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Amateur Radio Exam Course — Canada, Basic Qualification

ISED Amateur Radio Operator Certificate, Basic Qualification: one chapter for each of the 100 topics of the official question bank (in effect since July 15, 2025).

Author, contact and licence

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Regulations and Policies

B-001-001 The Radiocommunication Act and Regulations

Who makes the rules?

- The **Radiocommunication Act** gives the authority to make Canadian regulations on radiocommunication. It is also the source of the **Standards for the Operation of Radio Stations in the Amateur Radio Service** (RBR-4).
- The **Radiocommunication Regulations** define the **amateur radio service**.
- The department that administers the Act is **Innovation, Science and Economic Development Canada** (ISED).

Document	Role
Radiocommunication Act	Authority to regulate, offences and penalties
Radiocommunication Regulations	Definitions, including the amateur radio service; operating conditions
RBR-4	Technical and operating standards for amateur radio stations

Remember the chain: the Act gives the authority, the Regulations and the standards (RBR-4) follow from it, and ISED applies them.

Source: Radiocommunication Act; Radiocommunication Regulations; RBR-4 (ISED).

B-001-002 The Amateur Radio Operator Certificate

Validity and where to keep it

- The Amateur Radio Operator Certificate is valid **for life**.
- It must be **retained at the station**, at the address provided to ISED.
- A radio inspector may ask to see it (or a copy): you have **48 hours** to comply.

Change of address

You must inform **ISED** within **30 days** of a change of mailing address.

Fees

Request	Fee
First certificate	Free
Replacement call sign with a new prefix after moving to another province or territory	Free
Changing an existing call sign (including to a two-letter call sign)	\$60

Source: Radiocommunication Regulations; RIC-3, Information on the Amateur Radio Service (ISED).

B-001-003 Offences and penalties

What is prohibited

- Transmitting **outside amateur radio bands**: prohibited; penalties could be assessed to the control operator.
- Transmitting a **false or fraudulent message**, such as a false "MAYDAY": never permitted.
- **Interfering with or obstructing** a radiocommunication without lawful cause: prohibited.

Penalties

The **Radiocommunication Act** sets out the offences and penalties. For a false distress signal or for obstructing a radiocommunication, an individual is liable to:

a fine not exceeding **\$5,000**, or a prison term not exceeding **one year**, or both.

Powers of the Minister and inspectors

- The Minister may suspend a certificate, but **with notice** and an opportunity to make representations.
- A radio inspector **may not enter a dwelling** without the occupant's consent or a warrant.

Source: Radiocommunication Act.

B-001-004 Getting the certificate: examinations and qualifications

Conditions

- **No age limit.**
- Candidates must have a **valid address in Canada.**
- The first examination to pass is the **Basic Qualification**. A holder of the **Radiocommunication Operator General Certificate Maritime (RGMC)** may also be issued an Amateur Radio Operator Certificate.

The qualifications

Qualification	Examination
Basic	100 questions, 70% to pass
Basic with Honours	80% or more on the Basic examination
Morse code	Sending and receiving at 5 wpm
Advanced	50 questions

After the Basic Qualification, the other qualifications may be taken **in any order**.

The certificate, even with Advanced Qualification, only authorizes operation in the **amateur radio service**, no other service.

Source: RIC-3, Information on the Amateur Radio Service (ISED).

B-001-005 Installing or repairing for someone else

To install, place in service, modify or repair an amateur radio transmitter **on behalf of another person**, **both you and the other person** must hold an Amateur Radio Operator Certificate.

- Reprogramming a land mobile transmitter for use on 2 metres for someone: **only if that person holds an Amateur Radio Operator Certificate.**
- Holding the Morse code qualification changes nothing: the other person must still hold a valid certificate.
- A holder of the **Advanced Qualification** may install, place in operation, modify or repair radio apparatus of another service for someone **if that person holds an authorization for the apparatus.**

Source: Radiocommunication Regulations; RIC-3 (ISED).

B-001-006 Authorized equipment and out-of-band operation

Who you may talk to

An amateur radio station communicates with **stations operated under similar authorizations**, that is, other amateur radio stations.

Outside amateur radio bands

- Amateur radio equipment, modified or not, may **never** be used outside the amateur radio bands: it is not certified for that.
- It is therefore **not correct** that it may be used on aeronautical, marine or land mobile frequencies.
- A VHF or UHF FM radio that can be programmed on land mobile frequencies may only transmit there if it is **certified for that service** and its use is **licensed**.

Licence-exempt devices

Using an amplifier to boost the output of a licence-exempt transmitter is **not permitted**.

Low power is still amateur radio

An amateur radio station of **2 watts** or less must still be operated under the supervision of a person holding a certificate and a call sign.

Source: Radiocommunication Regulations; RBR-4 (ISED).

B-001-007 What may not be transmitted

No broadcasting

An amateur radio operator may **never** broadcast to the general public. One-way broadcasts intended for the general public are prohibited.

- To avoid retransmitting music or other non-amateur signals, **turn down the volume** of background audio.

No business

- **Business communications** are not permitted under any circumstance, not even occasionally.
- **Business planning** is prohibited on an amateur radio net.

No secret codes

- Transmitting a **secret code** is not permitted.
- An encoded message is allowed **only when the encoding is not secret**. **Abbreviations** and **Q codes** are allowed, since they are public.
- A new digital encoding technique you developed may be used once it is **published in the public domain**.

Source: Radiocommunication Regulations; RBR-4 (ISED).

B-001-008 Qualifications needed for each activity

Where to operate

A certificate holder may operate a station **anywhere in Canada**: fixed, mobile or portable.

Which qualification for what?

Activity	Minimum qualifications
Assemble a commercially available transmitter kit of professional design	Basic
Operate cross-band repeaters	Basic
Install a repeater on a single band in a voice mode	Basic and Advanced
Install an amateur radio club station	Basic and Advanced
Build or operate a transmitter or RF amplifier that is neither professionally designed nor commercially manufactured	Basic and Advanced
Remotely operate a transmitter (frequency, mode, power)	Basic and Advanced

Beacons

A **beacon station** transmits **one-way** communications, for example to study propagation.

Source: RIC-3, Information on the Amateur Radio Service; RBR-4 (ISED).

B-001-009 Control operator and supervision

Who is responsible?

- **Both the control operator and the station owner** are responsible for the station's operation.
- If you transmit from another amateur's station, **both of you** are responsible.
- The owner is responsible for operating the station **in accordance with the regulations**.

The control operator

- **Any qualified amateur radio operator** chosen by the station owner.
- A station must have a control operator **whenever it is transmitting**.
- The control operator must be **at the station's control point**.

People without a certificate

- Family members without qualifications may not transmit alone: they must hold suitable qualifications to be control operators.
- A person **without a certificate** may operate a station **under the supervision and in the presence** of a person holding appropriate qualifications.

Source: Radiocommunication Regulations; RIC-3 (ISED).

B-001-010 Interference and band status

Harmful interference

Harmful interference seriously degrades, obstructs or repeatedly interrupts a radiocommunication service.

- **Deliberate** interference is **never** acceptable.
- If the Minister determines that an amateur station causes harmful interference, the Minister may **order its operation to cease or change**.
- Test transmissions are allowed when they will not interfere with other stations, amateur or not.

Same frequency

Two amateur operators have an **equal right** to a frequency: neither has priority.

Secondary service

Where the amateur radio service is **secondary**, amateurs may use the band **only if they do not cause interference** to primary users, and they are **not protected** from them.

Band	Status for amateurs
430.0 to 450.0 MHz	Secondary: must not interfere with other services
902 to 928 MHz	Secondary, not protected; heavily used by licence-exempt devices

Source: Radiocommunication Regulations; RBR-4 (ISED).

B-001-011 Distress and disasters

General rule

Amateur radio stations communicate **only with other amateur radio stations**, and only **within the amateur bands**. Even during relief operations after a disaster, transmitting outside the amateur bands is **never** permitted.

In distress

- An amateur **in distress** may use **any means of radiocommunication**, with **no power limitations**.
- If you hear an **unanswered distress signal** on a band where you have no privileges, you **may respond and offer assistance**.
- Radiocommunications required for the **safety of life and property** may be transmitted.
- The only time you may interfere with another station: when your station is **directly involved** in a distress situation.

Disasters and emergencies

- Amateur stations may relay essential communications and assist relief operations when **normal communication systems are overloaded, damaged or disrupted**.
- Amateurs may handle messages from recognized public service agencies **in peace time, during civil emergencies and during exercises**.
- If you are not part of the emergency net: **avoid needless transmissions** on or near its frequency.

Source: Radiocommunication Regulations; RBR-4 (ISED); ITU Radio Regulations, Article 25.

B-001-012 Payment and privacy of communications

No payment

An amateur radio operator may **never** demand or accept payment for exchanging messages, including third-party messages.

Divulging radiocommunications

- Communications from an **amateur radio station** may be divulged or used.
- Other radiocommunications (other than broadcasting) are generally protected. Divulging their content to answer questions from a **media organization** is an **offence**.

Source: Radiocommunication Act; Radiocommunication Regulations.

B-001-013 Station identification

The call sign

- You identify your station **with your call sign**.
- Canadian call signs normally start with **VA, VE, VO or VY** (for example VA3RAC).
- Identification is made in **English or French**.

When to identify

- **At the beginning and at the end** of each contact: **each station** transmits its own call sign.
- **At least every 30 minutes** during a contact: the longest time without identification.
- **Test transmissions** follow the same rules as a radio contact.

The only exception: signals used to **control a model craft** may be sent without identification.

Source: Radiocommunication Regulations; RBR-4 (ISED).

B-001-014 Third parties and foreign amateurs

Third-party communications

A **third party** is a person **without amateur certification** who communicates through an amateur radio station.

- Canada **does not prohibit** third-party communications: they are allowed with **any other amateur radio station**, when they are **personal and non-commercial**.
- Internationally, they are allowed unless the **other country objects**. If a country has filed an objection with the **ITU** to communications with its amateurs, Canadian stations do not communicate with it.
- In **emergencies** or **disaster relief**, they are permitted unless the foreign administration specifically prohibits them.
- If a non-certified friend is talking from your station and a foreign station breaks in: **keep monitoring** your friend's communications.
- If each amateur has a non-certified friend taking part, **both friends** are third parties.

Foreign amateurs in Canada

- A foreign amateur (other than a US citizen) may operate in Canada if their country has an **agreement** with Canada and they have obtained the **appropriate permit**.
- A **CEPT** licence holder is granted privileges equivalent to the **Basic and Advanced** qualifications.
- An **American** amateur in Canada identifies with their call sign, "mobile" or "portable", and the **Canadian prefix** of their location (for example W1AW portable VE3), and gives their **city and province** at least once per contact.

Source: Radiocommunication Regulations; RIC-3 (ISED); ITU Radio Regulations, Article 25.

B-001-015 Privileges and HF bands

Privileges follow the call sign and the operator

- An operator with more qualifications using **your call sign** has **only your privileges**.
- At the station of a more qualified amateur, you have **only the privileges of your own qualifications**.

Access below 30 MHz

The Basic Qualification alone gives access to the bands **above 30 MHz**. For the bands **below 30 MHz** (HF), you need:

- **80%** or more on the Basic examination (Basic with Honours), or
- to pass the **Advanced** or **Morse code** examination.

