ICARC Fox Transmitter Project

This presentation is coming from the latest FOX TRANSMITTER

It appears we need to purchase several 27” LCD monitors to deploy for the next fox hunt :-)

ICARC Fox Transmitter Project

W0PPF made me do it!

Contest fox transmitters not well suited to learning the art of fox hunting.

Not enough on time!

But we'll fix that problem...

ICARC Fox Transmitter Project

102-73161-7

First Prototype/Proof of concept

ZiLOG zNEO processor: 128K Program Flash, 4K SRAM
Large FRAM (like EEPROM/Flash but full speed write)
Sequence engine allows arbitrary schedules
Code engine from 2013 radio interface project
Network connection to synchronize time
on-board TOY clock.

USB interface (to zNEO) to allow easy download of operationg schedule.

ICARC Fox Transmitter Project

102-73161-12

Second Prototype

4 units built
Corrects errors/problems in the -7 artwork
Software compatible with -7

Adds battery voltage monitor
Adds HT control capability (audio and PTT connector)

ICARC Fox Transmitter Project

102-73161-25

Third Prototype
3 units built (so far)

Move RF amplifier off main board so we can experiment a bit

Change voltage regulator to switchmode (extend battery life)

Change RF modulation method to reduce cost.
Modulate capacitive load on reference crystal to shift frequency.

Switchmode regulator extends battery life to around 30 hours.

ICARC Fox Transmitter Project

102-73176-0

First *Raspberry PI* Prototype
Another *Proof of concept* project
Change clock synthesizer from ICS525 to ICS307 (ICS525 is EOL)

Raspberry PI Zero W
1GHz, 512KB RAM, uSD card, **WIFi**, bluetooth
Connector positions match -12, -25 boards.
VOICE!!! it talks, it talks, and did I mention it talks…
On-board audio amplifier and R/C servo control (Red Dwarf “Talkie Toaster”)
Maybe have servo wave a flag or something like that.

Expected battery life less than 10 hours (not good!).

ICARC Fox Transmitter Project

RF Amplifier

102-73161-25 and 102-73176-0 share RF section
(on daughterboard)

102-73161-24/102-73161-27 two Class-D amplifiers
Driver ON of OFF.
Power Amplifier is multiple CMOS gates, 74LVC1G04W5-7 5V
Square wave at carrier Frequency (lots of odd harmonics)

Filter: 7th order Chebyshev on main board to reduce harmonics
Amplifier is Digital, so no tuning parts
60mW/90mW

ICARC Fox Transmitter Project

102-73181-5

Allow the latest and greatest improvements rolled into one!

Change clock synthesizer to Si5351A, (ICS307, ICS525 are both EOL). Adds control over SA818/DRA818 PA module (low cost high power tranceiver module, 500mW/1000mW).

Adds current monitor from 102-73176 and 5V monitor.

Adds clock battery maintenance circuit.

Expected battery life back to > 24 hours.

ICARC Fox Transmitter Project

RF Amplifier

102-73181-24 daughterboard

Tranceiver module from, ebay seller

Serial control (using zNEO), just like a handie-talkie.

Receive channel may be routed to on-board speaker.

500mW/1000mW

ICARC Fox Transmitter Project

DTOA Switch

102-73170-A (555 timer)

102-73170-20 (CD4047)

Crude antenna elements, ½ λ spacing. Switch introduces a phase-discontinuity in the received signal when not pointing at receiver. Receiver (FM) *squeals*.

Long battery life with PP3 (9V alkaline) battery.

Will still DF without power! (WTF?!?)

ICARC Fox Transmitter Project

FOX Hunting

New Problem:

So many transmitters, how do you find them all!

Discipline...

ICARC Fox Transmitter Project

FOX Hunting

New Problem:
So many transmitters, how do you find them all!

FOX Hunt Contest Mode

All transmitters operate on one frequency using time division multiplexing

FOX Hunt Training Mode

Each transmitter operates on a unique frequency

FOX Hunt Combined Mode

Combination of the above modes, some in contest mode, other in training mode.

ICARC Fox Transmitter Project

FOX Hunting

New Problem:
So many transmitters, how do you find them all!

