CHAPTER A

A Brief History of Radio Regulation

Radio communication is more than 100 years old. It began with wireless dots and dashes, grew into a worldwide form of voice communications – thanks largely to amplitude modulation (AM) and shortwave frequencies – and today encompasses a wide array of modern technologies that can transmit data, voice, and pictures, employing everything from simple wire antennas to satellites orbiting the Earth.

From its earliest days as a viable form of communication, wireless has been seen as an invaluable tool to assure public safety at sea, in the air, and on land. *Table 1-1* lists some significant events and important actions between 1835 and 1910 that furthered electronic communications, which began with the invention of the telegraph.

Table 1-1. Electronic Communications 1835-1910

Year	Event and Action
1835	Electronic communications begin with the invention of the telegraph by Samuel F. B. Morse, a professor at New York University. Morse code is named after him, and was the international CW code used for many decades especially in the Maritime Service. With the advent of GMDSS, the primary use of this code today is in the Amateur Radio Service.
1849	Two European countries are linked by telegraph, causing the development of initial international agreements on rules and regulations governing the sharing of information.
1865	25 European nations meet in Paris to form the International Telegraphic Convention, which later becomes the International Telecommunications Union (ITU).
1865	Italian inventor Guglielmo Marconi proves the feasibility of radio communications, for which he receives a patent in 1897.
1899	Marconi makes the first successful transatlantic radio transmission from England to Newfoundland.
1901	Marine radio is born when the U.S. Navy adopts a wireless system.
1903	First international conference on governing radio communications is held in Berlin. Nine nations agree that public safety takes precedence over squabbles between commercial ventures.
1906	International conferees meeting in Berlin agree to require that ships be properly equipped with wireless transmitters and receivers, and to set the first international distress frequency as 500 kHz for ships to use to call for help. International regulation of wireless radio is added to the ITU's responsibilities.
1906	Reginald Aubrey Fessenden makes the world's first voice radio broadcast on Christmas Eve and again on New Year's Eve, one week later. Other Fessenden firsts besides voice over radio was the first two-way trans-Atlantic radio communications, the first voice heard across an ocean.
1909	Steamships Republic and Florida collide off the coast of New York and 1500 lives are saved by a distress call sent by radio operator Jack Binns. Later in the year, the S.S. Arapahoe calls for help using "SOS," which is adopted this year as the international radiotelegraph distress call. "Mayday" is adopted in 1927 as the international distress call for radiotelephony.

The Titanic Disaster

During the early years of the 20th century, the use of radio communications remained confined primarily to ships at sea. Few ships operated radio equipment, and those that did saw no reason to staff their stations around the clock. Doing so was considered an unnecessary luxury. All of that changed when the Titanic was ripped open by an iceberg in the North Atlantic and sent to the bottom of the sea just three hours later on the night of April 15, 1912.

Sinking of the Titanic led to the adoption of important radio regulations to help assure life safety of all ships at sea.

Source: www.titanic-experience.com

While the Titanic was sinking, her radio operator frantically called for help over the wireless. The Carpathia, 58 miles away, heard the call, responded, and managed to rescue 700 survivors. The Californian was just 20 miles away from the Titanic and could have rushed to the scene much faster. But the Californian radio operator had gone to bed, there was no one to relieve him, and the call went unheard. Some 1,500 passengers and crew perished!

The U.S. Congress had passed the Wireless Ship Act of 1910, which might have helped prevent the loss of so many lives, but the law's requirements were not comprehensive enough. Following the Titanic disaster, the Act was amended to require a minimum of two radio operators on board ships, a constant 24-hour watch, and the installation of backup power supplies to assure radio communications in emergency situations.

The Advent of Commercial Aviation

While shipping was a mature industry hundreds of years old, aviation was in its infancy. Wilbur and Orville Wright made their historic first flight just 9 years before the Titanic disaster. Aviation grew quickly, and the first U.S. airline was operating – however briefly – in Florida. It was the St. Petersburg-Tampa Airboat Line, which ran the world's first regularly scheduled airline service using heavier-than-air craft from January through March 1914.

Early Radio Legislation

Congress enacted the first law providing domestic control of general radio communications in 1912, partially in response to the Titanic. The Radio Act of 1912 was the beginning of government radio licensing. The Act placed the control of all wireless stations under the jurisdiction of the Department of Commerce and made access to the electromagnetic spectrum a privilege granted only by government approval. The law regulated the type of emissions, the transmission of distress calls, and set aside certain frequencies for government use.

At the time the Radio Act of 1912 was passed, the radio spectrum was so unoccupied that no one thought that frequencies would ever have to be assigned, much less shared. If you wanted to operate a transmitter, there was plenty of room in which to do it and all you had to do was apply for a license.

