sBitx Matures!

Gordon Gibby KX4Z NCS521

Feb. 2025

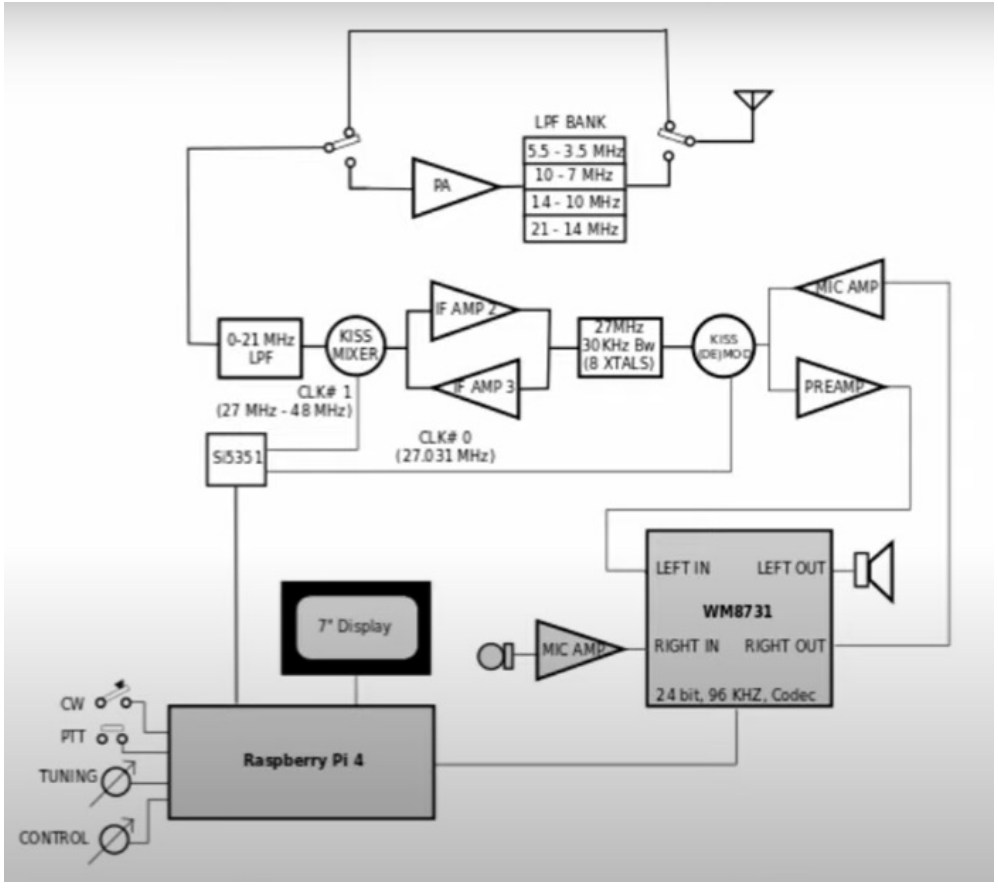
Sections:

1. Review of the sBitx & status a year ago.
2. Changes to the Version 3
3. Problem: Destroyed my first MOSFET
4. Problem: Deciding which replacement to use
   - SOLUTION & Measurements
5. Problem: Jerky CW responsiveness – SOLUTION
6. Problem: First Character T/R – SOLUTION
7. Problem: Birdies – SOLUTION: Shielding Improvements
8. Community Update: 64-bit Code / Operating System
9. HF Signals: Completely new spin-off radio: zBitx
10. Low Cost entry to SSB/CW VHF/UHF?

1. REVIEW: Sbitx Introduction

- Hybrid SDR architecture (but not I/Q)
- Modulation / demod performed in math (no FM yet)
- RPI 4 processor
- Touch Screen
- FT8 built in
- PSK31 built in
- Fantastic digital filtering.

Hybrid SDR (Heterodyne to 25 kHz)

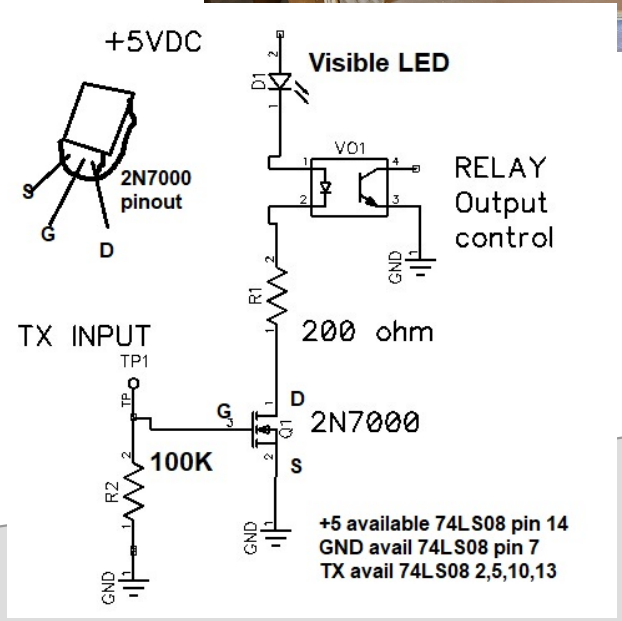


MY Situation Last Year: Finally working unit!

- USED Version 2: Found / fixed toasted diodes in control circuitry (likely my fault, but “traps” in circuitry
- W9JES software allowing external app control of frequency, etc
- Created external interface to provide ICOM7300 semi-emulation sufficient for WINLINK
- RS232-5VTTL adapter cables between laptop (winlink) and unit – full control of needed functions
- RFI-free commercial power supply
- My own homebrew go-box with Signalink and auto-antenna-tuner
- Working!!

MY Situation Last Year: Finally working unit!

- Audio output provided for external sound-card adapter
- SEND OUTPUT: PTT opto-coupler system derived from digital signal – works fine to key amplifier and does NOT affect purity of output signal (no connection to analog 12VDC signal.
- I added polarity protection system on power line.
- Added mic /key / keyer multiple inputs in separate box.
- Voltage-based RF output power and DC current measurement (taps on few inches of #16 power wire.



