Welcome to 2023 Amateur Radio General Class License Training

Amateur Radio General License Training

These presentations are sponsored by:

Mendocino Auxiliary Communications Service (MACS)

Mendocino County Amateur Radio Communications Service (McARCS)

Willits Amateur Radio Society (WARS)

Topics on General Class Exam

Section	Contents	Questions on Exam	Questions in Pool	Covered in Session
G1	FCC Rules and Regulations	5	57	**Session 5**
G2	Operating Procedures	5	50	**Session 4**
G3	***Radio Wave Propagation***	***3***	***37***	**Session 2**
G4	Amateur Radio Practices	5	60	**Session 3**
G5	Electrical Principles	3	40	**Session 1**
G6	Electronic Components	2	24	**Session 1**
G7	Practical Circuits	3	38	**Session 1**
G8	Signals and Emissions	3	43	**Session 3**
G9	Antennas and Feedlines	4	46	**Session 2**
G0	Safety	2	25	**Session 4**

Sub-element G3 – radio wave propagation

Topics in G3:

- **Radio wave propagation**
  - Sunspots and solar radiation; geomagnetic field and stability indices
  - Maximum Usable Frequency; Lowest Usable Frequency; short path and long path propagation; determining propagation conditions; ionospheric refraction
  - Ionospheric regions; critical angle and frequency; HF scatter; near vertical incidence skywave (NVIS)
- **One question from each of the three categories on exam**

Technician Propagation Review

- **Technician exam focused on VHF/UHF**
  - 30 to 300 MHz
- **General exam almost exclusively HF**
  - 3 to 30 MHz
  - General class = significantly more HF privileges
  - Global communications

