

Radio Quick Reference (2019-05)¹

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1 Introduction and Notation

There are three commonly used modes of radio transmission: *Continuous Wave* (CW), *Amplitude Modulation* (AM), and *Frequency Modulation* (FM). CW is a constant frequency and amplitude carrier wave that is switched on and off to encode information, typically using Morse code. AM encodes information by varying the amplitude of a constant frequency carrier wave. There are *Single Side Band* (SSB) specializations of AM called *Upper Side Band* (USB) and *Lower Side Band* (LSB). FM encodes information by varying the frequency of a constant amplitude carrier wave.

For FM, the *frequency deviation* (Δf) specifies the maximum difference between the carrier and modulated frequencies. In most modern equipment, $\Delta f = \pm 2.5$ kHz is called *Narrowband FM* (NFM), $\Delta f = \pm 5$ kHz is called FM, and the $\Delta f = \pm 75$ kHz used by broadcast FM radio stations is called *Wideband FM* (WFM).

Simplex operation uses a single frequency for both transmit and receive. A *calling* frequency is a well-known simplex frequency that is used to make contact with other radio operators. Once a contact has been made, the participants usually move the discussion to another simplex frequency in order to free up the calling frequency. *Repeaters* receive on one frequency and transmit on a different frequency. For bands with a standard offset between repeater input and output frequencies, the direction of the input offset is shown after the repeater's output frequency: a "+" means that the offset is added to the output frequency; a "-" means that the offset is subtracted from the output frequency.

For each radio service in the United States, the FCC specifies a maximum legal *Transmitter Power Output* (TPO), *Peak Envelope Power* (PEP), or *Effective Radiated Power* (ERP)². TPO and PEP describe how much power the radio transmitter supplies to the antenna. ERP describes the power radiated by the antenna in the primary direction(s) of the antenna's gain.

2 Communication Plans

During an emergency or disaster, or when establishing contact in remote locations, you want to conserve battery power while maximizing your probability of making radio contact. Communication plans coordinate frequencies, modes, and times for attempting radio contact. Outside of the specified time windows, you can turn off your radio in order to conserve battery power.

2.1 Amateur Radio Nets

An amateur radio *net* is an on-the-air gathering of amateur radio operators at a scheduled time on a specific repeater or simplex frequency. Local nets³ are usually sometime between 06:00 – 08:00 or 18:00 – 21:00; and run for about one hour.

2.2 Amateur Radio Wilderness Protocol (WP)⁴

Turn on your radio every 3 hours starting at 07:00 (07:00, 10:00, 13:00, 16:00, 19:00, and 22:00); Tune your radio to the WP primary frequency (146.520 MHz) and, if possible, any of the secondary

¹ The most recent version of this reference can be found at <https://www.misumasu.com/tutorials/radio-reference/>

² In watts (W): $ERP = TPO \times 10^{(G-L)/10}$. In decibel watts (dBW): $ERP = TPO - L + G$. Where L is cable loss and G is antenna gain in decibels (dB).

³ Search for local nets at <http://www.arrl.org/arrl-net-directory-search>

⁴ <http://www.arrl.org/files/file/ARESFieldResourcesManual.pdf>

frequencies (52.525 MHz, 223.500 MHz, 446.000 MHz, and 1294.500 MHz); Monitor that frequency for at least 5 minutes. The first 4 minutes after the hour are reserved for emergency or other priority communications. Standard calling use starts 4 minutes after the hour.

2.3 3-3-3 Radio Plan⁵

Turn on your radio every 3 hours (00:00, 03:00, 06:00, 09:00, 12:00, 15:00, 18:00, and 21:00); Tune your radio to channel 3 (CBRS, FRS, GMRS, or MURS) or to the designated emergency or calling frequency in bands that don't have channel numbers; Monitor that channel for at least 3 minutes.

2.4 Prepper Communications Plan (PCP)⁶

The PCP recommends the following frequencies and modes for sharing information and coordinating activities between various prepper groups: 3.818 MHz LSB, 7.073 MHz USB (Morse code / digital), 7.242 MHz LSB, 14.073 MHz USB (Morse code / digital), 14.242 MHz USB, 146.420 MHz FM, 446.420 MHz FM, and channel 4 (CBRS, FRS, GMRS, or MURS).

