INTRO TO AMATEUR RADIO DMR & DIGITAL VOICE

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The **D**igital **M**obile **R**adio / DMR standard was published by the European Telecommunications Standards Institute (ETSI) in 2005.

V10 Nov 10 2021

What is Digital Voice?

- You're all familiar with FM voice
- Digital voice modulates FM using tones
- Voice is encoded and transmitted as 1's and 0's similar to how FAX machines & dial up modems did it.
- Gov't mandated for commercial use, low cost equipment is now available to Hams
- Same repeaters, some can flip between FM and digital
- Lets compare Digital to FM: similarities vs. the differences

Digital vs. Analog?

Similar vs. Different	Analog	Digital
Squelch Tail	Yes	None
Courtesy Tone	Repeater's EoT	Radio's reset tone
CTCSS TX & RX	Optional (subaudible Hz)	Mandatory (colour code number)
Doubling during TX	Often happens	Repeater's Talk Permit
Repeater out of range?	Kerchunking = no squelch tail	Radio displays "repeater not found" & bonk tone
Conversations	1, on 1 shared channel	2, Simultaneous & isolated ie: Ecomm & normal, from >1,500 channels
Effective bandwidth	25 kHz wide band	12.5 kHz narrow band, (6.25 kHz equivalent for 2 conversations)
Networking	IRLP, AllStar, manual link	Local, regional, global. Reverts to a local repeater w/o internet
Can I have a signal report?	Depends on someone else, subjective	Parrot, plays back your voice. VU meter, shows your levels
There's an App for that?	EchoLink	DudeStar, DroidStar, hotspots

Digital vs. Analog?

Similar vs. Different	Analog	Digital
Repeater Hardware	Traditional w controller	same, digital controller
Radio Hardware	HT, mobiles, base	Same + hot spots
Operation (VHF/MHF/UHF)	Tri-band, FM mode	Tri-band, FM & digital modes
Operation on simplex	Yes, w static	Yes, no static
Range	S/N ratio increases w distance, readability decreases	100% until its not. Up to 35% more distance
Programmability	Basic, “easy”	Complex, “code plug”
HT battery life, on TX	100% duty cycle	45% duty cycle (27.5/60 mS)
Radio display	Channel name / frequency, power	Same, + name, call sign, QTH, talk group, time slot
GPS	Some models	Most models
APRS	TX analog	TX & RX, analog + digital

Digital vs. Analog?

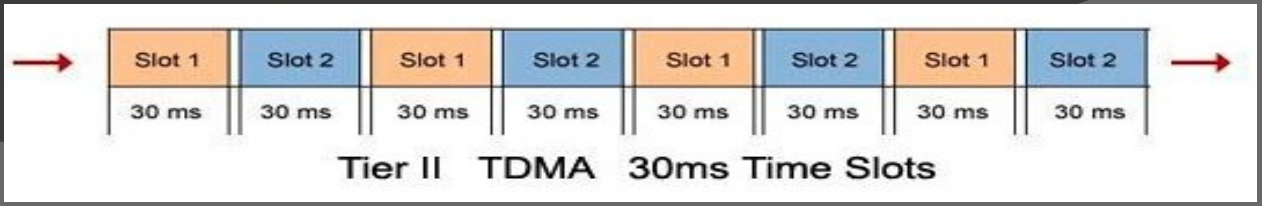
Similar vs. Different	Analog	Digital
Modulation	FM (deviation)	4 FSK, C4FM, or 0.5 GMSK* (phase shift)
Voice Multiplexing	None	2 using TDMA 2 using FDMA 1 using GMSK* + data *Gaussian Minimum Shift Keying (FSK)
Error Correction	None	Yes, using CRC or CRC & Forward Error Correction
Monitor mode	Dual receive, 2 repeaters	Any of >1,500 on either time slot on the same repeater
Acceptance	Universal, w band plans	2005 intro, growing fast
Qty of repeaters in BC	140 LML & FV BCARCC Apr 2020	"Big 3" = 78, + 10 NXDN / P25 Repeaterbook.com Oct 2021
Security	None	Encryption: widely used in Public Safety, not used by Hams.

Push-to-Talk Analog vs Digital

- Because of
  - >1500 TGs available, Full & Part Time,
  - 2 time slots available on a repeater,
  - it's *very* possible someone might be using a TG other than the one you are listening to. If this occurs, your signal could interfere with theirs.
  - This is avoided by the way DMR handles the PTT function.
- With analog:
  - pressing the PTT button always keys the transmitter.
  - its easy to have a double transmission.
- With DMR when the PTT is pressed:
  - a signal is sent to the repeater which checks to see if the Time Slot is available.
  - If it is, a signal is sent back to the radio giving you the All Clear, usually generating a beep tone. This occurs in just under a second.
  - Also a busy light on the handheld if lit = the time slot is already in use.
  - When pressing the PTT, wait 1 or 2 seconds before talking.

