Latest ICARC FOX Transmitters

in a looooong line of transmitters

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A dive into the hardware and software used to implement the ICARC Fox Hunting FOX Transmitters.

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Presentation Outline

Iowa City Amateur Radio Club

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Why

Because we can!

More Flexibility (extremely programmable)
- Uncanny ability to Fool&Frustrate the hunters

All setup performed day(s) before the hunt
- Ususlly set time&date and check battery condition

No timing critical tasks at the start of the hunt
- Turn it on when you *hide* it
- Turn it on again if you bump the power switch

Easy on batteries

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Hardware Genesis

ICARC Fox hunts started up again in 2018/2019

- WB6EYV MicroHunt Foxhunting Transmitter
  - Uses the ICS525 synthesizer.
  - Fixed Frequency, very low power.
- ICARC 73161 series transmitters
  - Three hardware revisions (all using ICS525 synthesizer).
  - W0PPF (George) asks: "does it talk?".
- ICARC 73176 series transmitters
  - Yes, it talks! (Raspberry-PI FOX Transmitter).
  - Power pig. Boots up slowly.
- ICARC 73181 series transmitters Add PWM audio feature
  - Again, three hardware revisions (ICS307 then SI5351).
    - ICS307 is *end-of-life*; Renesas just keeps on hosing me :-(
    - SI5351 is far more capable; we get everywhere in the band:-)
    - zNEO package change (80-pin package not readily available)
  - Add second FLASH device to store audio.(low cost)
    - (We retrofit the PWM audio feature to the 73161 models).

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Programming Flexibility

- Frequency 2M/VHF, 23cM/UHF, *and HF!*
  - Frequecy selection programmable within band
  - UHF requires SA818U/DRA818U tranceiver module
  - SI5351 is lower power than SA818/DRA818
  - SI5351 can generate HF frequencies
- Transmit Power
  - SA818/DRA818 may run 500mW or 1000mW
  - SI5351 uses several RF daughterboards (up to around 100mW)
  - Matching network pads on RF daughterboard
  - Attenuator pads on RF daughterboard
- CW and voice
  - CW audio tone programmable
  - CW chipping rate programmable
  - Voice sample rate 4KHz, 5KHz, or 8KHz

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Timing Flexibility

Based on modular arithmetic using time from TOY clock

Scheduling Parameters:

TOY (Time of Year, seconds from some epoch: DS1672)
TOD (calculate from TOY clock)
Period (seconds, from setup in FRAM)
Offset (must be less than seconds, from setup in FRAM)

Calculate Time of Day: **(TOD = TOY % 86400)**
Transmit when (**(TOD % Period) == Offset**)

Divide time-of-day by the scheduling-period taking only the remainder
Compare the remainder with the scheduling offset
Run transmit program when they match!

Start hunt (**STAR** 10:00:00)

Scheduling is suspended until specified time occurs
Early setup while avoiding early detection!

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Hardware

ZiLOG zNEO. 16 bit expansion of ZiLOG Z8/eZ8
- 128 K Byte program flash
- 4 K Byte RAM area

SMPS Regulator. switch-mode: more efficient than linear.

Battery Current and Voltage Monitor.

USB or logic-level interface. programming channel from host computer.

Second serial interface. External tranceiver or DRA818/SA818 module.
Interface for external radio, (i.e. a hand-held tranceiver)

TOY clock. Synchronize all transmitter schedules.

PWM Channel. Voice for identification and status reporting.

SI5351 synthesizer. VHF carrier, FM modulation through reference crystal.

RF Daughterboard. RF amplifier on daughterboard allows for experimentation.

RF Daughterboard power switch. unpowered when idle.

Output Filter. Lowpass filter between RF stage and the output (BNC) connector.

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Hardware

Amplifier 102-73181-28. A1A and F1A/F3E up to around 100mW

- MMIC gain element in SOT89 package (IF amplifier: Class-C).
- CHiRP specific amplifier (RF power switching using **TX_ENA** net).
- default mode F1A/F3E, **CONF CW** to operate A1A
- Wildlife tracker mode **CHRP** *tone.,per.,dur.,count*

Amplifier 102-73181-36. A1A and F1A/F3E up to around 1000mW

- DRA818/SA818 VHF or UHF tranceiver module.
- Work with CHiRP (PTT* using **TX_ENA** net).
- default mode F1A/F3E, **CONF CW** to operate A1A
- Wildlife tracker mode **CHRP** *tone.,per.,dur.,count*

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Software

Entirely written in "c". Small number of in-line assembly instructions.

