WSPRSONDE

A simultaneous eight-channel WSPR/FST4W beacon system

Quick-Start Guide

Document Version 0.1
March 14, 2024

Table of Contents

Illustration Index

IMPORTANT!

The WS-8 (WSPRSONDE) is an experimental Amateur Radio device, and has not been submitted for formal FCC certification. When operated under normal conditions the WS-8 should comply with U.S.A. FCC requirements for harmonic and other spurious content, but the responsibility for proper operation is assumed by the operator.

In no event shall Turn Island Systems LLC be liable for any direct, indirect, punitive, incidental, special, consequential damages to property or life, whatsoever arising out of or connected with the use or misuse of our products. .

Ground-Loops and USB

At least in some cases, the WS-8 USB port will not work when directly connected to a USB 3.0 port. However, it will work with an intermediate USB hub (even a USB3 hub.)

The USB, power, and transmitter jacks all share a common ground connection. This can lead to ground-loop currents and USB failure. Using a non-grounded +12V wall-wart power supply will eliminate potential supply-ground problems. However, a computer/USB and antenna system common ground can also be an issue. Using a USB isolator (such as: https://www.amazon.com/HiLetgo-ADUM3160-Voltage-Isolator-Support/dp/B07235PR4V) will break any USB ground-loops.

In any case I recommend using a USB hub with a fairly short cable to the WS-8. The USB connection is required for initial WS-8 configuration, but is not necessary for operation.

For more information, contact us at https://turnislandsystems.com/

Changes to This Document

V 0.1: First draft

Introducing the *WSPRSONDE*

What it Does

- Simultaneously transmits WSPR, FST4W-120 or FST4W-300 signals on up to eight channels, on any frequency between 1 and 60 MHz (usually the 160 – 6 meter ham bands).
- Precise frequency accuracy and stability using external 10 MHz reference clock
- One Watt output power on each channel
- Flexible per-channel transmit scheduling, optional CW identification
- Can run with or without USB-connected computer

Why

- Propagation research

- General beacon station

Dimensions

The *WSPRSONDE* is housed in a 1RU (Rack Unit) enclosure:

19" wide x 1.75" high x 10.5" deep

It weighs slightly under five pounds.

Connections

All ports are on the WS-8 front panel. They are:

- Channels 1-8 Output - SMA jacks

- GPS Antenna – SMA jack

- GPS Auxiliary (antenna connection splitter output) – SMA jack

- Reference Clock Input (10 MHz) – SMA jack

- USB - type B

- T/R Switch control output – 1/8" mono/stereo jack

- Power - 5.5 x 2.1mm barrel jack

Power

The *WSPRSONDE* requires a 9-16V DC power source, and uses a 5.5 x 2.1mm barrel jack power connector, positive pin and negative sleeve.

Please review the **IMPORTANT!** Section of this document for a discussion of potential ground-loop problems.

Typical Power Consumption, all ports transmitting into filters with 50 Ohm load:

Vin	I_{DC}	Watts
12 V	1.5 A	18 W

A regular 9V or 12V "wall wart" DC power supply is usually adequate, but any source of clean DC power can be used. Supply switching noise is typically not a problem, as this input voltage is connected to a secondary internal regulator with distributed supply-noise filtering.

Transmit / Receive Switch Control

This 1/8" mono jack provides an isolated, polarity-insensitive contact-closure for an external transmit/receive switch. The "GND" in the figure below is not actually grounded, but rather the other half of the switch.
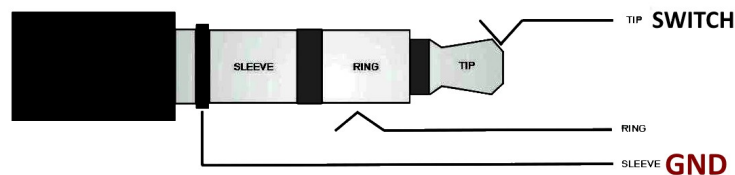
Illustration 1: T/R Switch Connections

GPS Antenna and GPS AUX

The WS-8 requires a connection to an external GPS antenna, either directly, or through a GPS antenna splitter. The WS-8 will provide 3.3V "phantom" power to the typical active GPS antenna.

