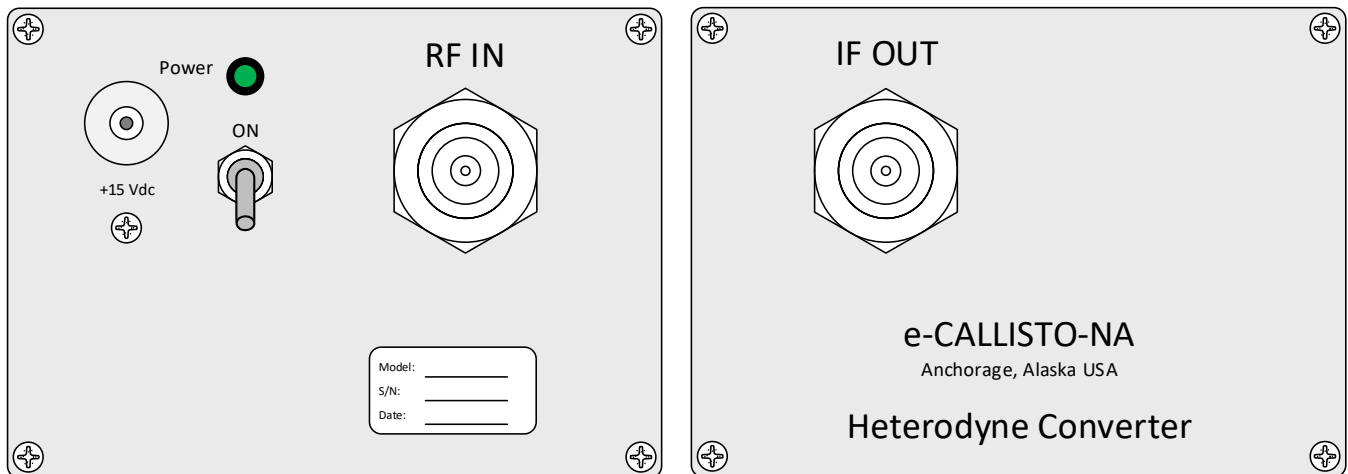


# UPC-1 Up-Converter Installation and Operation

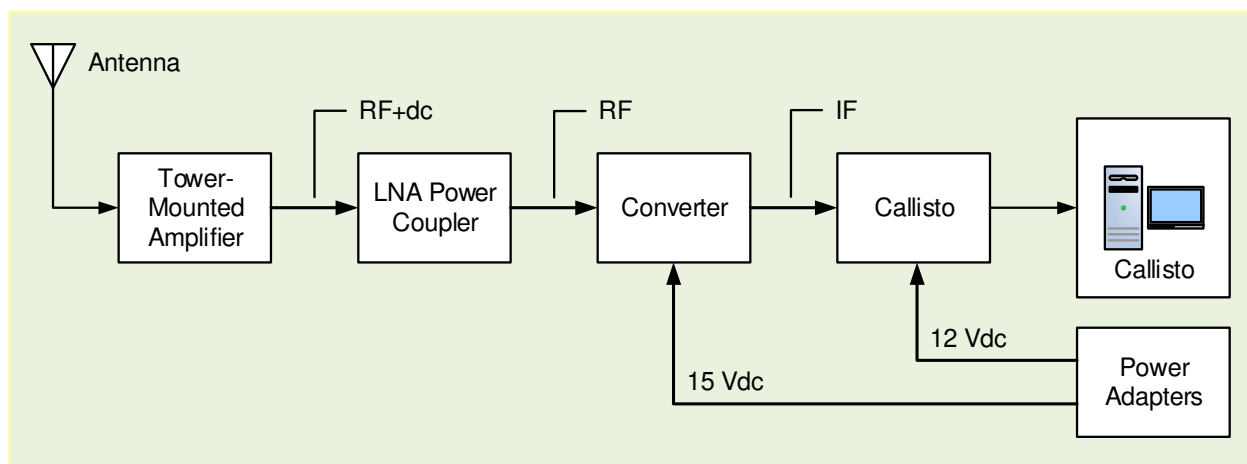
## 1. Description

The model UPC-1 is a heterodyne converter with 20 to 90 MHz RF input and 220 to 290 MHz IF output. It uses high-quality commercial RF modules and has internal regulated power supplies. The UPC-1 has the same form factor and is designed to be used with the Callisto instrument. Converters that are to be used with the LWA Antenna are factory modified to reduce the converter gain. These factory modifications are reversible as described in **Appendix I**. The factory modifications themselves are described in **Appendix II**.

The UPC-1 panel layouts are shown below. The front panel (left) has input connectors for power (2.1 x 5.5 mm coaxial jack) and RF from the antenna system (type N-female) and a power switch and power indicator. The rear panel (right) has an output connector for the IF to the receiver (type N-female).



The basic configuration is shown below. The up-converter provides approximately 16 dB conversion gain. A low noise preamplifier near the antenna (tower-mounted amplifier, TMA) will improve system sensitivity. The TMA-1 or TMA-2 tower-mounted amplifiers may be used with the UPC-1 up-converter (all TMAs are tested from 10 MHz to 1 GHz). The Converter is inserted between the LNA power coupler or bias-tee and the Callisto instrument.



# UPC-1 Up-Converter Installation and Operation

## 2. Installation

### Equipment location

The Converter should be placed in an indoor environmentally controlled location with a reliable source of power. It is recommended that the Converter be collocated with the Callisto instrument and connected to it with a short coaxial jumper cable.

### Power supply

The UPC-1 requires 15 to 17 Vdc input voltage. The power supply ac adapter should be regulated such that the input never drops below 15 V under all anticipated input and output conditions. The power supply should be high quality and electrically quiet with low ripple. It is recommended that ferrite beads be placed on the power supply lead at both the Converter end and power supply end. Clamshell beads will allow several windings of the power leads to be wrapped around the cores.

