

PROPAGATION

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PROPAGATION

PROPAGATE = TO SCATTER ABOUT
Physics: To move through a medium.

What is it that we want to Propagate?

Answer = Radio Waves

What is a “Radio Wave?”

**An “Electromagnetic Wave” near
the bottom of the Electromagnetic
spectrum**

The name “Electromagnetic Wave” gives us a clue to what it is.

Electro refers to an Electric Field.

You can create an Electric Field by taking two metal plates, close together but not touching. Connect a battery to these two plates and in the space between the plates is an electric field.

Magnetic refers to a Magnetic Field

A simple permanent magnet generates a magnetic field in it's vicinity.

BUT!

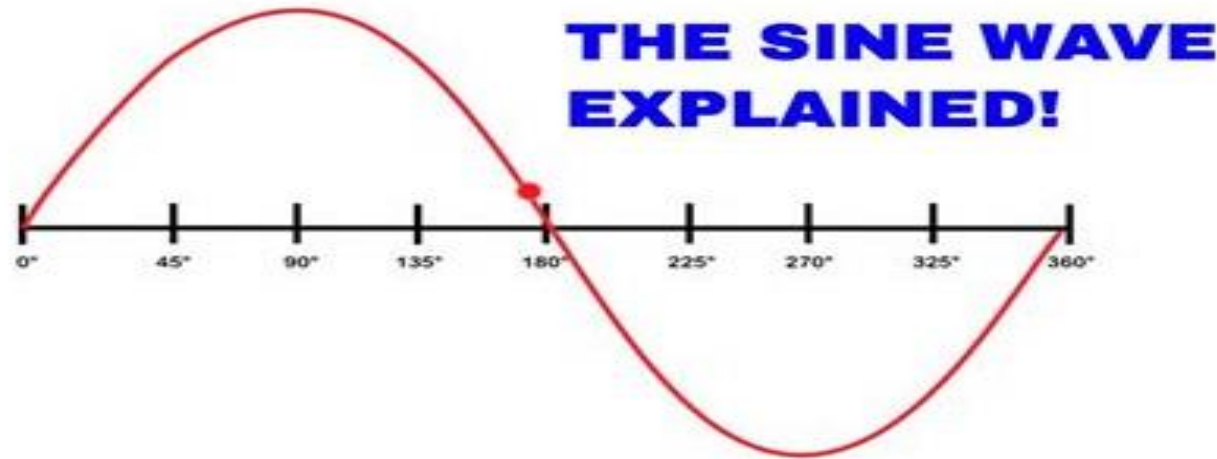
These are static or unchanging fields. That is not what will be discussed tonight

THE FIELDS WE ARE INTERESTED IN ARE CHANGING VERY RAPIDLY

**THEY INCREASE IN ONE POLARITY, DECREASE TO ZERO AND
THEN INCREASE IN THE OPPOSITE POLARITY.**

**THE WAY THEY CHANGE IS NORMALLY REFERRED TO
AS A SIN WAVE.**

AS OBSERVED ON AN OSCILLOSCOPE THEY LOOK LIKE:



THE VERTICAL AXIS IS AMPLITUDE AND THE HORIZONTAL AXIS IS TIME.

