Simplex

The most noticeable difference between a two-way radio and a cell phone is that with a two way radio, you can't talk and listen to the other person at the same time. The reason for this is that two-way radios typically share one frequency for transmitting and receiving. This mode of communication is called *Simplex* or *Half-Duplex*.[1)]

Cellphones, on the other hand, use two frequencies at the same time: one for transmitting, and the other for receiving. This is called *Full Duplex*.

Full Duplex[2)]	**Simplex**[3)]
Full duplex is like a regular road where traffic has its own lane and can travel in both directions at the same time. Cells phones can do this.	Simplex (or Half-Duplex) is like only having one lane open and forcing traffic to alternate. Most two-way radios can only do this.

Since most of the voice communications we have with amateur radios are not full duplex, it's really important that operators wait until the other person is finished before beginning to speak otherwise they'll miss part of the conversation. When that happens, we say that the operators “doubled”, which means neither heard the other (although a third person may have heard both). We usually recommend waiting half a second or so before beginning to transmit. This also gives the chance to other stations to jump in if needed (with emergency traffic for example).

Range

A common question people often have is how far they can talk with a ham radio. This is a tricky question because the range depends on three main factors:

- the antenna characteristics of both radios, their heights above the ground, and the line of sight between them.
- the transmitting power of both stations.
- the frequency band used (more on that later).

Depending on theses factors, two stations may barely be able to communicate to a kilometre, or have no problem making it all the way to the other side of the globe.

It's also a trick question because the range depends on the setup of *both* radio stations: it makes no sense to talk about the range of *one* radio.

Let's look at the first two factors now (we'll leave the third for later).

Antenna, Height, Line of Sight

The best way to improve your signal is to focus on the antenna system. A $2000 radio with a bad antenna system will do worse than a $100 radio with a great antenna system. The general principal is that an antenna should be the right type for the band used (much more on this later), as high as possible, and have a clear path to the other station.

For example:

- Under “normal” conditions, two VHF hand held radios operating in simplex at 5 watts could probably communicate with one another to a distance of about 1 km. If the line of sight is obstructed by buildings or hills, this range would drop, but if one (or both) of the stations were at the top of a hill with a clear view of the valley below the range would increase.
- A VHF base station with a good antenna up a tall tower might be able to communicate with a hand held radio 10 or 15 km away.
- And two such base stations would probably be able communicate with one another to a distance of 50 to 100 km.

Again: it doesn't make sense to talk about the range of *one* radio; instead, the range depends on both stations. As soon as one station improves its antenna system and line of sight, both stations benefit.

Power

Personal radio services like CB or FRS require no license but have their power output regulated to a maximum of 4 Watts (for CB bands) and 2 Watts (for FRS bands). Ham radios, however, can be operated to hundreds of watts depending on the band, mode, and license type. This complicates the “range” question a bit.

For example, imagine that Alice and Bob can barely manage to hear each other at 5 W. What would happen if Alice cranks up her transmit (TX) power to 50 W? Would that help her hear Bob better?

Increasing your own power is like speaking louder: it helps *others* hear you better, but it doesn't help you hear them better. As such, one of the rules in ham radio is to use the minimum power required to make the contact. It's like adjusting the volume of your voice to the setting around you. You wouldn't shout to the person sitting in front of you in a quiet restaurant, but you might in a loud pub.

In general, it's best for both stations to try to match their TX power so that you're both “speaking” at an equal volume. If one person is transmitting at 50 W while the other is at 5 W, one person might not hear the other properly.

The rules[4] for how much power can be used are a little complicated because they depend on where it is measured in the radio and what kind of transmission is used. We'll see what these mean in more detail later, but for now, here's the summary:

	Basic	**Advanced**
DC input power to the anode or collector circuit of the transmitter stage that supplies radio frequency energy to the antenna	250W	1000W
Peak envelope output power measured across an impedance-matched load for SSB emissions	560W	2250W
Carrier output power measured across an impedance-matched load for any other type of emission.	190W	750W

So while an advanced license allows the use of roughly four times more power (which only improves the received signal by one S unit), having a better antenna doesn't require any special licensing and helps *both* stations at once, which is why it should be the number one focus.