HF bands in Canada

Band	Frequencies
160 m	1.8 to 2.0 MHz
80 m	3.5 to 4.0 MHz
40 m	7.0 to 7.3 MHz
20 m	14.000 to 14.350 MHz
15 m	21.000 to 21.450 MHz
10 m	28.000 to 29.700 MHz

The band name is roughly the wavelength: $\lambda = 300/F$, for example $300/3.75 = 80$ m.

Radio-controlled models

Radio control of models is allowed on **all amateur bands above 30 MHz**.

Source: RIC-3 (ISED); RBR-4 (ISED).

B-001-016 Authorized bandwidth

The limits

Bands	Maximum bandwidth
Between 7 and 25 MHz (except 30 m)	6 kHz
30 m: 10.100 to 10.150 MHz	1 kHz
10 m: 28.0 to 29.7 MHz	20 kHz
6 m (50 to 54 MHz) and 2 m (144 to 148 MHz)	30 kHz

Consequences

- An **SSB** signal is about 3 kHz wide: it is **prohibited on 30 m** (for example on 10.12 MHz). CW and narrow digital modes are allowed there.
- **Fast-scan television** (ATV) is several MHz wide: prohibited on 14.23 MHz and on 145 MHz. It is used on UHF, for example around 440 MHz.
- FM fits in 20 kHz: it is found around 29.6 MHz, at the top of the 10-metre band.

Near a **band edge**, make sure the **entire occupied bandwidth** of your signal stays inside the band, not just the displayed frequency. On upper sideband, the signal extends about 3 kHz above the displayed frequency.

Source: RBR-4, Standards for the Operation of Radio Stations in the Amateur Radio Service (ISED).

B-001-017 Power limits

The principle

Always use the **minimum legal power** necessary to communicate.

The limits

	Basic (with Honours or Morse)	Advanced
DC input power to the final stage	250 W	1,000 W
Peak envelope power (PEP) on SSB	560 W	2,250 W
Carrier power, modes other than SSB	190 W	—

- On **60 metres**, the limit is **100 W effective radiated power (ERP)**, expressed as PEP, whatever the qualification.
- On **630 metres** and **2200 metres**, the limit is expressed as **EIRP** (equivalent isotropically radiated power): the antenna **gain** must be taken into account.

Where to measure

Power is verified **at the output of the transmitter**, or of the **external amplifier** if there is one.

Source: RBR-4, Standards for the Operation of Radio Stations in the Amateur Radio Service (ISED).

B-001-018 Repeaters and unmodulated carriers

The repeater

A **repeater** is a station that **automatically retransmits** the signals of other stations: it receives on one frequency and retransmits on another, often from a high site.

- A holder of the Basic Qualification alone has no access below 30 MHz, but may use repeater outputs from **29.500 to 29.700 MHz**, at the top of the 10-metre band. The lowest output frequency they may use is therefore **29.500 MHz**.

Unmodulated carrier

An unmodulated carrier carries no information. It is allowed only for **brief tests below 30 MHz**, for example to adjust a tuner.

Source: RBR-4; RIC-3 (ISED).

B-001-019 Frequency stability and modulation

Frequency

- Every station must be able to **measure its frequency** reliably, whatever the mode.
- Below **148 MHz**, stability must be **equivalent to crystal control**.

Modulation

- Voice modulation must not exceed **100%**.
- The signal quality problem unique to voice modes is **overmodulation**: distortion and spurious emissions that widen the signal.
- On **SSB**, the station must have means to **prevent or indicate overmodulation** (for example ALC or a peak indicator).

Source: RBR-4, Standards for the Operation of Radio Stations in the Amateur Radio Service (ISED).

B-001-020 The ITU Radio Regulations

Besides the **Radiocommunication Act** and **Regulations**, Canadian amateurs comply with the **Radio Regulations** of the **International Telecommunication Union** (ITU).

What they say about amateurs

- International communications are **permitted** unless an administration has **registered an objection**.
- They are limited to the **purposes of amateur radio** and to **remarks of a personal nature**.
- Each **administration** decides whether **Morse code** proficiency is required for authorization.

Source: ITU Radio Regulations, Article 25.

B-001-021 ITU regions and operating abroad

The three regions

Region	Area
1	Europe, Africa, Middle East
2	The Americas, including Canada
3	Asia and Oceania: Australia, Japan, Southeast Asia

Operating abroad

You always follow the **rules of the country you operate in**.

- In Florida, or 7 km off its coast (US territorial waters), the **US band limits** apply.

Destination	Minimum qualification	Voice identification
United States	Basic	Canadian call sign, "portable" or "mobile", then the prefix of the US call area (VE3ABC portable W4)
CEPT countries	Advanced	Prefix of the country visited, "stroke", then the Canadian call sign (F stroke VE2XYZ)

Source: ITU Radio Regulations, Article 5; RIC-3 (ISED); CEPT Recommendation T/R 61-01.

B-001-022 Examinations: fees and conditions

Fees

- Examination at an **ISED office**: **no charge**.
- Examination by an **accredited examiner**: the examiner **may charge a fee to recover costs**.

Conditions

- Examinations are in **English or French**. **Interpreters** are not allowed; an **oral** examination may be offered to a candidate with reading difficulties.
- A **disabled** candidate may take an adapted examination, but is **never exempted** from any part of it.

Source: RIC-3, Information on the Amateur Radio Service; RIC-7, guide for accredited examiners (ISED).

B-001-023 Antenna structures and public consultation

Who decides?

Radiocommunication is under federal jurisdiction: the **Minister of Innovation, Science and Industry** has authority over antenna systems, masts and towers. The process is set out in ISED's **CPC-2-0-03**.

Consultation

- An amateur may not erect any antenna structure without consulting: they follow ISED's process and address the community's concerns.
- If the **land-use authority** (often the municipality) has its own process, **it** determines how consultation takes place.
- Otherwise, the amateur follows ISED's **default public consultation process**.

ISED's default process

- A written public notice, then answers to **reasonable and relevant concerns** received **in writing** within the **30-day** comment period.
- It does **not** include public meetings.
- If the proponent and a stakeholder other than the general public cannot agree, **ISED** decides.

Exclusions

Consultation may not be required if the structure is **excluded** by the municipal process **or** by CPC-2-0-03 (for example, an amateur antenna less than 15 m high). The tallest structure possible without consultation is therefore the tallest **excluded** by either authority.

Source: CPC-2-0-03, Radiocommunication and Broadcasting Antenna Systems (ISED).

B-001-024 Safety Code 6: RF exposure

The document

Safety Code 6 is published by **Health Canada**. It sets **RF exposure limits for the human body**.

- It sets limits on **electric and magnetic fields**, induced and contact currents and the **specific absorption rate, not** on the power fed to antennas.
- It therefore does **not** specify a "safe" maximum power for a hand-held radio.
- **No transmitter is exempt**, not even hand-held or low-power ones.

Two environments

Environment	People
Controlled	People aware of the risks
Uncontrolled	The general public: stricter limits

Effects on the body

- The main effect is **heating** through energy absorption. The limits are lowest from **48 to 300 MHz**, because the human body absorbs RF energy the most there (its size is close to half a wavelength).
- Below about **10 MHz**, **nerve stimulation** is a second established effect.

Source: Safety Code 6 (Health Canada); RSS-102 (ISED).

B-001-025 Interference and immunity: EMCAB-2

ISED's **Electromagnetic Compatibility Advisory Bulletin EMCAB-2** tells who is at fault when equipment malfunctions near a transmitter.

The criterion: field strength at the neighbour's

Field strength of your signal at the neighbour's premises	Conclusion
Below ISED's immunity criteria	The equipment lacks immunity: the problem is the equipment
Above ISED's immunity criteria	Your transmission is deemed the cause

Types of equipment

Category	Examples
Radio-sensitive equipment	Devices that contain a radio receiver: television, garage door opener
Associated equipment	Home entertainment devices that are not radio apparatus: stereo, player, amplifier

Source: EMCAB-2, Electromagnetic Compatibility Advisory Bulletin (ISED).

Operating and Procedures

B-002-001 Repeaters

What a repeater is for

A repeater, installed on a high site, **increases the range of portable and mobile stations**: it receives on one frequency (the input) and retransmits on another (the output).

- On **2 metres**, the normal offset between input and output is **600 kHz**; on 70 cm it is 5 MHz.
- **Frequency coordination** recommends repeater frequency pairs to **minimize interference** between neighbouring repeaters.
- The **time-out timer interrupts lengthy transmissions**.
- **CTCSS** is a **sub-audible tone** (about 67 to 254 Hz) that opens the receiver or repeater audio only when it is present.

Good practice

- To call a station: their call sign, then yours ("VE2ABC, this is VE2XYZ").
- To join a conversation: say your call sign **during a break**.
- **Pause briefly** between transmissions: someone may need the repeater.
- Keep conversations **short**: someone with an emergency must be able to get in.
- Speak plainly ("Where are you?"): 10-codes belong to CB and public services.

Source: ISED official question bank, Basic Qualification (section B-002); Radio Amateurs of Canada band plans.

B-002-002 The ITU phonetic alphabet

On voice, spell your call sign with the **code words of the ITU phonetic alphabet**: they avoid confusion between letters that sound alike (B, D, P, V...), especially with weak signals.

Letter	Word	Letter	Word	Letter	Word
A	Alfa	J	Juliatt	S	Sierra
B	Bravo	K	Kilo	T	Tango
C	Charlie	L	Lima	U	Uniform
D	Delta	M	Mike	V	Victor
E	Echo	N	November	W	Whiskey
F	Foxtrot	O	Oscar	X	X-ray
G	Golf	P	Papa	Y	Yankee
H	Hotel	Q	Quebec	Z	Zulu
I	India	R	Romeo		

Alfa is spelled with an "f". Words such as Able, Adam or Baker come from older alphabets: they are not the ITU words.

Example: VE2XYZ is said "Victor Echo 2 X-ray Yankee Zulu".

Source: ITU Radio Regulations, Appendix 14.

B-002-003 Voice calls, simplex and sidebands

Calling and answering

Situation	Format
General call (CQ)	"CQ" three times, "this is", then your call sign three times
Answering a CQ	The other station's call sign once, "this is", then your call sign
Calling a specific station	Their call sign, "this is", then your call sign

Simplex

Simplex means transmitting and receiving on **the same frequency**, without a repeater.

- If signals are reliable between all parties, switch to simplex: the repeater stays free.
- To check, listen on the repeater's **input frequency** ("reverse" key): if you hear the other station clearly, simplex will work.
- Choose your simplex frequency carefully: you could land on the **input of a local repeater**. If you are in simplex on a repeater frequency, move, so you do not interfere with its users.
- Use **VHF and UHF** for local contacts: this avoids cluttering the HF bands, which are better for long distance.

Which sideband?

Frequency	Usual voice sideband
Below 10 MHz (160, 80, 40 m; for example 3755 kHz)	Lower (LSB)
Above 10 MHz (20 m and up)	Upper (USB)

Source: ISED official question bank, Basic Qualification (section B-002).

B-002-004 Good operating practice

Before transmitting

- **Listen** carefully first, to make sure the frequency is clear and not interrupt a contact.
- On SSB, leave about **3 kHz** from a contact in progress (an SSB signal is about 3 kHz wide).

Power and tests

- If your signal is extremely strong and perfectly readable, **turn down your power** to the minimum necessary.
- For long tests, use a **dummy load**: a non-radiating 50 Ω resistor that replaces the antenna, so you can adjust the transmitter without interference.
- To adjust an antenna tuner before joining an SSB net, transmit **3 to 5 kHz away** from the net frequency.