It is recommended that the power supply be rated 200 mA. The power supply output voltage (Converter input voltage) must be high enough to provide 15.0 Vdc at the Converter.

### Coaxial cable transmission lines and connectors

Coaxial cables can build up a static charge that, if allowed to discharge by connecting to equipment, may damage sensitive input circuits. To avoid such damage, it is recommended that static charges be dissipated by momentarily shorting the cable connector center pin and shield before connecting to the converter. This should be done carefully to avoid damaging the connector center pin.

All coaxial cables and connectors used with the UPC-1 converter must be 50 ohms impedance.

The LWA Antenna may be used with the UPC-1 converter. The LWA Antenna requires a power coupler (for example, the LWAPC or LWAPC-Q) and has a built-in preamplifier called Front End Electronics (FEE). The FEE has 2.7 dB noise figure and 35 dB gain. The coaxial cable that connects the LWA Antenna FEE to the power coupler may be 5 or 6 mm diameter and its length is not critical within reasonable limits. See LWA Antenna documentation for specific details on installing the LWA Antenna. The coaxial cable that connects the LWA Antenna power coupler to the UPC-1 generally should be  $\geq 10$  mm diameter and  $\leq 50$  m long.

For systems that do not use the LWA Antenna, the system noise figure is primarily established by the low noise preamplifier located near the antenna. Each 1 dB of cable loss between the antenna and a nearby low noise amplifier increases the system noise figure by 1 dB. Therefore, the cable and RF connectors between the antenna and the low noise amplifier must be of the best possible quality and as short as possible.

The cable between the antenna and Converter should be  $\geq 10$  mm diameter and  $\leq 50$  m long. If a longer cable is required, an intermediate amplifier with 10 to 15 dB gain should be placed at the output of the TMA. Similarly, the cable between the Converter and Callisto should be  $\geq 10$  mm diameter and  $\leq 50$  m long, and an intermediate amplifier used with longer cables. Use only the best possible quality RF connectors and cables.

