Introduction

Mathematics warning

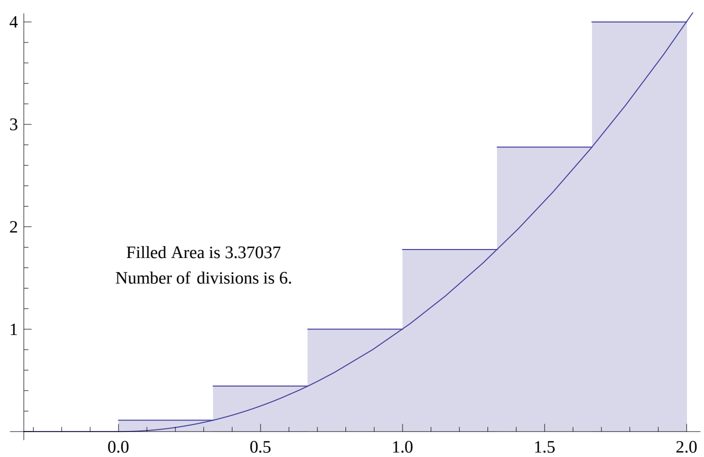
This chapter of The ARRL Extra Class License Manual uses college level mathematics: *calculus* (*limits*, *derivatives*, *integrals* and *infinite series*) in *real*, *complex* and *vector* forms. Fortunately, the potential Extra class operator does **not** have to know any of this to pass the examination!

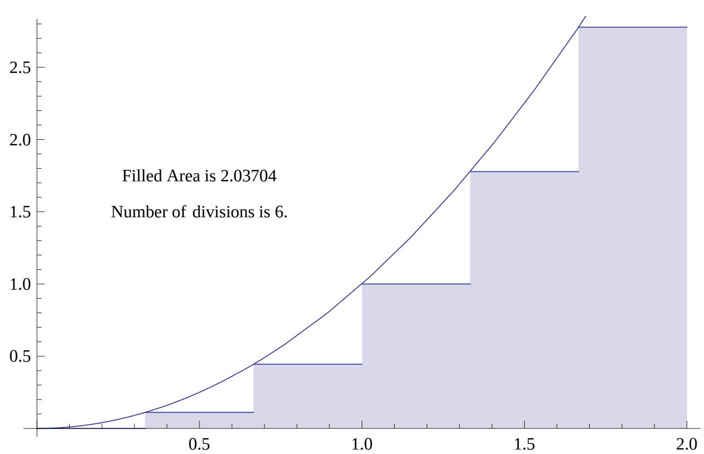
The book states, on page 7-5 mid-page: “The method . . . [computes] for a large number of points along the waveform . . . ,” which is a much simplified description of “taking a limit” in calculus. Fortunately, this description is adequate to form an understanding of the mathematical process sufficient to pass the examination.

The integral of x^2 from 0 to 2 is $\frac{8}{3}$ where the integral is the signed area (above the x-axis is positive and below the x-axis is negative).

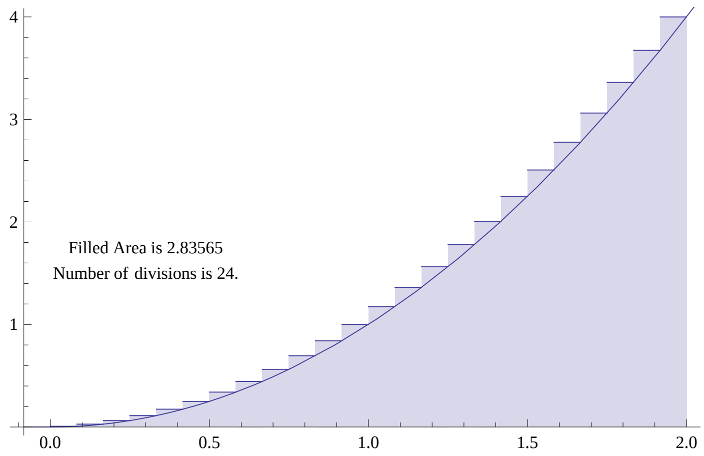
$$\int_0^2 x^2 dx = \frac{8}{3}$$

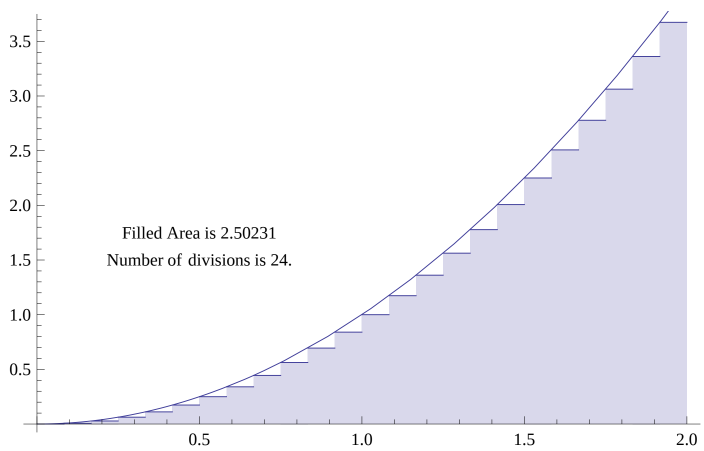
With six divisions, fitting above and below the curve:



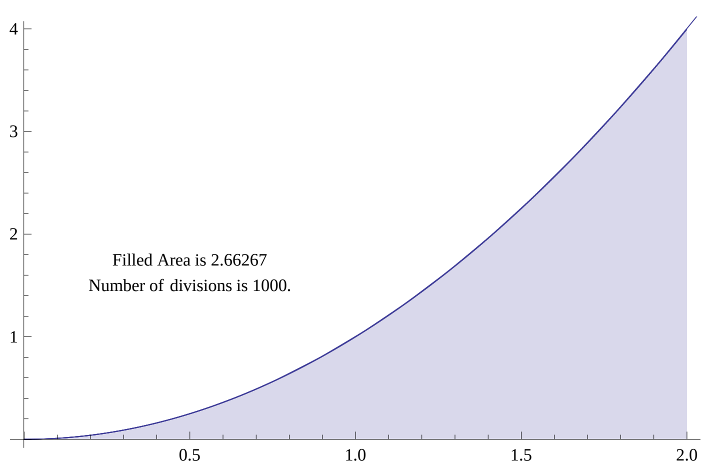


With 24 divisions, fitting above and below the curve:





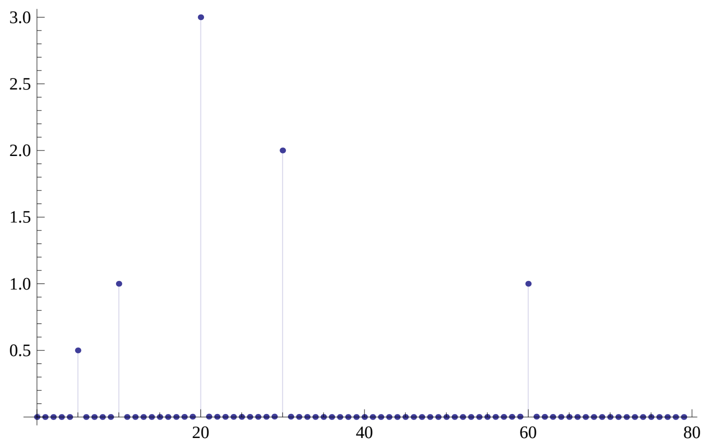
And, finally, 1000 divisions centered on the curve:



To demonstrate Fourier analysis, a table of 20,480 values were generated of the function

$$\frac{\cos(t)}{2} - \cos(t) + 2\cos(3t) - 3Sin(2t) + \cos(6t)$$

over ten cycles with steps of $\frac{1}{2048}$ of a cycle. This allows a $\frac{1}{10}$Hz resolution.