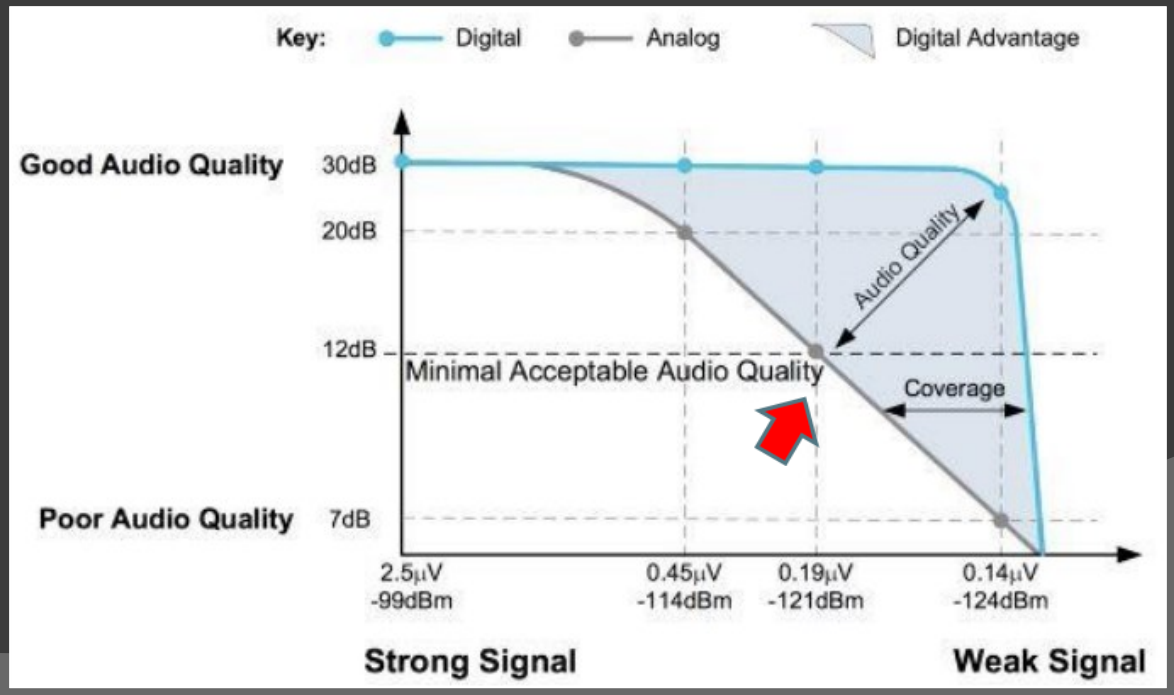
Time Slots? Time Division??

- Analog FM signal bandwidth is 25.0 kHz
- DMR bandwidth is 12.5 kHz
- Digital uses either :
  - TDMA (Time Division Multiple Access) or
  - FDMA (Frequency Division Multiple Access)
- Transmits two separate conversations at the same time in 12.5 kHz (equivalent to 6.25 kHz each).
- TDMA splits the transmitted signal into alternating 30 mS time slices referred to as Time Slots.
- FDMA splits the transmitted signal into concurrent upper and lower “deviations” (like sidebands).



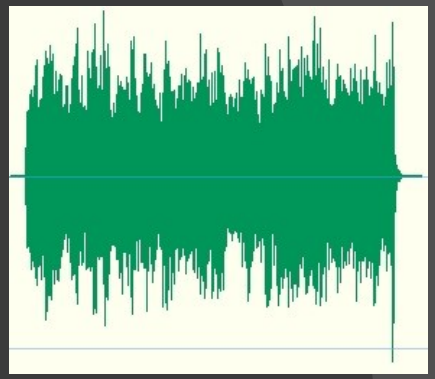
Audio Clarity

- The most noticeable difference between DMR and analog FM is audio clarity.
  - FM signals get progressively nosier as the signal gets weaker
  - Digital operation remains crystal clear up until the threshold of coverage is reached
  - Then it quickly becomes unusable, & “falls off a cliff” like cell phones drop calls
  - Some radios (DStar or old codecs) have robotized voices due to ‘commercial requirements’ whereas all other / new radios have better ‘amateur radio codecs’
  - DMR has 2 layers of packet recovery:
    - Forward Error Correction and Cyclic Redundancy Codes.

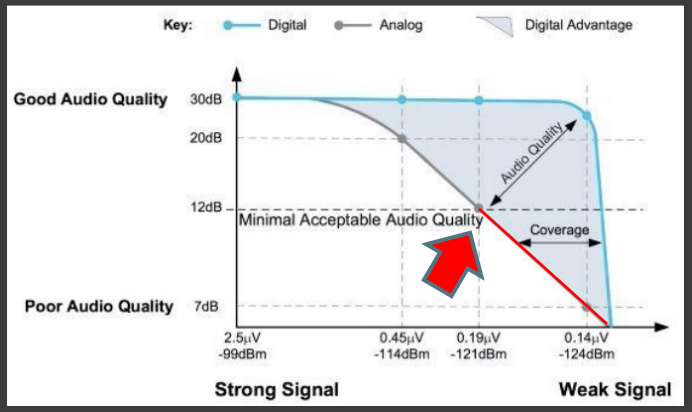


Voice Quality: Analog vs DMR

- We used 446.000 MHz Simplex
  - Same radio, location, power, & antenna



- This is an FM UHF simplex call (no sound).
  - Notice the noise in the waveform



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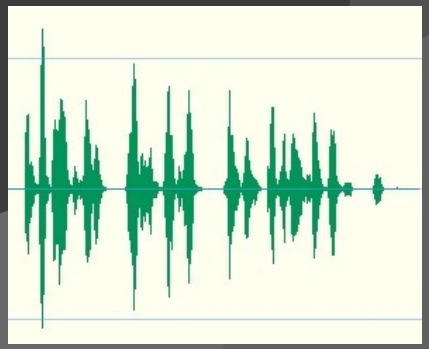


Digital Duel: Options & Choices

- Each standard was built for a different audience:
  - DMR, P25 & NXDN for Commercial: good in places where ‘terrain' can get in the way
  - DStar by Hams in Japan, close repeaters, less bad terrain, trees etc.
  - Fusion by Hams, also good where 'terrain' can get in the way
  - *AMBE™ = Advanced Multi-Band Excitation, Vocoder = voice encoder decoder

Standard	Modulation	Channels	Bandwidth	Highway Analogy
DMR	4 FSK F Error Correction AMBE+2™	2 TDMA	12.5 kHz (6.25 ea)	1 lane road, 2 cars alternating
D-STAR	0.5 GMSK (2 FSK) Error Correction	1 FDMA	10 / 6.25 kHz data / voice	1 lane, 1 car & small trailer (for data)
System Fusion / C4FM	C4FM Error Correction	1 FDMA	12.5 kHz	Private road. Yaesu only.
NXDN	4 FSK Error Correction AMBE+2™	2 FDMA	12.5 kHz (6.25 ea)	1 lane road, 2 cars parallel
P25 ph2	Control: C4FM Audio: H-CPM & H-DQPSK Error Correction ½ rate IMBE™	2 TDMA	12.5 kHz (6.25 ea)	1 lane road, 2 cars alternating

