

# Bench Testing the Chopper Board

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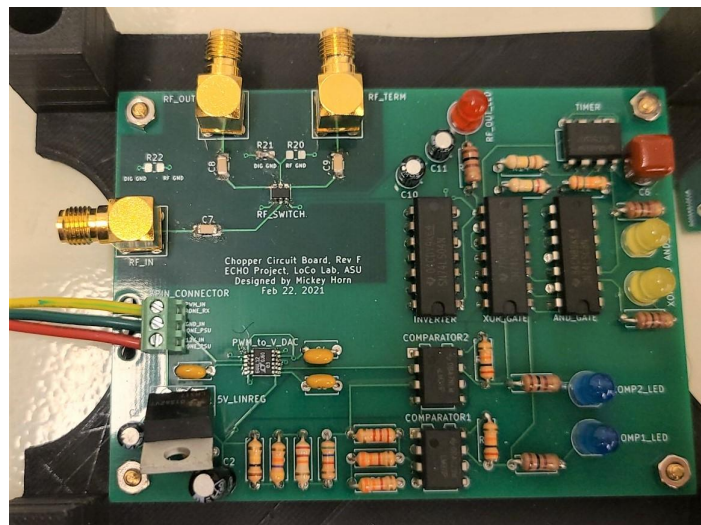
## Summary

I report on the bench tests done on the chopper board designed by Mickey Horn to study its response to two RF inputs--

1. Single tone transmitter (Valon 5009)
2. Broadband transmitter (by Titu Samson)

Test #1: Response of the chopper board when the RF & Digital ground of the RF switch are separated vs when the two grounds are common (shorted)

Test #2: Three modes of chopper board now with a common ground are recorded in RTSA mode.



## Introduction

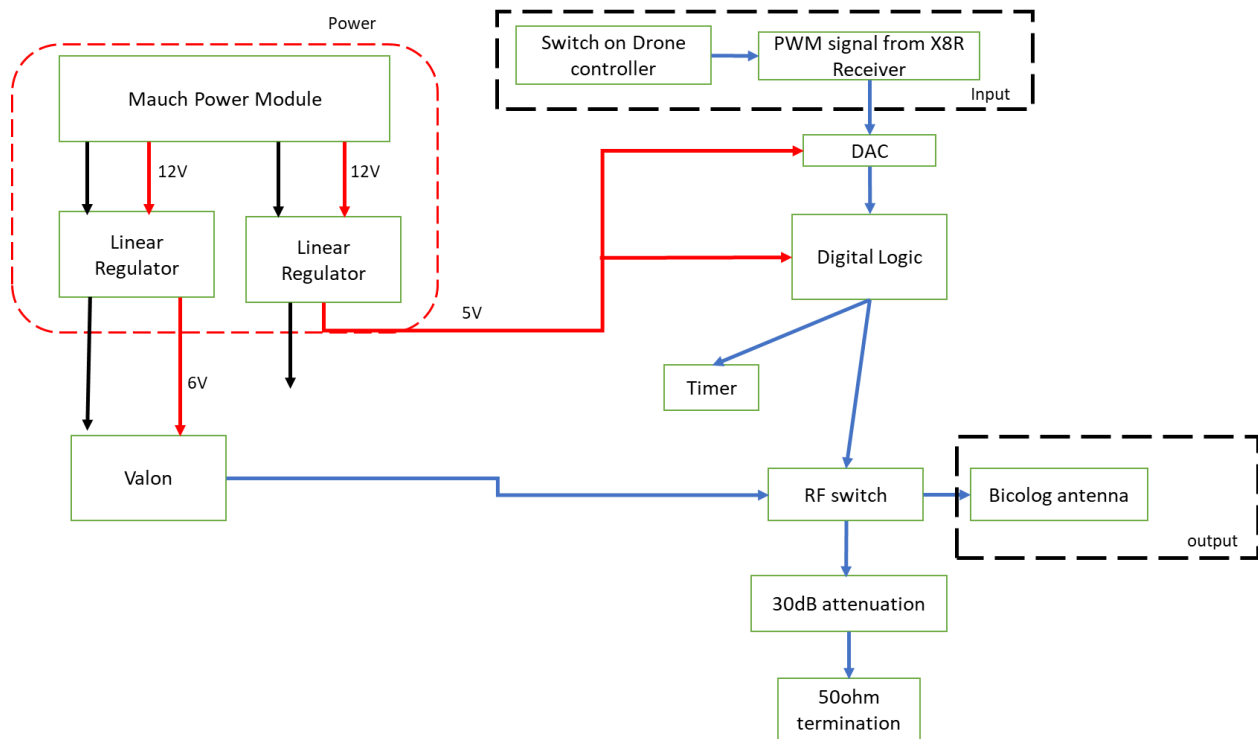
The chopper board allows us to control the ECHO calibration signal in three modes -- OFF, ON, ALTERNATING. The idea is to use data during the OFF times to quantify background noise and potential drone RFI.