3 Common Radio Services

3.1 NOAA Weather Radio (NWR)

The *NOAA Weather Radio* (NWR)⁷ is a nationwide network of FM radio stations broadcasting continuous weather information from the nearest National Weather Service office. NWR broadcasts official warnings, watches, forecasts, and other hazard information 24 hours a day, 7 days a week. NWR may also broadcast non-weather related emergency information during Emergency Alert System (EAS) activation or AMBER alerts.

NWR frequencies are listed in Table 1. NWR channels are 25 kHz wide ($\Delta f = \pm 5$ kHz). Transceivers MUST be receive-only on the NWR frequencies. Do NOT transmit on the NWR frequencies.

f (MHz)	162.400	162.425	162.450	162.475	162.500	162.525	162.550
Frequency Order	WX 1	WX 2	WX 3	WX 4	WX 5	WX 6	WX 7
Allocation Order	WX 2	WX 4	WX 5	WX 3	WX 6	WX 7	WX 1

Table 1 NOAA Weather Radio (NWR) frequencies

3.2 Multiple-Use Radio Service (MURS)

The *Multiple-Use Radio Service* (MURS)⁸ is an FM radio service in the 151 MHz and 154 MHz spectrum. MURS channels and frequencies are listed in Table 2. Channels 1 – 3 are 11.25 kHz wide ($\Delta f = \pm 2.5$ kHz). Channels 4 – 5 can be either 11.25 kHz or 20 kHz wide ($\Delta f = \pm 2.5$ kHz or ± 5 kHz respectively). Maximum TPO is 2 W.

Ch	f (MHz)	Notes	Ch	f (MHz)	Notes
01	151.820		04	154.570	Prepper (PCP), Blue Dot
02	151.880		05	154.600	Green Dot
03	151.940	Prepper (3-3-3)			

Table 2 MURS frequencies

⁵ <https://radiofreeq.wordpress.com/2013/07/15/3-3-3-radio-plan-for-shtf-communications/>

⁶ <http://radicalsurvivalism.com/web/2013/03/30/the-standardized-amateur-radio-prepper-communications-plan/>

⁷ <https://www.nws.noaa.gov/nwr/>

⁸ <https://www.fcc.gov/wireless/bureau-divisions/mobility-division/multi-use-radio-service-murs>

MURS is licensed by rule. An individual license is not required. You can operate a MURS device regardless of your age and for personal or business use so long as you are not a representative of a foreign government. MURS transmitters must be certified under Part 95 of the FCC rules.

3.3 Family Radio Service (FRS) and General Mobile Radio Service (GMRS)

The *Family Radio Service* (FRS)⁹ and *General Mobile Radio Service* (GMRS)¹⁰ are FM radio services in the 462 MHz and 467 MHz spectrum. FRS/GMRS channels¹¹ and frequencies are listed in Table 3. FRS channels are all 12.5 kHz wide ($\Delta f = \pm 2.5$ kHz). GMRS channels 8 – 14 are 12.5 kHz wide ($\Delta f = \pm 2.5$ kHz) and are limited to hand-held portable units. GMRS channels 1 – 7 and 15 – 22 are 20 kHz wide ($\Delta f = \pm 5$ kHz). FRS and GMRS maximum ERP is 0.5 W on channels 8 – 14. FRS maximum ERP is 2 W on channels 1 – 7 and 15 – 22. GMRS maximum ERP is 5 W on channels 1 – 7, and either 15 W (fixed) or 50 W (mobile) on channels 15 – 22. FRS/GMRS channels 1 – 22 allow simplex operation. GMRS channels 15 – 22 allow repeater operation with an input offset of +5 MHz. The *myGMRS*¹² and *RepeaterFinder*¹³ websites are free resources for locating GMRS repeaters.

Ch	<i>f</i> (MHz)	Notes	Ch	<i>f</i> (MHz)	Notes
01	462.5625	Emergency and Calling	15	462.5500	
02	462.5875	Geocaching, Birding	16	462.5750	
03	462.6125	Prepper (3-3-3)	17	462.6000	Prepper (3-3-3)
04	462.6375	Prepper (PCP)	18	462.6250	
05	462.6625		19	462.6500	
06	462.6875		20	462.6750	Emergency (CTCSS: 141.3)
07	462.7125		21	462.7000	
08	467.5625		22	462.7250	
09	467.5875				
10	467.6125				
11	467.6375				
12	467.6625				
13	467.6875				
14	467.7125				

Table 3 FRS and GMRS frequencies

Several groups recommend using FRS/GMRS channel 1 as an emergency and calling channel.