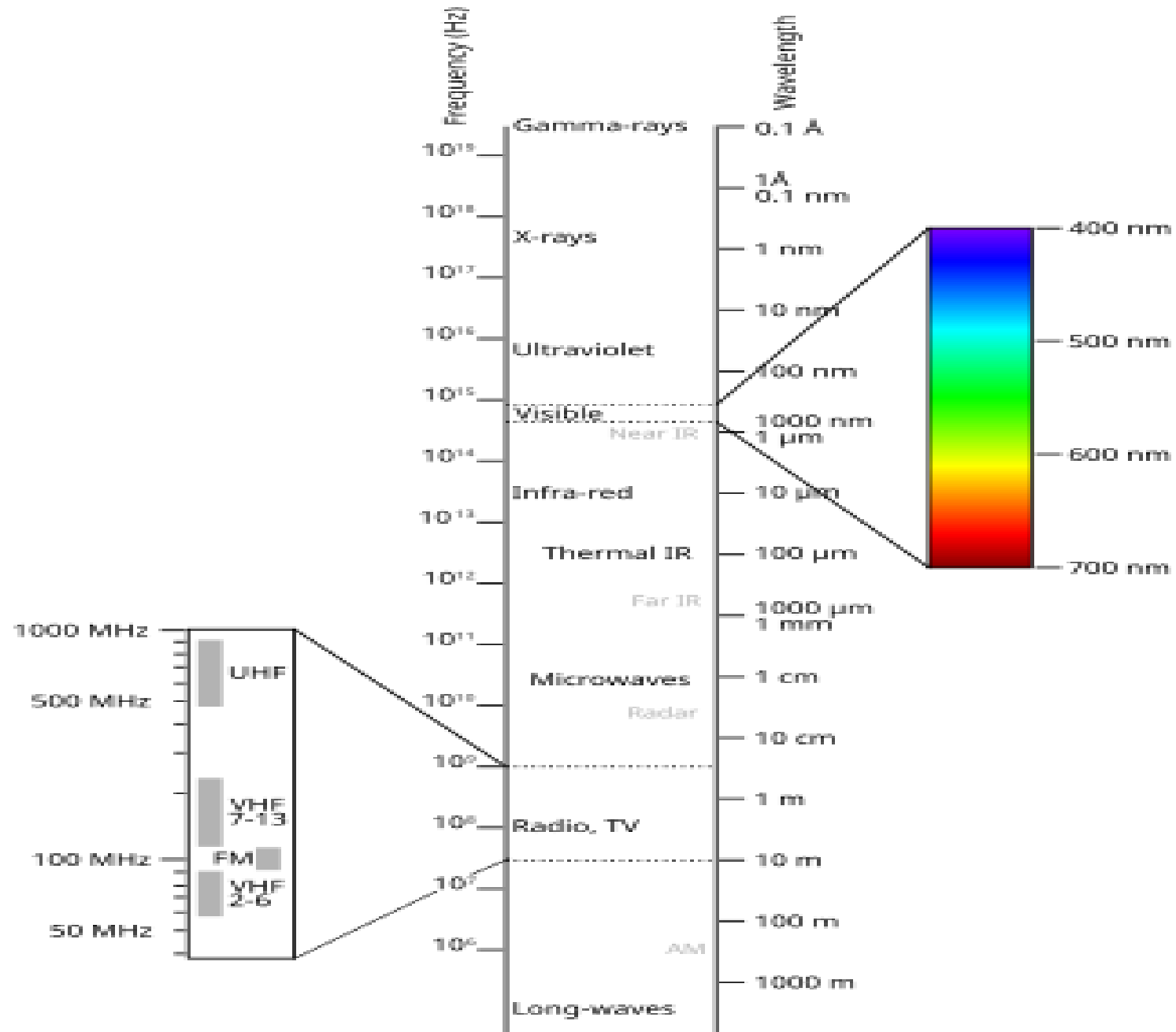
HOW MANY TIMES THIS WAVE REPEATS IN ONE SECOND WE CALL “FREQUENCY”

**THE LENGTH OF THIS WAVE IS CALLED “WAVE LENGTH”.
WAVE LENGTH IS TYPICALLY LISTED IN METERS.
ONE METER IS APPROXIMATELY 39.37 INCHES.**

**NOW, IF THE FREQUENCY IS RAISED TO A CERTAIN LEVEL THAT IS
WHEN **THE MAGIC HAPPENS!**
(AKA RADIATION)**

**THE RF SIGNAL SENT TO YOUR ANTENNA WILL BE RADIATED INTO SPACE
IN THE FORM OF AN ELECTROMAGNETIC WAVE COMPRISED OF ELECTRIC AND
MAGNETIC FIELDS.**

**NOW THAT WE HAVE COVERED WHAT AN RF OR ELECTROMAGNETIC WAVE IS,
LET'S TAKE A LOOK AT THE ELECTROMAGNETIC SPECTRUM.**



**THERE IS ONE MORE THING ABOUT RADIO WAVES
TO COVER BEFORE GETTING INTO PROPAGATION**

HOW FAST DOES A RADIO WAY GO?

