MK2 CALIBRATOR MANUAL

October 2020

Using the MK 2 Calibrator

The MK2 calibrator and Radio-Sky Spectrograph work together to allow two important new functions:

1. The observer can read antenna temperatures from the RSS display in review mode.
2. The observer can optimize SDR control settings such as those in the SDRPlay2RSS interface

Overview – The MK2 and measuring antenna temperature.

The MK2 contains an Arduino microcontroller and a programmable noise source which determines the temperature generated by the unit.

The MK2 is connected in-line between the antenna and the spectrograph (or multicoupler). In the *operate* mode the antenna is connected thru the MK2 to the spectrograph. In the *calibrate* mode the antenna is disconnected and the programmable noise source is connected to the spectrograph.

When a new file is started in RSS the MK2 will start a calibration sequence. This disconnects the antenna and steps the programmable noise source thru 16 known noise temperatures in 3 dB steps. The calibration temperature sequence information is stored in RSS and used by RSS to evaluate temperatures in the data file. The operator simply selects and loads the data file and in review mode points to any feature on the spectrogram and with the mouse and the temperature of the feature is computed and displayed.

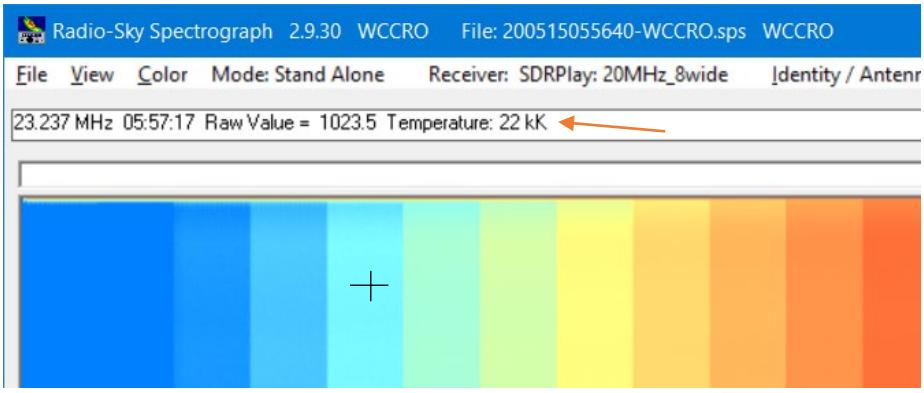

Figure 1. RSS display showing the temperature readout.

SDR control adjustment

The MK2 can be used as an aid in adjusting the software controls for the SDRPlay RSP2 and possibly other SDRs. This utility has been used successfully with Nathan Towne's SDRPlay2RSS interface to RSS. The goal in adjusting the numerous software controls is to achieve both good sensitivity and a good dynamic range.

The control interface for SDRPlay2 RSS is seen in Figure 2. The controls used to adjust sensitivity and dynamic range include Gain Reduction, Offset, and Gain.