You will note that the frequencies and their strenghs were recovered by the taking the magnitude of discrete Fourier transform in polar form. But, you ask, what were the phases of the signals? Those can be determined from the angle of the discrete Fourier transform in form.

0.5Hz $0°$ indicatng $\cos$

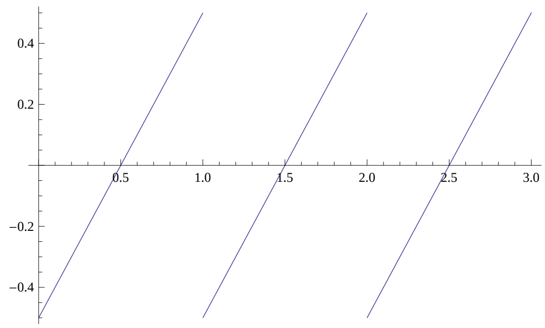
1Hz $180°$ indicating $-\cos$

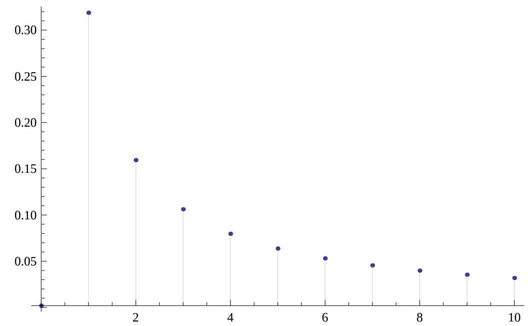
2Hz $-90°$ indicating $-\sin$

3Hz $90°$ indicating $\sin$

6Hz $-1°$ indicating $\cos$

Sawtooth and Triangle Wave Fourier Transforms



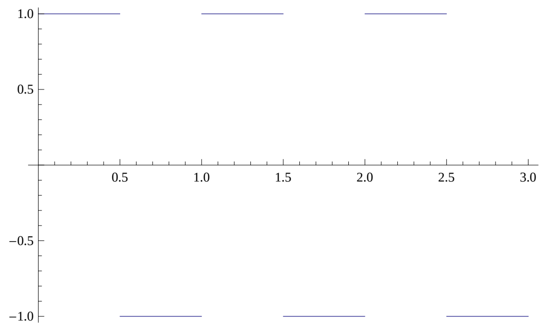


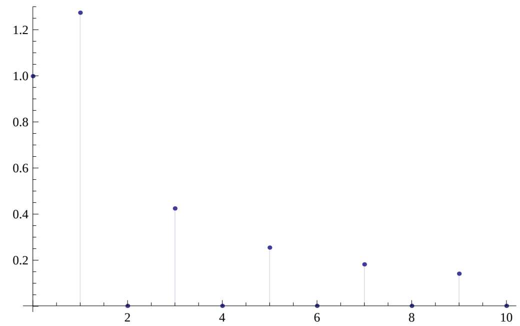
Note that all harmonics are present.

The difference a raising sawtooth, wave, a falling sawtooth wave and a centered triangle wave is in the phasing of the component frequencies.

If the wave is centered around zero, then there is no DC (zero frequency) component, which is how this demonstration was built.

Square Wave Fourier Transforms

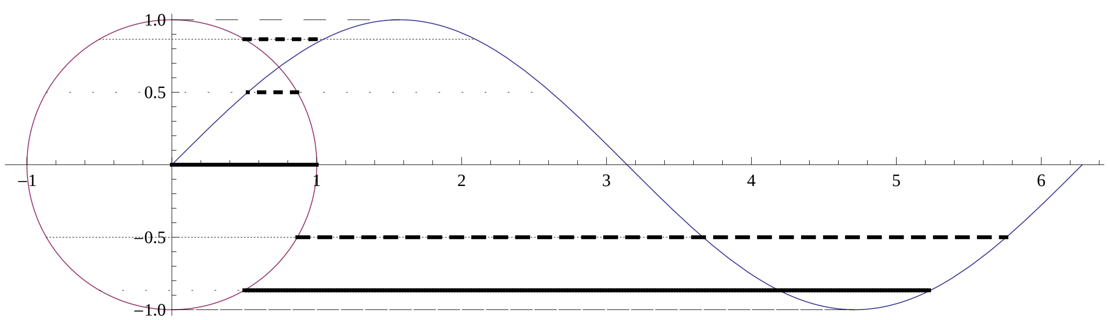




Note that only odd harmonics are present.

If the wave is centered around zero, then there is no DC (zero frequency) component, which is how this demonstration was built.

The Circle and the Sine Graph



The circumference of a circle is 2π time the radius of the circle. An angle of a radian is the angle of the distance of a radius along the circumference of the circle. Mathematicians often use this angle measure as it makes the Taylor series (more calculus!) expansions of the trigonometry functions particularly simple.

Chapter 7 Notes

AC Waveforms and Measurements

The Extra Class 2012 Pool concerns itself mostly with amplitude modulation (with and without carrier and single and double side band) and frequency modulation. The carrying of more than one stream of information in a transmitted signal is multiplexing. For example, NTSC[1] and PAL television signals have luminance (amount of light; black and white picture), chromance (how the picture is colored; there are two stream of color information and the third is computed in the receiver), three or more audio streams (left, right and secondary) and perhaps a closed captioning text string or signal management and timing data for the television stations. Multiplexing is considered with frequency division for AM and FM, time division for digital modes (pulse trains) and code divison for spread spectrum.

[1] http://en.wikipedia.org/wiki/NTSC

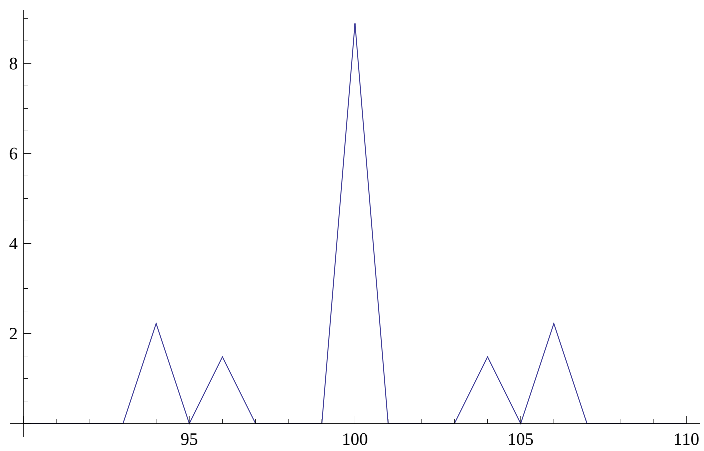
Frequency division can be viewed as separate transmitters operating on adjacent channels. Time division can be viewed as “dealing out” adjacent pulses in a pulse train to separate signals. Code divison in spread spectrum, which is very noise tolerant, just treats other signals sharing the same frequency range as noise, e.g., GPS signals.

Wikipedia articles exist for the following modulation types: *amplitude modulation* (AM), *angle modulation* (which includes both *freqency modulation* and *phase modulation*), *double side band suppressed carrier*, complex modulation (the phase of the signal viewed as rectangular coordinates is *quadrature modulation* and viewed as polar coordinates is *polar modulation*) and *spread spectrum*.

