Extra Class.
FCC License Preparation
Element 4B

To go to an explanation press the Search button and select the required question designator.

E1A01

Extra Class operators have privileges across the 80 meter band, 40 meter band, 20 meter band and 15 meter band. Generally this means exclusive privileges on the bottom 25 kHz of each band as well as some exclusive areas in the middle of each band. [97.301]

E1A02
This is a segment of the 75 - 80 meter band that is exclusive to Extra Class operators.
[97.301]

E1A03
The bottom 25 kHz of the 40 meter band is reserved exclusively for Extra Class operators.
[97.301]

E1A04
The Extra Class operator has two exclusive operating areas on the 20 meter band. [97.301]

E1A05
The Extra Class operator has two exclusive operating areas on the 15 meter band. [97.301]

E1A06
The originator and first forwarding station is responsible for making sure that the message does not violate FCC rules. Other forwarding stations are not accountable for inadvertently forwarding messages that violate the rules. However, they must not forward such messages if they become aware of the violation. [97.219]

E1A07
Message forwarding stations are not accountable for inadvertently forwarding messages that violate FCC rules. However, they must not forward such messages if they become aware of the violation. [97.219]

E1A08
Spurious emissions are radiated when your transmitter is faulty, badly adjusted or being used incorrectly. The most common cause of spurious emissions on SSB is overdriving and excessive speech processing. [97.307]

E1A09
Normally Radio Amateurs communicate with other Radio Amateurs. Other transmissions permitted include:

Communications with other FCC regulated stations in an emergency.
Communication with other US government stations for RACES purposes.
Communications with stations authorized by the FCC to communicate with amateur stations.
[97.111]

E1A10
The 219 - 220 MHz segment of this band is reserved for packet radio communications. Stations using this segment are also required to register their location with the ARRL. Some geographic restrictions also apply. [97.303]

E1A11
Written notice of 30 days or more is given by the FCC unless there is a threat to life or property. [97.27]

E1A12
You are bound by FCC rules if the vessel you are on flies the American flag in international waters. [97.5] There are some extra rules concerning operation of Amateur Radio stations aboard ships or aircraft. [97.11]

E1A13
You are bound by FCC rules if the vessel you are on flies the American flag in international waters. [97.5] There are some extra rules concerning operation of Amateur Radio stations aboard ships or aircraft. [97.11]

E1A14
This is an exception to the normal rule governing secret codes. A space telecommand station is also allowed to transmit one-way communications to the space station. [97.211]

E1B01
There are also some geographical restrictions. [97.13]

E1B02
A list is available showing the locations of the FCC monitoring facilities. [97.13]

E1B03
The actions that may be required are prescribed in FCC rules S1.1301 - 1.1319. [97.13]

E1B04
What constitutes a "well-engineered" receiver is not defined by the FCC Part 97 Rules.
[97.121]

E1B05
Restricted operation may involve keeping off particular amateur bands during the prescribed times. What constitutes a "well-engineered" receiver is not defined by the FCC Part 97 Rules. [97.121]

E1B06
This rule is designed to encourage the teaching of Amateur Radio in educational institutions.
[97.113]

E1B07
This rule is designed to encourage the teaching of Amateur Radio in educational institutions.
[97.113]

E1B08
This is a rule to help Radio Amateurs! Its purpose is to prevent State and local regulations from making it impossible to erect a reasonable antenna system. [97.15]

E1B09

This is unfortunate if you happen to live in a canyon since the antenna height is measured using local ground level. You may, however, erect an antenna 20 feet above an existing building regardless of the building height (provided that building safety and airport regulations are met.) [97.15]

E1B10
Repeaters, beacons, and auxiliary station antennas are subject to the same regulations as regular amateur radio station antenna systems. [97.15]

E1B11
Paragraph (c) of the relevant rule grants exemption for antennas less than 20 feet high.
[97.15]

E1B12
Although there are no FCC imposed restrictions there will be obvious considerations of road safety and the safety of third parties! The vehicle manufacturer and local authorities may impose or recommend restrictions but these are not under the remit of the FCC. [97.15]

E1C01
Licensed amateur operators from other countries may apply for a reciprocal permit to operate in the US. [97.17]

E1C02
Licensed amateur operators from other countries may apply for a reciprocal permit to operate in the US. [97.17]

E1C03
For example, if a foreign operator has VHF privileges in his/her own country then he/she will have VHF privileges in the US (unless the FCC specifies otherwise). [97.107]

E1C04
An alien operator uses a letter/numeral indicating location followed by his/her call sign (issued by his/her country). The station location must be given at least once per communication.
[97.119]

E1C05
US citizens are not eligible for reciprocal permits even though they may hold a call sign from another country. [97.17]

E1C06
Use FCC Form 610 for a new operator license.
Use FCC Form 610-A for a reciprocal permit.
Use FCC Form 610-B for a new club license.
[97.17]

E1C07
The person must be a citizen of the country that issued the amateur service license. [97.17]

E1C08
A Canadian government issued license is acceptable in place of a reciprocal permit. [97.17]

E1C09
Many young people enjoy Ham radio as a hobby. [97.17]

E1C10
An amateur license is good for ten years. A reciprocal permit is good for one year. [97.25]

E1C11
The rule that applies is: "No person who has been granted an amateur license is eligible for a reciprocal permit for alien and amateur licensee." [97.17]

E1D01
You may operate a Radio Amateur Civil Emergency Service (RACES) station if you hold an FCC issued operator license and are enrolled in a civil defense organization. [97.3]

E1D02
You may operate a Radio Amateur Civil Emergency Service (RACES) station if you hold an FCC issued operator license and are enrolled in a civil defense organization. [97.407]

E1D03
You may operate a Radio Amateur Civil Emergency Service (RACES) station if you hold an FCC issued operator license and are enrolled in a civil defense organization. [97.407]

E1D04
You may operate a Radio Amateur Civil Emergency Service (RACES) station if you hold an FCC issued operator license and are enrolled in a civil defense organization. [97.407]

E1D05
You may operate a Radio Amateur Civil Emergency Service (RACES) station if you hold an FCC issued operator license and are enrolled in a civil defense organization. [97.21]

E1D06
You may operate a Radio Amateur Civil Emergency Service (RACES) station if you hold an FCC issued operator license and are enrolled in a civil defense organization. [97.407]

E1D07
No extra bands or band segments are available to RACES stations. [97.407]

E1D08
No extra bands or band segments are available to RACES stations. [97.407]

E1D09
The frequencies available under such an emergency are listed in [97.407].

E1D10
Normally, Radio Amateurs communicate with other Radio Amateurs. Other transmissions permitted include:

Communications with other FCC regulated stations in an emergency.
Communication with other US government stations for RACES purposes.
Communications with stations authorized by the FCC to communicate with amateur stations.
[97.407]

E1D11
Normally, Radio Amateurs communicate with other Radio Amateurs. Other transmissions permitted include:

Communications with other FCC regulated stations in an emergency.
Communication with other US government stations for RACES purposes.
Communications with stations authorized by the FCC to communicate with amateur stations.
[97.407]

E1E01
Radio Amateurs may use the Amateur satellite service just like any other Amateur service.
Most Amateur Radio satellites are used as orbiting repeaters. [97.207]

E1E02
The bands and band segments available for space stations are listed in [97.207].

E1E03
The bands and band segments available for space stations are listed in [97.207].

E1E04
Telecommand operation is distinct from normal usage of a space station as a repeater.
[97.207].

E1E05
The telecommand station is subject to the privileges of the control operator. [97.207].

E1E06
The telemetry may relate to communications by way of the spacecraft or it may relate to other functions of the craft. [97.207].

E1E07
An altitude higher than 50 km above the earth's surface is considered to be space. Below this altitude is considered to be Earth. [97.3]

E1E08
The telecommand station must be operated within the license privileges of the control operator. [97.207].

E1E09
A further notification is required once the station is in operation. Notice must also be given when the station ceases operation. [97.207]

E1E10
Once the space station begins operation you have seven days to give the FCC written notice.
[97.207]

E1E11
After the space station ceases operation, the licensee should give notice to the FCC within three months of shut down. [97.207]

E1E12
An altitude higher than 50 km above the surface of the earth is considered to be space. Below this altitude, a station is considered to be an Earth station. [97.3] (Paragraph 38)

E1F01
The ARRL/VEC offers monthly examinations throughout the US. [97.521]

E1F02
This question is checking that you know the difference between a VE (Volunteer Examiner) and a VEC (Volunteer Examiner Coordinator). [97.519]

E1F03
A VEC must NOT be engaged in the manufacture or distribution of amateur station equipment or amateur license preparation materials without FCC approval. [97.521]

E1F04
A VEC must NOT be engaged in the manufacture or distribution of amateur station equipment or amateur license preparation materials without FCC approval. [97.521], [97.523]

E1F05
A VEC must NOT be engaged in the manufacture or distribution of amateur station equipment or amateur license preparation materials without FCC approval. [97.521], [97.523]

E1F06
This question is checking that you understand the function of a VEC (Volunteer Examiner Coordinator). [97.519]

E1F07
A VE must NOT be engaged in the manufacture or distribution of amateur station equipment or amateur license preparation materials without FCC approval. Approval may be granted so long as the VE is not involved with that part of the company that manufactures such equipment and materials. [97.521], [97.523]

E1F08
The examination candidates may be asked to pay an examination fee to reimburse the VE and the VEC for out of pocket expenses.   Currently, up to $6 is a typical amount (1996).
[97.527]

E1F09
To become accredited by a VEC a person must be:

Eighteen or more years old,
Competent to perform the duties of a VE,
Acceptable to the FCC,
A person who has been granted an FCC amateur operator license.

The person must not be
A person who has ever had a license revoked or suspended,
Involved in an activity that could result in a conflict of interest.

[97.509], [97.525]

E1F10
The FCC is advised of any discredited VE's. [97.527]

E1F11
Any question that you may be asked in your examination must be drawn from the FCC question pools. These are the same question pools that are used by NuTest. [97.523]

E1G01
To become accredited by a VEC a person must be:

Eighteen or more years old,
Competent to perform the duties of a VE,
Acceptable to the FCC,
A person who has been granted an FCC amateur operator license.

The person must not be
A person who has ever had a license revoked or suspended,
Involved in an activity that could result in a conflict of interest.

[97.5259], [97.527]

E1G02
To become accredited by a VEC a person must be:

Eighteen or more years old,
Competent to perform the duties of a VE,
Acceptable to the FCC,
A person who has been granted an FCC amateur operator license.

The person must not be
A person who has ever had a license revoked or suspended,
Involved in an activity that could result in a conflict of interest.

[97.509], [97.525]

E1G03
To become accredited by a VEC a person must be:

Eighteen or more years old,
Competent to perform the duties of a VE,
Acceptable to the FCC,
A person who has been granted an FCC amateur operator license.

The FCC amateur operator license class determines which classes of examination can be administered by the person. [97.509] contains further details. [97.525]

E1G04
Any amateur that has ever had his/her license suspended or revoked may not be an accredited volunteer examiner. [97.509]

E1G05
VEs must keep records of out-of-pocket expenses and reimbursements and forward them to the VEC annually on or before January 15 of the following year. The VEC must then forward them to the FCC by January 31 of that year. [97.527]

E1G06
VEs must keep records of out-of-pocket expenses and reimbursements and forward them to the VEC annually on or before January 15 of the following year. The VEC must then forward them to the FCC by January 31 of that year. The records must be kept for 3 years. [97.527]

E1G07
VEs must keep records of out-of-pocket expenses and reimbursements and forward them to the VEC annually on or before January 15 of the following year. The VEC must then forward them to the FCC by January 31 of that year. The records must be kept for 3 years. [97.527]

E1G08
The correct answer is almost a direct quotation from paragraph [97.527] of the Part 97 rules.

E1G09
Reimbursement for out-of-pocket expenses is the only payment allowed. [97.527] of the Part 97 rules apply.

E1G10
An Extra Class accredited VE may prepare code and theory exams for all license classes including Extra Class. A code or theory exam must be prepared or obtained by an accredited VE who has an FCC operator license at least one class above the candidate. However, this is not the case for the Extra class exam. Only Extra class Hams may prepare an Extra class examinations. A test properly pre-prepared by a qualified supplier on computer disk or cassette tape would be acceptable if the VEC permits this. [97.507]

E1G11
An Extra Class accredited VE may prepare code and theory exams for all license classes including Extra Class. A code or theory exam must be prepared or obtained by an accredited VE who has an FCC operator license at least one class above the candidate. However, this is not the case for the Extra class exam. Only Extra class Hams may prepare an Extra class examinations. A test properly pre-prepared by a qualified supplier on computer disk or cassette tape would be acceptable if the VEC permits this. [97.507]

E1G12
An Extra Class accredited VE may prepare code and theory exams for all license classes including Extra Class. A code or theory exam must be prepared or obtained by an accredited VE who has an FCC operator license at least one class above the candidate. However, this is not the case for the Extra class exam. Only Extra class Hams may prepare an Extra class examinations. A test properly pre-prepared by a qualified supplier on computer disk or cassette tape would be acceptable if the VEC permits this. [97.507]

E1G13
The administering VEs are coordinated by the VEC.   Section [97.509] of the FCC Part 97 rules lists the qualifications for an administering VE.

E1H01
VEs should make sure the candidate understands the importance of safekeeping of the CSCE. This is the proof that they have passed an examination element until their higher grade FCC license arrives in the mail. The successful applicant in possession of a CSCE can begin using new privileges immediately provided he/she appends specific letters to the existing call sign as follows:

AG General Class
AA Advanced Class
AE Extra Class.

[97.505]

E1H02
The observing should not be so obtrusive as to distract the candidates! [97.509]

E1H03
This is explained in Paragraph [97.509] of the Part 97 FCC Rules.