Sharing frequencies

- Nobody owns a frequency. If a net's usual frequency is busy, the net control asks the occupants to move, **otherwise moves the net**.
- If a net is about to start on the frequency you are using: **as a courtesy, move**.
- If propagation brings interference: **move to another frequency** rather than raising your power.

The band plan

A **band plan** is a **voluntary division** of each band between modes (CW, digital, voice) to avoid interference between incompatible modes.

Source: ISED official question bank, Basic Qualification (section B-002); IARU and Radio Amateurs of Canada band plans.

B-002-005 Morse code in practice

Calling and answering

Situation	Format
General call	"CQ" three times, "DE", your call sign three times, then "K"
Answering a CQ	The calling station's call sign twice, "DE", your call sign twice

- Send your CQ at a **speed you can reliably receive**: the answer will come at the same speed.
- Leave **150 to 500 Hz** from a contact in progress: a CW signal is very narrow.

Abbreviations

Abbreviation	Meaning
CQ	Calling any station
DE	From
K	Any station please reply
R	All received
DX	Distant station
73	Best regards

Full break-in (QSK)

With **full break-in** CW (QSK), incoming signals are received **between the transmitted dots and dashes**.

Source: ISED official question bank, Basic Qualification (section B-002); ITU Radio Regulations.

B-002-006 The RST report and the S meter

The RST report

The **RST** report describes how the other station's **signal is received**.

Letter	Quantity	Scale
R	Readability	1 (unreadable) to 5 (perfectly readable)
S	Signal strength	1 (barely perceptible) to 9 (very strong)
T	Tone (CW only)	1 to 9 (perfect tone)

Report	Meaning
5 7	Perfectly readable, moderately strong
3 3	Readable with considerable difficulty, weak
1 1	Unreadable, barely perceptible
5 9 plus 20 dB	Perfectly readable, 20 dB above S9
579	Perfectly readable, moderately strong, perfect tone
459	Quite readable, fair strength, perfect tone

Through a **repeater**, your S meter reads the repeater, not the distant station: report the quality of their signal and audio **as heard through the repeater**.

S units and power

By the IARU recommendation, one S unit is **6 dB**, a factor of **4** in power.

- From S8 to S9: multiply the power by **4**.
- A 100 W station received at S9 drops to S8 with $100/4 = 25$ W.

Source: ISED official question bank, Basic Qualification (section B-002); IARU recommendation on S-meter calibration.

B-002-007 Q signals

Code	Meaning	As a question
QRL	The frequency is busy	Is the frequency busy? (send it before transmitting in CW)
QRM	I am being interfered with (by other stations)	
QRN	I am troubled by static	
QRS	Send more slowly	
QRX	I will call you again (stand by)	
QRZ		Who is calling me?
QSB	Your signal is fading	
QSY	Change frequency	
QTH	My location is...	

Do not mix up **QRM** (man-made interference) and **QRN** (natural static, thunderstorms), nor **QRS** (slower) and **QRZ** (who is calling me?).

Source: ITU Radio Regulations, Appendix 14 (Q code).

B-002-008 Distress and urgency

The signals

Priority	Voice	Situation
1. Distress	MAYDAY (three times)	A life is threatened
2. Urgency (emergency message)	PAN PAN	Help needed, no immediate danger to life (for example a breakdown in a remote place)
3. Safety	SECURITE	Safety notice

- In Morse code, the distress signal is **SOS**.
- SOS and MAYDAY are only used in **life-threatening distress situations**.

Answering a distress call

- Distress has absolute priority: **acknowledge** the station, find its **location** and **what assistance** is needed.
- If you cannot help directly: **contact the authorities**, then keep listening.
- On a repeater, to report distress: give your call sign and situation **during a break**.

Being prepared

- Being able to run the station **without household AC power** lets you operate during power outages.
- For a hand-held: an adequate supply of **charged batteries**.
- For a portable HF station: a **dipole** or a **vertical**, light and quick to set up.

Source: ITU Radio Regulations; ISED official question bank, Basic Qualification (section B-002).

B-002-009 QSL cards, logs, maps and UTC

Confirming a contact

- A **QSL card** is **written proof** of a contact between two stations.
- Contacts are also confirmed through **web-based logs** (LoTW, eQSL, QRZ...).
- Keeping a **logbook** is **not** a regulatory requirement in Canada, but it is very useful.

Finding your way

- An **azimuthal map** is a projection **centred on a given location**: centred on your station, it shows the **bearing** to any place in the world.
- The **long path** is **180°** from the short path: if New Zealand does not come through in its direction, turn the antenna 180°.
- The **grid square** (Maidenhead system) gives your location as a **4 or 6-character code** (FN35 for Montréal), exchanged in VHF contests.

UTC

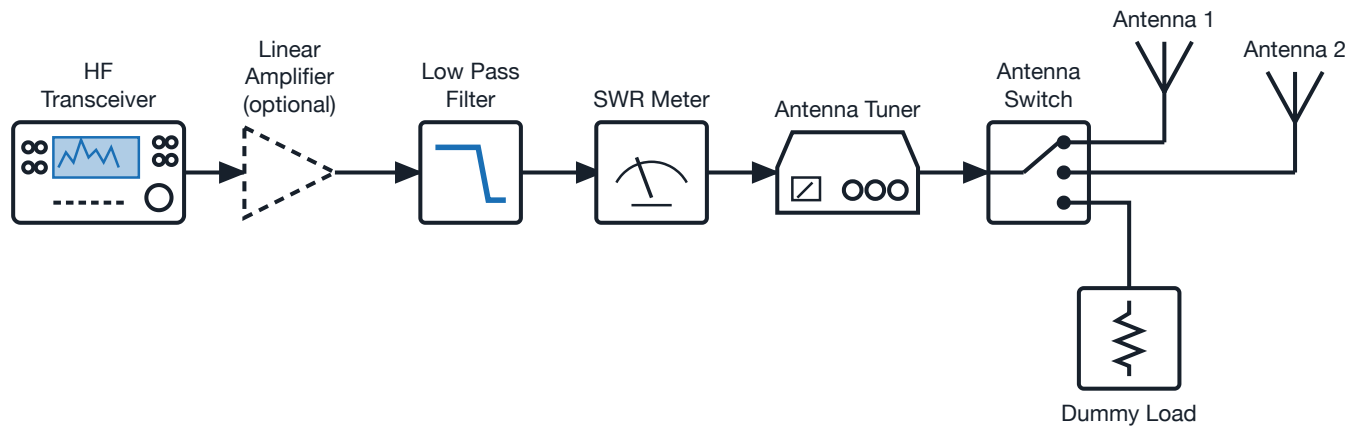
- **UTC** is measured from the **Greenwich** meridian (United Kingdom).
- Local time = UTC + offset. At UTC – 6 h, a net at 19:00 UTC starts at **1 PM** local time.
- **CHU** (Canada), **WWV** and **WWVH** (United States) broadcast **accurate time and frequency** signals.

Source: ISED official question bank, Basic Qualification (section B-002); National Research Council Canada (CHU).

Station Assembly, Practice and Safety

B-003-001 The typical HF station

In an HF station, the equipment follows this order: **transceiver**, (external amplifier), **low-pass filter**, **SWR meter**, **antenna tuner**, **antenna switch**, then the antennas and the dummy load.



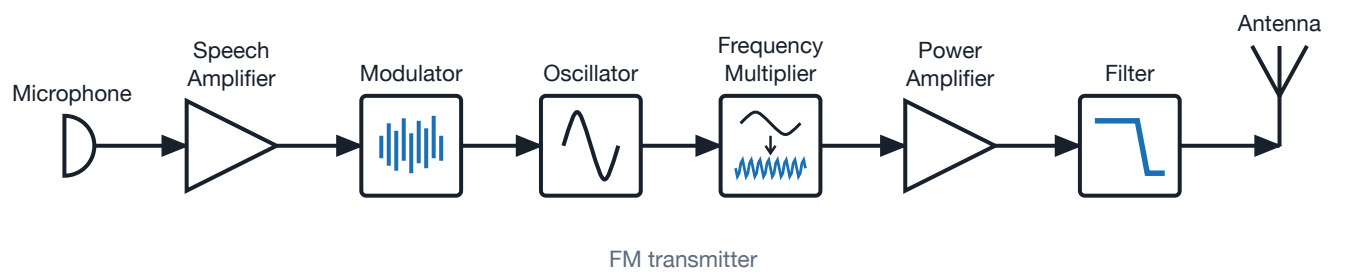
Typical HF installation

Equipment	Role
Low-pass filter	Reduces harmonic emissions; placed as close as possible to the transceiver output, or to the external amplifier output if there is one
SWR meter	Shows whether the antenna system impedance is matched to the transmitter; inserted right after the low-pass filter
Antenna tuner	Matches the antenna impedance, so an antenna can be used on a band it was not designed for
Antenna switch	Selects the desired antenna or the dummy load
Dummy load	Dissipates RF energy as heat without radiating

- Modern HF transmitters have a **built-in low-pass filter** to reduce harmonic emissions.
- Antenna impedance changes with frequency: with a solid-state final amplifier, the **antenna tuner** may need adjusting when you change frequency.

Source: ISED, Reference material for the Basic Qualification (typical HF installation diagram).

B-003-002 The FM transmitter

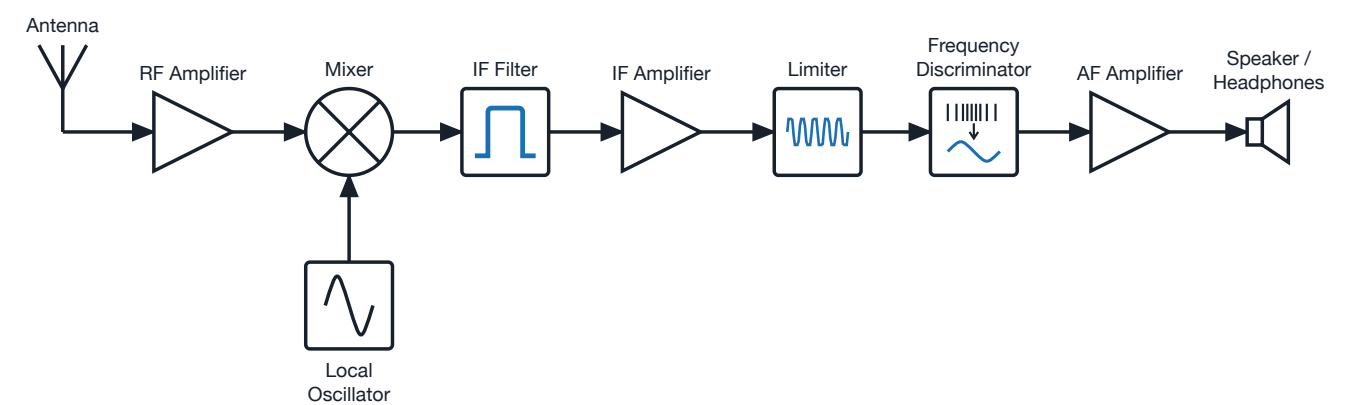


Stage	Role
Microphone	Produces an electrical signal from air pressure changes, driving the speech amplifier
Speech amplifier	Amplifies this weak signal
Modulator	Changes the oscillator frequency with the audio
Oscillator	Produces the basic signal; in FM it is the only kind of oscillator whose frequency varies
Frequency multiplier	Produces a useful harmonic of the oscillator: the output carrier frequency (for example $12 \times 12 \text{ MHz} = 144 \text{ MHz}$)
Power amplifier	Supplies RF power to the antenna; the stage that draws the most power

In AM, CW and SSB the oscillator stays on a fixed frequency. In FM the modulator alters its frequency.