## UPC-1 Up-Converter Installation and Operation

### 3. Software Setup

Before attempting to setup the Converter, refer to the Callisto **Software Setup Guide** for detailed instructions on using the Callisto software and the Frequency Genie software tool. Setup the Converter according to the steps below, while referring to the screenshots immediately following.

1. Connect all equipment; double-check all RF and power connections and power supply voltages
2. Apply power to Converter, Callisto and preamplifiers (Tower Mounted Amplifier). If the LWA Antenna is used, refer to the LWA Antenna instruction manual for connection and powering details.
3. Open callisto.exe and obtain a spectral overview (OVS) of the sky. This records the sky noise power at each frequency within Callisto's frequency range 45 to 870 MHz with 62.5 kHz resolution. This range includes frequencies within the up-converter IF output range. When finished with this step close callisto.exe
4. Open the Frequency Genie software tool and load the spectral overview from step 3
5. For the UPC-1 up-converter, setup Frequency Genie as follows.

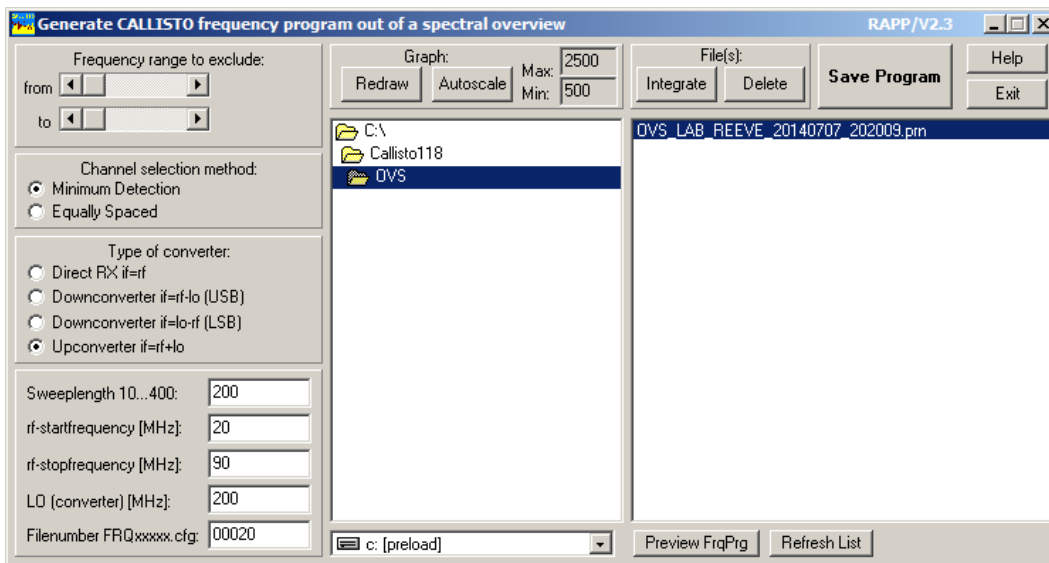
Channel selection method:	Minimum detection (see note)
Type of converter:	Upconverter (IF=RF+LO)
Sweeplength:	200
RF Startfrequency (MHz):	20
RF Stopfrequency (MHz):	90
LO (converter)(MHz):	200
Filename FRQxxxxx.cfg:	00000 to 99999 (example, 00020)

Note: To prepare a frequency list based only on equal spacing of the channels, select Equally Spaced; however, strong radio frequency interference (RFI) may exist on some channels and the frequency list with equal spacing may require manual editing.