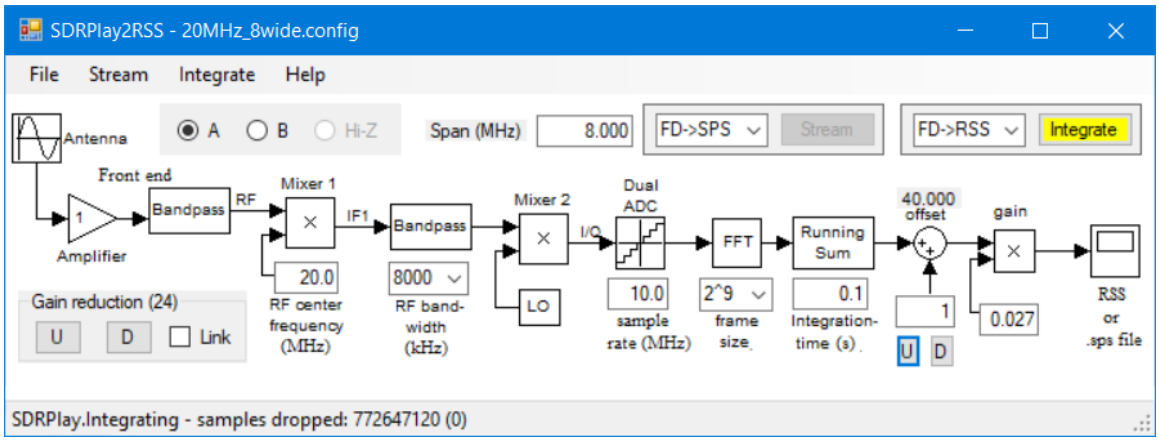

Figure 2. Control interface for Nathan Towne's SDRPlay2RSS

The plot in Figure 3 shows the response of an SDRPlay2 when the controls have been properly adjusted. The horizontal axis represents antenna temperature, (signal strength) increasing from left to right. The vertical axis represents the response of the spectrograph analog to digital converter with the maximum permissible count (4092 for the 12 bit ADC) at the top. As the temperature increases the ADC count increases linearly up to the point where the curve begins to flatten. The lower left point represents the level of the galactic background, while the curve flattening on the upper right represents saturation of the instrument. The linear dynamic range is on the order of (42-9 = 33 dB) which means that the instrument is capable of operating from a few kilo kelvin up to about 10 mega kelvin.

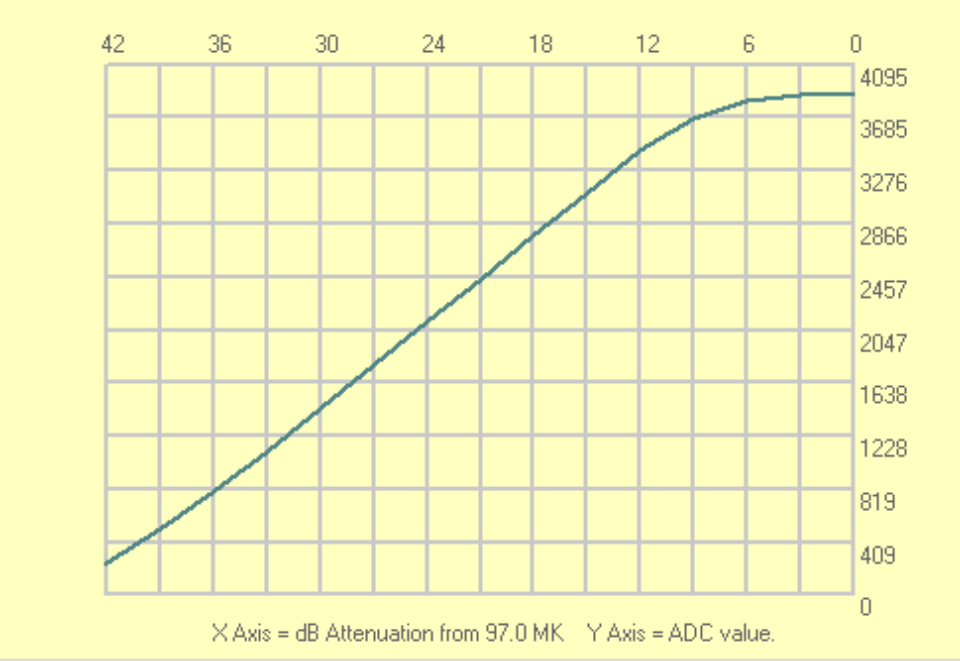

Figure 3. Dynamic range plot of a spectrograph receiver.

The MK2 Control Panel

As of May 2020 the two spectrograph instruments being used at SUG stations are the FSX and the SDRPlay RSP2. The FSX has no user controls, while the RSP2 requires that several software controls be adjusted for optimum performance. The purpose of the plot is to aid in adjusting those controls.

The Calibrator Panel (Figure 4) may be accessed under the View menu in Jim Sky's Radio Sky Spectrogram (RSS), version 2.9.30 or greater. This panel is used to control the new MK2 calibrator and also to display the dynamic range performance of the spectrograph.

