Cave Radio Developments

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Sastar Zoom Meeting

Aug 24, 2026

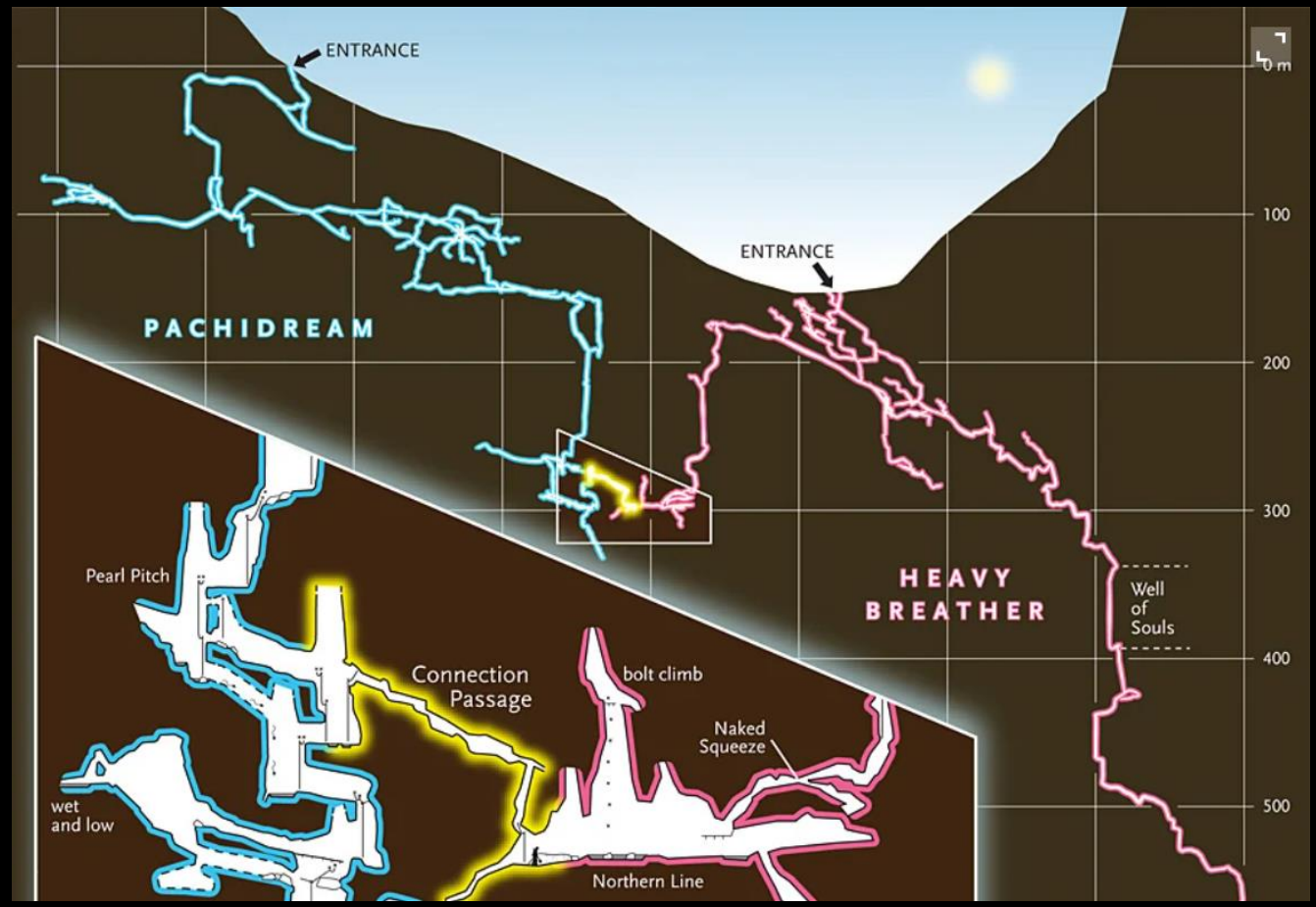
Agenda

- Cave Radio Missions
  - Radiolocation
  - Communication, voice, text and data
- Past technologies
  - Audio frequency
  - Single Sideband
    - Separation of Radiolocation and Communication functions
- What happened in 2005, 2015 and 2022 ?
  - Making cave radios better, lighter and cheaper using QRP Labs radio kits

Radiolocation and Cave Maps

Maps are made with compass, clino and tape
Loop closure used to judge accuracy

Scale: Depth 500m
Distance 1km +
thru limestone



Radiolocation and Cave Maps

- 1955 technology
  - Pulsed audio to a horizontal loop underground
  - Search coil and headphones on the surface to find the point on the surface above the Tx loop
  - Voice was needed to co-ordinate activity, just added a microphone!
  - Range was perhaps as much as 30m depth, through solid limestone

- Initially equipment was very rugged and simple to use
- Range (S/N) was increase by increasing signal strength
  - Eventually used 100’ loops, 300 watts, dedicated 4-man party

Single Sideband devices

- In the 1970s voice communication for SAR operation was becoming important.
  - SSB radios provided much better range (several hundred metres) by better S/N performance (reducing noise)
  - Frequency of operation 87 to 185 kHz depending upon the country
    - Wavelength about 2 km for near-field operation

- Radiolocation became specialized with equipment operating at 3.5 kHz in the near-field of the loop antenna

