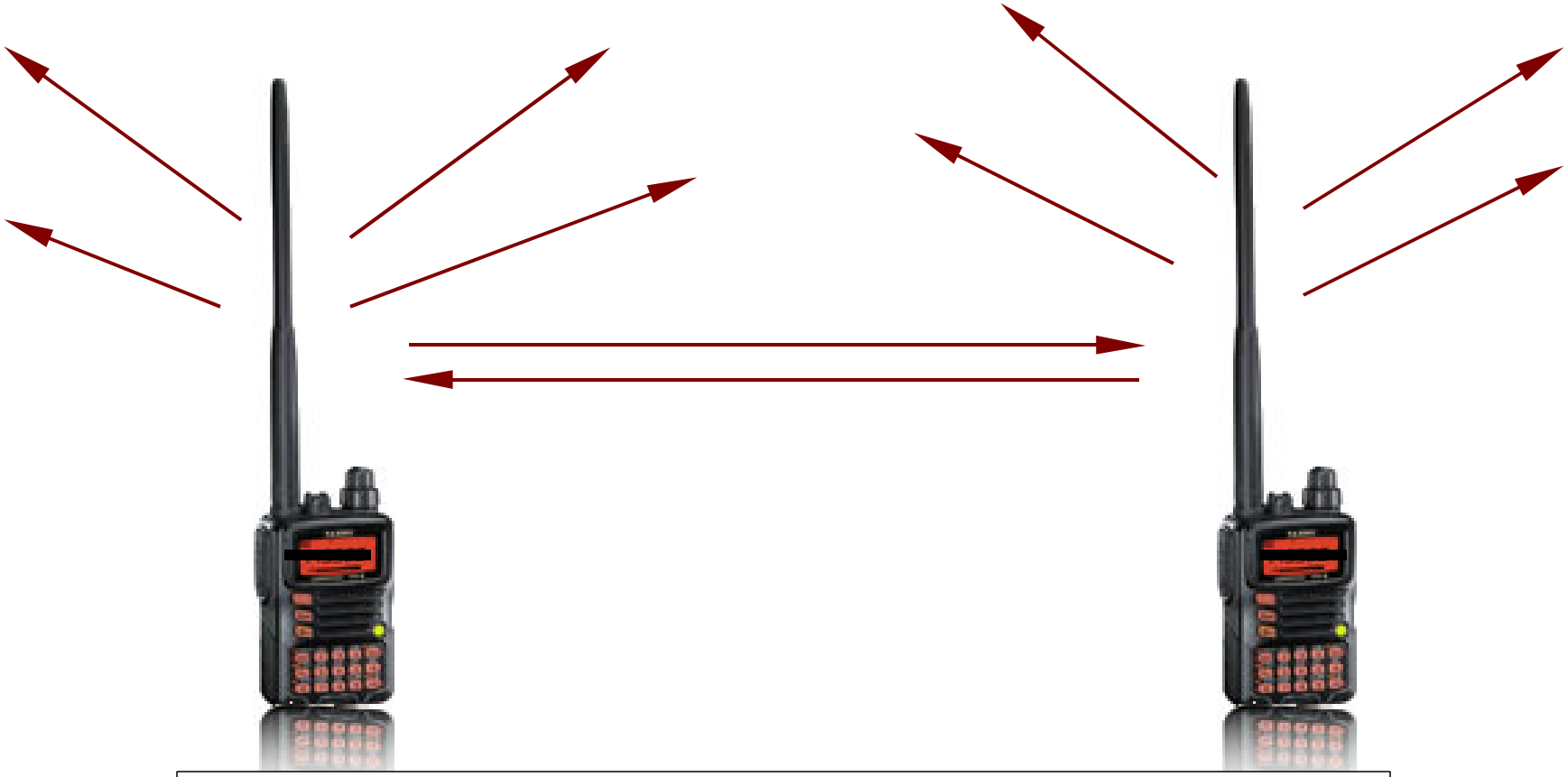
Repeater Basics/Refresher

Presented to the
Stamford Amateur Radio Association

by

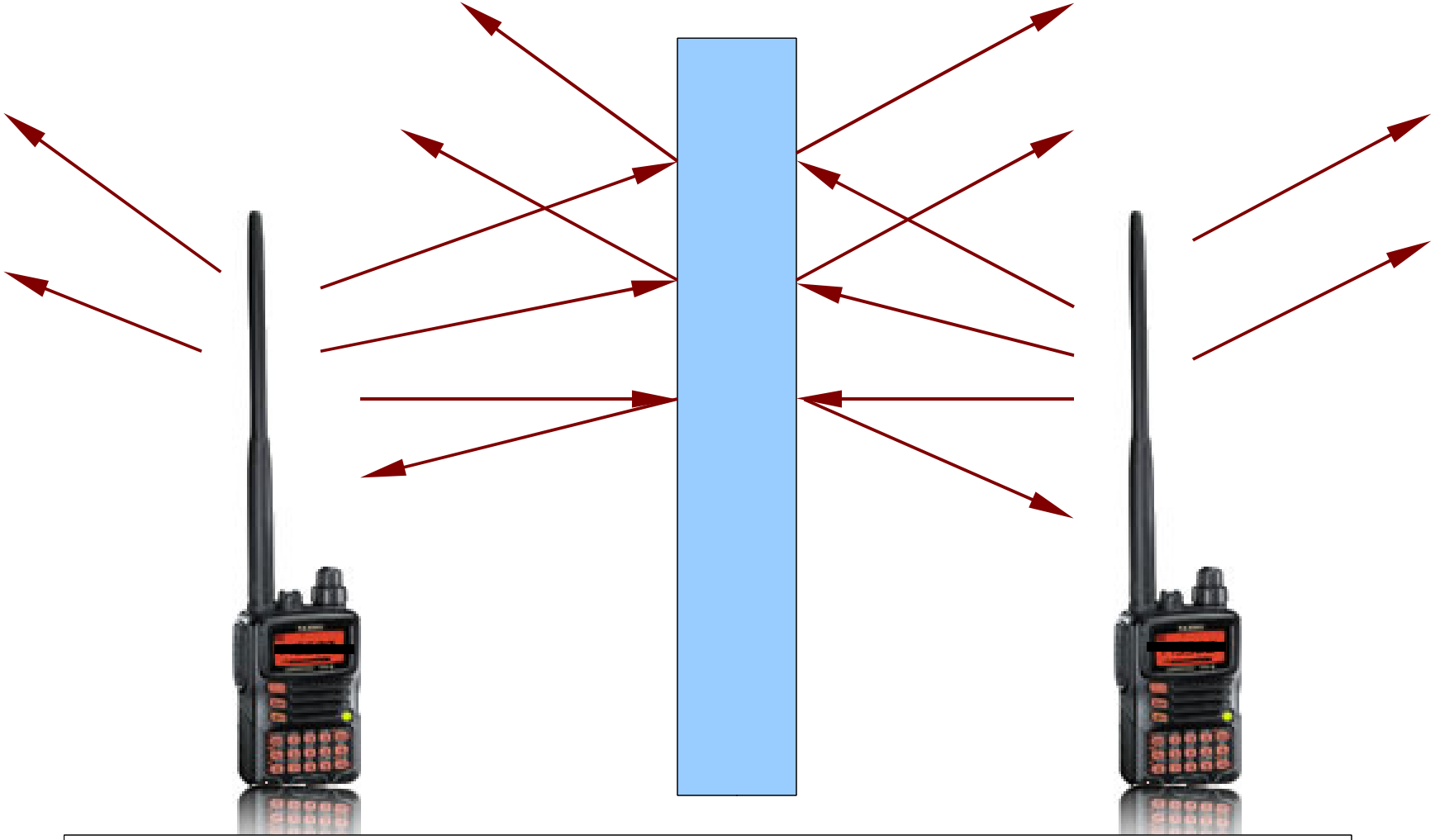
Jon Perelstein

The signal from the transmitter has to get to the receiver



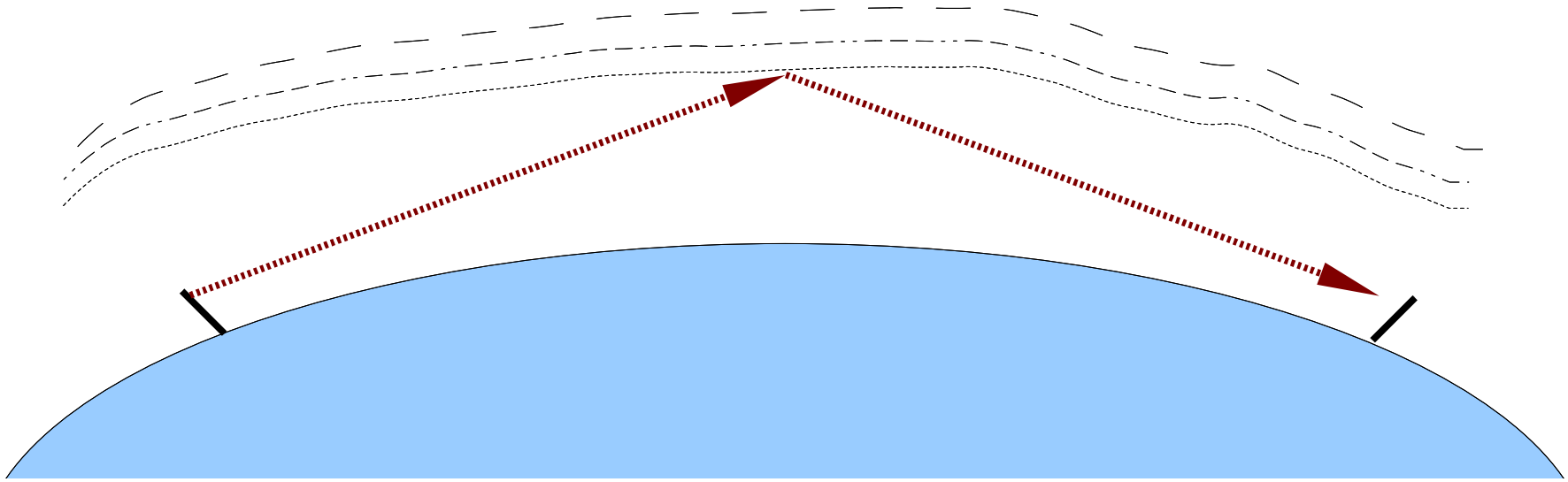
But radio waves mostly travel in straight lines

For the most part, radio waves cannot go around things



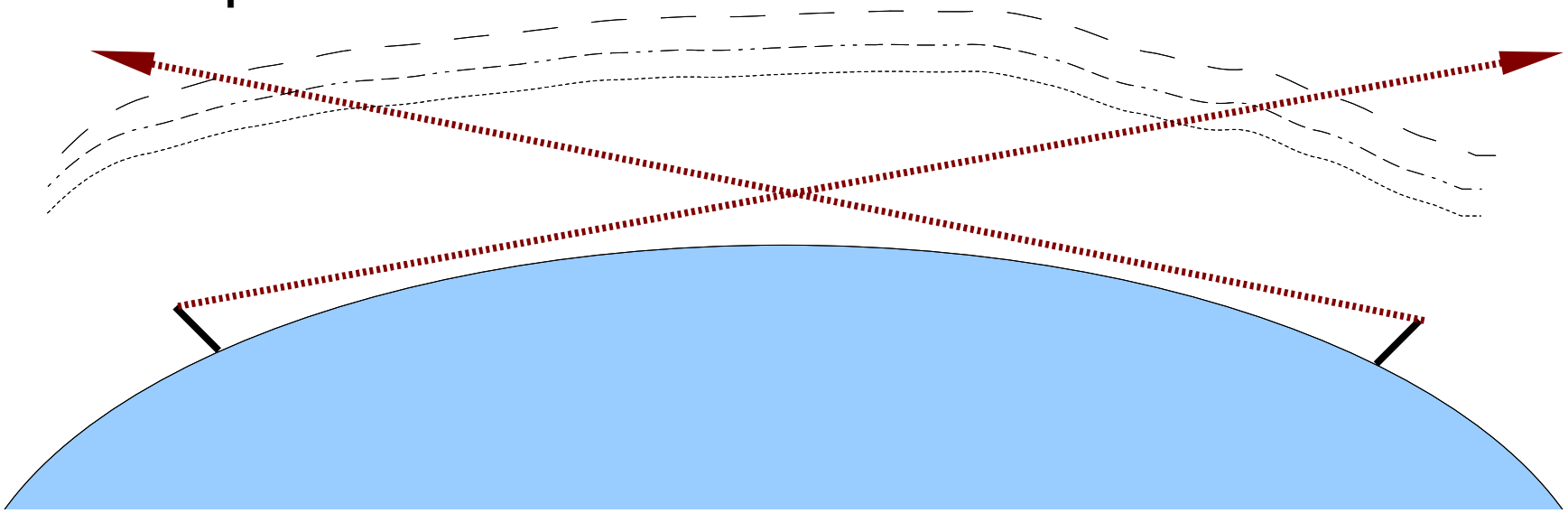
Hills, mountains, and even man-made structures like buildings can block the signal

HF will bounce off the upper layers of the atmosphere ...



HF is “High Frequency” – amateur bands:
160 meters (1.8MHz – 2.0MHz)
80/75 meters (3.5MHz – 4.0MHz)
60 meters (5.3MHz – 5.4Mhz)
40 meters (7.0MHz – 7.3MHz)
30 meters (10.10MHz – 10.15MHz)
20 meters (14.00MHz – 14.35MHz)
17 meters (18.068MHz – 18.168MHz)
15 meters (21.00MHz – 21.45MHz)
12 meters (24.89MHz – 29.99MHz)
10 meters (28.0MHz - 29.7MHz)

