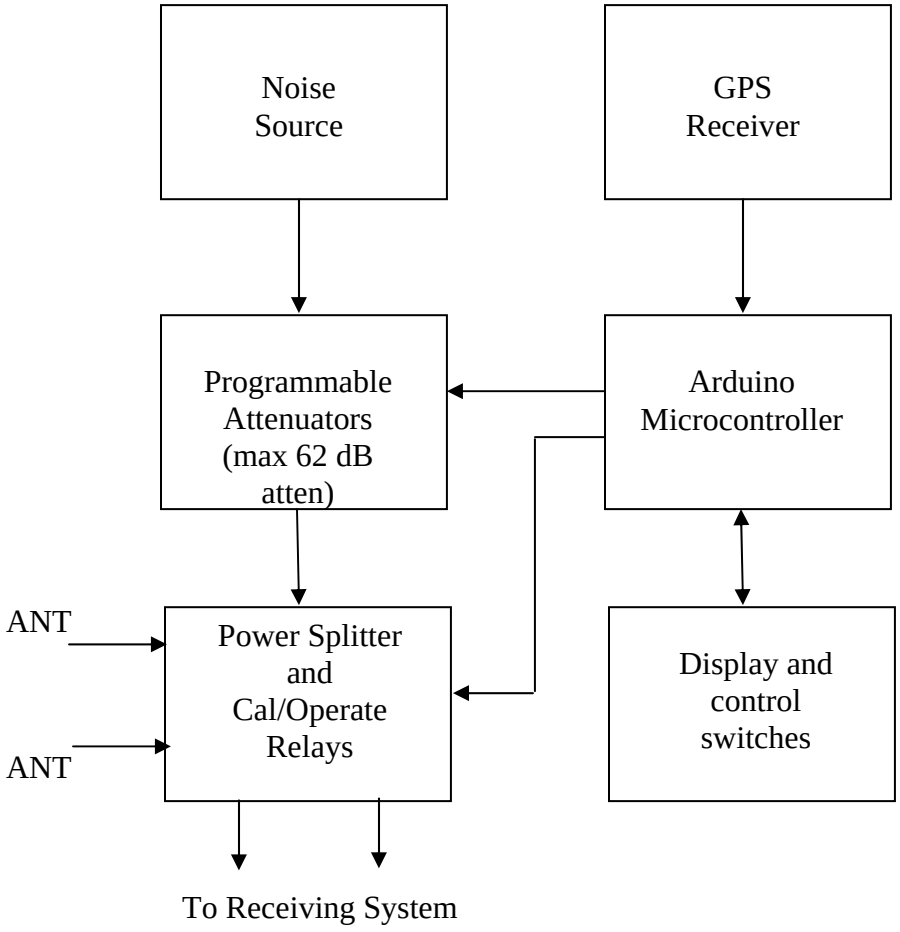
HEC / SUG

Automatic Calibrator
FBX-100

June 2017

HEC / SUG AutoCalibrator

This unit is designed for amplitude calibration of dual polarization instruments such as the FSX series and the SDRPlay2 radio spectrographs. For dual polarization systems the antenna inputs to the calibrator will either be RCP and LCP (if the calibrator is located between the polarization hybrid and the receiver) or EW and NS if the calibrator is located between the antenna and the hybrid. The unit can also be used to calibrate single polarization spectrographs and receivers.



The maximum temperature available at the output of the calibrator is 100 megakelvin (MK).

Calibration Sequences
The calibrator generates a sequence of noise temperatures in 3dB steps, dwelling at each temperature for either 5 or 10 seconds. Calibration will occur automatically at 00:05H UT and 12:05 H UT, and can also be initiated manually.

Manual Operation
There are two front panel switches that control the calibration range and dwell time at each step. The **range** switch is on the left and the **dwell time** switch is on the right.

The **dwell time** is controlled by a two position toggle switch labeled **F** (for Fast) and **S** (for slow). The fast cal dwell time is 5 seconds per step and the slow dwell time is 10 seconds per step. Set the desired dwell time before initiating the cal run with the range switch..

The calibration **range** is controlled by a center off momentary switch labeled **J** (for Jupiter) and **S** for the Sun. The maximum temperature for the Jupiter cal is 800 kK and the maximum temperature for the Sun cal is 100 MK.

When the range switch is toggled (just push it up or down and then release it – it will return to the center off position) the calibration sequence will start in 5 seconds.