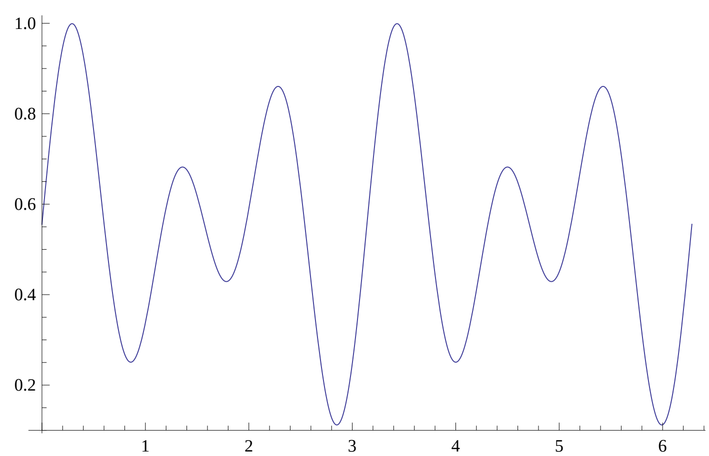
Wikipedia articles exist for some of the major multiplexing techniques: *time division multiplex*, *frequency division multiplex*, and *code division multiplex*. Polarization can also be used for multiplexing

AM modulated signal

The following is the discrete Fourier transform of a 100Hz carrier modulated with the sum of a 6Hz signak and a 4Hz signal with two-thirds of the amplitude of the 6Hz signal with a resolution of 1Hz.

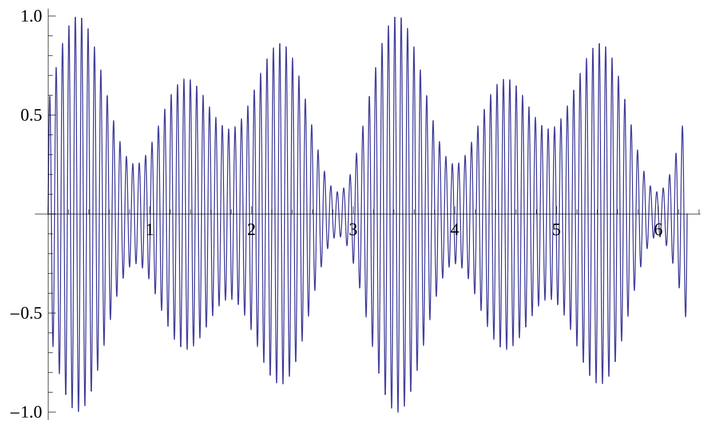


The modulating signal:

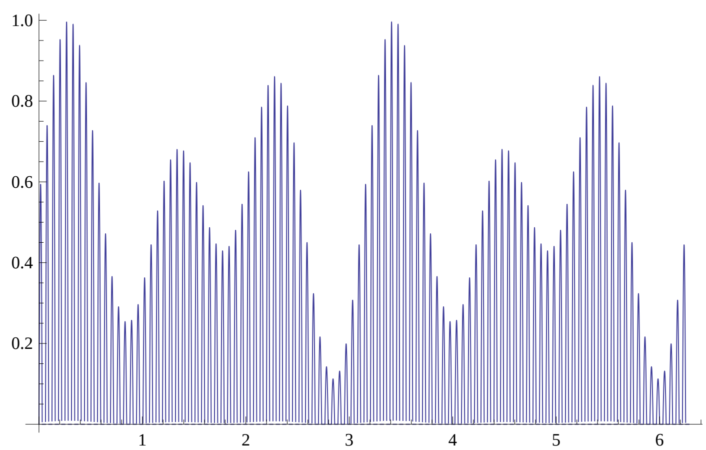


Amplitude modulation, or AM radio, transmission is not subject to [the FM signal capture effect (discussed below)]. This is one reason that the aviation industry, and others, have chosen to use AM for communications rather than FM, allowing multiple signals to be broadcast on the same channel. Similar phenomena to the capture effect are described in AM when offset carriers of different strengths are present in the passband of a receiver. For example, the aviation glideslope vertical guidance clearance beam is sometimes described as a "capture effect" system, even though it operates using AM signals.

The modulated signal:



The AM signal after detection (demodulation, rectification):



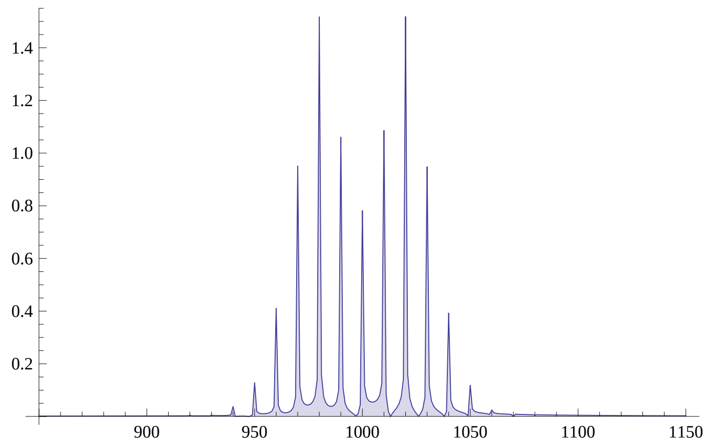
FM modulated signal

In telecommunications, the capture effect, or FM capture effect, is a phenomenon associated with FM reception in which only the stronger of two signals at, or near, the same frequency will be demodulated.

The capture effect is defined as the complete suppression of the weaker signal at the receiver limiter (if it has one) where the weaker signal is not amplified, but attenuated. When both signals are nearly equal in strength, or are fading independently, the receiver may switch from one to the other and exhibit picket fencing.

The capture effect can occur at the signal limiter, or in the demodulation stage, for circuits that do not require a signal limiter. Some types of radio receiver circuits have a stronger capture effect than others. The measurement of how well a receiver can reject a second signal on the same frequency is called the capture ratio for a specific receiver. It is measured as the lowest ratio of the power of two signals that will result in the suppression of the smaller signal.

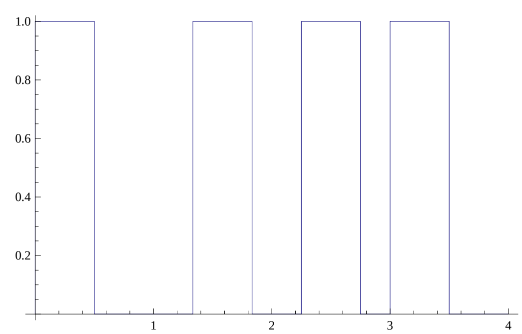
The following is the discrete Fourier transform of a 100Hz carrier modulated with a 3Hz deviation caused by a 1Hz signal with a resolution of 0.1Hz.



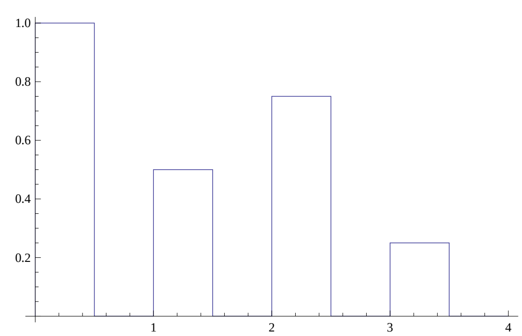
Pulse Trains

The presence, position, amplitude and width of the pulses in a pulse train may vary to carry the modulation.

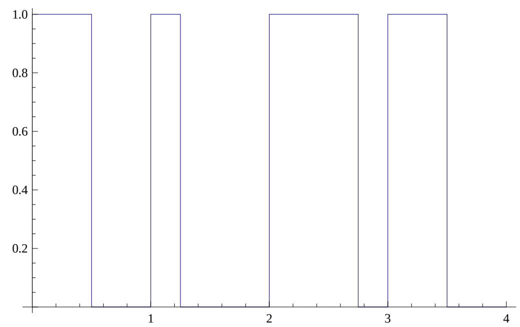
Variable position pulses:



Variable amplitude pulses:



Variable width pulses:



RADAR pulse modulation is a comples topic and radio amateurs do not operate RADAR as radio amateurs. The transmitted signal may consist of a CW pulse with a separation slightly longer than the maximum operating range of the radar or it may be a frequency swept chirp with a sweep fregency equal to the aforementioned pulse frequency where the returned frequency is analyzed to determine the range. These signals may be modulated for Identification Friend or Foe, originating transmitter identification or both. If a strong return occurs beyond the designed operating range, then a false closer return occurs.