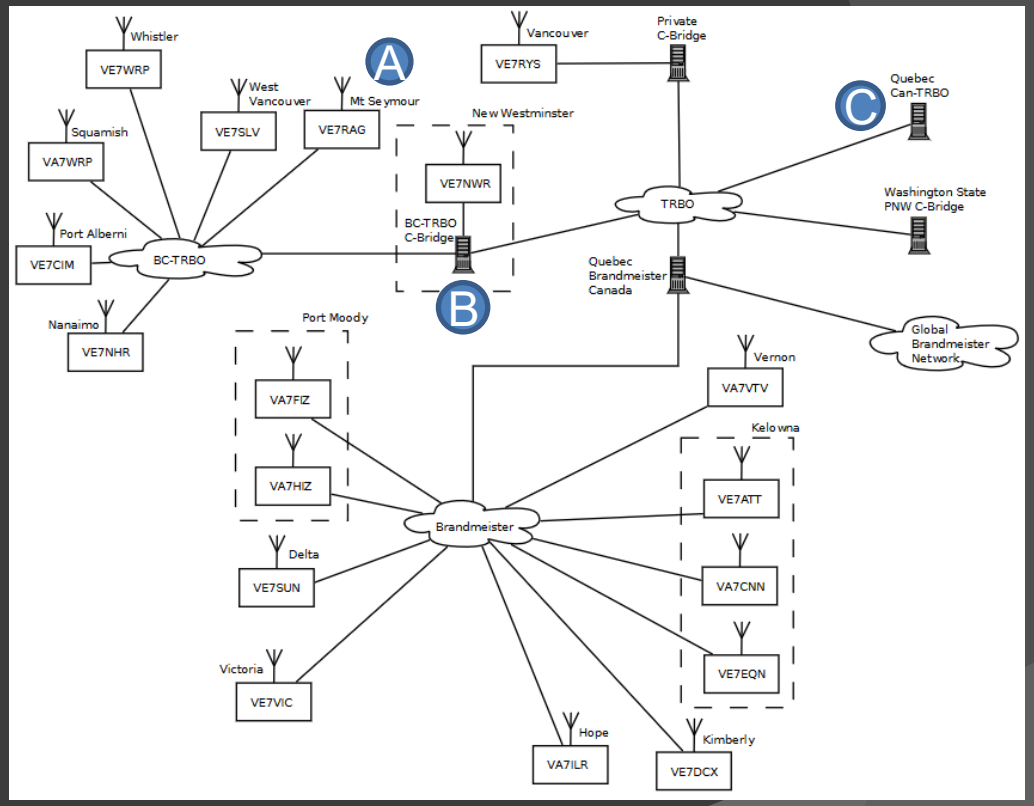
Digital Repeaters Available

(Oct 2021 vs. Feb 2020 repeaterbook.com)

	D-Star	DMR TRBO / Brandmeister	Yaesu Fusion / Wires X	NXDN	P25
Locally Vancouver	**9**	**8** / 7	**12** (4 Wires X)	**2**	**8** / 5
BC Total	**18**	**16** / 12	**44** (10 Wires X)	**2**	**6** / 5
Canada Total	**119** / 120 BC (18 / 17) AB (17 / 17) SK (2) MB (4 / 5) ON (39 / 43) PQ (28 / 25) NB (0) PEI (2) NS (3) NF (2) YK (4) NV & NWT (0)	**121** / 93 BC (16 / 12) AB (5 / 3) SK (2 / 1) MB (8 / 4) ON (43 / 31) PQ (34 / 30) NB (5) PEI (1) NS (5 / 4) NF (2) YK (0) NV & NWT (0)	**189** / 169 BC (44) AB (16 /14) SK (6) MB (10 / 8) ON (54 / 52) PQ (32 / 25) NB (6 / 4) PEI (4 / 1) NS (11) NF (6) YK (0) NV & NWT (0)	**8** / 9 BC (2) AB (0) SK (0) MB (0) ON (5) PQ (1 / 2) NB (0) PEI (0) NS (0) NF (0) YK (0) NV & NWT (0)	**46** / 26 BC (8 / 5) AB (6 / 3) SK (0) MB (4 / 3) ON (24 / 11) PQ (3 / 3) NB (0) PEI (0) NS (0) NF (1) YK (0) NV & NWT (0)
North Am. Inc Canada	**1,186** / 1,172	**2,029** / 1,725	**2,118** / 1,853 (723 Wires X)	**118** / 110	**495** / 396
Rest of World	**1,268** / 1,254	**1,810** / 1,434	**932** / 773 (271 Wires X)	**41** / 24	**79** / 67
Total	**2,454** / 2,426	**3,839** / 3,159	**3,050** / 2,626 (994 Wires X)	**159** / 134	**574** / 463

Repeater Network topology

- Your audio is digitally processed in your handheld
  - Sent over the air to the local repeater (A)
  - Forwarded to the regional network server (B: New West)
  - Forwarded to other servers worldwide (C: Montreal +)
- Latency, by as much as 2 seconds, is a propagation delay in your signal getting to the other end.



DMR Code Plugs (radio programming)

- What you'll need:
  - Your own unique DMR ID number.
  - Your radio's programming software "CPS"
    - Each brand has its own, limited cross compatibility
    - A programming cable between your PC & radio
  - Repeater's frequencies for each you use.
    - Each repeater's Colour Code
      - Colour Codes work like CTCSS tones, 16 total.
  - What Talk Groups each carries.
    - Each TG's unique number & Time Slot
- Or someone (like BCDMR.net) with a polished code plug you can load and 'just use' while learning.