For example, if you want to do a fast **S**un calibration you would first set the dwell to (**F**) and then toggle the momentary range switch to (**S**).

If you wanted to do a slow Jupiter calibration you would first set the dwell to (**S**) and toggle the momentary range switch to (**J**).

Each calibration begins and ends with a very low noise temperature (1kK), followed by the (approximate) 3dB sequence. The temperature being generated at each step appears on the display. When not calibrating the GPS time and date appear on the display.

Jupiter Range Calibration

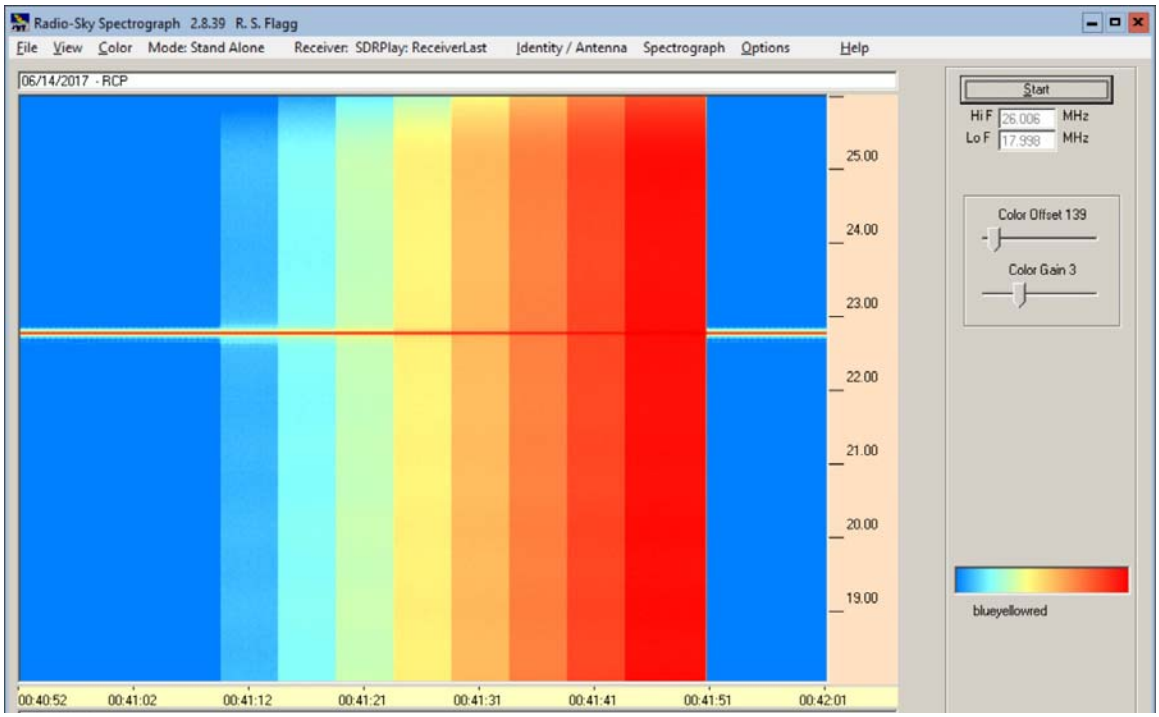
Step	Temperature
1	1 kK
2	6 kK
3	10 kK
4	22 kK
5	45 kK
6	90 kK
7	190kK
8	380kK
9	750kK
10	1 kK

The 10 steps of the Jupiter cal will take 50 seconds if you are doing a **F**ast cal or 100 seconds doing the **S**low cal

Solar Range Calibration

Step	Temperature
1	1 k Kelvin
2	6 kK
3	10 kK
4	22 kK
5	45 kK
6	90 kK
7	190kK
8	380kK
9	750kK
10	1.5MK
11	3 MK
12	6 MK
13	12 MK
14	25 MK
15	50MK
16	100MK
17	1 k Kelvin

The 17 steps of the Solar cal will take almost 1.5 minutes if you are doing a Fast cal or almost 3 minutes doing a **S**low cal.



Fast Jupiter Cal on Radio Sky Spectrograph using an SDRPlay2

Automatic Operation
While you can do a manual cal at almost any time, the automatic cal feature runs continuously in the background on a fixed schedule. Based on GPS time the calibrator will automatically run a sun cal at 1205 hours UTC and a Jupiter cal at 0005 hours UTC every day.