E1H04
Only the individual candidates' examination need be terminated, not the whole examination.
[97.509]

E1H05
After completion, the examination is immediately graded by a VE. [97.509]

E1H06
After completion, the examination is immediately graded by a VE. If the applicant failed to achieve a passing grade then he/she must be informed and the application form returned. [97.509]

E1H07
After completion, the examination is immediately graded by a VE. If the applicant achieves a pass grade then he/she must be informed and the qualification is certified. [97.509]

E1H08
Volunteer examiners have 10 days after the administering examinations to submit applications and test papers to the VEC.   [97.509]

E1H09
A code or theory exam must be prepared or obtained by an accredited VE who has an FCC operator license at least one class above the candidate. However, this is not the case for the Extra class exam. Only Extra class Hams may prepare an Extra class examinations.
[97.509]

E1H10
A code or theory exam must be prepared or obtained by an accredited VE who has an FCC operator license at least one class above the candidate. However, this is not the case for the Extra class exam. Only Extra class Hams may prepare an Extra class examinations.
[97.509]

E1H11
VEs should make sure the candidate understands the importance of safekeeping of the CSCE. Until their higher grade license arrives in the mail, this is the proof that they have passed an examination element. The successful applicant in possession of a CSCE can begin using new privileges immediately provided he/she appends specific letters to the existing call sign as follows:

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[97.505]

E1H12
VEs should make sure the candidate understands the importance of safekeeping of the CSCE. Until their higher grade license arrives in the mail, this is the proof that they have passed an examination element. The successful applicant in possession of a CSCE can begin using new privileges immediately provided he/she appends specific letters to the existing call sign as follows:

AG General Class
AA Advanced Class
AE Extra Class.

[97.505]

E2A01
When describing satellite orbits, the North Pole is assumed to be at the top. So a satellite with a tilted orbit will sometimes be "ascending" from South to North and sometimes "descending" from North to South.

E2A02

When describing satellite orbits, the North Pole of the Earth is assumed to be at the top. So a satellite with a tilted orbit will sometimes be "ascending" from South to North and sometimes "descending" from North to South.

E2A03
The "period" of an amateur satellite is the amount of time that it takes to make one complete orbit of the Earth.

E2A04
You need operating privileges on the relevant bands just like any other amateur repeater.

E2A05
In Mode B both input and output frequencies are VHF with the output on 2 meters. Mode B frequencies are reversed in Mode J where it is the output that is on 70 cm.

E2A06
In Mode B both input and output frequencies are VHF with the output on 2 meters. Mode B frequencies are reversed in Mode J where it is the output that is on 70 cm.

E2A07
In Mode L the satellite receives on 23 cm and re-transmits on 70 cm.

E2A08
A linear transponder is like a mixer. It re-transmits input signals in the output band exactly as they were received except for the frequency change. If the conversion involved a frequency difference then the output band will be inverted.

E2A09
As a satellite is approaching your receiving station, the Doppler effect will make its frequencies several hundred hertz higher. As a satellite moves away the signals will decrease in frequency.

E2A10
Satellites rotate to evenly distribute heat from solar radiation.

E2A11
A circularly polarized antenna minimizes fading due to changes in received signal polarization. However, it has a loss of approximately 3 dB gain over a correctly oriented dipole.

E2B01
A frame refresh rate of 30 times per second is similar to domestic TV. Domestic television receivers can be easily adapted for fast scan amateur TV service.

E2B02
The total lines are scanned in two passes, each one of 262.5 lines. This technique is called interlacing and helps reduce visible flicker.

E2B03
The total lines are scanned in two passes, each one of 262.5 lines. This technique is called interlacing and helps reduce visible flicker.

E2B04
If the signal is not blanked then the extra "flyback" lines will be visible. The frame "flyback" line can sometimes be seen on a faulty or maladjusted television set as one or more diagonal lines across the picture.

E2B05
One volt peak to peak is the standard video voltage.

E2B06
Fast scan television requires a wide bandwidth and therefore is only used on 432 MHz and above.

E2B07
At 0.7 volts the standard TV signal is at black level.

E2B08
At 0.125 volts the standard TV signal is at white level.

E2B09
At 0.75 volts the signal is at blanking or "blacker than black" level.

E2B10
Deep fading will result in a noisy picture.   FM TV is not immune from fading.

E2B11
A separate audio link on another band, such as the 2-meter band, is the most common method of providing accompanying audio.

E2C01
The 20 meter band is open mainly during daylight hours during a solar minimum. Due to the phenomena of gray line propagation, dawn and dusk are especially good times to operate DX. Near a solar minimum, openings on 28 MHz tend to be infrequent. So, this band is not a good choice for DX contest use. The 160 - 40 meter bands benefit from reduced D-layer absorption during the evening especially during years of low solar activity.

E2C02
A full DX operating code is published in the ARRL Radio Amateurs Handbook.

E2C03
The fundamental purpose of Amateur Radio is summarized in Paragraph [97.1] of the FCC rules. Of course, contests are great fun as well!

E2C04
The DX station may issue instructions such as "10U" meaning "call me 10 kHz up from this frequency."

E2C05
In the worldwide "Maidenhead" system the first two letters constitute a 20° x 10° field. This is followed by two numbers designating a 2° x 1° square. To indicate location more precisely, two final letters are used to indicate the 5' x 2.5' sub-square.

E2C06

In the worldwide "Maidenhead" system the first two letters constitute a 20° x 10° field. This is followed by two numbers designating a 2° x 1° square. To indicate location more precisely, two final letters are used to indicate the 5' x 2.5' sub-square.

E2C07
This is the basic "rubber stamp" QSO.

E2C08
By tradition, the lower parts of the amateur bands have been reserved for weak or esoteric signals.

E2C09
By tradition, the lower parts of the amateur bands have been reserved for weak or esoteric signals.

E2C10
By tradition, the lower parts of the amateur bands have been reserved for weak or esoteric signals.   A frequency of 1,832 kHz is in the lower frequency segment of the 160 meter amateur band.

E2C11
The MUF will decrease as the amount of ionization in the ionosphere decreases due to lack of solar flux.

E2D01
RTTY is still a common method of data transmission.

E2D02
Each character is transmitted twice and the received character pairs must match to be flagged as error free.

E2D03
Each character is transmitted twice and the received character pairs must match to be flagged as error free. There is no handshaking involved. The receiving station does not acknowledge correct receipt of the data.

E2D04
The "CMD:" prompt is analogous to the "C:>" DOS prompt on a PC screen.

E2D05
The ASCII 7 bit code allows upper and lower case text to be transmitted whereas the Baudot 5 bit code uses uppercase letters only.

E2D06
Selective fading can introduce a deep notch into the signal passband that can attenuate the mark or space signal.

E2D07
Facsimile is similar to slow scan TV except that the output image is printed as "hard copy".

E2D08
Facsimile is similar to slow scan TV except that the output image is printed as "hard copy". The sending rate of the image must be slow enough to keep the bandwidth down to the equivalent voice transmission. This restriction also applies to slow scan TV.

E2D09
AMTEX is a system that W1AW uses to transmit bulletins to radio amateurs. Each bulletin has a special message header containing information about the source and type of bulletin. This information, combined with a two-digit serial number, allows AMTEX receiving equipment to ignore bulletins that have already been received.

E2D10
Packet Clusters are groups of packet stations sharing a common local channel for distribution and sharing of information. The stations in the cluster typically share a common interest, such as DX working.

E2D11
Packet radio is open to all operators within their License class privileges.

E3A01
Moon bounce is a marginal, but exciting, communication method. Both stations need high power transmitters and high gain antennas. The main modulation method used in moon bounce is CW. The distance between stations is not relevant so long as both stations can see the Moon.

E3A02
Multiple radio paths will exist due to multiple reflections from the irregular lunar surface. As the Moon "wobbles" (libation) the signals alternately combine and cancel.

E3A03
The moon's orbit is not perfectly circular; it is an ellipse. Perigee is the time when the moon is closest to the earth.

E3A04
For EME operation, it is mandatory to use a receiver with front end transistors that have extremely high gain and low noise.

E3A05
Because EME contacts are rather marginal and subject to fading experience has shown that two minute sequencing gives the best chance of successful contacts on 144 MHz.

E3A06
Because EME contacts are rather marginal and subject to fading experience has shown that two and one half minute sequencing gives the best chance of successful contacts on 432 MHz.

E3A07
EME contacts are rather marginal and certainly qualify as weak signals. They are therefore found at the bottom end of the amateur bands.

E3A08
EME contacts are rather marginal and certainly qualify as weak signals. They are therefore found at the bottom end of the amateur bands.

E3A09
The ionized trails from meteors persist for seconds or tens of seconds and can be used for communications purposes. During a heavy meteor shower MS communication on CW and SSB is possible for minutes at a time. Unlike moon bounce communications, meteor shower communication can be achieved with relatively modest radio equipment.

E3A10
The ionized trails from meteors persist for seconds or tens of seconds and can be used for communications purposes. During a heavy meteor shower MS communication on CW and SSB is possible for minutes at a time. Unlike moon bounce communications, meteor shower communication can be achieved with relatively modest radio equipment.

E3A11
The ionized trails from meteors persist for seconds or tens of seconds and can be used for communications purposes. During a heavy meteor shower MS communication on CW and SSB is possible for minutes at a time. Usually, however, the signal path will exist for ten seconds or so and 15 second time sequences have been found to be the optimum.

E3B01
Transequatorial propagation is thought to occur by the F2 layer. Both CW and SSB are the normal modes for TE on VHF and UHF bands.

E3B02
The maximum distance for a TE (transequatorial) contact is 5000 miles.

E3B03
The best time of day for TE propagation is mid afternoon or early evening. This is the time when the level of ionization has had chance to build up during the day.

E3B04
Normally two stations will attempt to communicate by a great circle "short path". However, due to the position of the sun, a "long path" signal (in the opposite direction from the "short path") may offer better propagation conditions.

E3B05
Normally two stations will attempt to communicate by a great circle "short path". However, due to the position of the sun, a "long path" signal (in the opposite direction from the "short path") may offer better propagation conditions. Long path propagation will not occur on the VHF bands (above 6 meters).

E3B06
Normally two stations will attempt to communicate by a great circle "short path". However, due to the position of the sun, a "long path" signal (in the opposite direction from the "short path") may offer better propagation conditions. Long path signals are most common on the 20 meters band.

E3B07
The echo delay can be appreciable. It can last a fraction of a second and be noticeable. The echo delay is due to the difference in distance between the direct path and the long path..

E3B08
Enhanced gray line propagation may be present during a time window of 30 minutes.
Propagation will be North and South and at dusk and dawn.

E3B09
Enhanced gray line propagation may be present during a time window of 30 minutes.
Propagation will be North and South and at dusk and dawn.

E3B10
Enhanced gray line propagation may be present during a time window of 30 minutes. Propagation will be North and South and at dusk and dawn. Most signal absorption occurs in the D-layer and this rapidly disappears at twilight. The E and F layers take longer to weaken and so excellent propagation is likely for a short period.

E3B11

Enhanced gray line propagation may be present during a time window of 30 minutes. Propagation will be North and South and at dusk and dawn. Most signal absorption occurs in the D-layer and this rapidly disappears at twilight. The E and F layers take longer to weaken and so excellent propagation is likely for a short period.

E4A01
The horizontal axis in an oscilloscope usually represents time. In a spectrum analyzer the horizontal axis represents frequency. Spectrum analyzers are great for observing transmitter output signals. Spurious emissions and the effect of various adjustments can be clearly seen. A spectrum analyzer is required to tune most modern solid state amplifiers.

E4A02
The display of a spectrum analyzer is a graph of signal strength versus frequency. The horizontal axis represents frequency. The frequency range to be observed can be adjusted.

E4A03
The display of a spectrum analyzer is a graph of signal strength versus frequency. The vertical axis represents the amplitude of the signal.

E4A04

Spectrum analyzers are great for observing transmitter output signals. Spurious emissions and the effect of various adjustments can be clearly seen. A spectrum analyzer is required to tune most modern solid state amplifiers.

E4A05
Spectrum analyzers are great for observing transmitter output signals. Spurious emissions and the effect of various adjustments can be clearly seen. A spectrum analyzer is required to tune most modern solid state amplifiers.

E4A06
This is a time measurement and an oscilloscope would be the best measuring instrument.

E4A07

Spectrum analyzers are great for observing transmitter output signals. Spurious emissions and the effect of various adjustments can be clearly seen. A spectrum analyzer is required to tune most modern solid state amplifiers.

E4A08

A logic probe indicates points in a circuit that are in either a logic low or a logic high state. This is a quick way to determine logic circuit operation. There are two variations of logic circuits that may require different types of logic probe (dual purpose probes are also available). The TTL device family has nominal logic levels of 0 and +5 volts. The CMOS device family has nominal logic levels of +/-V(supply).

E4A09

A logic probe indicates points in a circuit that are in either a logic low or a logic high state. This is a quick way to determine logic circuit operation. There are two variations of logic circuits that may require different types of logic probe (dual purpose probes are also available). The TTL device family has nominal logic levels of 0 and +5 volts. The CMOS device family has nominal logic levels of +/-V(supply).

E4A10

A logic probe indicates points in a circuit that are in either a logic low or a logic high state. This is a quick way to determine logic circuit operation. There are two variations of logic circuits that may require different types of logic probe (dual purpose probes are also available). The TTL device family has nominal logic levels of 0 and +5 volts. The CMOS device family has nominal logic levels of +/-V(supply).

E4A11
A logic probe indicates points in a circuit that are in either a logic low or a logic high state. This is a quick way to determine logic circuit operation. There are two variations of logic circuits that may require different types of logic probe (dual purpose probes are also available). The TTL device family has nominal logic levels of 0 and +5 volts. The CMOS device family has nominal logic levels of +/-V(supply). Very short logic pulses might not be directly seen, but most logic probes have a feature that allows short pulses to be detected and indicated in some way.

E4B01
The noise figure will determine the level of the weakest signal that can be heard. The bandwidth will affect the noise figure. As the bandwidth increases, the noise figure will increase.

E4B02
The noise floor will determine the level of the weakest signal that can be heard.

E4B03
A preselector with a fairly narrow passband helps reduce reception of image signals.

E4B04
A ringing CW filter will blur the "dits" and "dahs" into each other making copy difficult.

E4B05
An RTTY signal often has a bandwidth of less than 300 Hz, but setting the filter bandwidth to exactly the required bandwidth would make tuning of these signals extremely difficult.

E4B06
A 2.4 kHz filter is good for communications voice quality. If the filter is more narrow than this, the audio quality will be degraded. Speech will be difficult to understand.