Personal Record

The furthest VA7FI has been able to communicate in simplex on VHF (146.520 MHz) was 300 km away. The other station (KG7EGT) was atop of Summit Lake Peak (47.03969,-121.83162) at an elevation of 1650m in Washington State and VA7FI was using his GP-9 antenna up a 20m tall tree with the base of the tree 100m above sea level with

a direct view of the water. VA7FI could hear KG7EGT 57 and KG7EGT could hear VA7FI 59. This difference in signal strength was because VA7FI was using full power on his base station while KG7EGT was using a portable radio with less power.

Frequency Coordination

As we saw on the previous page, ham operators are allowed to use very specific bands of the electromagnetic spectrum, but each band is also further sub-divided for different usage. The following links from Radio Amateur of Canada (RAC) should be printed and used as reference:

- HF band plan
- 6m band plan
- 2m band plan
- 440 band plan

And for British Columbia:

- Plan "A" by Functional Allocation

Let's use the 2m band as an example. Even though, we are allowed to transmit between 144 and 148 MHz, only the following frequencies should be used for simplex, voice operation:

> 146.415, 146.430, 146.445, 146.460, 146.475, 146.490, 146.505, 146.520, 146.535, 146.550, 146.565, 146.580, 146.595, 147.420, 147.450, 147.480, 147.510, 147.540, 147.570

You'll notice that the first 13 channels are 0.015 MHz (or 15 kHz) apart and the last 6 channels are 30 kHz apart. That's to ensure that someone talking on one frequency doesn't interfere with someone talking on another. For example, if a group is using 146.415 MHz and another is using 146.430 MHz, they probably won't bother each other, (unless they are really close to each other), but if you tune your radio to 146.420 MHz or 146.425 MHz, you might hear noise from both groups. That's because communications on a frequency also have what we call *bandwidth*. Radio signals never only take just “one” frequency. Instead, they take up a certain amount of space on the electromagnetic spectrum.

The fourth column of the table on the previous page shows the maximum allowed bandwidth for each band. This bandwidth is regulated so that no one station takes more space than needed, which would cause interference on the other frequencies.

	Band	Range (MHz)	Max Bandwidth	License	⚠ Notes
LF	2200m	0.1357 – 0.1378	100 Hz	B +	D, 1
MF	160m	1.8 – 2.0	6 kHz	B +	
HF	80m	3.5 – 4.0	6 kHz	B +	
HF	60m	5.332, 5.348, 5.3585	2.8 kHz	B +	2

The Radio

Now that we understand a bit more about simplex communications, let's look at some buttons on an actual radio to see what each does.



This particular radio is the Icom IC-2730A. The first thing to notice about this radio is that it's actually two radios in one. You can listen to two different frequencies at the same time, with their own independent volumes and dials. So looking at the left side for example, we see...

VFO / MR

Two buttons labelled V/MHz and MR. They simply allow the main DIAL to tune the radio either by frequency or by channels saved by the operator. On other radios, these two buttons are sometimes a single button labelled VFO / MR.

Squelch

The SQL (squelch) dial is a circuit within the radio that keeps the speaker silenced (squelched) until the signal level exceeds a certain point set by the squelch control. Normally you set the squelch to just block out noise and allow signals to pass. The reason for this is that there is always some radio background noise on the air. Sometimes that noise is low, but sometimes it's high. Being able to silence it depending on its intensity ensures that we may be able to hear weak stations that are just above that noise level.

CTCSS

Another feature hidden in the MENU of the radio is called CTCSS (Continuous Tone-Coded Squelch System) or sub-audible tone (or sometimes just called “tone”). Imagine that you reside in a congested area where there is a lot of interference that opens the squelch unnecessarily. What you and the other operator can do is send a specific tone (which is just a pure note) on top of your voice when you transmit. That way, you can set your radio to only open

the squelch if that note is heard. Typically, there are 50 tones available to choose from ranging from 67.0Hz to 254.1Hz. Have a listen at three of them here:

67.0 Hz	67 Hz
151.4 Hz	151.4 Hz
254.1 Hz	254.1 Hz

You probably noticed that you had to use headphones or good speakers to hear them (at least for the first two tones). That's because, although they are within our normal range of hearing (20 Hz – 20 kHz), the lower frequencies require bigger speaker to play properly. Which is why, we tend not to actually hear these tones over the radio when we use them.