Probably best not to try to do a manual cal during an automatic cal.

The dwell time used for these automatic cals depends on the dwell switch setting (**F**ast or **S**low).

Connections
Power
The 12 v power port requires 12v DC at 350 ma. The same Jameco 12 vdc wall wart power supply used for the Jove receiver is suitable (Jameco part number 162996).

USB The USB connection on the front panel of the unit is only used for program loading and is not used during normal operation.

GPS
A powered SMA port is available for the included external GPS antenna.
The 1 PPS pulse derived from the GPS receiver is available from the rear panel RCA jack. This is a 100 msec long, positive going, 3 volt pulse occurring once every second. The GPS antenna has a magnetic base so be careful where you put it. The antenna seems to work fine indoors.

Antenna Connections
BNC connectors are provided for input lines from the antenna (ANT) and output lines to the receiving system (RCVR). The ports are labeled (LCP or NS) and (RCP or EW). If the calibrator is installed between the hybrid and the receiver (if for example the hybrid is located in the field), then follow the RCP, LCP labeling. If the calibrator is located between the antenna and the hybrid, in which case you have access to the NS and EW antenna cables, then follow the NS, EW labeling.

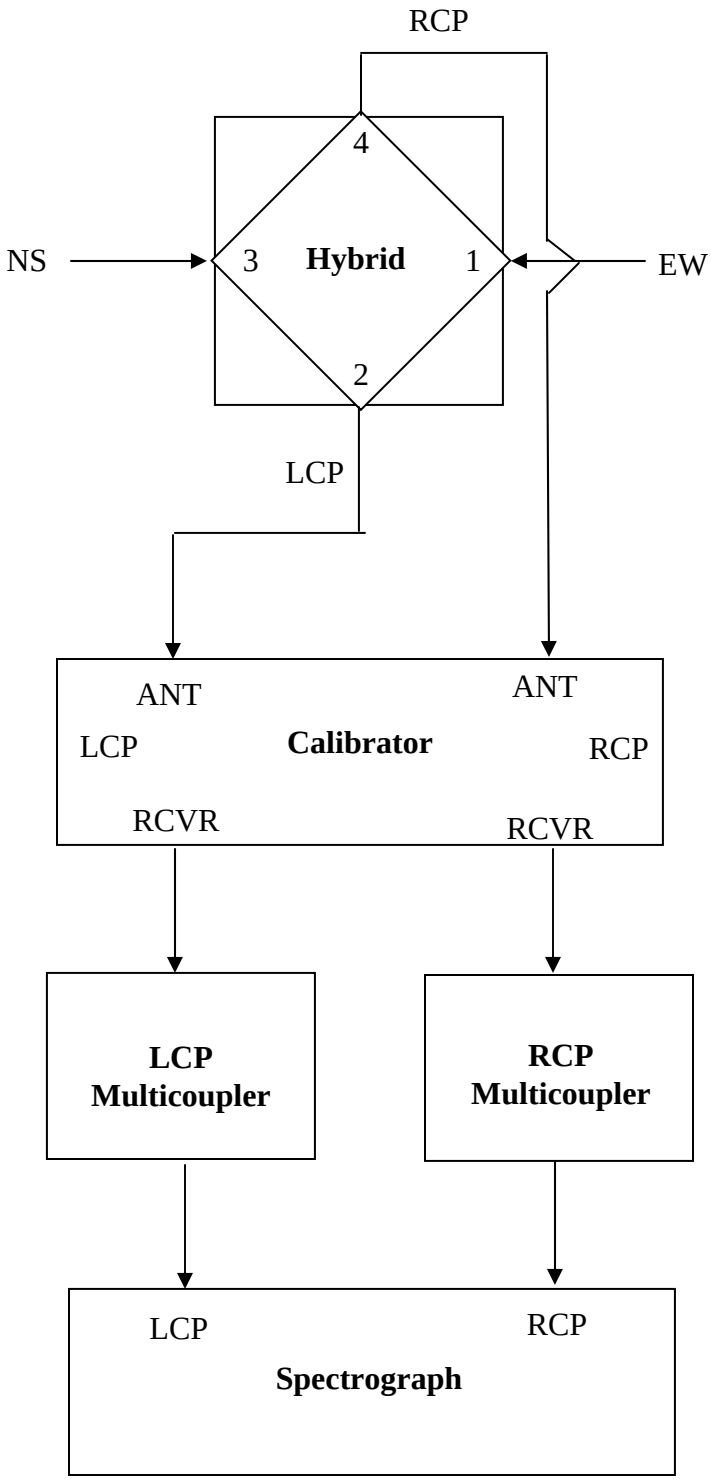
Two connection diagrams are provided – one for locating the calibrator in front of the hybrid and the other for locating the calibrator after the hybrid.