The WS-8 GPS antenna port feeds an internal passive splitter, one output feeding the internal GPS receiver, and the other connected to the GPS AUX jack. This AUX jack can be used to feed an external GPSDO. This internal splitter has a 6dB loss, so low input levels may not provide enough signal for WS-8 or GPSDO operation. If an external splitter is used, it should probably be one with amplification.

10 MHz Reference Clock

An accurate and stable 10 MHz reference clock is required by the WS-8, with an input level

(sine or square-wave) between -10dBm and +20 dBm. A GPS Disciplined Oscillator is typically used. The REF CLK port provides a 50 Ohm termination.

If no reference clock is provided, the WS-8 will optionally still function, but at a greatly-reduced accuracy and stability. See the "CLK" command for configuration details.

USB connection (for configuration and monitoring)

The WS-8 USB port provides:

- A serial port connection used for monitoring and temporary configuration changes
- A "flash drive" style file access to the "commands.txt" configuration file
- A "flash drive" style file access used when updating the WS-8 program

The USB connection is required for initial WS-8 configuration, but is not necessary after configuration. No DC power is taken from the WS-8 USB port, so it must be provided through the power jack.

Please review the **IMPORTANT!** Section of this document for management of potential USB and other ground-loop problems.

Channels 1-8 Output

These SMA jacks are the outputs of the eight WS-8 channels. They provide a 1W square-wave signal, which *must* be passed through an appropriate filter before being connected to the antenna. While these outputs can be operated unloaded (no connection) they should not drive an impedance below 25 Ohms. Keeping the SWR at 2:1 or better is recommended. The amplifiers do have over-current protection, and will shut down when over-loaded. Should you see overloads, you may wish to increase the current-monitoring threshold. See the **OVER** command for details.

Output Filters or Filter/Combiner

Six-Band Filter/Combiner

The 6-Band Filter/Combiner has connections for 80, 40, 30, 20, 15, and 10 meters, with loss of about 1dB.

Configuring the WS-8, Step by Step

Status LED:

When USB or Power is connected to the WS-8 the multicolor Status LED will blink to show the current state:

- Solid Green : Initializing

- Slow Green on/off : No channels transmitting

- Blue with off-flash : One or more channels transmitting

- Red, one flash repeating : Amplifier power Voltage fault

- Red, two flashes repeating : Channel amplifier over-current

- Red, three flashes repeating : Loss of GPS

- Red, four flashes repeating : Input power supply fault

- Red, continuous flash : Loss of Reference Clock fault

-

Connect the +12V power source

Connect the USB Cable

A "Flash Drive" file window will probably pop up. If not, search for the drive (it will probably be named "WS-8 #(serial #)", but this name can be changed at will.)
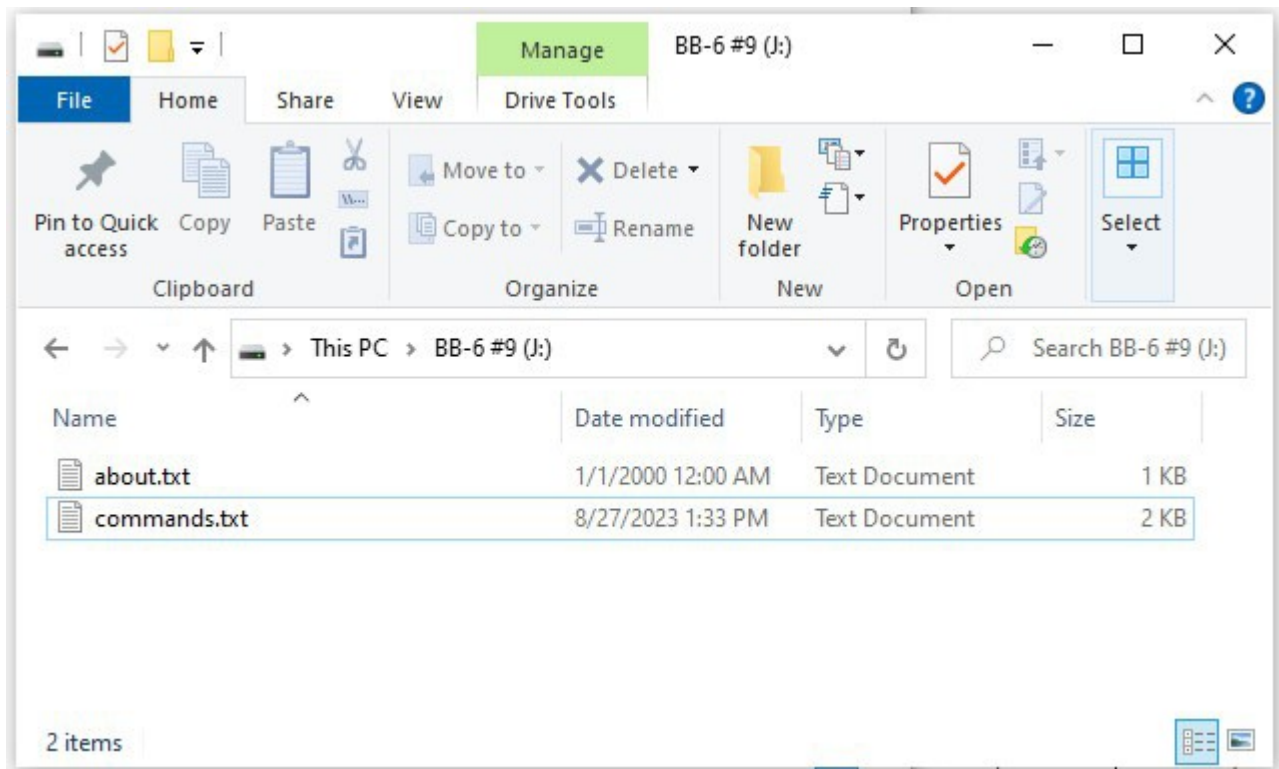
There will be at least two files shown:

- "about.txt" – This shows the 32-bit Controller Board ID, and the current program version.

- "config.txt" – This is the configuration file for the WS-8, and is read at power-up, or when the command "config r" (read the configuration file) is entered on the command line.
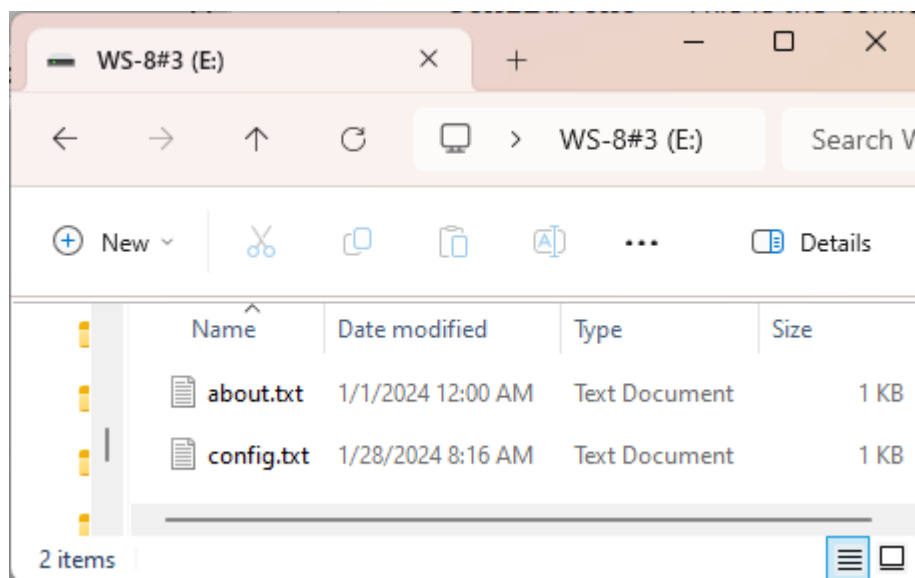
```
config.txt ●     +

File    Edit    View

mode f 120
call wb6cxc
freq 1 160 1450
freq 2 80 1425
freq 3 40
freq 4 30 1450
freq 5 20 1450
freq 6 15 1450
freq 7 10 1450
freq 8 6
sched all 1 1
sched 5 1 2
sched 8 r 4
report 1

Ln 12, Col 12  183 characters    100%    Window  UTF-8
```

```
about.txt ✕     +

File    Edit    View

WSPRSONDE-8
Board ID # 8b172539
Code version: v0.6.4
www.TurnIslandSystems.com

Ln 1, Col 1    80 characters    100%    Window  UTF-8
```