That being said, there is a trade off when picking a tone: the lower frequency tones are the less likely to be heard but they take longer to be recognized by the radio because they take more time to go through a full cycle. That means that it's even more important to wait a half a second before speaking after keying up the PPT (Push To Talk) button to give time to the other radio to recognize the tone and open the squelch for you.

Microphone



The microphone on this particular radio contains some new buttons, but some that are also on the radio itself like the VFO/MR, VOL and SQL

PTT

The PTT (push to talk) is the button used to engage the transmitter and talk on the air. This is the button you must

wait half a second before talking after you press it.

DTMF

The DTMF (Dual-tone Multi-frequency) buttons are the same as on a regular phone. They allow radios to transmit numbers and four letters to activate various functions on remote radios. For example, it's possible to configure some radios to have their squelch on (to silence any incoming transmission) until a specific sequence of DTMF is heard. More often, they're used to control repeaters (which we'll see next).

From wikipedia:

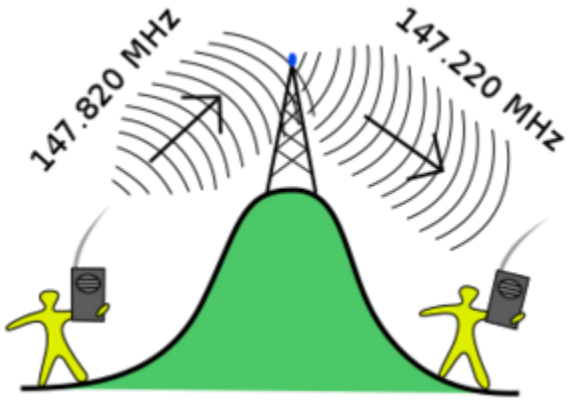
> "The DTMF system uses a set of eight audio frequencies transmitted in pairs to represent 16 signals, represented by the ten digits, the letters A to D, and the symbols # and *. As the signals are audible tones in the voice frequency range, they can be transmitted through electrical repeaters and amplifiers, and over radio and microwave links, thus eliminating the need for intermediate operators on long-distance circuits.
>
> The *, #, A, B, C and D keys are still widely used worldwide by amateur radio operators and commercial two-way radio systems for equipment control, repeater control, remote-base operations and some telephone communications systems."

They are created by playing two notes at the same time:

	1209 Hz	1336 Hz	1477 Hz	1633 Hz
697 Hz	**1**	**2**	**3**	**A**
770 Hz	**4**	**5**	**6**	**B**
852 Hz	**7**	**8**	**9**	**C**
941 Hz	*	**0**	#	**D**

Repeaters

5)



To extend the range of VHF and UHF communications, repeater stations are often used. These stations are special radios located on mountain tops that have high quality antennas up tall towers. They work by listening on one frequency (the input) and automatically re-transmitting what they hear on another frequency (the output). The

difference between the two frequencies is called the *offset*.

For example, to use VE7RXZ, individual radio stations need to transmit (TX) on 147.800 MHz (the repeater's input frequency) with a Tone of 100.0 Hz, but listen (RX) on 147.200 MHz (the repeater's output frequency).

In this case we'd say that the repeater frequency is:

> *147.200 MHz with a + offset of 600 kHz and a Tone of 100 Hz.*

So two radio stations communicating through a repeater are not actually hearing each other's signals directly. Instead, they're hearing the repeater's signal, which is usually stronger and goes further.

At first glance, it might look like operating through a repeater would be a lot of work (with this constant flipping back and forth between two frequencies), but once radios are programmed with the proper RX frequency and offset, they will switch frequencies automatically when the Push-to-Talk (PTT) is button is pressed.

Repeater Frequency Coordination

In the same way that simplex frequencies are specified, the same is true for repeater frequencies. For example, here's a sample of http://wp.rac.ca/144-mhz-2m-page/:



With the following note:

> "(10) Repeaters may include FM, ACSSB or digital modes of modulation. **Consult with your local coordination body for frequency and modulation scheme allocations**."