2. Retooled V3 Units: Toned-Down, IRF510 finals

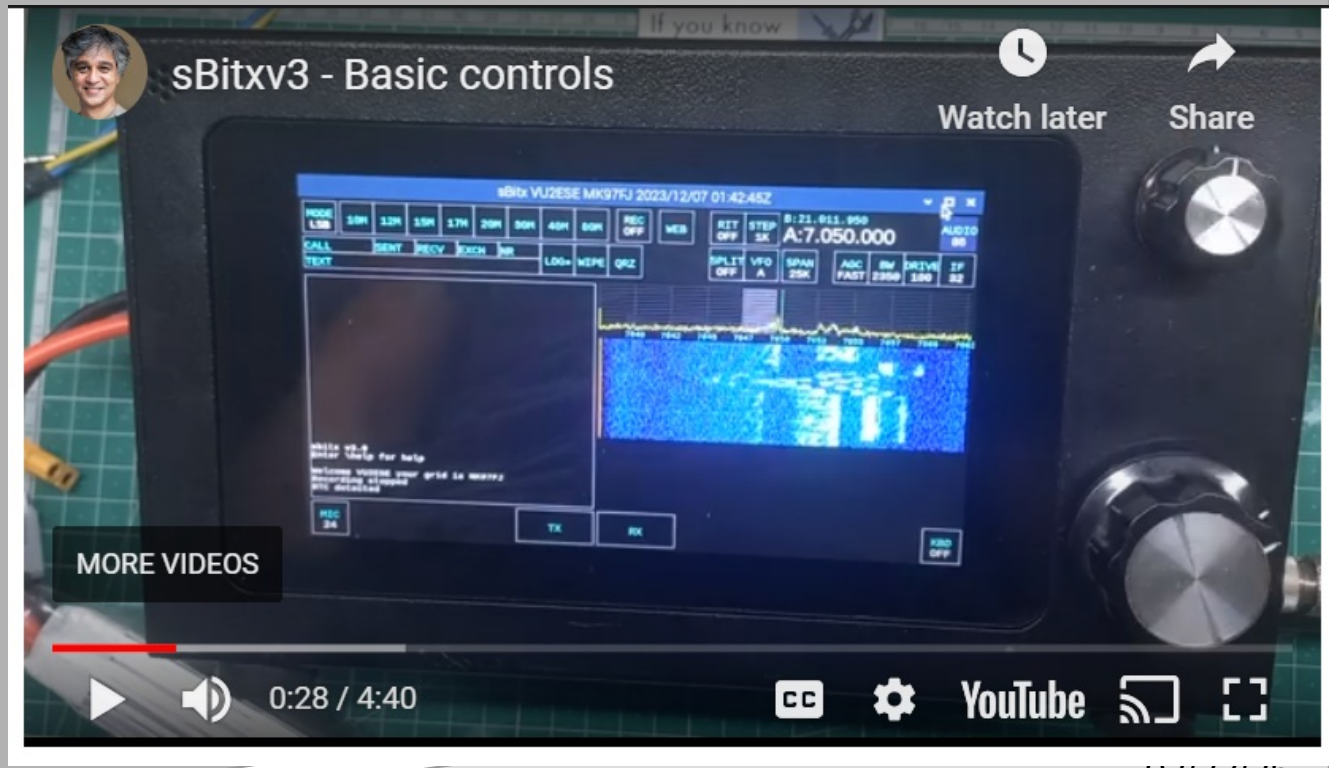
- Ashhar switched to 100-V_{DS} IRF510 from the more powerful 50-V_{DS} IRFZ24 after some MOSFET failures
- Assessed it as more rugged with 25W output on lower bands (declining on higher bands)
- I stuck with my IRFZ24's to have higher power on lower HF bands…
- I was still using huge zeners on the gates….*capacitance limiting drive on higher bands.*

https://docs.google.com/document/d/1HvpgnS6zuPcygxmB6lvFZztqSC

Freq (KHz)	IRF510 gate (volts)	At RF Dummy load
3535	11.5V	25W
7035	16.6V	25W
10135	15V	25W
14035	16.8V	20W
18035	12.5V	20W
21035	15.2	20W
24895	12.6	11W
28035	12V	9W

V3 Hardware/software

- December 14, 2023
- Improved software in many ways
- Better connection to CODEC
- Went down in power to IRF510, more stable, more resilient 25W
- Better documentation



3. Then my “OOPS!” moment

- Simply getting the rig working on 80m with vacuum tube SB-200 amplifier
- Sent a few DITS as part of checking SWR on North Carolina end-fed resonant antenna
- **Screen goes BLANK, unit DEAD**.
- Cycle power – dead screen – drawing huge amounts of amperage….
- SHORTED one of the 2 IRFZ24N finals…..
- FIRST lost MOSFET ever for me.

4. What to replace with???

- Replace with two new IRFZ24N’s (and risk a repeat?)
- Downgrade to Ashhar’s choice of IRF510 (25W max)
- IRF520 used by some – 100Vds but same 20V gate limitation (no built in protection)
- Switch to Ashhar’s suggested TVS diodes?

HexFET structure

- THREE inexpensive potential RF Amplifier devices
- IRF510 “3rd” Gen Hexfet
- IRF520 “5th” Gen Hexfet
- IRFZ24N “5th” Gen Hexfet