Very modular. 40+ individual *source units* make up the load image.

Architecture is a simple loop and a few interrupt handlers.

- Look for incoming command buffer.
- Look for scheduling match (**(TOD % Period) == Offset**)

Clock Interrupt.

- TOY clock sets system clock at startup.
- 10mS interrupt updates system clock (100 ticks/second).

UART Interrupt.

- buffer incoming commands until a **0x0D** is detected.

CW Interrupt. Controls **TONE_ENABLE** pin.

- Interrupt period is set to CW chipping rate (*dit*).
- Interrupt routine counts out longer periods (*dah* is 3 interrupts).

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Synthesizer: SI5351

- SI5351 exists only on 102-73181-5 and 102-73181-10 boards.
- I2C device with very large register space. Many bits to load!
- Tables built into program flash when software is built.
  - Table size somewhat limited by available space in program flash.
  - Table has frequency and six register values. many other SI5351 fields written!
- Three outputs from SI5351. Only one of them can be selected.
  - CLK0 goes directly to RF daughterboard (50 ohm!). Drives SOT89 amplifiers
  - CLK1 is buffered by a high-speed CMOS logic gate. gate addition required
  - CLK2 is buffered by an LVDS driver. LVDS pair sent to daughterboard
- Command path to directly load the *Multi Synth* registers.
  - **NO sanity checking.**
  - Allow configuring the SI5351 for any frequency.
  - Easy to generate out-of-band signals. (like 10M or 6M)
- Frequency Tables in FRAM.
  - Setup any target frequency.

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Synthesizer: DRA818/SA818

- Functions correctly only with 102-73181-10 boards.
- Low-cost tranceiver module. (Rx channel as well as Tx channel.)
  - Daughterboard 102-73181-36 used to mount DRA818/SA818 module.
  - Serial command interface for frequency selection.
  - Digital levels for power-down (**PD***) and Push-to-Talk (**PTT***).
- Daughterboard 102-73181-36 connects receive channel to tiny speaker.
  - Low power audio amplifier.
  - Amplifier disabled during transmit.
  - Audio path not populated for typical fox hunt application.
  - Audio modulation from motherboard connects to audio-in.
  - Board can be built as a software test fixture (speaker and LEDs).
- The 102-73181-5 doesn't cut it!
  - This artwork doesn't split the *power down* (**PD***) and the *push-to-talk* (**PTT***) signals.
- Doesn't seem to produce advertised power.
  - Six to eight dB down from spec.

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Synthesizer: ICS525

Exists only on 102-73161-25 boards.

Current software release provides an upgrade path for older transmitters.

- The new software is based on the software from these units.
- The new software is more modular. Streamlined command decoder.
- Most existing commands carry forward unchanged.

Frequency Selection.

- Table based, much like SI5351 implementation.
- Support for directly programming the 3 registers.
- Frequency selection much more limited due to ICS525 architecture.
- 19 discrete bits set the frequency (the 3 registers).
- RF modulation achieved by varying the load on the reference crystal (same method as the SI5351 modulator).

Poor RF performance.

- power from ICS525 spotty, some good, some bad.

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Programming

FOX Transmitter operating programs.

- Loads through 57,600 b/S serial channel.

Stored in FRAM device.

- FRAM does not require device erase, we can change single commands when developing new operating programs.
- FRAM size somewhat limited, but doesn't seem to be a problem (other than cost for a large device).

Simple verb-object structure

- Four character command stem (the *verb*).
- A variable number of parameters (the *object*) (command dependant).
- Small subset actually used to implement a fox message.

Waveform data (audio) stored in FLASH.

- Large device for not too many dollars!
- Can boost serial rate to 115,200 b/S.

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Programming

Access to the *FOX Transmitter operating programs* uses serial port.

- Linux utility to set time and load *FOX Transmitter operating programs*.

Early boards have USB UART on board.

- Standard USB-B connector (not mini or micro).
- Each board has unique USB port (COM492 on Windoze)
- Linux uses ID string in the USB device.
  - FOX10: /dev/serial/by-id/usb-UIowa_KC0JFQ_FOX_V2_2078-0-0105-if00-port0
  - FOX14: /dev/serial/by-id/usb-UIowa_KC0JFQ_FOX_V2_2078-0-0109-if00-port0
- Night before we open every enclosure (USB cable) to update time

Later boards have logic-level serial port.