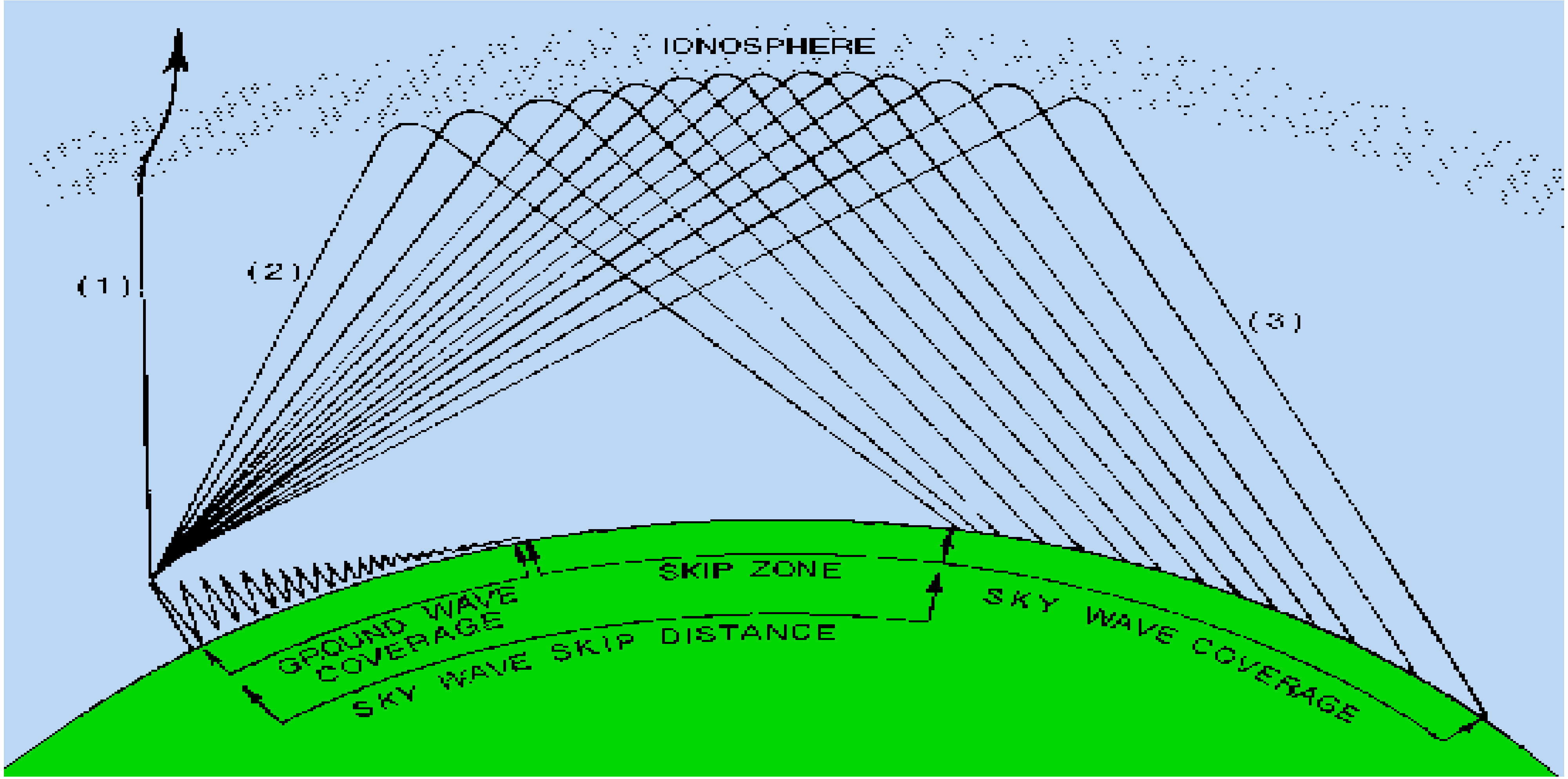
Technician Propagation Review

Radio Waves

- **Electromagnetic energy, same as visible light**
- **Travel in straight line, how is global propagation possible?**
  - Can be reflected, bent, focused, and adsorbed
  - Radio wave path bent (refracted) by ionosphere
  - Signals returned to Earth = skywave or skip
  - Distance between stations = hop
  - Space between stations = skip zone

Technician Propagation Review

Radio Waves Refracted by Ionosphere



General Class Radio Wave Propagation

Ionosphere

Multiple layers or regions

- 50 to 250+ miles altitude
- Thin atmosphere ionized by solar radiation
- Ionization depends on season, time of day, activity on the sun (sunspots)

Ionosphere enables propagation around the world

- Thin atmosphere is ionized (electrically charged) by solar radiation
- Higher ionization refracts or bends radio waves more strongly and at higher frequencies
- Degree of ionization varies with solar energy input