Source: ISED, Reference material for the Basic Qualification (FM transmitter diagram).

B-003-003 The FM superheterodyne receiver

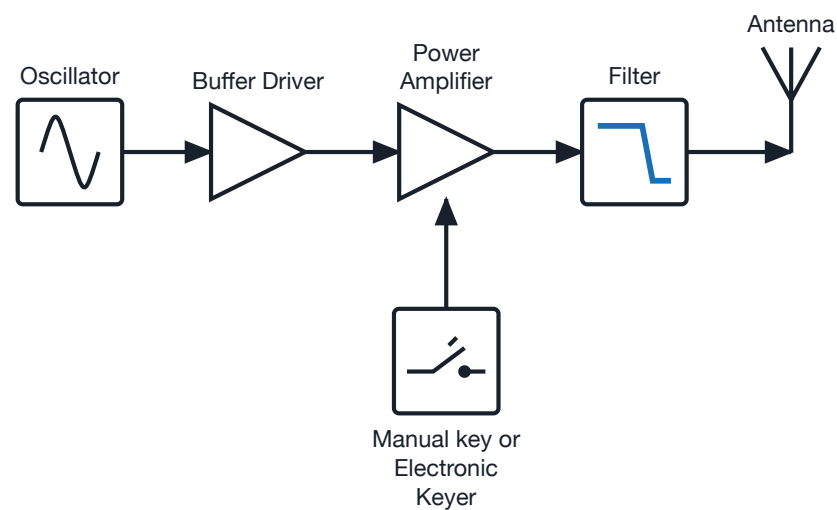


Superheterodyne FM receiver

Stage	Role
RF amplifier	The front-end ; on VHF it must produce very little noise
Local oscillator	Sets the received frequency
Mixer	Converts any received frequency to a fixed intermediate frequency (IF) , so detection works at a single frequency
IF filter	Rejects signals on adjacent channels (selectivity)
IF amplifier	Provides the final signal power to drive the detector
Limiter	Removes amplitude variations (noise, static)
Discriminator	Recovers the original modulation : turns frequency variations into audio
AF amplifier	Controlled by the volume control; includes the squelch

Source: ISED, Reference material for the Basic Qualification (FM receiver diagram).

B-003-004 The CW transmitter



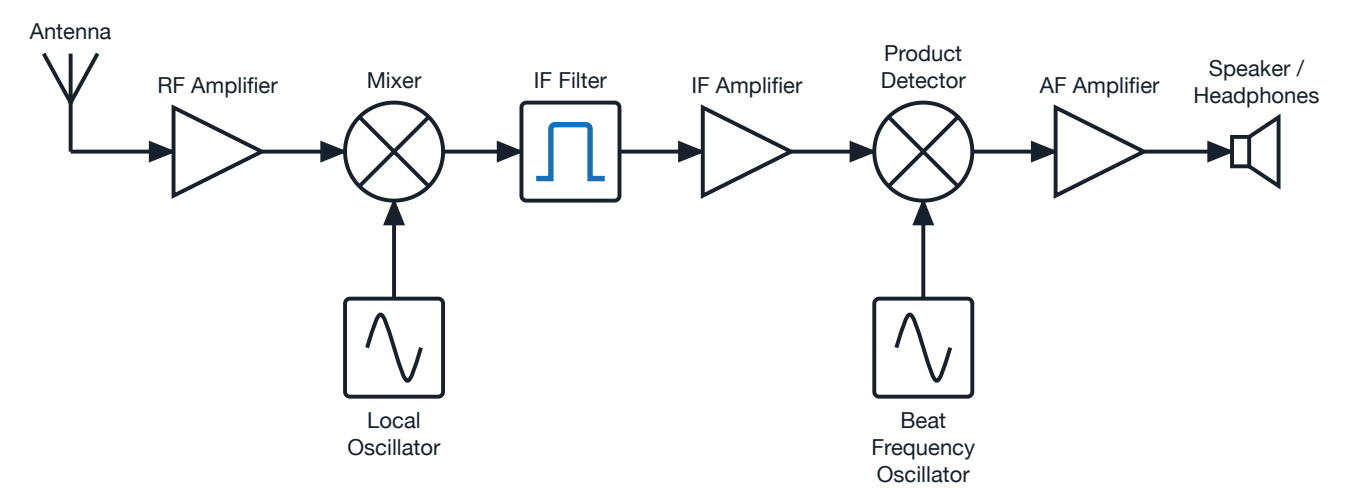
CW transmitter

Stage	Role
Oscillator	Produces the transmitted frequency directly
Driver/buffer	Prevents load changes from shifting the oscillator frequency
Power amplifier	Increases the output power
Key	Switches the carrier on and off , so it controls its amplitude

- Each stage is powered by **direct current**.
- In the three-stage transmitter, the key acts on the power amplifier: the oscillator keeps running, which avoids chirp.

Source: ISED, Reference material for the Basic Qualification (CW transmitter diagram).

B-003-005 The SSB/CW receiver

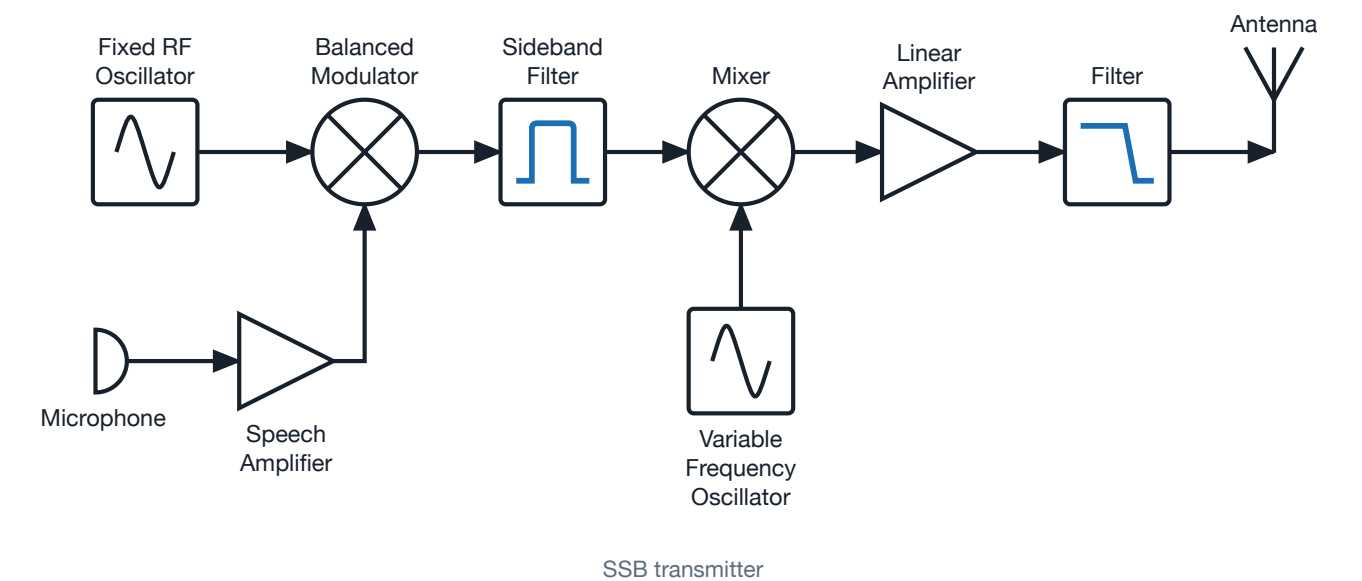


Superheterodyne SSB/CW receiver

Stage	Role
Antenna	Converts electromagnetic waves into electrical currents
RF amplifier	Increases sensitivity
Local oscillator	Mixed with the incoming signal to produce the IF
Mixer	Converts the received signal to the intermediate frequency
IF filter	Provides most of the selectivity
IF amplifier	Provides most of the gain
Beat frequency oscillator (BFO)	Mixed with the IF to recover the modulation: it recreates the missing carrier
Product detector	Recovers the transmitted modulation (voice on SSB, tone on CW)
AF amplifier	Increases the level of the recovered audio; may include an audio band-pass filter

Source: ISED, Reference material for the Basic Qualification (SSB/CW receiver diagram).

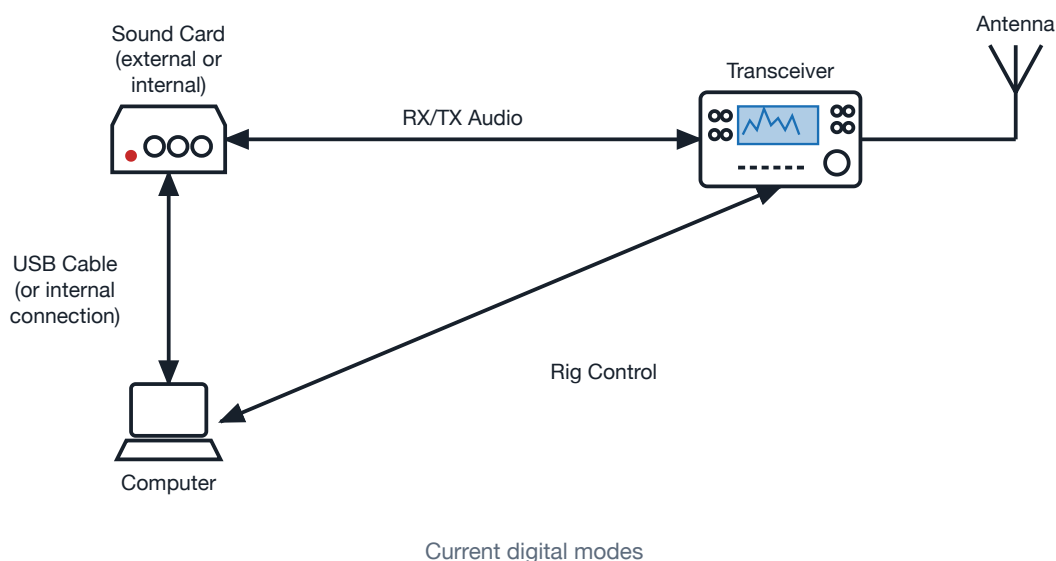
B-003-006 The SSB transmitter



Stage	Role
Speech amplifier	Amplifies the audio: microphones have a low output
Fixed RF oscillator	Produces an RF carrier
Balanced modulator	Moves the voice from the audio spectrum to the radio spectrum ; suppresses the carrier and passes both sidebands
Sideband filter	Removes the unwanted sideband ; tuned near the fixed RF oscillator frequency
Variable frequency oscillator (VFO)	Lets you adjust the transmit frequency
Mixer	Moves the SSB signal to the operating frequency
Final amplifier	Amplifies the signal; includes protection against high SWR

Source: ISED, Reference material for the Basic Qualification (SSB transmitter diagram).