- 3.5mm stereo audio connector.
- All stations share a common USB serial cable (mine is called TACH).
  - TACH: /dev/serial/by-id/usb-KC0JFQ_KC0JFQ_Debug_5000-0-0115-if00-port0
- Night before we just switch the USB-UART cable from box-to-box.
- FTDI Chip part number: **TTL-232R-3V3-AJ**
- Retain pads for USB UART (not populated).

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System Commands

System configuration commands.

ONCE Execute program one time. (for testing)
RUN0 Enable the specified schedule.
STAT Status Report.
CONF Hardware Configuration.
TIME Read or write TOY clock.
STAR Start scheduling at specified time.

System setup commands.

CALL Set FCC Callsign. (W0IO W0JV KC0JFQ, etc.)
NAME Set unit "nickname". (FOX1, FOX2, FOX3, ...)
TIME Set system time from TOY clock. (Scheduling ignores days)
EPOC Set local time zone. (In Iowa we use -5.0 or -6.0)

Both **CALL** and **NAME** can be substituted into the **CODE** and **TALK** commands using the <CALL> and <NAME> construct. These *System setup commands* should only appear in the **INI=** file.

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Program Commands

Program Commands.

BEGN Enable transmitter, send signon message.
DONE Disable transmitter, send signoff message.
CODE Send CW message.
TALK Send Voice message.
CHRP Emulate wildlife tracker.
BATV Battery Report (Voice).
BATC Battery Report (CW).

These *Program Commands* appear in the *operating programs*

Program Scheduling Commands.

MODS Load (or set) a schedule.

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FRAM and FLASH Commands

FRAM Commands.

ESAV Save a command string to the FRAM device.
EZER Zero out a command. Allows for overwrite.
ERAS Erase a command. Changes it to a dummy command.
EDMP Dump FRAM.
EDID Dump FRAM and FLASH JEDEC ID bytes.

FLASH commands.

HERA Erase entire FLASH device.
HDMP Dump all or parts of the FLASH device.
:hex Load FLASH device using Intel HEX records.

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TEST Commands

TEST Routines. Used for hardware test and debug.

HALT Halt processor asm(" HALT");.

STOP Stop processor asm(" STOP");.

REST Reset Processor.

TEST Test routines.

STOP requires a hardware reset or power cycle!

Test routines are used to exercise various parts of the system during hardware and software debugging.

There is room in program flash to leave these diagnostic and testing routines in place.

The **TEST** commands have the potential to damage hardware if used incorrectly.

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Talk Directory

Listing 1: TALK directory

```
esav TALK=BATTI 0                                                    1
esav TALK=BATTV 4224                                                 2
esav TALK=REG5 8704                                                  3
esav TALK=POINT 13824                                                4
esav TALK=V_HZ 15232                                                 5
esav TALK=V_KHZ 17664                                                6
esav TALK=V_MHZ 20864                                                7
esav TALK=V_N0 24064                                                 8
esav TALK=V_N1 26752                                                 9
esav TALK=V_N2 28544                                                 10
esav TALK=V_N3 30720                                                 11
esav TALK=V_N4 32640                                                 12
esav TALK=V_N5 34560                                                 13
esav TALK=V_N6 36736                                                 14
esav TALK=V_N7 38528                                                 15
esav TALK=V_N8 40448                                                 16
esav TALK=V_N9 41984                                                 17
esav TALK=V_MAMP 44416                                               18
esav TALK=V_VOLTS 48128                                              19
```

Directory entries for the audio clips.

The begining of the **TALK directory**.

Name and starting address in FLASH.

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Talk Directory

```
esav TALK=KC0JFQ 51200                                    20
esav TALK=W0JV 56960                                      21
esav TALK=FOX20 63104                                     22
esav TALK=FOX21 66048                                     23
esav TALK=FOX22 70272                                     24
esav TALK=FOX23 74624                                     25
esav TALK=FOX24 79872                                     26
esav TALK=FOX25 84608                                     27
esav TALK=FOX26 90752                                     28
esav TALK=FOX27 95744                                     29
esav TALK=FOX28 100352                                    30
esav TALK=FOX29 104832                                    31
esav TALK=FOX30 109824                                    32
esav TALK=FOX31 113664                                    33
esav TALK=FOX32 118400                                    34
```

More Directory entries...