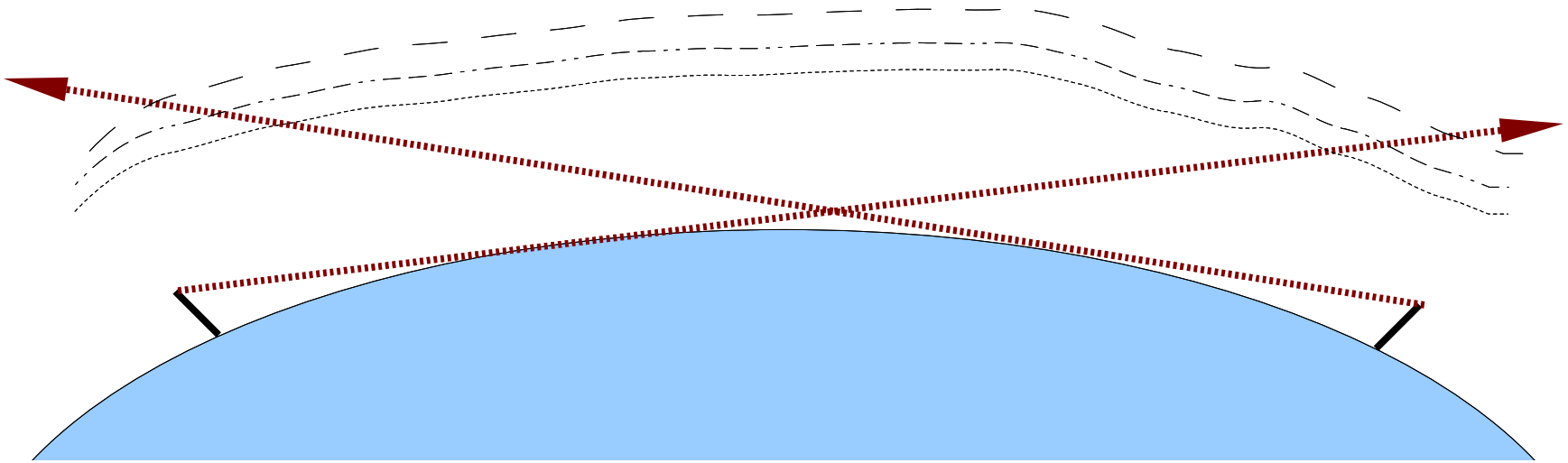
… but VHF and UHF and higher frequencies generally do NOT bounce off the atmosphere ...



VHF is “Very High Frequency” – amateur bands:
6 meters (50.0MHz – 54.0MHz)
2 meters (144.0MHz – 148.0MHz)
1.25 meters (219.0MHz – 225.0MHz)

UHF is “Ultra High Frequencies” – amateur bands:
70 centimeters (420MHz – 450MHz)
33 centimeters (902MHz – 928MHz)
23 centimeters (1240MHz - 1300MHz)

… thus, VHF/UHF is generally considered “line of sight” communications

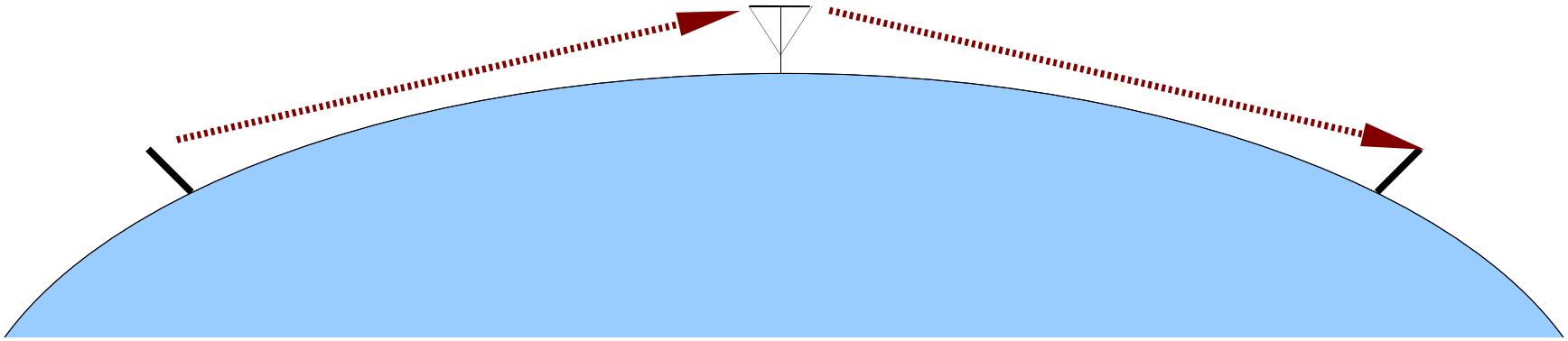


With all the hills here in southwestern Fairfield County CT, consider yourself lucky if you can get:

- **5-6 miles from one hand-held to another**
- **12-18 miles from one good roof-mounted antenna to another**

On occasion, atmospheric conditions will allow VHF signals to bounce, but not often and not for very long

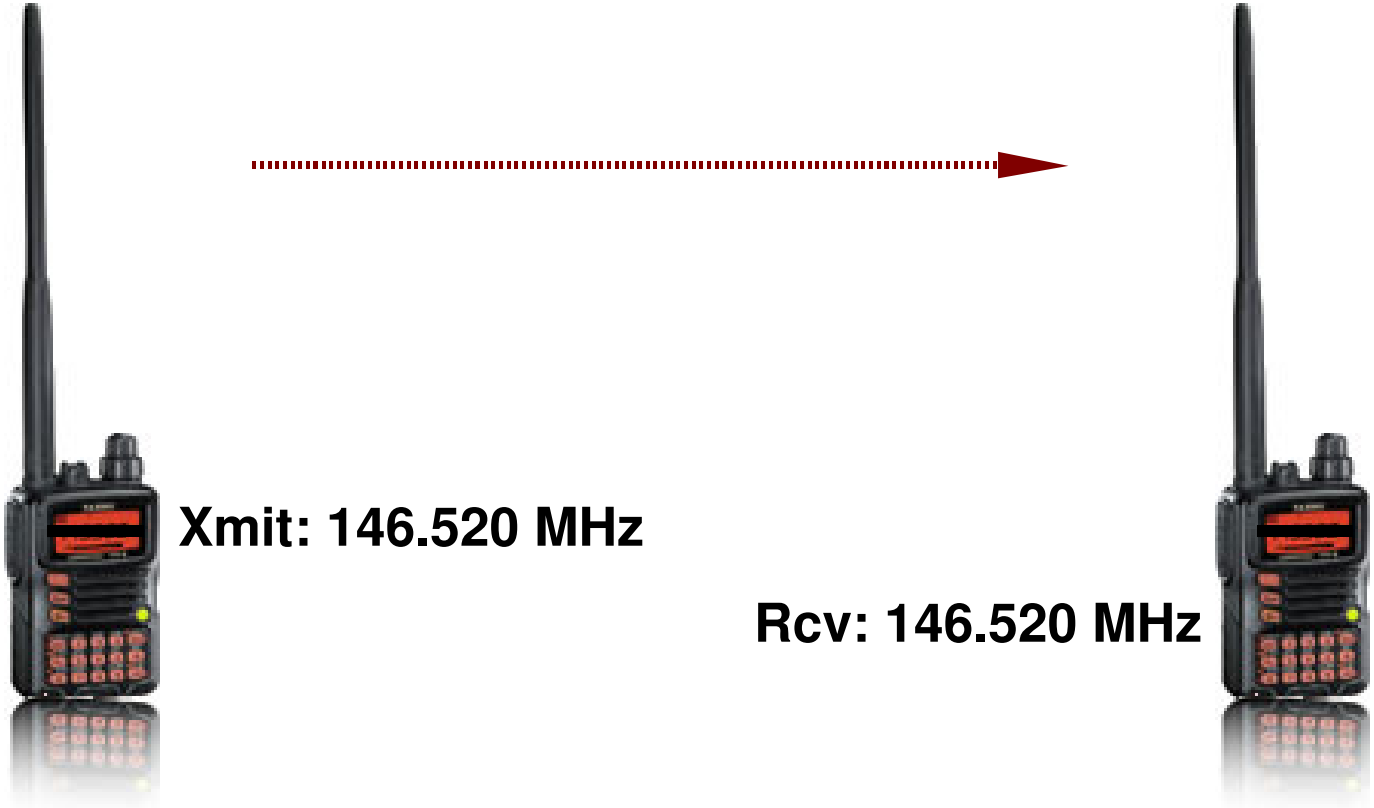
We use repeaters to get more range



The repeater REPEATS your signal so that it can go further

Plus, most repeaters have their antennas mounted up high so that they naturally have cover more land