General Class Radio Wave Propagation

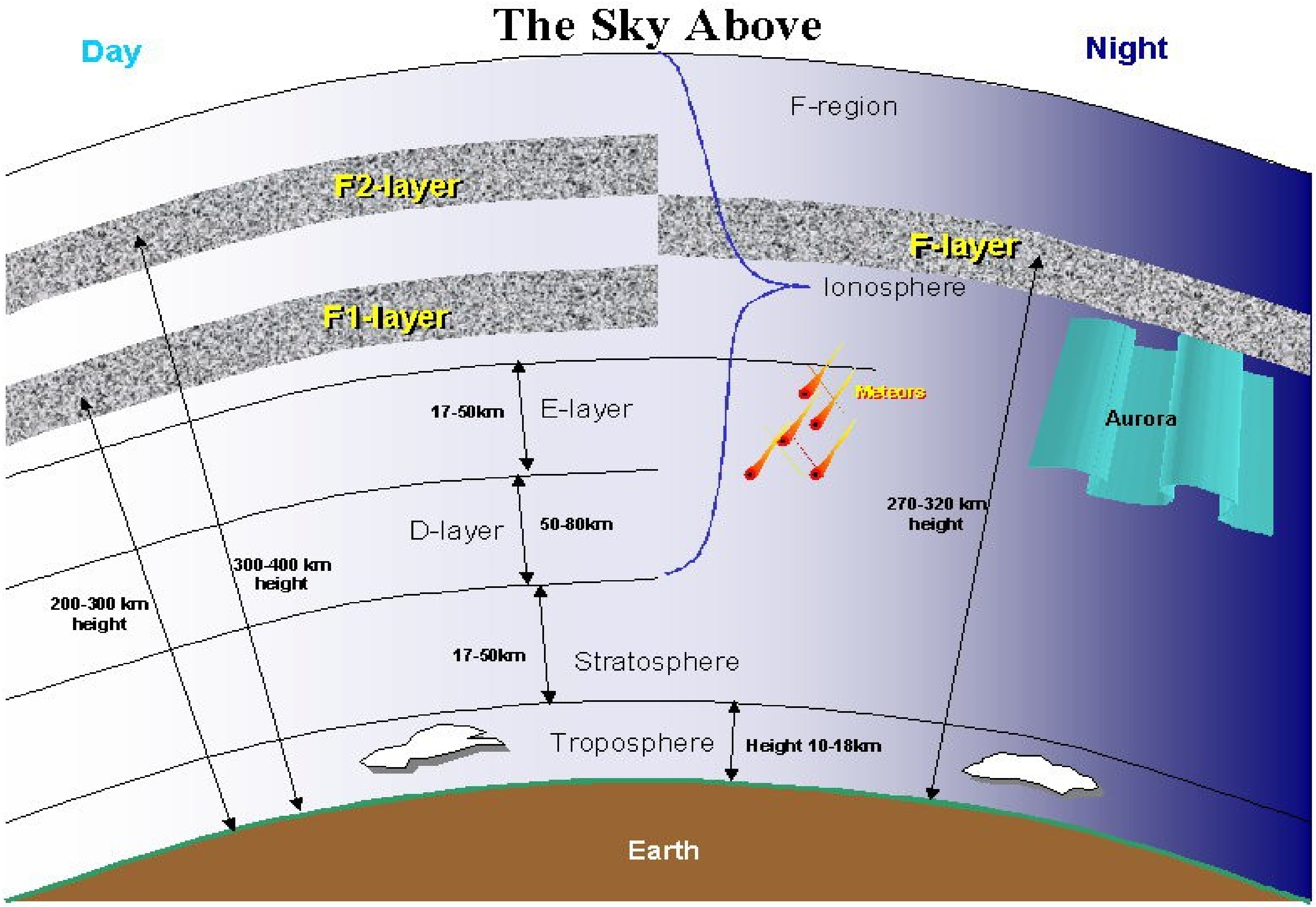
F1/F2 combine at night

F2 region 200 - 300 miles

F1 region 100 - 140 miles

E region 60 - 70 miles

D region closest to Earth



General Class Radio Wave Propagation

D region

- **Closest region to Earth**
- **Forms in day time, dissipates at night**
  - Absorbs signals below 10 MHz during daylight hours
  - Long-distance communication on 40-, 60-, 80-, 160-meter bands (7- 1.8 MHz) difficult during the day
  - Lower HF frequencies further impacted in summer by high atmospheric noise or static

General Class Radio Wave Propagation

E region

- **60 – 70 mile altitude**
- **Also dissipates at night**
  - Single E region hop covers approximately 1200 miles
  - Highly ionized “clouds” yield VHF sporadic E skip

General Class Radio Wave Propagation

F region

Workhorse of the ionosphere

- **F1** 100 – 140 mile altitude
- **F2** 200 – 300 mile altitude

Combine at night

- Higher F2 altitude = longer skip propagation than other ionospheric regions
- Single F2 region hop approximately 2500 miles
- Global circumference = 25000 miles
- Signal may make multiple hops to circle Earth

Section questions:

G3C11

Which ionospheric region is the most absorbent of signals below 10 MHz during daylight hours?

A. The F2 region
B. The F1 region
C. The E region
D. The D region

Section questions:

G3C03

Why is skip propagation via the F2 region longer than that via the other ionospheric regions?