B-003-007 Digital modes: computer and sound card



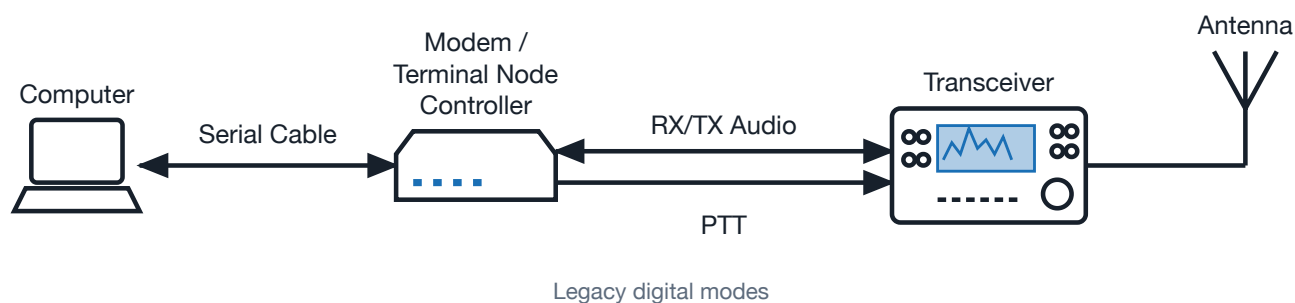
The sound card interface

It provides **audio frequency coupling** between the computer and the transceiver, both ways:

- on receive, the transceiver's analog audio is **converted to digital** for the software;
- on transmit, the software's digital signal becomes an **audio signal** to transmit;
- most interfaces also **switch** the transceiver between receive and transmit (PTT).

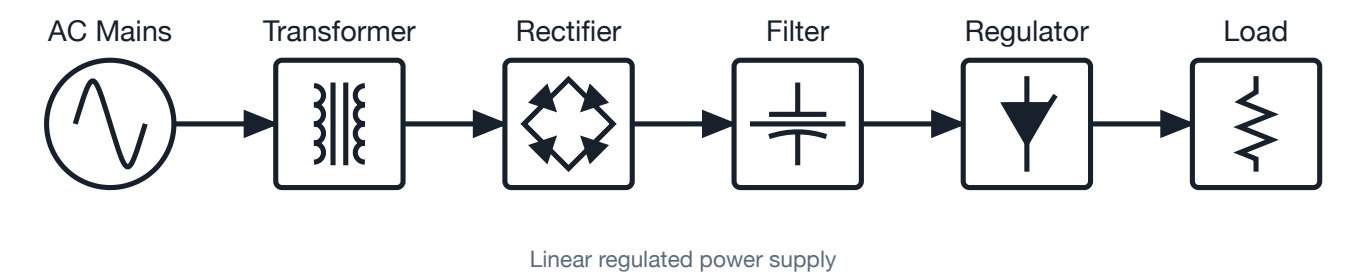
Isolation transformers keep the computer-to-radio connection from introducing **hum** and interference (ground loops).

Some transceivers include an **audio codec**: a USB cable is enough, without a separate sound card.



Source: ISED, Reference material for the Basic Qualification (digital mode diagrams).

B-003-008 The linear regulated power supply

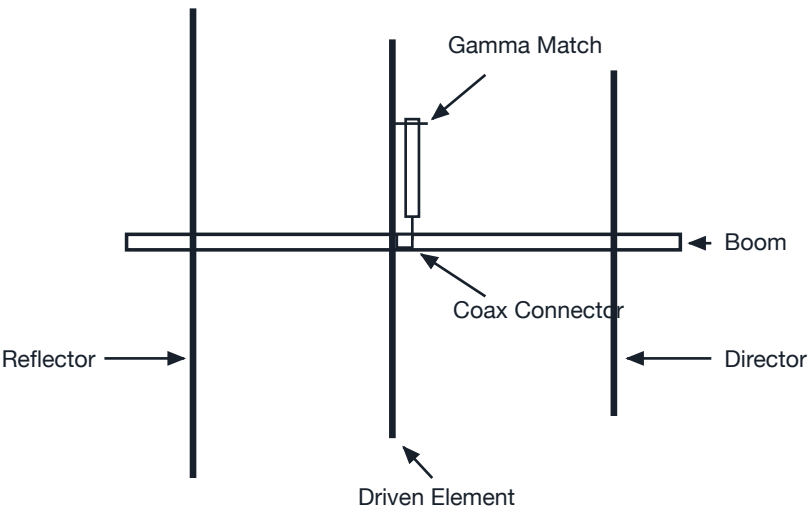


Stage	Role
Transformer	Steps the mains voltage up or down and provides isolation
Rectifier	Converts alternating current to direct current (pulsating)
Filter	Smooths the pulsating direct current
Regulator	Keeps the voltage constant when the demand varies; it gets hot and needs a heat sink

Overvoltage protection monitors the voltage **at the output of the regulator**.

Source: ISED, Reference material for the Basic Qualification (power supply diagram).

B-003-009 The 3-element Yagi antenna



Yagi-Uda antenna

Element	Role
Reflector	The longest element, behind the driven element
Driven element	The only one connected to the transmission line
Director	The shortest element, in front; radiation goes its way
Boom	Mechanical support for the elements

The reflector and the director are **parasitic** elements: they are excited by coupling with the driven element.

Source: ISED, Reference material for the Basic Qualification (Yagi antenna diagram).

B-003-010 Receiver performance

Three criteria

- **Sensitivity**: the RF input signal needed to achieve a given **signal-to-noise ratio**.
- **Selectivity**: the ability to reject nearby signals.
- **Dynamic range**: receiving a weak signal in the presence of very strong ones.

Bandwidths and filters

From narrowest to widest: **CW** (100 to 150 Hz), **SSB** (2.4 to 3 kHz), **FM** (10 to 16 kHz).

Filter	Use
250 Hz	CW with heavy interference
500 Hz	CW
2.4 kHz	SSB
6 kHz	AM

- For CW, the best pass band is narrow, around the tone: for example **750 to 850 Hz**.
- Too narrow a bandwidth causes **loss of information**.
- **SSB** needs accurate tuning, **within 100 Hz**.

Other functions

- **Automatic gain control** (AGC) limits volume changes caused by large signal strength variations.
- The **waterfall** display shows the **amplitude** and **frequency** of signals over time.

Local oscillator calculation

With the local oscillator above the received frequency: $f_{LO} = f + IF$. To receive 3.54 MHz with a 455 kHz IF: $3.54 + 0.455 = 3.995$ MHz.

Source: ISED official question bank, Basic Qualification (section B-003).

B-003-011 CW, AM and transmitter stability

CW

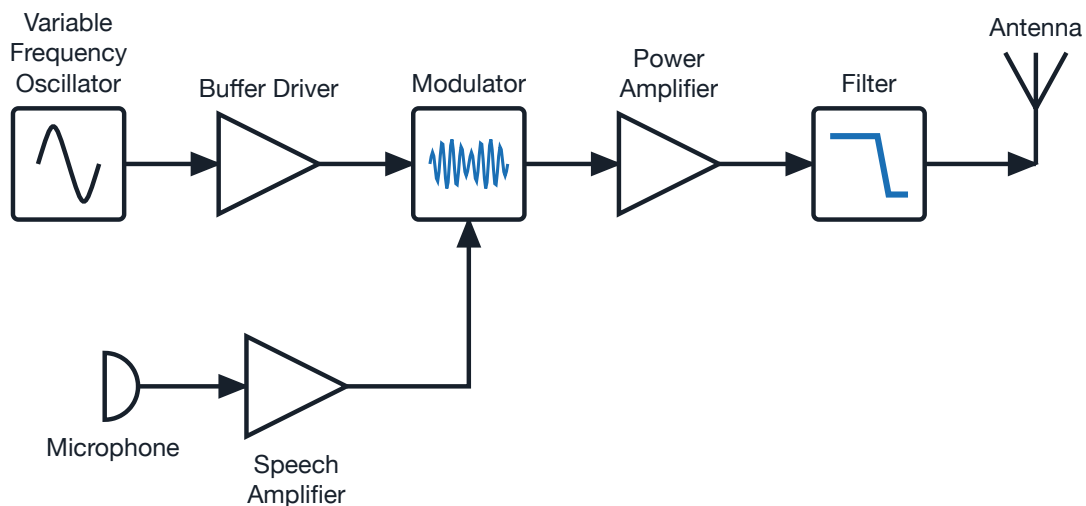
- Morse code is sent as an **interrupted carrier**.
- **Chirp** is a small change in output frequency each time a dit or dah is sent. Prevent it by keeping the **power supply voltage very steady** under varying load.
- A **variable frequency oscillator** (VFO) frees you from the crystals you have.
- An oscillator must be electrically and mechanically stable to avoid **frequency drift**.

AM

- **Amplitude modulation** varies the carrier amplitude: its **envelope** follows the audio.
- An AM signal contains **a carrier and two sidebands**.
- Its bandwidth is twice the highest audio frequency: voice up to 3 kHz → **6 kHz**.

Efficiency

DC power that does not come out as RF **appears as heat**: 200 W input and 125 W output → 75 W of heat, efficiency $125/200 = 62.5\%$.



AM transmitter

Source: ISED official question bank, Basic Qualification (section B-003).

B-003-012 Single sideband (SSB)

How it works

- The **balanced modulator** suppresses the carrier and passes both sidebands; a filter keeps one.
- Suppressing the carrier puts **more of the output power into the sidebands**, which carry the information.
- An SSB signal is **2 to 3 kHz** wide.
- The power amplifier must be **linear**, otherwise the voice becomes unintelligible.

Peak envelope power (PEP)

Peak envelope power is the average power during one RF cycle, at the **crest of the modulation envelope**.

Adjusting the transmitter

- Set the microphone gain so the **ALC** meter's range is never exceeded on voice peaks.
- **ALC** limits audio peaks so the transmitter is not overdriven.
- Too much microphone gain or **speech processing** causes **distortion** and splatter on nearby frequencies: **overmodulation** widens the signal.

Lower sideband

On LSB the signal is **below** the displayed frequency: at 7100 kHz with a 1000 Hz tone, the transmitted signal is at **7099 kHz**.

Source: ISED official question bank, Basic Qualification (section B-003).

B-003-013 Frequency modulation (FM)

How it works

- **Deviation** is the change in frequency caused by modulation. A louder modulating signal gives a **larger deviation**.
- The method closest to FM is **phase modulation**.
- With no audio (failed microphone), the transmitter sends an **unmodulated carrier**.

Bandwidth

Carson's rule: $B = 2 \times (\Delta F + f_{audio})$. With 5 kHz deviation and 3 kHz audio: 16 kHz, so **between 10 and 20 kHz**.

FM is not used **below 28 MHz**: its bandwidth would exceed the regulatory limits.

Strengths and quirks

- FM gives a **good signal-to-noise ratio** at low signal levels: ideal for local VHF and UHF.
- **Capture effect**: the receiver demodulates only the strongest signal.
- With no signal, a loud noise comes from the very large gain of the stages ahead of the discriminator.

Common problems

Symptom	Cause
Low audio on a 5 kHz deviation repeater	Your transmitter is set to 2.5 kHz
Loud, distorted audio	Speaking too loudly into the microphone

Source: ISED official question bank, Basic Qualification (section B-003).

B-003-014 Accessories and noise reduction

Keying and speaking

- An **electronic keyer** helps form good Morse characters by **regulating the lengths of dits and dahs**.
- Before using a new microphone, set the **microphone gain**.
- A **dynamic** microphone has internal parts similar to a loudspeaker.
- **VOX** switches the transmitter on when you speak.
- **Transmit/receive switching** lets **one antenna** serve for both transmitting and receiving.

Speech processor

Properly adjusted, it makes the signal **more intelligible**: it **increases the average power** without exceeding peak power.

Reducing noise

Device	Action
Noise blanker	Recognizes and removes short, high-amplitude pulses (ignition, electric fences)
DSP noise reduction	Analyzes noise and signal to partially remove the noise

Source: ISED official question bank, Basic Qualification (section B-003).

