General Class  Element 3 Course  Presentation

- **ELEMENT 3 SUB-ELEMENTS**
  - G1 – Commission's Rules
  - G2 – Operating Procedures
  - G3 – Radio Wave Propagation
  - G4 – Amateur Radio Practices
  - G5 – Electrical Principles
  - G6 – Circuit Components
  - G7 – Practical Circuits
  - G8 – Signals and Emissions
  - G9 – Antennas
  - G0 – Electrical and RF Safety

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**Radio Wave Propagation**

- The sunspot number is a **measure of solar activity** based on counting sunspots and sunspot groups. (G3A01)
- The effect of a **Sudden Ionospheric Disturbance** has on the daytime ionospheric propagation of HF radio waves is that **it disrupts signals on lower frequencies more than those on higher frequencies**. (G3A02)

A Sudden Ionospheric Disturbance (SID) is a phenomenon that can have a drastic effect on propagation.

During an SID, the sun emits a great deal of ultraviolet and X-ray radiation.

**Radio Wave Propagation**

- **8 minutes** is approximately how long it takes for the increased ultraviolet and X-ray radiation from solar flares to affect radio-wave propagation on the Earth. (G3A03)

**Radio Wave Propagation**

- **21 MHz and higher** are the amateur radio HF frequencies that are **least reliable** for **long distance communications** during periods of low solar activity. (G3A04)

- The **solar-flux index** is a **measure of solar radiation** at 10.7 cm. 10.7 cm wavelength = 2.80 GHz (G3A05)

**Radio Wave Propagation**

- Geomagnetic activity, such as a geomagnetic storm, can also affect radio propagation. A geomagnetic storm is a **temporary disturbance in the Earth’s magnetosphere**. (G3A06)

Geomorphic activity, such as a geomagnetic storm, can also affect radio propagation. A geomagnetic storm is a temporary disturbance in the Earth’s magnetosphere.

- **At any point in the solar cycle**, the 20 meter band usually supports worldwide propagation during daylight hours. (G3A07)
- One of the effects a geomagnetic storm can have on radio-wave propagation is **degraded high-latitude HF propagation**. (G3A08)

**Radio Wave Propagation**

- The effect that high sunspot numbers have on radio communications is that long-distance communication in the upper HF and lower VHF range is enhanced. (G3A09)
- The sunspot cycle is a long-term phenomenon. There are other phenomena that affect radio wave propagation in the short term. For example, the Sun's rotation on its axis causes HF propagation conditions to vary periodically in a 28-day cycle. (G3A10)

- Solar flares and magnetic storms affect radio-wave propagation.
Radio Wave Propagation

- The phenomenon that most affects amateur radio communications on the HF bands is the sunspot cycle. The typical sunspot cycle is approximately 11 years long. (G3A11)

Notice 11 year cycles
2011 is coming into cycle 24.

Radio Wave Propagation

- There are two indices that give an indication of the stability of the Earth’s magnetic field. The K-index indicates the short term stability of the Earth’s magnetic field. (G3A12)

<table>
<thead>
<tr>
<th>K Index</th>
<th>A Index</th>
<th>HF Skip Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>K1 - K4</td>
<td>A0 - A2</td>
<td>Bands are normal</td>
</tr>
<tr>
<td>K4</td>
<td>A16 - A30</td>
<td>Bands are unpredictable</td>
</tr>
<tr>
<td>K5</td>
<td>A30 - A50</td>
<td>Lower bands are unstable</td>
</tr>
<tr>
<td>K6</td>
<td>A50 - A99</td>
<td>Few skywaves below 15 MHz</td>
</tr>
<tr>
<td>K7 - K9</td>
<td>A100 - A400</td>
<td>Radio blackout is likely</td>
</tr>
</tbody>
</table>

Go fishing or watch for an aurora.

A possible benefit to radio communications resulting from periods of high geomagnetic activity is the aurora that can reflect VHF signals. (G3A16)

Geomagnetic disturbances caused by the Sun result in the Northern Lights.

Radio Wave Propagation

- A reliable way to determine if the Maximum Usable Frequency (MUF) is high enough to support skip propagation between your station and a distant location on frequencies between 14 and 30 MHz is to listen for signals from an international beacon. (G3B04)

There are websites that provide skywave DX conditions.

Radio Wave Propagation

- HF communications are disturbed by the charged particles that reach the Earth from solar coronal holes. (G3A13)

- It takes 20 to 40 hours for charged particles from Coronal Mass Ejections (CME) to affect radio-wave propagation on the Earth. (G3A14)

A coronal mass ejection (CME) is a massive burst of solar wind and magnetic fields rising above the solar corona or being released into space.