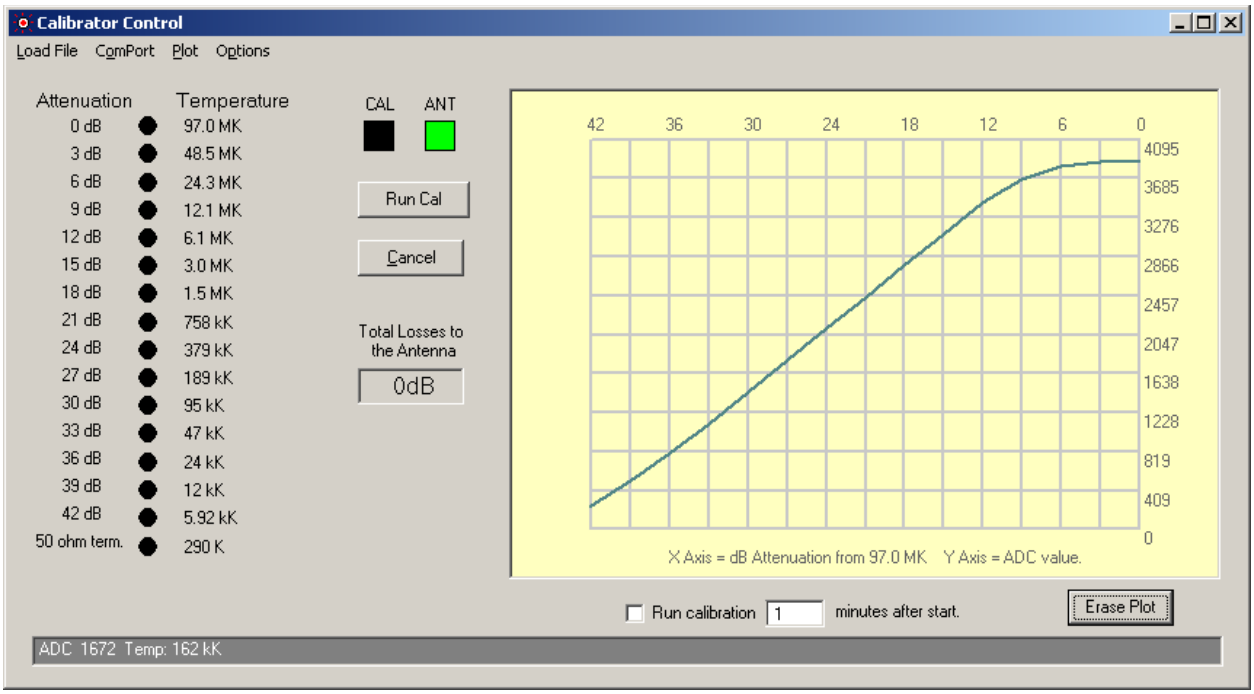

Figure 4. Calibrator Control Panel in RSS showing the response of an SdRPlay

The calibration sequence can be initiated both manually (clicking the Run Cal button) and automatically by selecting the Run calibration check box under the plot. *[On occasion you may need to click the Run Cal button twice]* The manual mode is used to set up the spectrograph software controls. The automatic mode is used during normal operations with the MK2 calibrating shortly after the beginning of each RSS data taking run.

On the left side of the control panel is a vertical display of calibration temperatures and the attenuations in decibels (dB) used to generate them. Note that temperatures are in 3dB steps and that the maximum temperature (in this example) is 97 MK (mega-Kelvin). When the calibration sequence is running, green lights indicate the current temperature and noise source attenuation. To reference the temperature to the antenna terminals in the field the attenuation between the antenna feed point and the MK2 must be entered.

During the calibration sequence the antenna is disconnected and the green ANT square is turned off and replaced by a green CAL indication. A green LED on the front panel of the MK2 is also illuminated. When the CAL sequence begins you may hear the CAL/ANT relays click into position.

It is important to enter the maximum available temperature of the noise source in your MK2. The rear panel decal shows the serial number and maximum available temperature in mega kelvin. This temperature must be entered using the Options pull down on the Calibrator Control Panel called *Set Calibration Point*. The somewhat inconvenient format requires that if your temp is say 103 MK that you enter 103000000. Also be sure to enter the cable loss in dB from the MK2 input to the antenna feedpoint, using the *Total Losses to Antenna* box.

Power and Control

The MK2 requires a 12 volt connection to power the internal noise source and a USB connection to the RSS computer. A USB A to micro USB cable is provided for the MK2 to computer link and a 12 vdc "wall wart" power supply is included with the MK2 instrument. Current drain of the noise source is about 200 ma.

The front panel power switch controls the 12 volt bus and provides power to the noise source and the Arduino. The USB cable must be connected to communicate with the RSS computer. The noise source requires at least 10 hours to stabilize and generate the temperature listed on the rear panel decal.

The com port setting in the Calibrator Control Panel (ComPort) must match the number found in your RSS computer Device Manager under Ports (COM &LPT).

