FT-891 Amplifier/Preamp Sequencer
Version 1.1
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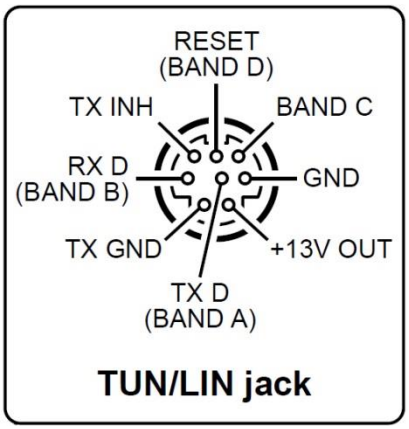
Introduction

This document describes a sequencer used to switch a Heathkit SB-200 linear (or pretty much any other) amplifier and an antenna mounted receive preamplifier that I use with my Yaesu FT-891 radio. My SB-200 has been converted for 6 meter operation only and the particular preamp I'm using is also for 6 meters.

Although designed specifically for the FT-891, it should work with any Yaesu radio which has the same *TUN/LIN* mini-DIN connector arrangement:



Additionally, it will probably work with any linear amplifier and with any preamp that relies on being switched based on whether or not it is receiving power (13 volts in this device).

Why would one need such a device you might ask? The preamplifier I'm using is the EME220-6M from Mini-Kits in Australia[1]. It has an RF sensing circuit built in that can switch it from receive mode to transmit (bypass) mode however, that circuit can only handle 100 watts; my SB-200 puts out about 400 watts, thus it is necessary to switch the preamp into transmit mode before sending all that power through it. Also note that this specific preamp is only rated to 500 watts even when sequencing is used.

[1] As Mini-Kits does not provide the schematic or manual for the preamp online, I can't provide a link to that, and for copyright reasons, can't insert it here.

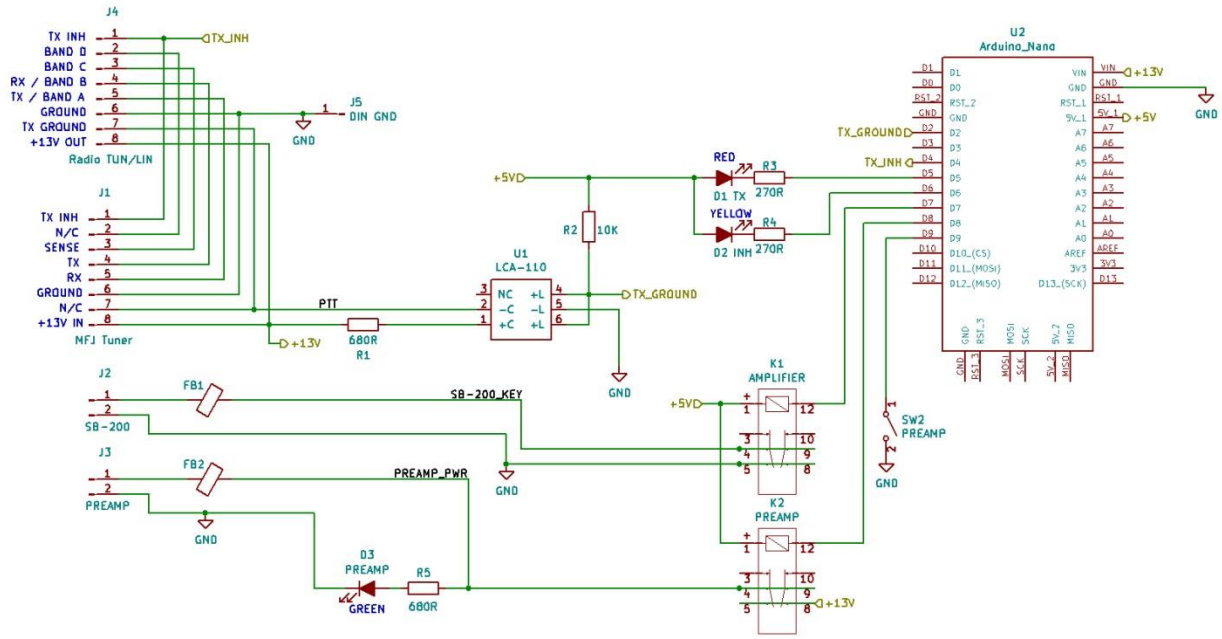
The FT-891 makes the solution to the problem rather simple. Notice one of the pins on the *TUN/LIN* connector is labeled *TX INH*. Applying +5V to this pin prevents the transmitter from producing power regardless of the state of its PTT line (*TX GND* on the connector).

