a preamplifier in the unit, but doing so would have had adverse effects on the frequency response, so I decided not to do so.

## Version 2.0 Modifications

The only change in version 2.0 is that I changed the splitter used. Version 1.0 used the Minicircuits PCS-2-1 RF Splitter. That device was only rated to 400 MHz, so the performance of the unit on the 70cm band was less than optimum.

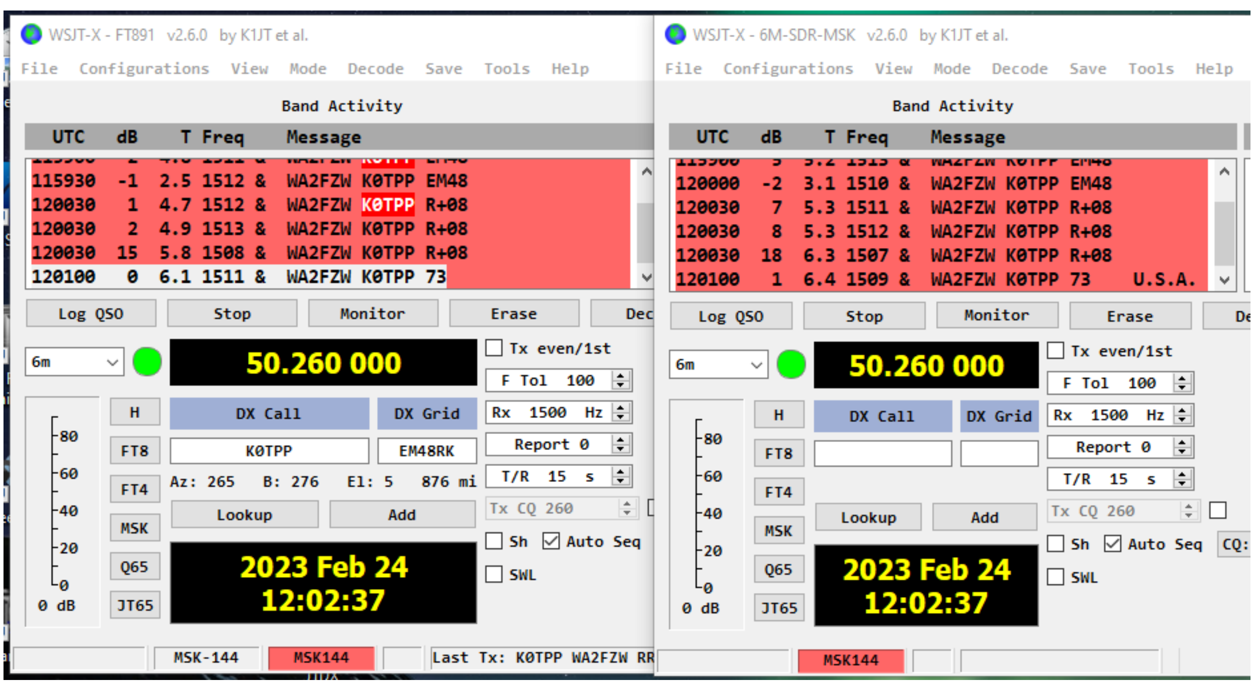
In version 2.0, I used the Minicircuits ADP-2-1W+ Power Splitter. It is rated to 650 MHz and is less than half the cost of the PCS-2-1.

I expected to see better measurements on the higher bands, but although a little better, the improvement was not as much as I had hoped. The problem has to be either in the relays used or in the trace layout on the PCB itself.