FRS is licensed by rule. An individual license is not required. You can operate an FRS device regardless of your age and for personal or business use so long as you are not a representative of a foreign government. FRS transmitters must be certified under Part 95 of the FCC rules.

An individual FCC license is required to operate a GMRS system. Licenses are issued for a 10-year term and can be renewed within the 90 days before the license expiration date. You can apply for a GMRS license if you are 18 years or older and not a representative of a foreign government. If you receive a license, any family member, regardless of age, can operate GMRS stations and units within your licensed system. GMRS transmitters must be certified under Part 95 of the FCC rules.

3.4 Citizens Band Radio Service (CBRS)

The *Citizens Band Radio Service* (CBRS)¹⁴ is an AM radio service in the 26.960 – 27.410 MHz spectrum. CBRS channels and frequencies are listed in Table 4. Each channel is 10 kHz wide. Maximum PEP is 4 W for AM and 12 W for SSB.

⁹ <https://www.fcc.gov/wireless/bureau-divisions/mobility-division/family-radio-service-frs>

¹⁰ <https://www.fcc.gov/wireless/bureau-divisions/mobility-division/general-mobile-radio-service-gmrs>

¹¹ The Motorola FRS and GMRS channel numbers are shown. Other manufacturers may use different channel numbers.

¹² <https://mygmrs.com/>

¹³ <https://repeaterfinder.com/>

¹⁴ <https://www.fcc.gov/wireless/bureau-divisions/mobility-division/citizens-band-radio-service-cbrs>

Ch	f (MHz)	Notes	Ch	f (MHz)	Notes
01	26.965		21	27.215	
02	26.975		22	27.225	
03	26.985	Prepper (3-3-3)	23	27.255	
04	27.005	Prepper (PCP), 4x4 off-road	24	27.235	
05	27.015		25	27.245	
06	27.025		26	27.265	
07	27.035		27	27.275	
08	27.055		28	27.285	
09	27.065	Emergency	29	27.295	
10	27.075		30	27.305	
11	27.085		31	27.315	
12	27.105		32	27.325	
13	27.115	Campers, RV, and Marine	33	27.335	
14	27.125		34	27.345	
15	27.135		35	27.355	
16	27.155		36	27.365	SSB [USB] Survivalist
17	27.165		37	27.375	SSB [USB] Prepper
18	27.175		38	27.385	SSB [LSB] Calling
19	27.185	Travelers and Calling	39	27.395	SSB
20	27.205		40	27.405	SSB

Table 4 CBRS frequencies

Channel 9 is the official emergency channel. Channel 19 is the unofficial traveler and calling channel.

CBRS is licensed by rule. An individual license is not required. You can operate a CBRS device regardless of your age and for personal or business use so long as you are not a representative of a foreign government. CBRS transmitters must be certified under Part 95 of the FCC rules.

3.5 Amateur (Ham) Radio Service

An individual FCC license is required to operate an amateur radio station. There are three increasing classes of amateur radio license: *Technician*, *General*, and *Amateur Extra*. A Technician class license grants full operating privileges in all of the amateur radio bands above 30 MHz. The General and Amateur Extra class licenses grant increasing privileges in the amateur radio bands below 30 MHz. The *American Radio Relay League* (ARRL)¹⁵ is the national association for amateur radio in the United States. The amateur radio service is regulated under Part 97 of the FCC rules.

This guide focuses on the amateur radio bands above 30 MHz on which Technician class licensees can legally operate. The 10 m band is also covered because it is supported by many radio scanners and Technician class licensees have limited operating privileges¹⁶ in this band. The 10 m – 23 cm amateur radio bands, with the ARRL-recommended repeater offsets and channel spacings, are listed in Table 5. Maximum PEP is typically 1500 W, but is lower in certain geographic regions or amateur radio bands. However, the FCC requires that amateur radio stations transmit with the minimum power necessary to carry out the desired communication.

