

Full Doppler on the FT-847 for
ISS and other “same-band” satellites
Using CAT commands

Preliminary DRAFT

Revision 4

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Introduction

Several people have looked at the Yaesu FT-847 CAT command set and concluded it can't do full Doppler control on "same-band" satellites like ISS – I.E. those where the TX and RX frequencies are in the same-band. The premise of this belief was linked to a "10 kHz limitation". The FT-847 CAT "offset" command appears to offer 10 Hz resolution, but anything entered beyond 10 kHz resolution is ignored - this is the only CAT function which is limited to this resolution – in fact all other frequency related commands offer as fine as 10 Hz resolution.

The FT-847 cannot be used to work "same-band" satellites in "satellite" mode because the FT-847 satellite mode can't have the same band for both the TX and RX sides.

My work in this document is based on using the "Main Frequency VFO" rather than "satellite" mode. I will also utilize the "repeater shift" function" and the "offset" function. All of the examples in this paper can be achieved using the existing CAT commands found on the FT-847.

How do we tune ISS under CAT control?

Using the FT-847 CAT commands you can enter a receive/downlink frequency into the main VFO and an "offset" along with a "repeater shift" (+/-) and then a transmit/uplink frequency will be calculated and entered into the VFO with the receive/downlink frequency as a receive/transmit pair.

CAT Commands used

- 1) CAT ON
- 2) SATELLITE MODE OFF
- 3) OPERATING MODE FM
- 4) SET FREQUENCY MAIN VFO (RX Frequency with 10 Hz resolution I.E. 145.xxxxx)
- 5) SET REPEATER OFFSET (Number with 10kHz resolution I.E. 1.32)
- 6) SET REPEATER SHIFT (Plus/Minus)
- 7) CAT OFF

In this paper we will use an estimated maximum Doppler scenario using ISS' voice frequencies. At 2 meters you will see a maximum of approximately +/- 4kHz Doppler on ISS – most of the time it will be around +/- 2-2.5 kHz of Doppler.

The Perceived Problem

In the chart below you will see that if you attempt to use the CAT “offset” function with the “10 kHz limitation” (Real Offset rounded up/down) and the “repeater shift” function on the downlink frequency to obtain the desired uplink frequency you will experience as much as 4 kHz of error – this is clearly not acceptable and on the surface and it looks like there is no way to solve this problem so you can obtain 1 kHz or less error.

	Real Uplink	Resulting Uplink	Real Downlink	Real Offset	847 Offset	Uplink Error KHZ
AOS	144.486	144.484	145.8040	-1.318	-1.320	-2.0000
	144.487	144.483	145.8030	-1.316	-1.320	-4.0000
	144.488	144.492	145.8020	-1.314	-1.310	4.0000
	144.489	144.491	145.8010	-1.312	-1.310	2.0000
TCA	144.490	144.490	145.8000	-1.310	-1.310	0.0000
	144.491	144.489	145.7990	-1.308	-1.310	-2.0000
	144.492	144.488	145.7980	-1.306	-1.310	-4.0000
	144.493	144.497	145.7970	-1.304	-1.300	4.0000
LOS	144.494	144.496	145.7960	-1.302	-1.300	2.0000

Good
Close
Bad

Note: The “Real Offset” can’t be used to achieve the desired uplink because it attempts to use 1khz resolution and the FT-847 CAT offset command would ignore anything less than 10khz.

Possible Solution One

While there is a “10khz” limitation on the offset function, the “Main Frequency VFO” can be set as fine as 10hz resolution via CAT commands. With this information I decided to see what could be achieved – first I attempted to adjust the downlink frequency in 1 kHz increments - I could have used as fine as 10 Hz increments. By adjusting the downlink and using the 847’s “offset” function with the “10 kHz limitation” along with the “repeater shift” function, we can spread the error between the uplink and the downlink.

	Real Uplink	Resulting Uplink	Real Downlink	Adjusted Downlink	Real Offset	Adj. Offset	Uplink Error KHZ	Downlink Error KHZ
AOS	144.486	144.485	145.804	145.80500	-1.318	-1.320	-1.0000	-1.0000
	144.487	144.485	145.803	145.80500	-1.316	-1.320	-2.0000	-2.0000
	144.488	144.490	145.802	145.80000	-1.314	-1.310	2.0000	2.0000
	144.489	144.490	145.801	145.80000	-1.312	-1.310	1.0000	1.0000
TCA	144.490	144.490	145.800	145.80000	-1.310	-1.310	0.0000	0.0000
	144.491	144.490	145.799	145.80000	-1.308	-1.310	-1.0000	-1.0000
	144.492	144.490	145.798	145.80000	-1.306	-1.310	-2.0000	-2.0000
	144.493	144.495	145.797	145.79500	-1.304	-1.300	2.0000	2.0000
LOS	144.494	144.495	145.796	145.79500	-1.302	-1.300	1.0000	1.0000

Good
Close
Bad

By using this method we can achieve fairly good results – see chart above - but a 2 kHz error may still present some issues.