B-003-015 Digital communications

Digital and analog

- **Digital** data is encoded as **discrete pre-agreed values**; analog data varies continuously.
- Any analog information (voice, images) can be **converted to digital data**: a digital system can carry everything.

Packet and networks

- A **digipeater** receives digital data and retransmits the data **marked for retransmission**.
- A **network** connects stations so data can be sent over long distances.
- Packet offers **reliable messaging**: guaranteed delivery or notification of failure, useful in emergencies.
- **ARQ** (automatic repeat request) provides **error correction** by retransmission.

FT8 and RTTY

- An **FT8** signal is very narrow (about 50 Hz): dozens of contacts fit in one SSB channel. It works at the **lowest signal-to-noise ratio**.
- On **RTTY**, leave **250 to 500 Hz** from a contact in progress.

Audio level

Too much audio into the transmitter causes **splatter** or out-of-channel emissions. To check, ask a **local station** whether your signal is clean.

Source: ISED official question bank, Basic Qualification (section B-003).

B-003-016 Batteries

Basics

- A battery has a **positive and a negative terminal**; it is a source of **electromotive force** (EMF).
- A battery that can be recharged many times is a **storage battery**.
- A car starter battery supplies about **12 V**.
- The terminal voltage drops when the battery supplies current, because of its **internal resistance**.

Types

Type	Advantage
NiMH	Can be recharged many times (unlike an alkaline cell)
Lithium	High capacity per kilogram compared with lead-acid

A **lithium-ion** battery must **never be short-circuited**: it can overheat and catch fire.

Capacity and connections

- Capacity is stated for a given current: drawing more current makes the battery **discharge faster** than specified.

Two 12 V, 20 Ah batteries	Voltage	Capacity
In parallel	12 V	40 Ah
In series	24 V	20 Ah

Source: ISED official question bank, Basic Qualification (section B-003).

B-003-017 Powering the station

Choosing a power supply

- A **power supply** converts 120 V AC to 12 V DC.
- For a 13.8 V supply, the key specification is its **output current capability** (about 20 to 25 A for 100 W).
- Homes are supplied with **120 V and 240 V**.

Supply	Advantage
Linear	Lower risk of radio frequency noise
Switching (switch mode)	Smaller and lighter , more efficient

- An unregulated supply (transformer, rectifier, capacitor) makes a CW transmitter **chirp**, because its voltage drops each time you key.
- A loud low-frequency **hum** on your signal comes first from the **power supply** (filtering).

Mobile installation

- Use **heavy-gauge wire** to **minimize voltage drop**.
- Put a **fuse** on the positive lead, **as close as possible to the battery**: it protects the whole circuit and prevents a **fire** from overcurrent.

Voltage drop calculation

Count both the positive and the return wire: a 3 m run means 6 m of wire. With No. 10 wire (0.07 V per metre at 22 A): $6 \times 0.07 = 0.42$ V, under the 0.5 V limit.

Source: ISED official question bank, Basic Qualification (section B-003).

B-003-018 Electrical safety

Preventing unauthorized use

- At home: a **key-operated switch** in the main power line.
- In the car: **remove the microphone**.

The hazards

- A current of about **20 mA** can be fatal; the most vulnerable organ is the **heart**.
- **30 V** or more is usually considered hazardous.
- A starter battery can deliver a **very high short-circuit current**.
- A high-voltage power supply has an **interlock switch** that turns it off when the cabinet is opened.
- Troubleshooting a live power supply risks **electric shock**: **turn off the power and unplug** it first.

Helping a victim

If someone is in contact with high voltage: **turn off the power** before touching them, call for emergency help, then give first aid.

Source: ISED official question bank, Basic Qualification (section B-003).

B-003-019 Grounding and fuses

Grounding

- **All station equipment** is grounded, to the station's **single-point ground**.
- Bonding all ground electrodes together with heavy conductors **prevents voltage differences** between devices during a lightning strike.
- The best ground rod: **copper-clad steel**.
- The **green wire** of the line cord connects to the **chassis**: in a fault, the chassis does not become energized.
- A long ground wire (10 m down from a third floor) can have **high impedance** on HF: you may get an RF burn touching the equipment.

Fuses

- Never use a fuse with a **higher current rating** than specified: a fault could cause a **fire**.
- A fuse's **voltage rating** is the voltage it can interrupt **without arcing**.

Capacitors

Even with the power off, filter capacitors stay charged: **discharge them** first, with an **insulated shorting stick with an inline resistor**.

Source: ISED official question bank, Basic Qualification (section B-003).

B-003-020 Lightning and antenna work

Lightning

- Ground all antenna and rotator cables when the station is not in use.
- Install the **lightning surge protector outside**, as close as possible to the earth ground.
- The best protection: **disconnect** the equipment from the power lines and antenna cables.

Working on a tower

- Wear **approved fall arrest equipment**, to limit injuries if you fall.
- On the ground, wear a **hard hat** against dropped objects.
- Before repairing an antenna: transmitter **off** and transmission line **disconnected**.

RF burns

- Mount antennas **high enough** that nobody can touch them while you transmit: contact causes **RF burns**.
- Nobody must be able to touch an **open-wire** transmission line while you transmit.
- Around a **ground-mounted** antenna, keep people at a **safe distance**.

Source: ISED official question bank, Basic Qualification (section B-003).

B-003-021 RF exposure precautions

Effects

- A large amount of RF energy **heats body tissue**.
- The **eyes** are the most vulnerable to this heating.
- In free space, power density **decreases as the square of the distance**: twice as far, four times less.

Precautions

- At UHF and microwaves: keep the antenna **away from your eyes** while transmitting, and place it where **nobody can get near it**.
- Before removing the shielding of a UHF amplifier: make sure it **cannot be turned on accidentally**.
- Hand-held: antenna **away from your head and away from others**.
- Indoor antennas: **as far as possible** from occupied living spaces.
- Directional high-gain antennas: **higher than nearby structures**.
- Dipoles: ends and centre **as high as possible**.

Source: ISED official question bank, Basic Qualification (section B-003); Safety Code 6 (Health Canada).

Circuit Components

B-004-001 Amplifiers

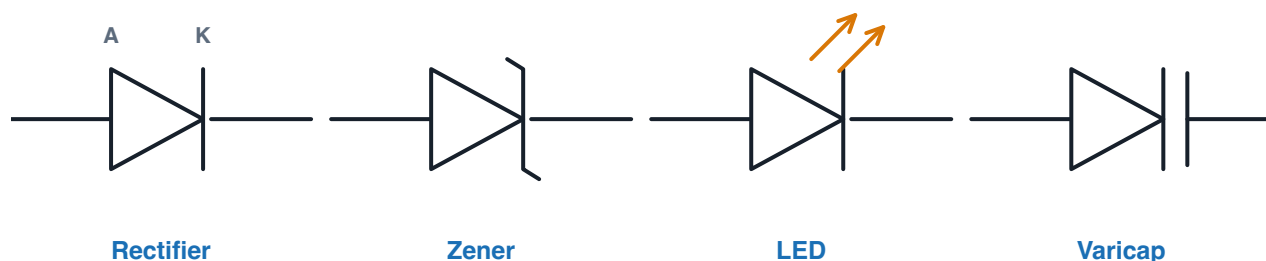
- An **amplifier** increases the amplitude of a signal: its **power**, **current** or **voltage**.
- The increase is called **gain**; a device with gain has the property of **amplification**. "Gain = 10 dB" marks an amplifier.
- **Efficiency** is the ratio of output power to DC input power.
- A **non-linear** amplifier makes the signal **distorted**.
- Too much **positive feedback** makes **oscillations** appear: the amplifier becomes an oscillator.

Signal to amplify	Amplifier
Very weak radio signal from the antenna	RF amplifier
Signal from a microphone	Audio amplifier

The speech amplifier of a transceiver typically handles **300 to 3,000 Hz**, enough for intelligible speech.

Source: ISED official question bank, Basic Qualification (section B-004).

B-004-002 Diodes



A = anode, K = cathode: the diode conducts when the anode is more positive

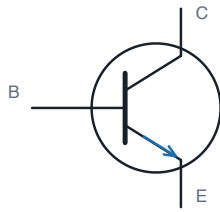
Diode symbols

- The electrodes of a diode are the **anode** and the **cathode**.
- A diode **conducts in one direction only**: it conducts when **forward biased** (anode more positive than cathode). Electrons flow **from cathode to anode**.
- With AC on the anode, the cathode gives **pulsating direct current**.

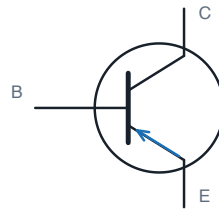
Use	Name
Changing AC to DC	Rectification
Recovering information from a modulated signal	Detection
Diode in series in a transceiver's positive lead	Reverse polarity protection
Zener diode	Regulate (hold constant) a voltage
Light-emitting diode (LED)	Glows; its colour depends on its chemical make-up

Source: ISED official question bank, Basic Qualification (section B-004).

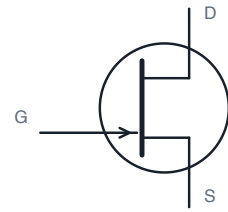
B-004-003 The bipolar transistor



NPN



PNP



N-channel FET

B base, C collector, E emitter; G gate, D drain, S source

Transistor symbols

- The **transistor** is the most basic semiconductor component used to **amplify**, even at low voltage.
- Its three electrodes: **collector**, **emitter** and **base**.
- The two types: **NPN** and **PNP**. One cannot replace the other: their **polarities are reversed**. "General purpose audio NPN device" means a bipolar transistor.
- The **base** controls the output current: a small base current controls a large collector current.
- A low-level signal at the input giving a higher-level signal at the output: **amplification**.

The transistor as a switch

Driven alternately into **saturation** and **cut-off**, the transistor acts as a **switch**; the **base** controls its state.

A transistor's enemy is **excessive heat**.

Source: ISED official question bank, Basic Qualification (section B-004).

B-004-004 The field-effect transistor (FET)

- Its electrodes: **gate**, **drain** and **source**.
- Depending on the material between source and drain, it is **N channel** or **P channel**.
- Charge carriers **enter** the channel at the **source** and **leave** at the **drain**; these two electrodes are at the ends of the channel.
- The **gate** controls the channel resistance: it is the control electrode.
- The gate **never conducts current**: the FET is a **high impedance** device.
- **Decreasing the reverse bias** on the gate **increases** the current.

Bipolar transistor	FET
Base	Gate
Emitter	Source
Collector	Drain

Source: ISED official question bank, Basic Qualification (section B-004).

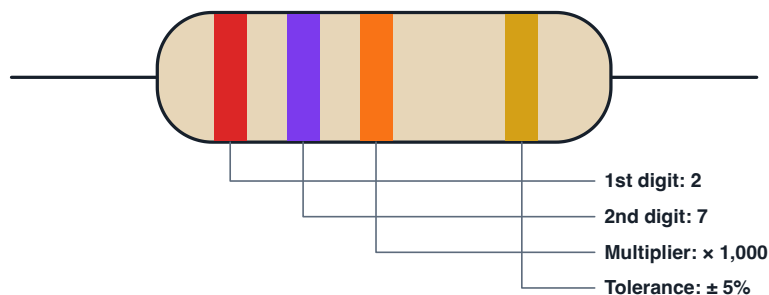
B-004-005 Vacuum tubes

- A **triode** contains a **vacuum** and three electrodes: **cathode**, one **grid** and **plate**.
- The **cathode** emits electrons; the **plate** collects them and runs at the **highest positive voltage**.
- The output current flows between **cathode and plate**; the **grid** controls it.
- Like the transistor, the triode can **amplify**. The semiconductor most similar to it is the **field-effect transistor**.
- One reason to use a triode: it **may handle higher power**.