Radio was so new that very few understood its potential. Some barely knew what "wireless" meant. Radio pioneer Lee de Forest, the inventor of the Audion three-element vacuum tube amplifier (a very essential ingredient in the advancement of both wired and wireless communications) was prosecuted for mail fraud. The prosecutor accused de Forest of "...willfully and deliberately misleading the public by stating that soon it will be possible to transmit the human voice across the Atlantic Ocean."

A Pause in Development for World War I

The growth in commercial and public use of radio was placed on hold when the U.S. entered World War I in 1917. The Woodrow Wilson administration was concerned about possible misuse of radio by German spies. So the Federal government took over control of all commercial radio stations. And all amateur radio operators were required to cease operations and dismantle their stations under penalty of imprisonment. Radio manufacturers pooled their knowledge and expertise and turned their attention to putting this new technology to work winning the War.

World War I also provided the impetus for major advances in aircraft. New designs emerged for small fighter planes, as well as large, heavy bombers. These advances would lead to viable aircraft designs for commercial aviation after the War.

When World War I ended in November, 1918, the massive military market for radio transmitters and receivers disappeared.

The Growth of Commercial Broadcast Radio

In 1919, the American Marconi company was purchased by the Radio Corporation of America (RCA). David Sarnoff became its manager, and he led RCA into the radio business. Sarnoff envisioned a "radio music box" that would receive programs broadcast for public information and entertainment. Around the same time, General Electric and Westinghouse also began making radio receivers. Public demand for the new radio receivers was small at first because there were few stations to listen to. At the end of 1920, only 30 radio stations in the U.S. offered regular broadcasts. That changed rapidly as licensed stations went on the air and began regular broadcasting.

In Pittsburgh, Westinghouse engineer Dr. Frank Conrad set up an amateur radiotelephone station, 8XK, in 1916. Four years later, 8XK became KDKA, the nation's first commercial broadcast station transmitting on a wavelength of 360 meters (833 kHz). It signed on the air on election night, November 2, 1920, and today is the nation's oldest commercial radio station still in operation.

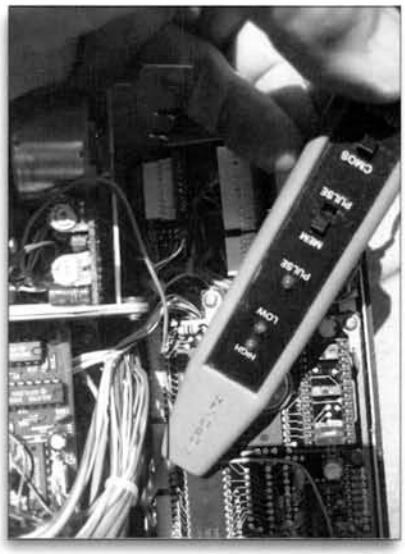
Radio history was made at 6:00 p.m. Tuesday, November 2, 1920 when four men gathered in a shack atop the Westinghouse Electric Building in Pittsburgh to broadcast election result reports to the public. KDKA, the world's first commercial broadcast radio station, was on the air!

Source: News Radio 1020, KDKA, Pittsburgh, PA

3-74L5 What instrument is used to indicate high and low digital voltage states?

A. Ohmmeter.
B. Logic probe.
C. Megger.
D. Signal strength meter.

It is the job of the logic probe to indicate high and low voltage states in a digital circuit. **ANSWER B**



Logic probe to trace digital circuits.

3-74L6 What instrument may be used to verify proper radio antenna functioning?

A. Digital ohm meter.
B. Hewlett-Packard frequency meter.
C. An SWR meter.
D. Different radio.

The instrument used to measure transmitter power output, as well as antenna forward and reflected power levels, is the Standing Wave Ratio (SWR) meter. **ANSWER C**

Key Topic 75: Test Equipment

3-75L1 How is a frequency counter used?

A. To provide reference points on an analog receiver dial thereby aiding in the alignment of the receiver.
B. To heterodyne the frequency being measured with a known variable frequency oscillator until zero beat is achieved, thereby indicating the unknown frequency.
C. To measure the deviation in an FM transmitter in order to determine the percentage of modulation.
D. To measure the time between events, or the frequency, which is the reciprocal of the time.

You must never directly couple a frequency counter to your transmitter output. Most portable counters have a small rubber antenna that will pick up the signal from a nearby antenna quite nicely. Most counters can read out a signal within 50 feet. The more expensive the counter, the further away it can read a transmitting signal. If you plan to use the counter outside, make sure you purchase a counter with an LCD display. Stay away from LED displays for outside use because you can't see their readout in the bright sunlight! **ANSWER D**

3-75L2 What is a frequency standard?