HA! That’s not my problem :-)

Some of them try to confuse you!, as Emmet has discovered
102-73161/102-73181 models have a built in operations control language
102-73176 models run Linux so we can use a bash script for control
102-73176 models have **Wifi**, so we can mess with it while you are looking for it (not actually doing this in practice).

ICARC Fox Transmitter Project

FOX Hunting

Message content variable.
Enough storage so we don’t need to repeat the same message.

We can change the audio pitch in the middle of the message

We can make it talk (callsign, unit name, etc.)

Switch RF on/off as well, sounds like a message exchange is in progress between multiple stations.

We can even change the carrier frequency.

ICARC Fox Transmitter Project

FOX Hunting

102-73176

And then we add the ***Don Rickles*** transmitter feature.
It heckles you while you hunt (retrofit to 102-73161).

Raspberry-PI ZERO has microSD card, so it effectively has unlimited storage. Message content is (in practice) unlimited. WAV files are typically small as they are mono with 8KHz sample rate. We can also used compressed .mp3 files.

No hardware CW assist, but we simply approach it differently.
Generate .wav file (cwwav) and copy to PI-Zero file system.

ICARC Fox Transmitter Project

FOX Hunting

3) club owned contest transmitters
1) 102-73161-7, power: 1@mW
4) 102-73161-12 4@20mW
3) 102-73161-25, power 1@30mW, 2@1mW
1) 102-73176-0, power 1@60mW
?) 102-73181-5, power 500mW/1000mW

ICARC Fox Transmitter Project

Direction Finding

YAGI

Pattern ineffective at close range, too much isotropic gain

Attenuator

Use with YAGI to attenuate close-in gain, use body as attenuator

Antenna Switch (DToA)

Effective when used with FM demodulator. Front/Back ambiguity.

Direction Finding Array

Expensive, takes all the fun out of it?

ICARC Fox Transmitter Project

Direction Finding

The transmitters are not completely stealth.
Use your ears to monitor the transmit audio, use your eyes to locate the transmitter (antenna).

Keep track of who's who.
Critical to recognize when a new transmitter becomes active.

Is the station talking to itself?
Is a 2-way conversation coming from one transmitter to confuse trackers.

Are multiple stations active at the same time?
Poor discipline or intentional interference.

ICARC Fox Transmitter Project

Direction Finding

Using the DTOA switch.

isotropic gain

ICARC Fox Transmitter Project

Direction Finding

The.

isotropic gain

ICARC Fox Transmitter Project

This presentation is coming from the latest FOX TRANSMITTER

It appears we need to purchase several 27” LCD monitors to deploy for the next fox hunt :-)

Monitors so all us ‘old timers’ can read it!

3 minimal transmitters

8 fully programmable CW low power transmitters

1 fully programmable voice low power transmitters

ICARC Fox Transmitter Project

W0PPF made me do it!

Contest fox transmitters not well suited to learning the art of fox hunting.

Not enough on time!

But we'll fix that problem...

George mentioned the difficulty in finding things during the first hunt. This, in effect, got the ball rolling on this project as well as a couple of others.

ICARC FOX Transmitter Project intended to result in a universal fox transmitter that is flexible enough to address novice as well as expert hunters.

Easy to program. Switched/Buttons approach a bit too difficult. Why not use a USB serial port!

ICARC Fox Transmitter Project

102-73161-7

First Prototype/Proof of concept

ZiLOG zNEO processor: 128K Program Flash, 4K SRAM
Large FRAM (like EEPROM/Flash but full speed write)
Sequence engine allows arbitrary schedules
Code engine from 2013 radio interface project
Network connection to synchronize time
on-board TOY clock.

USB interface (to zNEO) to allow easy download of operationg schedule.

OK, here we go…

A few shortcomings that required some haywires.

RF section sucked, poor amplifier selection.

A lot of experimentation with the AF filter to get reasonable modulation.

Discovered a few mechanical fit issues.

ICARC Fox Transmitter Project

102-73161-12

Second Prototype

4 units built
Corrects errors/problems in the -7 artwork
Software compatible with -7

Adds battery voltage monitor
Adds HT control capability (audio and PTT connector)

Correct the wiring issues from the -7 (first) artwork

Add connector for external tranceiver. Allow higher powered transmitter to be used.