On October 5, 1960, the moonrise occurred directly in the path of the Thule detection radar, producing a strong signal return. While the computer system never generated an impact prediction, the large amount of data caused enough concern that the equipment was subsequently modified to reject moon returns based on their long (2.5 second) delay.

Spread spectrum

The original frequency hopping spread spectrum modulation technique was invented by Heddy Lamarr, movie actress, and George Antheil, composer, during early World War II (US patent 2,292,397) and was intended for remote control of torpedoes.

The idea of chirped freguency hopping spread spectrum is to use a pseudo-random number generator to select pairs of frequencies and for each bit of information to be sent send a large number of consecutive chirps using the 0 bit encoding or the 1 bit encoding depending on the bit to be sent. The receiver uses the same pseudo-random number generator running with the same seed value. When the receiver detects a match to either the 0 or 1 bit chirp, it counts the chirp. If the preponderance of the bits are detected and the preponderance of those bits are of one value, then becomes the received bit value. For example, the GPS system uses fifty chirps per bit of data. This permits the detection of signals which are “in the noise” as the noise averages out and the signal does not.

Peak, Peak-to-peak and RMS voltages

Root mean square is defined as:

$$\sqrt{\frac{\int_0^p f(p)^2\,dt}{p}}$$

Where the integration is the continuous equivalent of the sum over the period and the division by the period length is the equivalent of the number of elements in the computation of the average.

For a sine wave:

$$\sqrt{\frac{\int_0^{2\pi} \sin(t)^2 \, dt}{2\pi}} = \frac{1}{\sqrt{2}}$$

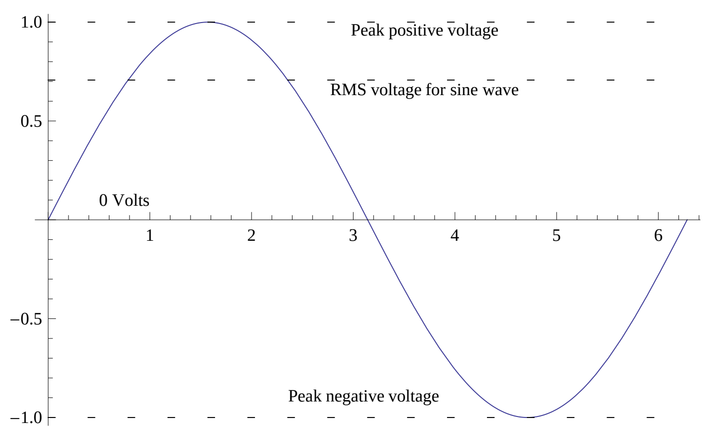
For a triangle or sawtooth wave:

$$\sqrt{\frac{\int_0^{1} (2t-1)^2 \, dt}{1}} = \frac{1}{\sqrt{3}}$$

For a square wave (which rectifies to DC!):

$$\sqrt{\frac{\int_0^{1} 1^2 \, dt}{1}} = 1$$

Peak, peak-to-peak and RMS voltages



For a signal that is complex, assymetrical or has a DC component, the positive and negative peak voltages may be different. The peak-to-peak voltage is the maximum peak voltage minus the minimum peak voltage.

If a signal has no DC component, then the average voltage is 0.

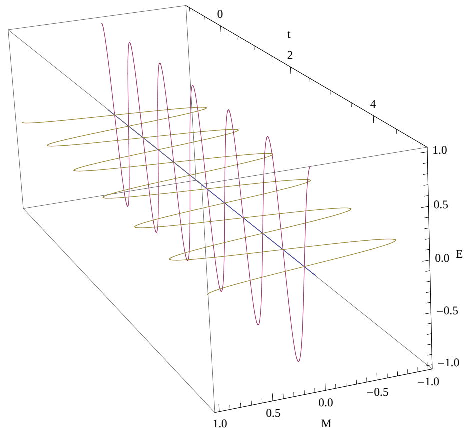
Power

$$P = E \times I = \frac{E^2}{Z} = I^2 Z$$

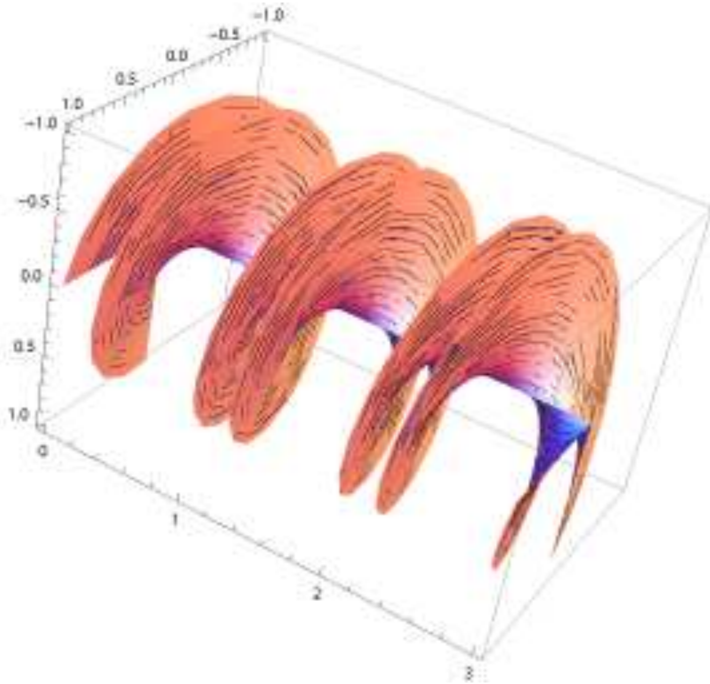
Peak envelope power (**PEP**) is $\frac{E^2}{Z}$ where the value used for is the greatest deviation from 0 Volts.

Electromagnetic Waves

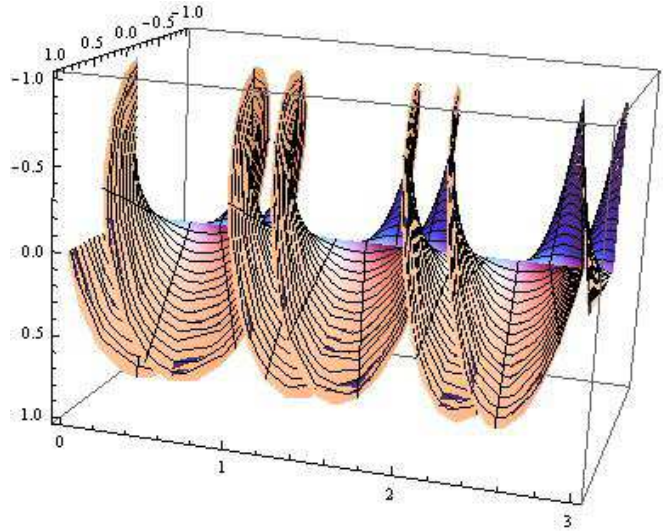
Vertically polarized electromagnetic wave (for a horizonally polarized wave, the E and M fields are swapped):



Left hand circularly polarized electromagnetic wave (one surface is the E field and the other is the M field):



For a right hand circularly polarized electromagnetic wave, the heiices would have the opposite handedness (think, left and right handed threads on a screw).



Test Equipment

Voltmeter

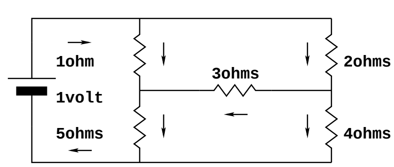
These instruments often measure other parameters that just voltage. Some measure current, resistance, capacitance and inductance. There are two performance measures of interest: precision and accuracy. Precision is how finely can the meter be read. Accuracy is expressed in a percentage of a sclae's full reading and may range from 5% to 0.01%; of course, you have to pay for more accuracy.