Edit the `config.txt` file as appropriate for your station. You can also type these commands in via the serial port command line interface, but any changes will not be saved. Once the configuration file is as you want it, either type "CONFIG R" (read the config file), or power off the WS-8 (unplug the power). When the WS-8 restarts it will read the updated `config.txt` file

Typical Configuration File [`config.txt`]

```
# this is a comment
# commands aRe NoT cAsE sEnSiTiVe
CALL [your callsign]
# GRID is optional; if not set the grid will be calculated using GPS position:
GRID [4-character grid]
# POWER is optional; if this is not set a power level of "30" (dBm / 1 Watt) will
be used:
POW [0, 3, 7, 10, 13, 17 ... 50, 53, 57, 60]
# See configuration commands for mode options, WSPR is default
MODE WSPR


# Sets channel 1 to the 80 meter WSPR band, 1400 Hz default effective tone:
FREQ 1 80
# Sets channel 2 to the 40 meter WSPR band, 1525 Hz effective tone:
FREQ 2 40 1525
# Sets channel 3 to 10.140000 MHz (10.138 MHz + 2000 Hz effective tone
FREQ 3 10140000


# setting all channels for continuous transmission
SCHED a 1 1
# setting channel 2 to transmit every other frame, starting at minute 00:
SCHED 2 1 2
# setting channel 3 for one out of four frames, randomized:
SCHED 3 R 4


# All channels are disabled at startup.  Turn them on:
ON all
# Turn off any unused channels
OFF 7
OFF 8


# Enable the serial port report of basic per-channel status
# at the start of each frame:
report 1
```

Updating the WS-8 Program

You can install a different version of the WS-8 program, found at
https://turnislandsystems.com/downloads/

On the command line, enter "`LOADNEW 1`", and the WS-8 will halt normal operations and enter the program update mode. A flash drive folder will pop up (or you may have to search for it):
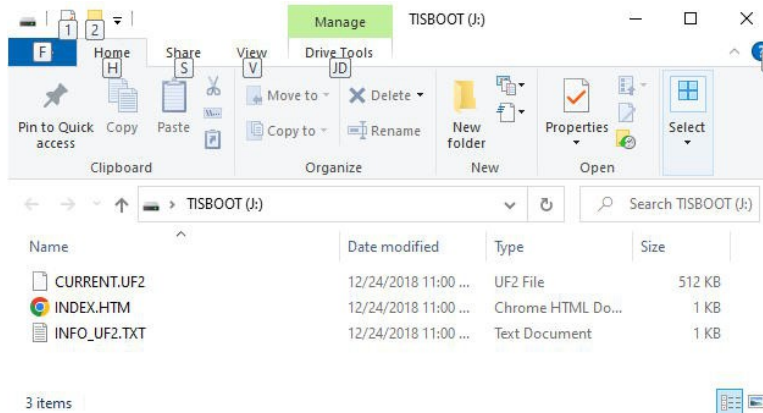
On a linux GUI, the drive might look like this:
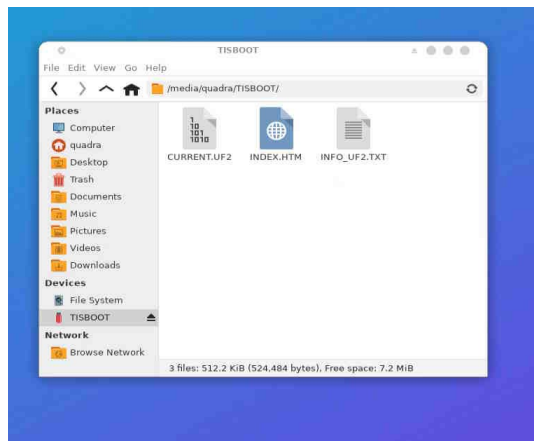
Just drag and drop the new ".UF2" file onto the drive window. The WS-8 will install the new program and reboot. Your configuration settings will not be changed.

Configuration Commands

Command List

To see the full list of available commands, type "?" or "??" in the command line.

These will change as the software evolves, but the basics will retain compatibility. All commands are completely case-insensitive.