Source: ISED official question bank, Basic Qualification (section B-004).

B-004-006 Resistors and the colour code

Red – Violet – Orange – Gold = 27 k Ω $\pm$ 5%



									
0	1	2	3	4	5	6	7	8	9
black	brown	red	orange	yellow	green	blue	violet	grey	white

Resistor colour code

Four bands

Band	Meaning
1st	First digit
2nd	Second digit
3rd	Multiplier
4th	Tolerance in percent

The first three bands give the **value in ohms**.

Colour	Black	Brown	Red	Orange	Yellow	Green	Blue	Violet	Grey	White
Digit	0	1	2	3	4	5	6	7	8	9

- Red, violet, yellow: $27 \times 10,000 = 270 \text{ k}\Omega$.
- 33 Ω and 39 Ω differ only in the **second** band; 120 Ω and 1,200 Ω , in the **third**.

Tolerance

- A 100 Ω resistor at 10% is between **90 and 110 Ω** .
- The smaller the tolerance, the more precise: **0.1%** is very precise, **20%** is not.

Temperature

The value changes with temperature according to the **temperature coefficient**, given as a fraction per degree Celsius.

Source: ISED official question bank, Basic Qualification (section B-004).

Basic Electronics and Theory

B-005-001 Units and prefixes

Prefix	Symbol	Factor
Giga	G	1,000,000,000
Mega	M	1,000,000
Kilo	k	1,000
Milli	m	1/1,000
Micro	μ	1/1,000,000
Pico	p	1/1,000,000,000,000

Examples

- 3.525 MHz = **3,525 kHz**; 7,040 kHz = **7.040 MHz**; MHz to GHz: **divide by 1,000**.
- 1 kHz = **1,000 Hz**; 1 k Ω = **1,000 Ω** .
- 3,000 mA = **3 A**; a quarter ampere = **250 mA**.
- 500 mW = **0.5 W**; 2 V = **2,000 mV**.
- 1,000,000 pF = **1 μ F**; 10,000 μ H = **10 mH**.

Source: ISED official question bank, Basic Qualification (section B-005).

B-005-002 Conductors, insulators and resistance

- **Good conductors:** gold, silver, aluminum, and above all **copper**. A conductor has **low resistance**.
- **Good insulators:** glass, air, porcelain.
- **Current** is the flow of electric charge in a circuit.
- **R** is the symbol for **resistance**; its inverse is **conductance**.
- A **voltage drop** is the loss of voltage caused by current flowing through a circuit.
- The resistance of a conductor changes with **temperature**.
- In a DC circuit, **polarity** describes the direction of current.

Source: ISED official question bank, Basic Qualification (section B-005).

B-005-003 Power and circuits

Power

- **Power** is the **rate** at which electrical energy is used; its unit is the **watt**.
- $P = E \times I$: volts $\times$ amperes = watts.
- A 100 W bulb uses more energy than a 40 W bulb.
- A resistor that gets very hot and burns is dissipating too much **power**.

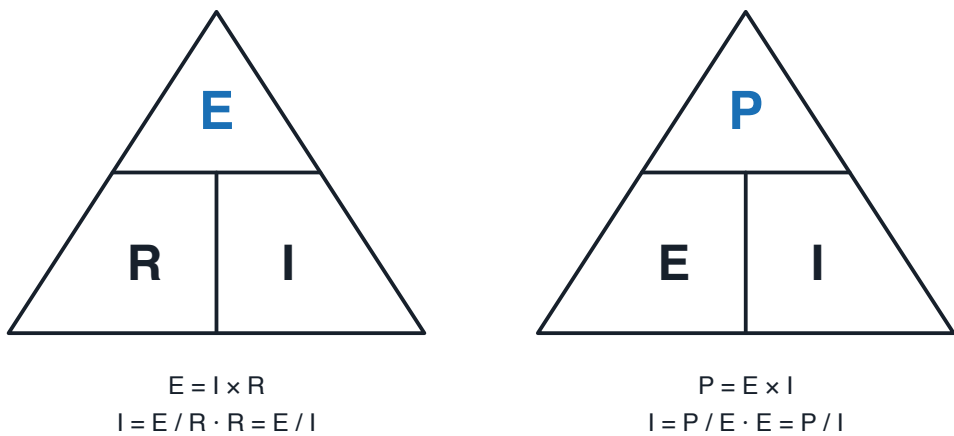
Circuit faults

Fault	Effect
Open circuit	No current flows
Short circuit	Too much current; the fuse blows at once

Continuity means the circuit is **closed**.

Source: ISED official question bank, Basic Qualification (section B-005).

B-005-004 Ohm's law



Ohm's law and power triangles

$E = I \times R \quad I = \frac{E}{R} \quad R = \frac{E}{I}$

E in volts, I in amperes, R in ohms. Convert milliamperes to amperes first.

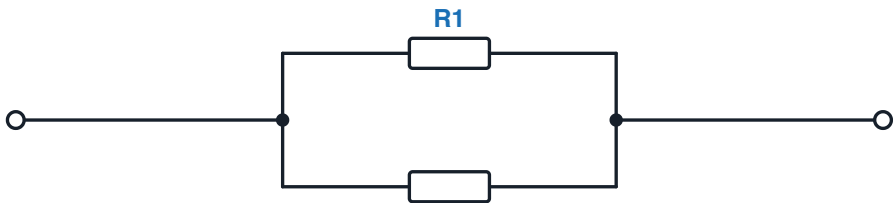
Data	Calculation
0.5 A through 2 Ω	$E = 0.5 \times 2 = 1 \text{ V}$
0.44 A through 50 Ω	$E = 22 \text{ V}$
6 V across 30 Ω	$I = 6/30 = 0.2 \text{ A}$
12 V, 0.25 A	$R = 12/0.25 = 48 \text{ Ω}$
9 V, 10 mA	$R = 9/0.01 = 900 \text{ Ω}$
3 V, 300 mA	$R = 3/0.3 = 10 \text{ Ω}$
200 mA through 25 Ω	$E = 0.2 \times 25 = 5 \text{ V}$

Source: ISED official question bank, Basic Qualification (section B-005).

B-005-005 Resistors in series and parallel



Series: $R = R_1 + R_2 + R_3$



Parallel: $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$ (two: $\frac{R_1 \cdot R_2}{R_1 + R_2}$)

Resistors in series and in parallel

Series

$R_t = R_1 + R_2 + \dots$: the total is **greater** than any one resistor.

- Five 10 Ω resistors: **50 Ω** . Five 24 Ω resistors replace one 120 Ω resistor.

Parallel

$\frac{1}{R_t} = \frac{1}{R_1} + \frac{1}{R_2} + \dots$: the total is **less** than the smallest resistor.

- N equal resistors: R/N . Four 68 Ω : **17 Ω** ; ten of R: **R/10**.
- The **total current** is the **sum of the branch currents**.
- All branches have the same voltage: the resistor carrying **twice the current** has **half the resistance**.

Example	Calculation
4 $\times$ 100 Ω in parallel across 12 V	25 $\Omega \rightarrow$ 480 mA
2 $\times$ 1,000 Ω in parallel across 12 V	500 $\Omega \rightarrow$ 24 mA

Source: ISED official question bank, Basic Qualification (section B-005).

B-005-006 Power calculations

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

Data	Result
12 V, 5 A	60 W
12 V, 500 mA	6 W
30 W at 12 V	$I = 30/12 = 2.5 \text{ A}$
$2 \times 10 \Omega$ in series across 10 V	$10^2/20 = 5 \text{ W}$

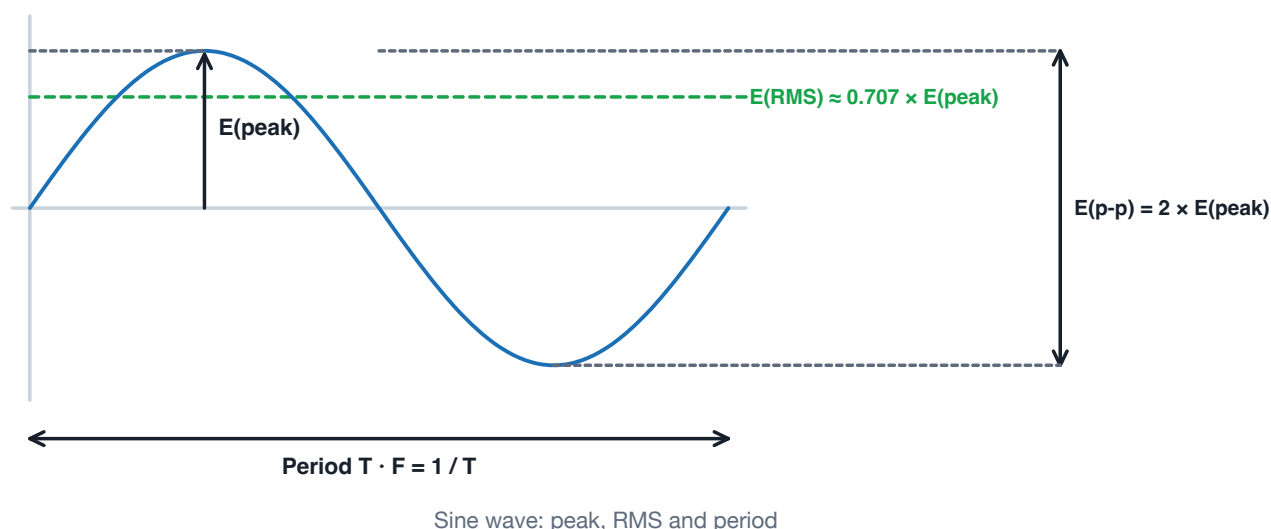
- **Doubling the voltage** makes the power **four times** greater (E^2).

Resistor power ratings

- They depend on how well the resistor **dissipates heat**: a **larger** resistor dissipates more.
- Two equal 1 W resistors, in **series** or in **parallel**, handle **2 W** together.
- Two 100Ω resistors in parallel replace a 50Ω resistor with a **greater power rating**.
- 50Ω , 5 W dummy load: **four 200Ω , 2 W resistors in parallel** (each dissipates 1.25 W).

Source: ISED official question bank, Basic Qualification (section B-005).

B-005-007 Alternating current, frequency and wavelength



- **Frequency** is the number of cycles per second: 60 Hz = **60 cycles per second**, the mains frequency, a **sine wave**.
- Humans hear from about **20 Hz to 20,000 Hz**: the **audio frequencies**.
- **Wavelength** is the distance travelled during one cycle: $\lambda = 300 / F$ (λ in metres, F in MHz). When frequency **increases**, wavelength **decreases**, and the reverse.
- **Phase** describes the time offset between two waves of the same frequency.
- A multiple of the fundamental frequency is a **harmonic**: 4 kHz is the second harmonic of 2 kHz.

Range	Frequencies
MF	0.3 to 3 MHz
HF	3 to 30 MHz (7125 kHz is HF)
VHF	30 to 300 MHz
UHF	300 to 3,000 MHz

Source: ISSED official question bank, Basic Qualification (section B-005).