A. Because it is the densest
B. Because of the Doppler effect
C. Because it is the highest
D. Because of temperature inversions

Section questions:

G3B10

What is the approximate maximum distance along the Earth's surface normally covered in one hop using the E region?

A. 180 miles
B. 1,200 miles
C. 2,500 miles
D. 12,000 miles

Section questions:

G3C05

Why is long-distance communication on the 40-, 60-, 80-, and 160-meter bands more difficult during the day?

A. The F region absorbs signals at these frequencies during daylight hours
B. The F region is unstable during daylight hours
C. The D region absorbs signals at these frequencies during daylight hours
D. The E region is unstable during daylight hours

General Class Radio Wave Propagation

Long path propagation

More than one way for signal to reach receiving station

- Most direct path = short path
- Signal can travel 180 degrees opposite direction = long path

Long path contacts

- Point directional antenna 180 degrees from the short path heading
- Slightly delayed echo when skywave signals received by short-path and long-path

General Class Radio Wave Propagation

Frequency dependent response

MUF = Maximum **U**sable **F**requency

- Highest frequency that may be used for communications between two points
- MUF affected by path distance, location, time of day, season, solar radiation, ionospheric disturbances
- <u>Least attenuation</u> of long-distance skip occurs at frequencies <u>just below the MUF</u>

LUF = Lowest **U**sable **F**requency

- Lowest frequency that may be used for communications between two points
- Frequencies <u>below</u> LUF are attenuated before reaching their destination

General Class Radio Wave Propagation

Frequency dependent response

Frequencies between MUF and LUF - refracted back to Earth by ionosphere
When LUF > MUF - HF skywave propagation not possible over that path

Critical frequency

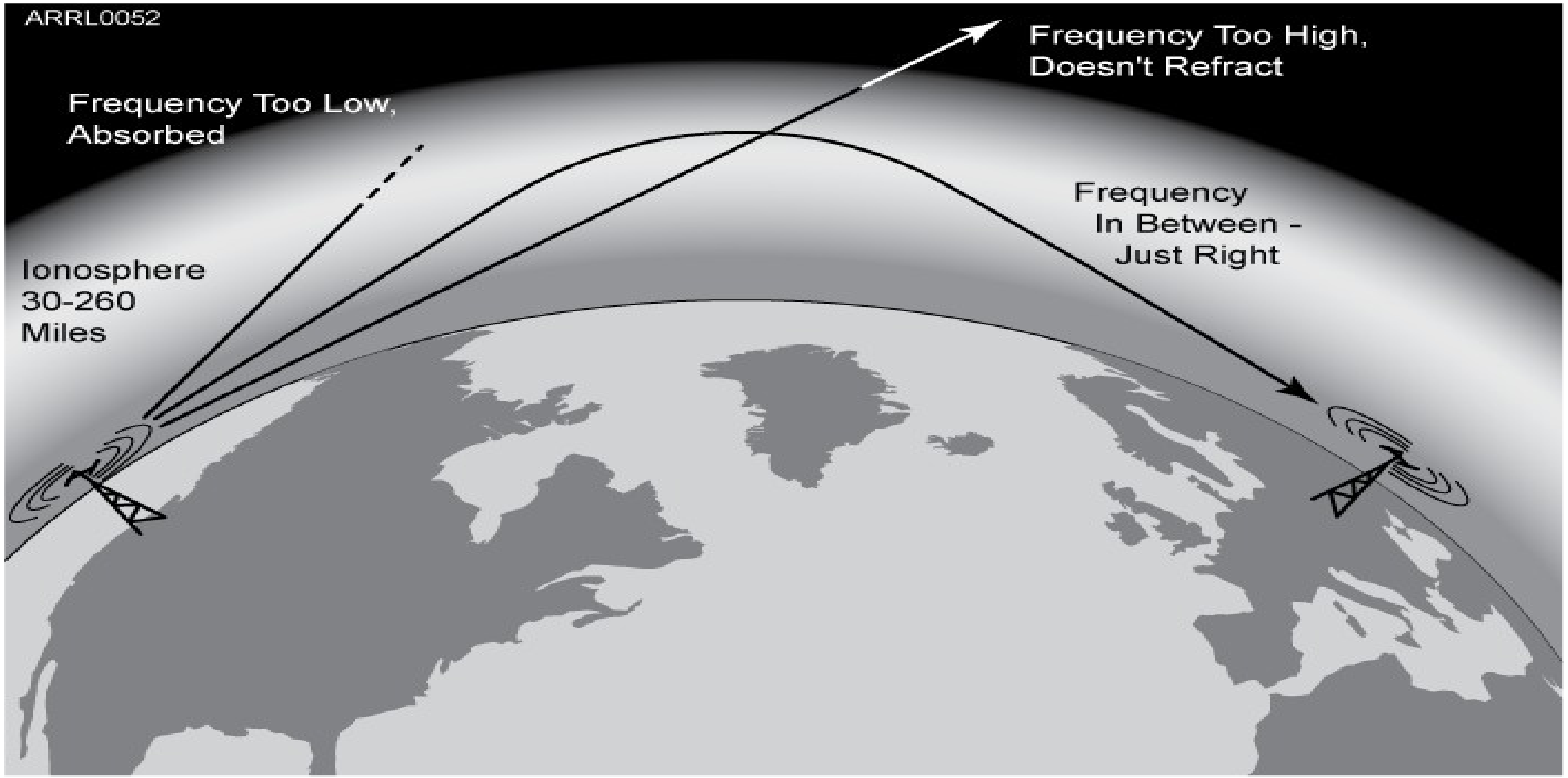
- Highest frequency signal refracted back to Earth at a given incidence angle