The *NickName* clips for all Fox stations are present

Both club callsign and personal callsign are in the FLASH.

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Talk Directory

```
esav TALK=V_F144 123264                                    35
esav TALK=V_F145 128000                                    36
esav TALK=V_F200 134016                                    37
esav TALK=V_F225 139776                                    38
esav TALK=V_F250 145792                                    39
esav TALK=V_F275 152192                                    40
esav TALK=V_F300 158080                                    41
esav TALK=V_F325 163968                                    42
esav TALK=V_F350 168704                                    43
esav TALK=V_F375 173312                                    44
```

Even more Directory entries...

Frequency clips for the ANN= message at startup

(ANN announces operating frequency!)

As you should expect, order is not critical

When a **TALK** command is executed,

we match names to get the start address in FLASH.

We then look for a **RIFF/WAVE** header to get the data size and sample rate.

SPI clock rate is set to 8x the audio sample rate.

This drives the target sample rate (1 sample every 8 SPI clocks).

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INI File

Listing 2: "INI File"

```
esav INI=NAME 'name'                                    33
esav INI=CALL 'call'                                    34
esav INI=TIME                                           35
esav INI=EPOC -5.0                                      36
#                                                       37
#esav INI=CONF BMON 12.5V                               38
esav INI=CONF SI5351                                    39
esav INI=CONF 8MA CLK0                                  40
esav INI=CONF DRA818                                    41
esav INI=FREQ 144.150                                   42
#                                                       43
#       Set schedules, leaving ONLY                     44
#                                                       45
REM- 01234567890123456789012345678901234567890         46
esav INI=MODS S0 'run'                                  47
esav INI=MODS S1 30 0                                   48
esav INI=MODS S5 60 0                                   49
esav INI=MODS S6 10 0                                   50
esav INI=MODS S7 300 0                                  51
esav INI=MODS S9 300 0                                  52
```

The INI= file; system initialization.

I use a single setup file to load FOX20..FOX32
'call', **'name'**, and **'run'** substituted from the

loader utility command line

This file runs when one or no jumpers installed

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ANN File

Listing 3: "ANN File"

```
esav ANN=REM- fox_ann_V2023.fox                    64
esav ANN=TONE 1.0                                  65
esav ANN=CWPM 30,-1,-1,-1,-1                       66
esav ANN=BEGN                                      67
esav ANN=TALK <CALL>                               68
esav ANN=TALK <NAME>                               69
esav ANN=WAIT 1.0                                  70
esav ANN=BATV V                                    71
esav ANN=BATV I                                    72
esav ANN=WAIT 0.3                                  73
esav ANN=TALK 'freqM'                              74
esav ANN=TALK 'freqK'                              75
esav ANN=TONE 1.0                                  76
esav ANN=CWPM 30,-1,-1,-1,-1                       77
esav ANN=DONE                                      78
esav ANN=FREQ 'freq'                               79
esav ANN=STAT                                      80
esav ANN=RUN0 S0                                   81
```

The ANN= file; system announce message.

- Runs **after** INI= when **no** jumpers are installed. Tell 'em we're alive!
- More parameter substitution from command line: **'freq..'**
- Parameter substitution from INI= setup: <CALL><NAME>
- Frequency change to operating frequency in line 57
- Schedule **S0** enabled in the last command in line 59

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TEST File

Listing 4: "TEST File"

```
esav TEST=CWPM 35,-1,-1,-1,-1                                    54
esav TEST=CONF                                                   55
esav TEST=STAT                                                   56
```

The TEST= file; system test.

- Runs **after** INI= when TEST jumper installed
- You are free to do whatever you want here
- ANN= message is **not** sent

Did you notice

- that we changed frequency!
- In the **INI=** command and again in the **ANN=** command?
- We can do that! (even in the middle of a message)

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MAS File

Listing 5: "MAS File"

```
esav MAS=CWPM 35,-1,-1,-1,-1                                    59
esav MAS=STAT                                                   60
```

The MAS= file; alternate system test.

- Runs **after** INI= when MAS jumper installed
- You are free to do whatever you want here too!
- ANN= message is **not** sent

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System Recovery

System Recovery (error recovery)

Install both **MAS** and **TEST** jumpers

Nothing is read from either the **program** or **waveform** memory.

Use to recover from fouled up programs

When you really screwed it, so it won't even talk to you!

With both jumpers in, the software skips all setup files...