A. A well-known (standard) frequency used for transmitting certain messages.
B. A device used to produce a highly accurate reference frequency.
C. A device for accurately measuring frequency to within 1 Hz.
D. A device used to generate wide-band random frequencies.

You may already have a frequency standard in your test equipment kit, but the world's most expensive frequency standards are stations WWV and WWVH. You can pick up time signals from them on 5-, 10-, 15-, and 20-MHz. These signals are absolutely on frequency, 24 hours a day, for your equipment and test apparatus calibration. **ANSWER B**

3-75L3 What equipment may be useful to track down EMI aboard a ship or aircraft?

A. Fluke multimeter.
B. An oscilloscope.
C. Portable AM receiver.
D. A logic probe.

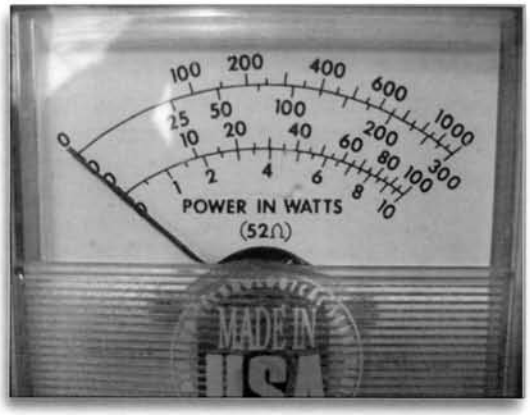
EMI stands for ElectroMagnetic Interference. EMI can cause interference problems on frequencies below 30 MHz. A small portable AM receiver – including an AM portable broadcast receiver – is a handy tool to localize the source of EMI aboard a ship or aircraft. **ANSWER C**

Simple AM radio with added loop antenna for sniffing RFI from a voltage panel.

3-75L4 On an analog wattmeter, what part of the scale is most accurate and how much does that accuracy extend to the rest of the reading scale?

A. The accuracy is only at full scale, and that absolute number reading is carried through to the rest of the range. The upper 1/3 of the meter is the only truly calibrated part.
B. The accuracy is constant throughout the entire range of the meter.
C. The accuracy is only there at the upper 5% of the meter, and is not carried through at any other reading.
D. The accuracy cannot be determined at any reading.

The accuracy is only at full scale, and that absolute number reading is carried through to the rest of the range. Many analog watt meters will use individual slugs for certain voltage scales. If you expect to accurately measure a 100 watt output transmitter, use a 100 watt slug, not a 500 watt or one kilowatt slug! Also, only depend on the upper 1/3 of the meter to be well calibrated. **ANSWER A**



Professional wattmeter.

3-75L5 Which of the following frequency standards is used as a time base standard by field technicians?

A. Quartz Crystal.
B. Rubidium Standard.
C. Cesium Beam Standard.
D. LC Tank Oscillator.

The rubidium oscillator is a dramatic improvement over the common quartz crystal. The rubidium oscillator takes about 3 minutes to lock up, and provides a much improved time standard. A 10 MHz sine wave rubidium oscillator may sometimes be found on internet swap sites for under $99! The rubidium oscillator requires a heat sink, and they take +20 to +36 volts input, at about 1.7 amps on power on, and then settling in to about ½ an amp. **ANSWER B**

3-75L6 Which of the following contains a multirange AF voltmeter calibrated in dB and a sharp, internal 1000 Hz bandstop filter, both used in conjunction with each other to perform quieting tests?

A. SINAD meter.
B. Reflectometer.
C. Dip meter.
D. Vector-impedance meter.

The term SINAD stands for Signal Plus Noise And Distortion. The SINAD meter is most commonly used to measure the sensitivity of a VHF FM receiver. **ANSWER A**

Key Topic 76: Oscilloscopes

3-76L1 What is used to decrease circuit loading when using an oscilloscope?

A. Dual input amplifiers. B. 10:1 divider probe. C. Inductive probe. D. Resistive probe.

An oscilloscope 10:1 divider probe would allow us to work with integrated circuits, minimizing any circuit loading by the test probe. **ANSWER B**

3-76L2 How does a spectrum analyzer differ from a conventional oscilloscope?