Talk Groups

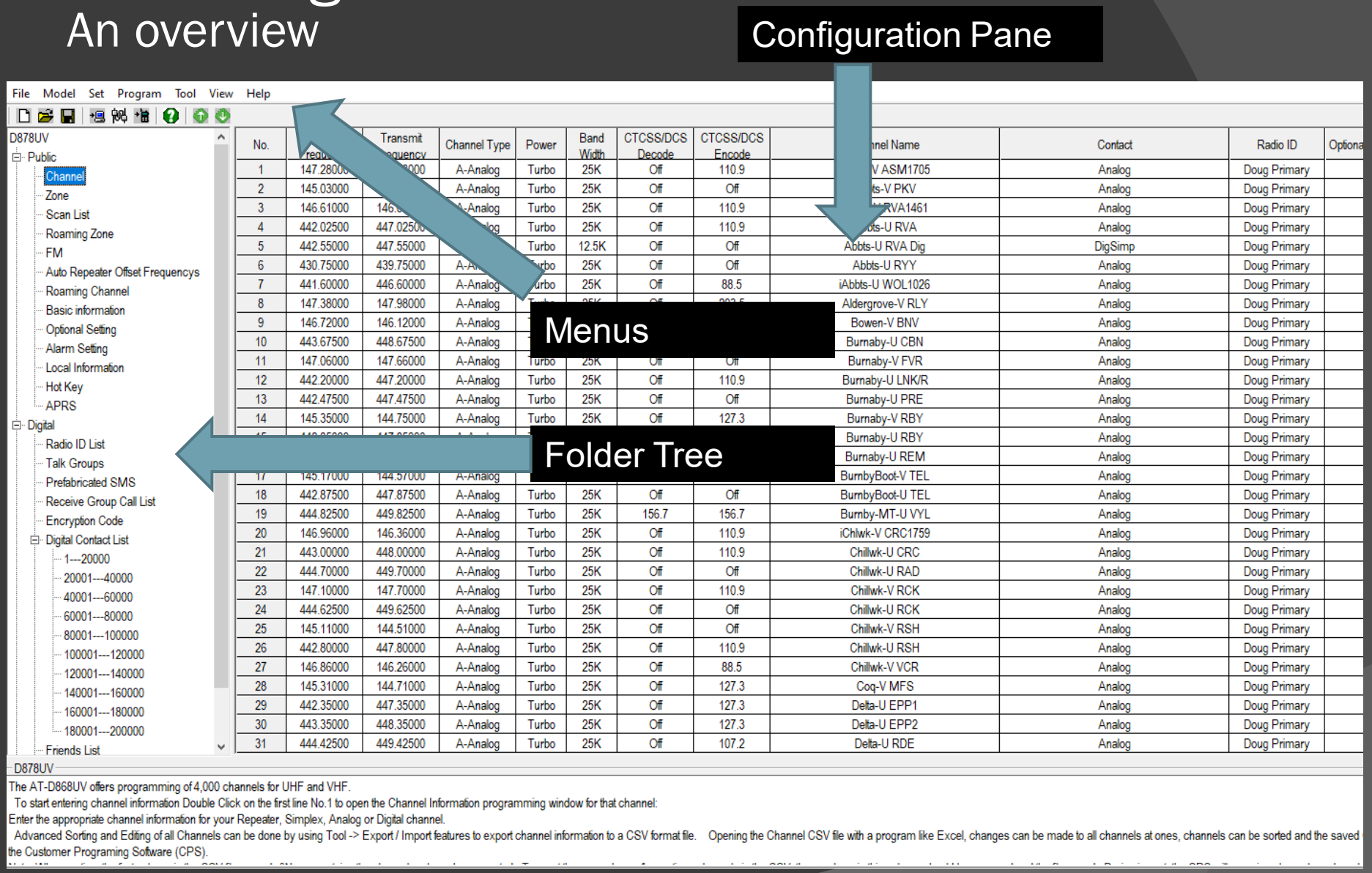
- On BC-TRBO the repeater's owner assigns the TG and TS structure most beneficial for their area. (BrandMeister is self serve).
- Not all repeaters carry all Talk Groups (TG).
- This allows a mix of the most popular & less used TG.
- A typical BC-TRBO partial configuration:

Talk Group	Coverage	TG ID #	Time Slot	Timer
Local Net 1	Local Emergency & Nets	3183	1	FT
BC1	Prov call	3027	1	FT
BC2	Prov chat	10327	2	FT
Ontario2	Prov chat	3023	2	PTT
Canada2	National	302	2	FT
NA2	N America	3163	2	PTT
WW English2	Global	13	2	PTT

FT = full time / always on

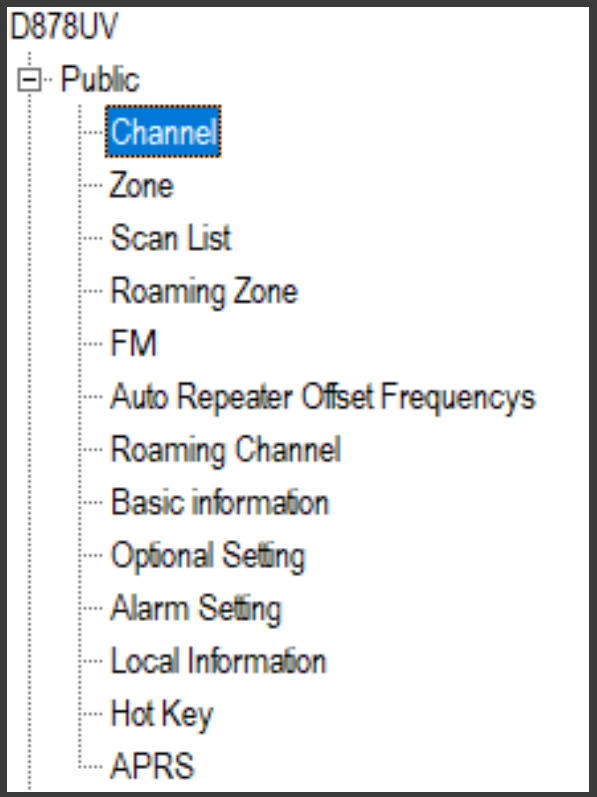
PTT = part time / push to talk (kerchunk 1st)