https://www.infineon.com/dgdl/an-937.pdf?fileId=5546d462533600a40153559ea1481181

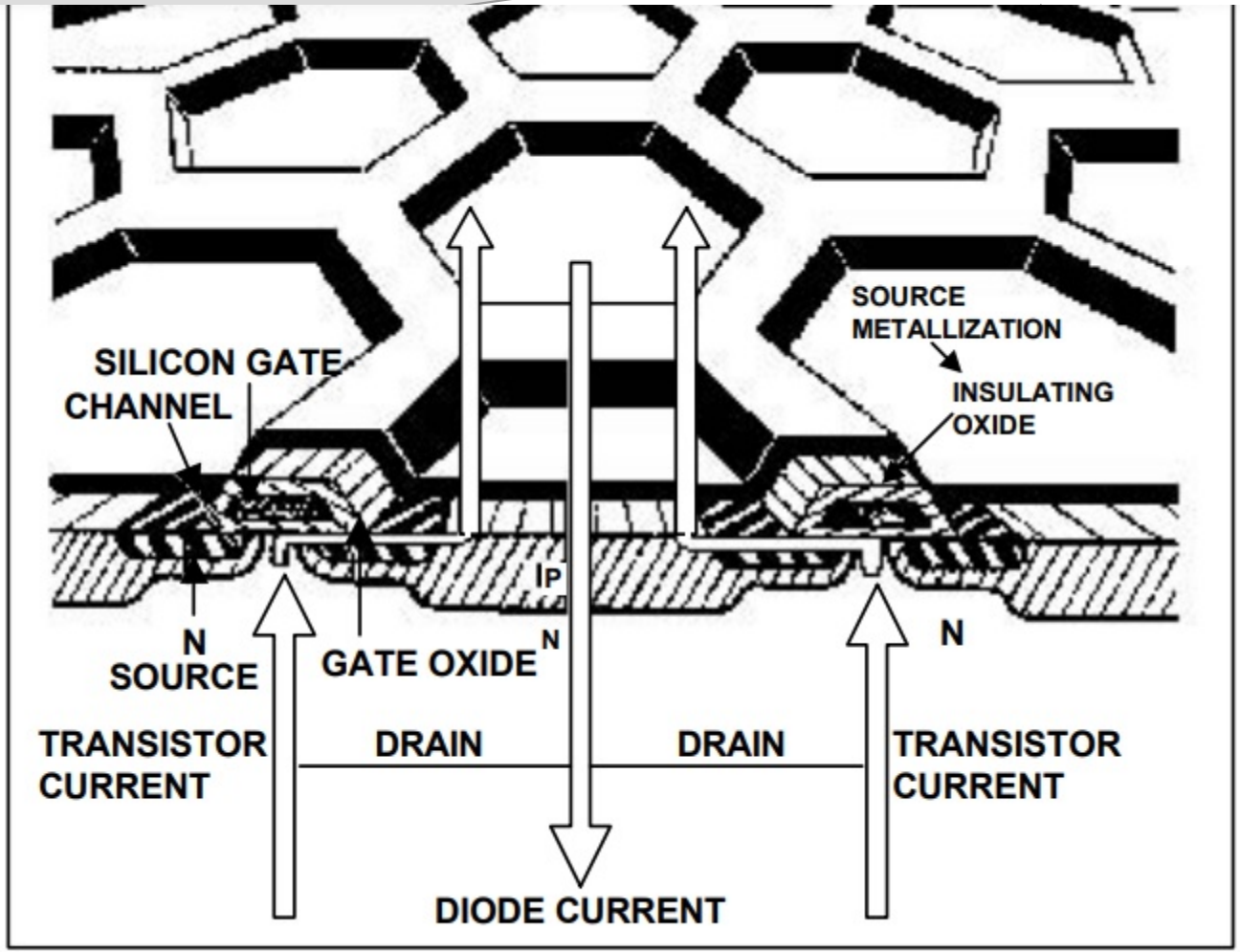


Figure 2. Basic HEXFET Structure

Ominous warning on Gate Reactance:

- “Even if the applied gate voltage is kept below the maximum rated gate voltage, **the stray inductance of the gate connection, coupled with the gate capacitance, may generate voltages that could lead to the destruction of the oxide layer**. Overvoltages can also be coupled through the drain-gate self-capacitance due to transients in the drain circuit. A gate drive circuit with very low impedance insures that the gate voltage is not exceeded in normal operation. This is explained in more detail in the next section.
- “Zeners are frequently used “to protect the gate from transients”. Unfortunately they also contribute to oscillations and have been known to cause device failures.
- “A transient can get to the gate from the drive side or from the drain side. In either case, it would be an indication of a more fundamental problem: a high impedance drive circuit. **A zener would compound this problem, rather than solving it**. Sometimes a zener is added to reduce the ringing generated by the leakage of a gate drive transformer, in combination with the input capacitance of the MOSFET. If this is necessary, **it is advisable to insert a small series resistor (5-10Ohms) between the zener and the gate, to prevent oscillations**.”
- (emphases added.
https://www.infineon.com/dgdl/an-937.pdf?fileId=5546d462533600a40153559ea1481181)

100V IRF520 vs IRF510

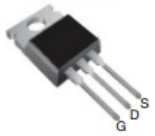
VISHAY
www.vishay.com

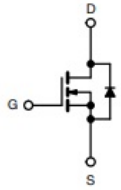
IRF520

Vishay Siliconix

Power MOSFET

TO-220AB





N-Channel MOSFET

FEATURES

- Dynamic dV/dt rating
- Repetitive avalanche rated
- 175 °C operating temperature
- Fast switching
- Ease of paralleling
- Simple drive requirements
- Material categorization: for definitions of compliance please see www.vishay.com/doc?99912

Available RoHS* Available HALOGEN FREE Available

Note

* This datasheet provides information about parts that are RoHS-compliant and / or parts that are non RoHS-compliant. For example, parts with lead (Pb) terminations are not RoHS-compliant. Please see the information / tables in this datasheet for details

PRODUCT SUMMARY		
V_{DS} (V)	100	
$R_{DS(on)}$ (Ω)	V_{GS} = 10 V	0.27
Q_g max. (nC)	16	
Q_{gs} (nC)	4.4	
Q_{gd} (nC)	7.7	
Configuration	Single	

DESCRIPTION

Third generation power MOSFETs from Vishay provide the designer with the best combination of fast switching, ruggedized device design, low on-resistance and cost-effectiveness.

The TO-220AB package is universally preferred for all commercial-industrial applications at power dissipation levels to approximately 50 W. The low thermal resistance and low package cost of the TO-220AB contribute to its wide acceptance throughout the industry.

ORDERING INFORMATION	
Package	TO-220AB
Lead (Pb)-free	IRF520PbF
Lead (Pb)-free and halogen-free	IRF520PbF-BE3

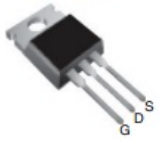
VISHAY
www.vishay.com

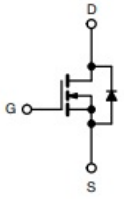
IRF510

Vishay Siliconix

Power MOSFET

TO-220AB





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PRODUCT SUMMARY		
V_{DS} (V)	100	
$R_{DS(on)}$ (Ω)	V_{GS} = 10 V	0.54
Q_g max. (nC)	8.3	
Q_{gs} (nC)	2.3	
Q_{gd} (nC)	3.8	
Configuration	Single	

DESCRIPTION

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ORDERING INFORMATION INFORMATION	
Package	TO-220AB
Lead (Pb)-free	IRF510PbF
Lead (Pb)-free and halogen-free	IRF510PbF-BE3

IRF520 vs IRF510

- Same max Drain voltage (100V)
- Same gate limits (20V)

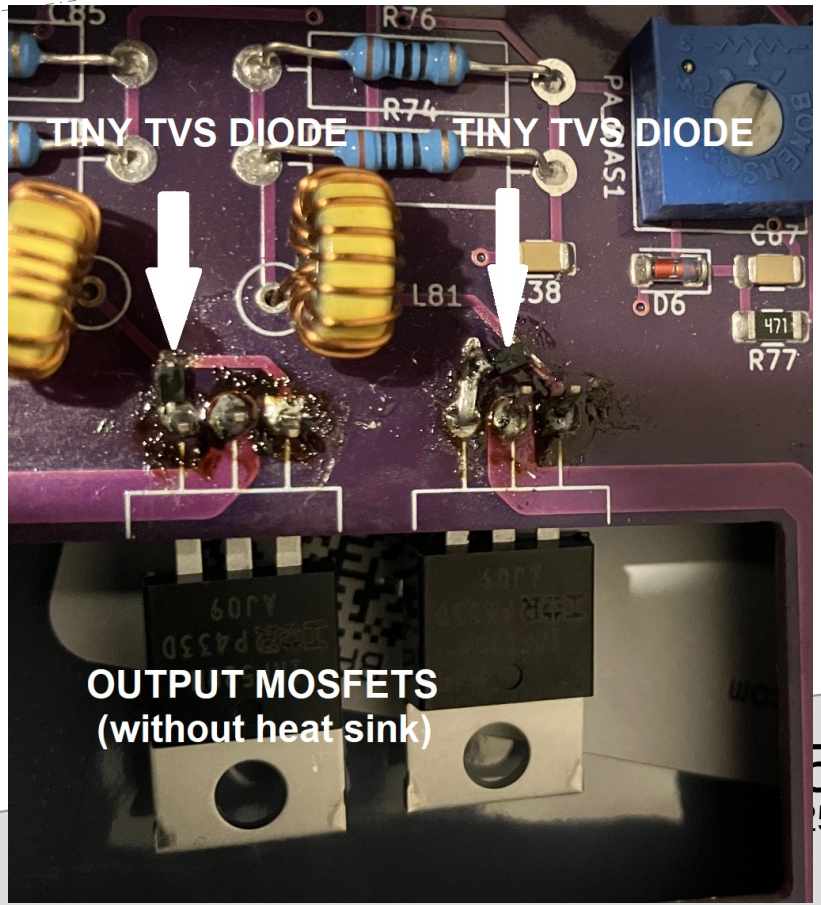
	IRF520	IRF510
Rds_{on}	0.27 ohms	0.54 ohms
Gate capacitance	360 pf	180 pf

