



Effectively Using the CTCSS and DCS Tone Capability of Your Radio

Steve Aberle – WA7PTM Clark County ARES/RACES General Meeting 20 July 2020



Outline



- Review, definitions
- Use of sub-audible tones on our radios
- CTCSS history, tones, standards, manufacturer support
- DCS history, tones, standards, manufacturer support
- Tone squelch use in emergency communications
- A radio-based alert system for Clark County ARES/RACES
- Radio programming, protocols, and practice







Technician License Question Pool (2018-2022)

- T2B02 CTCSS is the correct answer
- T2B04 "All of these choices are correct" (includes CTCSS and DCS) is the correct answer
- T2B06, T3A01, T4B02, T4B04, T8C06 CTCSS is the wrong answer



Acronyms Definitions



(US)

- CTCSS <u>Continuous Tone Coded Squelch System</u> (US)
- CTCSS <u>Continuous Tone Controlled Signalling</u>[†] System (Europe)
- DCS <u>D</u>igital-<u>C</u>oded <u>S</u>quelch
- DCS <u>D</u>igitally <u>C</u>oded <u>S</u>quelch (Europe)
- DCSS <u>Digitally Coded Squelch Signalling</u>⁺ (Europe)



Use of Sub-Audible Tones



- Both CTCSS and DCS were designed to ignore other users on a radio frequency
- Think of them as electronic ear plugs
- CTCSS is analog (a selection of tones, generally between 67 Hz and 255 Hz)
- DCS is digital (one 134.4 Hz tone carrying 23 bits of data)
- Most of the time, we only think in terms of transmitting tones
- For repeaters, tone squelch on the input avoids false key-ups



How do these terms differ?



- Call Guard (E. F. Johnson)
- Channel Guard / CG (General Electric)
- CTCSS (Telecommunications Industry Association)
- Electronic Tone Squelch / ETS (Marconi Company Ltd.)
- Quiet Call (*Ritron, Inc.*)
- Quiet Channel / QC (RCA)
- Quiet Tone *(Kenwood)*
- Private Line / PL (Motorola)

Answer: They are all the same!



How Does CTCSS Work?



- Encoding: A low frequency audio tone is transmitted simultaneously with voice
- Decoding: Receiver audio is muted until a carrier with the desired tone is received



How Does CTCSS Work?



- CTCSS decoding is implemented with a very narrow band pass filter set to the CTCSS range of tones
- The disadvantage of using tone squelch is that one cannot hear if the frequency is busy before transmitting, so could easily double with a QSO in progress



CTCSS History and "Standards"



• The use of sub-audible tones dates back to the 1950's when Motorola used it in their tube-based radios

Motorola customers had the option of buying a "Vibrasender" (for encode) and a "Vibrasponder" (for decode)





CTCSS History and "Standards"



- The Electronic Industries Alliance (EIA) released "Minimum Standards for Land Mobile Communication Continuous Tone-Controlled Squelch Systems (CTCSS)" in March 1979 as RS-220
- When the EIA went defunct in 2010, the Telecommunications Industry Association (TIA) assumed maintenance of the standard
- The latest release of the CTCSS standard was ANSI/TIA-603-E (March 2016) as part of the "Land Mobile FM or PM Communications Equipment Measurement and Performance Standards" document



CTCSS History and "Standards"



- There are other "standards"
- One tone (150 Hz) is used by armed forces in NATO countries, and does not typically appear in standards or tone charts, nor can it be set in amateur radios





How Many CTCSS Tones Are There?



Several "standard" tone sets exist, so you could have 32, 37, 38, 41, 42, 47, or 50 tones available

Examples:

- 10 Motorola manual from November 1952
- 32 Com-Spec 5-bit DIP switch (2002)
- 38 Electronic Industries Alliance (EIA) standard RS-220
- 39 European Telecommunications Standards Institute (ETSI) standard 103 236 (2014)



How Many CTCSS Tones Are There?