Difficulties in SSB Development

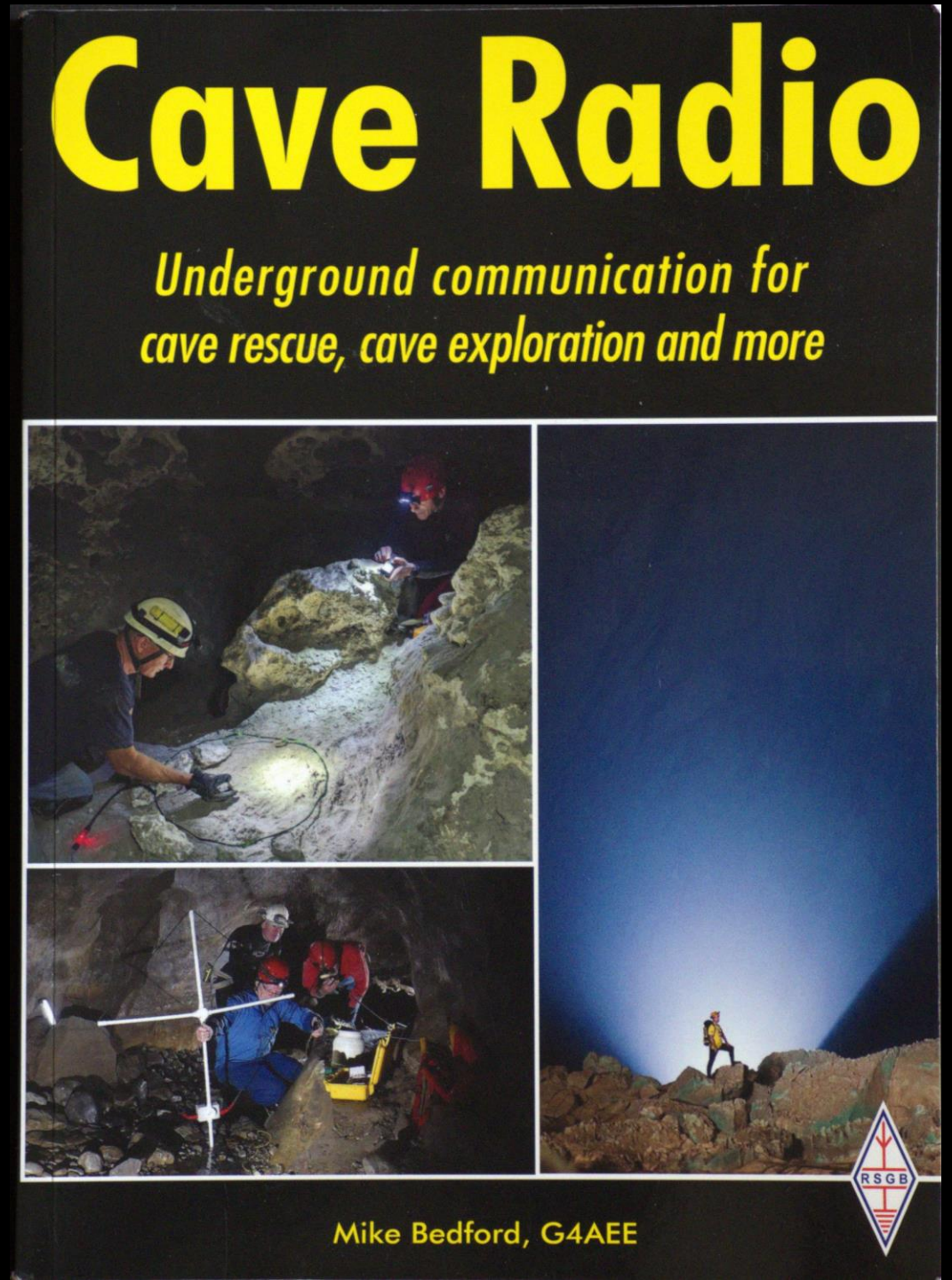
- No easy model for predicting the range of the radios
  - Conductivity of the earth
  - Local EM noise on the surface
  - What frequency to use?
- Radios were constructed by individuals
  - Discrete components
  - Fixed frequency
  - Very few built in total
- Radios were used under very difficult conditions

The physical size, weight and durability are serious constraints

Tactics to improve the Radios

- Creation of groups to improve co-ordination between cavers
  - Cave Radio and Electronics Group (CREG) based in UK (British Cave Research Association)
    - https://bcra.org.uk/pub/cregj/covers.html
  - International Congress of Speleology, Holloch, Switzerland (1997)
  - Academic research to create better models (David Gibson in UK)
- Use of purchased modules to speed construction
  - Drummond Transverter (Canada) CB radio, variable frequency and mode
- Nicola radio (France) Public funding of SAR groups
  - Problems with obsolete components

Published by RSGB in 2025
by Mike Bedford G4AEE



What happened in 2005 in amateur radio?

- WSJT-X was released
  - Opening the world of communication by digital modes
  - Improvement in S/N over SSB by 20 dB

- In 2007 Fldigi (Fast light digital) was released
  - Making available keyboard-to-keyboard modes such as PSK31, RTTY, CW, Olivia, Throb, THOR and many other modes

What effect did this have on Cave Radios?

Almost nothing

Amateur radio and digital modes

- Digital modes were implemented by
  - Computer with soundcard
  - Audio interface
  - SSB radio

Digital modes and cave radios

- Compared to an SSB cave radio, a digital cave radio would be
  - Larger
  - Heavier
  - More expensive
  - Harder to use
  - More delicate
- Few digital installations were used, mainly in fixed camps
- BUT,
  - what about the 20 dB improvement in S/N over SSB?

What changed in 2015?

- Hans Summers G0UPL discovered the SA5351A chip
  - It can directly synthesize WSPR RF signals
    - Precise to better than 0.05 Hz at 30 MHz
    - Faster response than 500Hz Hz (clean transitions)
    - Minimal phase noise or jitter (Even integer dividers)
    - Three independent outputs
      - Same frequency, but accurate phase difference (90 and 180 degrees)
  - No carrier
  - No unwanted sideband

What happened next?