Attempt to improve the RF section… Didn't work well.

Drive antenna directly from clock generator (CMOS levels) yields 20mW with ICS525 powered from 3.3V

ZNEO has integrated A/D, so read battery voltage and send its current state as part of the message traffic.

Change some of the discrete controls. Polarity change.

ICARC Fox Transmitter Project
102-73161-25

Third Prototype
3 units built (so far)

Move RF amplifier off main board so we can experiment a bit

Change voltage regulator to switchmode (extend battery life)

Change RF modulation method to reduce cost.
Modulate capacitive load on reference crystal to shift frequency.

Switchmode regulator extends battery life to around 30 hours.

Now we're cookin' with gas. This one appears to be production quality.

Move RF amplifier off-board so we can experiment.
The small size and need for only 2 layers reduces cost of the RF amplifier board significantly. Shipping becomes the major cost!

Change 5V regulator to switch-mode to make batt3ery last longer.

Connectors (RF, network) move a bit more away from the board center to make mounting easier.

ICARC Fox Transmitter Project

102-73176-0

First *Raspberry PI* Prototype
Another *Proof of concept* project
Change clock synthesizer from ICS525 to ICS307 (ICS525 is EOL)

Raspberry PI Zero W
1GHz, 512KB RAM, uSD card, **WIFi**, bluetooth
Connector positions match -12, -25 boards.
VOICE!!! it talks, it talks, and did I mention it talks…
On-board audio amplifier and R/C servo control (Red Dwarf “Talkie Toaster”)
Maybe have servo wave a flag or something like that.

Expected battery life less than 10 hours (not good!).

I think I’m going to blame George,, W0PPF, for this :-) Didn’t you ask why it didn’t talk once? Well, now it does.

Biggest problem is the Raspberry-PI Zero itself. Difficult to obtain, draws too much power, takes long time to start after power applied. Also susceptible to file-system corruption when power is removed.

Mounting locations for BNC, network, and power switch identical to other revisions. Same drill jig may be used for all.

Development board has Zero-W, so it’s network accessible. NFS mount drive on host computer to make file movement a snap. Mechanically compatible with $5 PI-ZERO.

Can run a web server so we can monitor remotely. There are some logistics involved as the WiFi range of the Zero-W is limited.

ICARC Fox Transmitter Project

RF Amplifier

102-73161-25 and 102-73176-0 share RF section
(on daughterboard)

102-73161-24/102-73161-27 two Class-D amplifiers
Driver ON of OFF.
Power Amplifier is multiple CMOS gates, 74LVC1G04W5-7 5V
Square wave at carrier Frequency (lots of odd harmonics)

Filter: 7th order Chebyshev on main board to reduce harmonics
Amplifier is Digital, so no tuning parts
60mW/90mW

- Just plop down a couple of high speed CMOS gates and call it a day.
- The *74LVC1G04W5-7* device is the fastest gate found on DigiKey. Trace lengths are equalized on both sides of the devices to equalize propogation delay.
- 102-73176-24 is 2-gate amplifier on 2-sided board. Room to route power and maintain good ground.
- 102-73176-27 is 3-gate amplifier on 4-sided board. Extra layers required to maintain good ground. Should be around 90mW. Calculated peak power for Class-D at 5V is around 300mW.
- Several traditional analog designs are in-house but untested.

ICARC Fox Transmitter Project

102-73181-5

Allow the latest and greatest improvements rolled into one!

Change clock synthesizer to Si5351A, (ICS307, ICS525 are both EOL). Adds control over SA818/DRA818 PA module (low cost high power tranceiver module, 500mW/1000mW).

Adds current monitor from 102-73176 and 5V monitor.

Adds clock battery maintenance circuit.

Expected battery life back to > 24 hours.

Can't seem to keep up with obsolesence, the clock synthesizer keeps getting retired, so we pick another one… But the SA818/DRA818 module is less expensive than the parts needed to implement the Si5351A synthesizer. More about the PA module in a bit.

102-73176 current monitor added, zNEO has the A/D channels to support this and a 5V bus monitor.