Examples (continued):

- 42 Kenwood (TM-D710G)
- 50 Icom (ID-5100A), Yaesu (FT-2980R), Racing Electronics (RELM) [RELM is 0.1Hz off on one tone]
- 51 Anytone (D578, D878), Wulfsberg Electronics (aviation) [but not the same tones]
- 64 Com-Spec 6-bit DIP switch (2002) [13 tones below standards and common implementations]



ANSI/TIA-603-E (2016)



38 ANSI Standard CTCSS Tones (Hz)

67.0	82.5	100.0	118.8	141.3	167.9	203.5	241.8
71.9	85.4	103.5	123.0	146.2	173.8	210.7	250.3
74.4	88.5	107.2	127.3	151.4	179.9	218.1	259.1
77.0	91.5	110.9	131.8	156.7	186.2	225.7	
79.7	94.8	114.8	136.5	162.2	192.8	233.6	

Common Non-Standard CTCSS Tones (Hz)

69.3	97.4	165.5	177.3	189.9	199.5	229.1
69.4	159.8	171.3	183.5	196.6	206.5	254.1



How do these terms differ?



- DCS (Telecommunications Industry Association)
- Digital Channel Guard / DCG (General Electric)
- Digital Private Line / DPL (Motorola)
- Digital Quiet Call / DQC (RCA)
- Digital Quiet Talk / DQT (Kenwood)

Answer: They are all the same!



How Does DCS Work?



• Encoding: A low frequency bit stream is transmitted simultaneously with voice



 The stream consists of 23 repeating digits ... 11 check bits, 3 signature bits (always 100) and 9 DCS code bits



How Does DCS Work?



- With 9 bits, DCS codes are always denoted in base 8 (octal)
- It can detect and correct errors of 3 or fewer bits, thus cutting down on the number of false key-ups
- This 23-bit word is known as a Golay (23,12) code



Marcel Jules Edouard Golay



b. May 3, 1902, Neuchâtel, Switzerland d. April 27, 1989, La Conversion, Switzerland Researcher in information theory, optics, and instrumentation Developed an infrared radar used to detect ships in WWII Former Chief Scientist with the US Army Signal Corps Discoverer of binary and ternary error-correcting codes which were used in Voyager spacecraft communications



DCS History and "Standards"



- Incorporation of digital tones into the standards occurred after the introduction of "Digital Private Line" by Motorola
- The latest release of the DCS standard was ANSI/ TIA-603-E (March 2016) as part of the "Land Mobile FM or PM Communications Equipment Measurement and Performance Standards" document



How Many DCS Codes Are There?



- 83 ANSI/TIA-603-E (2016) standard
- 104 Alinco, Icom, Kenwood, Yaesu
- 512 Anytone (D578, D878)

Note: Using codes beyond the 83 defined in the specification will reduce/eliminate the ability for error correction



ANSI/TIA-603-E (2016)



83 ANSI-Standard **DCS Codes**

)23	114	205	306	411	503	606	703
)25	115	223	311	412	506	612	712
)26	116	226	315	413	516	624	723
)31	125	243	331	423	532	627	731
)32	131	244	343	431	546	631	732
)43	132	245	346	432	565	632	734
)47	134	251	351	445		654	743
)51	143	261	364	464		662	754
)54	152	263	365	465		664	
)65	155	265	371	466			
)71	156	271					
)72	162						
)73	165						

074

172

174





- Radio-only activations can be implemented when commercial communications infrastructure fails
- One or more subsets of all resources can be more easily activated



- Resources within the same radio coverage area can alert each other to incidents
- Radio is quiet until the specified tone is used to unlock the receiver



Care Should be Taken in the Selection of Tones



- CTCSS-enabled radios are more common than
 DCS-enabled radios
- Need to make sure all radios have the same tone squelch capability
- Each activation area should use a different tone
- Certain "valid" tones should be avoided



Care Should be Taken in the Selection of Tones



Tones to avoid:

- 58.8 Hz, 62.5 Hz, 63.0 Hz close to 60 Hz AC line current
- 118.8 Hz, 123.0 Hz close to the first harmonic of 60 Hz AC line current
- 131.8 Hz, 136.5 Hz close to the DCS signaling frequency
- 179.9 Hz close to the third harmonic of 60 Hz AC line current
- 241.8 Hz close to the fourth harmonic of 60 Hz AC line current







A Radio-Based Alert System for Clark County ARES/RACES:

- Use CLRK 2A as the radio alert method for the organization
- Use each Team's VHF channel (with a CTCSS tone) as the radio alert method for that team
- Members leave radios on 24x7 with tone squelch enabled The radio (or an extension speaker) need to be in the sleeping area
- To activate members, transmit using the alternate tone



Radio Programming



- All members should ensure that CLRK 1A, CLRK 2A, and CLRK 3A are programmed into their radio(s)
- All team CTCSS tones should be unique and recorded on the Handi-Card
- All members should program their team VHF frequency twice, one memory channel set with no CTCSS tone and a second memory with the Team CTCSS tone and tone squelch enabled