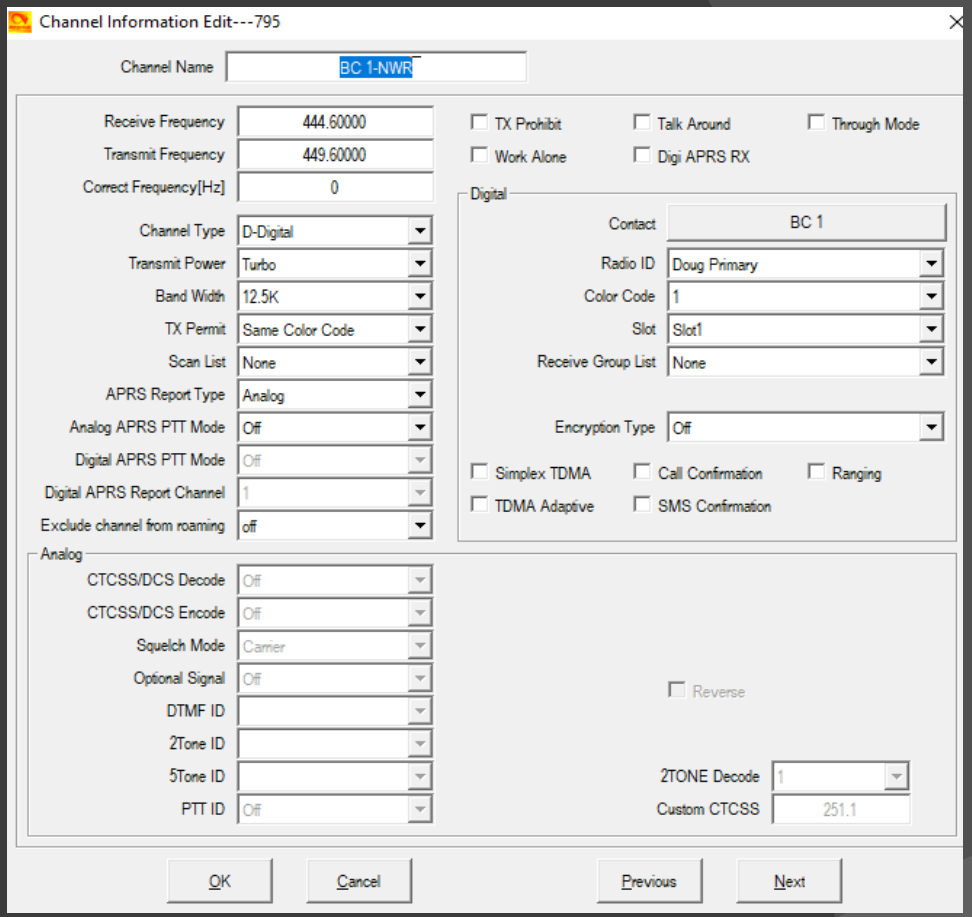
Code Plug? What's CPS?
An overview



- lets look at each of these in turn in more detail…

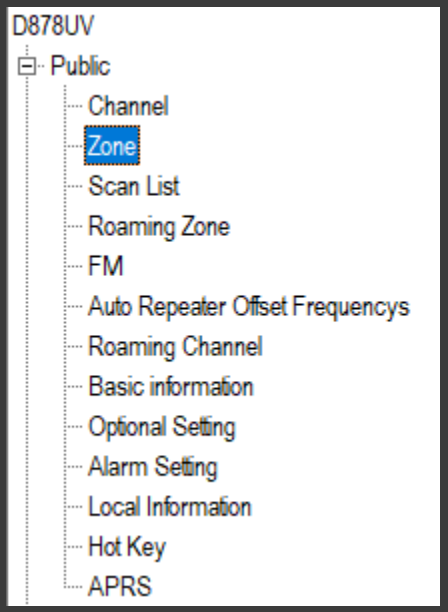
Channel Folder

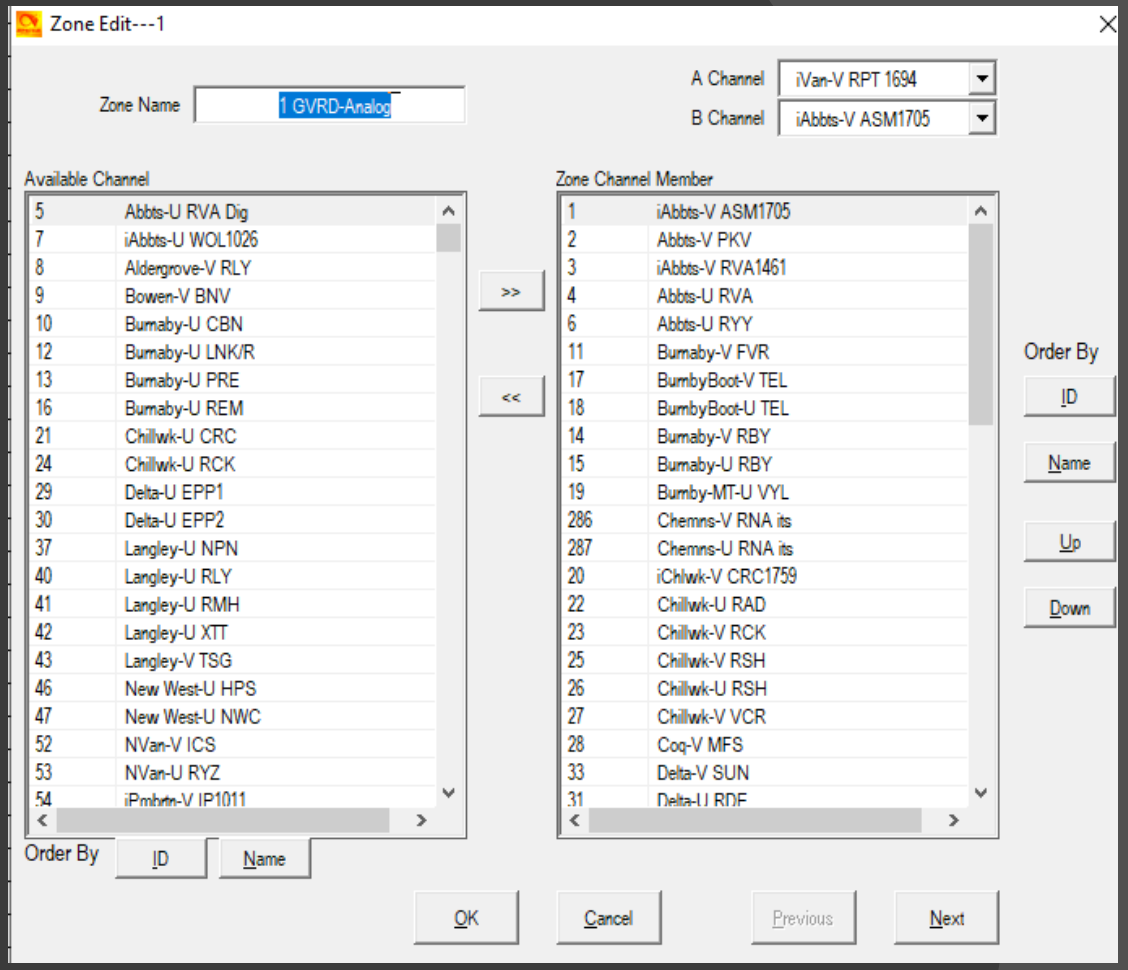




No.	Receive Frequency	Transmit Frequency	Channel Type	Power	Band Width	CTCSS/DCS Decode	CTCSS/DCS Encode	Channel Name	Contact	Radio ID	Optional Signal
1	147.28000	147.88000	A-Analog	Turbo	25K	Off	110.9	iAbbts-V ASM1705	Analog	Doug Primary	
2	145.03000	145.63000	A-Analog	Turbo	25K	Off	Off	Abbts-V PKV	Analog	Doug Primary	