- QRP Labs developed a series of products
  - 2015 Ultimate 3 Beacon (WSPR, QRSS)
  - 2018 QCX CW transceiver
    - Single band, CW only
  - 2021 QDX Digital transceiver
    - 5 Bands, single tone digital modes only (most WSJT-X and Fldigi modes)
    - QDX-M for LF single band (137.4 kHz, 475 kHz, 1.800MHz, cost US$65)
    - The assembly manual has useful design information
      - https://qrp-labs.com/images/qdxm/manual_assembly1_05.pdf
  - 2023 QMX CW, Digital and SSB Transceiver (work in progress)
    - https://qrp-labs.com/images/qmx/docs/fdim2023.pdf
    - https://www.youtube.com/watch?v=06FHSH7LQKs

Are cavers interested in a digital messaging system?

- Cavers want to send text messages from underground!
  - Texting from a phone is very familiar
  - Texting is clear, little opportunity for misunderstanding
  - Texting provides a time-stamped record of the communications
  - Options for acknowledgement of messages (testing if path is viable)
  - Unattended mailbox for receiving messages
  - Ability to forward messages built-in to phone apps

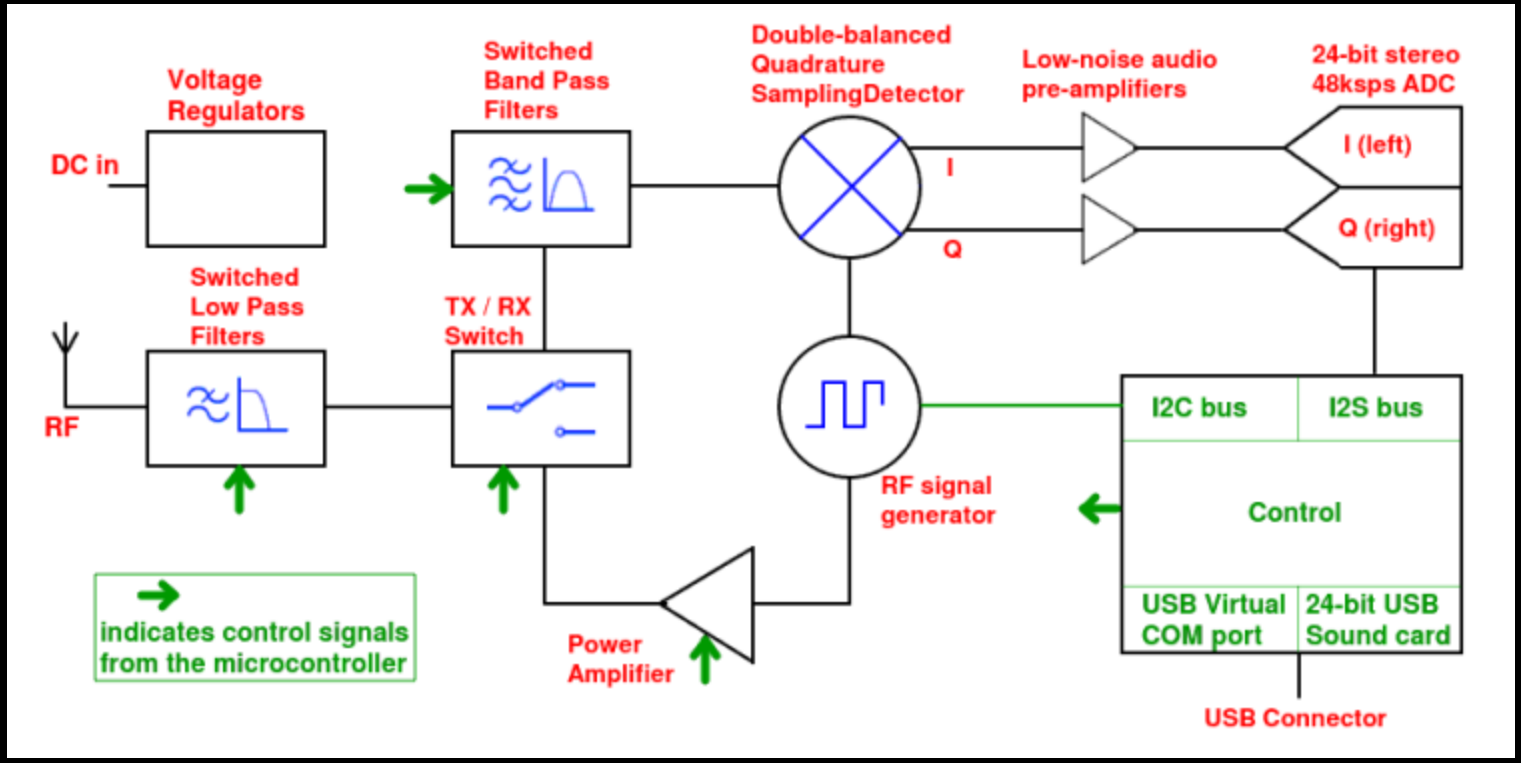
- Yes, it is worth investigating if the QDX-M radio is a useful building block to implement a digital messaging system

Implications of the QDX design for cave radios

- Direct synthesis of the RF digital signal means no SSB radio
- No mixer means the amplifier chain does not have to be linear
  - Class D, push-pull switched amplifiers are more efficient
    - Less battery, no heat sink for 5w output
- No carrier and no unwanted sideband relaxes filter design

- For Cave Radio usage the QDX *might* be
  - Smaller
  - Lighter
  - Cheaper, the QDX kit is US$65