Band	f (MHz)	\pm (MHz)	Spacing (kHz)	Band	f (MHz)	\pm (MHz)	Spacing (kHz)
10 m	28.0000 – 29.7000	0.1	20	70 cm	420.000 – 450.000	5	25
6 m	50.0000 – 54.0000	0.5 / 1	20	33 cm	902.000 – 928.000	25	12.5
2 m	144.000 – 148.000	0.6	15 / 20 / 30	23 cm	1240.00 – 1300.00	12	25
1.25 m	222.000 – 225.000	1.6	20				

Table 5 Amateur radio bands with ARRL-recommended repeater offsets and channel spacings

¹⁵ <http://www.arrl.org/>

¹⁶ In the 10 m band, Technician class licensees are limited to 28.000 – 28.500 MHz and a maximum PEP of 200 W.

An abbreviated version of the ARRL-recommended band plans¹⁷ are presented in Table 6. However, local frequency coordinators may use different frequency allocations within the amateur bands due to local conditions. The two most widely used amateur radio bands are the 2 m and 70 cm bands. The 6 m band has additional recommended FM simplex frequencies of 52.020, 52.040, 52.525, 52.540, 53.000, 53.020, 53.520, and 53.900 MHz.

Band	f (MHz)	Notes	Band	f (MHz)	Notes
10 m	28.3000 – 29.3000	Phone	1.25 m	222.150 – 222.250	Local Option
10 m	29.5200 – 29.5900	Repeater Inputs (4)	1.25 m	222.250 – 223.380	Repeater Inputs
10 m	29.6100 – 29.7000	Repeater Outputs (4)	1.25 m	223.400 – 223.520	Simplex (7)
6 m	50.3000 – 50.6000	All Modes	1.25 m	223.710 – 223.850	Local Option
6 m	51.1200 – 51.4800	Repeater Inputs (19)	1.25 m	223.850 – 224.980	Repeater Outputs
6 m	51.5000 – 51.6000	Simplex (6)	70 cm	435.000 – 438.000	Satellite (internationally)
6 m	51.6200 – 51.9800	Repeater Outputs (19)	70 cm	442.000 – 445.000	Repeater Inputs/Outputs
6 m	52.0000 – 52.4800	Repeater Inputs (23)	70 cm	445.000 – 447.000	Simplex, Control
6 m	52.5000 – 52.9800	Repeater Outputs (23)	70 cm	447.000 – 450.000	Repeater Inputs/Outputs
6 m	53.0000 – 53.4800	Repeater Inputs (19)	33 cm	902.000 – 902.075	Repeater Inputs
6 m	53.5000 – 53.9800	Repeater Outputs (19)	33 cm	902.125 – 903.000	Repeater Inputs
2 m	144.600 – 144.900	Repeater Inputs	33 cm	927.000 – 927.075	Repeater Outputs
2 m	145.200 – 145.500	Repeater Outputs	33 cm	927.075 – 927.125	Simplex
2 m	146.010 – 146.370	Repeater Inputs	33 cm	927.125 – 928.000	Repeater Outputs
2 m	146.400 – 146.580	Simplex	23 cm	1270.00 – 1276.00	Repeater Inputs
2 m	146.610 – 146.970	Repeater Outputs	23 cm	1282.00 – 1288.00	Repeater Outputs
2 m	147.000 – 147.390	Repeater Outputs	23 cm	1294.00 – 1295.00	Simplex
2 m	147.420 – 147.570	Simplex			
2 m	147.600 – 147.990	Repeater Inputs			

Table 6 Abbreviated ARRL-recommended band plans (repeaters and simplex)¹⁸

The *ARRL Repeater Directory* contains a listing of almost every 10 m – 23 cm amateur radio repeater in the United States and Canada. Buy a recent edition of the Repeater Directory to include in your radio kit. Additionally, the *RepeaterBook*¹⁹ website and smartphone app are free resources for locating amateur radio repeaters.

Calling and other simplex frequencies in the 10 m – 23 cm amateur radio bands are listed in Table 7.