REALLY FAST!

**IT GOES THE SAME SPEED AS
ALL ELECTROMAGNETIC WAVES**

**APPROXIMATELY 300 THOUSAND KILOMETERS PER
SECOND**

OR 186 THOUSAND MILES PER SECOND

DOES IT ALWAYS GO THE SAME SPEED?

ANSWER: NO

**IF IT TRAVELS THROUGH SOMETHING
OTHER THAN A VACUUM IT SLOWS DOWN**

VACUUM = 186,282 MILES PER SECOND

AIR = 186,225 MILES PER SECOND

WATER = 139,809 MILES PER SECOND

GLASS = 124,274 MILES PER SECOND

**SO THAT WAS A SOMEWHAT SIMPLISTIC EXPLANATION
OF WHAT A RADIO WAVE IS.**

**NOW LETS GET INTO THE MEAT AND POTATOES OF THIS
PRESENTATION, NAMELY “PROPAGATION”**

**ABIDING BY THE KISS PRINCIPAL (Keep It Simple Stupid)
LETS LOOK FIRST AT THE THREE PRIMARY MODES OR
TYPES OF PROPAGATION.**

- 1. SKY WAVE (MY FAVORITE)**
- 2. GROUND WAVE**
- 3. DIRECT WAVE**

**WITH SKY WAVE THE RADIO WAVE LEAVES YOUR ANTENNA
AND TAKES OFF INTO THE WILD BLUE YONDER**

**LETS ASSUME YOUR ANTENNA RADIATES REALLY WELL SHOOTING
OUT A SIGNAL (RF WAVE) AT 15 DEGREES ABOVE THE HORIZON.
THIS IS USUALLY CALLED THE LAUNCH ANGLE.**

**AS IT IS TRAVELING AT THE SPEED OF LIGHT (186 THOUSAND MILES PER
SECOND) IT IS COVERING AT LOT OF DISTANCE ON THE GROUND AS IT
CLIMBS INTO THE SKY.**

**BY THE TIME IT HAS REACHED AN ALTITUDE OF AROUND 300 MILES
IT HAS TRAVELED A DISTANCE ON THE GROUND OF SOMEWHERE
AROUND 1,000+ MILES.**

**WHEN YOUR RADIO WAVE REACHES THIS ALTITUDE OF 300 MILES OR SO
IT ENCOUNTERS A LAYER IN THE ATMOSPHERE CALLED THE IONOSPHERE.**

NOW, THIS IS THE IMPORTANT PART!

IF YOUR TRANSMIT FREQUENCY IS NOT TOO HIGH (MORE INFO COMING ABOUT “TOO HIGH”) AND THE IONOSPHERE IS ADEQUATLY CHARGED UP BY THE SUN, YOUR SIGNAL WILL BE REFLECTED OR REFRACTED BACK DOWN TO THE GROUND. (REFLECTED OR REFRACTED IS A DEBATEABLE CHOICE OF WORDS AND YOU WILL FIND THEM TYPICALLY USED INTERCHANGEABLY.

YOUR SIGNAL COVERED A BIT OVER 1,000 MILES GROUND DISTANCE TO GET TO THE IONOSPHERE AND IT WILL COVER THE SAME DISTANCE ON THE GROUND TO GET BACK DOWN.

**SO, THAT MEANS YOUR SIGNAL CAN BE RECEIVED BY STATIONS OVER 2,000 MILES FROM LAS VEGAS. IN OTHER WORDS YOU CAN HAVE QSOs WITH STATIONS ON THE EAST COAST. IS THAT COOL OR WHAT?
THIS IS CALLED “ONE HOP” OR ONE “SKIP”**

WHAT DETERMINES IF SKY WAVE PROPAGATION TAKES PLACE?