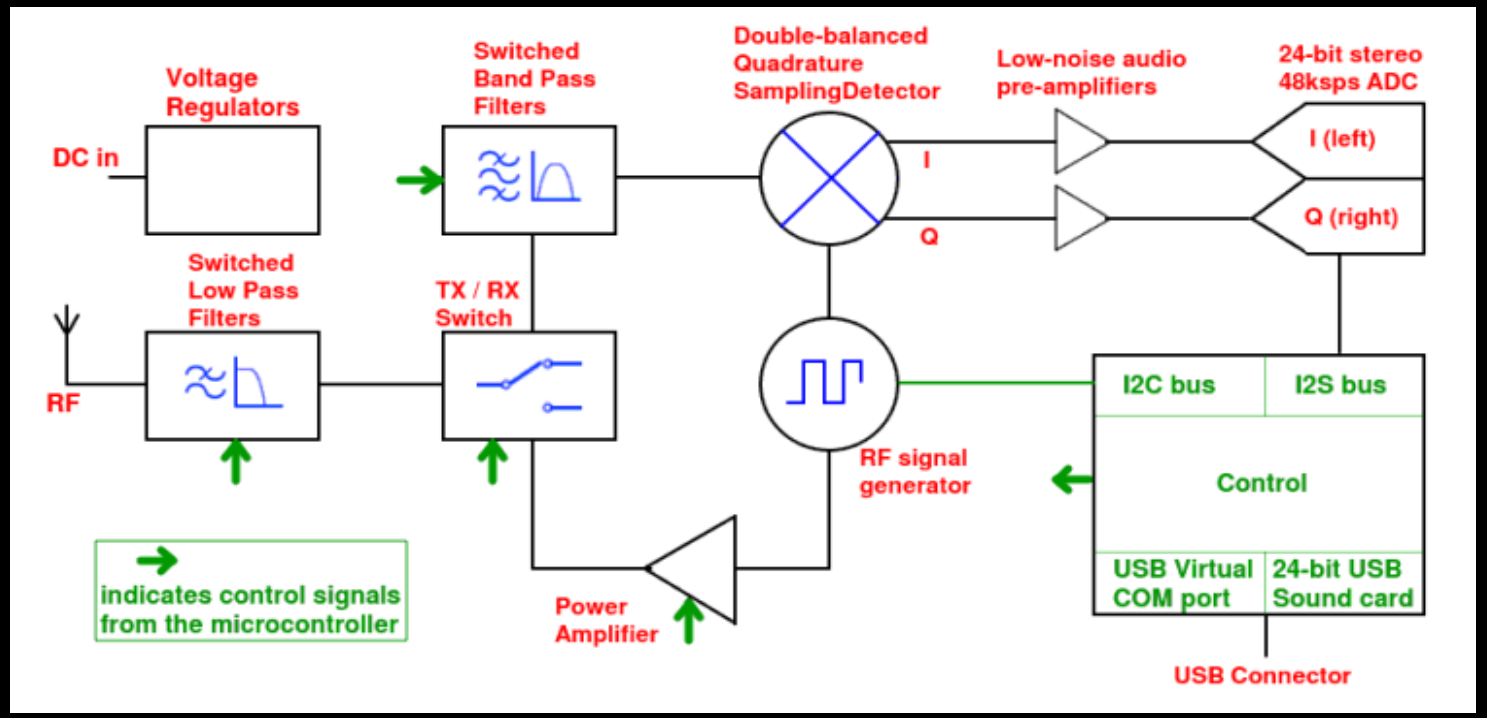
QDX block diagram



QDX-M Modifications for LF operation

Mono-band BPF
for 137.5 kHz

Change input transformer
for Tayloe detector



LPF Mono-band
for 2200m

What frequency
will the firmware
handle ?