Band	f (MHz)	Mode	Notes	Band	f (MHz)	Mode	Notes
10 m	28.400	SSB	Calling	1.25 m	222.100	SSB	Calling
10 m	29.600	FM	Calling	1.25 m	223.500	FM	Calling (WP: secondary)
6 m	50.125	SSB	Calling	70 cm	432.100	SSB	Calling
6 m	50.400	AM	Calling	70 cm	446.000	FM	Calling (WP: secondary)
6 m	52.525	FM	Calling (WP: secondary)	70 cm	446.420	FM	Prepper (PCP)
6 m	52.540	FM	Calling: alternate	33 cm	902.100	SSB	Calling: weak signal
6 m	53.000	FM	Remote Base Simplex	33 cm	903.100	SSB	Calling: weak signal
2 m	144.200	SSB	Calling	33 cm	927.500	FM	Calling
2 m	146.420	FM	Prepper (PCP)	23 cm	1294.500	FM	Calling (WP: secondary)
2 m	146.520	FM	Calling (WP: primary)	23 cm	1296.100	SSB	Calling

Table 7 Important amateur radio simplex frequencies

¹⁷ <http://www.arrl.org/band-plan>

¹⁸ Not shown are the frequencies allocated for CW, beacons, packet radio, and other purposes.

¹⁹ <https://www.repeaterbook.com/>

3.6 Marine, Air, and Emergency Responder Radio Services

The marine VHF band is an FM radio service in the 156.000 – 162.025 MHz spectrum. Marine channels are 16 kHz wide ($\Delta f = \pm 5$ kHz) with 25 kHz spacing. Maximum TPO is 25 W. All ships must carry a marine VHF radio. The Coast Guard, all coast stations, and most ships are required to continuously monitor channel 16 (156.800 MHz) for distress calls.

The aircraft bands are AM radio services. The civilian aircraft band is in the 108 – 137 MHz spectrum. The military aircraft band is in the 225 – 400 MHz spectrum. Aircraft and air traffic controllers are required to continuously monitor 121.500 MHz for distress calls.

Important marine, air, and emergency responder frequencies are listed in Table 8. It is important to note that unauthorized transmission on any of these frequencies is illegal unless there is an emergency.

Service	f (MHz)	Δf (kHz)	Description
Red Cross	47.420	± 5	American Red Cross Emergency Operations (primary)
Red Cross	47.500	± 5	American Red Cross Emergency Operations (secondary)
Air: Civilian	121.500	AM	International Air Distress (IAD) and Emergency Guard
Air: Civilian	123.100	AM	Search and Rescue (SAR): Aircraft
Responder	155.160	± 2.5	Search and Rescue (SAR): Land
Responder	155.475	± 2.5	National Law Enforcement Mutual Aid Radio System (NALEMARS)
Marine	156.450	± 5	Channel 09: Calling
Marine	156.650	± 5	Channel 13: International Intership Navigation (Bridge-to-Bridge Safety)
Marine	156.800	± 5	Channel 16: International Distress, Safety, and Calling
Air: Military	243.000	AM	NATO Military Air Distress (MAD) and Emergency Guard
Air: Military	282.800	AM	Search and Rescue (SAR): Aircraft

Table 8 Important marine, air, and emergency responder frequencies

4 Operating Procedures

1. Listen for about one minute to check if the channel is in use before starting a new conversation.
 - Don't jump in and transmit over someone else's conversation.
2. Depress the *Push to Talk* (PTT) key on your radio and wait for one second before speaking.
 - It takes a small amount of time for your transmitter to power up.
 - It takes a small amount of time for repeaters or receivers to detect a CTCSS tone or DCS code.
 - If you immediately start talking, the first part of your transmission will be cut off.
3. Clearly speak into the microphone while continuing to depress the PTT key.
 - Keep your message short, 2 – 3 minutes maximum.
 - Provide all necessary information and identification.
4. Release the PTT key to end your transmission.
5. Wait for at least one minute before repeating your message or transmitting another message.
 - This allows others to respond to your transmission or interrupt with an emergency.

5 Continuous Tone-Coded (CTCSS) and Digital-Coded (DCS) Squelch Systems

The *Continuous Tone-Coded Squelch System* (CTCSS) is used to mute interference and other groups of users that are on the same channel. A transmitter with the CTCSS enabled adds the configured sub-audible continuous tone to any transmission. A receiver with the CTCSS enabled only unmutes the audio when a radio transmission is present and the configured sub-audible tone is detected. Each group on a shared channel can use a different CTCSS tone to avoid hearing conversations from other groups. The CTCSS tones are listed in Table 9.