Dip meter

This is a tunable radio frequency oscillator with an exposed tuning coil. When the device is loosely coupled to a tuned circuit, either capacitively or inductively, is close in frequency to the resonant frequency of that tuned circuit, thd dip meter's oscillator transfers some power to the tuned circuit. This pumping action demands more power from the dip meter's oscillator and it draws more more current on its control element.

Impedance or Whetstone bridge

When the impedance ratios are the same on both sides of the circuit, there is no voltage supplied to the voltmeter. If the "upper" impedances are accurately known and the comparison impedance is well calibrated, then the unknown impedance can be computed.



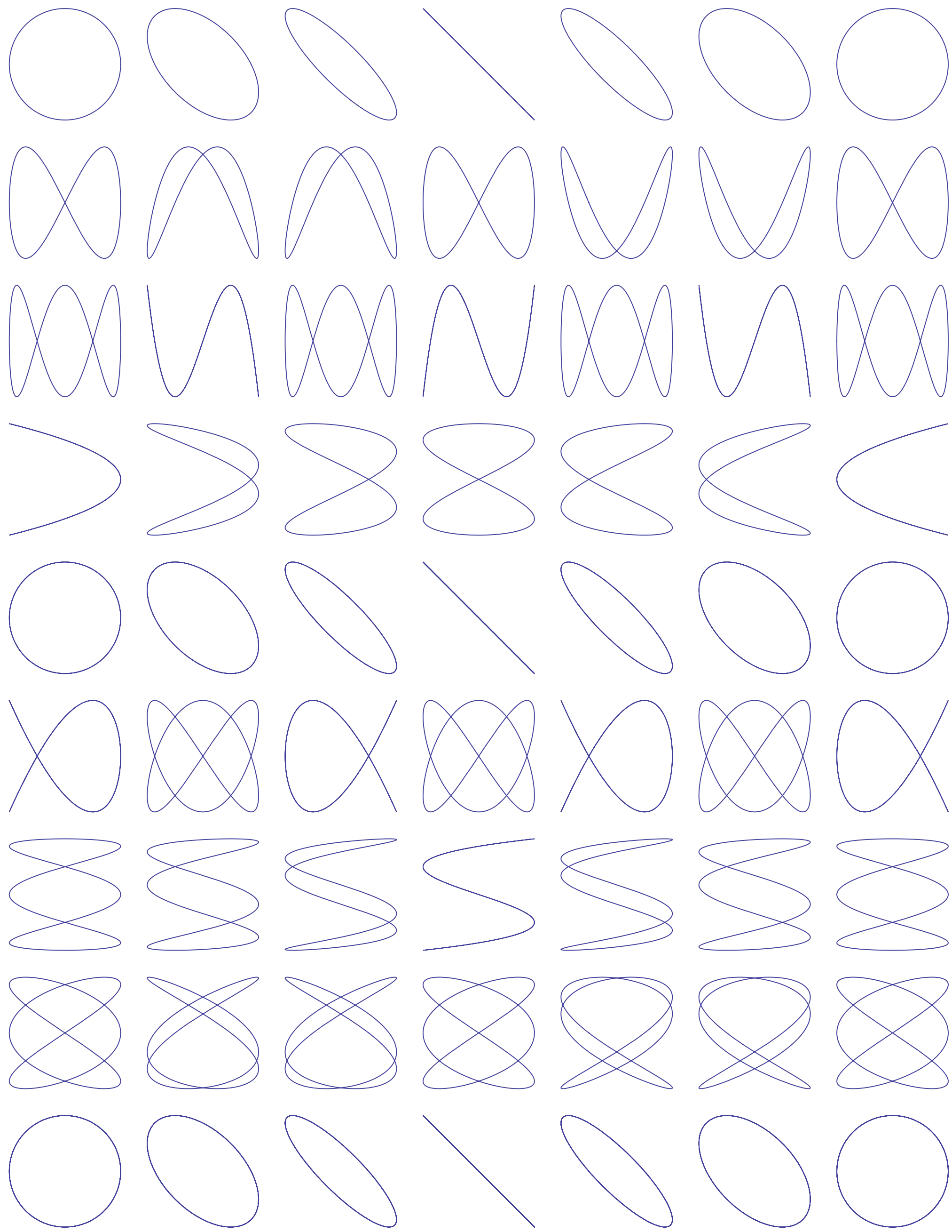
If the 4Ω resistor were 10Ω, then the impedance bridge would be balanced, there would no voltage across the 3Ω resistor and no current through it.

Frequency meter

A frequency meter either counts the number of events per second, possibly scaled, or the time between events and converts that to a frequency. The accuracy of a frequency meter is dependent of the accuracy of its time base oscillator.

Oscilloscope

An oscilloscope displays one or more signals over a time base period. Or, one sign may be applied to a horizonal and another to the vertical input. In this way, frequency ratios can be compared using Lissajous figures.



In this figure, the signals are sine waves. The phase varies from $o°$ in $30°$ increments to $180°$ horizonally. Vertically, there are three blocks of three rows of subfigures. In the subblocks, the horizonal base frequency is base frequency, second harmonic and third harmonic. Within each subblock, in each line of figures, the vertical input is base frequency, second harmonic and third harmonic.

The accuracy of an oscilloscope is dependent of the accuracy of its time base oscillator and on the linearity and accuracy of its signal amplifiers and attenuators. its input impedances should be very high so as not to affect the behavior of the circuit being measured. Its inputs should be able to withstand the input voltages to which it may be exposed.

Spectrum Analyzer

A spectrum analyzer may be either analog or digital. An analog spectrum analyzer sweeps through the frequency with a very narrow radio receiver and measures the signal strength. A digital spectrum analyzer does a discrete Fast Fourier Transform and displays the results. its input impedances should be very high so as not to affect the behavior of the circuit being measured. Its inputs should be able to withstand the input voltages to which it may be exposed.

SWR meter

A SWR meter has two directional couplers. A directional coupler extracts a small fraction of tadio frequency signal traveling in one direction only! One of the directional couplers samples the transmiter output; the other samples the power reflected by an impedance mismatched antenna. If the antenna or remote dummy load is perflectly matched, then there is no reflected power and the SWR is 1.

$$\Gamma = \frac{V_{\text{reflected}}}{V_{\text{transmitted}}}$$

$$\text{VSWR} = \frac{1+\Gamma}{1-\Gamma}$$

http://en.wikipedia.org/wiki/SWR_meter

http://www.hatdaw.com/papers/DC_Construction_Details.pdf

Modulation Systems

First	Modulation Type
N	Unmodulated carrier
A	Double sideband full carrier
R	Single sideband reduced carrier
J	Single sideband suppressed carrier
C	Vestigal sideband with full or reduced carrier
F	Frequency modulation
G	Phase modulation
P, X, L, M, Q, V, W, X	Pulse modulations

Second	Modulating signal type
0	None
1	A single digital channel w/o modulating subcarrier
2	A single digital channel with modulating subcarrier
3	A single analog channel
7	Multiple digital channels
8	Multiple analog channels

Third	Type of data
N	None
A	Telegraphy for aural reception
B	Telegraphy for automated reception
C	Facsimile
D	Data (data, telemetry or telecommand)
E	Telephony
F	Television

Interference and Noise

Transmitter intermodulation

When two or more radio sources (usually transmitters as they are generall the strongest sources) or their harmonics mix to generate sum or difference signals in any of the transmitters or some some nearby non-linear “natural” circuit (e.g., a corroded metal joint), intermodulation products are produced. These intermodulation products can cause interference and be close to desired signals.

Natural static

Lightning is a multi-gigawatt spark gap transmitter!