Yes, it has been used to recover from a *FUBAR*

That *FUBAR* triggered the software update to implement this recovey feature.

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S0 File

Listing 6: "S0 File"

```
#       Operating Schedules
#       The power draw of the PS may cause the
#       "BATC" form of the report to take too long, so we
#       ALWAYS use the vocal report.
#       ALSO We're making use of the <CALL> and <NAME> substitution
#              inside the fox transmitter!!!
#
esav S0=CONF -AM
esav S0=TONE 1.0
esav S0=CWPM 30,-1,-1,-1,-1
esav S0=BEGN
esav S0=TALK <CALL>
esav S0=TALK <NAME>
esav S0=WAIT 0.5
```

The S0= file; operating program for schedule 0.

Set audio tone and CW chipping parameters to:

1KHz and 30WPM (fast signon message)

BEGN enables carrier and sends signon message

TALK verbalizes our callsign and name

WAIT for half a second, unmodulated carrier

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S0 File

```
#                                                                    100
#    Fill time so they have a chance of finding me                   101
#                                                                    102
esav S0=TONE 1.5                                                    103
esav S0=CWPM 25,-1,-1,-1,-1                                         104
esav S0=WAIT 0.15                                                   105
#esav S0=CODE hi hi hi                                              106
esav S0=BATC EV 7.2                                                 107
esav S0=WAIT 0.5                                                    108
esav S0=CODE IOWA CITY                                              109
esav S0=CODE AMATEUR RADIO                                          110
esav S0=CODE CLUB FOXHUNT                                           111
esav S0=CODE F W KENT PARK                                          112
```

Change what we sound like, 1.5KHz and 25WPM

WAIT for 150 milli-seconds, more unmodulated carrier

Line 107, send *encoded* battery report (count the dah/dits)

When above 7.2V, send "**HI HI HI BATV ttttttt eee**"

When below 7.2V, send "**SOS SOS BATV tttttt e**"

Lines 109-112; send our message in code

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S0 File

```
# Prepare (kinda...) for Signoff                                    116
#    these extr REM- commands can be deleted (EZER)                 117
#    and replaced with more CODE commands to adjust time...         118
esav S0=REM-                                                        119
esav S0=REM-                                                        120
esav S0=REM-                                                        121
#                                                                   122
# Signoff                                                           123
#                                                                   124
esav S0=TONE 1.0                                                    125
esav S0=CWPM 30,-1,-1,-1,-1                                         126
esav S0=DONE                                                        127
```

lines 119-121 can be replaced to fix *problems*.

lines 125-127 return the code generator to the same state it was in for the **BEGN** message

DONE sends our callsign in the signoff message and removes carrier (ID at end-of-message).

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Help Pages

HELP list from current software:

Starting with the **System** commands.

Listing 7: fox27.help_1

```
sts01,00* TEST HELP **  TEST HELP **  TEST HELP **                          1
sts01,00* Idx MNE  Class      ————————Arguments————————  Command Function  2
sts01,01*   1 HELP SYS                                   Help Menu and Items 3
sts01,02*   2 HELP SYS        <string>                   matching help items 4
sts01,03*   3 ONCE SYS        <name>                     Test run the named seqwuence 5
sts01,04*   4 REM– SYS                                   Remark, (side-effect: stops 6
                                                       ↪ schedules)
sts01,05*   5 RUN0 SYS                                   RUN ALL Schedules   7
sts01,06*   6 RUN0 SYS        <name>                     RUN Specific Schedule 8
sts01,07*   7 STAR SYS        <time>                     Start running schedules at 9
                                                       ↪ specified time
sts01,08*   8 IDLE SYS                                   STOP ALL Schedules  10
sts01,09*   9 STAT SYS        <flag>                     System Status, (I)ident scan 11
```

ONCE Sequence testing feature
RUN0
IDLE
STAT Verbose dump of system status.
Adding the **I** dumps the version/date strings
from all the software modules.

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Help Pages

More **System** commands.

Listing 8: fox27.help_12

```
sts01,10*   10 CONF SYS      <keywords>                Hardware Configuration      12
sts01,11*   11 TOYC SYS      <res> (250 2K 4K NONE)    Hi chg rte DS1672 bat       13
sts01,12*   12 TIME SYS      <time value>              Set Time (set DS1672)       14
sts01,13*   13 D525 SYS      <sub-command>             ICS525 debug routines       15
```

CONF defines the hardware we are running on.