- (Input capacitance of previous IRFZ24N was 370pf….)
- Basically, the 520 is somewhat like two 510's in parallel….and the V2 drivers are already suited for driving 360pf
- (Not the V3 driver circuitry, however)

Elected to put in TVS diodes instead of zeners

https://www.digikey.com/en/products/detail/bourns-inc/CDSOD323-T08SC/3781955

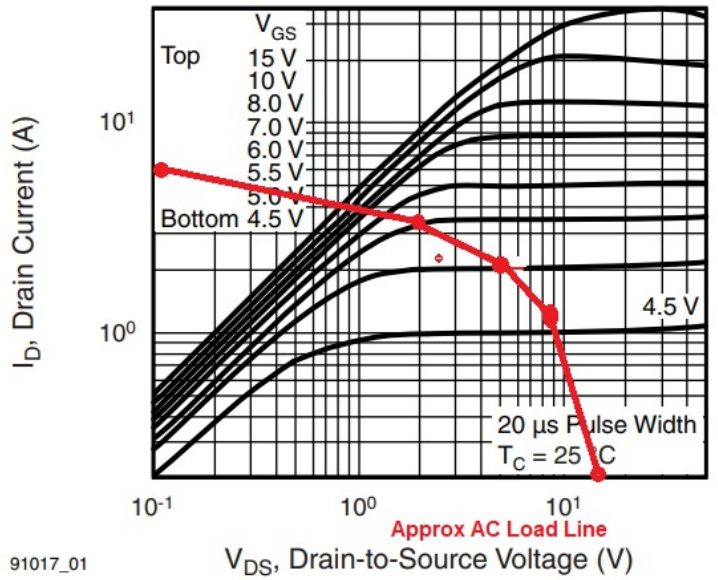
- TVS surface mount diodes
- Working peak voltage 8 V (bidirectional)
- Max clamping at 1 Ampere = 13.4V
- Possibly much less capacitance than huge zeners?



IRF520: Good power output!

FREQ	100% Output	hw_settings	Comment
3.5	32W	0.0037	
7.	33.3	0.0028	
10.1	22.6	0.0028	(Z24N ~21W)
14	16	0.0032	
18.1	9.33	0.0061	(Z24N 11-12W)
21	16.6	0.0054	(Z24N 15W)
24.9	12.3	0.0063	(Z24N 10W)
28	11.5	0.0063	(Z24N 8 W)

Note MY IRFZ24N system had 5W Zeners – so probably worse higher end performance



https://www.vishay.com/docs/91017/irf520.pdf

5. CW Issues with my V2

- Issue #1: Simply wouldn't key properly with external CW keyer….**very jerky**
- Made it impossible to use the WINKEYER (e.g. for contests) or have direct physical control of keyer speed.
- Somewhat better if direct paddle input to sBitx
- I thought my external keyer RELAY was bad – but it happened with all external keyers.

Mike Johnshoy KB2ML

from "A Standard for Morse Timing Using the Farnsworth Techniques", Jon Bloom KE3Z ARRL Laboratory

u = 1.2 / c where u is one unit (a dit) in seconds, and c is words per minute

Notes:

- ui_tick is called about every 1.2 msec wall clock time on my sbitx RPI4
- ui_tick increments a ticks counter every time it gets called and modem_poll gets called once every 20 ticks to read the straight key in sbitx 4.2

sbitx 4.2 software timing data

wpm	dit length (msec)	modem_poll() interval	~ number of times modem_poll() checks straight key status during one dit in version 4.2	~ number of times modem_poll() checks straight key status during one dit in version 4.2 in kb2ml branch
10	120	20 x 1.2 msec = 24 msec	5.0	100.0
15	80	20 x 1.2 msec = 24 msec	3.3	66.7
20	60	20 x 1.2 msec = 24 msec	2.5	50.0
25	48	20 x 1.2 msec = 24 msec	2.0	40.0
30	40	20 x 1.2 msec = 24 msec	1.7	33.3
35	34	20 x 1.2 msec = 24 msec	1.4	28.6
40	30	20 x 1.2 msec = 24 msec	1.3	25.0
45	27	20 x 1.2 msec = 24 msec	1.1	22.2
50	24	20 x 1.2 msec = 24 msec	1.0	20.0

https://groups.io/g/BITX20/message/114962

Inadequate sampling rate

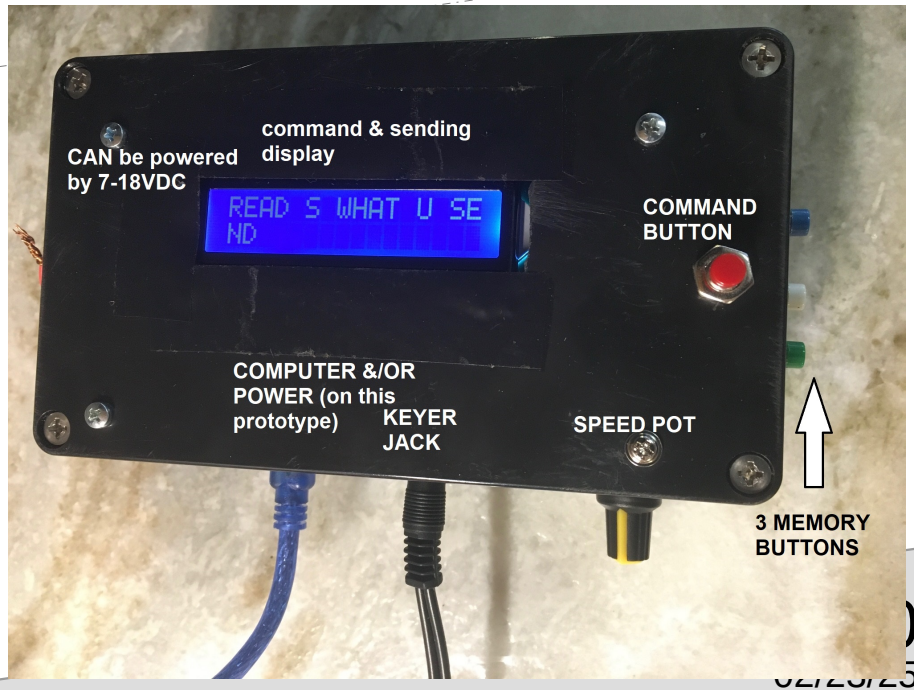
- **Mike Johnshoy** – function ui_tick() in sbitx_gtk.c increments tick counter every time called.
- Only every TWENTY TICKS is the cw key checked!

```
// every 20 ticks call modem_poll to see if any modes need work done
  if (ticks % 20 == 0)
    modem_poll(mode_id(get_field("r1:mode")->value));
  else {
    // calling modem_poll every 20 ticks isn't enough to keep up with a fast
    // straight key, so now we go on _every_ tick in MODE_CW or MODE_CWR
    if ((mode_id(get_field("r1:mode")->value)) == MODE_CW ||
    (mode_id(get_field("r1:mode")->value)) == MODE_CWR)
modem_poll(mode_id(get_field("r1:mode")->value));
  }
```

- Checks for key closure 20X more often!