In the following commands unless noted otherwise **[channel]** will be a value from 1 to 8.

Entering a command followed by a '?' will display help for that command.

Essential Commands

MODE [W/F] ([rate])

The MODE command sets the beacon mode: **W**SPR or **F**ST4W (you can type in "WSPR" or "FST...", only the first character is used. If there is no MODE command then the WS-8 defaults to WSPR mode.

`MODE WSPR` : Puts the WS-8 in WSPR mode.

`MODE FST4W` : FST4W-120 mode.

`MODE F 300` : FST4W-300 mode.

When the mode is changed, the WS-8 will re-configure all channel FSK rates and frequencies

CALL [callsign]

The callsign must be entered for the WSPR or FST4W frame data to be created. Only basic callsigns are supported.

`CALL wb6cxc`

GRID [four-character grid square]

This optionally sets a fixed four-character grid square. The default is that the grid be continuously updated using the GPS position.

`GRID cn88`

POWER [dBm]

This optionally sets the WSPR/FST4W power parameter. The default value is 30 dBm (1 Watt). The valid settings are 0, 3, 7, 13, 17,..., 53, 57, 60.

`POW 30`

FREQ [channel] [frequency] ([optional band offset])

This sets a channel frequency.

If a band number (160 to 6 meters) is entered as the frequency parameter, the default offset (effectively a tone frequency offset from the standard WSPR dial frequency) is 1400 Hz.

A different tone offset between 0 and 3000 Hz can be entered.

If the frequency parameter contains a value between 600,000 and 60,000,000 then it is interpreted as a frequency (in Hz).

When in WSPR mode, the requested and set frequency is "tone 1.5".

In FST4W mode the requested and set frequency is "tone 0".

The actual set frequency will generally be close to, but not exactly the frequency requested.

Set channel 1 to the 80 meter WSPR band, 1400 Hz default effective tone:

```
FREQ 1 80
```

Set channel 2 to the 40 meter WSPR band, 1525 Hz effective tone:

```
FREQ 2 40 1525
```

Set channel 3 to 10.140000 MHz (10.138 MHz + 2000 Hz effective tone

```
FREQ 3 10140000
```

In most cases the actual frequency set will slightly different than requested. However it will be off by no more than a small fraction of a Hz. The actual "set" frequency will be reported:

```
freq 1 28126001
Channel 1, frequency: 28126000.975610 Hz
```

Entering FREQ with only the CHANNEL parameter will display that channel's frequency.

Entering FREQ with no parameters will display the frequency for all channels.

SCHED [channel] [sequence] [repeat]

This sets the channel transmit schedules. The **channel** parameter will be a number between 1 and 8, or optionally '**A**' (or "**ALL**"), which will apply the following parameters to all eight WS-8 channels.

Sequence can be set to **R**andom. Each channel is independently randomized.

Sequence and **Repeat** establish the transmit rate as follows (two-minute WSPR frames):

```
SCHED A 0
```
All channels disabled.

```
SCHED 7 0
```
Channel 7 disabled.

```
SCHED A 1 1
```
All channels transmit every frame

```
SCHED 1 1 2
```
Channel 1 transmits every other frame, starting at minutes = 00

```
SCHED 2 2 2       Channel 2 transmits every other frame, starting at minutes = 02
SCHED 3 3 3       Channel 3 transmits every third frame, starting at minutes = 04
SCHED 4 R 1       Channel 4 transmits one out of two frames at random.
SCHED 5 R 4       Channel 5 transmits one out of eight frames at random.
```

Entering SCHED with only the CHANNEL parameter will display that channel's schedule.

Entering SCHED with no parameters will display the schedule for all channels.

SCHED can also be used to set a channel to fixed-frequency continuous output mode. This allows a channel to be used as a 1 Watt fixed-frequency source. The frequency will be the "Tone 0" as set by the FREQ or CUSTOM command:

SCHED [channel] F

A channel in FIXED mode will not trigger the front-panel blue LED, nor the external T/R switch control output.

Entering any other valid SCHED command for a channel will re-establish normal channel operation.

ID [short message]

This optionally enters a short ID message that will be sent at the end of every frame transmission using on/off keyed Morse code. This message must be no longer than about nine seconds or it will be truncated. Depending on the selected mode, the morse code speed will be between 18 and 28 wpm.