# Some Applications

## Digital Modes

So why would one want to implement a similar setup? My main use has been on 6 meter meteor scatter (MSK144 mode). Here’s a screenshot of a QSO with Larry (K0TPP) on Feb. 24, 2023 that shows how the FT-891 and the RSPdx SDR compare:



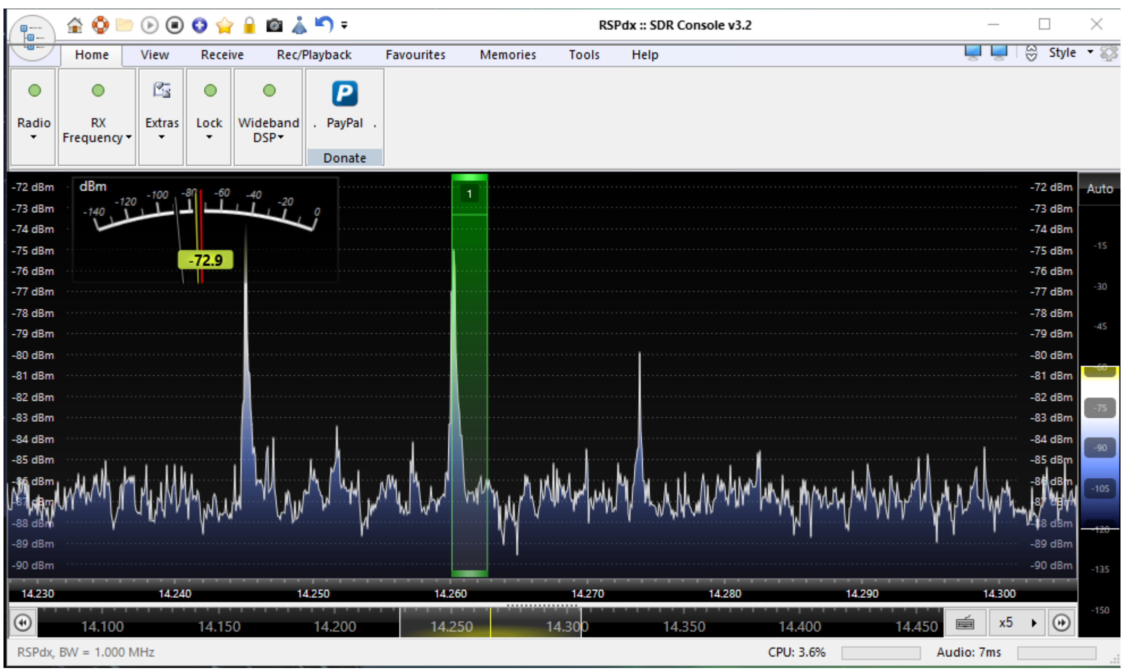
The instance of WSJT-X monitoring the FT-891 is on the left and the one monitoring the SDR is on the right. You can see that there are more decodes on the SDR and the S/N ratio of the SDR decodes is generally better on the SDR. The bandwidths on both are the same as is the audio input level to the two instances of WSJT-X.

For the record, when using this setup for FT8 or Q65, the performance is about the same for both, but I haven’t spent a lot of time trying to optimize the SDR parameters for those modes.

Eventually I hope to use the setup for 2 meter EME as Relu (NJ9R) has been doing with the version 1.0 unit with good results.

## As a Panadapter

This screenshot shows the SDR being used with SDR Console as a panadapter for my FT-891:




Because SDR Console can be synced with the radio using [Omni-rig](), I can click on a signal and the radio and SDR both tune to the selected frequency. Changing the frequency on the radio causes the SDR to also follow.

This was on 40 meters on Feb. 24, 2023 at about 13:30 UTC.

You can also use this capability to monitor a second band assuming your antenna is capable.