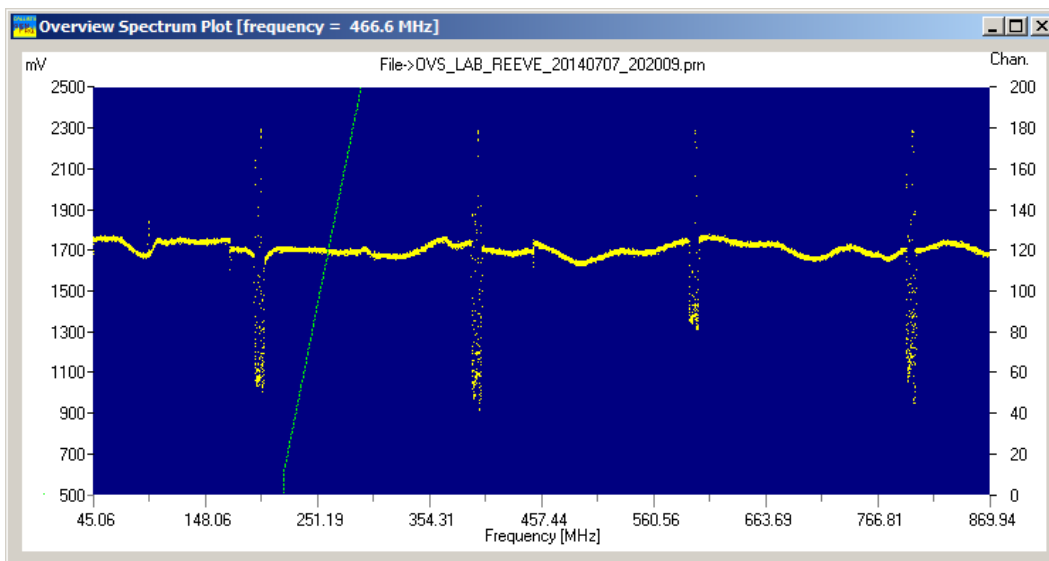
6. To view the frequency range on the Spectral Overview, click the Preview FrqPrg button on lower-right of the Frequency Genie main window. The programmed frequency range will be shown as a green slanted line
7. Click the Save Program button on the upper-right of the main window to generate the frequency list
8. Move or copy the frequency list file to the same folder as callisto.exe
9. Edit callisto.cfg parameter [frqfile] to use the frequency file from step 7. It may be necessary to reduce the Callisto gain parameter [agclevel] due to the gain of the up-converter. A new setting will have to be found experimentally and will depend on whether or not a preamplifier is used. Finally, change the focus code parameter [focuscode]; suggested code is 58.

## UPC-1 Up-Converter Installation and Operation

10. Edit scheduler.cfg for the desired observing schedule
11. Open callisto.exe. It will automatically load the new frequency file
12. If callisto.cfg is not setup for automatic execution, manually start the new observation. When the Automatic radio button is selected, Callisto will observe according to the scheduler.cfg file setup in step 10
13. On the callisto.exe main window, click on Spectrum  $y(f)$  to view the spectrum of the programmed frequency range

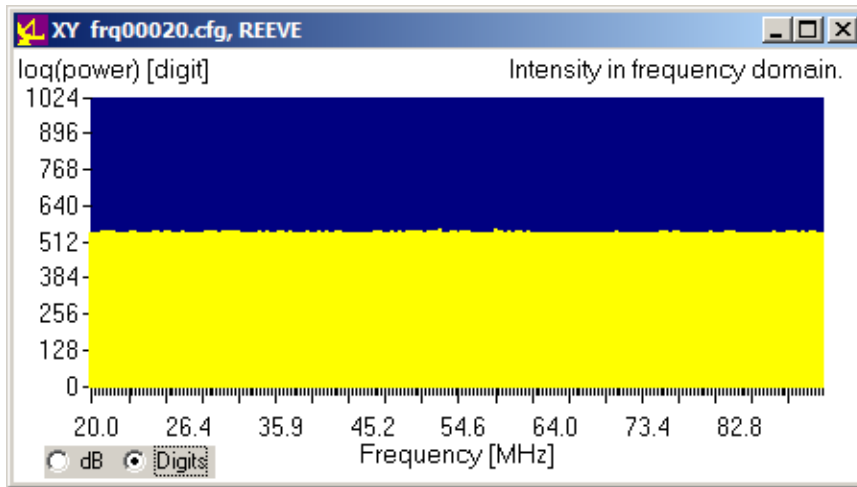


Frequency Genie main window showing setup for an up-converter with 200 MHz LO and 20 to 90 MHz RF input