RF Wiring

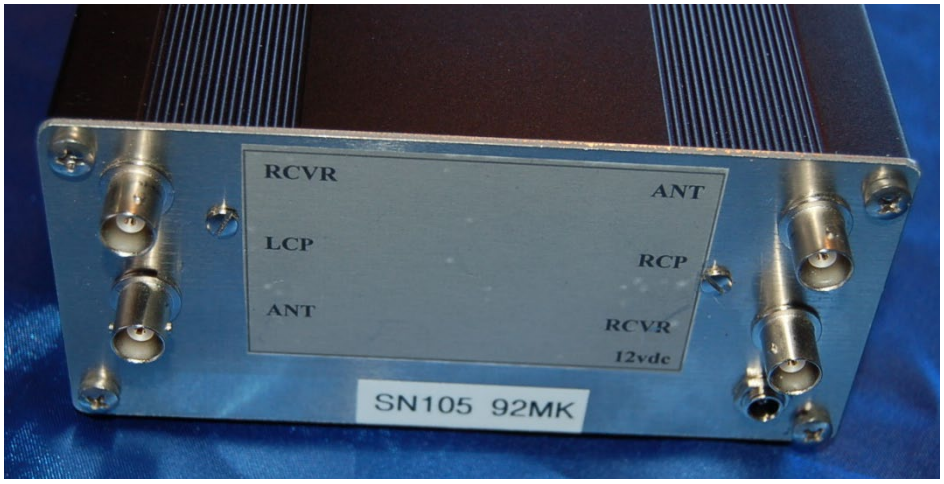

Figure 5 Rear panel of the MK2 showing antenna inputs and outputs to the spectrograph.

The 12 vdc input jack is in the lower right

The MK2 will function with either a dual polarization antenna such as the TFD or a single polarization antenna.

TFD Antenna

If the MK2 is installed between the hybrid and the spectrograph then the TFD cables are properly labeled LCP and RCP and match the labeling on the back of the MK2.

If the MK2 is installed between the TFD and the hybrid then the TFD cables are properly labeled EW and NS. In this case just be sure that the output wires from the MK2 go to the proper hybrid input ports. For example, if you connect the EW cable to the MK2 LCP ANT port then the LCP RCVR output cable will go to the hybrid port 1. Following this example, the NS cable would be connected to the MK2 RCP ANT port and the RCP RCVR output cable will go to the hybrid port 3.

Single Polarization Antenna

You can use either the left or right ANT and RCVR ports on the MK2, however you must terminate the unused RCVR port on the MK2 with a 50 ohm termination (50 ohm BNC male termination provided). If you are using the Ports labeled LCP for your single polarization cable runs then the 50 ohm termination must be on the RCP RCVR port.

Saving and Loading Files

RSS generates a CSV calibration file each time the MK2 calibrator runs. This file has a file name that matches the SPS data file and is saved in the same folder as the SPS file. When you load a data file for review the CSV calibration file is automatically loaded with it.

Quickstart Guide (assuming you are using an SDRPlay2)

Set SDRPlay2 Gain Reduction to 24, Offset to 40 and Gain to .027 for starters.

1. Connect 12 VDC to the MK 2 and the USB cable from MK2 to RSS computer.
2. If you are using WinXP computer, see step 11.
3. Turn ON MK2 front panel switch. For best accuracy leave MK2 on for at least 10-hour warm-up.
4. In RSS select the Calibrator Control from the View menu item.
5. Identify the Com Port number for the MK2 from the RSS computer device manager.
6. Set the MK2 Com Port to the same number.
7. Enter the temperature from the MK2 rear panel decal using Options> Set Calibration Point. Enter cable loss from MK2 input to antenna feed point.
8. With RSS collecting data from your spectrograph hit Run Cal. The MK2 will step thru the cal sequence. RSS will display increasing temperature colors on its display and generate a plot of ADC count vs signal strength in the calibration panel in the plot area
9. If the response curve is very different from that seen in figures 3 and 4 adjust SDRplay2RSS controls and run another manual cal to achieve the desired response curve.
10. Once you have the desired response stop RSS. Check the Run Calibration box under the plot area and restart RSS. Future data runs will now begin automatically with a calibration sequence allowing you to measure antenna temperature in RSS.
11. WinXP does not come with the USB driver needed to allow RSS to talk to the Mark II calibrator. However, it's quite easy to install. Download the WinXP versions of the driver here, unzip it, then run the x86 version of the driver's installer.

    https://www.silabs.com/products/development-tools/software/usb-to-uart-bridge-vcp-drivers

    Then go into device manger as usual and find the virtual com port for the Mark II's USB interface. That's the port number (i.e., 4) that needs to be entered in the RSS calibrator panel/window/dialog.

RS Flagg 19 May 2020