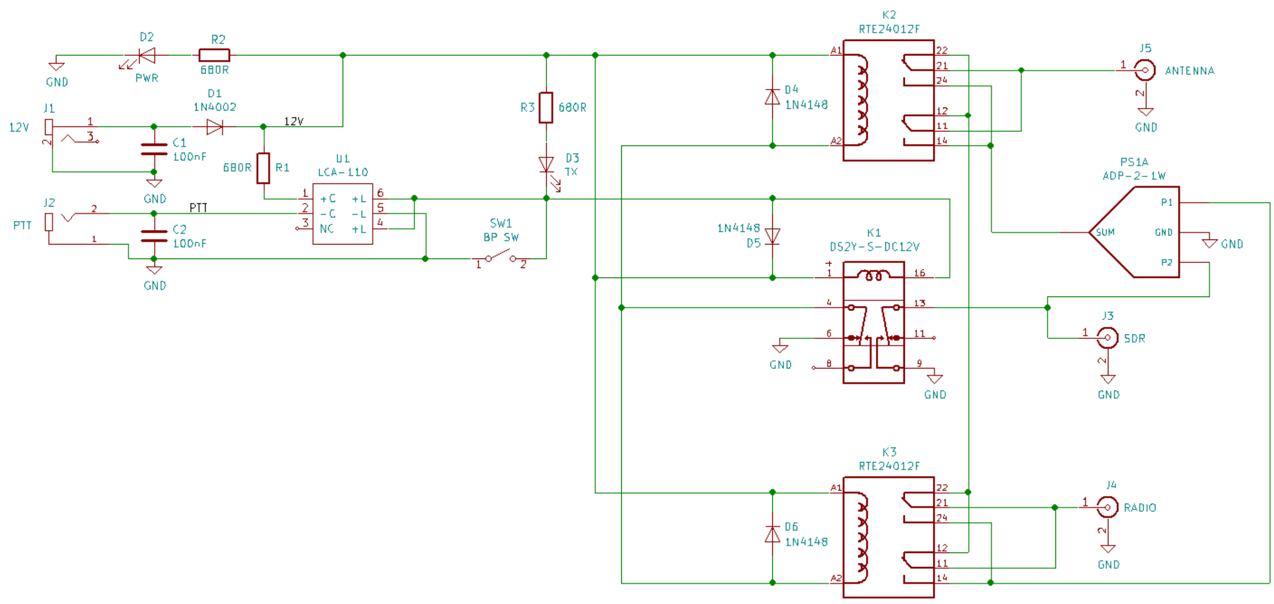
# The Hardware

## Some Assumptions

- The radio has a *PTT* line that goes to ground when the radio is put into transmit mode either manually or via CAT control.
- In the event that power to the unit is lost, the unit will switch to bypass (transmit) mode where the antenna is connected directly to the transceiver and the SDR is disabled (but the SDR input won’t be grounded).

## Theory of Operation

Here’s the schematic:




When power is applied to the unit, relays K2 and K3 are activated, which causes the antenna to be connected to the RF splitter (PS1A). One output of the splitter is connected through K3 to the transceiver and the other output is connected to the SDR port.

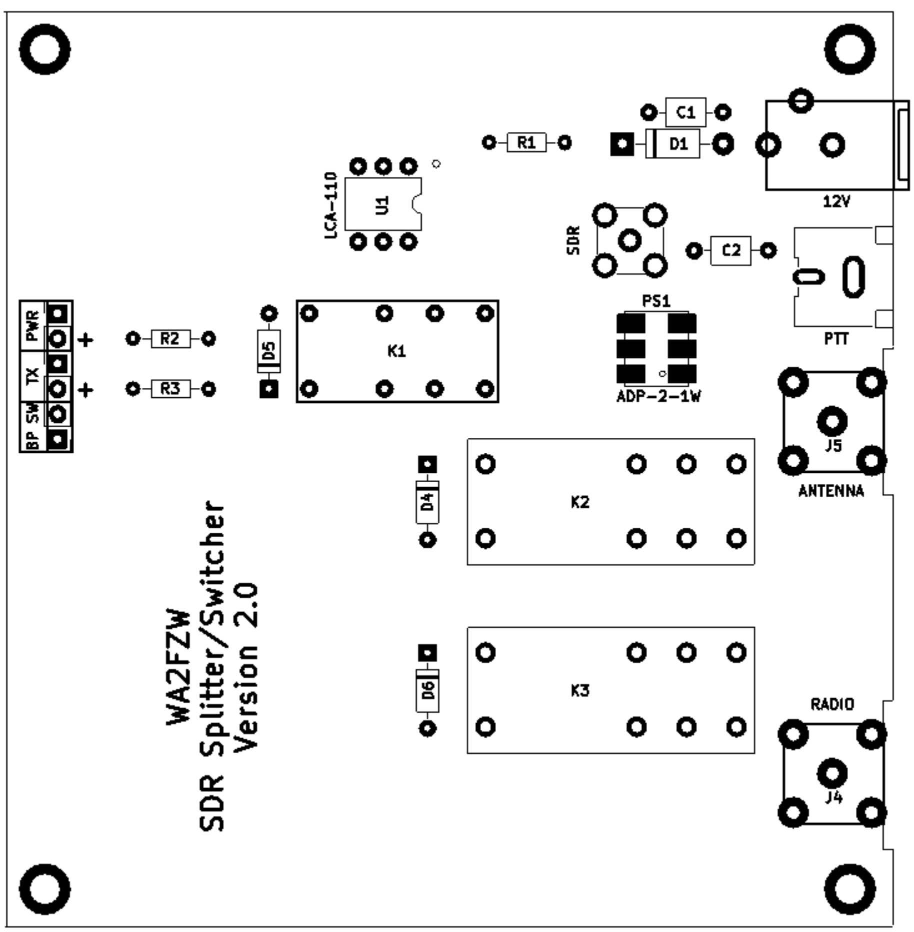
When the PTT input goes low, the output of the LCA-110 solid state relay (U1) also goes low. This activates relay K1, which causes relays K2 and K3 to switch to the bypass (transmit) mode in which the antenna port is connected directly to the radio port. When operated, K1 also grounds the SDR port to prevent excessive RF going to the SDR.