REPORT [1/0]

This command enables or disables a basic status report at the start of a frame

Entering REPORT with no parameters will display the current enable value.

STATUS [report #]

This command generates one of the several different status reports.

0	Channel status
1	Channel schedules
2	Current and Voltage monitors
3	Channel Frequencies
4	Channel synthesizer settings (reported frequency is "Tone 0")
5	Reference Clock and GPS status
6	Fault condition report

7	Time display (hh:mm:ss)
8	Callsign, Grid, Power
9	About this WS-8
10	List of LED status states
11	List of WS-8 parameters and monitor conditions in csv format
12	Channel ON/OFF settings

Entering STATUS with no parameters will display report #0. Entering 'A' for the report number will display all reports.

This command can be abbreviated to a single **S**.

ON [chan # / ALL]

OFF [chan # / ALL]

The ON and OFF commands enable or disable one or all of the WS-8 transmitter outputs. The default is OFF.

MAN [command / *]

HELP [command / *]

This displays the help text for a command, or for all commands. HELP is a synonym for MAN.

File and Update Commands

These commands allow you to read the configuration files on the WS-8 flash drive, and upload a software updates.

CONFIG [R / D] [optional file name]

CONFIG R : Load the "config.txt" file. This is useful when making changes to the WS-8 configuration.

CONFIG R *filename* : load *filename* as a configuration file. *Filename* must not contain spaces.

CONFIG D : show all files on the WS-8 flash drive.

FILE [R / D] [file name]

FILE R *filename* : Display *filename* contents. *Filename* must not contain spaces.

FILE D : show all files on the WS-8 flash drive.

LOADNEW 1

This will shut down the WS-8 and enable drag-and-drop program update.

Fault-monitoring Commands

These commands allow you to set various fault thresholds. These thresholds all initialize to appropriate values, and changing them is generally not necessary.

REF [1/0]

This command enables or disables the loss-of-Reference-Clock fault. Setting this parameter to 0 will disable the loss-of-clock fault. The 10 MHz reference clock is critical to proper WS-8 operation, so the default is 1 (enabled)

Entering REF with no parameters will display the current enable value.

GPS [timeout]

This command sets the timeout before the loss of GPS fault is declared. The default is ten seconds, but this can be set between 1 and 600 seconds. Setting this parameter to 0 will disable the loss-of-GPS fault.

Entering GPS with no parameters will display the current timeout value.

V5 [voltage in millivolts]

This command sets the voltage below which the loss of channel output amplifier voltage is declared. The default is 4500 (4.5V), but this can be set between 1000 and 6000 mV. Setting this parameter to 0 will disable the loss-of-voltage fault. In normal operation there should be no need to change this setting.

Entering VAMP with no parameters will display the current value.

V12 [minimum voltage in millivolts] [maximum voltage in millivolts]

This command sets the allowable voltage range for the WS-8 power supply (nominal 12V). The default is 8500 (8.5V) and 24000 (24V). In normal operation there should be no need to change this setting.

Entering V12 with no parameters will display the current values.

OVER [maximum amplifier current in milliamps]

This command sets the allowable maximum DC current level for the channel output amplifiers. When the current in any of the amplifiers exceeds this value it will be shut down and a fault declared. In normal operation there should be no need to change this setting.

Entering OVER with no parameters will display the current value.

Other Commands

These commands are not needed in typical WS-8 operation, but are available for debugging or custom configuration.

LED

This displays the status LED blink-pattern information.

TIME [0 / 1]

TIME 1 : enables continuous display of the GPS time once per second.

TIME 0 : disables display of the GPS time.

Entering TIME with no parameters will display the current time (hh:mm:ss).

NMEA [0 / 1 / 2]

This command enables GPS NMEA sentences to be displayed as they arrive.

NMEA 0 : monitor none

NMEA 1 : monitor "RMC" sentence (RMC contains time and location).

NMEA 2 : monitor all sentences.

Entering NMEA with no parameters will display the current setting.

TEST [option]

This command puts the WS-8 into the test mode. All channels with the frequency set will be continuously activated.