In the ON mode, the transmitter output is connected to the input of the transmitting antenna

In the OFF mode, the transmitter output is disconnected to the input of the transmitting antenna

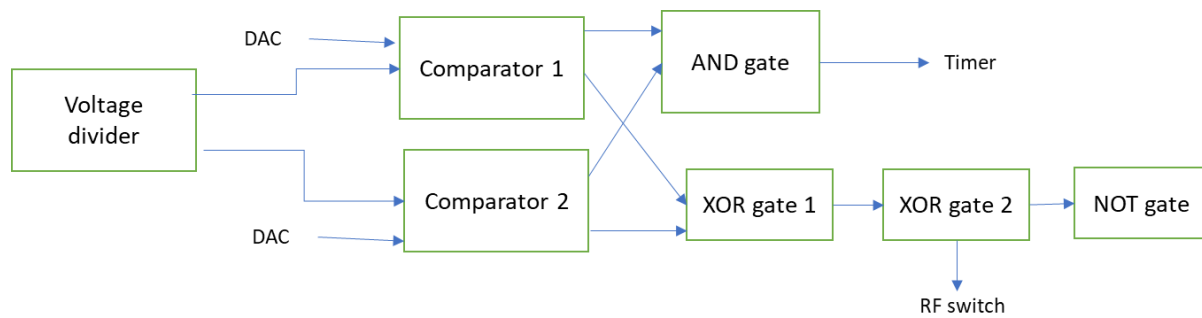
In the ALTERNATING mode, the transmitter output is switched on and off in 0.2s intervals and then fed to the input of the tx antenna.

## Chopper Block Diagram



Note: the 5V linear regulator that powering the DAC and digital logic circuit is on the chopper board. The 6V regulator is a separate circuit external to chopper board.

## Digital Logic



## Logic Table

Switch Position	Voltage Level	Comparat or 1 State	Comparat or 2 State	XOR Gate 1 State	AND Gate State	XOR Gate 2 State	RF Switch State	Payload Action
Low	0.14V	Off	Off	Off	Off	Off	B High, RF2	Off
Medium	0.21V	On	Off	On	Off	On	A High, RF1	On - Steady
High	0.28V	On	On	Off	On	On - Alternating	Alternating	On - Alternating

## Chopper Inputs

- PWM signal from X8R receiver on the drone (command)
- 12V power supply

- Ground
- RF input (tx)

### Chopper Outputs

- RF out connected to Bicollog antenna
- RF termination

### Characteristics of input PWM signal from the X8R receiver on the drone

Three PWM signals associated with controller switch position have the following properties-

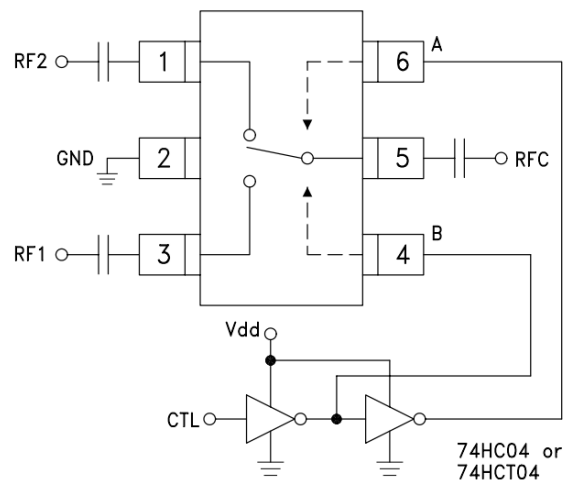
- Freq : 55.5Hz
- Mag : 3.9 V
- Width of signal for on-off-alternating controller switch pos: 2ms, 1.5ms, 1ms (990us) resp.