E4B07
As well as the desired signal, other signals on adjacent frequencies will be heard.

E4B08
Filter bandwidth should be slightly greater than the received signal bandwidth.

E4B09
This is because FM modulation produces a wider bandwidth signal than AM modulation.

E4B10
High Q filters have good out of band rejection and a steep skirt slope.

E4B11
The bottom end of the blocking dynamic range is determined by the receiver noise floor. The top end of the range is often determined by the "1 dB blocking level". This is the level where receiver desensitization of 1 dB occurs in the presence of a strong signal 20 kHz away from the test signal. A typical 1 dB blocking level is 30 dB. You want this level to be as high as possible.

E4B12

The top end of the dynamic range is determined by the "1 dB blocking level". This is the level where receiver desensitization of 1 dB occurs in the presence of a strong signal 20 kHz away from the test signal. A typical 1 dB blocking level is 30 dB. You want this level to be as high as possible to avoid cross modulation effects.

E4B13

The noise floor is the noise level generated by the receiver itself. This noise originates mainly from the receiver first stage with a small contribution from the mixer. It is vital that low noise active devices are used in the receiver first stage at VHF frequencies and above. At high frequencies, receiver noise is the largest contribution to total noise.

E4C01

Ignition noise is a big problem with mobile high-frequency installations. The main method of reducing this is at source by adding filters and replacing ignition components with low noise equivalent units.. Be aware that modern high performance vehicle ignition systems may not react well to the addition of RF filtering.

E4C02
The main method of reducing ignition noise is at source by adding filters and replacing ignition components with low noise equivalent units..   Be aware that modern high performance vehicle ignition systems may not react well to the addition of RF filtering. Careful shielding and bonding of the vehicle metalwork can also help.

E4C03
Primary and secondary ignition leads radiate strong electromagnetic pulses that create ignition noise. Ferrite beads fitted on these leads may help reduce RF noise.

E4C04
Bonding the body work components of a car will tend to lower the resonant frequency and, with luck, make them less efficient radiators of RF in the amateur bands.

E4C05
Connect your mobile set to an independent circuit that is fed directly from your car battery using the shortest leads possible.   Also, install capacitors in the alternator leads.

E4C06
Connect your mobile set to an independent circuit that is fed directly from your car battery. It should use the shortest leads possible. Also, install capacitors in the alternator leads.

E4C07
Lightening strokes can be heard up to a thousand miles away on some amateur bands.

E4C08
Common offenders are heating thermostats, televisions, faulty plugs and sockets and washing machines. If you find that electrical noise is being generated in your home then use a portable radio to "sniff out" the source.

E4C09
An AC-line filter contains capacitors and inductors to present a low shunt impedance and a high series impedance to high frequency pulses.

E4C10
"Common mode" means that the RF voltage is in the same phase on each conductor.

E4C11
An FM receiver that is not tuned to a radio signal will produce a constant noise signal at the output. The signal cannot be used for direction finding since it will not vary as the antenna is rotated.

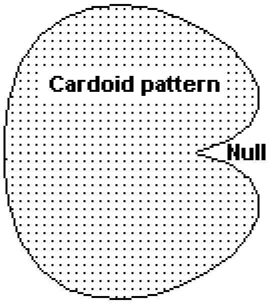
E4D01
There is always some ambiguity when using a wire lop antenna. The ambiguity can be resolved by using triangulation methods.

E4D02
A light weight Yagi or quad antenna makes a good DF antenna on 2 meters and 70 centimeters.

E4D03
A triangle is formed by two beam headings when drawn on a map with a baseline drawn between them. The crossing point of the beam headings indicates the approximate location of the radio source. Extra headings may help give a more accurate location. Usually extra sets of headings are taken as the target is approached.

E4D04
As the RF source is approached the field strength will become too high for the receiver to respond properly. For example, the S-meter will be "hard over" to the right of the scale. The correct heading cannot be found unless extra attenuation is provided at the receiver input.

E4D05
This is to remove the directional ambiguities caused by the bi-directional properties of a loop antenna. It allows direction as well as bearing to be obtained. A cardoid pattern means "heart-shaped" and the sharp null in this pattern is used to obtain the bearing.

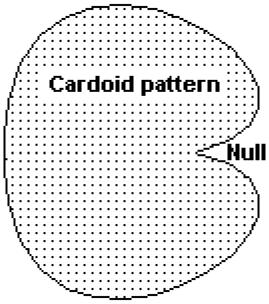


E4D06
An Adcock antenna is a 4 element antenna that uses phasing information to determine signal direction. By altering the phasing to the elements the field pattern can be rotated without physically moving the antenna.

E4D07
A wire loop antenna is used for direction finding. If there is sufficient signal strength it is better to use the null points to obtain a bearing because they are sharper.

E4D08
Making the loop larger increases the "capture area".

E4D09
A cardoid pattern means "heart-shaped" and the sharp null in this pattern is used to obtain the bearing.



E4D10
Mountains and valleys obstruct radio signals and cause them to be reflected.

E4D11
The hidden transmitter represents the fox.

E5A01
Most semiconductor junctions are affected by light. Usually light is excluded from them, but some devices are designed to exploit the photoelectric effect. Examples are simple photocells to detect light beam interruption and optoisolators (optocouplers) for coupling parts of a circuit at widely differing voltages.

E5A02
The increase in conductivity is due to the release of charge carriers in the depletion region of the junction.

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E5A05
Optocouplers (optoisolators) are used to provide a signal path between two circuits at widely different voltages. Typical isolation voltages are 2 kV.

E5A06

Optocouplers (optoisolators) are used to provide a signal path between two circuits at widely different voltages. Typical isolation voltages are 2 kV.

E5A07
In an optical shaft encoder a rotating wheel with slots cut in it allows differing light patterns to fall on to an array of semiconductor junctions. The output from the junctions is a binary code representing the shaft position.

E5A08
This change in resistance is produced by a similar mechanism to that in semiconductor junctions.

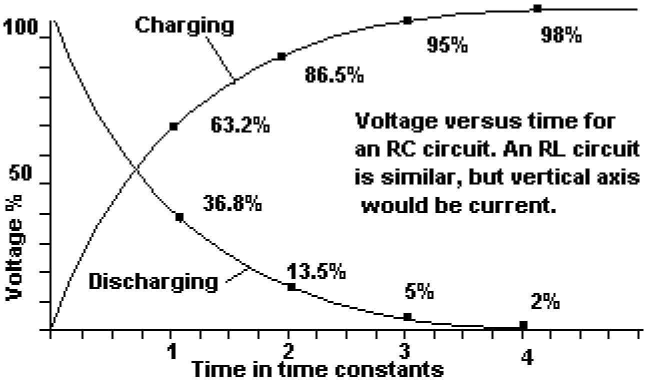
E5A09
The change in resistance is produced by a similar mechanism to that in semiconductor junctions. Cadmium sulfide was used in photoelectric devices before semiconductor junction devices became available.

E5A10
The change in resistance is produced by a similar mechanism to that in semiconductor junctions. Lead Sulfide infrared detectors are used in passive infrared alarm systems.

E5A11
The increase in conductivity is due to the release of charge carriers in the depletion region of the junctions that will be present in a crystalline semiconductor. The materials in the other options do not contain semiconductor junctions.

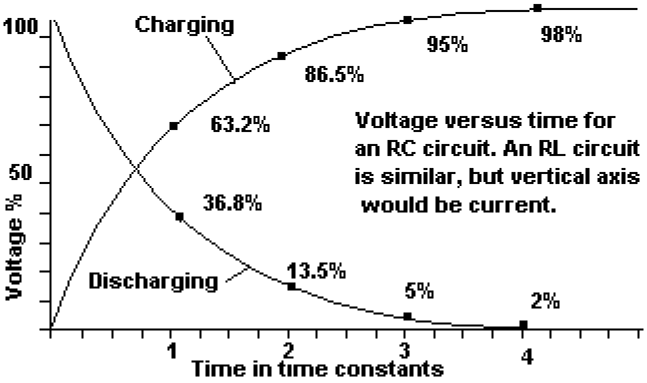
E5B01

The discharge time of a CR circuit is also determined by the time constant. With large amounts of capacitance and high resistance the time constant can be several hours, so beware of large capacitors in electronics equipment. In an RC circuit assuming there is no initial charge on the capacitor it takes a time of R x C seconds to charge a capacitor to 63.2% of its final value.



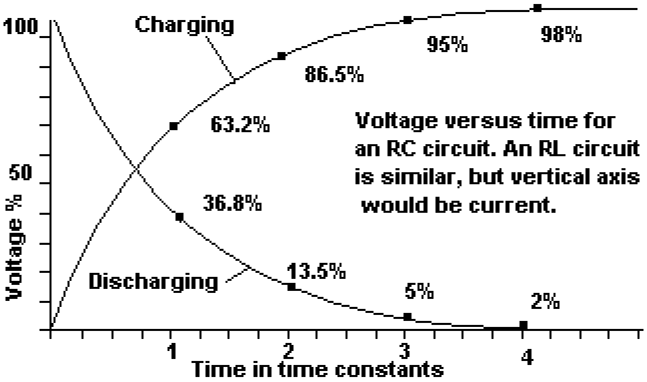
E5B02

In an RL circuit the coil will develop a back EMF that will oppose the flow of current and cause it to build up more slowly.   In an RL circuit assuming there is no initial current through the inductance it takes L x R seconds for the current to build up to 63.2 % of its final value.



E5B03

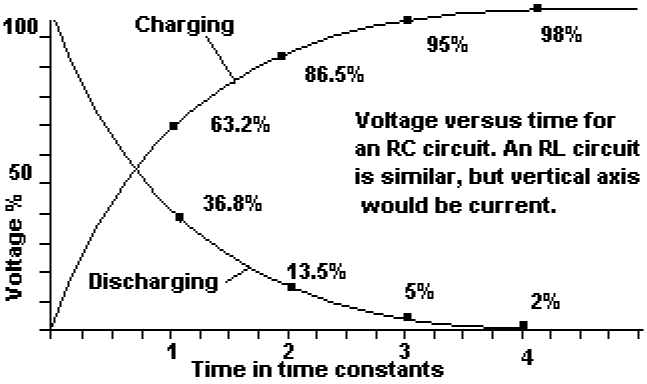
In an RC circuit it takes a time of R x C seconds to discharge a capacitor to 36.8% of its final value.



E5B04
During the first time constant period the voltage will reach 0.632 of the final value, this leaves 0.368 to go.

During the next time constant period the voltage will rise by 0.632 of the remaining voltage. This is 0.632 x 0.368 = 0.232.

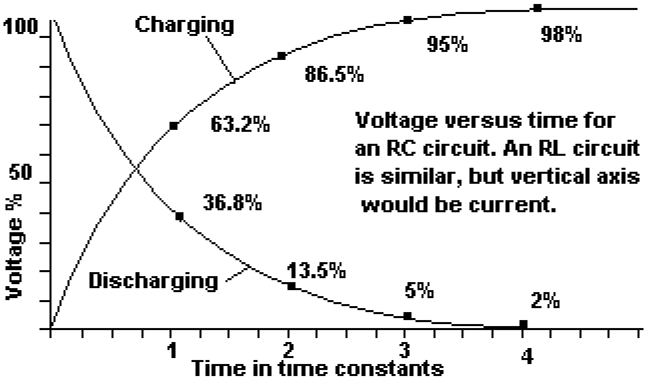
We now add the two voltage rises together to obtain 0.632 + 0.232 = 0.865, or 86.5%



Voltage versus time for an RC circuit. An RL circuit is similar, but vertical axis would be current.

E5B05
During the first time constant period the voltage will drop to 0.368 of the original value.

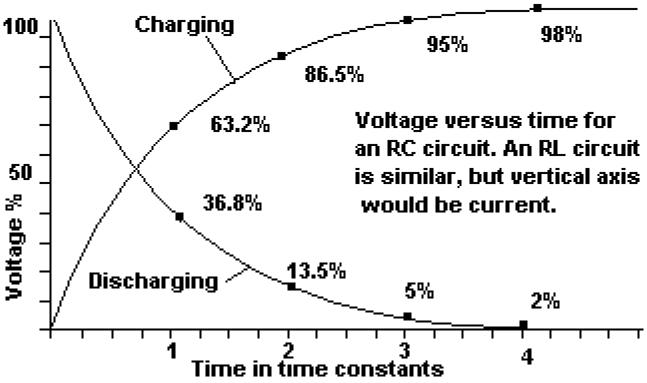
During the next time constant period the voltage will drop to 0.368 of the remaining voltage.
This is 0.368 x 0.368 = 0.135 = 13.5%



E5B06
We need to obtain total C and total R. For the special case of 2 equal capacitors C1 and C2 in series the total capacitance is C1/2 so we have C = 50 microfarads.

Resistors in series add up, so total resistance R = 470E3 + 470E3 = 940E3 ohms

Time constant of an RC circuit is R x C = 940E3 x 50E - 6 = 47 seconds

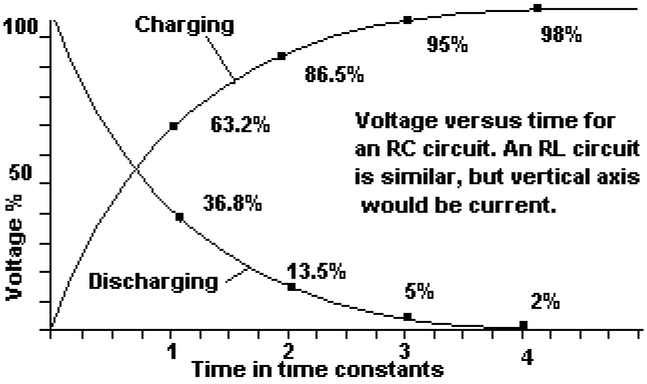


E5B07

We need to obtain total C. For the case of 2 capacitors C1 and C2 in parallel the total capacitance is C1 + C2 so we have C = 440 microfarads.