Modify Amplifier
for 137.5 kHz

Computer running
WSJT-X

Design Changes for 2200m

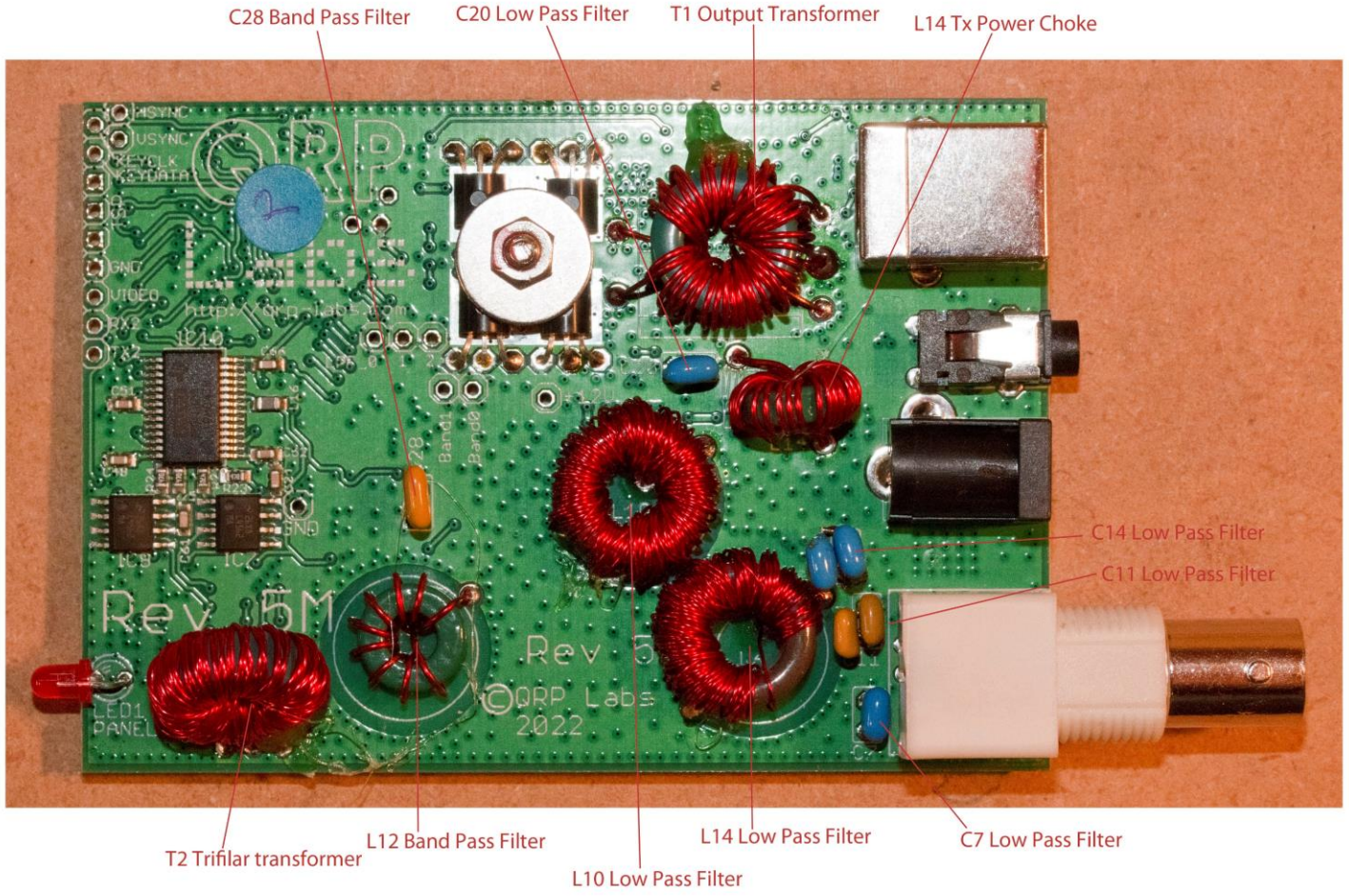
- Low Pass Filter
  - Standard design tool (Elsie Filter design tool)
- Band Pass filter
  - Simple LC filter (Allow for detector input impedance)
- Scale all other inductances for same impedance at 2200m
- Add 47V Zener diodes across power amplifier devices for spike suppression
- Details in CREG Journal, Issue 124, Dec 2023
  - https://bcra.org.uk/pub/cregj/covers.html

Toroids

- All frequency sensitive parts in QDX-M are thru-the-hole
  - Easy to identify for re-design work
  - Easy to install on board
- Excellent technical data on magnetic components (free)
  - https://amidoncorp.com/tech-data-flyer/
- Iron toroids used for tuned circuits
  - Handle higher power than ferrites because of higher no. of turns
  - Better temperature stability for tuned circuits
- Ferrites have higher inductance per turn

QDX-M for 2200m operation

Components modified for QDX-M to operate on 2200m (136 KHz)