In the next section, I will present a method using existing 847 CAT commands, which will provide 10hz resolution on the downlink and uplink Doppler corrected frequencies.

The Solution

Now that we know the limitations and strengths of the FT-847 CAT commands, we can put them to work to solve the problem.

We can set a downlink frequency in the “Main Frequency VFO” with as fine as 10 Hz resolution – when combined with the “offset” which has a 10 kHz resolution we can still obtain a desired uplink frequency with as fine as 10 Hz resolution.

To solve the problem at hand we first set the downlink frequency with 10 Hz resolution, which produces the exact Doppler corrected frequency.

Now lets turn our attention to the uplink frequency. To obtain our desired uplink frequency we can temporarily adjust the downlink frequency before transmitting to obtain the desired uplink frequency – see chart below. For programming simplicity I utilized the exact offset between the uplink and downlink for the “adjusted offset” as the basis of all calculations.

After we finish transmitting we must change the downlink back to the real downlink (Doppler corrected).

Utilizing this method provides us the exact downlink and uplink frequencies accurate to within 10 Hz – see chart below.

One additional CAT function that I have not mentioned until now is the “PTT” function, which allows us to turn “on” or “off” the transmitter as if using a PTT button on a mike. In the next section I’ll explain how a program can utilize all of this to provide full Doppler control on “same-band” satellites like ISS and PCSAT.

A solution to letting the program know when to switch the downlink frequency temporarily during transmit is to have a “PTT Button” on the user interface which would be utilized during “same-band” control. This button would utilize the CAT “PTT” function to toggle on/off transmit and to signal the program when to change frequencies to achieve the desired results.

	Real Uplink	Resulting Uplink	Real Downlink	Temp. Adj. Downlink	Real Offset	Adj. Offset	Uplink Error KHZ
AOS	144.486	144.486	145.804	145.7960	-1.318	-1.310	0.0000
	144.487	144.487	145.803	145.7970	-1.316	-1.310	0.0000
	144.488	144.488	145.802	145.7980	-1.314	-1.310	0.0000
	144.489	144.489	145.801	145.7990	-1.312	-1.310	0.0000
TCA	144.490	144.490	145.800	145.8000	-1.310	-1.310	0.0000
	144.491	144.491	145.799	145.8010	-1.308	-1.310	0.0000
	144.492	144.492	145.798	145.8020	-1.306	-1.310	0.0000
	144.493	144.493	145.797	145.8030	-1.304	-1.310	0.0000
LOS	144.494	144.494	145.796	145.8040	-1.302	-1.310	0.0000

Good

Close

Bad

How to utilize this solution in a Program

Below is some psuedo-code to implement this solution.

```
Open Serial Port to control FT-847 CAT
Send CAT ON command
Send CAT sat off command
Send CAT operating mode FM
Read non-Doppler corrected satellite frequencies (ISS 145.800=downlink and 144.490=uplink)
Send CAT set frequency main VFO with the downlink frequency
Determine the real offset between the non-Doppler corrected satellite uplink and downlink
Adjust real offset to fit FT-847 10 kHz limitation
Send CAT repeater offset command
Determine shift (+/-) between the non Doppler corrected satellite uplink and downlink
Send CAT Set Repeater Shift command

While (not done_working_sat)
    {
        calculate real Doppler corrected downlink
        Send CAT set frequency main VFO with the Doppler corrected downlink frequency
        calculate real Doppler corrected uplink

        if (PTT_button_pressed)
            {
                calculate downlink needed when combined with the offset to ...
                    temporarily achieve the desired real Doppler corrected uplink
                Send CAT set frequency main VFO with the temporary downlink frequency

                send PTT cat on

                while (not done_transmitting)
                    {
                        pause
                    } // done_transmitting

                send PTT cat off
            }
    } // done_working_sat

Send CAT OFF command
Close Serial Port
```

Conclusion

While the FT-847 CAT commands may have some limitations, a little bit of software can overcome these limitations and full Doppler correction can be achieved on “same-band” satellites like ISS and PCSAT.

I will leave it as an exercise to the reader to implement this method to achieve full Doppler correction. A test of concept was performed under Linux and the expected results were achieved – unfortunately I don’t have the time to write a full blown same-band satellite Doppler correcting program for the FT-847 – I’d rather see the various tracking/tuner programs implement this in their code.