Coronal Mass Ejections take 20 – 40 hours to reach the earth where ultraviolet and X-Ray radiation from solar flares take 8 minutes.

Radio Wave Propagation

- When selecting a frequency for lowest attenuation when transmitting on HF, select a frequency just below the MUF. (G3B03)

- While signals most often take the shortest path from point to point, sometimes the best path for radio propagation is in the opposite direction, also called the “long path.” A well-defined echo might be heard if a sky-wave signal arrives at your receiver by both short path and long path propagation. (G3B01)

A good indicator of the possibility of sky-wave propagation on the 6 meter band is that there is short skip sky-wave propagation on the 10 meter band. (G3B03)

There are websites that provide skywave DX conditions.
Radio Wave Propagation

- When they are sent into the ionosphere, radio waves with frequencies below the Maximum Usable Frequency (MUF) and above the Lowest Usable Frequency (LUF) are bent back to the Earth.
- When they are sent into the ionosphere, radio waves with frequencies below the Lowest Usable Frequency (LUF) are completely absorbed by the ionosphere.
- LUF stands for the Lowest Usable Frequency for communications between two points.
- MUF stands for the Maximum Usable Frequency for communications between two points.

Radio Wave Propagation

- 2,500 miles is the approximate maximum distance along the Earth's surface that is normally covered in one hop using the F2 region.
- 1,200 miles is the approximate maximum distance along the Earth's surface that is normally covered in one hop using the E region.
- No HF radio frequency will support ordinary skywave communications over the path when the Lowest Usable Frequency (LUF) exceeds the Maximum Usable Frequency (MUF).
- The following factors affect the Maximum Usable Frequency (MUF):
  - Path distance and location
  - Time of day and season
  - Solar radiation and ionospheric disturbances
  All of these choices are correct.

Radio Wave Propagation

- The ionospheric layer closest to the surface of the Earth is the D layer.
- Where the Sun is overhead, ionospheric layers reach their maximum height.

Radio Wave Propagation

- The F2 region is mainly responsible for the longest distance radio wave propagation because it is the highest ionospheric region.
Radio Wave Propagation

Atmospheric Layers

Terms we’ve heard before from space shuttle launches. Now apply them to Ham Radio.

- Ionosphere: 31 – 400 miles
- Stratosphere: 6 – 31 miles
- Troposphere: 0 – 6 miles

Regions in the Ionosphere

During the day:
- The “D” Region is closest to Earth
- The “D” Region absorbs MF/HF radio signals
- The “F2” Region is most responsible for long distance communication

At night:
- The “D” & “E” Regions disappear
- The “F1” & “F2” Regions combine into one with reduced ionization

Radio Wave Propagation

• The highest takeoff angle that will return a radio wave to the Earth under specific ionospheric conditions is called the *critical angle*. 

One factor that affects how well the ionosphere will reflect a signal is the angle at which the signal impinges upon it. If the angle is too high, it will pass right through the ionosphere and not be reflected back to earth.

Radio Wave Propagation

- Long distance communication on the 40, 60, 80 and 160 meter bands is more difficult during the day because the D layer absorbs signals at these frequencies during daylight hours.
- When they are sent into the ionosphere, radio waves with frequencies below the Lowest Usable Frequency (LUF) are completely absorbed by the ionosphere.
- LUF stands for the Lowest Usable Frequency for communications between two points.
- HF scatter signals in the skip zone are usually weak because only a small part of the signal energy is scattered into the skip zone.

Radio Wave Propagation

• One interesting propagation phenomenon is scatter propagation. Scatter propagation allows a signal to be detected at a distance too far for ground wave propagation but too near for normal sky-wave propagation.

Horizontal dipoles placed between 1/8 and 1/4 wavelength above the ground will be most effective for skip communications on 40 meters during the day.

Antennas used for DXing should have low takeoff angles.

One thing that affects the takeoff angle of an antenna is its height above ground.
Radio Wave Propagation

The D layer is the ionospheric layer that is the most absorbent of long skip signals during daylight hours on frequencies below 10 MHz.

G3A01 What is the sunspot number?

A. A measure of solar activity based on counting sunspots and sunspot groups
B. A 3 digit identifier which is used to track individual sunspots
C. A measure of the radio flux from the sun measured at 10.7 cm
D. A measure of the sunspot count based on radio flux measurements

G3A03 Approximately how long does it take the increased ultraviolet and X-ray radiation from solar flares to affect radio-wave propagation on the Earth?

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

G3A04 Which of the following amateur radio HF frequencies are least reliable for long distance communications during periods of low solar activity?