If the calibrator is located between the antenna and the hybrid then the two coax lines running from the calibrator RCVR ports to the hybrid must be the same length.

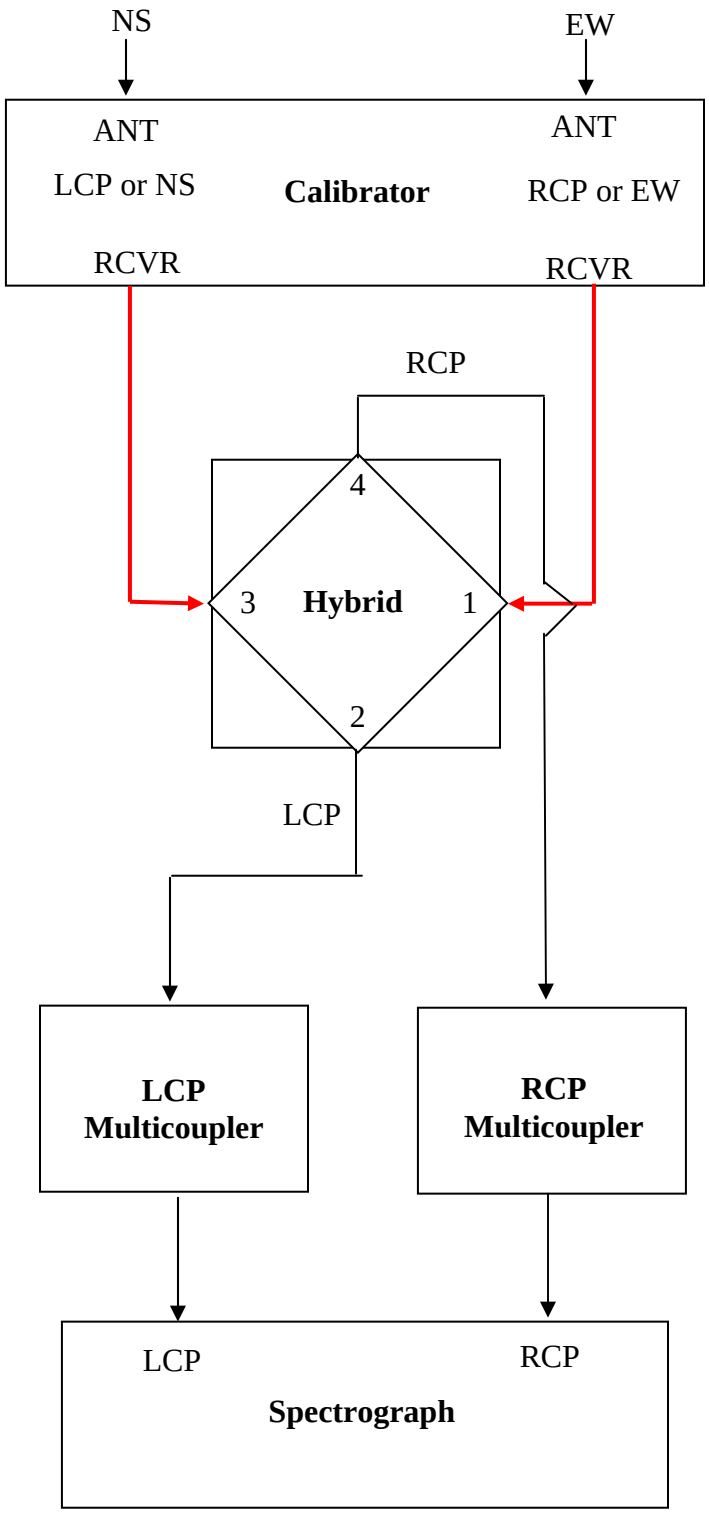
If the calibrator is located after the hybrid then coax lines running from the hybrid to the calibrator ANT ports may be different lengths.