Radio Programming





Alinco DR-235 with CTCSS Squelch enabled



Kenwood TM-D710G with DCS Transmit enabled

Yaesu FTM-400 Squelch menu entry





Radio Protocols



- When not listening to active conversations on their radio, members should tune to CLRK 2A and leave their radio on 24x7
- If a second band can be monitored simultaneously (dual-band radio or second radio), members should tune to their team VHF frequency on the second memory that has tone squelch enabled
- <u>Before transmitting with an alternate tone</u>, members should look at their S-Meter, or temporarily switch off the alternate tone, to ensure another conversation is not already in progress on that frequency



Tone Squelch Practice



- Each team should train and practice using tone squelch on their team's VHF channel
- The organization should train on the use of tone squelch and practice these techniques on at least one exercise each year

<u>Note:</u> The 5th Saturday Exercise on August 29th is designed around practicing tone squelch use



Further Reading



- https://wiki.radioreference.com/index.php/Continuous_Tone-Coded_Squelch_System
- https://wiki.radioreference.com/index.php/DCS
- https://blog.retevis.com/index.php/differences-ctcss-dcs
- http://www.repeater-builder.com/tech-info/ctcss/ctcss-overview.html
- http://www.repeater-builder.com/tech-info/ctcss/ctcss-doesnt-fix-anything.html
- http://www.repeater-builder.com/tech-info/pl+dpl/tone_signaling.pdf
- https://www.etsi.org/deliver/etsi_ts/103200_103299/103236/01.01.01_60/ ts_103236v010101p.pdf
- http://www.onfreq.com/syntorx/dcs.html
- https://en.wikipedia.org/wiki/Binary_Golay_code
- https://studylib.net/doc/11097608







You ASCII, we ANSI



CTCSS Tones - typical

Tone	ANSI/TIA standard	ETSI TS 103 236	Motorola manual	Wulfsberg Electronics	Racing Electronics		Com-spec	Alinco	Anytone	Icom	Kenwood	Yaesu	
(Hz)	tone group	standard	(11/1952)	(aviation)	(RELM)	5-bit DIP	6-bit DIP	DR-06, DR-235	D578, D878	ID-5100A	D710G	FT-2980R	
Total:	37	39	10	50	49	32	49	39	50	50	42	50	
67.0	А	•		01	001	•	•	•	•	•	•	•]
69.3		•		51				•	•	•	•	•	
71.9	В	•		02	002	•	•	•	•	•	•	•	
74.4	С	•		03	003	•	•	•	•	•	•	•	
77.0	А	•		04	004	•	•	•	•	•	•	•	
79.7	С	•		05	005	•	•	•	•	•	•	•	
82.5	В	•		06	006	•	•	•	•	•	•	•	
85.4	С	•		07	007	•	•	•	•	•	•	•	
88.5	А	•		08	008	•	•	•	•	•	•	•	
91.5	С	•		11	009	•	•	•	•	•	•	•	
94.8	В	•		12	010	•	•	•	•	•	•	•	
97.4		•		13	011	•	•	•	•	•	•	•	
100.0	А	•	•	14	012	•	•	•	•	•	•	•	
103.5	В	•		15	013	•	•	•	•	•	•	•	
107.2	А	•		16	014	•	•	•	•	•	•	•	
110.9	В	•	•	17	015	•	•	•	•	•	•	•	
114.8	А	•		18	016	•	•	•	•	•	•	•	
118.8	В	•		21	017	•	•	•	•	•	•	•	← 60 Hz AC x 2
123.0	А	•	•	22	018	•	•	•	•	•	•	•	← 60 Hz AC x 2
127.3	В	•		23	019	•	•	•	•	•	•	•	
131.8	А	•		24	020	•	•	•	•	•	•	•	← near DCS
136.5	В	•	•	25	021	•	•	•	•	•	•	•	← near DCS
141.3	А	•		26	022	•	•	•	•	•	•	•	
146.2	В	•		27	023	•	•	•	•	•	•	•	
151.4	А	•	•	28	024	•	•	•	•	•	•	•	
156.7	В	•		31	025	•	•	•	•	•	•	•	
159.8				52	040		•		•	•		•	
162.2	A	•		32	026	•	•	•	•	•	•	•	
165.5				53	041		•		•	•		•	
167.9	В	•	•	33	027	•	•	•	•	•	•	•]
171.3				54	042		•		•	•		•	