A. 3.5 MHz and lower.
B. 7 MHz.
C. 10 MHz.
D. 21 MHz and higher.

G3A02 What effect does a Sudden Ionospheric Disturbance have on the daytime ionospheric propagation of HF radio waves?

A. It enhances propagation on all HF frequencies.
B. It disrupts signals on lower frequencies more than those on higher frequencies.
C. It disrupts communications via satellite more than direct communications.
D. None, because only areas on the night side of the Earth are affected.
### G3A05 What is the solar-flux index?

A. A measure of the highest frequency that is useful for ionospheric propagation between two points on the Earth.
B. A count of sunspots which is adjusted for solar emissions.
C. Another name for the American sunspot number.
D. A measure of solar activity at 10.7 cm.

### G3A06 What is a geomagnetic storm?

A. A sudden drop in the solar-flux index.
B. A thunderstorm which affects radio propagation.
C. Ripples in the ionosphere.
D. A temporary disturbance in the Earth’s magnetosphere.

### G3A07 At what point in the solar cycle does the 20 meter band usually support worldwide propagation during daylight hours?

A. At the summer solstice.
B. Only at the maximum point of the solar cycle.
C. Only at the minimum point of the solar cycle.
D. At any point in the solar cycle.

### G3A08 Which of the following effects can a geomagnetic storm have on radio-wave propagation?

A. Improved high-latitude HF propagation.
B. Degraded high-latitude HF propagation.
C. Improved ground-wave propagation.
D. Improved chances of UHF ducting.

### G3A09 What effect do high sunspot numbers have on radio communications?

A. High-frequency radio signals become weak and distorted.
B. Frequencies above 300 MHz become usable for long-distance communication.
C. Long-distance communication in the upper HF and lower VHF range is enhanced.
D. Microwave communications become unstable.

### G3A10 What causes HF propagation conditions to vary periodically in a 28-day cycle?

A. Long-term oscillations in the upper atmosphere.
B. Cyclic variation in the Earth’s radiation belts.
C. The Sun’s rotation on its axis.
D. The position of the Moon in its orbit.
G3A11 How long is the typical sunspot cycle?
A. 8 minutes
B. 40 hours
C. 28 days
D. 11 years

G3A12 What is the K-index?
A. The relative position of sunspots on the surface of the sun.
B. The short term stability of the Earth’s magnetic field.
C. The stability of the Sun’s magnetic field.
D. The solar radio flux at Boulder, Colorado.

G3A13 What is the A-index?
A. The relative position of sunspots on the surface of the sun.
B. The amount of polarization of the Sun’s electric field.
C. The long term stability of the Earth’s geomagnetic field.
D. The solar radio flux at Boulder, Colorado.

G3A14 How are radio communications usually affected by the charged particles that reach the Earth from solar coronal holes?
A. HF communications are improved
B. HF communications are disturbed
C. VHF/UHF ducting is improved
D. VHF/UHF ducting is disturbed

G3A15 How long does it take charged particles from coronal mass ejections to affect radio-wave propagation on the Earth?
A. 28 days
B. 14 days
C. 4 to 8 minutes
D. 20 to 40 hours

G3A16 What is a possible benefit to radio communications resulting from periods of high geomagnetic activity?
A. Aurora that can reflect VHF signals
B. Higher signal strength for HF signals passing through the polar regions
C. Improved HF long path propagation
D. Reduced long delayed echoes
G3B01 How might a sky-wave signal sound if it arrives at your receiver 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 will be cancelled causing severe attenuation
D. A well-defined echo can be heard

G3B02 Which of the following is a good indicator of the possibility of skywave propagation on the 6 meter band?
A. Short skip skywave propagation on the 10 meter band
B. Long skip skywave propagation on the 10 meter band
C. Severe attenuation of signals on the 10 meter band
D. Long delayed echoes on the 10 meter band

G3B03 Which of the following applies when selecting a frequency for lowest attenuation when transmitting on HF?
A. Select a frequency just below the MUF
B. Select a frequency just above the LUF
C. Select a frequency just below the critical frequency
D. Select a frequency just above the critical frequency

G3B04 What is a reliable way to determine if the Maximum Usable Frequency (MUF) is high enough to support skip propagation between your station and a distant location on frequencies between 14 and 30 MHz?
A. Listen for signals from international beacon
B. Send a series of dots on the band and listen for echoes from your signal
C. Check the strength of TV signals from Western Europe
D. Check the strength of signals in the MF AM broadcast band

G3B05 What usually happens to radio waves with frequencies below the Maximum Usable Frequency (MUF) when they are sent into the ionosphere?
A. They are bent back to the Earth
B. They pass through the ionosphere
C. They are amplified by interaction with the ionosphere
D. They are bent and trapped in the ionosphere to circle the Earth