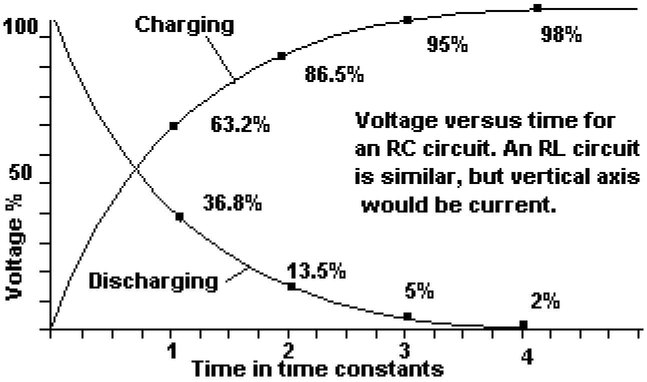
For the special case of two equal resistors R1 and R2 in parallel we have R = R1/2, so total resistance R = 1E6/2 = 500E3 ohms

Time constant of an RC circuit is R x C = 500E3 x 440E - 6 = 220 seconds



E5B08

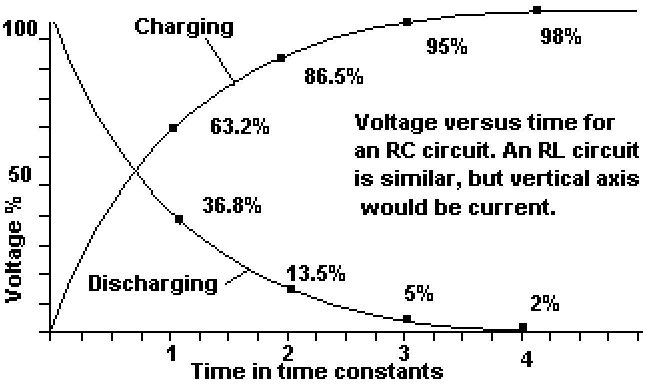
Time constant of an RC circuit is R x C = 470E3 x 220E - 6 = 103 seconds



Voltage versus time for an RC circuit. An RL circuit is similar, but vertical axis would be current.

E5B09
Time constant of an RC circuit is R x C = 2E6 x 0.01E - 6 = 0.02 seconds

In 0.02 seconds this circuit will discharge to 36.8% of the starting voltage. So, after 0.02 seconds the voltage will be 20 x 0.368 = 7.36 volts. This matches the required voltage in the question, so the time for discharge is 0.02 seconds.



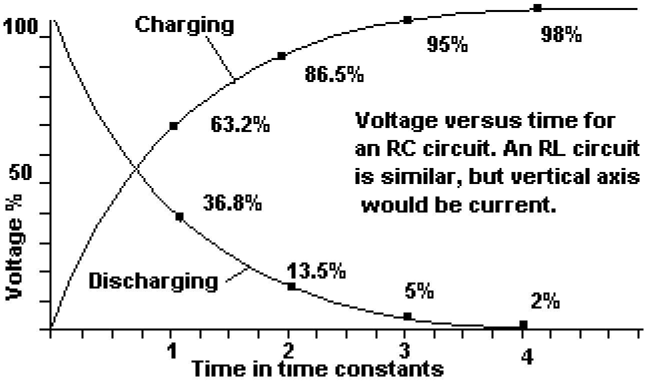
E5B10
Time constant of an RC circuit is R x C = 2E6 x 0.01E - 6 = 0.02 seconds.

In 0.02 seconds this circuit will discharge to 36.8% of the starting voltage. So, after 0.02 seconds the voltage will be 20 x 0.368 = 7.36 volts. The voltage is more than the required voltage, so we wait for 0.02 seconds.

After 0.04 seconds the voltage is
7.36 x 0.368 = 2.71 volts (approximately). This voltage is more than the required voltage, so we wait for another 0.02 seconds.

After 0.06 seconds the voltage is
2.71 x 0.368 = 1 volts (approximately). This voltage is more than the required voltage, so we wait for another 0.02 seconds.

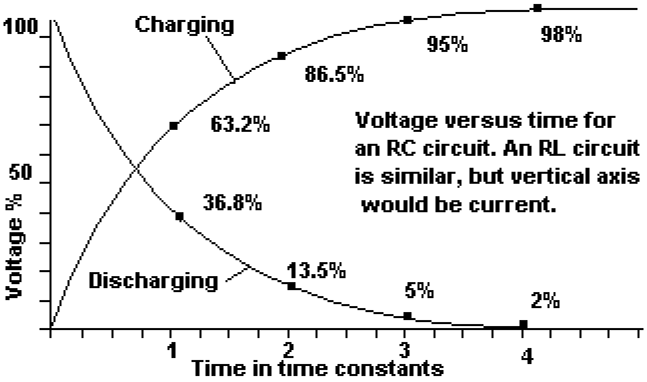
After 0.08 seconds the voltage is
1 x 0.368 = 0.37 volts (approximately). This matches the required voltage in the question, so the time for discharge is 0.08 seconds.



Voltage versus time for an RC circuit. An RL circuit is similar, but vertical axis would be current.

E5B11
Time constant of an RC circuit is R x C = 1E6 x 450E - 6 = 450 seconds.

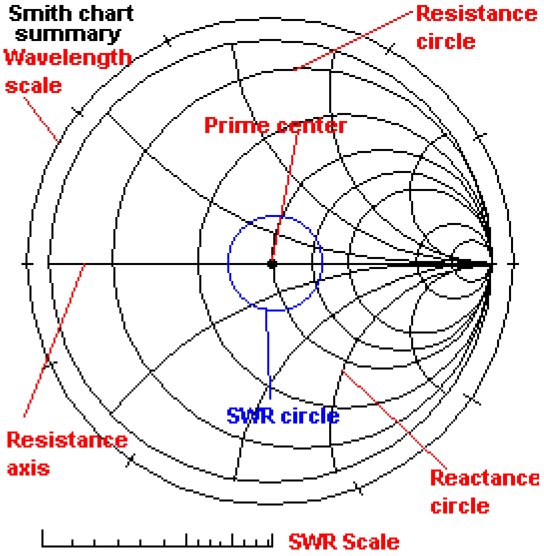
After a time of 450 seconds the circuit will discharge to 36.8% of its original voltage.
800 x 0.368 = 294. This matches the voltage in the question and so the time for discharge is 450 seconds.



Voltage versus time for an RC circuit. An RL circuit is similar, but vertical axis would be current.

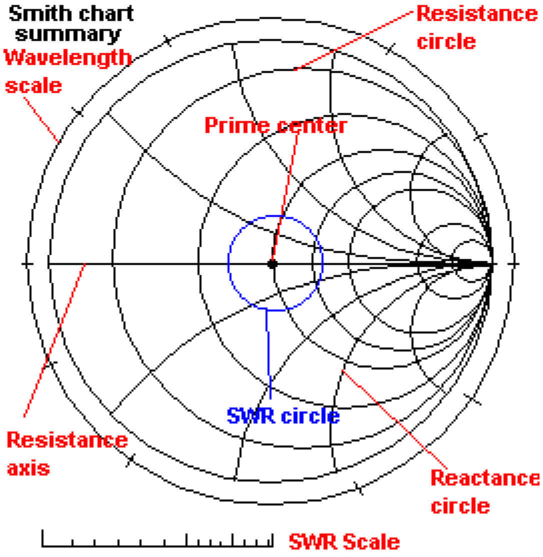
E5C01

The Smith chart is a graph for calculation of impedance along radio transmission lines. Given nominal line impedance and length plus a measured input impedance to the transmission line the SWR and node positions can be calculated as well as the impedance at the load (antenna) end.



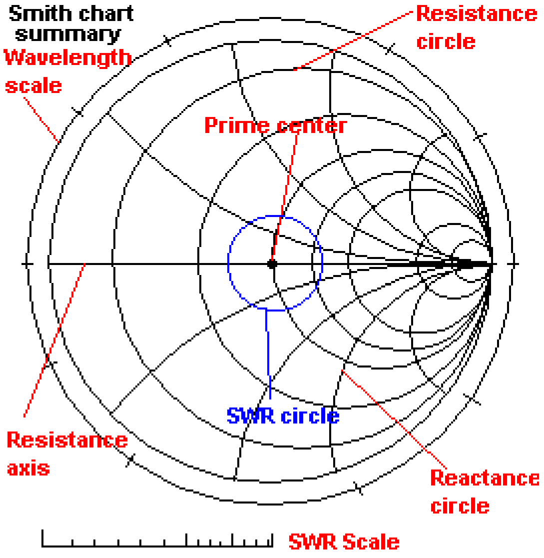
E5C02

A Smith chart has a number of curved resistance and reactance lines.



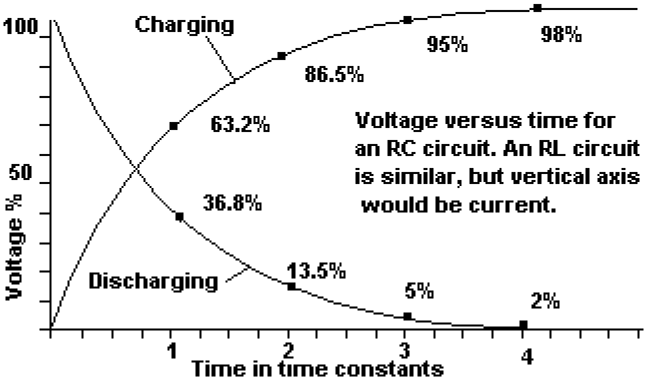
E5C03

The Smith chart is a graph for calculation of impedance along radio transmission lines. Given nominal line impedance and length plus a measured input impedance to the transmission line the SWR and node positions can be calculated as well as the impedance at the load (antenna) end.



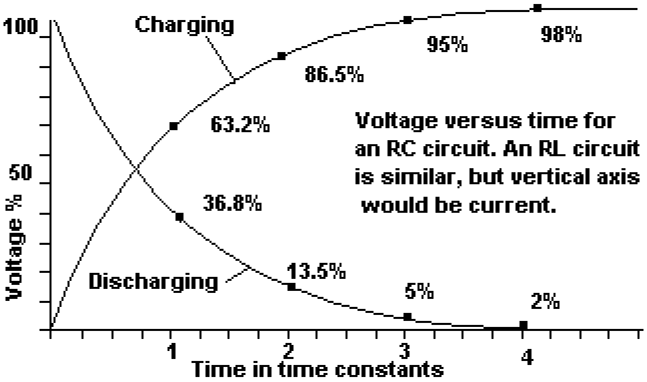
E5C04

A Smith chart has a number of curved resistance and reactance lines.

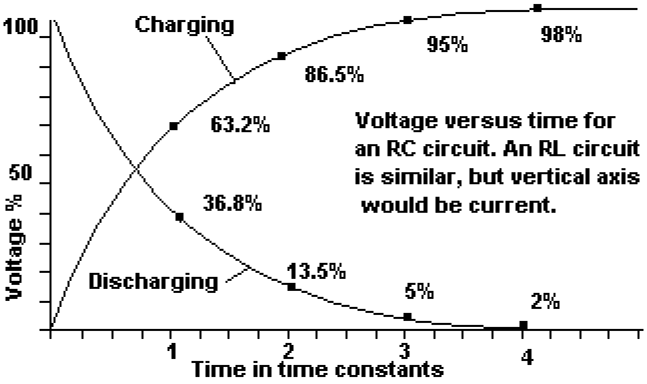


E5C05

The curved segments on a Smith chart are portions of reactance circles. The straight line is the resistance axis. The complete circles are resistance circles.

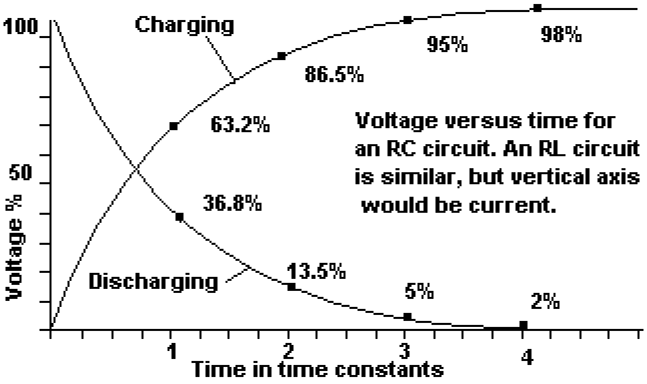


E5C06
A Smith chart has a number of curved resistance and reactance lines.



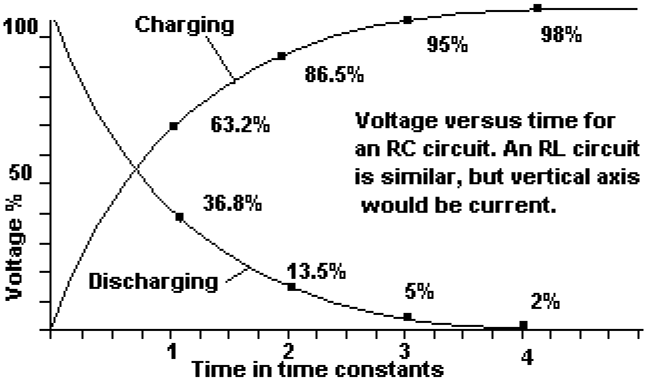
E5C07

The single straight line is the resistance axis.



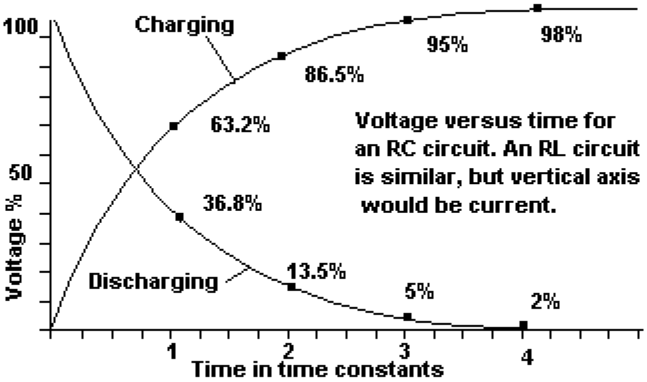
E5C08
A Smith chart is designed for lines with a characteristic impedance of 1 ohm. The "prime center" of a Smith chart is at 1 ohm resistive. No real transmission lines have such an impedance, but we can divide the measured impedance of any line by the characteristic impedance to use the Smith chart. This is called normalization.

After using the chart to obtain the required normalized results, we multiply them by the characteristic impedance of the real line to get the actual results.