20x Faster CW Key Monitoring

- STRAIGHT KEYS NOW WORK!
- EXTERNAL KEYERS NOW WORK!



6. DECREASE T/R DELAY
First Character Clipping

- FIRST element of first character is badly clipped – to the point that other operator likely to mis-copy it.
- Turned out LARGE delays (10, 20 milliseconds: Total 30ms) inserted in receive-→transmit state transition (possibly related to previous oscillation)

RX → TX Delays in V3 Code

```
//v2 t/r switch uses the lpfs to cut the feedback during t/r transitions
void tr_switch_v2(int tx_on){
            if (tx_on){
                  //first turn off the LPFs, so PA doesnt connect
            digitalWrite(LPF_A, LOW);
            digitalWrite(LPF_B, LOW);
            digitalWrite(LPF_C, LOW);
            digitalWrite(LPF_D, LOW);

                  //mute it all and hang on for a millisecond
                  sound_mixer(audio_card, "Master", 0);
                  sound_mixer(audio_card, "Capture", 0);
                  delay(1);

                  //now switch of the signal back
                  //now ramp up after 5 msecs
                  delay(2);
                  mute_count = 20;
                  tx_process_restart = 1;
                  digitalWrite(TX_LINE, HIGH);
                  delay(20);
                  set_tx_power_levels();
                  in_tx = 1;
                  prev_lpf = -1; //force this
                  set_lpf_40mhz(freq_hdr);
                  delay(10);
                  spectrum_reset();
            }
```

A 30+ millisecond delay is more than HALF of a Morse Code “dit” at 25 wpm.

- https://groups.io/g/BITX20/message/115262
- I tested delays as short as 5 mS after calculating that RC delays in the hardware T/R circuit were even shorter
- Tested with oscilloscope on all bands 80→10m and **did not see any evidence of oscillations with my V2-modified unit (IRF520)**
- Settled on “middle ground” delays that don’t significantly impact first element

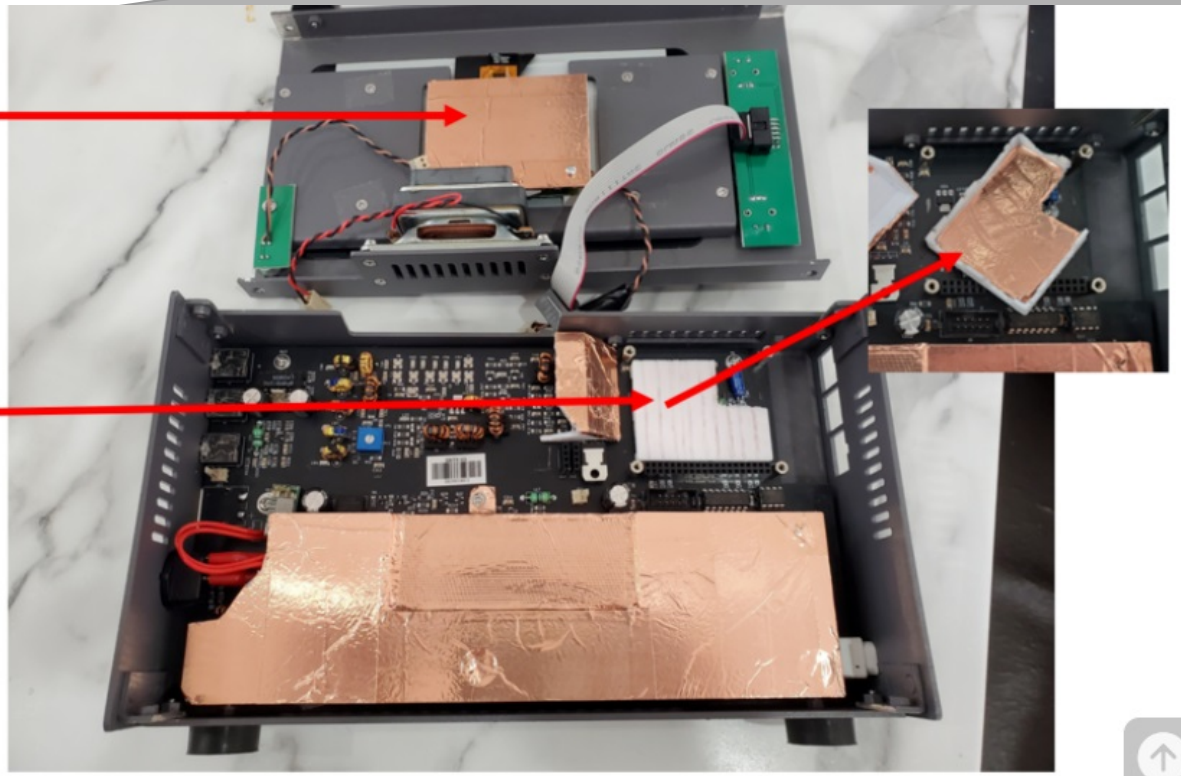
7. Receiver Birdies

- Most receivers (perhaps ALL) have spurious responses
- Intermodulation effects between harmonics of various oscillators
- Impacts of power supply oscillators
- All microprocessors / clocks
- Displays
- Easily noticed when no antenna input!
- Normal galactic / lightning background levels usually supervene
- But not always!

Improved SHIELDING

Put a shield over the display board. Not sure it does anything.

Made a cover under the Rpi with shielding tape but ended up taking out because of concerns over running temps. It fit very nice