Add 2nd. SPI memory device: 1 FRAM and 1 FLASH. Smaller FRAM (expensive) for commands and large FLASH (very inexpensive) for waveform storage. Best of both worlds.

Add 1uA trickle to clock battery so it lasts longer. Needs 9V pack continuously connected to keep clock battery from supplying current.

Host interface has both USB-B and 3.5mm so no need to populate FT232RL (reduce unit cost). Programming access through battery door (no need to remove screws to update time).

ICARC Fox Transmitter Project

RF Amplifier

102-73181-24 daughterboard

Tranceiver module from, ebay seller

Serial control (using zNEO), just like a handie-talkie.

Receive channel may be routed to on-board speaker.

500mW/1000mW

- Found the walkie-talkie module on ebay. It is low cost and seems to be available. Power output control: 500mW or 1 W.
- DRA818/SA818 module held in standby when not transmitting. “E” (enable) from zNEO brings DRA818/SA818 out of staandby and 100mS later assertes the PTT control signal. The control signal (“E”) works same as 102-73161 board.
- This power control scheme extends battery life, reducing power draw when not transmitting.
- ZNEO (host) still has control of 9V/5V power to board.

ICARC Fox Transmitter Project

DTOA Switch

102-73170-A (555 timer)

102-73170-20 (CD4047)

Crude antenna elements, ½ λ spacing. Switch introduces a phase-discontinuity in the received signal when not pointing at receiver. Receiver (FM) *squeals*.

Long battery life with PP3 (9V alkaline) battery.

Will still DF without power! (WTF?!?)

Most cost effective DF antenna!

Doesn't suffer from AGC issues (like YAGI or body-shield).

2 Layouts: 555 timer (CMOS) needs timing parts selection (2xR + 1xC). CD4047 also need timing parts (R + C) but parts selection less critical as CD4047 always produces a square wave.

Direction detect is indeterminate. Only provides *line of position*. Source may be in front or behind the antenna.

Without power (just 2 antennas spaced ½ λ) the antenna is still directional. Signal strength attenuates when antennas are not equidistant from source. Seems more effective than YAGI!

ICARC Fox Transmitter Project

FOX Hunting

New Problem:

So many transmitters, how do you find them all!

Discipline...

Boy, this is going to be overwhelming.

We have enough resources to operate a multi-level fox hunt. We can run some transmitters on a staggered schedule and some on a much higher duty cycle.

Scoring system to address skill level. Award points inversely proportional to on-time, etc.

We have the facilities to operate a formal hunt!

ICARC Fox Transmitter Project

FOX Hunting

New Problem:
So many transmitters, how do you find them all!

FOX Hunt Contest Mode

All transmitters operate on one frequency using time division multiplexing

FOX Hunt Training Mode

Each transmitter operates on a unique frequency

FOX Hunt Combined Mode

Combination of the above modes, some in contest mode, other in training mode.

Contest mode: all transmitters on same frequency, operating on synchronized schedule so only one active at a time. Transmitters can emulate any contest mode.

Training mode: give you enough on-time to become familiar with DF techniques. Transition from brute-force to techniques that would work across town.

Combined mode: consider having new operators working alongside experienced operators. We have enough resources to operate everything at once.

ICARC Fox Transmitter Project

FOX Hunting

New Problem:
So many transmitters, how do you find them all!

HA! That's not my problem :-)

Some of them try to confuse you!, as Emmet has discovered
102-73161/102-73181 models have a built in operations control language
102-73176 models run Linux so we can use a bash script for control
102-73176 models have **Wifi**, so we can mess with it while you are looking for it (not actually doing this in practice).

Software architecture allows complete control of the fox transmitter.

Frequency hopping in the RF domain

Frequency hopping in the AF domain

Sophisticated scheduling methodology

Power control for the DRA818/SA818 PS module.

And to make it even more challenging, the Raspberry-PI model has WiFi. If the transmitter is close to a WiFI hotspot, event organizers can mess with things in real time.

Mel Brooks: "It's nice to be the king" ← HA! That's not my problem

ICARC Fox Transmitter Project

FOX Hunting

Message content variable.
Enough storage so we don't need to repeat the same message.