The final option for using the calibrator is with a single polarization antenna. In this case you may connect the antenna to either the RCP or LCP side of the calibrator. A coax line of any length may be used to run from the RCVR port to the multicoupler or spectrograph. However, and this is **important,** the two receiver ports must both be terminated in 50 ohms. If you are using a single polarization antenna (with an SDRPlay 1 for example) then the unused RCVR port of the calibrator must be terminated in a 50 ohm BNC load.

Receiving System RF Connections for Hybrid in front of the Calibrator



Receiving System RF Connections for Hybrid after the Calibrator
(red color indicates the two cables that must be the same length)

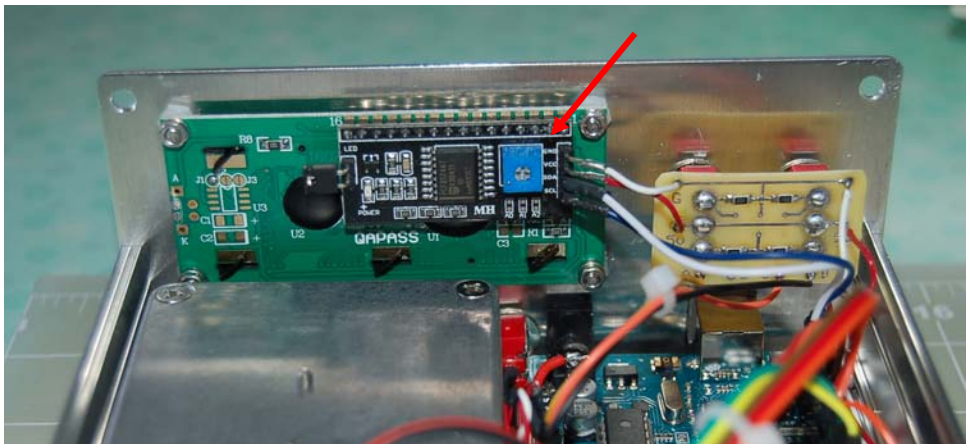


Performance
The calibrator noise source has been adjusted such that the maximum output temperature (at the RCVR port during a Solar cal)) is nominally 100MK.
The output temperature of the noise source itself is adequate to overcome the 5.5 dB losses in the internal attenuators and power splitter. Long term measurements (12 hours) of the calibrator have shown that the noise source drift in amplitude is less than +-0.20 dB from the average noise source temperature. The noise source has been adjusted to yield an average calibrator maximum output temperature of within +/- 0.25 dB of 100MK. The noise source itself has been measured to be flat across the 15-30 MHz frequency range to better than 0.25 dB.

Static discharge protection
Back to back diodes and a 10 K resistor from the calibrator antenna input ports to ground are intended to help protect the calibrator relays and following receiving equipment from static discharges. (this doesn't mean nearby lightning)

Power
Twelve volt power from the external power supply goes thru the front panel PWR switch. When the PWR switch is ON 12 volts is applied to the noise source and the Arduino microcontroller board. The noise source itself has internal voltage regulators. An onboard 5v regulator on the Arduino board provides 5 volts for the attenuators, relays, and display. No fusing of the 12 v supply is provided. It is up to the user to provide fuse protection if they so desire.

Display
The intensity of the LCD display can be adjusted with a small Philips screwdriver. To access this adjustment you need to remove the four metric (M4) screws which attach the top cover to the front and rear panels. The blue trimpot adjustment is seen below on the right center of the rear of the display board. I have seen the display blank out when touched so it may be sensitive to a static charge. Petting the cat and touching the display is therefore not recommended.



Blue trimpot intensity control on the rear of the display board.

Getting Started

1. Connect the GPS antenna to the SMA jack on the rear panel.

2. Connect a suitable source of 12 v power to the rear panel jack.

3. Turn the unit on. You will notice that within several seconds the display will show the correct universal time in HH:MM:SS format. It takes several seconds, maybe a bit longer for the GPS receiver to acquire and process GPS signals. After you have run a manual calibration once or twice or gone thru an automatic calibration you will see that the display has updated to show not only the time but also the date.

This calibrator was developed for the NASA HEC grant program – specifically for use with radio spectrographs operating in the 15 to 30 MHz frequency range. Software was written by Jim Brown and hardware fabricated by RF Associates LLC.