When the ‘BP SW’ switch (SW1) is closed, relay K1 is activated which places the unit into permanent bypass mode.

Note that as the splitter induces approximately a 3 dB signal reduction to both the radio and SDR the use of an external preamplifier is recommended for weak signal work.

## The Printed Circuit Board

Here’s the layout of the PCB:



A few people have asked why I put the SMA connector for the SDR where I did as opposed to placing it on the edge of the PCB as I did with the BNC connectors. The design decision was that I wanted the traces between the splitter, the SMA connector and the contact on K1 that grounds the SDR input in transmit mode to be as short as possible.

## Front Panel Controls and Indicators

Here's what front panel looks like:


The green LED indicates that the unit is getting power and the red LED indicates that either the radio is transmitting or the 'SDR' switch is in the 'BYPASS' position. If no power is applied, neither LED will be lit but the unit will be in bypass mode. But note, that without power, the SDR input will NOT be grounded as it would when the unit is powered up and in transmit (bypass) mode.

Note that if you are using one of my sequencers which have the ability to enable or disable an SDR switch (any one), setting the SDR switch on the sequencer to the 'DISABLE' position will also put the SDR switch into bypass mode.

## Rear Panel Connections

Here's what my rear panel looks like:


The 'RADIO' and 'ANTENNA' connectors are BNC females and are mounted directly on the main PCB.

The 'SDR' connector is an SMA female to female bulkhead type connector. It is connected to the SMA connector on the PCB by a short cable and there is a right angle adapter on the PCB SMA connector.

The 'PTT' jack is an RCA type and the '12V' jack accepts a 2.1mm coaxial type plug.