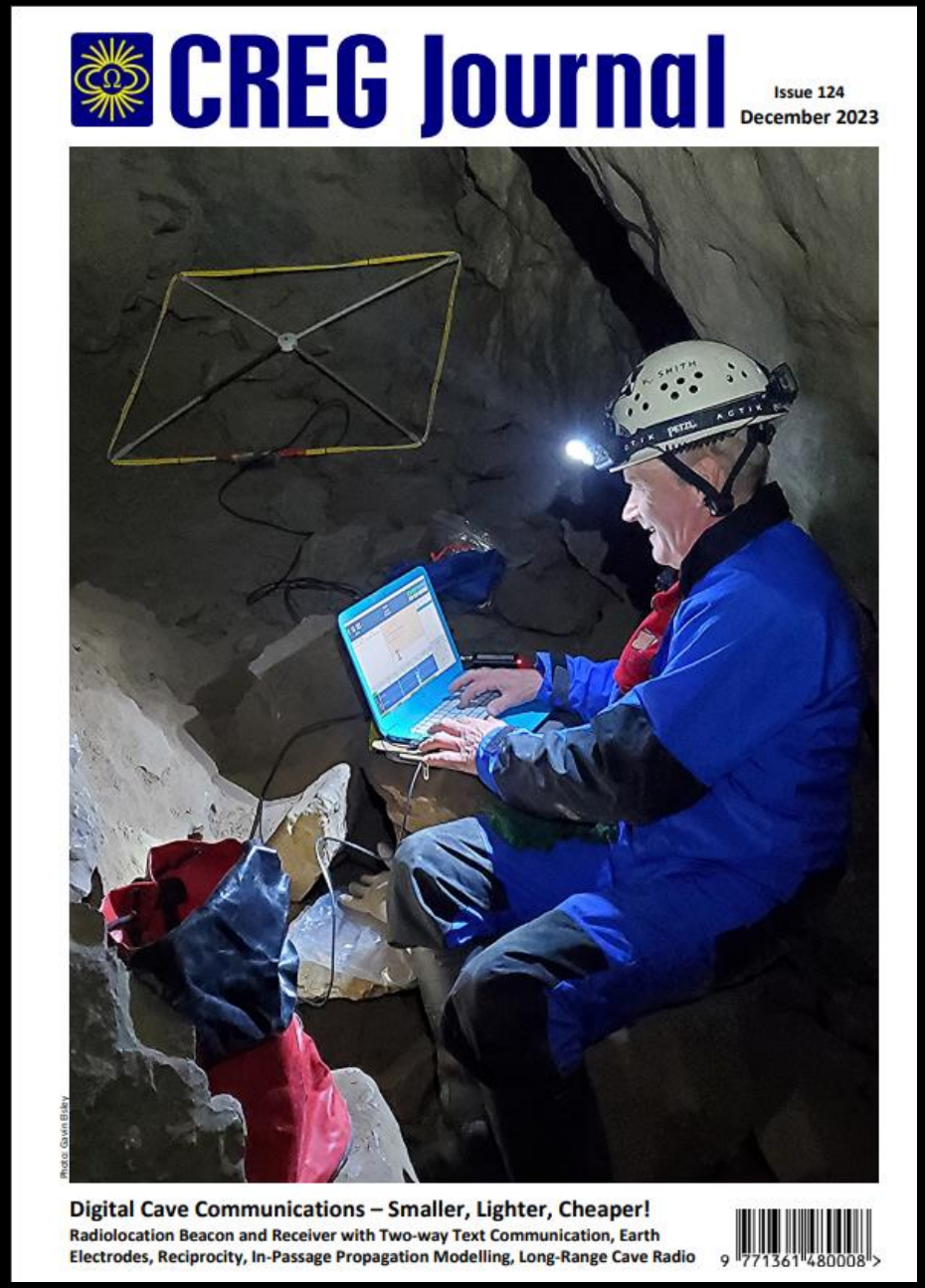
SOTA field test using FT8

Cave to Surface Test in Canmore Caverns

600 m distance, 400m depth

Over surface 2 km easily and over 8km in optimum conditions

Next steps:
Decide on digital mode to use
Replace laptop with phone
Package the kit for cave use.



Keyboard-to-keyboard modes

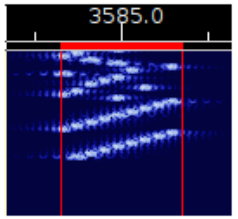
JT8-Call and Fldigi

- Both ran on a laptop and had a complex interface – Not useful for cave radio
- Fldigi web-site is useful for explaining the different modes
- https://www.w1hkj.org/modes/index.htm

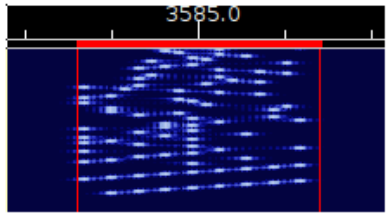
- David W1HKJ put me in touch with John VK2ETA

CW | Contestia | DominoEX | Feld | FSQ | IFKP | MFSK | MT-63 | Olivia | RTTY | THOR