Spectrum plot from Frequency Genie showing spectrum for the OVS. The slanted green line is the programmed frequency range. The spikes are LO leakage outside the programmed frequency range.

## UPC-1 Up-Converter Installation and Operation



Spectrum  $Y(f)$  plot from callisto.exe showing the frequency range 20 to 90 MHz for the UPC-1 up-converter with no signal input

```
frq00020.cfg - Notepad
File Edit Format View Help
-----*/
/* (C) Copyright Institute of Astronomy ETHZ 8093 Zurich */
/* Programname: FRQ00020.cfg [minimum of a spectral overview]*/
/* Revision: V2.2 Date: 7/7/2014 Autor: Chr. Monstein */
/* Purpose: Frequencyprogram for Callisto spectrometer */
/* all entries may be edited manually using Notepad... */
/*-----*/

[target]=CALLISTO

[on_line_testpoint_number]=100

[number_of_measurements_per_sweep]=200
[number_of_sweeps_per_second]=4

[external_lo]=-200.000000

[0001]=0020.000,0
[0002]=0020.000,0
[0003]=0020.000,0
[0004]=0020.000,0
[0005]=0020.000,0
[0006]=0020.000,0
[0007]=0020.000,0
[0008]=0020.000,0
[0009]=0020.250,0
[0010]=0020.375,0
[0011]=0021.063,0
[0012]=0021.125,0
[0013]=0021.500,0
[0014]=0021.938,0
[0015]=0022.438,0
[0016]=0022.625,0
```

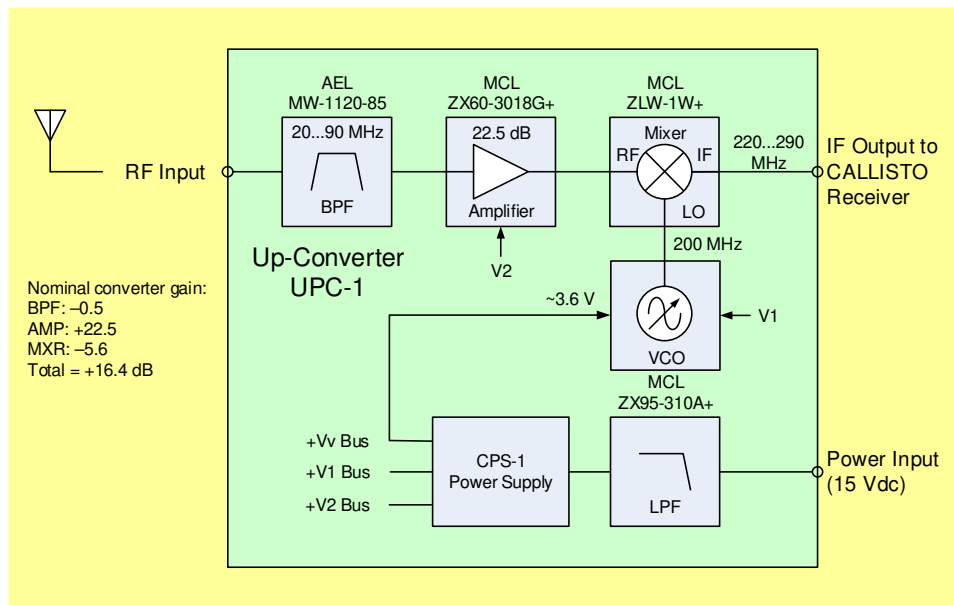
Part of an example frequency list generated by Frequency Genie with 200 channels/sweep between 20 and 90 MHz and local oscillator of 200 MHz