We can change the audio pitch in the middle of the message

We can make it talk (callsign, unit name, etc.)

Switch RF on/off as well, sounds like a message exchange is in progress between multiple stations.

We can even change the carrier frequency.

Event at city park, one unit was carrying on a conversation with itself. It would key down, send ID and message and then key-up. Immediately key-down, send next ID at different audio frequency and send message then key-up. And on-and-on… Good distraction!

Although we haven't set any of the foxes to operate in a psuedo-spread spectrum mode, it is within the capability of the transmitter. Frequency is selectable, so it can be changed in the operating code. This would make the NVARC fox finder extremely useful!

ICARC Fox Transmitter Project

FOX Hunting

102-73176

And then we add the ***Don Rickles*** transmitter feature.
It heckles you while you hunt (retrofit to 102-73161).

Raspberry-PI ZERO has microSD card, so it effectively has unlimited storage. Message content is (in practice) unlimited. WAV files are typically small as they are mono with 8KHz sample rate. We can also used compressed .mp3 files.

No hardware CW assist, but we simply approach it differently.
Generate .wav file (cwwav) and copy to PI-Zero file system.

- Having the ability to talk makes things interesting. This does make identification of the many transmitters more “accessible” to those that can’t copy CW.
- Downside is power requirement is MUCH GREATER than zNEO.
- Upside is 102-73181 unit returns to the zNEO while adding a large FLASH device for waveform storage. FLASH/FRAM is split to make data management easier.

ICARC Fox Transmitter Project

FOX Hunting

3) club owned contest transmitters
1) 102-73161-7, power: 1@mW
4) 102-73161-12 4@20mW
3) 102-73161-25, power 1@30mW, 2@1mW
1) 102-73176-0, power 1@60mW
?) 102-73181-5, power 500mW/1000mW

This is getting out of hand, isn't it!?!

Move over to 102-73181 and eliminate the 102-73176 units altogether (battery life on the 102-73176 units sucks).

Plan on having at least 5 of the 102-73181 units to allow a formal hunt to be conducted. Greater power output allows operating in a larger thater (i.e. Kent Park).

Move the 102-73161 units into a training role.

ICARC Fox Transmitter Project

Direction Finding

YAGI
Pattern ineffective at close range, too much isotropic gain

Attenuator
Use with YAGI to attenuate close-in gain, use body as attenuator

Antenna Switch (DToA)
Effective when used with FM demodulator. Front/Back ambiguity.

Direction Finding Array
Expensive, takes all the fun out of it?

How do we determine where to look? Which direction.

Yagi is directional, but F/B ratio for a 3-element that is poorly dimensioned is ???. Receiver AGC swamps out antenna directivity.

An attenuator can mitigate some of these shortcomings. Commercial units are $$$$ (around $1K). Homebrew much less $$$, but difficult to get precise attenuation steps (but we don't care!).

Differential Time of Arrival. Switch between 2 antennas ½ λ apart. Imparts audio squeal when not pointing at source.

Commercial DF arrays, cartop for example. Expensive. Not so man portable.

ICARC Fox Transmitter Project

Direction Finding

The transmitters are not completely stealth.
Use your ears to monitor the transmit audio, use your eyes to locate the transmitter (antenna).

Keep track of who's who.
Critical to recognize when a new transmitter becomes active.

Is the station talking to itself?
Is a 2-way conversation coming from one transmitter to confuse trackers.

Are multiple stations active at the same time?
Poor discipline or intentional interference.

The antenna has to be somewhere where it can transmit. In the case of our fox transmitters, the ribber ducky is ALWAYS orange. It should be obvious once you locate it, but probably not open to a casual visual scan.

Make the jump when the transmitters change. Paper map to record LOP (line of position) may help.

Audio frequency may change and the station may drop carrier between message segments. Station outout power may also change.

The internal clocks may be off a bit or the message traffic may be just a few seconds too long causing more than one station to be active at once. They may ne doing this simply to confuse you!

ICARC Fox Transmitter Project

Direction Finding

Using the DTOA switch.

isotropic gain

This

ICARC Fox Transmitter Project

Direction Finding

The.
isotropic gain

This