If your radio doesn't have this capability, this device probably won't work as designed.

The Hardware

The hardware consists of a printed circuit board (PCB) containing an Arduino Nano (or clone) processor, a couple of relays, a solid state relay (SSR), a few resistors and three LEDs (which could be mounted on or off the PCB).

Here's the schematic:



The board is powered from the radio's *13V OUT* line on the *TUN/LIN* connector. The *TX GND* operates U1, which is an LCA-110 SSR to provide isolation between whatever voltage might be on that line in receive mode and the processor.

Relays K1 and K2 are used to key the amplifier (my SB-200 has been modified to have a low voltage keying input as opposed to the original 110V arrangement) and provide power to the preamp respectively.

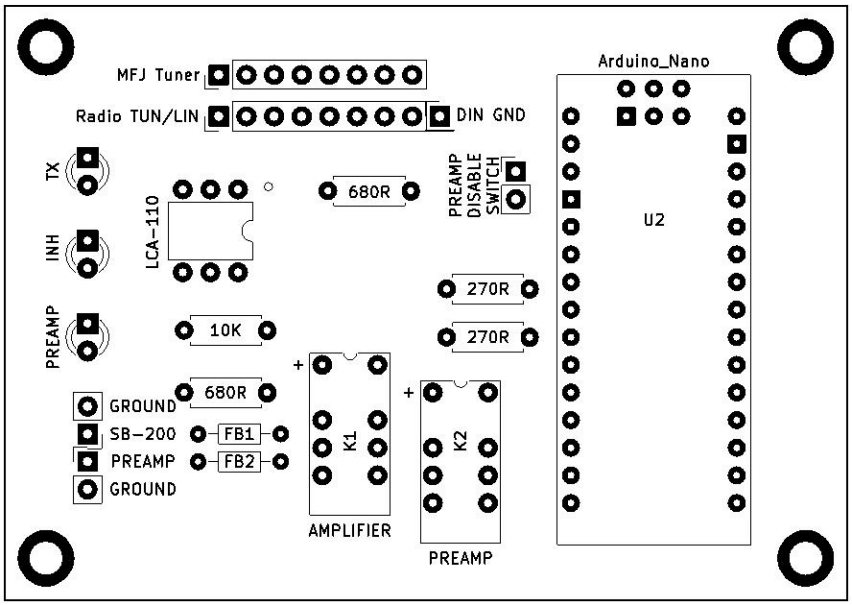
The LEDs indicate when the radio's PTT line is active (red), when the *TX INH* is active (yellow) and when the preamp is in receive mode (green). The transmit and inhibit LEDs are operated by the software in the processor but the preamp LED is operated by the relay which supplies power to the preamp in receive mode providing a positive indication that power is actually being sent to the preamp.

SW2 allows the preamp to be disabled (always in bypass mode).

J1 and J4 provide a means to connect 8 pin mini-DIN jacks like the one on the back of the radio. This allows the radio to also work with the Yaesu tuners or the MFJ-969Y tuner which I use on HF. If you don't need the capability to operate an automatic tuner, you need only connect the radio. Also note that even though the pads on the PCB are labeled as being for the radio and the tuner, there is no difference; in other words, either device can be connected to either pad.