## Some Construction Notes

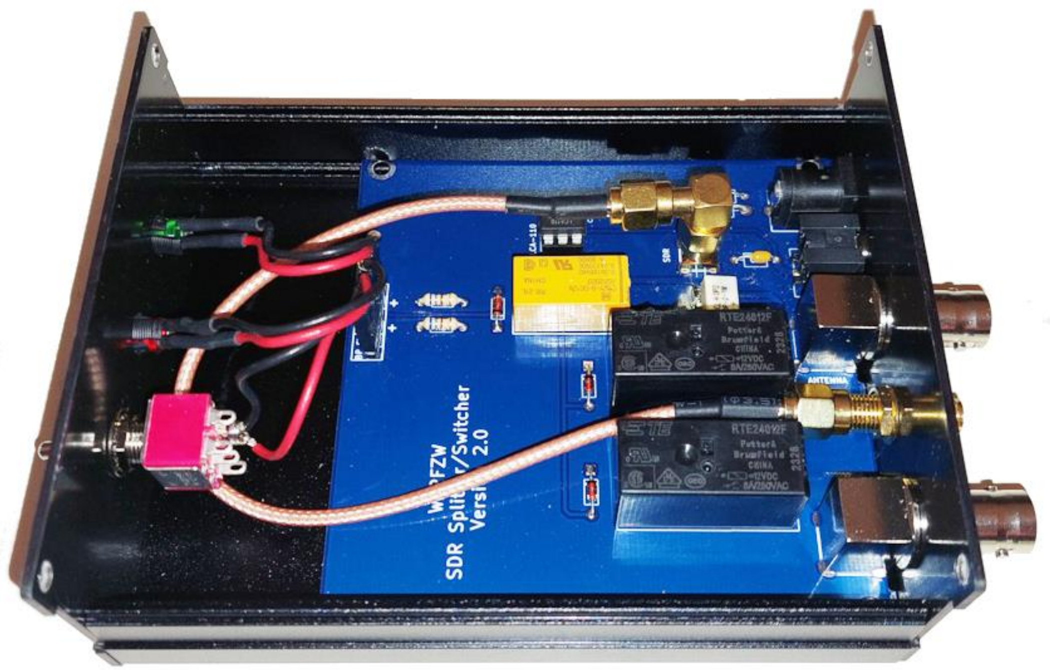
Both panels and the main PCB are designed to fit [this specific extruded aluminum enclosure from Amazon]() (you might also find them on eBay). The front and rear panels are actually printed circuit boards; the Gerber files to fabricate them are included in the distribution package. Of course you can use a different enclosure.

You may notice that the edges of the front and back panels are more gray than black. I found that going over the edges with a black Sharpie makes for a much nicer look.

The 'ANTENNA' and 'RADIO' connectors are female BNC type connectors that are both PCB and panel mounted, however one should be able to enlarge the holes and use either SO-239 or 'N' connectors wired to the PCB although that might obliterate the labels.

The screws to attach the front and rear panels that come with the enclosure are countersunk types. To use them, you’ll have to countersink the holes in the panels or use round-head type screws (3mm).

Here’s the finished PCB mounted in the enclosure:



# Specifications

## Measurements

The SWR and insertion loss measurements were done using a calibrated NanoVNA. The table shows the comparison with 2 units of the Version 1.0 model which I built and two units the Version 2.0 unit.

| Version 1.0 (Unit #1) | 50MHz | 144MHz | 222MHz | 432MHz |
|---|---|---|---|---|
| SWR (Radio to Antenna - TX Mode) | 1.0:1 | 1.02:1 | 1.09:1 | 1.79:1 |
| Insertion Loss (dB) | | | | |
| Radio to Antenna (TX Mode) | 0.03 | 0.10 | 0.26 | 1.20 |
| Antenna to Radio (RX Mode) | 3.13 | 3.36 | 3.92 | 4.13 |
| Antenna to SDR (RX Mode) | 3.15 | 3.30 | 3.60 | 4.90 |
| | | | | |
| Version 1.0 (Unit #2) | 50MHz | 144MHz | 222MHz | 432MHz |
| SWR (Radio to Antenna - TX Mode) | 1.01:1 | 1.07:1 | 1.16:1 | 1.86:1 |
| Insertion Loss (dB) | | | | |
| Radio to Antenna (TX Mode) | 0.03 | 0.09 | 0.27 | 1.31 |
| Antenna to Radio (RX Mode) | 3.13 | 3.33 | 3.62 | 4.40 |
| Antenna to SDR (RX Mode) | 3.14 | 3.32 | 3.59 | 5.25 |
| | | | | |
| Version 2.0 (Unit #1) | 50MHz | 144MHz | 222MHz | 432MHz |
| SWR (Radio to Antenna - TX Mode) | 1.14:1 | 1.16:1 | 1.17:1 | 1.54:1 |
| Insertion Loss (dB) | | | | |
| Radio to Antenna (TX Mode) | 0.08 | 0.14 | 0.34 | 1.22 |
| Antenna to Radio (RX Mode) | 3.11 | 3.27 | 3.55 | 4.81 |
| Antenna to SDR (RX Mode) | 3.13 | 3.21 | 3.42 | 4.24 |
| | | | | |
| Version 2.0 (Unit #2) | 50MHz | 144MHz | 222MHz | 432MHz |
| SWR (Radio to Antenna - TX Mode) | 1.01:1 | 1.06:1 | 1.18:1 | 1.86:1 |
| Insertion Loss (dB) | | | | |
| Radio to Antenna (TX Mode) | 0.05 | 0.16 | 0.44 | 1.42 |
| Antenna to Radio (RX Mode) | 3.11 | 3.33 | 3.62 | 4.91 |
| Antenna to SDR (RX Mode) | 3.13 | 3.20 | 3.49 | 4.25 |