### Bench Tests

In these tests, the performance of the chopper is tested with two different RF inputs:

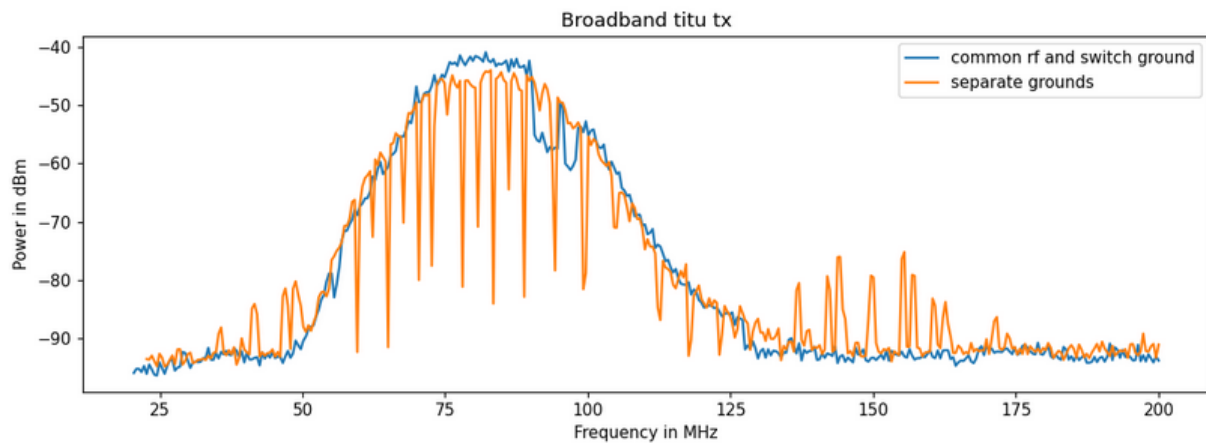
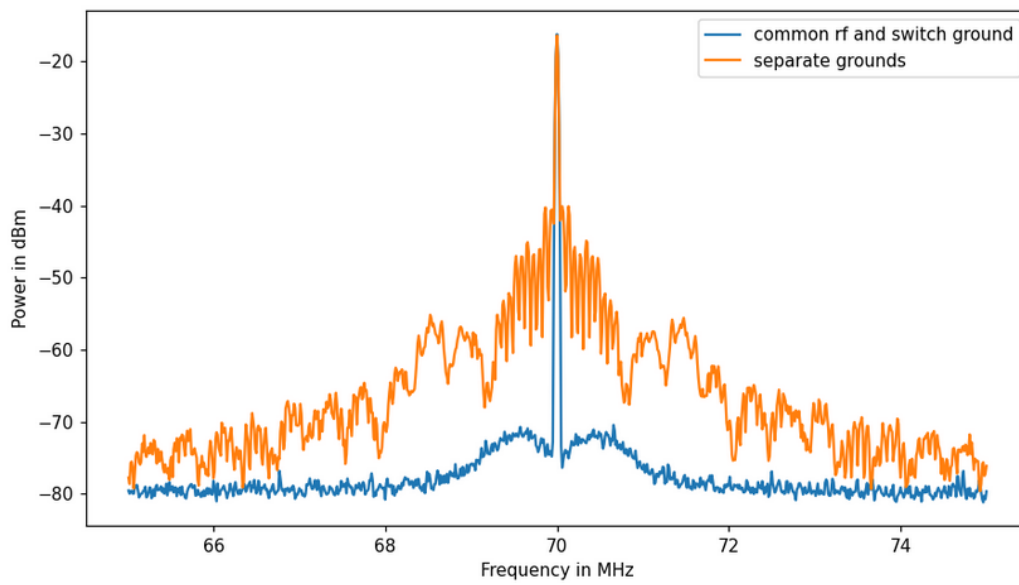
- Valon 5009 programmed to 70MHz: a well-known source
- Broadband transmitter board (V2\_B with filter A) designed by Titu Samson