G3B06 What usually happens to radio waves with frequencies below the Lowest Usable Frequency (LUF)?
A. They are bent back to the Earth
B. They pass through the ionosphere
C. They are completely absorbed by the ionosphere
D. They are bent and trapped in the ionosphere to circle the Earth
**G3B07 What does LUF stand for?**

A. The Lowest Usable Frequency for communications between two points

B. The Longest Universal Function for communications between two points

C. The Lowest Usable Frequency during a 24 hour period

D. The Longest Universal Function during a 24 hour period

**G3B08 What does MUF stand for?**

A. The Minimum Usable Frequency for communications between two points

B. The Maximum Usable Frequency for communications between two points

C. The Minimum Usable Frequency during a 24 hour period

D. The Maximum Usable Frequency during a 24 hour period

**G3B09 What is the approximate maximum distance along the Earth’s surface that is normally covered in one hop using the F2 region?**

A. 180 miles

B. 1,200 miles

C. 2,500 miles

D. 12,000 miles

**G3B10 What is the approximate maximum distance along the Earth’s surface that is normally covered in one hop using the E region?**

A. 180 miles

B. 1,200 miles

C. 2,500 miles

D. 12,000 miles

**G3B11 What happens to HF propagation when the Lowest Usable Frequency (LUF) exceeds the Maximum Usable Frequency (MUF)?**

A. No HF radio frequency will support communications over the path.

B. HF communications over the path are enhanced.

C. Double hop propagation along the path is more common

D. Propagation over the path on all HF frequencies is enhanced

**G3B12 What factors affect the Maximum Usable Frequency (MUF)?**

A. Path distance and location

B. Time of day and season

C. Solar radiation and ionospheric disturbance

D. All of these choices are correct
G3C01 Which of the following ionospheric layers is closest to the surface of the Earth?

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

G3C02 Where on the Earth do ionospheric layers reach their maximum height?

A. Where the Sun is overhead.
B. Where the Sun is on the opposite side of the Earth.
C. Where the Sun is rising.
D. Where the Sun has just set.

G3C03 Why is the F2 region mainly responsible for the longest distance radio wave propagation?

A. Because it is the densest ionospheric layer
B. Because it does not absorb radio waves as much as other ionospheric regions
C. Because it is the highest ionospheric region
D. All of these choices are correct

G3C04 What does the term “critical angle” mean as used in radio wave propagation?

A. The long path azimuth of a distant station
B. The short path azimuth of a distant station
C. The lowest takeoff angle that will return a radio wave to the Earth under specific ionospheric conditions
D. The highest takeoff angle that will return a radio wave to the Earth under specific ionospheric conditions

G3C05 Why is long-distance communication on the 40, 60, 80 and 160 meter bands more difficult during the day?

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

G3C06 What is a characteristic of HF scatter signals?

A. They have high intelligibility
B. They have a wavering sound
C. They have very large swings in signal strength
D. All of these choices are correct
G3C07 What makes HF scatter signals often sound distorted?
A. The ionospheric layer 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 radio wave paths

G3C08 Why are HF scatter signals in the skip zone usually weak?
A. Only a small part of the signal energy is scattered into the skip zone.
B. Signals are scattered from the magnetosphere which is not a good reflector.
C. Propagation is through ground waves which absorb most of the signal energy.
D. Propagation is through ducts in F region which absorb most of the energy.

G3C09 What type of radio wave propagation allows a signal to be detected at a distance too far for ground wave propagation but too near for normal sky wave propagation?
A. Faraday rotation.
B. Scatter
C. Sporadic-E skip
D. Short-path skip

G3C10 Which of the following might be an indication that signals heard on the HF bands are being received via scatter propagation?
A. The communication is during a sunspot maximum
B. The communication is during a sudden ionospheric disturbance
C. The signal is heard on a frequency below the maximum usable frequency
D. The signal is heard on a frequency above the maximum usable frequency

G3C11 Which of the following antenna types will be most effective for skip communications on 40 meters during the day?
A. A vertical antenna
B. A horizontal dipole placed between 1/8 and 1/4 wavelength above the ground
C. A left-hand circularly polarized antenna
D. A right-hand circularly polarized antenna

G3C12 Which ionospheric layer is the most absorbent of long skip signals during daylight hours on frequencies below 10 MHz?
A. The F2 layer
B. The F1 layer
C. The E layer
D. The D layer
What is Near Vertical Incidence Sky-wave (NVIS) propagation?

A. Propagation near the MUF

B. Short distance HF propagation using high elevation angles

C. Long path HF propagation at sunrise and sunset

D. Double hop propagation near the LUF