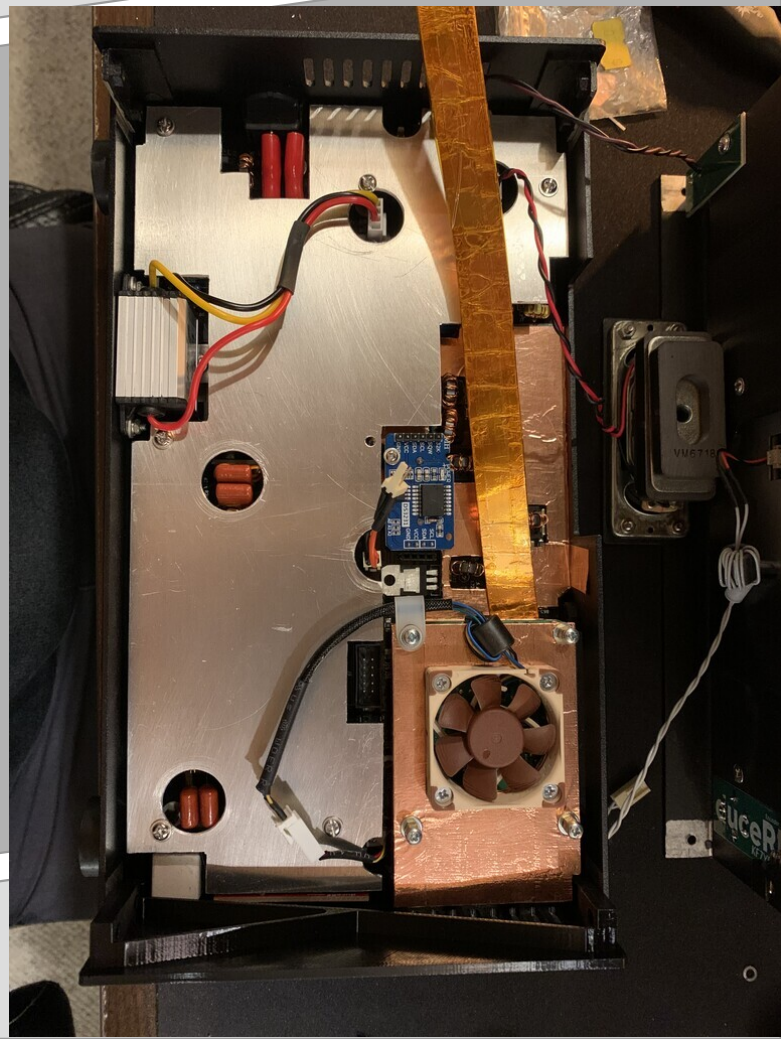


- *First effort by W9BLW*
- *https://groups.io/g/BITX20/message/115010*

02/23/25

Impact of Improved SHIELDING

- *Ryan Wesolowski final shielding – note the display cable shield and the entire RF board.*
- *https://groups.io/g/BITX20/message/115020*
- *General consensus that shielding the ribbon cable is the first and most productive impact!*
- *Easy to do with aluminum metallic tape.*
- *Cover with non-conductive tape to avoid shorts.*



8. 64-BIT CODE

- Big effort by JJ
- Produced entire image of 64-bit operating system
- 64-bit recompiled code
- Well received

9. HFSignals Surprise! Zbitx Released!

Compact version of sBitx with lower power final and lower voltage operation.

2 LIPO cells.

5+ watts out

Basically SAME SOFTWARE

Astonishingly low price!

Incredible demand!

- 400 Units immediately sold upon announcement.
- Sales paused so units can be fabricated
- (Delays in materials / Chinese New Year etc)
- Hope to have units shipping in March?

10. Getting into VHF/UHF SSB/CW

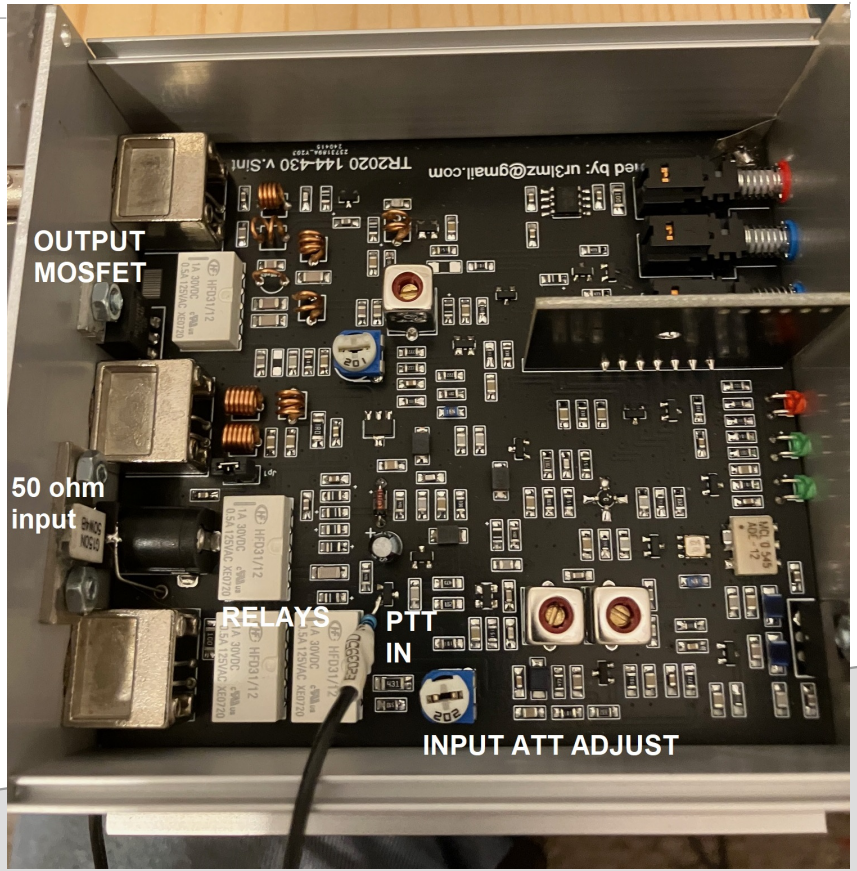
- Our ARES® group never gets Satellite Contacts – only 1 guy really knows how….
- Wonder if those Ukrainian transverters really work?
- So I bit, and ordered one!

FIRST STEP: Local 2M SSB/CW CONTACTS (Easy)

Minor Improvements to Ukrainian Unit

SSB VOX doesn't hold in properly during TX, and only 0.8W maxes out the transmitter on 2 meters….

Added a PTT line (ground to TX) – fixes the hold-in problem on Transmit completely.



Quite SMALL!!


Medium power Dual Band VHF-UHF Transverter
to 28 MHz conv
430 144 5V
F+ BND ON

My First 2m SSB QSO!

Local SSB is one thing…..but

Satellites?….much bigger project

Compared to $1700 dedicated duplex VHF/UHF Satellite radios, sBitx/Transverter is a LOW COST entry…

And it may be a complete bust, too. I have ZERO previous experience.

But it’s fun contemplating!

Could you build a full duplex CW/SSB Satellite Station from sBitx's & transverters?