# UPC-1 Up-Converter Installation and Operation

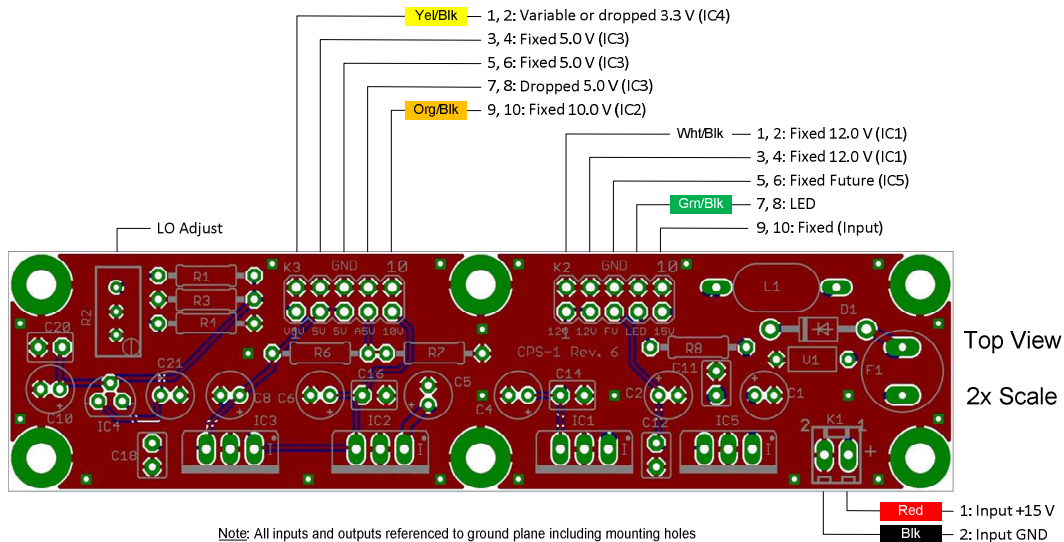
## 4. UPC-1 Up-Converter Description

### Block diagram

Refer to block diagram below. The RF input is first applied to a 20 to 90 MHz bandpass filter and then amplified approximately 22 dB by a low noise amplifier (typical noise figure 2.9 dB). A voltage controlled oscillator (VCO), tuned to 200 MHz, is mixed with the filtered RF input to provide an IF output range of 220 to 290 MHz. The mixer conversion loss is approximately 6 dB. Calculated and measured conversion gain is  $16 \pm 0.5$  dB across the band. The VCO may be adjusted to any frequency within the range of approximately 160 to 350 MHz, and the IF output will change accordingly (it is recommended that the VCO not be adjusted from its original setting of 200 MHz). A universal power supply printed circuit board (model CPS-1) uses linear low noise, low dropout voltage regulators and allows a variety of amplifiers and voltage controlled oscillators to be used in this and other converters. The variable supply for tuning the VCO is set to a nominal 3.695 V; the actual setting varies slightly among different VCO modules. R2 on CPS-1 is used to adjust the LO frequency.



### CPS-1 power supply PCB



## UPC-1 Up-Converter Installation and Operation

### Specifications (all values nominal)

- RF input frequency range: 20 to 90 MHz
- RF input connector: Type N-female
- IF output frequency range: 220 to 290 MHz
- IF output connector: Type N-female
- Input voltage: 15 ... 17 Vdc
- Input current: 100 mA maximum
- Input power connector: 2.1x5.5 mm coaxial jack (center positive +)
- Gain: 16 dB
- Dimensions: 168 mm long x 110 mm wide x 79 mm high
- Weight: 1 kg

## 5. Operation and Maintenance

### Operation:

All RF connections should be made to the Converter and receiver before the power supply is connected and turned on. Power is applied by toggling the power switch on the front panel to the UP position. Power is removed by moving the toggle to the DOWN position.