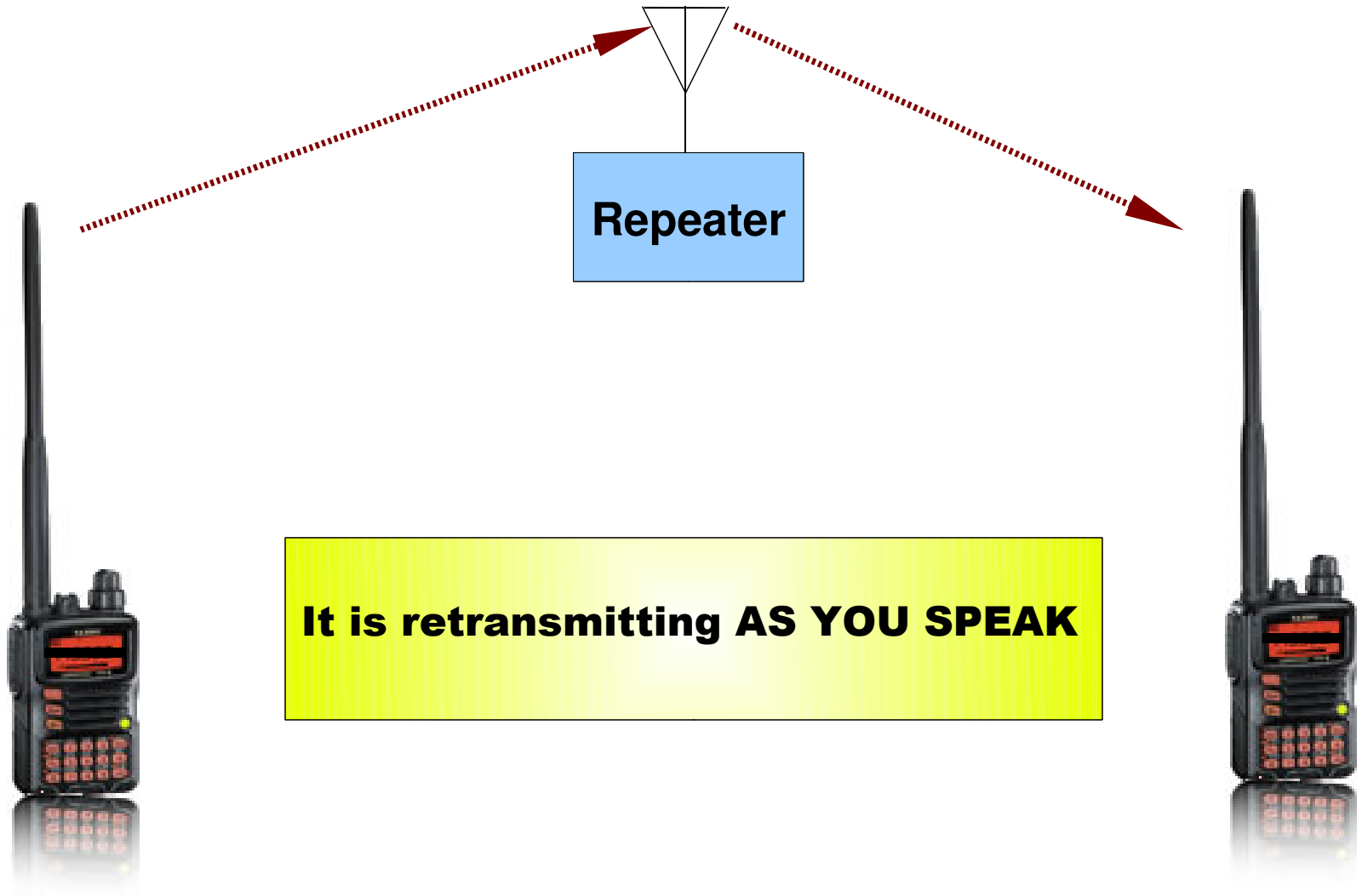
To understand repeater operations, let's start with basic simplex operation



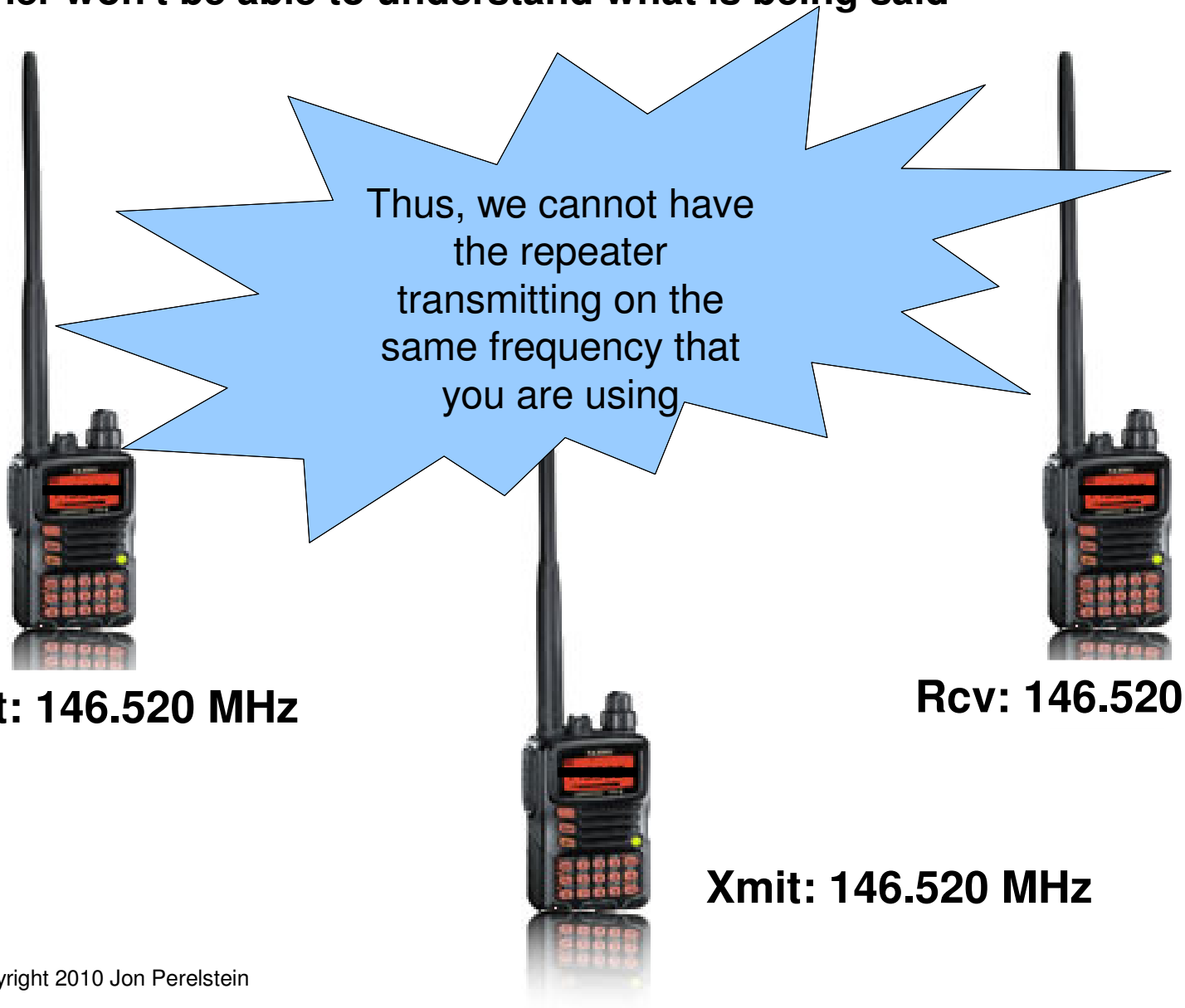
Simplex – both radios are transmitting and receiving on the same frequency.