TEST 0 : Transmit Tone 0

TEST 1: Transmit Tone 1

TEST 2 : Transmit Tone 2

TEST 3 : Transmit Tone 3

TEST 4 : Transmit Tone 0 – 3 stairstep at the mode symbol rate

TEST 5 : Transmit Tone 0 – 3 random sequence at the mode symbol rate

TEST X : Resume normal operation

TEST OFF : Resume normal operation

Entering TEST with no parameters will display the current test mode.

FILTER [0 / 1]

This command enables (1) or disables (0) the Gaussion FSK digital filter.

Entering FILTER with no parameters will display the current setting.

In FST4W mode, the filter is enabled by default

In WSPR mode, the filter is disables by default

CUSTOM [channel] [OutDiv] [A] [B] [C] [Step]

This command allows a channel clock generator to be set to arbitrary values. The parameters are:

channel : channel # (1 – 8)

OutDiv : output divider value (integer-only)

A : PLL integer divider value

B : PLL fractional numerator

C : PLL fractional denominator

Step : Integer value to be added to the B parameter for FSK shift. This can be negative or positive.

While a modest amount of value-checking is performed, it is recommended that the specifications for the Si5351 Clock Generator be well-studied before using this command.

DEBUG [?]

This command will do something, or nothing, depending on the most recent needs of the designer.

Make Your Own Harmonic Filter

The WS-8 outputs are square-wave, and so have strong harmonic components that must be attenuated. The Filter/Combiners use series band-pass sections, which permits the several filter outputs to be connected with minimal interaction.

But a basic single-band filter need only be a low-pass design. While the typical capacitor-input "C/L/C Pi" network will work, the shunt capacitor at the filter input will cause heavier loading of the amplifier than necessary. A better option is to use an inductor-input "L/C/L Tee" design. The filter need not have a lot of attenuation at the second-harmonic, as this is generally already down below -30 dBc. But filter attenuation at the third and higher odd harmonic frequencies should exceed 30dB at a minimum.