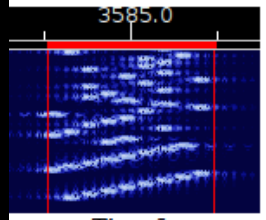
THOR Modes



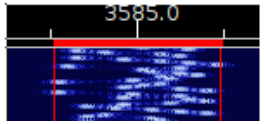
Thor-4
Spectrum
Sound



Thor-8
Spectrum
Sound



Thor-5
Spectrum



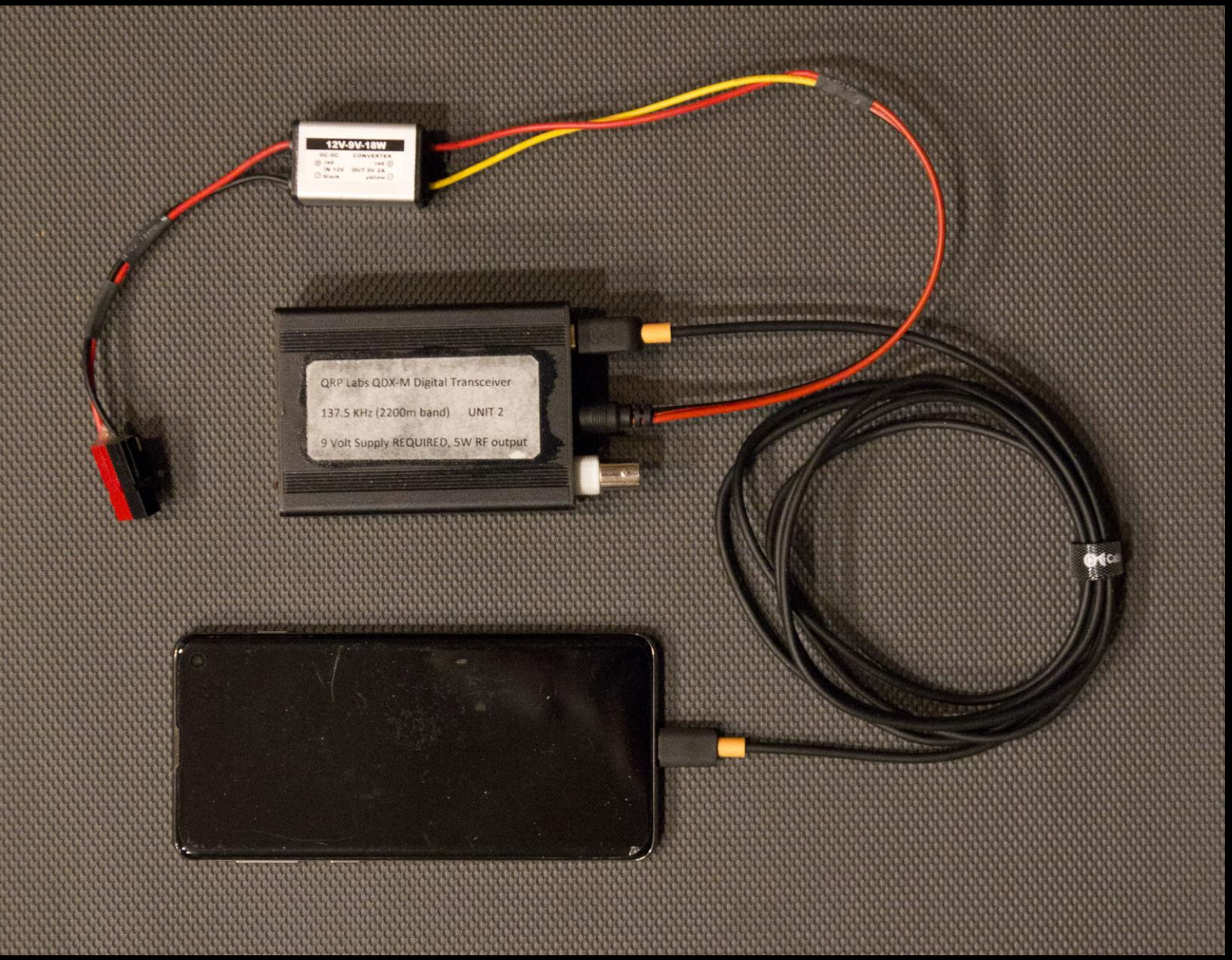
Operating Parameters

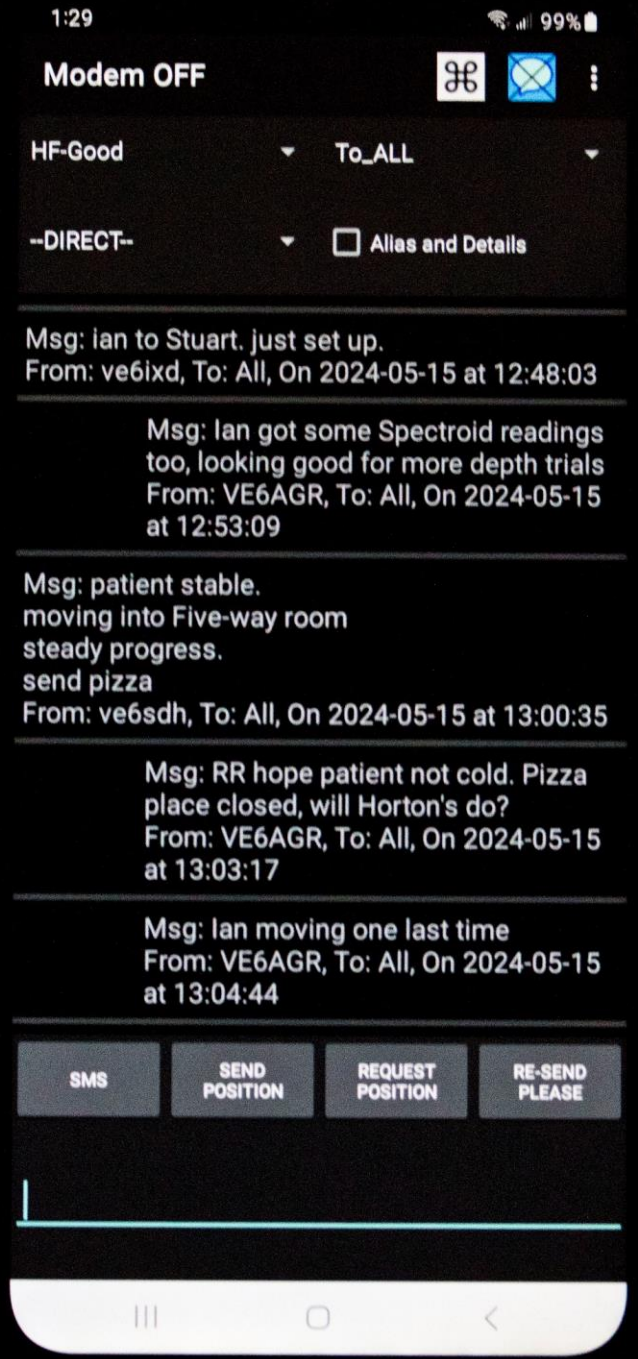
Mode	Symbol Rate	Typing Speed[1]	Duty Cycle[2]	Bandwidth[3]	ITU Designation[4]
THOR4[5]	3.90625 baud	14 wpm	100%	173 Hz	173HF1B
THOR5[5]	5.3833 baud	22 wpm	100%	244 Hz	244HF1B
THOR8[5]	7.8125 baud	28 wpm	100%	346 Hz	346HF1B
THOR11[6]	10.766 baud	40 wpm	100%	262 Hz	262HF1B
THOR16	15.625 baud	58 wpm	100%	355 Hz	355HF1B
THOR22	21.533 baud	78 wpm	100%	524 Hz	524HF1B

RadioMsg

- John has created an Android app
  - RadioMsg
  - https://github.com/VK2ETA/RadioMsg/releases
  - Open-source software
  - Uses the Fldigi code for the modems

- John was very interested in the project and most helpful
- Just like sending text messages on a phone!
- Single USB cable connects phone and QDX-M
  - All data transfer, CAT control and battery charging is via the one cable
- The phone can forward messages, store and acknowledge them


12V-9V-18W
QRP Labs QDX-M Digital Transceiver
137.5 KHz (2200m band) UNIT 2
9 Volt Supply REQUIRED, 5W RF output