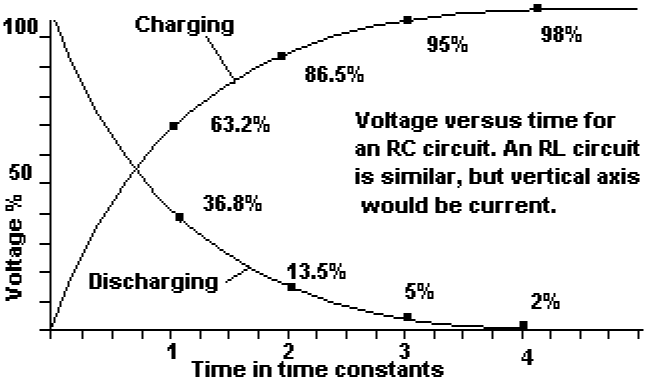


E5C09

The curved segments on a Smith chart are portions of reactance circles. The straight line is the resistance axis. The complete circles are resistance circles.

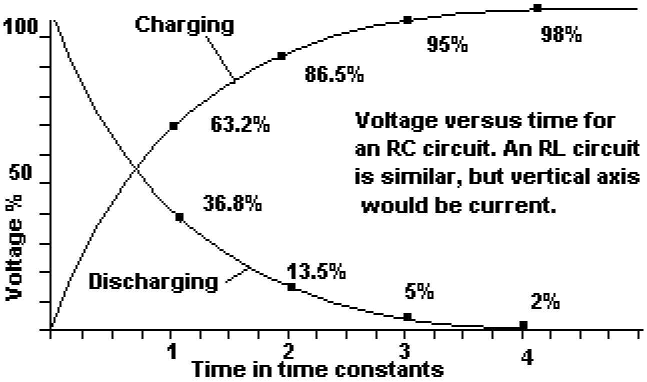


E5C10
SWR circles will be centered on the prime center of the chart. The radius of these circles is read off on an auxiliary scale to give SWR readings.



Voltage versus time for an RC circuit. An RL circuit is similar, but vertical axis would be current.

E5C11
A complete rotation of the wavelength scale is 0.5 transmission line electrical wavelengths. Electrical length is less than free space wavelength by a factor called the velocity factor.



E5D01
This is a rectangular coordinate question.
We have resistance and inductive reactance in the circuit. The resistance contributes to the real part of the result and is 20 ohms. (Without any calculations we see that the correct answer must be either 20+j19 or 20-j19 !)

The inductive reactance contributes to the "imaginary" part. Inductive reactance is always regarded as positive in sign. To signify that it is a reactance we add a "j" to the front of the number. You can now select the correct answer as 20+j19 because this one has a positive reactance. The following calculation is just a double check

Using the standard formula for inductive reactance gives: Xl = 2 x pi x F x L = 2 x 3.141 x 30E6 x 0.1E - 6 = 18.846 ohms

So the inductive reactance is approximately 19 Ohms. The total impedance is
20 + j19 ohms

E5D02
This is a rectangular coordinate question.
We have resistance and inductive reactance in the circuit. The resistance contributes to the real part of the result and is 30 ohms. (Without any calculations we see that the correct option must be either 30-j3 or 30+j3 !)

The inductive reactance contributes to the "imaginary" part. Inductive reactance is always regarded as positive in sign. To signify that it is a reactance we add a "j" to the front of the number. You can now select the correct answer as 30+j3 because this one has a positive reactance. The following calculation is just a double check

Using the standard formula for inductive reactance gives: Xl = 2 x pi x F x L = 2 x 3.141 x 5E6 x 0.1E - 6 = 3.141 ohms.

So the inductive reactance is approximately 3 Ohms. The total impedance is
30 + j3 ohms

E5D03
This is a rectangular coordinate question.
We have resistance and inductive reactance in the circuit. The resistance contributes to the real part of the result and is 40 ohms. (Without any calculations we see that the correct option must be either 40+j31400 or 40-j31400 !)

The inductive reactance contributes to the "imaginary" part. Inductive reactance is always regarded as positive in sign. To signify that it is a reactance we add a "j" to the front of the number. You can now select the correct answer as 40+j31400 because this one has a positive reactance. The following calculation is just a double check

Using the standard formula for inductive reactance gives: Xl = 2 x pi x F x L = 2 x 3.141 x 500E6 x 10E - 6 = 31410 ohms

So the inductive reactance is approximately 31400 Ohms. The total impedance is
40 + j31400 ohms

E5D04
This is a polar coordinate question.
The capacitive reactance is Xc=1/ (2 x pi x f x C) = 1 / (2 x 3.141 x 500E3 x 100E - 12) = 3183 ohms

Polar coordinates are given as impedance magnitude Z and an angle.

This is a parallel circuit with 2 components that we shall call Z1 (the resistor) and Z2 (the capacitor) , so we use the "product over sum formula"

Z total = (Z1 x Z2) / (Z1 + Z2).

Z1 and Z2 are "complex" quantities. This means that they contain both resistance and reactance. Therefore, we must use vector multiplication and addition using the rules given in the polar coordinate help topic.

The resistor Z1 = 4000 ohms at 0 degrees. (Pure resistance has phase angle 0)
The capacitor Z2 = 3183 ohms at -90 degrees. (Pure capacitance has phase angle -90)

Z1 x Z2 = (4000 at 0) x (3183 at -90) = (4000 x 3183) at (0 - 90) = 12.732E6 ohms at -90 degrees

(Z1 + Z2) = square root (Z1 squared + Z2 squared) ohms at INV Tan (Z2/Z1) degrees

This gives (Z1 + Z2) = square root (26.1E6) at INV tan (0.795) = 5.1E3 ohms at -38.5 degrees.
(INV tan means press the INV button on your calculator before pressing the tan button)

So Ztotal = (12.732E6 ohms at -90 degrees) / (5.1E3 ohms at -38.5 degrees)

Using vector division this gives

Ztotal = (12.732E6 / 5.1E3) ohms at (-90 -(-38.5)) degrees = 2.493 kilohms at -51.5 degrees.

E5D05
This is a rectangular coordinate question.
We have resistance and capacitive reactance in the circuit. The resistance contributes to the real part of the result and is 400 ohms. (Without any calculations we see that the correct option must be either 400-j318 or 400+j318 !)

The capacitive reactance contributes to the "imaginary" part. Capacitive reactance is always regarded as negative in sign. To signify that it is a reactance we add a "j" to the front of the number. You can now select the correct answer as 400 - j318 because this one has a negative reactance. The following calculation is just a double check

Using the standard formula for capacitive reactance gives: Xc = 1/(2 x pi x F x C) = 1/(2 x 3.141 x 500E3 x 0.001E-6) = 318 ohms

So the capacitive reactance is approximately 318 ohms. The total impedance is
400 - j318 ohms.

E5D06
This is a rectangular coordinate question.
We have resistance and capacitive reactance in the circuit. The resistance contributes to the real part of the result and is 50 ohms. (Without any calculations we see that the correct option must be either 50-j162 or 50+j162 !)

The capacitive reactance contributes to the "imaginary" part and is always regarded as negative in sign. To signify that it is a reactance we add a "j" to the front of the number. You can now select the correct answer as 50-j162 because this one has a negative reactance. The following calculation is just a double check

Using the standard formula for capacitive reactance gives: Xc = 1/(2 x pi x F x C) = 1/(2 x 3.141 x 7E6 x 140E-12) = 162 ohms

So the capacitive reactance is approximately 318 ohms. The total impedance is
50 - J162 ohms.

E5D07
This is a polar coordinate question.

The best approach is to first calculate the total reactance, which is the sum of each individual reactance. This gives:

capacitive reactance + inductive reactance = -1 + 4 = 3 ohms.
(Remember, capacitive reactance is a negative quantity)

Polar coordinates are given as impedance magnitude Z and an angle.

This is a series circuit and so we add the impedances using vector arithmetic to obtain:

Ztotal squared = R squared + Xl squared = 4 squared + 3 squared = 25

So Ztotal = square root (25) = 5 ohms

We find the angle

Angle = INV tan (X/R) = INV tan(3/4) = 37 degrees.
(INV tan means press the INV button on your calculator before pressing the tan button)

So the impedance in polar notation is:

5 ohms at 37 degrees

E5D08
On the diagram horizontal directions from the Y-axis represent resistance and vertical directions up and down from the X-axis represent reactance. Inductive reactance is positive (above the X-axis) and capacitive reactance is negative (below the X-axis).

We immediately know that the correct point must be either 2,6 or 4 since they are all at 400 ohms horizontally to the right of the Y-axis.

We know that capacitive reactance is regarded as negative so that narrows the options down to points 6 and 4.

Since a capacitor is present the capacitive reactance is not zero. This rules out point 6 and gives us the correct answer as point 4 without doing any calculations!

As a double check we can calculate the capacitive reactance.

Using the standard formula for capacitive reactance gives: Xc = 1/(2 x pi x F x C) = 1/(2 x 3.141 x 14E6 x 38E-12) = -300 ohms
(Capacitive reactance is always regarded as negative)

So the correct answer is point 4, which is 300 units below the X-axis.

E5D09
On the diagram horizontal directions from the Y-axis represent resistance and vertical directions up and down from the X-axis represent reactance.   Inductive reactance is positive (above the X-axis) and capacitive reactance is negative (below the X-axis).

We immediately know that the correct point must be either 3,8 or 1, since they are all at 300 ohms horizontally to the right of the Y-axis.

We know that inductive reactance is regarded as positive so that narrows the options down to points 3 and 8.

The value of the inductive reactance is given by the standard formula
Xl = 2 x pi x F x L = 2 x 3.141 x 3.505E6 x 18E - 6 = 396 ohms

So the correct answer is point 3, which is 400 units above the X-axis.

E5D10
On the diagram horizontal directions from the Y-axis represent resistance and vertical directions up and down from the X-axis represent reactance. Inductive reactance is positive (above the X-axis) and capacitive reactance is negative (below the X-axis).

We immediately know that the correct point must be either 3,8 or 1 since they are all at 300 ohms horizontally to the right of the Y-axis.

We know that capacitive reactance is regarded as negative so that narrows the options down to point 1 and gives us the correct answer without doing any calculations!

As a double check we can calculate the capacitive reactance.

Using the standard formula for capacitive reactance gives: Xc = 1/(2 x pi x F x C) = 1/(2 x 3.141 x 21200E3 x 19E-12) = -400 ohms
(Capacitive reactance is always regarded as negative)

So the correct answer is point 1, which is 400 units below the X-axis.

E5D11
On the diagram horizontal directions from the Y-axis represent resistance and vertical directions up and down from the X-axis represent reactance. Inductive reactance is positive (above the X-axis) and capacitive reactance is negative (below the X-axis).

We immediately know that the correct point must be either 3,8 or 1 since they are all at 300 ohms horizontally to the right of the Y-axis.

Using the standard formula for capacitive reactance gives: Xc = 1/(2 x pi x F x C) = 1/(2 x 3.141 x 24900E3 x 85E-12) = -75 ohms
(Capacitive reactance is always regarded as negative)

The value of the inductive reactance is given by the standard formula
Xl = 2 x pi x F x L = 2 x 3.141 x 24900E3 x 0.64E - 6 = 100 ohms

The total circuit reactance is 100 - 75 = 25 ohms.
(an inductive reactance, since it is positive)

So the correct answer is point 8, which is 25 units above the X-axis.

E5E01
This is a polar coordinate question.
The impedances are in series and so we can add them (using vector arithmetic).

Ztotal squared = R squared + Xl squared = 100 squared + 100 squared = 20000

So Ztotal = square root (20000) = 141 ohms

This is enough information to be able to select 141 ohms at 45 degrees as the correct answer.

As a double check we find the angle

Angle = INV tan (Xl/R) = INV tan(1) = 45 degrees.

So the impedance in polar notation is

141 ohms at 45 degrees.

E5E02
This is a polar coordinate question.
There is a short cut here. The inductive and capacitive reactances are equal. Since they are of opposite sign they cancel each other. This means that the phase angle is 0 degrees so the correct answer is either 10 ohms at 0 degrees or 100 ohms at 0 degrees.

The resistance is 100 ohms and so the complete answer is
100 ohms at 0 degrees.

E5E03
This is a polar coordinate question.
The impedances are in series and so we can add them (using vector arithmetic).

Ztotal squared = R squared + Xl squared = 300 squared + (-400) squared = 250E3

So Ztotal = square root (250E3) = 500 ohms

We now find the angle:

Angle = INV tan (Xc/R) = INV tan (-400/300) = -53.1 degrees.

So the impedance in polar notation is

500 ohms at -53.1 degrees

E5E04
This is a polar coordinate question.
The impedances are in series and so we can add them (using vector arithmetic).

The total reactance is Xl - Xc = 300 ohms inductive.

Ztotal squared = R squared + Xc squared = 400 squared + 300 squared = 250E3

So Ztotal = square root (250E3) = 500 ohms

This is enough information to be able to select 500 ohms at 37 degrees as the correct answer.

As a double check we now find the angle

Angle = INV tan (Xc/R) = INV tan(300/400) = 37 degrees.

So the impedance in polar notation is:

500 ohms at 37 degrees

E5E05
This is a polar coordinate question.
Polar coordinates are given as impedance magnitude Z and an angle.

This is a parallel circuit with 2 components that we shall call Z1 (the resistor) and Z2 (the inductor), so we use the "product over sum formula":

Ztotal = (Z1 x Z2) / (Z1 + Z2)

Z1 and Z2 are "complex" quantities. This means that they contain both resistance and reactance. Therefore, we must use vector multiplication and addition using the rules given in the polar coordinate Help topic.

The resistor Z1 = 300 ohms at 0 degrees. (A pure resistance has phase angle of 0)
The inductor Z2 = 400 ohms at 90 degrees. (A pure inductance has phase angle of 90)

Z1 x Z2 = (300 at 0) x (400 at 90) = (300 x 400) at (0+90) = 120E3 ohms at 90 degrees

(Z1 + Z2) = square root (Z1 squared + Z2 squared) ohms at INV Tan (Z2/Z1) degrees

This gives (Z1 + Z2) = square root (90E3+160E3) at INV tan (400/300) = 500 ohms at 53.1 degrees.
(INV tan means press the INV button on your calculator before pressing the tan button)

So Ztotal = (120E3 ohms at 90 degrees) / (500 ohms at 53.1 degrees)

Using vector division this gives:

Ztotal = (120E3 / 500) ohms at (90 -53.1) degrees = 240 kilohms at 36.9 degrees.