Digital-Coded Squelch (DCS) is a digital version of CTCSS. The configured DCS code is continuously sent over a 134.4 bps bitstream added to any transmission. DCS codes can be transmitted with either

positive or negative polarity. Transceivers with opposite DCS polarity can still inter-operate by using inverted pairs of DCS codes. The DCS codes, and compatible inverted codes, are listed in Table 10.

Interference Eliminator Codes (IEC) 1 – 38 and *Private-Line (PL)* codes typically map to CTCSS tones as shown in Table 9. IECs 39 – 121, or 1 – 83 if numbering starts over, typically map to DCS codes as shown in Table 10.

<i>f</i> (Hz)	IEC	PL	<i>f</i> (Hz)	IEC	PL	<i>f</i> (Hz)	IEC	PL	<i>f</i> (Hz)	IEC	PL
None	000		100.0	012	1Z	151.4	024	5Z	192.8	031	7A
67.0	001	XZ	103.5	013	1A	156.7	025	5A	196.6		
69.3		WZ	107.2	014	1B	159.8			199.5		
71.9	002	XA	110.9	015	2Z	162.2	026	5B	203.5	032	M1
74.4	003	WA	114.8	016	2A	165.5			206.5		8Z
77.0	004	XB	118.8	017	2B	167.9	027	6Z	210.7	033	M2
79.7	005	WB	123.0	018	3Z	171.3			218.1	034	M3
82.5	006	YZ	127.3	019	3A	173.8	028	6A	225.7	035	M4
85.4	007	YA	131.8	020	3B	177.3			229.1		9Z
88.5	008	YB	136.5	021	4Z	179.9	029	6B	233.6	036	M5
91.5	009	ZZ	141.3	022	4A	183.5			241.8	037	M6
94.8	010	ZA	146.2	023	4B	186.2	030	7Z	250.3	038	M7
97.4	011	ZB	150.0		NATO	189.9			254.1		0Z

Table 9 CTCSS tones

DCS	-DCS	IEC	DCS	-DCS	IEC	DCS	-DCS	IEC	DCS	-DCS	IEC
023	047	039/001	152	115	061/023	311	664	080/042	466	662	098/060
025	244	040/002	155	731	062/024	315	423	081/043	503	162	099/061
026	464	041/003	156	265	063/025	325	526		506	073	100/062
031	627	042/004	162	503	064/026	331	465	082/044	516	432	101/063
032	051	043/005	165	251	065/027	332	455		523	246	
036	172		172	036	066/028	343	532	083/045	526	325	
043	445	044/006	174	074	067/029	346	612	084/046	532	343	102/064
047	023	045/007	205	263	068/030	351	243	085/047	546	132	103/065
051	032	046/008	212	356		356	212		565	703	104/066
053	452		223	134	069/031	364	131	086/048	606	631	105/067
054	413	047/009	225	122		365	125	087/049	612	346	106/068
065	271	048/010	226	411	070/032	371	734	088/050	624	632	107/069
071	306	049/011	243	351	071/033	411	226	089/051	627	031	108/070
072	245	050/012	244	025	072/034	412	143	090/052	631	606	109/071
073	506	051/013	245	072	073/035	413	054	091/053	632	624	110/072
074	174	052/014	246	523		423	315	092/054	654	743	111/073
114	712	053/015	251	165	074/036	431	723	093/055	662	466	112/074
115	152	054/016	252	462		432	516	094/056	664	311	113/075
116	754	055/017	255	446		445	043	095/057	703	565	114/076
122	225		261	732	075/037	446	255		712	114	115/077
125	365	056/018	263	205	076/038	452	053		723	431	116/078
131	364	057/019	265	156	077/039	454	266		731	155	117/079
132	546	058/020	266	454		455	332		732	261	118/080
134	223	059/021	271	065	078/040	462	252		734	371	119/081
143	412	060/022	274	145		464	026	096/058	743	654	120/082
145	274		306	071	079/041	465	331	097/059	754	116	121/083

Table 10 DCS codes

Some transceivers use CTCSS tones and DCS codes. Other transceivers use PL codes or IECs. Table 9 and Table 10 can be used to translate between devices.