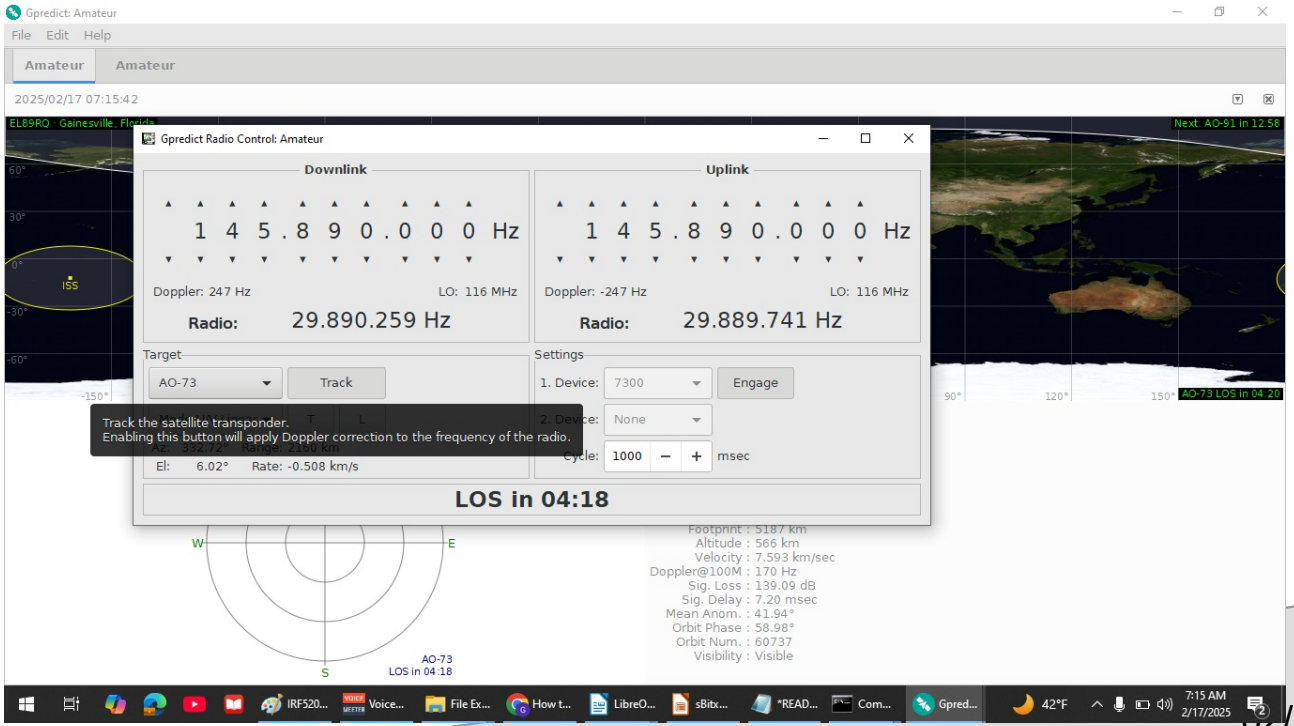
- Low costs of Sbitx's and transverters, and HF ability also make this attractive solution.
- Two problems to solve for Satellite Ground Station
  - 1 – Need to **control azimuth & ideally elevatio**n of two antennas
  - (Possibly use crossed yagi's and right hand circular)
  - (only 3-db loss R vs L – but avoids big losses when wrong polarization)
  - 2 – **Doppler Shift** – and need to be able to listen to your own signal!
  - Sbitx 10meter CAT-control provides inexpensive way to provide both sides
- **Limitation: VHF/UHF POWER is an issue….**

Sbitx makes Doppler Corrections Easy

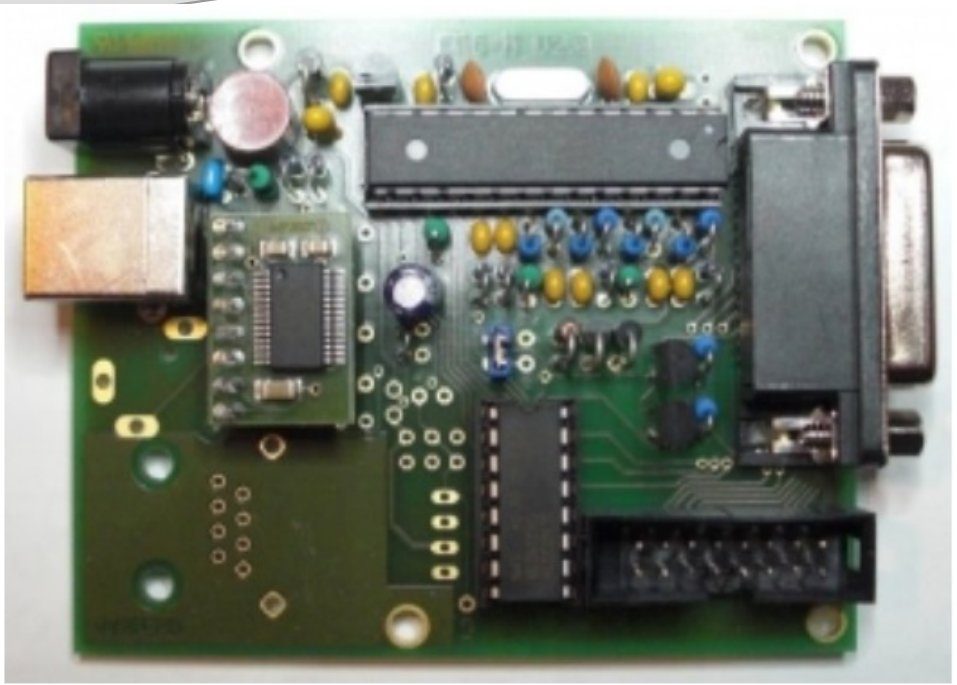
Directly accepts (port 4523) commands to set frequency
(acts like rigctld)

FREE gpredict can generate the Doppler Corrections.

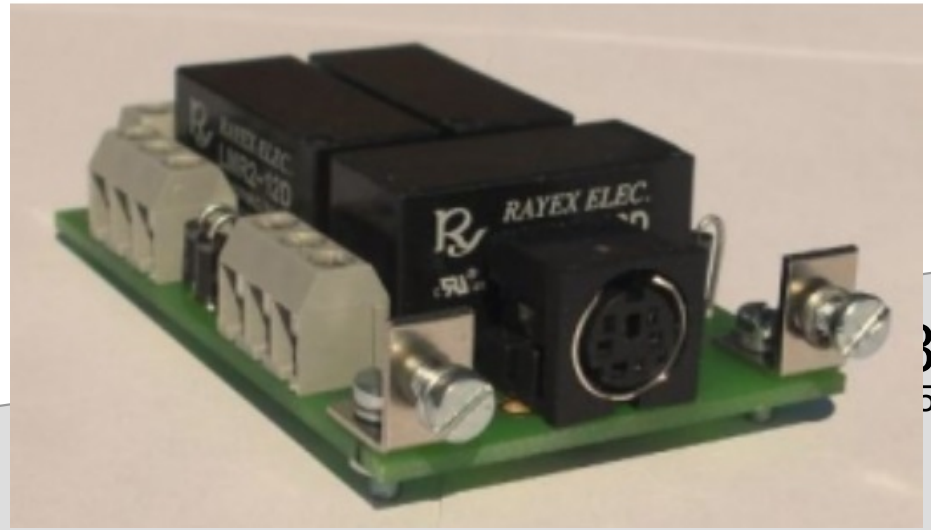
https://sourceforge.net/projects/gpredict/