I didn’t bother tabulating the measurements for the HF bands, but they are as good or better than the ones shown here for 50MHz in all 4 units.

As for power limits, I’m not sure! But the RTE24012F relays which handle the transmitter power are the same ones used in the Minikits EME220 preamps. Those preamps are advertised to be good for 500W when operated in switched mode.

Note that the splitter adds ~3dB to the insertion loss to both the radio and SDR in receive mode.

### Analysis

As expected, the numbers indicate that Version 2.0 is slightly better on the 70cm band, but not as much better as I expected! My only conclusion is that the limiting factors are either the relays or perhaps the layout of the PCB.

I noticed that in one version of the N2EME switcher, Paul is using real coax relays (2 of them). I priced them out and they are about $40 each; not sure if that would be worth the expense.

The material used for the PCB (FR4) might also be a factor. Other substrate materials with lower dielectric constants such as PPO, PPE or PTFE might be better although certainly more expensive.

## Suggestion Box

I welcome any suggestions for further improvements. Please feel free to email me at WA2FZW@ARRL.net.

## Bill of Materials

Here is a list of the parts you will need and in many cases, links to where you can get the less common parts.

There are hyperlinks to Mouser Electronics for some of the parts. Mouser has implemented a Captcha-like guard against robots. Thus, you can’t simply click on the links, but if you copy the links and paste them into your browser they work (at least they did when I wrote this).

There are also hyperlinks for some items available from Jameco Electronics. Jameco has recently instituted a $25 minimum order policy, so if you order from them, find some other stuff you need!

The total cost of all the major parts was less than $50 when I built it.

| | | |
|---|---|---|
| The PCB | | Gerber files are available on Github. |
| Front & Back Panels | | Gerber files are available on Github. |
| R1 – R3 | 680R 1/4W | |
| C1, C2 | 100nF 25V | |
| U1 | LCA-110 SSR | 6-pin DIP package; available from Mouser and other common suppliers |
| PS1A | Minicircuits ADP-2-1W+ Power Splitter | Available from Mouser. |
| D1 | 1N4002 | |
| D1 & D3 | General purpose LEDs (20mA) | Pick whatever colors you like. |
| D4 – D6 | 1N4148 | |

| | | |
|---|---|---|
| SW1 | SPST Toggle Switch | |
| K1 | DS2Y-S-DC12V | Available from Amazon |
| K2 & K3 | RTE24012F | Available from Mouser |
| J1 | Coaxial power receptacle | Available from Amazon |
| J2 | RCJ-041 PCB Mount RCA Jack | Available from Mouser |
| J3 | SMA Female | Amphenol 901-144 or equivalent. |
| J4 & J5 | PCB/Panel Mount BNC Female | Available from Amazon |
| | F-F bulkhead SMA connector and short M-M SMA cable. | The short cable connects the female SMA connector on the PCB to the F-F connector mounted on the rear panel. A right-angle adapter makes the connection a bit neater. |
| Enclosure | | Extruded aluminum from Amazon. Gerbers for the front and back panels assume this specific enclosure. |