CTCSS Tones - typical

Tone	ANSI/TIA standard	ETSI TS 103 236	Motorola manual	Wulfsberg Electronics	Racing Electronics		Com-spec	Alinco	Anytone	lcom	Kenwood	Yaesu	
(Hz)	tone group	standard	(11/1952)	(aviation)	(RELM)	5-bit DIP	6-bit DIP	DR-06, DR-235	D578, D878	ID-5100A	D710G	FT-2980R	
Total:	37	39	10	50	49	32	49	39	50	50	42	50	
173.8	А	•		34	028	•	•	•	•	•	•	•	
177.3				55	043		•		•	•		•	
179.9	В	•		35	029	•	•	•	•	•	•	•	← 60 Hz AC x 3
183.5				56	044		•		•	•		•	
186.2	А	•	•	36	030	•	•	•	•	•	•	•	
189.9				57	045		•		•	•		•	
192.8	В	•		37	031	•	•	•	•	•	•	•	
196.6				58	046		•		•	•		•	
199.5				61	047		•		•	•		•	
203.5	А	•		38	032	•	•	•	•	•	•	•	
206.5			•	62	048		•		•	•	•	•	
210.7	В	•		41	033		•	•	•	•	•	•	
218.1	А	•		42	034		•	•	•	•	•	•	
225.7	В	•		43	035		•	•	•	•	•	•	
229.1			•	47	049		•		•	•	•	•	
233.6	А	•		44	036		•	•	•	•	•	•	
241.8	В	•		45	037		•	•	•	•	•	•	← 60 Hz AC x 4
250.3	А	•		46	038		•	•	•	•	•	•	
254.1			•	63	050		•		•	•	•	•	

CTCSS Tones - extended

Tone	ANSI/TIA standard	ETSI TS 103 236	Motorola manual	Wulfsberg Electronics	Racing Electronics		Com-spec	Alinco	Anytone	Icom	Kenwood	Yaesu	
(Hz)	tone group	standard	(11/1952)	(aviation)	(RELM)	5-bit DIP	6-bit DIP	DR-06, DR-235	D578, D878	ID-5100A	D710G	FT-2980R	
Total:	1	0	0	1	1	0	15	0	1	0	0	0	
33.0							•						
35.4							•						
36.6							•						
37.9							•						
39.6							•						
44.4							•						
47.5							•						
49.2							•						
51.2							•						
53.0							•						
54.9							•						
56.8							•						
58.8							•						← 60 Hz AC x 1
62.5									•				← 60 Hz AC x 1
63.0							•						← 60 Hz AC x 1
69.4					039		•						
134.4													← DCS
150.0				48									← NATO
259.1	С												

DCS Codes - 83 standard

	-		-				1
Code	ANSI/TIA- 603-E	Alinco	Anytone	lcom	Kenwood	Yaesu	
(at 134.4 Hz)	standard	DR-06, DR-235	D578, D878	ID-5100A	D710G	FT-2980R	
Totals:	83	83	83	83	83	83	
023	•	•	•	•	•	•	
025	•	•	•	•	•	•	
026	•	•	•	•	•	•	
031	•	•	•	•	•	•	
032	•	•	•	•	•	•	
043	•	•	•	•	•	•	
047	•	•	•	•	•	•	
051	•	•	•	•	•	•	
054	•	•	•	•	•	•	
065	•	•	•	•	•	•	
071	•	•	•	•	•	•	
072	•	•	•	•	•	•	
073	•	•	•	•	•	•	
074	•	•	•	•	•	•	
114	•	•	•	•	•	•	
115	•	•	•	•	•	•	
116	•	•	•	•	•	•	
125	•	•	•	•	•	•	
131	•	•	•	•	•	•	
132	•	•	•	•	•	•	
134	•	•	•	•	•	•	
143	•	•	•	•	•	•	
152	•	•	•	•	•	•	
155	•	•	•	•	•	•	
156	•	•	•	•	•	•	
162	•	•	•	•	•	•	
165	•	•	•	•	•	•	
172	•	•	•	•	•	•	
174	•	•	•	•	•	•	
205	•	•	•	•	•	•	
223	•	•	•	•	•	•	