THERE ARE THREE PRIMARY FACTORS INVOLVED

- 1. WHAT FREQUENCY YOUR SIGNAL IS AT.**
- 2. AT WHAT ANGLE DOES YOUR SIGNAL HIT THE IONOSPHERE.**
- 3. HOW CHARGED UP OR ENERGIZED THE IONOSPHERE IS**
- 4. HOW STABLE THE EARTH'S MAGNETIC FIELD IS.**

NUMBER ONE:

IF YOUR FREQUENCY IS TOO HIGH IT WILL NOT BE REFLECTED BY THE IONOSPHERE BUT WILL PASS THROUGH IT AND CONTINUE TO OUTER SPACE. THIS IS WHERE THE TERM "MUF" Maximum Usable Frequency COMES INTO PLAY.

NUMBER TWO:

IF YOUR SIGNAL REACHES THE IONOSPHERE AT TOO HIGH AN ANGLE, DEPENDING ON OTHER CONDITIONS IT MAY PASS RIGHT THROUGH AND NOT BE RELECTED BACK DOWN.

NUMBER THREE:

THE IONOSPHERE'S ABILITY TO REFLECT YOUR SIGNAL DEPENDS ON HOW ENERGIZED OR IONIZED IT HAS BECOME DUE TO RADIATION FROM THE SUN. THIS IS MEASURED WITH A TERM CALLED THE SFI "Solar Flux Index". A BIGGER NUMBER IS BETTER.

50 = FAIR

100 = GOOD

150 = REALLY GOOD

200 = FANTASTIC

NUMBER FOUR:

THE EARTH'S MAGNETIC FIELD CAN BECOME DISTURBED OR UNSTABLE FROM EVENTS ON THE SUN LIKE LARGE FLARES OR CME "Coronal Mass Ejections" . AN UNSTABLE MAGNETIC FIELD CAUSES THE IONOSPHERE TO BECOME UNSTABLE OR DISTURBED. THE LEVEL OF DISTURBANCE IS MEASURED BY TWO TERMS, THE "K" INDEX AND THE "A" INDEX. THESE TWO INDEX'S HAVE DIFFERENT SCALES, ONE IS LINEAR AND ONE IS NOT SO THEY ARE NOT DIRECTLY COMPARABLE. THE "A" IS THE AVERAGE OVER A LONGER PERIOD OF TIME. THE "K" IS DURING THE LAST 3 HOURS.

A "K" OF 0 – 1 = GOOD

2 - 3 = FAIR

4 – 5 = REALLY BAD, POSSIBLE RADIO BLACKOUTS.

LETS REALLY “GO THE DISTANCE”

SO AS WAS MENTIONED, ONE HOP WILL GET YOU FROM LAS VEGAS TO THE EAST COAST.

TO GO FARTHER TAKES MULTIPLE HOPS. WHEN YOUR SIGNAL REACHES THE GROUND AFTER BEING REFLECTED BACK DOWN BY THE IONOSPHERE THE GROUND WILL RELECT SOME OF THAT ENERGY BACK UP FOR ANOTHER TRIP TO THE IONOSPHERE.

HIGHER FREQUENCIES REFLECT OFF OF OBJECTS BETTER THAN LOWER FREQUENCIES SO THE OPTIMUM WOULD BE TO BE JUST BELOW THE “MUF”.

ALSO, HOW WELL A SIGNAL REFLECTS OFF A SURFACE DEPENDS ON WHAT THAT SURFACE IS. ONE OF THE BEST MIRROR’S FOR RADIO WAVES IS SALT WATER. ONE OF THE WORST IS DESERT TERRAIN. THIS EXPLAINS WHY FOR US HERE IN VEGAS, CONTACTS IN JAPAN ARE A PIECE OF CAKE WHEREAS CONTACTS IN EUROPE ARE NOT SO EASY.

UNDER GOOD CONDITIONS UP TO 4 OR 5 HOPS ARE POSSIBLE.

OK, ENOUGH ABOUT SKY WAVE, WHAT ABOUT GROUND WAVE?

GROUND WAVE IS KINDA WEIRD. YOUR SIGNAL FOLLOWS THE CURVATURE OF THE EARTH WITH NO HELP REQUIRED FROM THE IONOSPHERE.