### Test #1 : Separate grounds for RF/DC pin and Digital logic pin of the RF Switch

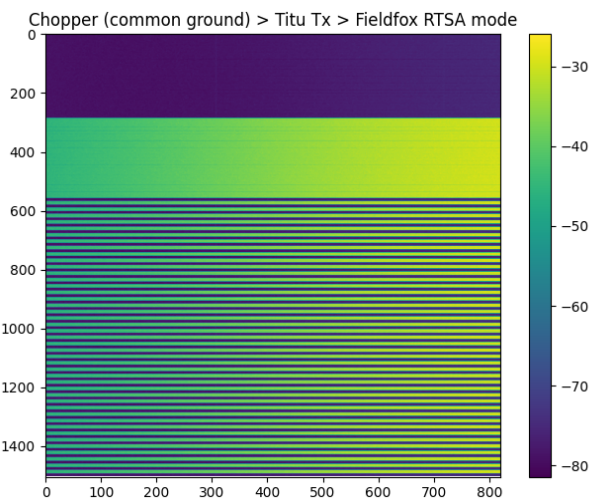
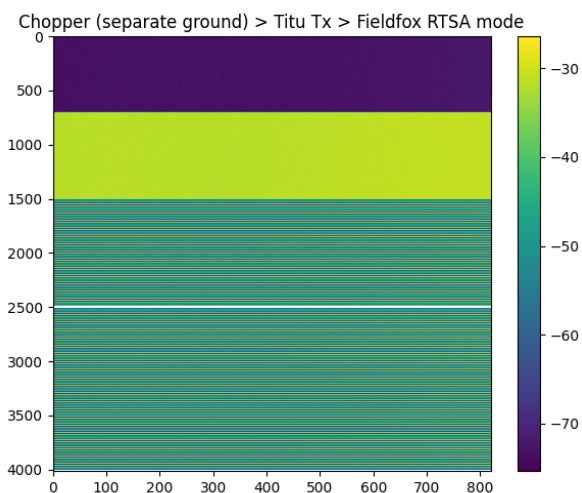


Pin out of RF Switch from [datasheet](#)

**Setup:** RF input > Chopper set to ON > Fieldfox Spectrum Analyzer in SA mode



- All three states of the chopper board (on, off, alternating) as seen on Fieldfox RTSA mode.



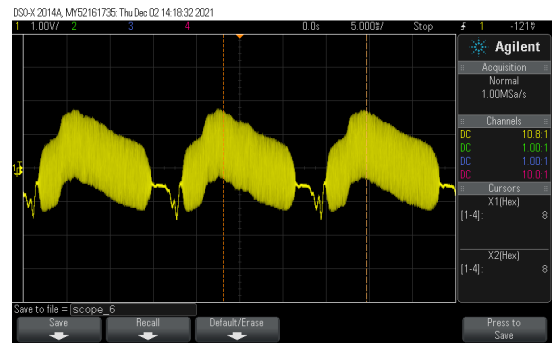
Notes:

- When the RF and Digital pins are grounded are separately, we see a 60Hz pickup modulating the input RF signal. For further investigation, I looked at the time-domain waveform of RF output of the chopper with 70MHz tone valon as input.

Screengrabs from the oscilloscope-

<p>Valon &gt; Scope</p>	
<p>Chopper board RF_output &gt; scope</p>	

Valon > chopper > scope



### Investigating the 60Hz pickup

- Was it stray pick up from an unterminated RF\_term sma port? - Not likely since the amplitude of 2V is too strong to be stray pickup
- Do we still see the pickup after terminating open sma ports? - yes. The source was narrowed down to the chopper's input power cable.

Summary of 60Hz pickup amplitudes with Rf\_in and RF\_term terminated:

- Drone not powered, x8r cable > chopper rf output port > oscillator ~ 3V
- Drone not powered, x8r cable > RF switch pin A > oscilloscope ~ 400mV
- Human touching the power cable > chopper rf output port > oscilloscope ~3V
- Human touching one end of sma cable > other end of sma > oscilloscope ~350mV