TIME with argument sets the DS1672 TOY clock.

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Help Pages

Next in line are the **Setup** commands.

Listing 9: fox27.help_16

```
sts01,14*   14 TIME SETUP                          Time from DS1672 to System (NO   16
                                                 ↪ Argument!)
sts01,15*   15 EPOC SETUP      <hours>             Epoch offset (i.e. time zone)    17
sts01,16*   16 CALL SETUP      <call>              FCC Assigned Callsign            18
sts01,17*   17 NAME SETUP      <nick>              Local Nickname                   19
sts01,18*   18 NICK SETUP      <nick>              alias for "NAME", but don't use  20
                                                 ↪  it!
```

TIME with no argument sets system time from TOY clock.

EPOC sets a timezone offset (TOY is kept in UT, not local) (negative west of Z).

CALL save the FCC assigned callsign for later use.
AA0AAA/5 is OK, but must have audio file for each station!

NAME & **NICK** save a tactical callsign (nickname) for later use.
Use this to distinguish stations!

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Help Pages

Followed by **Program** commands.

Listing 10: fox27.help_21

```
sts01,19*   19 TONE PGM      <freq>)                        Audio Tone (in KHz)          21
sts01,20*   20 CWPM PGM      <wpm gap1 gap2 gap3>           CW Chipping Rate             22
sts01,21*   21 FREQ PGM      <freq>                         Frequency (in MHz)           23
sts01,22*   22 5351 PGM      <key>,<value>,<value>,...SI5351 setup group                 24
sts01,23*   23 BEGN PGM                                    Key TX and Send Callsign (CW) 25
sts01,24*   24 CODE PGM      <message>                      Send Message (CW) up to 22 char 26
sts01,25*   25 TALK PGM      <file-name>                    Play Voiced Message (EDMP TALK) 27
sts01,26*   26 WAIT PGM      <secon.ds>                     Wait (simple delay)          28
sts01,27*   27 CHRP PGM      <tone> <dur> <del> <cnt>Send carrier chirp                  29
sts01,28*   28 DONE PGM                                    Send Callsign (CW), SK (CW),  30
                                                        ↪ and unkey TX
```

TONE Audio frequency for code generator.
TONE 0.0 will disable tone generater for unmodulated carrier.

CWPM Code rate and timings.

FREQ Nominal Carrier Center Frequency.

BEGN Turn on RF and send signon message.

CODE Send text in code.

TALK Send audio file.

WAIT Simple delay.

DONE Turn off RF and send signoff message.

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Help Pages

Add some battery status reports.

Listing 11: fox27.help_31

```
sts01,29*   29 BATC PGM      <mod>,<key>,<setpoint>  Transmit Code Battery Report      31
sts01,30*   30 BATV PGM      <mod>,<key>             Transmit Vocal Battery Report     32
                                          mod: "E" encode (not CW) for BATC            33
                                          mod: "B" battery reading taken before BEGN   34
                                          mod: "A" battery reading taken after BEGN    35
                                          key: "V" battery voltage,                    36
                                               "I" battery current,                    37
                                               "R" 5V rail                             38
```

BATC Battery Report, CODE.

Adding **E** to command changes from using proper code to using 'T' and 'E' characters to encode the voltage or current.

BATV Battery Report, Voice.
Reporting audio clips must be loaded in FLASH for this to function.

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Help Pages

A few **Scheduling** commands.

Listing 12: fox27.help_39

```
sts01,31*   31 MODS SCHED     <Sname period offset>   Modulus Schedule Set     39
sts01,32*   32 MODC SCHED     <Sname=>                Modulus Schedule Clear   40
```

MODS Modular Schedule.

Schedule name: S0 through S9 (up to 10 of them).

Period is the cycle time, expressed in seconds.

Offset is offset into the scheduling Period.

Always less than the Period.

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Help Pages

A single **Directory** command.

Listing 13: fox27.help_39

```
sts01,33*   33 TALK DIRECTORY esav TALK=name,Strt,Len,rate      (appears in FRAM as      41
                                                              ↪ the TALK= file)
                                                                Waveform Directory Entry  42
                                                                rate keys: 4K 5K 8K 10K 16K  43
```

TALK= Audio File Directory.

This is the directory of audio clips stored in FLASH.
You will see one for each fragment of speech.
Number of them limited by space in FRAM to store the directory and space in FLASH to store data samples.
Data rate can be one of three rates (mind bandwidth limitations!)