Code	ANSI/TIA- 603-E	Alinco	Anytone	Icom	Kenwood	Yaesu
(at 134.4 Hz)	standard	DR-06, DR-235	D578, D878	ID-5100A	D710G	FT-2980R
226	•	•	•	•	•	•
243	•	•	•	•	•	•
244	•	•	•	•	•	•
245	•	•	•	•	•	•
251	•	•	•	•	•	•
261	•	•	•	•	•	•
263	•	•	•	•	•	•
265	•	•	•	•	•	•
271	•	•	•	•	•	•
306	•	•	•	•	•	•
311	•	•	•	•	•	•
315	•	•	•	•	•	•
331	•	•	•	•	•	•
343	•	•	•	•	•	•
346	•	•	•	•	•	•
351	•	•	•	•	•	•
364	•	•	•	•	•	•
365	•	•	•	•	•	•
371	•	•	•	•	•	•
411	•	•	•	•	•	•
412	•	•	•	•	•	•
413	•	•	•	•	•	•
423	•	•	•	•	•	•
431	•	•	•	•	•	•
432	•	•	•	•	•	•
445	•	•	•	•	•	•
464	•	•	•	•	•	•
465	•	•	•	•	•	•
466	•	•	•	•	•	•
503	•	•	•	•	•	•
506	•	•	•	•	•	•

DCS Codes - 83 standard

Code	ANSI/TIA- 603-E	Alinco	Anytone	Icom	Kenwood	Yaesu		Code
(at 134.4 Hz)	standard	DR-06, DR-235	D578, D878	ID-5100A	D710G	FT-2980R		(at 134 Hz)
Totals:	83	83	83	83	83	83	-	
516	•	•	•	•	•	•		6
532	•	•	•	•	•	•		6
546	•	•	•	•	•	•		7
565	•	•	•	•	•	•		7
606	•	•	•	•	•	•		7:
612	•	•	•	•	•	•		73
624	•	•	•	•	•	•		73
627	•	•	•	•	•	•		7
631	•	•	•	•	•	•		7.
632	•	•	•	•	•	•		7
654	•	•	•	•	•	•		

Code	ANSI/TIA- 603-E	Alinco	Anytone	Icom	Kenwood	Yaesu
(at 134.4 Hz)	standard	DR-06, DR-235	D578, D878	ID-5100A	D710G	FT-2980R
662	•	•	•	•	•	•
664	•	•	•	•	•	•
703	•	•	•	•	•	•
712	•	•	•	•	•	•
723	•	•	•	•	•	•
731	•	•	•	•	•	•
732	•	•	•	•	•	•
734	•	•	•	•	•	•
743	•	•	•	•	•	•
754	•	•	•	•	٠	٠

DCS Codes - extended

Code	ANSI/TIA- 603-E	Alinco	Anytone	Icom	Kenwood	Yaesu
(at 134.4 Hz)	standard	DR-06, DR-235	D578, D878	ID-5100A	D710G	FT-2980R
Totals:	0	21	21	21	21	21
036		•	•	•	•	•
053		•	•	•	•	•
122		•	•	•	•	•
145		•	•	•	•	•
212		•	•	•	•	•
225		•	•	•	•	•
246		•	•	•	•	•
252		•	•	•	•	•
255		•	•	•	•	•
266		•	•	•	•	•
274		•	•	•	•	•

Code	ANSI/TIA- 603-E	Alinco	Anytone	Icom	Kenwood	Yaesu
(at 134.4 Hz)	standard	DR-06, DR-235	D578, D878	ID-5100A	D710G	FT-2980R
325		•	•	•	•	٠
332		•	•	•	•	•

1					
332	•	•	•	•	•
356	•	•	•	•	•
446	•	•	•	•	•
452	•	•	•	•	•
454	•	•	•	•	•
455	•	•	•	•	•
462	•	•	•	•	•
523	•	•	•	•	•
526	•	•	•	•	•







Code	ANSI/TIA- 603-E	Anytone	Code	ANSI/TIA- 603-E	Anytone	Code	ANSI/TIA- 603-E	Anytone	Code	ANSI/TIA- 603-E	Anytone
(at 134.4 Hz)	standard	D578, D878	(at 134.4 Hz)	standard	D578, D878	(at 134.4 Hz)	standard	D578, D878	 (at 134.4 Hz)	standard	D578, D878
Totals:	0	408									
727		•	744		•	756		•	767		•
730		•	745		•	757		•	770		•
733		•	746		•	760		•	771		•
735		•	747		•	761		•	772		•
736		•	750		•	762		•	773		•
737		•	751		•	763		•	774		•
740		•	752		•	764		•	775		•
741		•	753		•	765		•	776		•
742		•	755		•	766		•	777		•