E5E06
We have an inductive reactance, so it is positive.
The resistance is 200 ohms and so that gives 200 + j188 as the correct option.
As a check Xl = 2 x pi x F x L = 2 x 3.141 x 30E3 x 1E-3 = 188 Ohms giving Z = 200 + j188.

E5E07
We have an inductive reactance, so it is positive.
The resistance is 600 ohms that gives 600+j628 as the correct option.
As a check Xl = 2 x pi x F x L = 2 x 3.141 x 10E3 x 10E-3 = 628 Ohms giving Z = 600 + j628.

E5E08
We have a capacitive reactance, so it is negative.
The resistance is 40 ohms that gives 40 - j32 as the correct option.
As a check Xc = 1 / (2 x pi x F x C) = 1/ (2 x 3.141 x 50E3 x 0.1E-6) = 32 Ohms giving Z = 40 - j32.

E5E09
This is a polar coordinate question.
The impedances are in series and so we can add them (using vector arithmetic).

The total reactance Xc = -100 ohms capacitive.

Ztotal squared = R squared + Xc squared = 100 squared + (-100) squared = 20000

So Ztotal = square root (20000) = 141 ohms

This is enough information to be able to select 141 ohms at -45 degrees as the correct answer.

As a double check we now find the angle:

Angle = INV tan (Xc/R) = INV tan (-100/100) = -45 degrees.

So the impedance in polar notation is:

141 ohms at -45 degrees.

E5E10
This is a parallel circuit with 2 components that we shall call Z1 (the resistor) and Z2 (the capacitor) , so we use the "product over sum formula":

Ztotal = (Z1 x Z2) / (Z1 + Z2)

Z1 and Z2 are "complex" quantities. This means that they contain both resistance and reactance. Therefore, we must use vector multiplication and addition using the rules given in the vector Help topic.

The resistor Z1 = 100 ohms at 0 degrees. (A pure resistance has phase angle of 0 degrees.)
The capacitor Z2 = 100 ohms at -90 degrees. (A pure capacitance has phase angle of -90 degrees.)

Z1 x Z2 = (100 at 0) x (100 at -90) = (100 x 100) at (0 - 90) = 10E3 at -90 degrees

(Z1 + Z2) = square root (Z1 squared + Z2 squared) ohms at INV Tan (Z2/Z1) degrees

This gives (Z1 + Z2) = square root (10000+10000) at INV tan (-100/100) = 141 ohms at -45 degrees.
(INV tan means press the INV button on your calculator before pressing the tan button)

So Ztotal = (10E3 ohms at -90 degrees) / (141 ohms at -45 degrees).

Using vector division this gives:

Ztotal = (10E3 / 141) ohms at (-90 -(-45)) degrees = 70.7 ohms at -45 degrees.

E5E11
This is a polar coordinate question.
The impedances are in series and so we can add them (using vector arithmetic).

Ztotal squared = R squared + Xc squared = 300 squared + 400 squared = 250E3

So Ztotal = square root (250E3) = 500 ohms

We now find the angle:

Angle = INV tan (Xl/R) = INV tan(300/400) = 37 degrees.

So the impedance in polar notation is:

500 ohms at 37 degrees.

E5F01

Horizontal directions represent the resistive component. Vertical directions represent reactive component. The region above the X-axis represents positive reactance, or inductance. The region below the X-axis represents negative reactance, or capacitance. A graph like this is a visual representation of the rectangular coordinates system.

E5F02

Horizontal directions represent the resistive component. Vertical directions represent reactive component. The region above the X-axis represents positive reactance, or inductance. The region below the X-axis represents negative reactance, or capacitance. A graph like this is a visual representation of the rectangular coordinates system.

E5F03

Horizontal directions represent the resistive component. Vertical directions represent reactive component. The region above the X-axis represents positive reactance, or inductance. The region below the X-axis represents negative reactance, or capacitance. A graph like this is a visual representation of the rectangular coordinates system.

E5F04

Horizontal directions represent the resistive component. Vertical directions represent reactive component. The region above the X-axis represents positive reactance, or inductance. The region below the X-axis represents negative reactance, or capacitance. A graph like this is a visual representation of the rectangular coordinates system. A point on the horizontal axis represents pure resistance.

E5F05
Horizontal directions represent the resistive component. Vertical directions represent reactive component. The region above the X-axis represents positive reactance, or inductance. The region below the X-axis represents negative reactance, or capacitance. A graph like this is a visual representation of the rectangular coordinates system. The position of a point on the graph can also be determined by the distance from the crossing point of the axes plus a direction. This is the polar coordinate vector system.

E5F06

Horizontal directions represent the resistive component. Vertical directions represent reactive component. The region above the X-axis represents positive reactance, or inductance. The region below the X-axis represents negative reactance, or capacitance. A graph like this is a visual representation of the rectangular coordinates system. A point on the horizontal axis represents pure resistance.

E5F07
The position of a point on a graph can be determined by the distance from the crossing point of the axes plus a direction. This is the polar coordinate vector system.

E5F08
This is a polar coordinate question.
The impedances are in series and so we can add them (using vector arithmetic).

The total reactance Xc = -100 ohms capacitive.

Ztotal squared = R squared + Xc squared = 100 squared + (-100) squared = 20000

So Ztotal = square root (20000) = 141 ohms

This is enough information to be able to select 141 ohms at -45 degrees as the correct answer.

As a double check we now find the angle:

Angle = INV tan (Xc/R) = INV tan (-100/100) = -45 degrees.

So the impedance in polar notation is:

141 ohms at -45 degrees.

E5F09
The siemen is the unit of admittance. To convert from ohms to siemens we just take the reciprocal of the magnitude of the impedance. If there is a reactive component we simply change the sign of the angle .

7.09 millisiemens at 45 degrees = 1/(7.09E-3) ohms at -45 degrees =
141 ohms at -45 degrees.

E5F10
The siemen is the unit of admittance. To convert from ohms to siemens we just take the reciprocal of the magnitude of the impedance. If there is a reactive component we simply change the sign of the angle .

5 millisiemens at -30 degrees = 1/(5E-3) ohms at 30 degrees =
200 ohms at 30 degrees.

This answer is in polar coordinates so we need to convert to rectangular coordinates using
Z at angle = Z x cos(angle) + j Z x sin(angle)
Giving
200 x cos(30) + j 200 sin(30)=
173 + j 100 ohms

E5F11
The siemen is the unit of admittance. To convert from ohms to siemens we just take the reciprocal of the magnitude of the impedance. If there is a reactive component we simply change the sign of the angle .

240 ohms at 36.9 degrees = 1/(240) siemens at -36.9 degrees =
4.16 millisiemens at -36.9 degrees.

This is in polar coordinates so we need to convert to rectangular coordinates using
Z at angle = Z x cos(angle) + j Z x sin(angle)
Giving
4.16 x cos(-36.9) + j 4.16 sin(-36.9) millisiemens=
3.33 - j 2.50 millisiemens

E6A01
The conduction channel is created by the gate voltage. Therefore, the output current is enhanced by the input bias. Under no bias conditions no current flows in the device.

E6A02
The conduction channel is reduced by the gate voltage. Under no bias conditions a constant current flows in the device. The device can be biased "off".

E6A03
In an N-channel MOSFET the arrow points **in**.

E6A04
In a P-channel MOSFET the arrow points **out**.

E6A05
In an N-channel dual-gate MOSFET the arrow points **in**.

E6A06
In a P-channel dual-gate MOSFET the arrow points **out**.

E6A07
In an N-channel FET the arrow points **in**. A FET has a gate, a drain and a source.

E6A08
A FET has a gate, a drain and a source.

E6A09

In a P-channel FET the arrow points **out**.   A FET has a gate, a drain and a source.

E6A10
The gate electrode has no internal connection. It is insulated from the rest of the device by a very thin layer of oxide. The electric field of the gate is used to control the device. Because the oxide layer is so thin, static charges can easily destroy the gate insulation. To avoid this problem, small Zener diodes are often built in to MOSFET devices to protect them from high voltages.

E6A11
MOSFET devices use metal oxide as a very thin insulating layer between the gate and the rest of the device. Static charges can easily destroy this gate insulation. Complementary pairs of junctions are used to reduce power consumption of MOSFET based ICs to almost zero.

E6A12
FETs behave more like tube triode devices. They have a high input impedance and large dynamic range.

E6B01
Operational amplifiers are single chip devices that have inherently very high gain. In practice the gain is determined by external components. Operational amplifiers are direct coupled. The output is determined by differences between the two input terminals.

E6B02
High input impedance means no loading on the previous circuit. Low output impedance means that following components have little effect on the output. Infinite gain allows complete control of the gain by external components. Flat frequency response means that the actual frequency response can be set by external components.

E6B03
The inherent gain is very high. External feedback components are used to reduce the gain to practical levels. The frequency response can be tailored by putting frequency sensitive components in the feedback circuit.

E6B04
Ideally this should be zero. In practice it can be a few millivolts.

E6B05
High input impedance means no loading on the previous circuit.

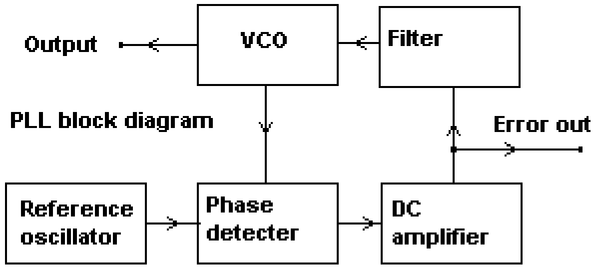
E6B06

Low output impedance means that following components in a circuit have little effect on the output signal.

E6B07
All of the other symbols are for logic devices.

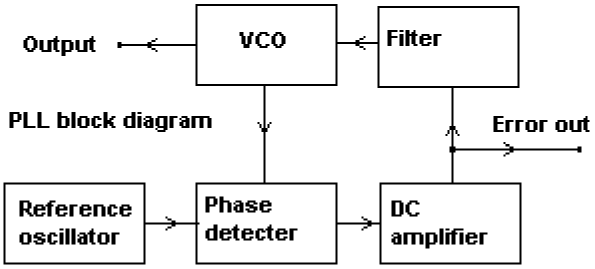
E6B08
A PLL is used for frequency synthesis. The synthesized frequency is locked to an accurate frequency standard.

There is a feedback circuit in a PLL. The error signal in this feedback circuit is proportional to the frequency difference between the VCO output and the reference frequency. If an FM signal is substituted for the reference frequency then the error signal is a copy of the original modulating signal and the PLL functions as an FM demodulator.

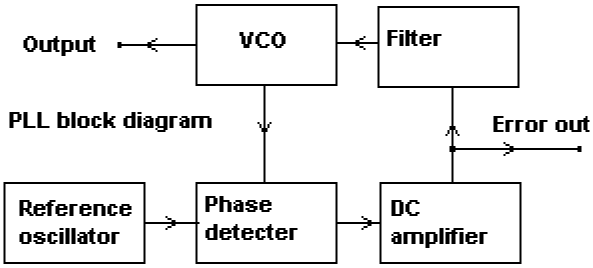


E6B09
A PLL is used for frequency synthesis. The synthesized frequency is locked to an accurate frequency standard.

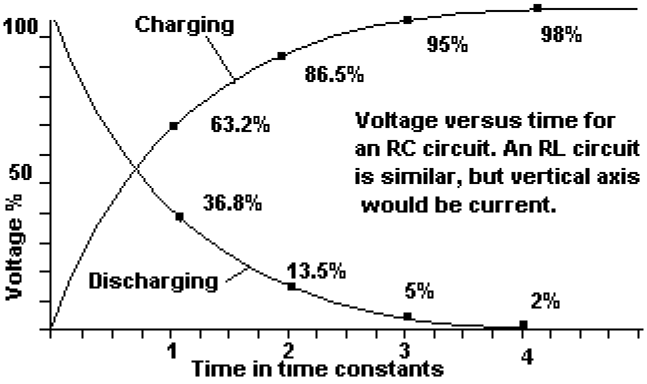
There is a feedback circuit in a PLL. The error signal in this feedback circuit is proportional to the frequency difference between the VCO output and the reference frequency. If an FM signal is substituted for the reference frequency then the error signal is a copy of the original modulating signal and the PLL functions as an FM demodulator.



E6B10
In a phase locked loop circuit, the output frequency of a voltage controlled oscillator is locked to a highly stable reference frequency.



E6B11
In a phase locked loop circuit, the output frequency of a voltage controlled oscillator is locked to a highly stable reference frequency. The frequency range over which the VCO can remain locked to the reference is called the capture range.



E6C01
Transistor-transistor logic uses two logic levels.   Nominally these are 0 and +5 volts.

E6C02
It is normal practice to fix unused TTL inputs to either supply rail by a "pull up" or "pull down" resistor.

E6C03

Although logic "high" is nominally +5 volts the actual voltage will be between +5 and +2 volts. The voltage will be lower if several TTL inputs are connected to a TTL output. This is an arrangement known as "fan out".

E6C04
Although logic "low" is nominally 0 volts the actual output can be between -0.6 and 0.8 volts.

E6C05
If complementary pairs of semiconductor junctions are used, both logic states consume very little current from the supply rail.

E6C06
Power supply noise transients or input transients have to be much larger for spurious switching to occur.

E6C07
There can be more than 2 inputs on an AND gate.

E6C08
The little circles represent negation. It is the output of the NAND gate that is negated (inverted).

E6C09
There can be more than 2 inputs on an OR gate.

E6C10
The little circles represent negation. It is the output of the NOR gate that is negated (inverted).

E6C11
The NOT gate will negate (invert) the input logic state. A 1 input will produce a 0 output and vice versa.

E6D01
A vidicon tube works like a television cathode ray tube in reverse.

E6D02
The electron beam is deflected by varying electromagnetic fields in coils surrounding the tube just like in a television cathode ray tube.