AC line noise

Arcing in power circuits are also spark gap transmitters.

Locating signal sources, including noise and interfence

1. Notice timing and concurrent events.
2. Turn off suspected signal sources.
3. Use directional antennae.
4. Use appropriate receivers (usually AM).

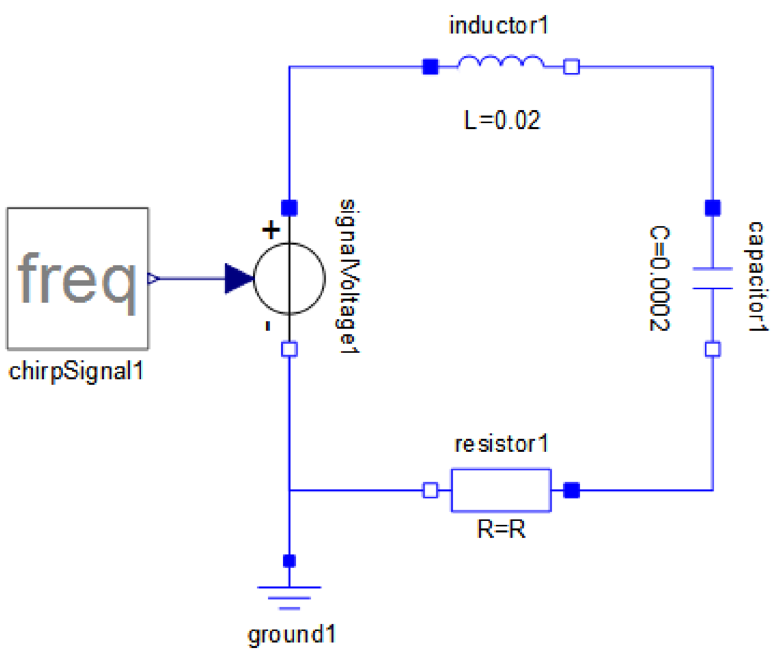
Addressing noise and interference

1. Avoid use of source.

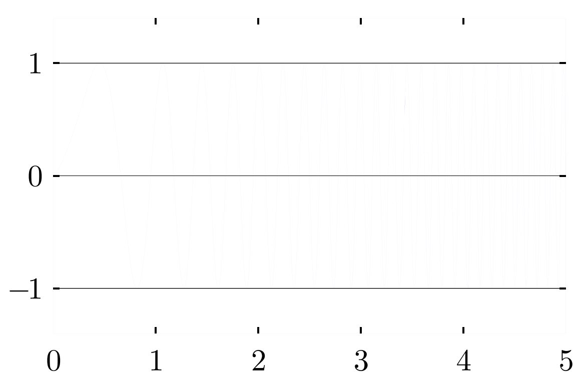
2. Repair or replace source source.
3. Isolate source with filters.
4. Prevent coupling of source to the environment.
5. Use signal processing in the receiver to avoid the noise or interference.

Circuit simulation

This simulation of a series resonant circuit with resistive damping illustrates what can be done by simulation and the effects of ringing on low and high Q circuits. The series resonant circuit is being driven by a chirped signal varying from 0 to 159 Hz (0 to 1000 radians Hz). The circuit is resonant at about 80 Hz (500 radians Hz).

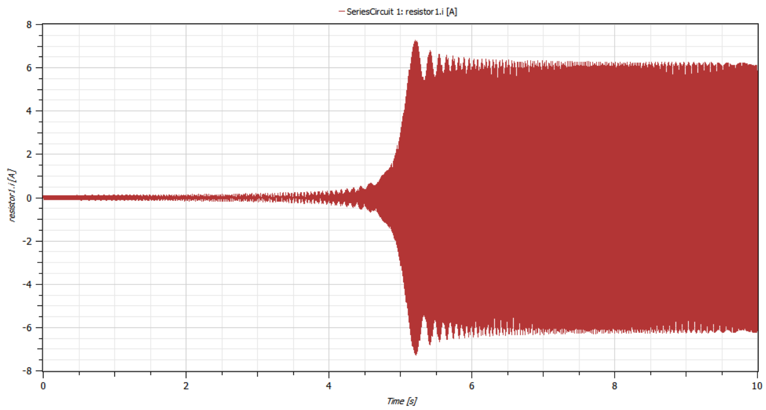


A linear chirp signal illustration from Wikipedia Commons:

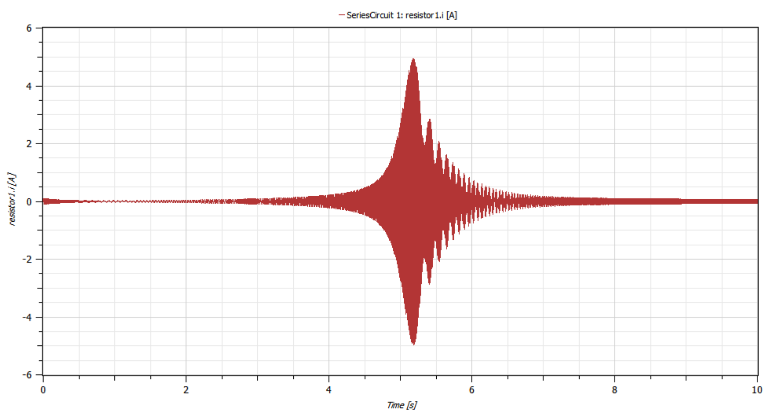


At zero resistance, the circuit is high Q. Once the resonant frequency is reached, the circuit is pumped with energy and rings “forever.” With increased resistance, the ringing becomes more and more “damped” and the peak resonant response broadens. Finally, at very low Q, the circuit broadly responses to all frequencies.

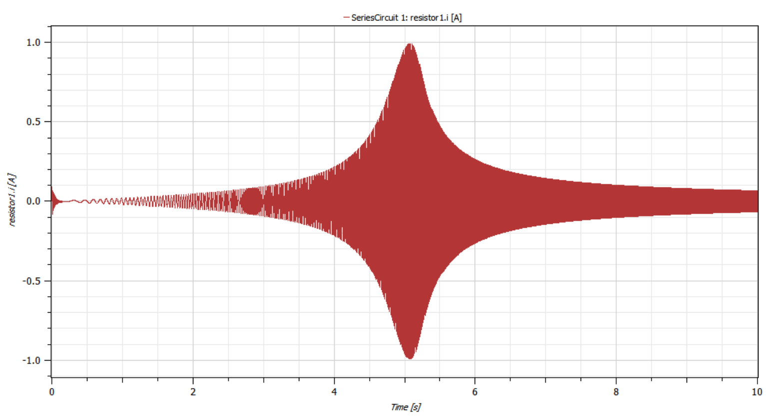
Zero resistance:



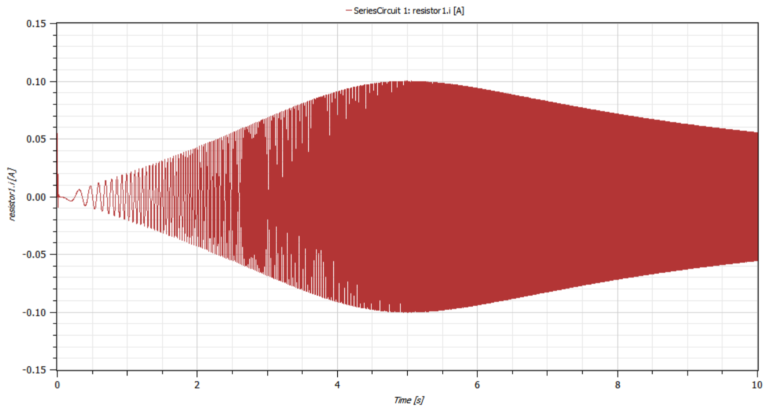
One tenth Ohm resistance:



One Ohm resistance:



Ten Ohms resistance:



1 Question by question explanations

Rather than try to give you the material so that you can answer the questions from “first principles,” I will provide enough information that you can recognize the correct answer to each question.