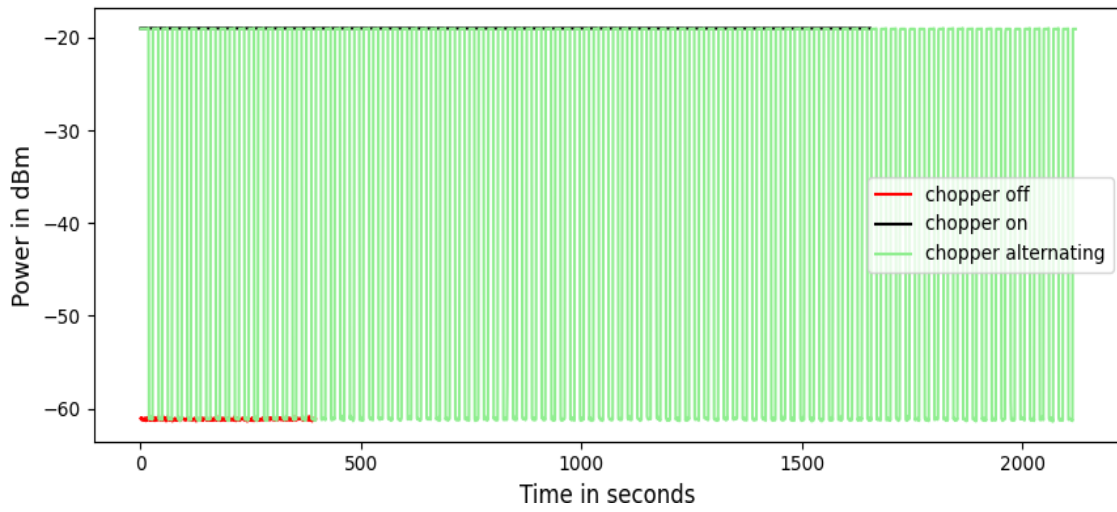
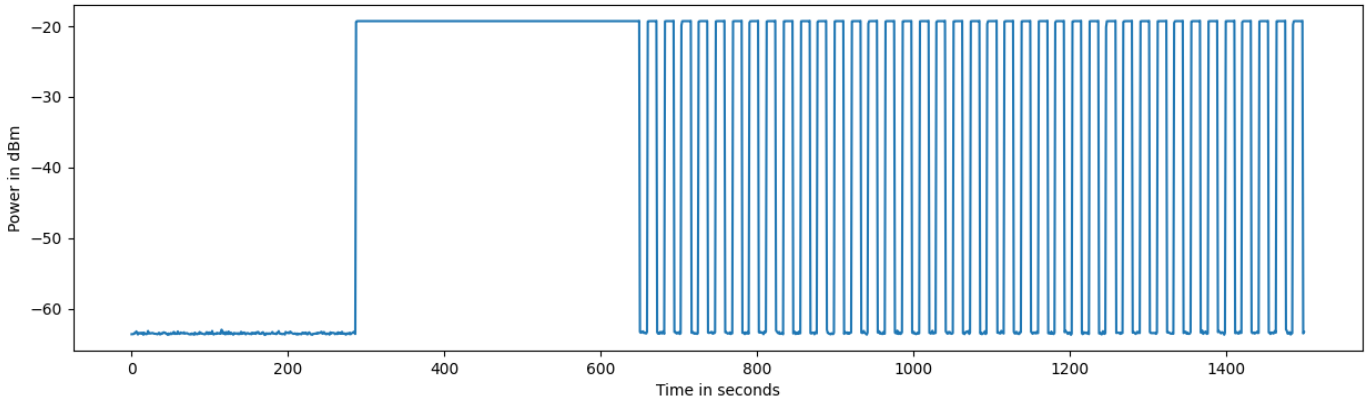
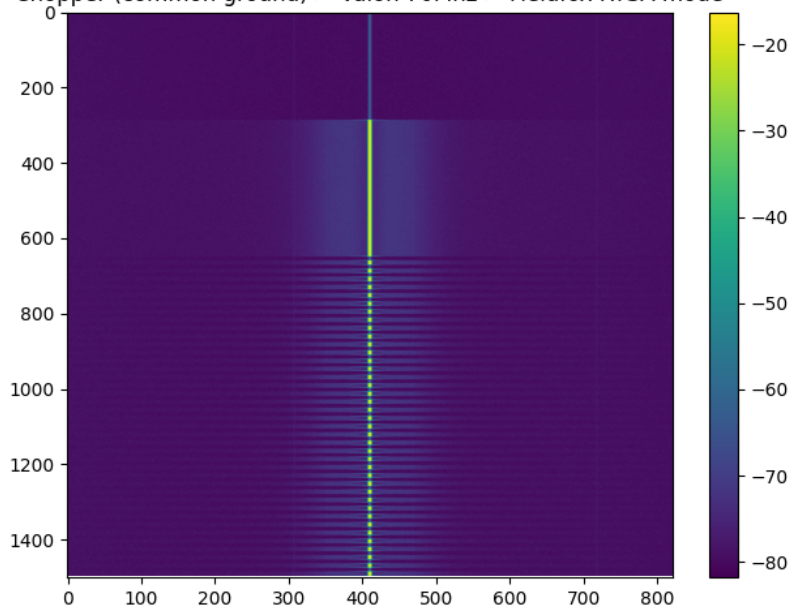
### Test #2: Performance of chopper in RTSA mode when the RF and Digital logic pins of the Rf switch have a common ground

The three states of the chopper: on, off and alternating, are recorded in the RTSA mode.