E6D03
In electromagnetic deflection systems coils are used to produce the required magnetic fields. These coils are inductive and the reactance will vary with frequency. It is difficult to drive the deflection coils consistently over a range of frequencies.

E6D04
Persistence is a function of the type of phosphor materials used to coat the front of the tube. This effect is similar to, but distinct from, the persistence that occurs in our eyes.

E6D05

The image will be smaller (and brighter) because the electrons will be traveling at higher speeds and will be more difficult to deflect. The X-rays produced by a CRT under such fault conditions are a health hazard.

E6D06
The image will be smaller (and brighter) because the electrons will be traveling at higher speeds and will be more difficult to deflect. The X-rays produced by a CRT under such fault conditions are a health hazard.

E6D07
The analog signals stored by a CCD are in response to incident light levels. There is no way to input an analog electrical signal to a CCD.

E6D08
The analogue signal passed on by the stage is based on the number of photons striking the junctions over a period of time.

E6D09
CCD based cameras are much more sensitive than vidicon types.

E6D10
An LCD display has very low power consumption. No light is emitted by a LCD display.

E6D11
An LCD display has very low power consumption.   No light is emitted by a LCD display.

E7A01
The circuit remains in one stable state until triggered to change to the other stable state; it has two stable states. One state represents the bit in the "off" state while the other state represents the bit in the "on" state.

E7A02
Each flip-flop divides by two.   Connecting two of them in cascade divides by four.

E7A03
Each flip-flop divides by two.   Connecting two of them in cascade divides by four.

E7A04
Each flip-flop divides by two. Connecting two of them in cascade divides by four.

E7A05
An astable multivibrator has no stable states. It constantly switches between its two unstable states. It is commonly called a "flip-flop" because it never stops changing states.

E7A06

A monostable multivibrator has one stable state. A trigger input will switch it to the unstable state. After a time period it will switch back to the stable state. The time period is set by external components.

E7A07

Here is a list of input-output states for a two input AND gate:

Input A	Input B	Output
1	0	0
0	1	0
0	0	0
1	1	1

E7A08

NAND means NOT AND. Here is a list of input-output states for a two input NAND gate:

Input A	Input B	Output
1	0	1
0	1	1
0	0	1
1	1	0

E7A09

Here is a list of input-output states for a two input OR gate:

Input A	Input B	Output
1	0	1
0	1	1
0	0	0
1	1	1

E7A10

The NOR gate produces a logic 0 at its output if any inputs are logic 1. Here is a list of input-output states for a two input NOR gate:

Input A	Input B	Output
1	0	0
0	1	0
0	0	1
1	1	0

E7A11

We use a truth table in digital circuitry to characterize the function of logic devices. The lists shown in some of the preceding logic device explanations are truth tables.

E7A12
In a positive logic circuit a logic 0 is a lower voltage and 1 is a higher voltage.

E7A13
In a negative logic circuit a logic 1 is a lower voltage and 0 is a higher voltage.

E7B01
A prescaler is a frequency divider circuit. It allows HF and VHF signals to be used with relatively inexpensive frequency counters designed to work at lower frequencies.

E7B02
Decade means powers of ten (like decimal). A decade counter gives one output pulse for every ten input pulses.

E7B03
Decade means powers of ten (like decimal). A decade counter gives one output pulse for every ten input pulses.

E7B04
Two flip-flops running at 50 kHz and 25 kHz would provide the 50 kHz and 25 kHz fundamental frequencies. The output of flip-flops is a square wave that is rich in harmonics. Therefore, signals would be present at 25 kHz and 50 kHz intervals.

E7B05
The prescaler circuit would output a 100 kHz square wave. Such a waveform is rich in regularly spaced harmonics.

E7B06
Normally the stable oscillator frequency is divided by a prescaler or flip-flop chain to give a low frequency square wave output that is rich in regularly spaced harmonics. The harmonics provide the "marks" at precisely defined frequencies.

E7B07
A pure sine wave has no harmonics.   Only one frequency would be present in the output.

E7B08

A marker oscillator is designed to output a low frequency square wave output that is rich in regularly spaced harmonics. The regularly spaced harmonics provide the "marks" at precisely defined frequencies. Typical fundamental output frequencies are 100 kHz, 50 kHz, and 25 kHz.

E7B09
All frequency counters will depend on an internal reference, usually a crystal oscillator. The internal reference is calibrated against other known frequency standards. Some frequency counters have a facility for making the internal reference lock to an external frequency standard.

E7B10
The internal reference sets the time period for the input pulse count. It must be accurate and is calibrated against other known frequency standards. Some frequency counters have a facility for making the internal reference lock to an external frequency standard.

E7B11

A frequency counter operates by counting the number of input pulses in a time period. If more than one signal is present the counter will, at best, count the pulses of the strongest signal. If several signals of similar magnitude are present then the displayed count may not bear any relationship to the correct frequency.

E7C01
The gain of an audio filter circuit containing an op-amp can be determined entirely by the external components. In a passive LC audio filter there will always be some loss.

E7C02
You would use a spectrum analyzer for looking at the frequency response of a filter.

E7C03
The gain of an audio filter circuit containing an op-amp can be determined entirely by the external components. In a passive LC audio filter there will always be some loss.

E7C04
Polystyrene capacitors have good temperature stability and have a high Q.

E7C05
High gain audio circuits are prone to "howling" and "ringing". An audio circuit that is close to oscillation gives a "speaking through a pipe" sound to the audio signal.

E7C06
Active op-amp filters can be designed for almost any frequency response and can also be made variable.

E7C07
A preselector with a fairly narrow passband helps reduce reception of image signals. However a preselector with a narrow bandwidth will have more insertion loss and will reduce the receiver front-end sensitivity.

E7C08

Standard value resistors are available for a wide range of values in small increments. Standard value capacitors have a more restricted range and the steps between standard values are larger.

E7C09
Standard value resistors are available for a wide range of values in small increments. Standard value capacitors have a more restricted range and the steps between standard values are larger.

E7C10

Op-amps are best used at fairly low signal levels. An example is in the low level audio stages of a receiver.

E7C11

Op-amps are best used at fairly low signal levels. An example is in the low level audio stages of a receiver.

E7D01

Op-amps have two signal inputs. One is inverting and the other one is non-inverting.

E7D02
Op-amps have two signal inputs. One is inverting and the other one is non-inverting.

E7D03
In the figure, Gain = Rf/R1,
Where Rf is feedback resistance in ohms,
and R1 is input resistance in ohms.

This gives Gain = 100E3 / 1000 = 100
This is an inverting op-amp circuit.

E7D04
In the figure, Gain = Rf/R1,
Where Rf is feedback resistance in ohms,
and R1 is input resistance in ohms.

This gives Gain = 68E3 / 1800 = 38
This is an inverting op-amp circuit.

E7D05
In the figure, Gain = Rf/R1,
Where Rf is feedback resistance in ohms,
and R1 is input resistance in ohms.

This gives Gain = 47E3 / 3,300 = 14
This is an inverting op-amp circuit.

E7D06
In the figure, Gain = Rf/R1,
Where Rf is feedback resistance in ohms,
and R1 is input resistance in ohms.

This gives Gain = 47E3 / 10 = 4700
This is an inverting op-amp circuit.

E7D07

An ideal op amp should have unlimited bandwidth. It should be the external components that determine the bandwidth of the op-amp circuit.

E7D08
The input impedance to the gate is very high since it is either a reverse biased junction in a JFET or an electrically isolated electrode in a MOSFET. So it is the biasing network that is effectively in parallel with the gate that will determine the input impedance.

E7D09
The output impedance is inherently very low and determined mainly by the drain resistor that is effectively in series with the output.

E7D10
In the figure, Gain = Rf/R1,
Where Rf is feedback resistance in ohms,
and R1 is input resistance in ohms.

This gives Gain = 1000 / 1000 = 1

A gain of 1 indicates unity gain, the output signal amplitude will be the same as the input signal amplitude which is -10 millivolts. However his is an inverting op-amp circuit with the signal fed to the inverting input (the one with the minus sign) and so the output voltage will be of opposite sign to the input. Therefore the output signal will be -(-10 millivolts) = 10 Millivolts.

E7D11
In the figure, Gain = Rf/R1,
Where Rf is feedback resistance in ohms,
and R1 is input resistance in ohms.

This gives Gain = 10000 / 1000 = 10
Output signal amplitude = 10 x input signal amplitude = 23 volts.

However his is an inverting op-amp circuit with the signal fed to the inverting input (the one with the minus sign) and so the output voltage will be of opposite sign to the input. Therefore the output signal will be -23 volts.

E8A01
The duty cycle can be a lot less than 100% allowing a moderately rated transmitter to generate high pulse levels without overheating. High transient currents and voltages will be present in the output stages of a pulse transmitter.

E8A02
The modulating signal varies the duration of the pulses. It is easy to demodulate a pulse width signal by using a simple RC circuit.

E8A03
The pulse timing varies with the modulating signal.

E8A04
The modulating signal varies the duration of the pulses. It is easy to demodulate a pulse width signal by using a simple RC circuit.

E8A05
The modulating signal varies the duration of the pulses. It is easy to demodulate a pulse width signal by using a simple RC circuit.

E8A06
This gives a duty cycle of 1/1000.

E8A07
The duty cycle can be a lot less than 100% allowing a moderately rated transmitter to generate high pulse levels without overheating. High transient currents and voltages will be present in the output stages of a pulse transmitter.

E8A08
In a switching regulator the duty cycle is varied to control the output.

E8A09
In a switching regulator the duty cycle is varied to control the output.

E8B01
As we all know, "dahs" are three times the length of "dits".

E8B02
The ASCII 7 bit code allows upper and lower case text to be transmitted whereas the Baudot 5 bit code uses uppercase letters only.

E8B03
The ASCII 7 bit code allows upper and lower case text to be transmitted whereas the Baudot 5 bit code uses uppercase letters only.

E8B04
Meteor scatter propagation is sporadic. Short bursts of data are handled well by packet radio systems because each packet is of short duration and can be repeated many times.

E8B05
In mode A AMTOR if the signal is not received correctly the receiving system automatically requests a repeat of the frame.

E8B06
In mode B AMTOR characters are sent twice. There is no feedback from the receiving system. The is called forward error correction.

E8B07
The emission type is not relevant.   The formula for Morse Code required bandwidth is:

Bandwidth = 4 x Words per minute.

This gives a bandwidth of 4 x 13 = 52 Hz.

E8B08
The emission type is not relevant. The formula for required bandwidth of data transmissions is:

Bandwidth = baud rate + (1.2 x frequency shift).

This gives a bandwidth of 300 + (1.2 x 170) = 500 Hz.

E8B09
The emission type is not relevant. The formula for required bandwidth of data transmissions is:

Bandwidth = baud rate + (1.2 x frequency shift).

This gives a bandwidth of 1200 + (1.2 x 1000) = 2,400 Hz.

E8B10
The emission type is not relevant. The formula for required bandwidth of data transmissions is:

Bandwidth = baud rate + (1.2 x frequency shift).

This gives a bandwidth of 9600 + (1.2 x 4800) = 15,360 Hz.

E8C01
Four 2.5 kHz ACSB transmissions take up the bandwidth of one 10 kHz FM transmission.
This process allows more efficient use of transmitter power and band space.

E8C02
Four 2.5 kHz ACSB transmissions take up the bandwidth of one 10 kHz FM transmission.
This process allows more efficient use of transmitter power and band space.

E8C03
The 3 kHz pilot tone facilitates automatic tuning of SSB signals. This is useful in mobile "hands free" operation.

E8C04
The 3 kHz pilot tone facilitates automatic tuning of SSB signals. This is useful in mobile "hands free" operation.

E8C05
Four 2.5 kHz ACSB transmissions take up the bandwidth of one 10 kHz FM transmission. The narrower bandwidth allows more efficient use of transmitter power and band space.

E8C06

In spread spectrum communications the signal moves around in a prearranged pseudo-random pattern. The receiver tracks the signal using the same pseudo-random sequence. Interference averages out while the required signal accumulates. SS transmission gives interference free private communications. Frequency hopping generally occurs at a low rate compared to the modulation information rate.

E8C07
In spread spectrum communications the signal moves around in a prearranged pseudo-random pattern. Interference averages out while the required signal accumulates. SS transmission gives interference free private communications. The receiver tracks the signal using the same pseudo-random sequence. Frequency hopping generally occurs at a low rate compared to the modulation information rate.

E8C08

The term direct sequence is used to describe shifts in the phase of an RF carrier to achieve spread spectrum communications. The carrier is phase shift keyed according to a pseudo-random code at a faster rate than the modulation information. The receiver tracks the signal using the same pseudo-random sequence.

E8C09
This is a technique that allows many pseudo random sequences to be generated by selection of feedback digits. A SS receiver must have the same sequence as the transmitter to receive information. Selection of pseudo random sequences effectively allows a number of private channels to be used.

E8C10
In spread spectrum communications, the signal moves around in a prearranged pseudo-random pattern. At the receiver interference averages out while the required signal accumulates.

E8C11

In spread spectrum communications, the signal moves around in a prearranged pseudo-random pattern. This has the effect of "smearing" the signal across a wide bandwidth. The energy at any given narrowband channel is very small.

E8D01
AC signals swing from one extreme to the other. The maximum positive excursion is called peak positive voltage.

E8D02
AC signals swing from one extreme to the other.   The maximum negative excursion is called the peak negative voltage.

E8D03
It is easier to measure the peak to peak voltage and divide by two to get the peak voltage. This is because the negative and positive peaks are well defined but the zero axis may not be. This assumes that the waveform is symmetrical.

E8D04
Peak voltage is half the peak to peak voltage only if the waveform is symmetrical about the zero axis.

E8D05
The peak voltage is required to determine the electrical stresses in the amplifier circuitry. For example the capacitors and active device in the amplifier must be capable of withstanding the peak voltage .

E8D06
Peak envelope power (PEP) is the parameter used to express the maximum allowable power in the FCC rules. [97.313]

E8D07
To calculate peak envelope power:

Multiply the peak voltage by 0.707.
Square the result.
Divide by the load impedance.:

Power = ((Vp x 0.707) squared)/RL = ((30 x 0.707) squared)/50 = 9

E8D08
To calculate average power over one RF cycle:

Multiply the peak voltage by 0.707.
Square the result.
Divide by the load impedance.:

Power = ((Vp x 0.707) squared)/RL = ((35 x 0.707) squared)/50 = 12.2

E8D09
To calculate peak voltage we divide RMS voltage by 0.707.
65 / 0.707 = 92.