3	146.61000	146.01000	A-Analog	Turbo	25K	Off	110.9	iAbbts-V RVA1461	Analog	Doug Primary	
4	442.02500	447.02500	A-Analog	Turbo	25K	Off	110.9	Abbts-U RVA	Analog	Doug Primary	

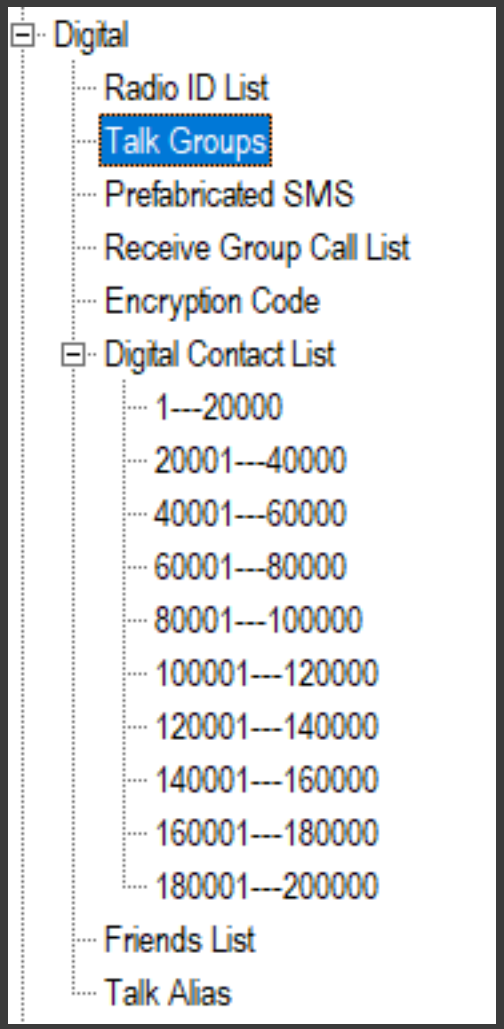
Zone Folder





No.	Name	Zone Channels	A Channel	B Channel
1	1 GVRD-Analog	58	iVan-V RPT 1694	iAbbts-V ASM1705
2	2 Amb Dig U SLV	24	TAC 310p-AmSLV	TAC 310p-AmSLV
3	3 NWR Dig UHF	29	TAC 310p-NWR	TAC 310p-NWR
4	4 NVan Dig U RAG	24	TAC 310p-NVnRAG	TAC 310p-NVnRAG
5	5 UBC Dig U RYS	5	BC 2-U UBC RYS	BC 1-U UBC RYS
6	6 Vic Dig U VIC	25	LocalNet 1-UVic	TAC 310p-UVic