Critical angle

- Highest takeoff angle that returns radio wave to Earth under specific ionospheric conditions

General Class Radio Wave Propagation

Reflection depends on frequency and angle of incidence
Too high a frequency or angle and the waves are lost to space.



General Class Radio Wave Propagation

Real versus theoretical response

Determine actual propagation conditions

- Listen for propagation beacon stations on desired band
- Use network of automated receiving stations to see where transmissions are being received

General Class Radio Wave Propagation

Propagation within skip zone

Scatter

- Type of propagation allows signals to be heard in transmitting station’s skip zone
- Reflections from Earth's surface (ocean or mountain ranges) may return wave back
- Erratic reflections from within ionosphere
- HF scatter signals usually weak because only part of the signal energy is scattered
- HF scatter often has fluttering sound
- Signal sounds distorted, energy is scattered into the skip zone via different paths

Near vertical incidence skywave

- Short distance MF or HF propagation at high elevation angles
- Signal is sent nearly straight up and reflected back to Earth

Section questions:

G3B02

What factors affect the MUF?

A. Path distance and location
B. Time of day and season
C. Solar radiation and ionospheric disturbances
D. All these choices are correct

Section questions:

G3B01

What is a characteristic of skywave signals arriving at your location by both short-path and long-path propagation?

A. Periodic fading approximately every 10 seconds
B. Signal strength increased by 3 dB
C. The signal might be cancelled causing severe attenuation
D. A slightly delayed echo might be heard

Section questions:

G3B07

What does LUF stand for?

A. The Lowest Usable Frequency for communications between two specific points
B. Lowest Usable Frequency for communications to any point outside a 100-mile radius
C. The Lowest Usable Frequency during a 24-hour period
D. Lowest Usable Frequency during the past 60 minutes

Section questions:

G3B04

Which of the following is a way to determine current propagation on a desired band from your station?

A. Use a network of automated receiving stations on the internet to see where your transmissions are being received
B. Check the A-index
C. Send a series of dots and listen for echoes
D. All these choices are correct

Section questions:

G3C07

What makes HF scatter signals often sound distorted?