We now multiply the peak voltage by 2 to obtain the peak-to-peak voltage of 184.

E8D10
To calculate peak voltage we divide RMS voltage by 0.707.
34 / 0.707 = 48.

E8D11
Peak envelope power (PEP) is the parameter used to express the maximum allowable power in the FCC rules. [97.313]

E9A01
No real antenna radiates equally in all directions, but we can refer to a theoretical antenna that does. This antenna is known as an isotropic radiator. A dipole radiates equally in all directions in one plane only. When comparing antenna gain to an isotropic radiator we use dBi, a simple dipole has a gain of about 2.1 dBi. If we compare antenna gain to a simple dipole we use dBd.

E9A02

No real antenna radiates equally in all directions, but we can refer to a theoretical antenna that does. This antenna is known as an isotropic radiator. A dipole radiates equally in all directions in one plane only. When comparing antenna gain to an isotropic radiator we use dBi, a simple dipole has a gain of about 2.1 dBi. If we compare antenna gain to a simple dipole we use dBd.

E9A03

No real antenna radiates equally in all directions, but we can refer to a theoretical antenna that does. This antenna is known as an isotropic radiator. A dipole radiates equally in all directions in one plane only. When comparing antenna gain to an isotropic radiator we use dBi, a simple dipole has a gain of about 2.1 dBi. If we compare antenna gain to a simple dipole we use dBd.

E9A04
No real antenna radiates equally in all directions, but we can refer to a theoretical antenna that does. This antenna is known as an isotropic radiator. A dipole radiates equally in all directions in one plane only. When comparing antenna gain to an isotropic radiator we use dBi, a simple dipole has a gain of about 2.1 dBi. If we compare antenna gain to a simple dipole we use dBd.

E9A05

No real antenna radiates equally in all directions, but we can refer to a theoretical antenna that does. This antenna is known as an isotropic radiator. A dipole radiates equally in all directions in one plane only. When comparing antenna gain to an isotropic radiator we use dBi, a simple dipole has a gain of about 2.1 dBi. If we compare antenna gain to a simple dipole we use dBd.

E9A06

When comparing antenna gain to an isotropic radiator we use dBi, a simple dipole has a gain of about 2.1 dBi. If we compare antenna gain to a simple dipole we use dBd.

E9A07
When comparing antenna gain to an isotropic radiator we use dBi, a simple dipole has a gain of about 2.1 dBi. If we compare antenna gain to a simple dipole we use dBd.

Gain (dBd) = Gain (dBi) - 2.1 = 6 - 2.1 = 3.9 dBd

E9A08
When comparing antenna gain to an isotropic radiator we use dBi, a simple dipole has a gain of about 2.1 dBi. If we compare antenna gain to a simple dipole we use dBd.

Gain (dBd) = Gain (dBi) - 2.1 = 12 - 2.1 = 9.9 dBd

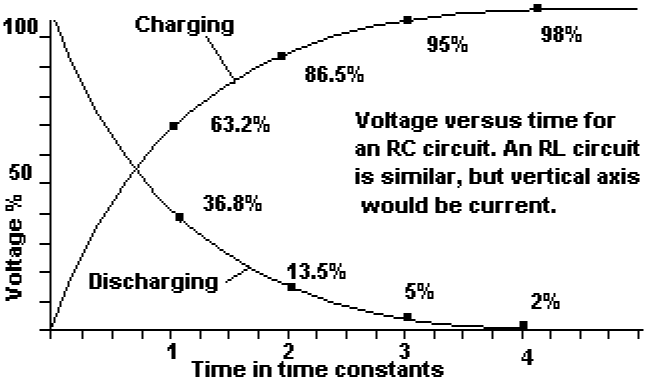
E9A09
No real antenna radiates equally in all directions, but we can refer to a theoretical antenna that does. This antenna is known as an isotropic radiator and has no gain in any direction.

E9A10
No real antenna radiates equally in all directions, but we can refer to a theoretical antenna that does. This antenna is known as an isotropic radiator and has no gain in any direction, the radiation patterns is a sphere indicating that the radiation is the same in all directions.

E9A11
No real antenna radiates equally in all directions, but we can refer to a theoretical antenna that does. This antenna is known as an isotropic radiator and has no gain in any direction, the radiation patterns is a sphere indicating that the radiation is the same in all directions, that is, it has no directivity.

E9B01
Two quarter wavelength antennas spaced one half wavelength apart fed 180 degrees out of phase produces a figure eight pattern in line with the elements.

E9B02
Two quarter wave verticals spaced one quarter apart fed 90 degrees out of phase results in a unidirectional cardoid pattern.   The sharp null is useful for direction finding.



E9B03
Two quarter wavelength antennas spaced one half wavelength apart fed in phase produces a figure eight pattern broadside to the line of the elements.

E9B04
Two quarter wavelength antennas spaced one quarter wavelength apart fed 180 degrees out of phase produces a figure eight pattern in line with the elements. However, if the elements are spaced more closely the pattern will start to resemble a single quarter wave vertical. It will be a less well defined figure of eight than a half wave spaced array.

E9B05
The two quarter wavelength vertical antennas spaced one eighth wavelength apart and fed 180 degrees out of phase produce an end fire figure eight pattern in line with the vertical elements.   The pattern will be less well defined than a half wave spaced array.

E9B06
Two quarter wavelength verticals spaced one quarter wavelength apart and fed in phase will present a pattern part way between a figure of eight and a circular pattern. The result will be an elliptical pattern.

E9B07
A resonant rhombic has an open circuit at the end opposite to the feedline. Each side is one wavelength long. Resonant rhombic antennas are big!

E9B08

A non-resonant rhombic is unidirectional and has a terminating resistance at the end opposite to the feedline. They can work over a four to one frequency range.

E9B09

A non-resonant rhombic antenna works over a wide frequency range of up to four to one. It has plenty of gain (10-15 dB) and a good front to back ratio.

E9B10
Although it is non-resonant, the sides still need to be about one wavelength long.

E9B11
The terminating resistor should be around 800 ohms to match the characteristic impedance.

E9C01

The satellite transmitter power is one factor that will determine the strength of the received signals. The satellite transmitter antenna type will determine the strength and polarization of the received signals. The satellite height will influence signal strength and how long each pass will last.

E9C02
The satellite receive antenna gain will be one factor determining the earth station EIRP requirements as will the satellite receiver sensitivity. The satellite height defines the path lengths involved and this will also be a factor in determining EIRP requirements.

E9C03
The satellite receive antenna gain will be one factor determining the earth station EIRP requirements as will the satellite receiver sensitivity. The satellite height defines the path lengths involved and this will also be a factor in determining EIRP requirements.

E9C04
If you double the size of a dish the gain increases by four times, which is a 6 dB increase. If you halve the wavelength (double the frequency) the same thing happens. Parabolic antennas become feasible for most Radio Amateurs at frequencies of 1270 MHz and above.

E9C05
The greater the gain is, the narrower the beam width will be. The radiated signal is being focused in one direction.

E9C06
The beam width of a parabolic antenna is given by
G = 203 / (3.16 to the power of (gain /10)).

This gives G = 203 / 3.162 to the power of (20/10)
= 203 / 3.162 to the power of 2.

"To the power of 2" means "squared".

So G = 203 / 10 = 20.3 degrees.

E9C07
The beam width of a parabolic antenna is given by
G = 203 / (3.16 to the power of (gain /10)).

This gives G = 203 / 3.162 to the power of (30/10)
= 203 / 3.162 to the power of 3.

"To the power of 3" means "cubed".

So G = 203 / 31.62 = 6.42 degrees.

E9C08
The beam width of a parabolic antenna is given by
G = 203 / (3.16 to the power of (gain /10)).

This gives G = 203 / 3.162 to the power of (15/10)
= 203 / 3.162 to the power of 1.5.

To calculate 3.162 to power 1.5 you need a calculator that has an exponent key. If you do not have one then you will have to estimate it. This can be considered to be half way between 3.162 to power of 1 (which is 3.162) and 3.162 to the power of 2 (which is 10). This will give you a value of 6.6 that will be close enough for you to select the correct option. The actual value of 3.162 to the power of 1.5 is 5.62

So G = 203 / 5.62 = 36.1 degrees

E9C09
The beam width of a parabolic antenna is given by
G = 203 / (3.16 to the power of (gain /10)).

This gives G = 203 / 3.162 to the power of (12/10)
= 203 / 3.162 to the power of 1.2.

To calculate 3.162 to power 1.2 you need a calculator that has an exponent key.

If you do not have such a calculator then here is a trick
N to the power of P = N x P approximately, if P is close to 1

Using this trick gives an estimate of 3.8.

The actual value of 3.162 to the power of 1.2 is 3.98.

So G = 203 / 3.98 = 51 degrees.

Using the estimate method gives 203 / 3.8 = 53 degrees.

E9C10
To get circular polarization using a pair of Yagis arrange them perpendicular to each other and feed them 90 degrees out of phase.   The resulting array will have a gain 3 dB down on a single Yagi, but will not suffer from fades due to polarization changes.

E9C11
You need up/down nodding movement as well as side to side movement to track satellites because their path across the sky is rarely North-South or East-West.

E9D01
Delta means triangular. The matching sections form two sides of a triangle. Delta matching sections are used with balanced feedline.

E9D02
Gamma matches are popular because they match unbalanced coaxial feedline to a balanced driven element. They also provide impedance matching.

E9D03
A stub can be used to add small amounts of reactance to help matching.

E9D04
Use 7 picofarads per meter of wavelength: 7 x 20 = 140 picofarads.

E9D05
Use 7 picofarads per meter of wavelength: 7 x 10 = 70 picofarads.

E9D06
A 1/8 wavelength stub with the far end shorted will present inductive reactance at the near end.

E9D07
A 1/8 wavelength stub with the far end open will present capacitive reactance at the near end.

E9D08
A 1/4 wavelength stub with the far end shorted will present an open circuit at the near end.

E9D09
A 1/4 wavelength stub with the far end open will present a short circuit at the near end.

E9D10
A 1/2 wavelength stub with the far end shorted will present a short circuit at the near end.

E9D11
A 1/2 wavelength stub with the far end open will present an open circuit at the near end.

Vector Arithmetic.

Suggestion:

Get yourself a scientific calculator for the Extra Class exam!

Check that it supports SIN, COS, TAN, and the inverses of these functions. These may be called ASIN, ACOS, ATAN, or there may be a separate key labeled INV. Also, some questions require you to raise numbers "to the power of" other numbers, so check that an exponent key is available. This will probably be labeled $\boxed{y^x}$

Vectors are quantities that have a magnitude (just like normal numbers) but they also have direction, or angle, and this means that we have to use special arithmetic when adding, subtracting, multiplying or dividing them.

Impedance is a "complex" vector quantity. This means that an impedance value contains two parts that are called the "real part" and the "imaginary" part.

The real part is contributed by the circuit resistance.

The imaginary part is contributed by the circuit reactance that can be either inductive or capacitive. If the total reactance is capacitive, then the reactance is regarded as being negative.

There are two ways of describing vector quantities:

Rectangular notation. The real and imaginary parts of an impedance Z are written:

Z = R + jXl.

This is the impedance of a series RL circuit containing resistance R and inductive reactance Xl. If the circuit has resistance R and capacitive reactance Xc then the impedance would be written

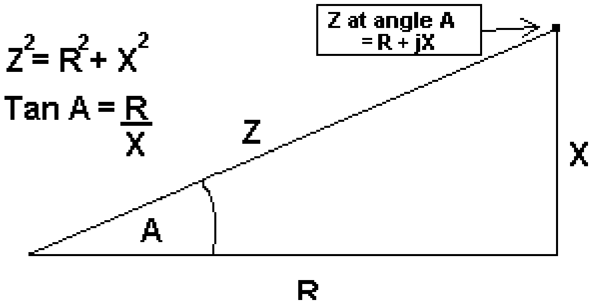
Z = R - jXc.

The "j" is **not** a quantity, it is a way of indicating that the following value is imaginary. Indicators like this are called operators.

Polar notation. The real and imaginary parts of an impedance Z are written:

Z at angle A.

The two notations are simply two different ways of describing the same thing. They can be demonstrated geometrically as follows



The diagram also shows how the two notations relate to each other. You will need to be able to convert an impedance from polar notation to vector notation and vice versa. Here are the relevant formulae:

Polar to rectangular conversion:

Z at angle A = Z x cos(A) + jZ x sin(A).

Example:

120 ohms at angle 30 degrees
= 120 x cos(30) + j 120 x sin(30)
= 120 x 0.866 + 120 x 0.5
= 104 + j60 ohms.

Rectangular to polar conversion:

R + jX = square root (R squared + X squared) at angle INV Tan (X/R).

Example:

104 + j60 ohms
= square root(104 squared + 60 squared) at angle INV Tan (60/104)
= 120 at angle 30 degrees.

Arithmetic.

Addition and subtraction is easiest with rectangular notation, so if the impedances are in polar notation then convert to rectangular first.

(A + jB) + (C + jD) = (A + C) + j(B + D).

Example:

If Z1 = 104 + j60 (A resistance of 104 ohms and an inductor of reactance 60 ohms)
Z2 = 50 - j40 (A resistance of 50 ohms and an capacitor of reactance 40 ohms)
Then to total series impedance is
Z1 + Z2 = (104 + j60) + (50 - j40)
= (104 + 50) + j(60 - 40)
= 54 + j10 ohms.

Multiplication and division is easier with polar notation. Therefore, if the impedances are in rectangular notation then convert to polar first:

(Z1 at angle A) x (Z2 at angle B) = Z1 x Z2 at angle (A + B),

(Z1 at angle A) / (Z2 at angle B) = Z1 / Z2 at angle (A - B).

Example:
Z1 = 120 ohms at angle 30 degrees,
Z2 = 60 ohms at angle 45 degrees.

Z1/Z2 = 120/60 at angle (30 - 45),
Z1/Z2 = 2 ohms at angle -15 degrees.