4KHz, 5KHz, 8KHz, 10KHz, 16KHz

RIFF/WAVE files have length and rate information in the header.

So they only require the starting address in the directory entry.

This **TALK** key is context sensitive. This keyword defines a directory entry and a command.

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Additional Frequency Parameters.

Listing 14: fox27.help_44

```
sts01,34*   34 freq DIRECTORY esav 144.150=13BF,70E40,F4240,100 (appears in FRAM as    44
                                                    ↪ frequency record)
                                                    Register Parameters are           45
```

Frequency setup for SI5351/ICS525

- The frequency entry is a text record (so think string match)
- The *freq* is the frequency in MHz (3 decimal digits)
- For the SI5351 we have four values to be sent to the synthesizer.
- For the ICS525 we have the 3 register values.

Used when target frequency is not in the zNEO internal table.

External utility to generate a table of frequencies

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FLASH and FRAM Control COmmands

First of them are the **FRAM** commands.

Listing 15: fox27.help_46

```
sts01,35*   35 ESAV FRAM      NAM=<text>              Save named record in next free location   44
sts01,36*   36 EDMP FRAM      "match string"          Dump active records                       45
sts01,37*   37 EDID FRAM                              Flash JEDEC-ID table dump (PROG & WAVE)   46
sts01,38*   38 ERAS FRAM      <number> or "DEV"       Rewrite <record> to REM- (DEV, QTR, HALF) 47
sts01,39*   39 EZER FRAM      <number>                Erase <record> to ZERO                    48
sts01,40*   40 ETAB FRAM                              Dump JEDEC-ID device table                49
```

ESAV Save record.
EDMP Dump records. The *match string* will report only matching strings.
EDID Read and report of the ID bytes in the FRAM and FLASH device.
ERAS Rewrite the numbered record to be a *REM-* command.
EZER Rewrite the numbered record to the empty value.

Records after the **zero**ed record are lost until something is written to this replace the **zero**ed record .

ETAB List of recgonized memory devices

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And then the small number of **FLASH** commands.

Listing 16: fox27.help_52

```
sts01,41*   41 HERA FLASH      ALL                                  Hex erase (entire WAVE device)    50
sts01,42*   42 HDMP FLASH      <len-32B-lines <hex-start <*>>>      Hex dump (WAVE device)            51
sts01,43*   43 H56K FLASH                                          Fast terminql bit rate            52
sts01,44*   44 :hex FLASH-HEX  :llaaaattddddddddcc                 Intel HEX loader (WAVE device)    53
```

The FLASH is used to store audio data (i.e. no commands stored here).
These are 8-bit mono *reduced sample rate* WAV files (4KHz to 16KHz).
The *TALK=* entries point to a starting point for each audio fragment.
- Length and sample rate in RIFF/WAVE header, otherwise in directory entry (see sheet 19)

Start pointer points at RIFF/WAVE header, otherwise to the start of the waveform data
Only write path to FLASH is using an Intel HEX file to store audio data.
Intel HEX file may have embedded spaces.
- character text may appear following the checksum, but that may cause buffer overflow.

Intel HEX record length limited to 32 data points.
- There is very little SRAM in the zNEO to buffer longer records

H56K is now H115 to buzz-up the transfer rate (to 115,200)!
- Nominal rate 57,600 b/S. Input channel buffered (ISR).
- Write timing open-loop, zNEO allows 10mS to 20mS before status report.

HERA can be sloooooooooooooooooooooooooow
- Sends device erase to FLASH device, reports expected erase time but doesn't wait!
- Some flash devices take hundreds of seconds to erase!
- Flash device appears dead or broken until erase function completes.

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Finally, some **Test** commands.

Listing 17: fox27.help_56

```
sts01,45*   45 HALT TEST          Halt Processor                54
sts01,46*   46 STOP TEST          Stop Processor                55
sts01,47*   47 REST TEST          Reset System                  56
sts01,48*   48 TEST TEST          Hardware Test Subsystem       57
```

HALT Executes the zNEO HALT instruction. Next interrupt releases the halt state.

STOP Executes the zNEO STOP instruction. Causes the system to hang.

REST Sets the *USER_RST* bit int the zNEO *RSTSCR* register.
Causes the zNEO to reset (like a power cycle or mashing the reset button).

TEST This is a gateway command to a set of hardware debugging routines.
TEST HLP Produces a list of test routines.
Used for hardware test and debug.