Here is an example filter for the 80-meter band. It includes a 3rd harmonic notch, improving the overall filter performance where it counts.
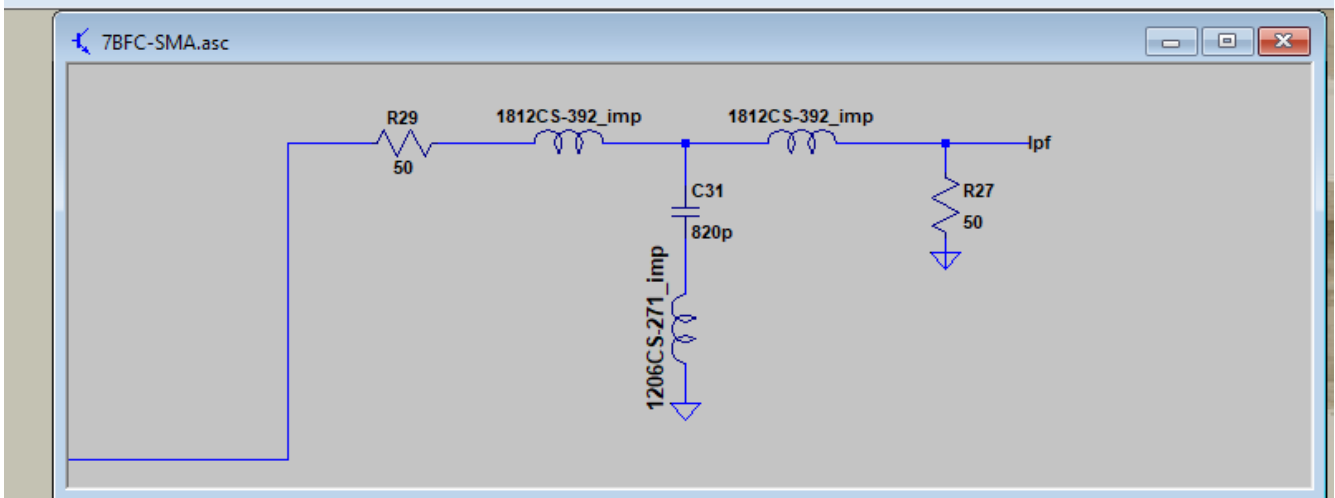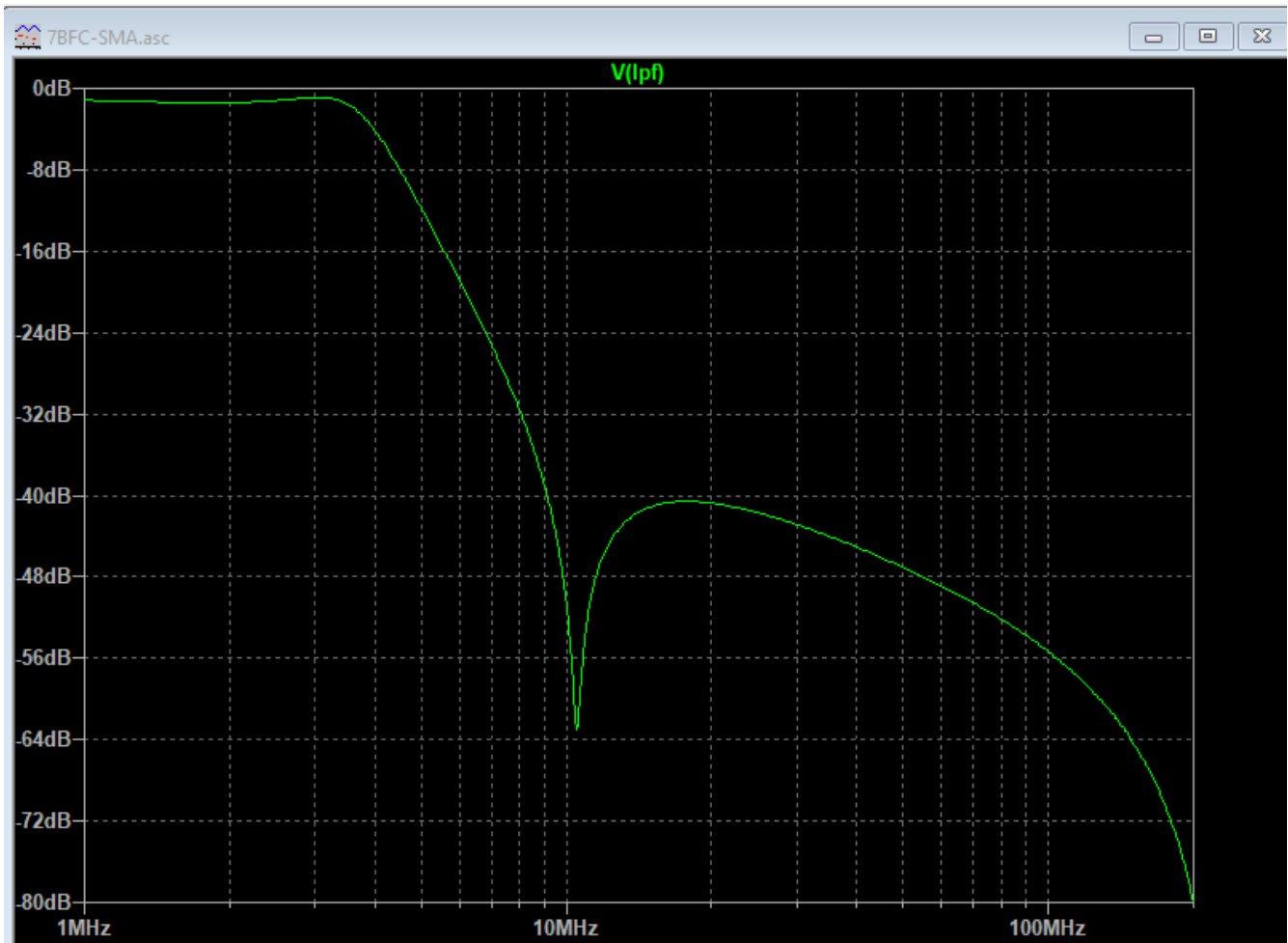
Illustration 2: Single-Band Filter Example

The series inductors (CoilCraft surface-mount style) are 3.9 uH, the shunt inductor is 270 nH.
If higher Q inductors (such as iron powder toroids) are used there may be no need for the
shunt inductor.