The *DIN GND* pad on the PCB provides a convenient place to connect a ground wire that goes to the shell grounds on the mini-DIN connectors, the connectors for the amplifier and preamplifier (I used RCA jacks) and the ground side of the preamp enable/disable switch.

Here's what the printed circuit board looks like:



If you use the same mini-DIN jacks as I used, here's the color codes and pin names used by Yaesu and MFJ for the various pins:

Pin	Color	FT-891 Nomenclature	MFJ-939Y Nomenclature
1	Red	TX INH	
2	Orange	RESET (BAND D)	
3	Yellow	BAND C	
4	Green	RX D (BAND B)	TT/KY/TX
5	Blue	TX D (BAND A)	TS/ST/RX
6	Black	GROUND	GROUND
7	White	TX GROUND	
8	Brown	+13V OUT	Power In

The Software

GPIO Pin and Other Symbols Defined

The following are the GPIO pin assignments; for the most part, the symbols used match the net names on the schematic:

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TX_GROUND     2       PTT Indication (interrupt capable)
TX_INH        4       Transmit inhibit output to the radio
TX_LED        5       Transmit indicator LED
TX_INH_LED    6       Transmit inhibit LED
AMP_RELAY     7       Operates the SB-200 relay
PREAMP_RELAY  8       Operates the preamp relay
PREAMP_SWITCH 9       Preamp enable/disable switch
```

There are several definitions of states for the various GPIO pins, for example:

AMP_ON	LOW	A LOW on the *AMP_RELAY* pin keys the SB-200
AMP_OFF	HIGH	

Those definitions are followed by definitions for the time delays needed in the sequences to switch from receive to transmit and vice-versa; the numbers are microseconds and are based on actual measured switching times plus rather large fudge factors; for a different amplifier and/or preamp, these might need to be adjusted:

AMP_ON_DLY	50	Delay between turning the amplifier on and releasing the transmit inhibit line.
AMP_OFF_DLY	50	Delay between turning the amplifier off and returning the preamp to receive mode.
PREAMP_ON_DLY	25	Delay time between switching the preamp to transmit mode and keying the amplifier.
PREAMP_OFF_DLY	100	Currently not used

There are only three global variables:

txState	Current transmit/receive state
oldTxState	Previous transmit/receive state
preampEnabled	True when the switch is in the enable position

Overall Functionality

The software is pretty trivial. The *setup* function sets up all the GPIO pins used and sets them to the proper initial states. Note that there is a specific order in which those are handled that should prevent accidently hitting the preamp with any power before the *setup* is complete.

At the end of the *setup* function is a call to the *TestLEDs* function which is normally commented out. If the function call is un-commented, that function will cycle through all the possible states at 2 second intervals, which allows one to test the operation of the device. It must be connected to the radio or another source of 13V power in order for the preamp LED to light or for power to be provided to the preamp.

The *loop* function really only does two things; it first calls the *SwitchPreamp* function which may or may not switch the preamp into receive mode. I'll explain that function in more detail momentarily.

Next, the *loop* function looks for changes in the transmit/receive state of the radio and if the state has changed, executes the appropriate sequence of operations to initiate the state change.

The *SetTransmit* and *SetReceive* functions perform the state change operations by turning things on or off with the appropriate delays between operations.