When you are transmitting, the other radio is listening.
When the other radio is transmitting, you are listening.

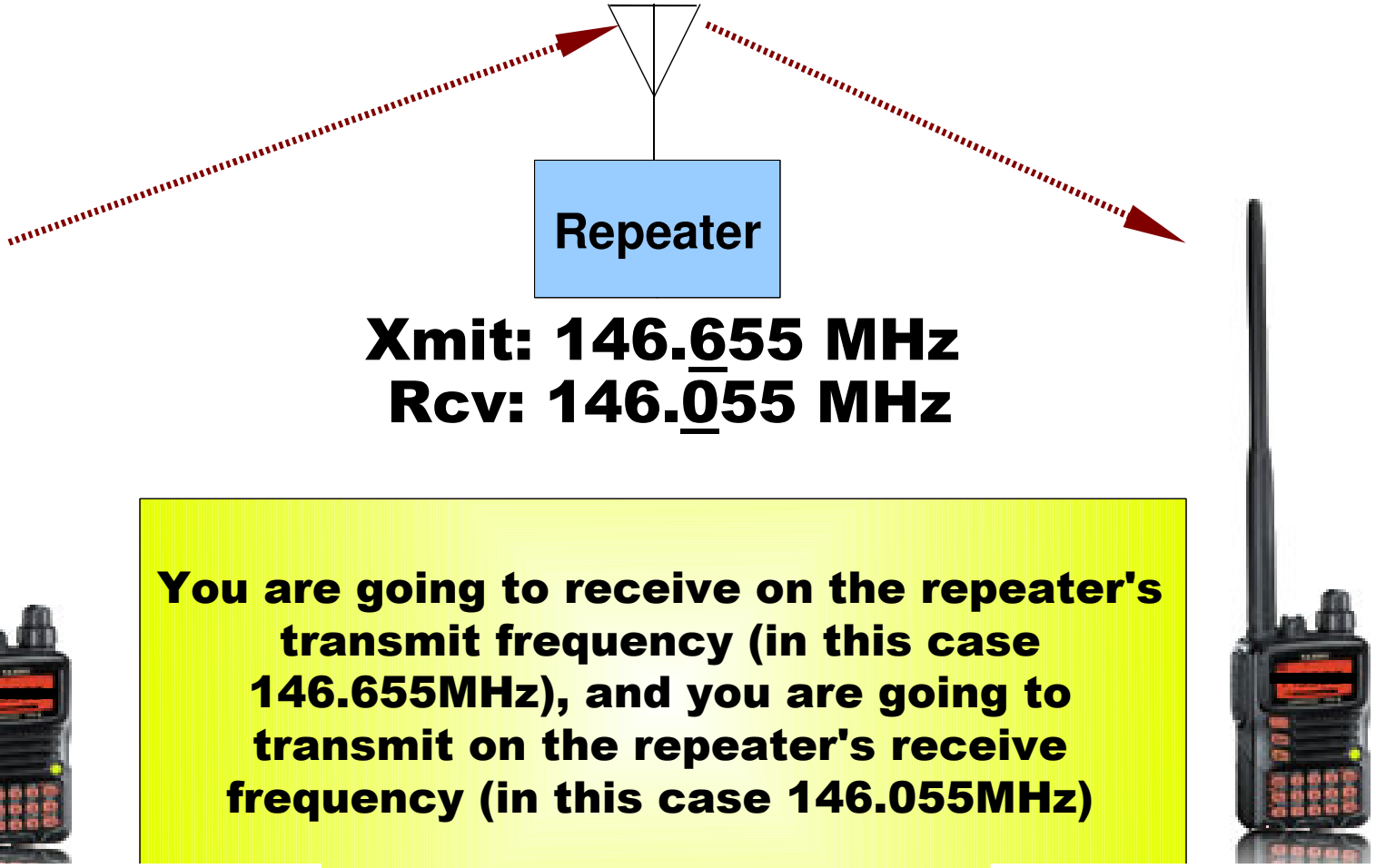
The repeater is going to listen to your signal and retransmit it



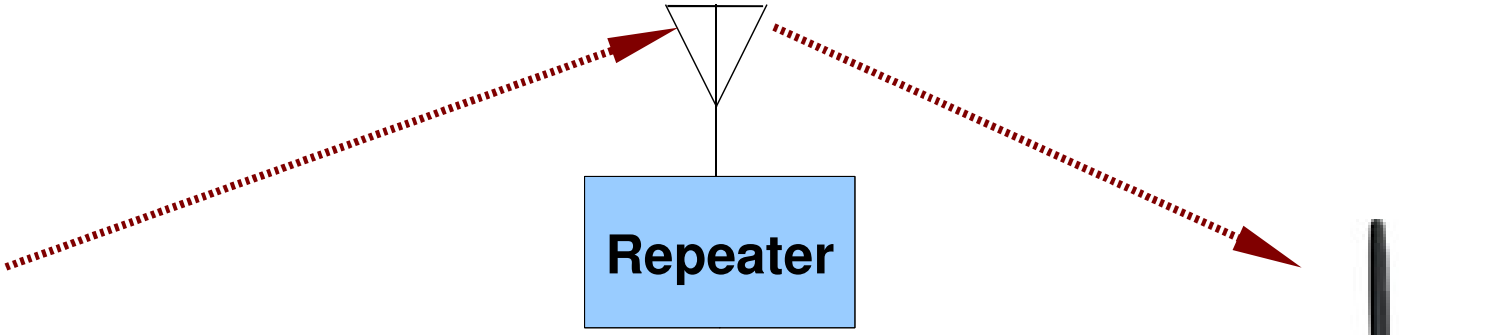
But there is a problem – if two radios are transmitting on the same frequency at the same time they will interfere with each other and the listener won't be able to understand what is being said