In several case, the correct answer among the available answer choices is also a reasonable explanation of the correct answer. In that case, I just quote the correct answer.

E1B12 What is the highest modulation index permitted at the highest modulation frequency for angle modulation?

1.0.

Frequency modulation and phase modulation are two types of angle modulation.

E4A01 How does a spectrum analyzer differ from an oscilloscope?

A spectrum analyzer displays signals in the frequency domain; an oscilloscope displays signals in the time domain.

A spectrum analyzer presents a good approximation of the instanteous Fourier transform of the signal, giving, e.g., an indication of the bandwidth of the signal.

E4A02 Which of the following parameters would a spectrum analyzer display on the horizontal axis?

Frequency.

E4A03 Which of the following parameters would a spectrum analyzer display on the vertical axis?

Amplitude.

Or, signal strength at that frequency.

E4A04 Which of the following test instruments is used to display spurious signals from a radio transmitter?

Spectrum analyzer.

E4A05 Which of the following test instruments is used to display intermodulation distortion products in an SSB transmission?

Spectrum analyzer.

E4A06 Which of the following could be determined with a spectrum analyzer?

All of these choices are correct.

All of these choices are correct: The degree of isolation between the input and output ports of a 2 meter duplexer (although this one is a bit of a stretch), whether a crystal is operating on its fundamental or overtone frequency, and the spectral output of a transmitter (this is a job that it is designed to do).

E4A10 Which of the following tests establishes that a silicon NPN junction transistor is biased on?

Measure base-to-emitter voltage with a voltmeter; it should be approximately 0.6 to 0.7 volts.

E4A11 Which of these instruments could be used for detailed analysis of digital signals?

Oscilloscope.

A spectrum analyzer could be effective as well; but that is not one of the choices.

E4A12 Which of the following procedures is an important precaution to follow when connecting a spectrum analyzer to a transmitter output?

Attenuate the transmitter output going to the spectrum analyzer.

Taking high voltage and high current precautions are also wise. These are not among the choices. These precautions are wise regardless of the type of directly attached instrument.

E4B01 Which of the following factors most affects the accuracy of a frequency counter?

Time base accuracy.

E4B02 What is an advantage of using a bridge circuit to measure impedance?

The measurement is based on obtaining a signal null, which can be done very precisely.

E4B03 If a frequency counter with a specified accuracy of +/- 1.0 ppm reads 146,520,000 Hz, what is the most the actual frequency being measured could differ from the reading?

146.52 Hz.

$\frac{146520000\ \text{Hz}}{1000000} = 146.52$ Hz .

By the way, did you notice what the frequency is: it is the 2m calling frequency.

E4B04 If a frequency counter with a specified accuracy of +/- 0.1 ppm reads 146,520,000 Hz, what is the most the actual frequency being measured could differ from the reading?

14.652 Hz.

$\frac{146520000\ \text{Hz}}{10000000} = 14.652$ Hz .

By the way, did you notice what the frequency is: it is the 2m calling frequency.

E4B05 If a frequency counter with a specified accuracy of +/- 10 ppm reads 146,520,000 Hz, what is the most the actual frequency being measured could differ from the reading?

1465.2 Hz.

$\frac{146520000\ \text{Hz}}{100000} = 1465.2$ Hz .

By the way, did you notice what the frequency is: it is the 2m calling frequency.

E4B07 Which of the following is good practice when using an oscilloscope probe?

Keep the signal ground connection of the probe as short as possible.

Long wires are antennae. They pick up (unwanted) signals.

E4B08 Which of the following is a characteristic of a good DC voltmeter?

High impedance input.

If you load down the circuit, then you may stop the circuit from working and generally will cause spurious readings and behaviors.

This is why the input stage of a good voltmeter is a grounded cathode or grounded source FET amplifier.

E4B10 Which of the following describes a method to measure intermodulation distortion in an SSB transmitter?

Modulate the transmitter with two non-harmonically related audio frequencies and observe the RF output with a spectrum analyzer.

What you are looking for are signal mixing (sum and difference frequencies) between the two audio frequencies.

E4B12 What is the significance of voltmeter sensitivity expressed in ohms per volt?

The full scale reading of the voltmeter multiplied by its ohms per volt rating will provide the input impedance of the voltmeter.

If you load down the circuit, then you may stop the circuit from working and generally will cause spurious readings and behaviors.

E4B13 How is the compensation of an oscilloscope probe typically adjusted?

A square wave is displayed and the probe is adjusted until the horizontal portions of the displayed wave are as nearly flat as possible.

This is an indication that the frequency response of the probe and oscilloscope are are “flat” as practical. Consider the Fourier composition of a square wave.

E4B14 What happens if a dip meter is too tightly coupled to a tuned circuit being checked?

A less accurate reading results.

With tight coupling, the dip meter become part of the circuit.

E4D03 How can intermodulation interference between two repeaters occur?

When the repeaters are in close proximity and the signals mix in the final amplifier of one or both transmitters.

E4D04 Which of the following may reduce or eliminate intermodulation interference in a repeater caused by another transmitter operating in close proximity?

A properly terminated circulator at the output of the transmitter.

The circulator routes the incoming signal to a matched dummy load which absorbs the power and it diverts that power from the transmitter power output amplifier preventing mixing of the signals.

E4D06 What is the term for unwanted signals generated by the mixing of two or more signals?

Intermodulation interference.

E4D07 Which of the following describes the most significant effect of an off-frequency signal when it is causing cross-modulation interference to a desired signal?

The off-frequency unwanted signal is heard in addition to the desired signal.

E4D08 What causes intermodulation in an electronic circuit?

Nonlinear circuits or devices.

E4E01 Which of the following types of receiver noise can often be reduced by use of a receiver noise blanker?

Ignition noise.

E4E02 Which of the following types of receiver noise can often be reduced with a DSP noise filter?

All of these choices are correct.

All of these choices are correct: broadband white noise, ignition noise and power line noise.

E4E03 Which of the following signals might a receiver noise blanker be able to remove from desired signals?

Signals which appear across a wide bandwidth.

E4E04 How can conducted and radiated noise caused by an automobile alternator be suppressed?

By connecting the radio's power leads directly to the battery and by installing coaxial capacitors in line with the alternator leads.

The idea is to short the RF to ground (the chassis).

E4E05 How can noise from an electric motor be suppressed?

By installing a brute-force AC-line filter in series with the motor leads.

Yes, a brute-force AC-line filter resembles a power supply output filter. It is doing a similar function.

E4E06 What is a major cause of atmospheric static?

Thunderstorms.

Did you ever hear of a spark gap transmitter? A lightning bolt is a multi-gigawatt spark gap transmitter.

E4E07 How can you determine if line noise interference is being generated within your home?

By turning off the AC power line main circuit breaker and listening on a battery operated radio.

Trying turn off the transmitter's power and use a working receiver (line powered radios would need a portable generator or battery power inverter).

E4E08 What type of signal is picked up by electrical wiring near a radio antenna?

A common-mode signal at the frequency of the radio transmitter.

E4E09 What undesirable effect can occur when using an IF noise blanker?

Nearby signals may appear to be excessively wide even if they meet emission standards.

E4E10 What is a common characteristic of interference caused by a touch controlled electrical device?

All of these choices are correct

All of these choices are correct: the interfering signal sounds like AC hum on an AM receiver or a carrier modulated by 60 Hz hum on a SSB or CW receiver, the interfering signal may drift slowly across the HF spectrum and the interfering signal can be several kHz in width and usually repeats at regular intervals across a HF band.

E4E11 Which of the following is the most likely cause if you are hearing combinations of local AM broadcast signals within one or more of the MF or HF ham bands?