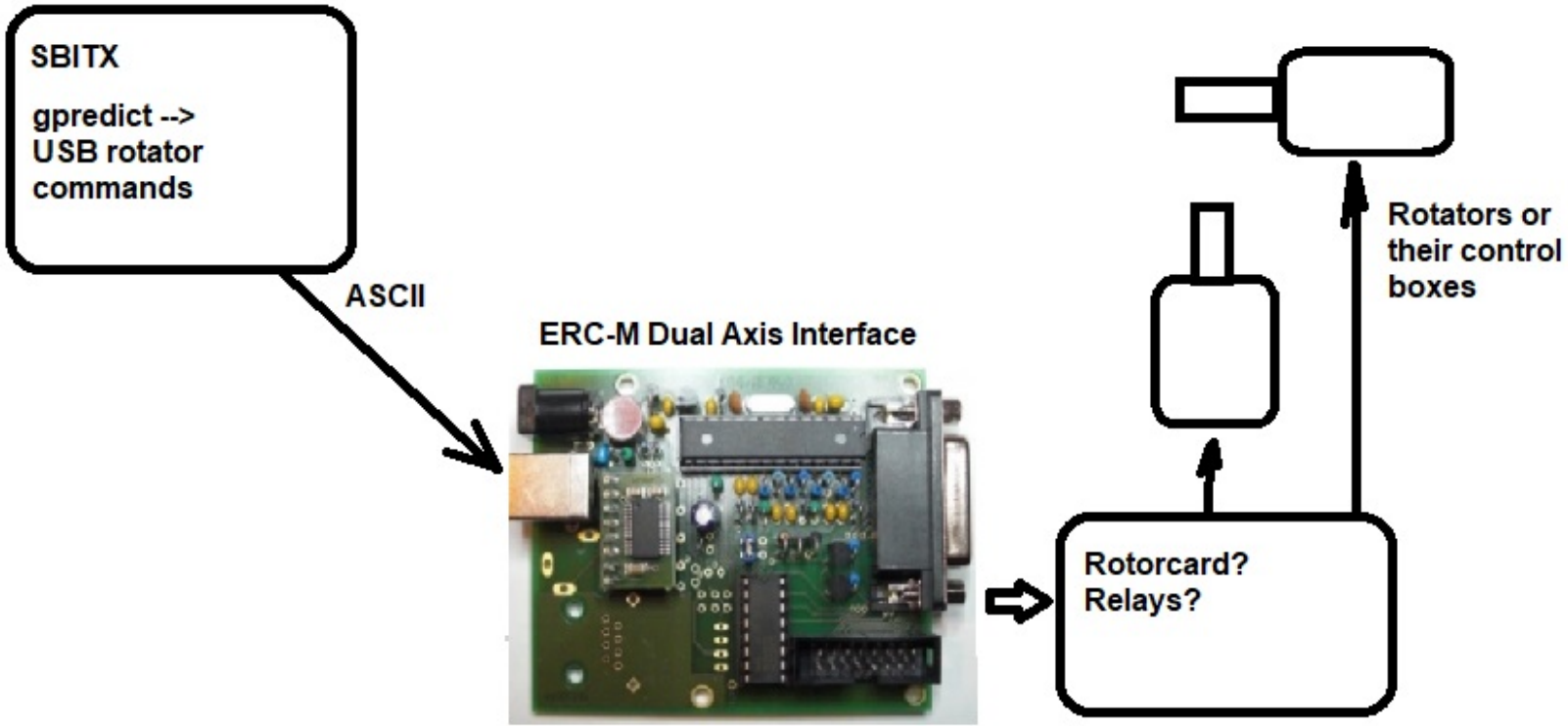
Potential Dual-Axis Rotator Control #1



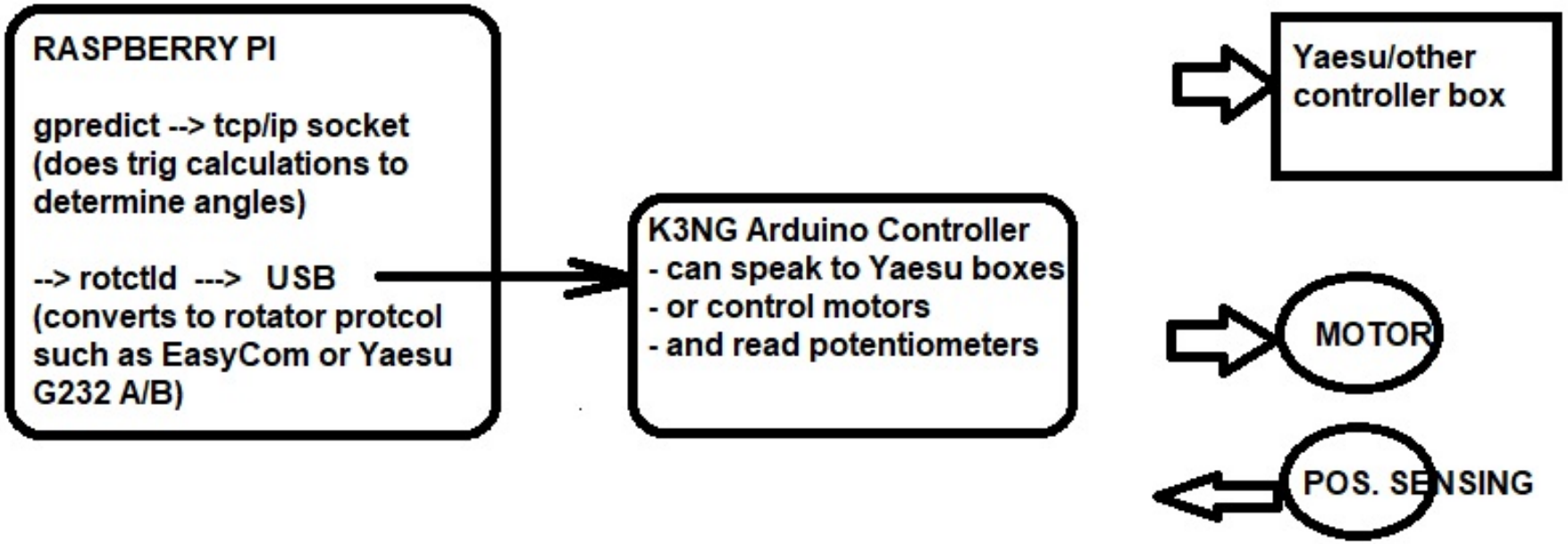
ERC-M Interface inputs ASCII commands, provides control to rotator boxes / rotators



Inexpensive Rotator Control



Alternative #2: K3NG Arduino



Small Signals & Preamps?
Transverters' Positioning Advantage

- Transverters can be placed (weather-protected) much closer to antennas
- Reduced VHF/UHF signal loss (effectively an improvement in NF)
- Protect from strong signals on other band (stubs or filters?)
- 10 meter signals to paired sBitx over lower-loss coax
- Sbitx 25kHz spectrum display helpful!

Sbitx: Where we are...

- Commercial success with multiple variants, from $180 “board alone” to $399 25-watt hybrid SDR with 25kHz spectrum visualization
- Spurious emissions under control.
- 100-V MOSFETs much more robust
- Options for experimenter include the IRF520 with prior driver system for more digital headroom, same 100-V
- Shielding display cable low-hanging-fruit for reducing birdies
- Good solutions for improving CW responsiveness and T/R delays

...now...

- Successful debut of 5W battery-powered version for only $199
- Possible platform for other projects – VHF/UHF digital SSB CW
- Even possible platform for lower cost Satellite work
- **Cost of computing likely to continue downward**
- **Pushing costs of entry-level HF ham radio gear down, down, down!**
- **Improvements to come:**
  - Still could use better PowerAmp section!
  - Needs Polarity Protection & lower-noise 5V regulator
  - 64-bit OS/code available