A. The ionospheric region involved is unstable
B. Ground waves are absorbing much of the signal
C. The E region is not present
D. Energy is scattered into the skip zone through several different paths

General Class Radio Wave Propagation

The Sun and HF propagation

Energy from the sun

- More than visible light radiated by sun

Ultraviolet and X-ray radiation come from solar flares

- Travel at speed of light, affects HF propagation on Earth in about 8 minutes
- Sudden ionospheric disturbances impact daytime ionospheric propagation, disrupting signals on lower frequencies vs higher frequencies

Coronal Mass Ejections (CME)

- Source of solar wind, a stream of charged particles (plasma)
- Much lower velocity than UV or X-ray
- Takes 15 hours to several days affect radio propagation on Earth

General Class Radio Wave Propagation

The Sun and HF propagation

Ultraviolet and X-ray radiation

- Interact with/energize ionosphere

Coronal Mass Ejections (CME)

- Plasma stream interacts with Earth's magnetic field
- Triggers geomagnetic storm, a temporary disturbance in Earth’s geomagnetic field
- Geomagnetic storms affect HF propagation, degrading high-latitude HF propagation
- Long distance radio communication affected by charged particles reaching Earth from solar coronal holes (CME's), HF communication may be disturbed
- High geomagnetic activity can create auroras that may reflect VHF signals

General Class Radio Wave Propagation

The Sun and HF propagation

Sun is VERY dynamic

- Sunspot cycle repeats approximately every 11 years
- Number of sunspots goes from a minimum to a maximum in about 5.5 years
- Higher sunspot numbers = greater probability of good HF propagation.
- <u>Least reliable bands</u> during periods of <u>low solar activity</u> = 15, 12, 10 meters
- 20m supports worldwide propagation during daylight hours at any point in the 11-year cycle

The Sun and HF propagation

Solar parameters are measured and reported daily

- K-index - short-term stability of Earth’s geomagnetic field
- A-index - long-term stability of Earth’s geomagnetic field
- Solar flux index – measure of solar radiation with wavelength = 10.7 cm

Solar conditions also change on a much shorter cycle

- Sun’s surface layers rotate around axis, in a 26 to 28-day cycle
- Causes HF propagation conditions to vary periodically on same cycle
- Rotation causes sunspot regions to appear, move across visible solar disk, disappear, then return a few weeks later

Section questions:

G3A05

What is the solar flux index?

A. A measure of the highest frequency that is useful for ionospheric propagation between two points on Earth
B. A count of sunspots that is adjusted for solar emissions
C. Another name for the American sunspot number
D. A measure of solar radiation with a wavelength of 10.7 centimeters

Section questions:

G3A03

Approximately how long does it take the increased ultraviolet and X-ray radiation from a solar flare to affect radio propagation on Earth?

A. 28 days
B. 1 to 2 hours
C. 8 minutes
D. 20 to 40 hours

Section questions:

G3A06

What is a geomagnetic storm?

A. A sudden drop in the solar flux index
B. A thunderstorm that affects radio propagation
C. Ripples in the geomagnetic force
D. A temporary disturbance in Earth’s geomagnetic field

Section questions:

G3A14

How is long distance radio communication usually affected by the charged particles that reach Earth from solar coronal holes?

A. HF communication is improved
B. HF communication is disturbed
C. VHF/UHF ducting is improved
D. VHF/UHF ducting is disturbed

Section questions:

G3A10

What causes HF propagation conditions to vary periodically in a 26- to 28-day cycle?

A. Long term oscillations in the upper atmosphere
B. Cyclic variation in Earth’s radiation belts
C. Rotation of the Sun’s surface layers around its axis
D. The position of the Moon in its orbit

Section questions:

G3A01

How does a higher sunspot number affect HF propagation?

A. Higher sunspot numbers generally indicate a greater probability of good propagation at higher frequencies
B. Lower sunspot numbers generally indicate greater probability of sporadic E propagation
C. A zero sunspot number indicates that radio propagation is not possible on any band
D. A zero sunspot number indicates undisturbed conditions

End of G3 - Radio Wave Propagation

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