After the Converter has been in operation and if the coaxial cables need to be disconnected, the power switch should be turned off before disconnecting the coaxial cables.

### Maintenance:

The Converter requires very little periodic maintenance. Converter maintenance described below should be performed when performing regular maintenance on the Callisto instrument as described in the Maintenance section in the Callisto Construction Manual.

#### A. Monthly Preventative Maintenance

- ☀ Brush dust off the instrument being careful to not disturb the connections
- ☀ If additional cleaning of the enclosure and panels is required, use a damp cloth; DO NOT use any chemicals (or else the silkscreen may dissolve)
- ☀ Check condition of all cables and connectors

#### B. Annual Preventative Maintenance

- ☀ Check power supply voltage, 15 ... 17 Vdc
- ☀ Check local oscillator frequency,  $200 \pm 30$  kHz (measure at IF Output with a frequency counter) after > 2 h warmup. Do not adjust the LO unless it is out of tolerance. To adjust, remove the top cover and slowly turn R2 on the power supply PCB, CW to increase frequency and CCW to decrease frequency. The VCO tuning voltage power supply has a long time constant; adjust the frequency in very small increments and wait for the frequency to stabilize before adjusting again.

#### C. Internal RF connectors

- ☀ If internal RF connectors are loose or removed and replaced, torque them to 45 N-cm (4 in-lb).

## UPC-1 Up-Converter Installation and Operation

### Appendix I ~ Restore Modified UPC-1 Converter

The unmodified UPC-1 converter has an internal low noise amplifier and provides approximately +16 dB conversion gain. The LWA Antenna is an active antenna with 35 dB gain and 2.7 dB noise figure. Therefore, when the LWA Antenna is used with the UPC-1 and Callisto instrument, the internal amplifier in the UPC-1 is not required and the IF Output level must be reduced.

Factory modifications include disconnection of the UPC-1 internal amplifier (both RF and power) and insertion of a 20 dB attenuator in series with the IF Output. These modifications are made in the factory prior to shipment when it is known that the UPC-1 will be used with the LWA Antenna. Modified units are labeled "Modified for LWA Antenna". The modifications are done in such a way that they are easily reversible. The coaxial cables are left connected to the amplifier and the two conductors with socket terminal contacts for amplifier power are removed from the power supply connector.

The following steps are required to reverse the modifications:

1. Remove the UPC-1 top clamshell cover by removing the four screws in the upper corners of the two end panels. Set the cover and screws aside;
2. Remove the coaxial cable between the Mixer IF port and the Attenuator. Also remove the Attenuator and SMA-F coupler (female-female adapter) from the IF Output cable. The cable, Attenuator and adapter are no longer needed;
3. Remove the IF Output end panel by removing the two screws in the lower corners. Set the end panel and screws aside;
4. Remove the coaxial cable between the Filter output port (this is the port closest to the IF Output end panel) and the Mixer RF port. The cable is no longer needed;
5. Connect the cable on the IF Output connector to the IF port on the Mixer. Torque the connection;
6. Replace the IF Output end panel;
7. Connect the cable on the Amplifier Out port to the Mixer RF port. Torque the connection;
8. Connect the cable on the Amplifier In port to the Filter output port. Torque the connection;
9. Carefully remove the Power Connector from the K2 header on the dc Power Supply module. Remember its orientation (one end is painted red). Make a sketch of the Power Supply and Power Connector orientation for reference later. Do not disturb the connectors on K1 or K3;
10. Carefully remove the heat shrink tubing from the end of the white and black power conductors connected to the Amplifier. Be careful to not damage the socket terminal contacts while removing the tubing.
11. Examine the two socket terminal contacts. Locate and identify the small metal lip on one side of each contact;
12. Orient the contact on the white conductor so that the lip is pointed toward the outside of the Power Connector and slip it into position 1. Note the small window in the connector – the contact should click into position and the small lip should be visible in the window;
13. Repeat the previous step with the black conductor except place it into position 2;
14. Reconnect the Power Connector to the K2 header on the Power Supply module being careful to orient it the same as when removed. The black conductors on the Power Connector should be closest to the edge of the PCB. Check that the power connector on K3 has not been disturbed;