Talk Groups Folder



No.	TG/DMR ID	Call Alert	Name	Call Type
1	0	None	Analog	Group Call
2	3102	None	Alaska	Group Call
3	3026	None	Alberta 2	Group Call
4	3104	None	Arizona	Group Call
5	9999	None	Audio Test 9999	Group Call
6	3027	None	BC 1	Group Call
7	103027	None	BC 2	Group Call
8	103100	None	Bridge 2 - BC	Group Call
9				
10				
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13				
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16				
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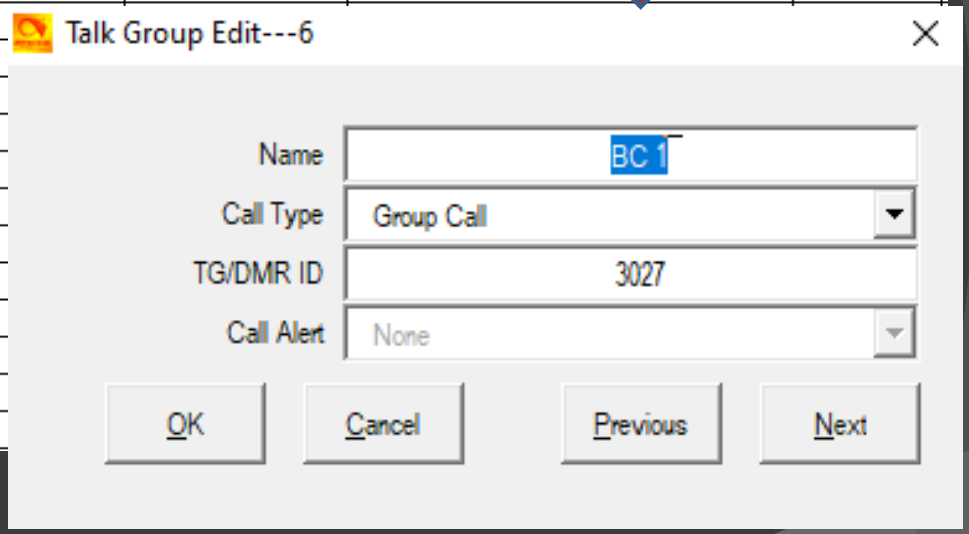
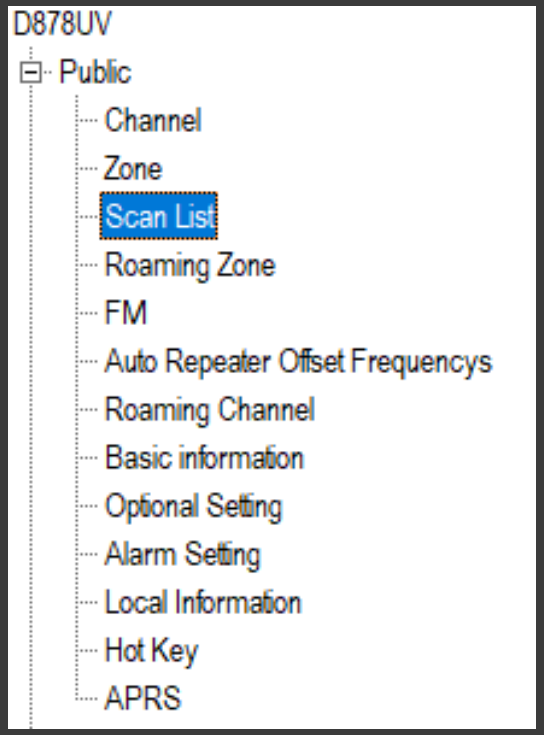
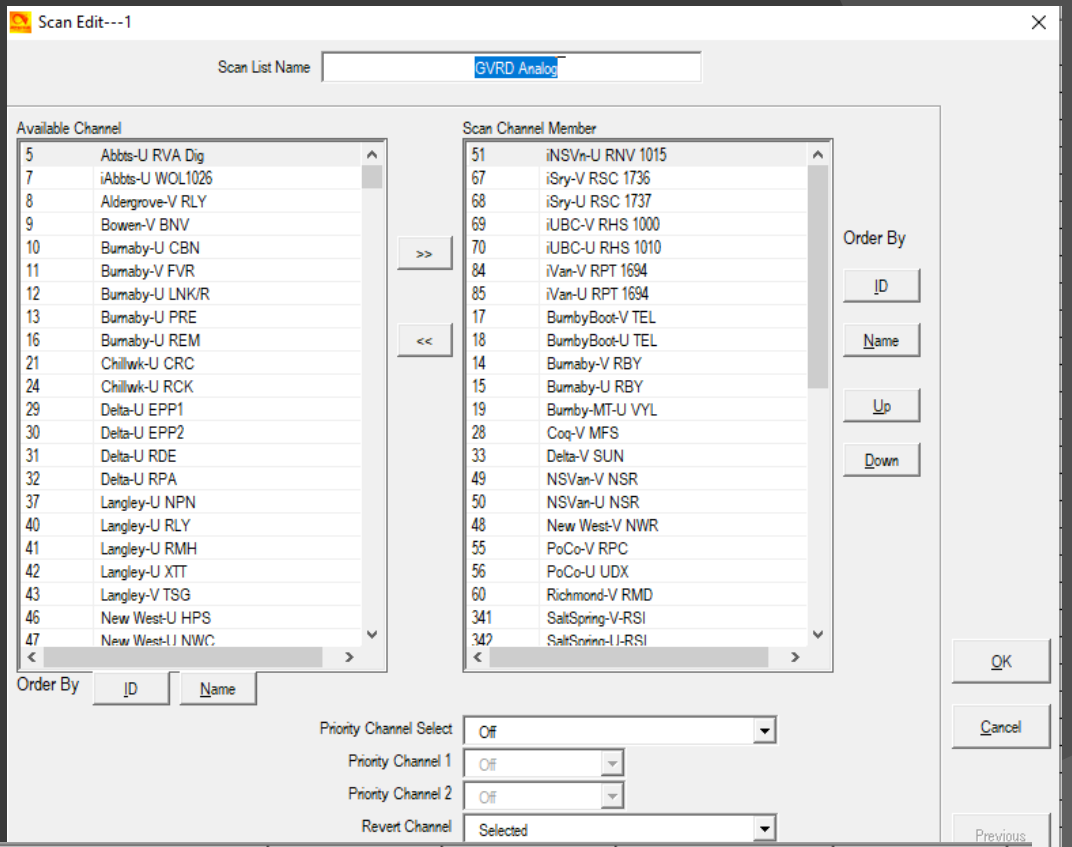
19				
20				



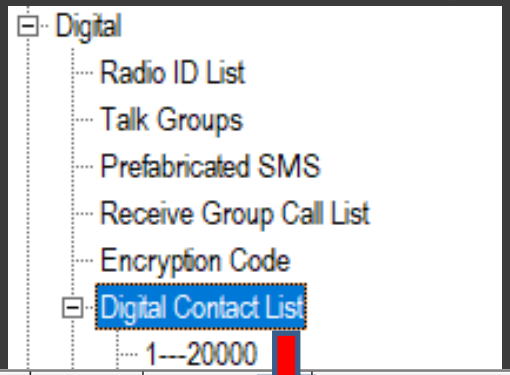
Scan List Folder





No.	Name	Channels	Priority Channel 1	Priority Channel 2	Look Back Time A[s]	Look Back Time B[s]	Dropout Delay Time[s]	Dwell Time[s]
1	GVRD Analog	43	Off	Off	2.0	3.0	3.1	3.1
2	Analog Simplex	46	Off	Off	2.0	3.0	3.1	3.1
3	BC Ferries	9	Off	Off	2.0	3.0	3.1	3.1
4	BC Transit	17	Off	Off	2.0	3.0	3.1	3.1
5	FRS/GMRS	22	Off	Off	2.0	3.0	3.1	3.1