The sender (you) and the repeater each have to transmit on a different frequency



The difference in frequency between the sender and the repeater is called the SHIFT (or offset)



Xmit: 146.655 MHz
Rcv: 146.055 MHz

In this case, the amount of shift is 0.6MHz (600KHz)

Xmit 146.055MHz
Rcv 146.655Mhz

Xmit 146.055MHz
Rcv 146.655Mhz

The DIRECTION of the shift tells you if you are transmitting at a lower frequency than you receive (-) or higher frequency than you receive (+)

Xmit 146.055MHz
Rcv 146.655Mhz

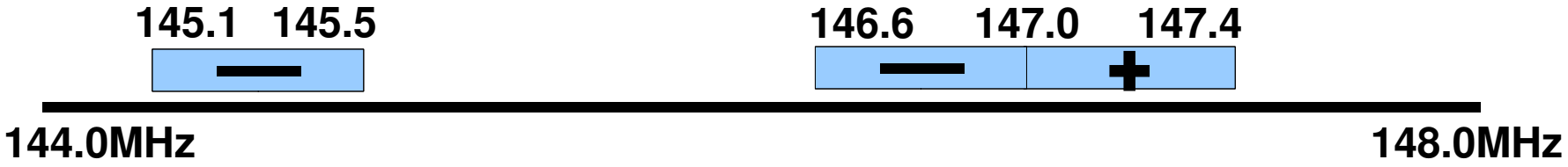
In this case, you are transmitting at a lower frequency than you receive, so it is (-) shift

Xmit 147.455MHz
Rcv 146.475Mhz

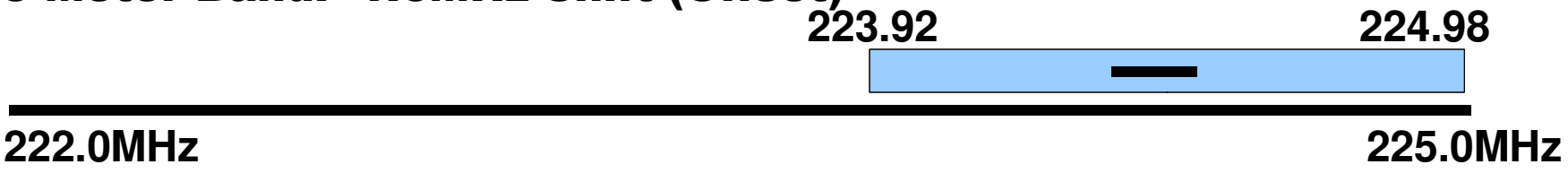
In this case, you are transmitting at a higher frequency than you receive, so it is (+) shift

The amount of repeater shift and direction of repeater shift is a voluntary standard in the United States

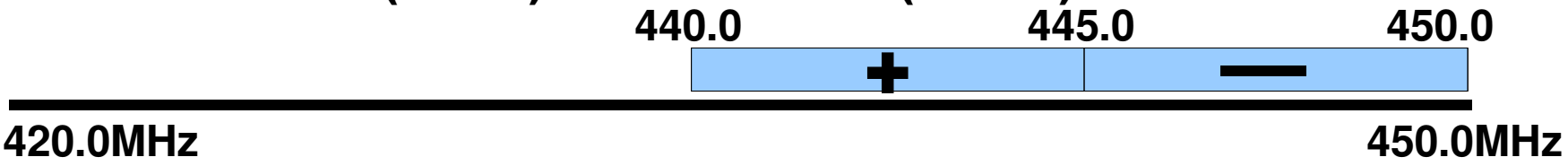
2 Meter Band: 0.6MHz Shift (Offset)



1.25 Meter Band: 1.6MHz Shift (Offset)

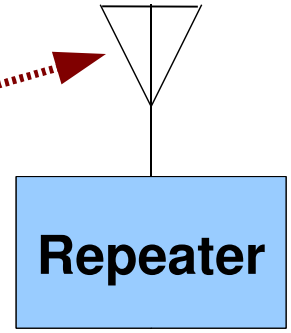


0.70 Meter Band (70cm): 5.0MHz Shift (Offset)



In the U.S., these standards are voluntary. Most repeaters follow these standards but not all (e.g., Norwalk). Most VHF/UHF radios sold in the U.S. automatically apply these offsets (Automatic Repeater Shift or ARS).

PL© tones are sub-audible tones used to prevent the repeater from responding to signals that are not meant to be repeated (e.g., static and interference)



Xmit: 146.655 MHz
Rcv: 146.055 MHz
PL: 100

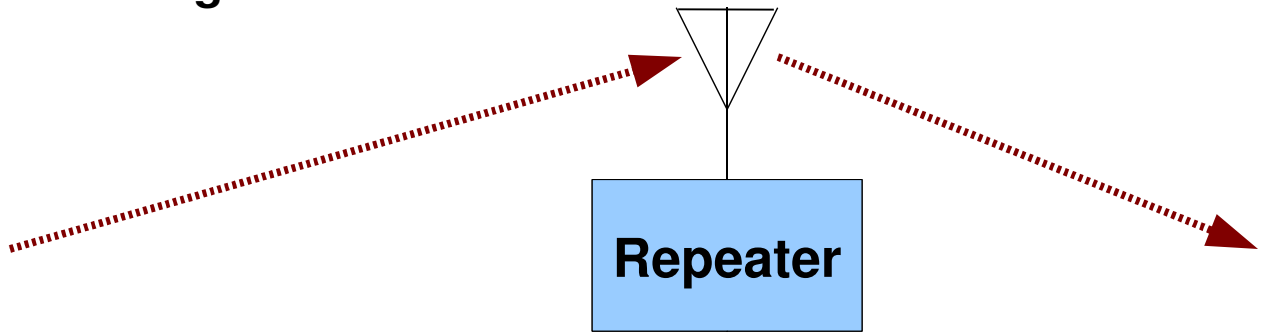
PL stands for Private Line and is a copyright of Motorola. More correctly, it is called CTCSS (Continuous Tone-Coded Squelch System)

Xmit: 146.055 MHz
Rcv: 146.655MHz
PL: Not 100

Xmit: 146.055 MHz
Rcv: 146.655MHz

Since the transmitting station is NOT sending the correct PL code, the repeater does not repeat the signal

When the transmitting station sends the correct PL code, the repeater repeats the signal



Xmit: 146.655 MHz
Rcv: 146.055 MHz
PL: 100

Rcv: 146.655MHz
Xmit: 146.055 MHz
PL: 100

This is called "TONE" CTCSS

It only determines whether or not the repeater will repeat the signal. It has no impact on the receiver's ability to receive a signal

Rcv: 146.655MHz
Xmit: 146.055 MHz
PL: 100

There are different types of PL

- **TONE mode (sometimes referred to as CODE or just CTCSS) is the most common. Remember, it is an inbound tone *to the repeater***
  - **There are 50 commonly used frequencies:**

CTCSS Tone Frequencies (Hz)