The *TxInterrupt* function is executed via a hardware interrupt anytime the transmit/receive state of the radio changes and simply sets the *txState* variable as appropriate.

The *SwitchPreamp* Function

This function perhaps deserves a bit more explanation than the other functions. It takes one argument which is the new preamp state requested (*PREAMP_RX* or *PREAMP_TX*).

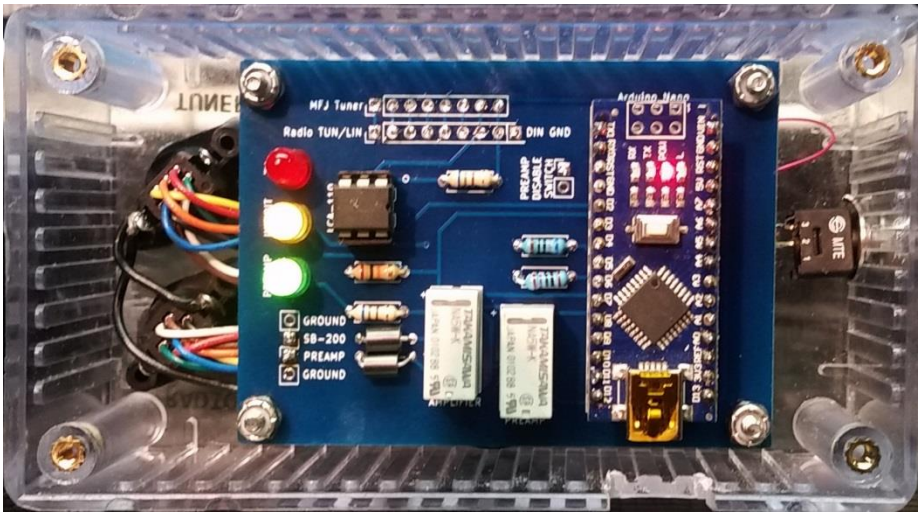
When the argument is *PREAMP_TX*, the preamp will always be put into transmit (bypass) mode.

However, if the argument is *PREAMP_RX*, the preamp will only be switched into receive (active) mode if the preamp enable switch is in the enabled position and the PTT is not currently active (*TX_OFF*).

Construction

I built the unit into a Hammond 1951C plastic project box. These are not only available from Amazon, but most of the common component suppliers stock them as well. I actually got mine at a local electronics store (yes, a few of those still exist).

Here’s the front view of the completed unit in receive mode:



You can see the mini-DIN connectors for the radio and the tuner mounted on the rear side of the box on the left and the preamp enable/disable switch on the right. Not visible under the circuit board are the two RCA jacks for the amplifier and preamp connections.

Some Operational Notes

Preamp Overload Protection

My preamp contains circuitry to protect it from strong nearby signals (in-band or off-band). If you use a preamp without such protection, it is important that the enable/disable switch be use to put yours into bypass mode before using a different nearby transmitter and/or antenna. I do this even though my preamp has the protection circuit.

Digital Mode Inhibit Workaround

As mentioned in the *Introduction*, the usability of this device depends on the fact that the Yaesu FT-891 has the transmit inhibit capability. But if you are working digital modes using WSJT-X, there is a way of using this without the inhibit capability.

Under the *Settings* menu - *Advanced* tab in WSJT-X, there is a setting for “Tx delay”. The default setting for this is 0.2 seconds and what it does is delay the actual start of the transmitted output for that amount of time after the radio is keyed. 0.2 seconds is plenty of time for the preamp and amplifier to switch modes before any power is transmitted.

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:

R1,R5	680R 1/4W	
R2	10K 1/4W	
R3,R4	270R 1/4W	
FB1,FB2	BL01RN1A1D2B	Available from Mouser
U1	LCA-110 SSR	6-pin DIP package; available from Mouser and other common suppliers
U2	Arduino Nano	I used clones which are much cheaper than genuine Arduinos.
D1-D3	General purpose LEDs – 20mA	Pick whatever colors you like!
SW2	SPST Toggle switch	
K1,K2	Fujitsu NA5W-K DPDT relay	Available from Jameco
J1,J4	8-pin male header	Optional – I hardwired the mini-DIN jacks to the PCB
	2 mini-DIN jacks	CUI Devices MD-80PL100 – Available from Mouser
J2,J2	2-pin male header	Or you can use a single 4-pin male header; again, I hardwired the amplifier and preamplifier connectors
J5	Just a pad really	A place to connect a ground wire for the mini-DIN shields and the RCA jacks
	2 RCA Jacks	Or whatever you like as connectors for the amplifier and preamp

	Box	I used a Hammond 1591C. They are available from Amazon and some of the other usual suppliers.

Suggestion Box

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