Notes on RTSA Mode:

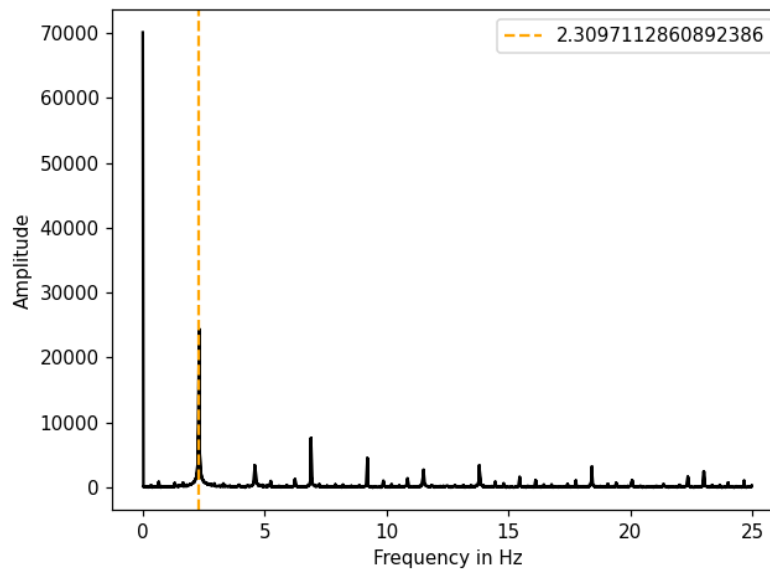
- Max BW: 10MHz
- Lowest RBW: 24.4KHz
- Acq Time: 20.1ms (lowest)
- Recording settings: Set Time interval to MIN
- Two settings in the RTSA mode dictate the recording interval - "Acquisition Time" and other "Recording Interval"
  - Recording interval sets the time to wait between trace recordings. Default is MIN which is to wait 0 seconds, record as fast as possible.
  - Acquisition Time affects the quantity of information captured. Default is set to 20ms.

Chopper (common ground) > Valon 70Mhz > Fieldfox RTSA mode

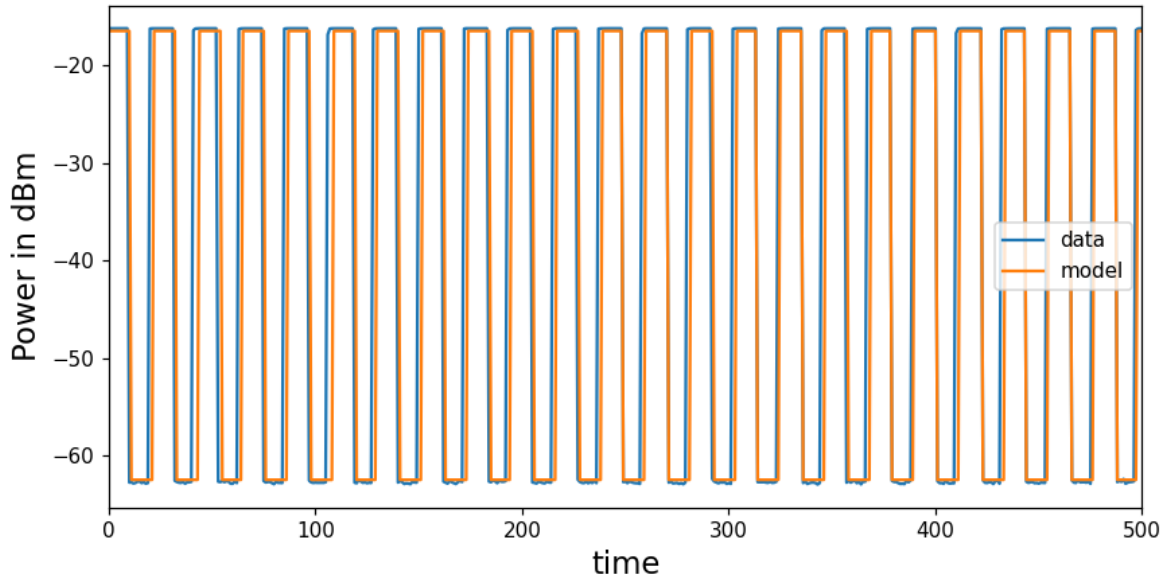


## Modeling Chopper Output

The chopper output in alternating mode can be modeled with a square wave of frequency = switching frequency. Switching frequency can be determined by fourier transforming the time series. Larger input time series data increases the accuracy of the switching frequency determined.



FFT plot of the chopper alternating mode time series data



Fitting the model to data