67.0	69.3	71.9	74.4	77.0	79.7	82.5
85.4	88.5	91.5	94.8	97.4	100.0	103.5
107.2	110.9	114.8	118.8	123.0	127.3	131.8
136.5	141.3	146.2	151.4	156.7	159.8	162.2
165.5	167.9	171.3	173.8	177.3	179.9	186.2
183.5	189.9	192.8	196.6	199.5	203.5	206.5
210.7	218.1	225.7	229.1	233.6	241.8	250.3
254.1						

- **TONE SQUELCH mode (usually called TSQL) adds a PL tone outbound *from the repeater*. You can set your radio so that the radio does not break squelch until it hears that outbound tone**
  - **Note that the repeater still needs the inbound tone before it will retransmit your signal**
  - **The inbound and outbound tones may be different**
- **DCS mode (Digital Tone Squelch) uses digital signals instead of a tone to do the same things**
  - **DCS is new and not used much around here**

Review: What you need to access a repeater

- **The repeater's FREQUENCY.**
  - **This is the frequency on which the repeater transmits**
  - **It is the frequency on which you listen with your radio**
- **The repeater's SHIFT (sometimes called OFFSET)**
  - **The difference in frequency between what you receive and what you transmit**
- **The repeater's SHIFT DIRECTION**
  - **Positive (+) means you will be transmitting on a frequency that is higher than the one on which you listen**
  - **Negative (-) means you will be transmitting on a frequency that is lower than the one on which you listen**
- **The repeater's PL (CTCSS) tone frequency and mode (TONE or DCS)**

How you set your radio to use a repeater is different for each different radio vendor AND is often different between different radios from the same vendor

An example: Stamford Connecticut 2 meter repeater W1EE

146.655- PL100

- You will tune your radio to 146.655 and listen on that frequency.
- The direction of shift (offset) is NEGATIVE (-).
  - You will be transmitting at a lower frequency than you receive.
- Since the amount of shift is not given, this repeater uses the standard for this band.
  - The standard for the 2 meter band is 0.6MHz (600KHz).
  - That means that you will be transmitting at 146.055MHz
- The PL (CTCSS) is 100
  - Since nothing is mentioned about DCS, you can assume that this is a simple TONE CTCSS

Another example: Stamford Connecticut 70 CM repeater W1EE

The repeater's web site lists the repeater as:
447.125 Out 442.125 In PL-114.8Hz

- **The repeater's FREQUENCY is 447.125MHz.**
  - **You will be tuning your radio to that frequency.**
- **In this case, instead of giving you the direction and amount of shift, they gave you the input and output frequencies. Since your radio will want amount and direction shift, you have to do the math**

  The repeater transmits on: 447.125MHz (you receive)
  The repeater receives on: - 442.125MHz (you transmit)
  5.000MHz

  - **The shift amount is 5.000MHz**
  - **Since you transmit on a lower frequency than you receive, the direction of shift (offset) is NEGATIVE (-).**
- **The PL (CTCSS) is 114.8.**
  - **Since nothing is mentioned about DCS, you can assume that this is a simple TONE CTCSS.**

The - between the letters “PL” and the PL frequency (114.8) is just a dash, it doesn't tell you anything about shift direction

An example: Norwalk Connecticut 2 meter repeater W1NLK

The repeater's web site lists the repeater as:
146.475 (+ 1 MHz Split) PL 100.0

- The repeater's transmit FREQUENCY is 146.475MHz.
  - You will be tuning your radio to that frequency.
- The direction of shift is POSITIVE (+).
  - You will be transmitting at a higher frequency than you receive.
- This repeater uses a non-standard shift for this band of 1.0MHz.
  - The standard for the 2 meter band is 0.6MHz.
  - That means that you will be transmitting at 147.475MHz
- The PL (CTCSS) is 100
  - Since nothing is mentioned about DCS, you can assume that this is a simple TONE CTCSS.

There are various sources for getting the information about a repeater

- **Ask local hams**
- **Look for the website of the club that runs the repeater**
  - **e.g., the Stamford CT club is the Stamford Amateur Radio Association (SARA) and the website is www.ctsara.org**
  - **e.g., the Norwalk CT club is Greater Norwalk Amateur Radio Club (GNARC) and the website is www.gnarc.org**
  - **Many club websites will have info about other repeaters in their state or local area**
- **ARTSCI Publications publishes a repeater directory and has an online site at www.artscipub.com/repeaters/**
  - **Basic information free (e.g., you have to know where the repeater is located by city name**
  - **Advanced lookup requires a subscription (e.g., a map showing all the repeaters in a state)**
- **ARRL publishes the ARRL Repeater Directory**
- **Other local websites such as**
  - **New England Repeater Directory at www.nerepeaters.com**

Five general steps to tuning in a repeater

1. **Select the BAND and RECEIVE frequency**

2. **Set the SHIFT (offset) DIRECTION (if non-standard for the sub-band)**

3. **Set the SHIFT (offset) AMOUNT (if non-standard for the band)**

4. **Activate the TONE or DCS**

5. **Select the TONE FREQUENCY or DCS CODE**

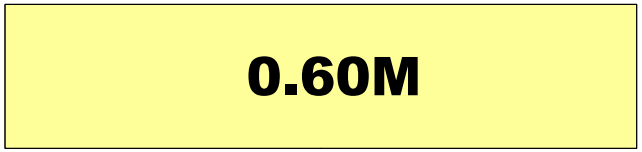
Tuning the typical Yaesu HT for the Stamford CT 2 meter repeater

146.655- PL100

1. Tune the radio to the 2 meter band, then tune it to 146.655

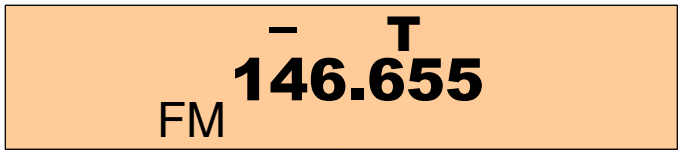
2. Since this is a standard shift direction, the radio should set it automatically. If it doesn't, set the shift direction using “RPT” function

3. Since this is a standard shift amount, the radio should set it automatically. If it doesn't, set the shift amount using the “SHIFT” function



4. Activate the tone by using the “SQL TYPE” function

5. Set the tone frequency by using the “TN FRQ” function

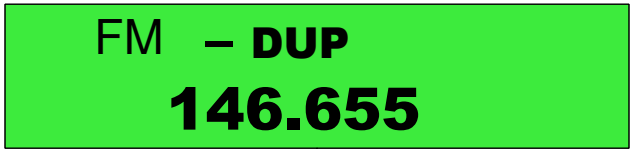


Tuning the typical Icom HT

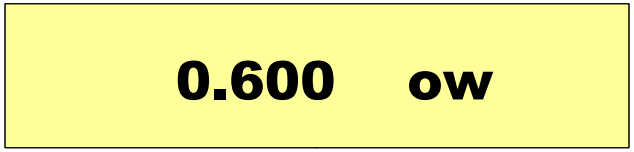
146.655- PL100

1. Tune the radio to the 2 meter band, then tune it to 146.655

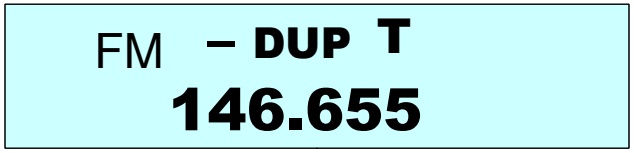
2. Since this is a standard shift direction, the radio should set it automatically. If it doesn't, set the shift direction by repeatedly pressing the "DUP" button to get a - DUP