What this means is that while there is a general agreement on which frequencies should be used for repeaters, the coordination of which repeater should use which specific frequency is managed at a more local level. In BC, the British Columbia Amateur Radio Coordination Council is responsible for coordinating repeater frequencies. Their website also includes pdf lists of repeaters.[6] Other provincial Coordination Council can be found on the RAC website.

In general, though, radios sold in Canada come pre-programmed with the following repeater offset scheme:

VHF (offset = 600 kHz)[7]	**UHF (offset = 5 MHz)**[8]
145.100 – 145.500 MHz (-)	442.000 – 445.000 MHz (+)
146.610 – 146.970 MHz (-)	
147.000 – 147.390 MHz (+)	

- (-) means that the repeater's input is lower than its output and
- (+) means that the repeater's input is higher than its output.

Repeater Use

To call someone, we always say their call sign first, then our own. To answer a call is more flexible, but the rules[9] say that each station has to identify themselves in either English or French:

1. at the beginning of the conversation,
2. at least every 30 minutes during the conversation, and
3. at the end of the conversation.

Suppose that Graham, VE7ABC, wants to call Linda, VE7XYZ on a local VHF repeater.

- Graham would first tune in to the repeater's output frequency and wait a few seconds to make sure the repeater is not in use.
- When ready, Graham would then say: “VE7XYZ, VE7ABC”
- If Linda is there, she would reply something like: “VE7ABC, this is VE7XYZ. Go ahead Graham.”

During their conversation, Linda and Graham should keep each transmission short and leave about half a second between them to allow others to break in. Some repeaters have a courtesy tone (or Roger beep) after each transmission to help operators slow down. Most also have a time-out timer to interrupt lengthy transmissions without pause. That way, if someone wants to join in, all they'd have to do is say their call sign between transmissions and wait to be called.

So when Linda and Graham are done, they could close with something like this:

- “Ok Linda, talk to you later. VE7ABC clear on your final.”
- “Very good Graham. 73. VE7XYZ clear.

The rules on station identification are very important. The only time a station is allowed to transmit without identification is to remote control a model craft. Even repeaters have to identify themselves (usually in morse code, but not always).

The procedure to send a general call varies a bit depending on whether we are using a repeater or calling in simplex:

In simplex, we use the code “CQ”. So if Graham wanted to talk with anyone, and Linda replied, the exchange would look like this:

- “CQ CQ CQ, this is VE7ABC, VE7ABC, VE7ABC”
- “VE7ABC, this is VE7XYZ.”

On repeaters, we usually simply state our callsign:

- This is VE7ABC listening.

Of course, all call signs should be given in phonetic, especially when sending and replying to a CQ call since the two operators may not know each other.

Repeater Etiquette

Since repeaters extend the coverage of VHF/UHF transmissions, they also extend the number of operators monitoring or potentially needing to use a given frequency. As such, the following etiquette should be followed:

- Keep transmissions short.
- Give enough time between transmissions for others to break in.
- Move to a simplex frequency whenever possible.

To know if it's possible for you to communicate with someone in simplex, you can listen on the repeater's input when the other station is transmitting. If you can hear their direct signal well, then you can reach them in simplex. When choosing a simplex frequency, remember to use one of the 13 dedicated frequencies otherwise you could fall on the input of another repeater, or between two pre-determined channels.

Questions

- B-001-013-002 → B-001-013-010
- B-001-017-001 → B-001-018-001
- B-002-001-001 → B-002-001-011
- B-002-003-001 → B-002-003-008
- B-002-004-001 → B-002-004-002
- B-002-004-010

1)
Technically, simplex refers to “a communication channel that sends information in one direction only.” However, “the International Telecommunication Union definition is a communications channel that operates in one direction at a time, but that may be reversible; this is termed half duplex in other contexts.” Simplex_communication
2)
Picture from: Duplex_(telecommunications)#Full-duplex
3)
Picture from: Duplex_(telecommunications)#Half_duplex
4)
See RBR-4 Sec. 10
5)
Picture modified from Repeater
6)
Another good place to find repeater frequencies is http://repeaterbook.com. They also have a phone app that's very convinient
7)
See http://wp.rac.ca/144-mhz-2m-page/
8)
See http://wp.rac.ca/432-mhz-70-cm-page/
9)
See RBR-3, p.1 and RBR-4, Sec 9