AN IMPORTANT FACT ABOUT GROUND WAVE PROPAGATION IS IT ONLY HAPPENS AT THE VERY LOW AMATEUR RADIO FREQUENCIES. TYPICALLY BELOW 80 METERS.

SO, IF SOMEONE TELLS YOU THEY WORKED A STATION IN TEXAS ON 10 METERS USING GROUND WAVE YOU HAVE A CHOICE. YOU CAN LET THEM KNOW THAT GROUND WAVE DOES NOT WORK AT 10 METERS OR, IF THAT'S TOO CONFRONTATIONAL JUST SMILE AND SAY THAT'S NICE.



HOW DOES GROUND WAVE WORK?

FIRST OFF THE SIGNAL NEEDS TO BE VERTICALLY POLARIZED. AT THE LOW FREQUENCIES WE ARE TALKING ABOUT THAT MEANS AN INCREDABLY TALL VERTICAL ANTENNA. NOT TOO FEASIBLE FOR MOST AMATEUR RADIO STATIONS.

AN EXPLANATION AS TO HOW THIS RADIO WAVE CAN FOLLOW THE CURVATURE OF THE EARTH IS AS FOLLOWS: WE KNOW WHEN A RADIO WAVE TRAVELS THROUGH SOMETHING OTHER THAN A VACUUM IT SLOWS DOWN. PICTURE A VERY TALL RADIO WAVE TRAVELING ALONG THE GROUND WITH THE BOTTOM PART OF THE WAVE DRAGGING ON THE GROUND. THIS SLOWS DOWN THE BOTTOM PART OF THE WAVE AND MAKES IT LEAN FORWARD IN THE DIRECTION OF TRAVEL.

WHAT ABOUT DIRECT WAVE?

THIS IS PRETTY SIMPLE. WITH DIRECT WAVE THE WAVE GOES FROM THE TRANSMITTING ANTENNA “DIRECTLY” TO THE RECEIVING ANTENNA. NO REFLECTING OFF THE IONOSPHERE AS IN SKY WAVE OR FOLLOWING THE CURVATURE OF THE EARTH AS IN GROUND WAVE. JUST PICTURE A BEAM OF LIGHT AND YOU UNDERSTAND “DIRECT WAVE”.

THIS IS GENERALLY WHAT GOES ON WHEN USING VHF OR UHF. THE MAXIMUM DISTANCE BETWEEN STATIONS IS PRETTY SMALL, USUALLY SOME WHERE IN THE 20 OR 30 MILE RANGE. IN ORDER TO INCREASE THE DISTANCE ANTENNA HEIGHT ABOVE THE GROUND IS VERY IMPORTANT. A HIGH ANTENNA GETS THE SIGNAL ABOVE OBSTRUCTIONS LIKE BUILDINGS OR EVEN THE CURVATURE OF THE EARTH. THE OPTIMUM SITUATION WOULD BE TRANSMITTING FROM THE TOP OF A MOUNTAIN OR HILL AND TO FURTHER INCREASE DISTANCE THE RECEIVING STATION COULD ALSO BE AT A HIGH SPOT LIKE THE TOP OF A MOUNTAIN OR HILL.

ANOTHER SOLUTION TO THE LIMITED RANGE IS THE USE OF A REPEATER. WE ARE ALL FAMILIAR WITH USING REPEATERS.

THAT COVERS THE 3 BASIC FORMS OF PROPAGATION

THERE ARE OTHERS LIKE METEOR SCATTER, EME (EARTH MOON EARTH), GRAY LINE, AND TROP E BUT BECAUSE THIS IS A LONG PRESENTATION I OPTED TO SKIP THESE.

**SO THIS CONCLUDES MY PRESENTATION.
I HOPE YOU FOUND IT INTERESTING AND
INFORMATIVE.**

HOPEFULLY I DIDN'T MAKE ANY SERIOUS MISTAKES

**THANK YOU VERY MUCH I REALLY APPRICIATE
YOUR BEING HERE AND LISTENING.**

WISHING YOU GREAT DX, NO QRM OR QSB AND LOW SWR

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