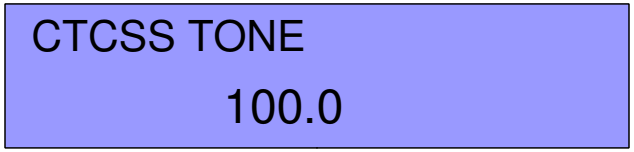
3. Since this is a standard shift amount, the radio should set it automatically. If it doesn't, set it by using the menu "OFFSET" function to set 0.600M

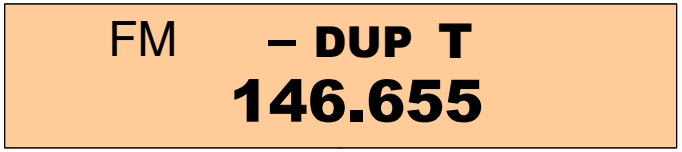


4. Activate the tone by repeatedly pressing the TONE button to set T



5. Set the tone frequency using the "DUP/TONE" function to set 100.0

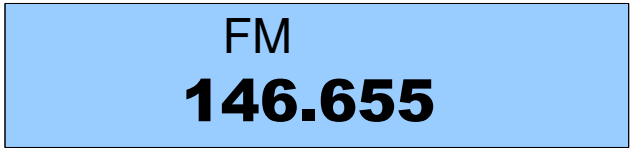




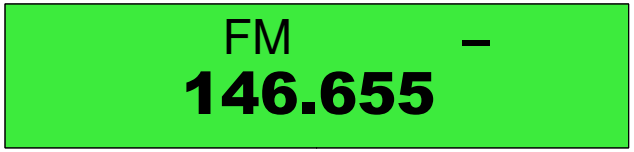
Tuning the typical Kenwood HT

146.655- PL100

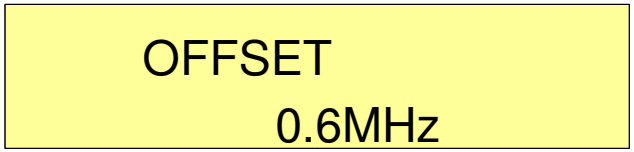
1. Tune the radio to the 2 meter band, then tune it to 146.655



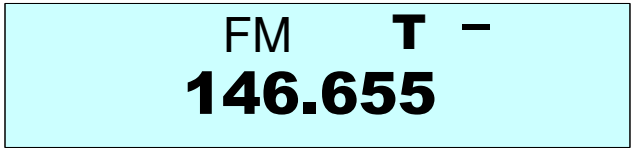
2. Since this is a standard shift direction, the radio should set it automatically. If it doesn't, set the shift direction using the “[F]/[REV]” to –



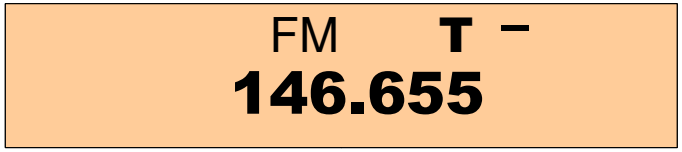
3. Since this is a standard shift amount, the radio should set it automatically. If it doesn't, set the shift amount using the menu “OFFSET” function



4. Activate the tone using “TONE” to set T



5. Set the tone frequency using “TONE, [F], [TONE]” to set 100.0HZ



WHEW, THAT'S A LOT OF WORK!!

Can you imagine doing all that every time you want to tune in a repeater?

Most HTs and Mobile rigs have MEMORIES so that we can save settings

- **Store**

Frequency (receive)
Offset/shift direction
Offset/shift amount

Tone Activation
Tone (PL)
Power Setting

Name/Tag
Other?

Memory Location	1	2	3
Receive Frequency	**146.655**	**447.125**	**146.475**
Shift Direction	**Negative**	**Negative**	**Plus**
Shift Amount	**0.6MHz**	**5.0MHz**	**1.0MHz**
CTCSS (tone activation)	**Tone**	**Tone**	**Tone**
PL Frequency	**100.0**	**114.8**	**100.0**
Power	**High**	**High**	**High**
Name/Tag	**STM 146**	**STM 447**	**NWK 146**

To save things to memory, you use the VFO mode

VFO mode is where you tune using the tuning dial and/or the keypad

- **In VFO mode, you can tune to anything the radio is capable of**

1. **Set the information in VFO mode**
   - **Set the repeater frequency, offset/shift direction, offset/shift amount, tone activation, tone frequency, power setting.**
2. **SAVE the information into a specific memory location.**
   - **Typical Yaesu: Press Memory Write key for one second, select the location you want, press the Memory Write key again**
   - **Typical Icom: Press the Memory Mode key to go into Memory Mode, press the Memory Write key for one second, select the location you want, press the VFO key**
3. **If the radio provides the capability, give the memory location a name (sometimes called "tag") to help you remember what is stored in that location)**
   - **For most people, remembering that FALMTH2 is the Falmouth 2 meter repeater is easier than remembering that 146.655 with a PL of 114 is the Falmouth 2 meter repeater and not the Stamford 2 meter repeater.**

To recall things from memory, you use Memory mode

- **Memory mode is where you select which specific memory location you want to use**
  - **Usually have a button on the radio that switches between VFO and Memory mode**
  - **e.g., on Yaesu, the V/M button**
  - **e.g., on Yaesu, the VFO button vs. the MR button**
- **Once in Memory mode, select the memory location that has the information you want.**
- **Start talking (or at least start listening).**
- **Some radios have complex memories in which you can set up different memory banks, such as**
  - **Local CT repeaters**
  - **Westchester repeaters**
  - **NYC repeaters**

Think of VFO mode as the tuning dial on your car radio, and think of Memory mode as the pre-sets on your car radio

A few words on repeater protocol

- **Rule 1: Listen before you transmit**
  Listen before you transmit
  Listen before you transmit.

- **A general call on a repeater is usually short and simple.**
  - **e.g., "KB1QBZ listening on the Stamford 2 meter repeater"**
  - **A long CQ, repeated over and over, is not needed because people are either listening on that repeater or not**
- **When you put out a general call, specify which repeater you're on – some people listen to a couple of different repeaters at the same time.**
- **When you put out a general call, wait a minute for an answer – it may take someone a minute or so to respond to you.**
- **When you're transmitting, wait a second between pushing your PTT and speaking because it takes a second for the repeater to be ready to transmit.**
  - **Otherwise your first word will be cut off**

And a few more words

- **Most repeaters provide a "courtesy tone" (some sort of beep or other sound) after the current user's carrier drops (i.e., they've released their PTT) – this indicates that it's okay for someone else to talk.**
- **Most repeaters "time out" after 3-5 minutes of continual transmission**
  - **Keep your transmissions shorter than that.**
- **It is generally considered acceptable to join conversations already underway**
  - **Give your call sign once quickly after the courtesy tone and then release your PTT**
- **If you're in a QSO and someone attempts to join, it is considered polite to acknowledge them**
  - **It is even more polite to quickly check with them to make sure that they don't have an emergency**
- **Repeaters are often used for public service events.**
  - **Do not interfere when it is being used for this purpose.**