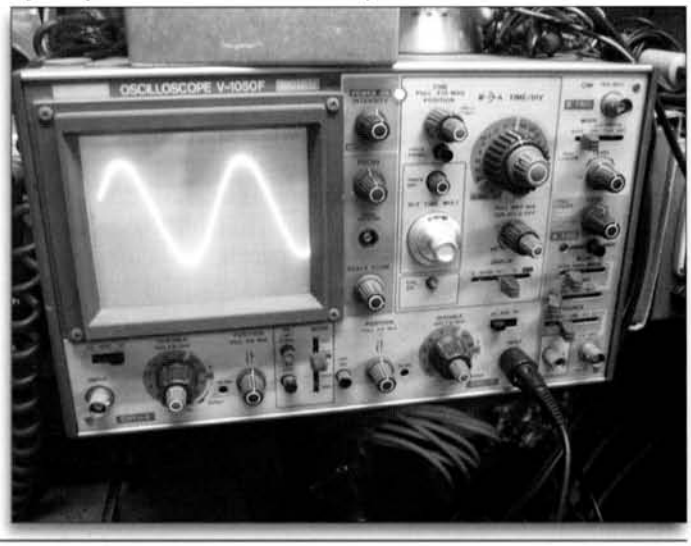
A. The oscilloscope is used to display electrical signals while the spectrum analyzer is used to measure ionospheric reflection.
B. The oscilloscope is used to display electrical signals in the frequency domain while the spectrum analyzer is used to display electrical signals in the time domain.
C. The oscilloscope is used to display electrical signals in the time domain while the spectrum analyzer is used to display electrical signals in the frequency domain.
D. The oscilloscope is used for displaying audio frequencies and the spectrum analyzer is used for displaying radio frequencies.

The spectrum analyzer displays the strength of signals at particular frequencies according to frequency (in a frequency domain) along a horizontal axis. A signal can be locked in and centered in the middle of the screen with 25 kHz to the left and 25 kHz to the right for a close examination of any off-frequency spurs it might have. A simple oscilloscope cannot display the signal in the frequency domain – it displays the signals on a time axis (in a time domain) going from left to right. With your output signal displayed on a spectrum analyzer, you may adjust your transmitter output network for minimum spurious signals. **ANSWER C**

3-76L3 What stage determines the maximum frequency response of an oscilloscope?

A. Time base.
B. Horizontal sweep.
C. Power supply.
D. Vertical amplifier.

When choosing an oscilloscope, select one with the greatest bandwidth within your price range. It is the vertical amplifier that determines the maximum frequency response of an oscilloscope. **ANSWER D**



Oscilloscope.

3-76L4 What factors limit the accuracy, frequency response, and stability of an oscilloscope?

A. Sweep oscillator quality and deflection amplifier bandwidth.
B. Tube face voltage increments and deflection amplifier voltage.
C. Sweep oscillator quality and tube face voltage increments.
D. Deflection amplifier output impedance and tube face frequency increments.

Every service shop should have a full-featured oscilloscope. Many new marine and aeronautical transceivers employ digital signal processing (DSP). This demands a stable, high-quality sweep oscillator circuit inside the scope, and the scope must also have enough bandwidth to handle high-frequency applications, as well as VHF and UHF. **ANSWER A**

3-76L5 An oscilloscope can be used to accomplish all of the following except:

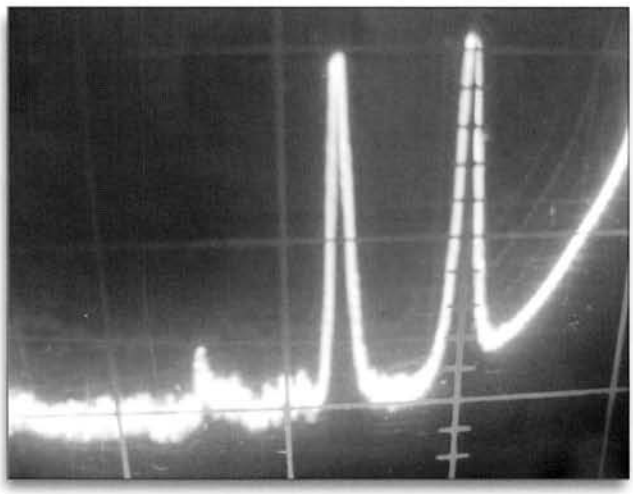
A. Measure electron flow with the aid of a resistor.
B. Measure phase difference between two signals.
C. Measure velocity of light with the aid of a light emitting diode.
D. Measure electrical voltage.

There is plenty that you can do with an oscilloscope, but one thing you cannot do is measure the velocity of light with the aid of a light emitting diode. You can measure voltage, phase, and electron flow with an oscilloscope, but not the velocity of light. **ANSWER C**

3-76L6 What instrument is used to check the signal quality of a single-sideband radio transmission?

A. Field strength meter.
B. Signal level meter.
C. Sidetone monitor.
D. Oscilloscope.

When servicing single sideband transmitters, it is the two tone test, observed on an oscilloscope, that lets you examine linearity of the transmitted signal. I also like to bring along a companion SSB receiver, first removing the antenna on the receiver, and then listening for a good quality single sideband transmission. **ANSWER D**



Oscilloscope measuring a two-tone test on an aircraft SSB.