DMR Digital Contacts



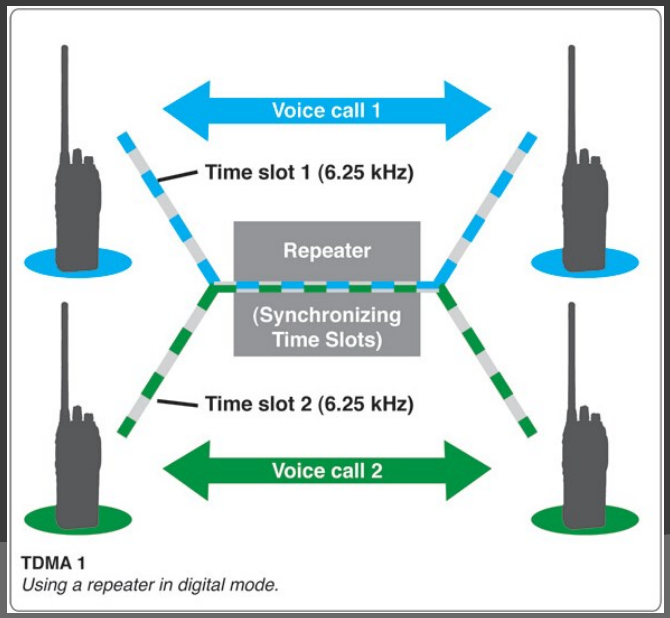
No.	TG/DMR ID	Call Alert	Name	City	Call Type	Callsign	State/Prov	Country
1	302911	None	RadioID net Radi		Private Call	RADIOID	All Regions	None
2	1023001	None	Wayne Edward	Toronto	Private Call	VE3THW	Ontario	Canada
3	1023002	None	Mathieu Goulet	Ottawa Hull	Private Call	VA3ECM	Quebec	Canada
4	1023003	None	Guy Charron	Gloucester	Private Call	VE3QC	Ontario	Canada
5	1023006	None	Allan Timothy Ha	Sparta	Private Call	VA3UZ	Ontario	Canada
6	1023007	None	Hans Juergen Boc	Cornwall	Private Call	VA3BOC	Ontario	Canada
7	1023008	None	Mark	Niagara Falls	Private Call	VE3JMR	Ontario	Canada
8	1023009	None	Rolando Parto	Scarborough	Private Call	VA3AMO	Ontario	Canada
9	1023010	None	Rolando Parto	Scarborough	Private Call	VA3AMO	Ontario	Canada
10	1023013	None	Barry Brousseau	Guelph	Private Call	VE3SLD	Ontario	Canada

206378	7486001	CX2RT	Daniel Mazzul	Maldonado-Lausana-	Maldonado	Uruguay
206379	7486002	CX1RE	Luis Olivera	Maldonado	Maldonado	Uruguay
206380	7486003	CX4RP	Mario Hector Paller Figueiras	Piriapolis Maldonado	Maldonado	Uruguay
206381	7489001	CX7SS	E. Eugenio De Marino	Villa Serrana		Uruguay
206382	7489002	CX2SE	Ruben Cabral Lopez	Minas		Uruguay

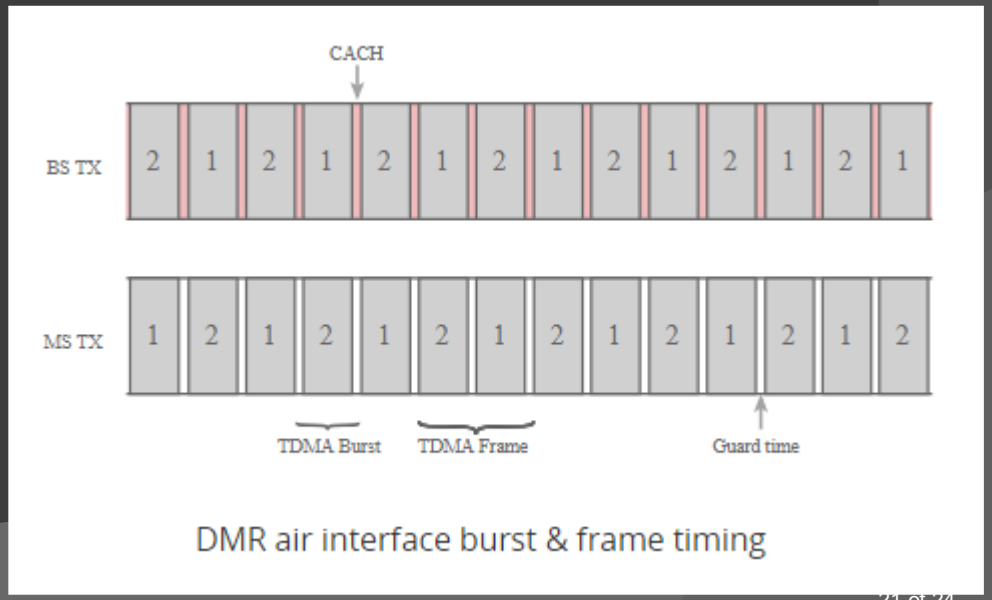
206,382 DMR IDs in use world wide, as of Nov 8, 2021 and growing daily!

DMR over the air

- The transmission is split into various blocks:
  - ***Burst:*** 30 ms long nominally
    - One Time Slot element: 27.5 mS of Tx followed by 2.5 mS gap or CACH.
    - Either Time Slot 1 or 2.
  - ***Frame:*** 2 Time Slot bursts, 60ms long total .
  - ***Super-frame:*** 6 frames for voice transmission.
  - ***BS TX***: base station transmission, transmits **Frames** continually when repeating.
    - Includes a CACH (Common Announcement CHannel) between the individual bursts, used for traffic management and signaling.
  - ***MS TX***, mobile station, only transmits 1 Time Slot.
    - Instead of the CACH it has a 2.5 mS Guard Time, for any propagation delays between different mobile stations.



TDMA 1
Using a repeater in digital mode.



DMR air interface burst & frame timing

Repeater vs Hot Spots

- Digital repeater connects to Internet
  - No repeater in range?
  - Travelling and don't know the repeaters?
- Use a Hot Spot and Internet connection
  - Low power, simplex RF to Internet device
    - At home, connects via your Wifi & ISP
    - Travelling, uses your Cell Phone data plan

For lots more Information

- Visit the BC DMR web sites:
  - https://bcdmr.wordpress.com/
  - https://www.facebook.com/groups/bcdmr
- Join us on the air on Talk Group BC 1:
  - Friday evenings at 8:00 pm Pacific
    - Announcements
    - Check ins, by alphabetical groupings
    - Q & A or technical discussion follows
    - Usually wraps up after 1 hour

Question time

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