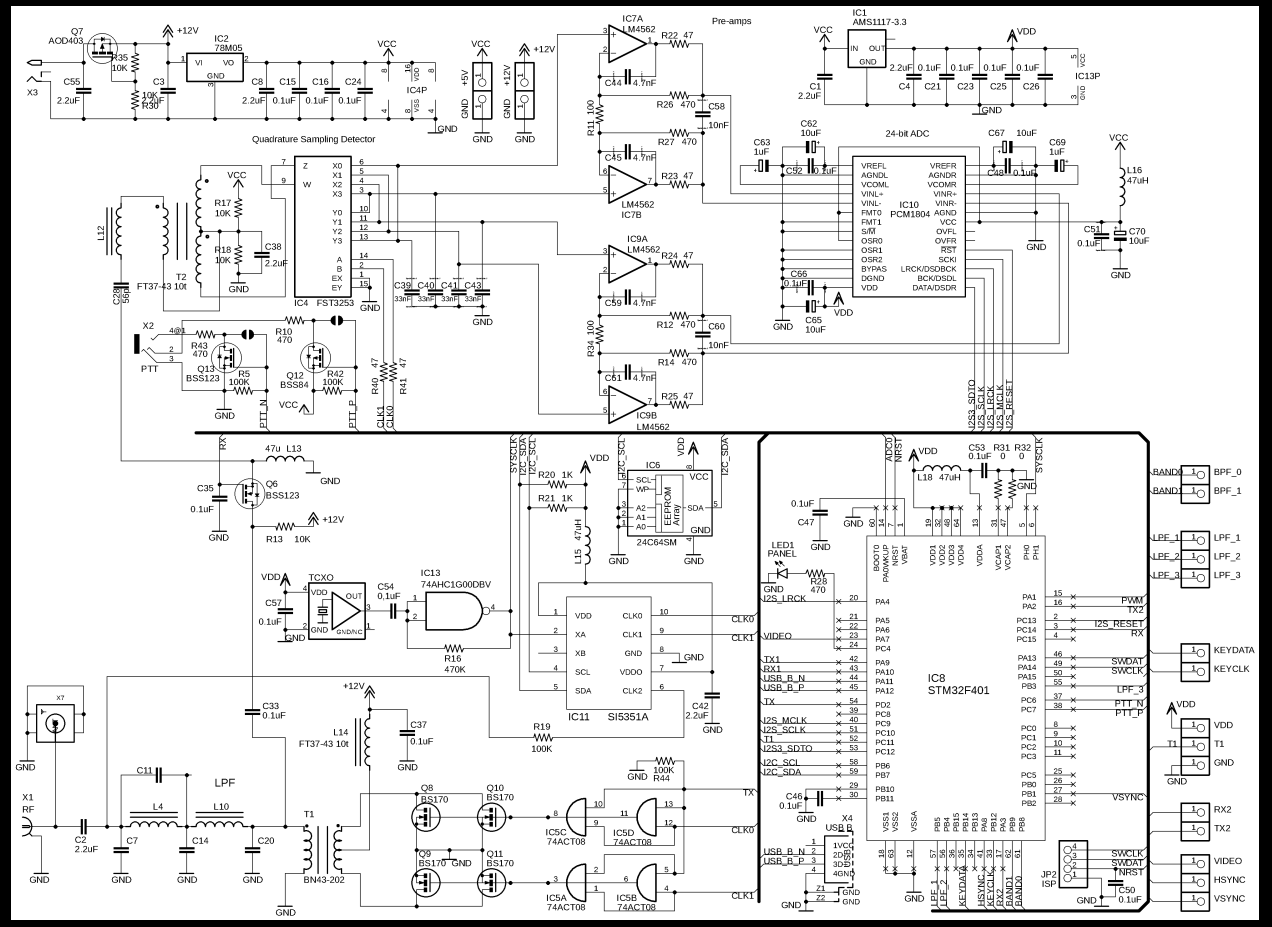

1:29
99%
Modem OFF
HF-Good
To_ALL
--DIRECT--
Alias and Details
Msg: ian to Stuart. just set up.
From: ve6ixd, To: All, On 2024-05-15 at 12:48:03
Msg: Ian got some Spectroid readings too, looking good for more depth trials
From: VE6AGR, To: All, On 2024-05-15 at 12:53:09
Msg: patient stable.
moving into Five-way room
steady progress.
send pizza
From: ve6sdh, To: All, On 2024-05-15 at 13:00:35
Msg: RR hope patient not cold. Pizza place closed, will Horton's do?
From: VE6AGR, To: All, On 2024-05-15 at 13:03:17
Msg: Ian moving one last time
From: VE6AGR, To: All, On 2024-05-15 at 13:04:44
SMS
SEND POSITION
REQUEST POSITION
RE-SEND PLEASE


ABCCRS
CAVE RADIO
SET #3
PHONE
RADIO
DEFYING
MOTHER NATURE

Personnel involved in the project

- Ian Drummond VE6IXD — Modifications of QDX-M radio
- John Douyere VK2ETA — Creation of RadioMsg app
- Brian Pease W1IR — Testing Radiomsg and QDX-M design
- Ken Smith VE6AGR — Testing and organizational support
- Stuart de Haas VE6SDH — Cave packaging and user training
- Leve and Evan — Power supply and distribution
- Christian Stenner — Obtaining funding via Alberta SAR
- The many cavers who have shown interest and helped with field trials

QDX-M Schematic



Input command from a QDX-M radio

The transition between
two WSPR tones
12.5 Hz apart.
The 5351 will generate
this at 30 MHz directly.

RF radiation from 1m loop antenna

- Radiation resistance (VLF Radio Engineering by A.D.Watt)
  - 10 microOhms over ground, less in free-space
  - Current in loop is 2 Amps
  - Radiated power is a maximum of 40 microWatts

- For ham transmitters, FCC requires harmonic suppression of 50dB below the fundamental.
- For a 100 W transmitter this is 1 mW of out-of-band signal.

- The cave radio with loop antenna meets the standard for not transmitting spurious signals in the 2200m band