## **UPC-1 Up-Converter Installation and Operation**

15. Check your work and do not apply power until you are sure the Power Connector is connected properly to the power supply PCB header. Check that the connectors on K1 and K3 have not been disturbed;
16. Apply power and check the converter operation. If all is okay, replace the top clamshell cover;
17. When installing the top cover note that its sides are keyed where it mates with the lower clamshell.

## UPC-1 Up-Converter Installation and Operation

### Appendix II ~ Modification of the UPC-1 Converter for the LWA Antenna

To modify the UPC-1 converter from its original unmodified condition follow the steps below. These steps add a 20 dB attenuator on the IF output, disconnect the preamplifier on the RF input and disconnect the power leads for the preamplifier:

1. Remove the top cover;
2. Locate and remove the RF cable on the mixer RF input (labeled R). Do not remove the amplifier end of this cable;
3. Locate and remove the RF cable on the mixer IF output (labeled I);
4. Remove the rear end panel with the IF output connector and cable assembly;
5. Replace the N-female connector and cable assembly on the IF output panel with an N-female to SMA-female adapter;
6. Install a 20 dB attenuator on the IF output connector that was installed on the end panel in the previous step;
7. Locate and remove the RF cable from the bandpass filter output. Do not remove the amplifier end of this cable;
8. Loosely tie the two cables on the RF preamplifier input and output together with a cable tie and move them away from the power supply. If necessary, slightly loosen the connectors so the cables can be moved. Retighten the connectors if necessary;
9. Note orientation and remove the power connector from K2 on the dc power supply module. Release the tabs on the white and black wires in positions 1 and 2, respectively, and pull out the terminal contacts. Place 3/4 in long heatshrink over the terminal contacts and tie off. Reinstall the power connector on K2 (be sure of proper orientation). Check that the power connector on K3 has not been disturbed;
10. Locate a 150 mm long, RG-316 cable with SMA-Right-Angle-male connectors on both ends and install one end on the bandpass filter output;
11. Install the IF output end panel;
12. Locate a 150 mm long, RG-316 cable with an SMA-Right-Angle-male connector on one end and an SMA-Straight-male connector on the other. Install the right-angle connector on the mixer IF output (labeled I). Route the cable over the power supply, loop back and install the straight connector on the 20 dB attenuator;
13. Route the cable from the bandpass filter output and connect to the mixer RF input (labeled R);
14. Test and replace top cover.

# UPC-1 Up-Converter Installation and Operation

## Document information

Author: Whitham D. Reeve

Copyright: © 2014, 2020 W. Reeve

Revision: 0.0 (Original draft started, 2 Jul 2014)  
0.1 (Added images and screenshots, 7 Jul 2014)  
0.2 (Corrected block diagram and revised description, 14 Jul 2014)  
0.3 (Final edits prior to distribution, 7 Aug 2014)  
1.0 (Distribution, 7 Aug 2014)  
1.1 (Added panel layouts, 13 Aug 2014)  
1.2 (Added static warning, power supply current rating, Operating info, 25 Aug 2014)  
1.3 (Added focus code parameter, corrected Frequency Genie settings, 27 Aug 2014)  
1.4 (Added annual frequency check and PCB layout, 19 Sep 2014)  
1.5 (Added connector torque, 28 Sep 2014)  
1.6 (Added tuning voltage adjustment, 4 Oct 2014)  
1.7 (Minor additions, 23 Oct 2014)  
1.8 (Added Appendix I to restore modified converter, 09 Jul 2020)  
1.9 (Added Appendix II to modify converter, 14 Aug 2020)