Nearby corroded metal joints are mixing and re-radiating the broadcast signals. Metal oxide or sulfide junctions generally are non linear electronically and often behave as signal diodes. This causes signal mixing. Galena, lead sulfide, is often used to make point contact diodes in crystal radios.

E4E12 What is one disadvantage of using some types of automatic DSP notch-filters when attempting to copy CW signals?

The DSP filter can remove the desired signal at the same time as it removes interfering signals.

E4E13 What might be the cause of a loud roaring or buzzing AC line interference that comes and goes at intervals?

All of these choices are correct.

All of these choices are correct: arcing contacts in a thermostatically controlled device, a defective doorbell or doorbell transformer inside a nearby residencei (including yours!) or a malfunctioning illuminated advertising display.

E4E14 What is one type of electrical interference that might be caused by the operation of a nearby personal computer?

The appearance of unstable modulated or unmodulated signals at specific frequencies.

Computers use digital signals which are pulse trains which are broadband signals.

E8A01 The appearance of unstable modulated or unmodulated signals at specific frequencies?

A square wave.

E8A02 What type of wave has a rise time significantly faster than its fall time (or vice versa)?

A sawtooth wave.

E8A03 What type of wave is made up of sine waves of a given fundamental frequency plus all its harmonics?

A sawtooth wave.

E8A04 What is equivalent to the root-mean-square value of an AC voltage?

The DC voltage causing the same amount of heating in a resistor as the corresponding RMS AC voltage.

E8A05 What would be the most accurate way of measuring the RMS voltage of a complex waveform?

By measuring the heating effect in a known resistor.

E8A06 What is the approximate ratio of PEP-to-average power in a typical single-sideband phone signal?

2.5 to 1.

E8A07 What determines the PEP-to-average power ratio of a single-sideband phone signal?

The characteristics of the modulating signal.

E8A08 What is the period of a wave?

The time required to complete one cycle.

The reciprocal of period is the frequency and vis-a-vis.

E8A09 What type of waveform is produced by human speech?

Irregular.

All the other choices are “regular” is some sense.

E8A10 Which of the following is a distinguishing characteristic of a pulse waveform?

Narrow bursts of energy separated by periods of no signal.

Morse code is an example.

E8A11 What is one use for a pulse modulated signal?

Digital data transmission.

PSK31 is digital; but, there are other digital modes.

E8B01 What is the term for the ratio between the frequency deviation of an RF carrier wave, and the modulating frequency of its corresponding FM-phone signal?

Modulation index.

E8B02 How does the modulation index of a phase-modulated emission vary with RF carrier frequency (the modulated frequency)?

It does not depend on the RF carrier frequency,

E8B03 What is the modulation index of an FM-phone signal having a maximum frequency deviation of 3000 Hz either side of the carrier frequency, when the modulating frequency is 1000 Hz?

3.

$\frac{3000}{1000} = 3$

E8B04 What is the modulation index of an FM-phone signal having a maximum carrier deviation of plus or minus 6 kHz when modulated with a 2-kHz modulating frequency?

3.

$\frac{6000}{2000} = 3$

E8B05 What is the deviation ratio of an FM-phone signal having a maximum frequency swing of plus-or-minus 5 kHz when the maximum modulation frequency is 3 kHz?

1.67.

$\frac{5000}{3000} = 1\frac{2}{3} \approx 1.67$

E8B06 What is the deviation ratio of an FM-phone signal having a maximum frequency swing of plus-or-minus 5 kHz when the maximum modulation frequency is 3 kHz?

2.14.

$\frac{7500}{3500} = 2\frac{1}{7} \approx 2.14$

E8B07 When using a pulse-width modulation system, why is the transmitter's peak power greater than its average power?

The signal duty cycle is less than 100

If the duty cycle were 100carrier and peak and average power would be the same.

E8B08 What parameter does the modulating signal vary in a pulse-position modulation system?

The time at which each pulse occurs.

The time at which each pulse occurs compared to the unmodulated timing of the pulse in the pulse train.

E8B09 What is meant by deviation ratio?

The ratio of the maximum carrier frequency deviation to the highest audio modulating frequency.

E8B10 Which of these methods can be used to combine several separate analog information streams into a single analog radio frequency signal?

Frequency division multiplexing.

An example is FM stereo broadcasting. The primary signal is a 38KHz wide signal with a 19KHz reduced carrier (pilot signal). The lower side band is a frequency inverted L+R audio signal so that it appears to be be a mon-aural signal to a non-stereo receiver and the upper side band is a L-R signal. The sum of the signals is 2L and the difference is 2R.

E8B11 Which of the following describes frequency division multiplexing?

Two or more information streams are merged into a "baseband", which then modulates the transmitter.

E8B12 What is digital time division multiplexing?

Two or more signals are arranged to share discrete time slots of a data transmission.

E8D01 Which of the following is the easiest voltage amplitude parameter to measure when viewing a pure sine wave signal on an analog oscilloscope?

Peak-to-peak voltage.

E8D02 What is the relationship between the peak-to-peak voltage and the peak voltage amplitude of a symmetrical waveform?

2:1.

E8D03 What input-amplitude parameter is valuable in evaluating the signal-handling capability of a Class A amplifier?

Peak voltage.

E8D04 What is the PEP output of a transmitter that develops a peak voltage of 30 volts into a 50-ohm load?

9 watts.

$\frac{30^2}{50} \times \frac{1}{2} = 9.$

The factor of $\frac{1}{2}$ comes from the conversion of peak voltage to RMS voltage.

E8D05 If an RMS-reading AC voltmeter reads 65 volts on a sinusoidal waveform, what is the peak-to-peak voltage?

184 volts.

$2 \times 65 \times \sqrt{2} \approx 184$

E8D06 What is the advantage of using a peak-reading wattmeter to monitor the output of a SSB phone transmitter?

It gives a more accurate display of the PEP output when modulation is present.

Peak reading compared to Peak envelope power.

E8D07 What is an electromagnetic wave?

A wave consisting of an electric field and a magnetic field oscillating at right angles to each other

The orientation of the electrical field gives the signal's polarization: horizonal, vertical, left circular or right circular.

E8D08 Which of the following best describes electromagnetic waves traveling in free space?

Changing electric and magnetic fields propagate the energy.

E8D09 What is meant by circularly polarized electromagnetic waves?

Waves with a rotating electric field.

The answer could have been waves with a rotating magnetic field. The convention is to refer to the electrical field.

E8D10 What type of meter should be used to monitor the output signal of a voice-modulated single-sideband transmitter to ensure you do not exceed the maximum allowable power?

A peak-reading wattmeter.

E8D11 What is the average power dissipated by a 50-ohm resistive load during one complete RF cycle having a peak voltage of 35 volts?

12.2 watts.

$\frac{35^2}{50} \times \frac{1}{2} = 12.25$

E8D12 What is the peak voltage of a sinusoidal waveform if an RMS-reading voltmeter reads 34 volts?

48 volts.

$34 \times \sqrt{2} \approx 48$

E8D13 Which of the following is a typical value for the peak voltage at a standard U.S. household electrical outlet?

170 volts.

$120 \times \sqrt{2} \approx 170$

E8D14 Which of the following is a typical value for the peak-to-peak voltage at a standard U.S. household electrical outlet?

340 volts.

$120 \times 2 \times \sqrt{2} \approx 370$

E8D15 Which of the following is a typical value for the RMS voltage at a standard U.S. household electrical power outlet?

120V AC.

Common US household voltages are 110 to 120 Volt and 208 to 220 Volts. Only one answer is close to either of these voltages.

E8D16 What is the RMS value of a 340-volt peak-to-peak pure sine wave?

120V AC.

$340\frac{1}{2}\frac{1}{\sqrt{2}} \approx 120$

Legalese