6 Phonetic Alphabets and Morse Code

Phonetic alphabets use a specific word for each spoken letter when spelling a word or a non-word series of characters. Phonetic alphabets are used when accurate transfer of each character is required, but noise in or limitations of the audio channel make it difficult to distinguish between spoken letters such as “B” and “D”, “M” and “N”, or “F” and “S”.

	Phonetic	Pronunciation	Morse Code		Phonetic	Pronunciation	Morse Code
A	Alfa	(AL-FAH)	..---	0	Zero	(ZEE-RO)	--- -- -- --
B	Bravo	(BRAH-VOH)	---	1	One	(WUN)	.. --- -- -- --
C	Charlie	(CHAR-LEE)	---	2	Two	(TOO)	.. . --- -- -- --
D	Delta	(DELL-TAH)	--- . . .	3	Three	(TREE)	.. . --- -- --
E	Echo	(ECK-OH)	..	4	Four	(FOW-ER) ---
F	Foxtrot	(FOKS-TROT)	.. . --- .	5	Five	(FIFE)	.. . . . .
G	Golf	(GOLF)	---	6	Six	(SIX)	---
H	Hotel	(HOH-TEL)	.. . . .	7	Seven	(SEV-EN)	---
I	India	(IN-DEE-AH)	.. .	8	Eight	(AIT)	---
J	Juliet	(JEW-LEE-ETT)	.. --- -- -- --	9	Nine	(NIN-ER)	---
K	Kilo	(KEY-LOH)	--- . . . .	.	Point/Stop		.. . . . .
L	Lima	(LEE-MAH)	.. . . .	,	Comma		---
M	Mike	(MIKE)	--- --	:	Colon		---
N	November	(NO-VEM-BER)	--- .	;	Semicolon		---
O	Oscar	(OSS-CAH)	--- -- --	?	Question		.. . . . .
P	Papa	(PAH-PAH)	.. --- -- .	!	Exclamation		---
Q	Quebec	(KEH-BECK)	---	'	Apostrophe		.. . . . .
R	Romeo	(ROW-ME-OH)	.. . . .	"	Quotation		.. . . . .
S	Sierra	(SEE-AIR-RAH)	.. . . .	/	Slash		---
T	Tango	(TANG-GO)	---	(	Open Paren		---
U	Uniform	(YOU-NEE-FORM)	.. . ---	)	Close Paren		---
V	Victor	(VIK-TAH)	.. . . .	&	Ampersand		.. . . . .
W	Whiskey	(WISS-KEY)	.. --- --	@	At		.. . . . .
X	X-ray	(ECKS-RAY)	---	\$	Dollar		.. . . . .
Y	Yankee	(YANG-KEY)	---	_	Underscore		.. . . . .
Z	Zulu	(ZOO-LOO)	---	+	Plus		.. . . . .
				-	Dash/Minus		---
				=	Equal		---

Table 11 NATO phonetic alphabet and Morse code

Using the NATO phonetic alphabet in Table 11: “WTF” is spoken as “Whiskey Tango Foxtrot”; the callsign “NA1SS” is spoken as “November Alfa One Sierra Sierra”; and “146.52” is spoken as “One Hundred Four Six Point Five Two”. A period (“.”) is pronounced as *Stop* when used to end a sentence and as *Point* when used as a decimal point in a number.

The NATO phonetic alphabet in Table 11 is used by all NATO armed forces, civilian aviation, amateur radio operators, and some law enforcement agencies. The LAPD phonetic alphabet in Table 12 is used by the Los Angeles Police Department and many other police departments across the United States. In some departments, *Nancy* is replaced by *Nora*.

	Phonetic		Phonetic		Phonetic		Phonetic		Phonetic		Phonetic
A	Adam	E	Edward	I	Ida	M	Mary	Q	Queen	U	Union
B	Boy	F	Frank	J	John	N	Nancy	R	Robert	V	Victor
C	Charles	G	George	K	King	O	Ocean	S	Sam	W	William
D	David	H	Henry	L	Lincoln	P	Paul	T	Tom	X	X-ray
										Y	Young
										Z	Zebra

Table 12 LAPD phonetic alphabet