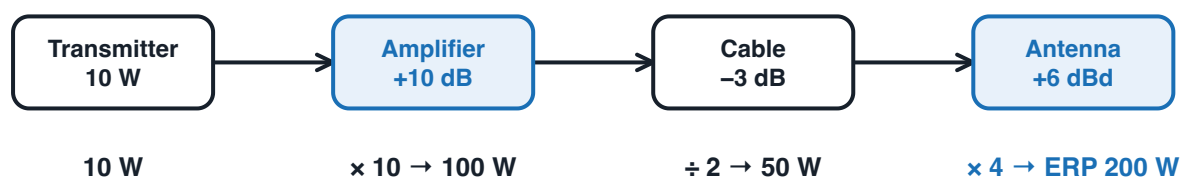
B-005-008 Decibels

The **decibel** measures the **ratio** of two signals: $dB = 10 \log \frac{P_2}{P_1}$.

Change	Power
+3 dB	$\times 2$
-3 dB	$\div 2$
+6 dB	$\times 4$
+9 dB	$\times 8$
+10 dB	$\times 10$
+30 dB	$\times 1,000$

Examples

- From 1 W to 2 W: **+3 dB**. From 5 W to 50 W: **+10 dB**.
- 2 W through a 9 dB amplifier: $2 \times 8 = 16$ W.
- 100 W through a line losing 6 dB: $100/4 = 25$ W at the antenna.
- Cutting 200 W to 20 W (-10 dB) takes S9 + 10 dB down to **S9**.
- From S9 + 30 dB down to S9 with 100 W: $100/1000 = 0.1$ W.



Total: +10 - 3 + 6 = +13 dB = $\times 20$

Working out ERP in decibels

Source: ISED official question bank, Basic Qualification (section B-005).

B-005-009 Inductors and capacitors

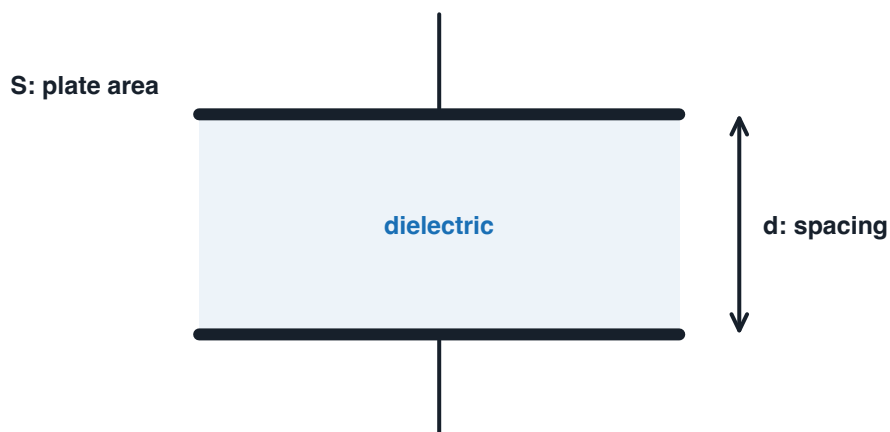
Combinations

	Series	Parallel
Inductors	Add up: $12 + 12 = 24 \text{ mH}$	Two equal: half ($20 \text{ mH} \rightarrow 10 \text{ mH}$)
Capacitors	Two equal: half ($20 \mu\text{F} \rightarrow 10 \mu\text{F}$)	Add up: $24 + 24 = 48 \mu\text{F}$

Inductors behave like resistors; capacitors do the opposite.

What sets their value

- **Air-core inductor:** the **coil diameter**, the **coil length** and the **number of turns**.
- **Air capacitor:** the **plate area** and the **spacing** between plates.



C increases with S and the dielectric, decreases as d increases

What sets the capacitance of a capacitor

Electrolytic capacitors

They are polarized: **never apply a reverse voltage**.

Source: ISED official question bank, Basic Qualification (section B-005).

B-005-010 Reactance and impedance

$$X_L = 2\pi fL \quad X_C = \frac{1}{2\pi fC}$$

Component	As frequency increases
Inductor	Its reactance increases
Capacitor	Its reactance decreases

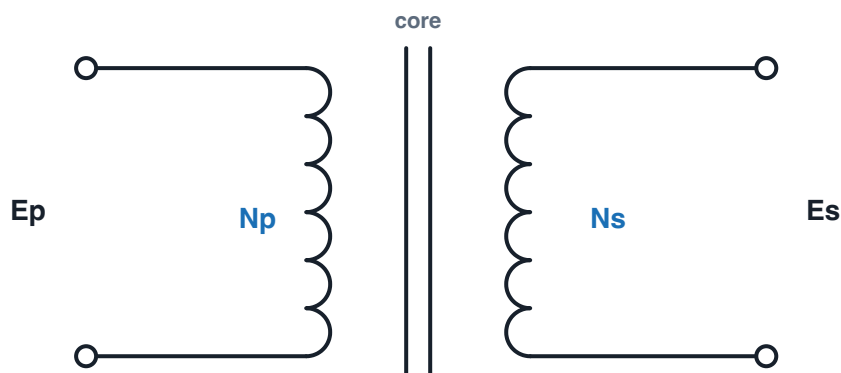
- **Impedance** is the combined opposition of resistance and reactance to alternating current; it is the ratio of AC voltage to AC current.

Uses against interference

Component	Useful property
Ferrite-core coil, RF choke	High reactance at RF : blocks the radio signal; low reactance at low frequencies , which pass through
Bypass capacitor	Low reactance at RF : diverts RF to ground; high reactance at audio , which it leaves alone

Source: ISED official question bank, Basic Qualification (section B-005).

B-005-011 Magnetism and transformers



$$E_s / E_p = N_s / N_p \cdot I_s / I_p = N_p / N_s \cdot P_p = P_s \text{ (ideal)}$$

The transformer

The transformer

- With no losses, **power is the same** in the primary and the secondary.
- Voltage follows the **turns ratio**: 250 turns primary, 500 turns secondary, 120 V → **240 V**.
- Current varies inversely with voltage.
- It changes **impedance** by carrying different voltages and currents in each winding.

Data	Result
250 W from a 120 V primary	$250/120 \approx 2.1 \text{ A}$
120 V, 0.5 A primary; 12 V secondary	$60 \text{ W} \rightarrow 5 \text{ A}$
10 W; 5 V secondary	2 A
1:5 step-up, 50 mA in the secondary	250 mA in the primary

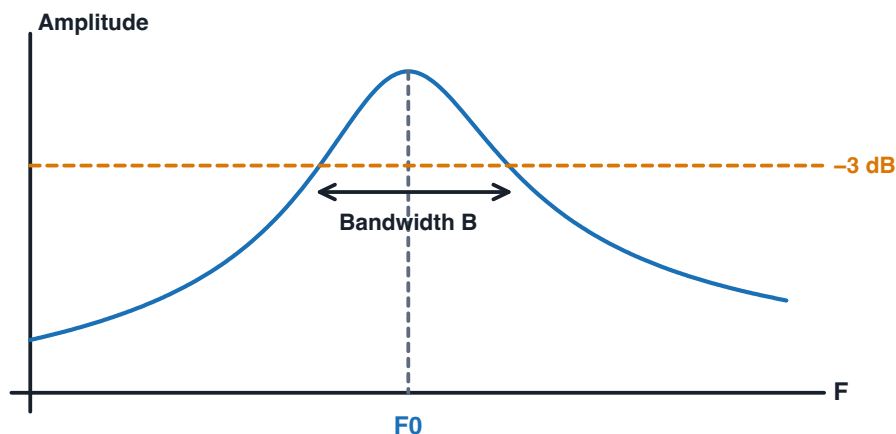
- **Warm iron laminations** show that the transfer is not perfect.

Magnetism

- The magnetic field around a conductor is **proportional to the current**.
- The induced voltage in a coil is greatest when the **current changes fastest**.
- Coupling between two wires is greatest when they are **close and parallel**.
- A permanent magnet is most likely made of **steel**.

Source: ISED official question bank, Basic Qualification (section B-005).

B-005-012 Resonance



$Q = F_0 / B$: the higher the Q , the narrower the curve

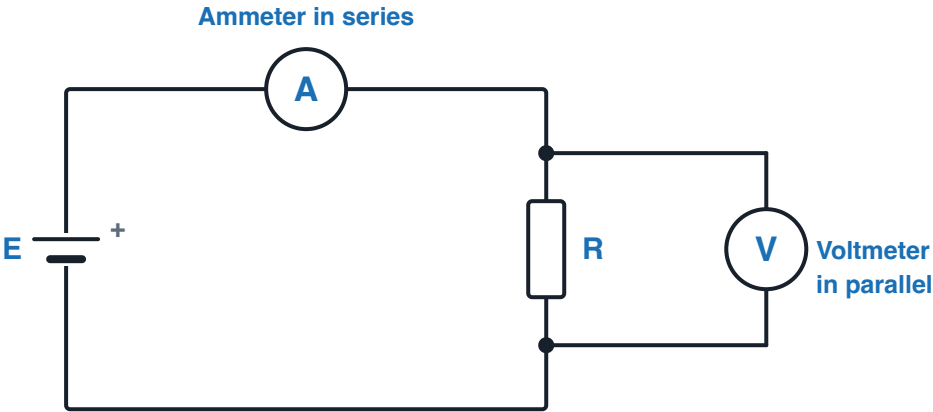
Resonance curve

- Resonance exists when **inductive and capacitive reactance are equal** (and opposite in sign): they cancel.
- A **tuned circuit** is made of an **inductor and a capacitor**: $f = \frac{1}{2\pi\sqrt{LC}}$.
- The resonant frequency depends only on L and C : **adding a resistor** does not change it.
- The range of frequencies where resonance is significant is the **bandwidth**.
- In a receiver, resonant circuits **select the desired frequencies**.

Circuit at resonance	Impedance	Current
Parallel	High (maximum)	Minimum
Series (RLC)	Low	Maximum

Source: ISED official question bank, Basic Qualification (section B-005).

B-005-013 Meters



Ammeter: very low internal resistance; voltmeter: very high

Connecting a voltmeter and an ammeter

Instrument	Measures	Connection	Acts like
Voltmeter	Potential difference (voltage)	In parallel	A high resistance
Ammeter	Current	In series	A low resistance
Multimeter	Voltage, current and resistance		
RF wattmeter	Transmitter output power, read directly	In the coaxial line	

- The final amplifier current of a transmitter is measured with an **ammeter**.
- **Accuracy** is an instrument's ability to show values that match reality.

Source: ISED official question bank, Basic Qualification (section B-005).

Feedlines and Antenna Systems

B-006-001 Transmission lines

The **transmission line** connects the transceiver to the antenna.

Characteristic impedance

- It depends on the **physical dimensions** of the conductors and their **relative positions** (and the dielectric), **not on length**: a 52 Ω cable cut in half is still 52 Ω .

Line	Impedance depends on
Coaxial cable	The ratio of the outer shield diameter to the inner conductor diameter; cables of different diameters can therefore have the same impedance
Open-wire line	The diameter of the conductors and their spacing (centre to centre)

- A resistive load **equal to the characteristic impedance** (50 Ω on a 50 Ω cable) absorbs all the energy.
- If the load differs greatly from the line impedance, the impedance seen at the input **depends on line length**.
- The **velocity factor** of a coax depends mainly on the **dielectric**.
- Coaxial cable** can be buried directly in the ground.

Source: ISED official question bank, Basic Qualification (section B-006).

B-006-002 Coax, window line and the balun

Types of lines

Line	Construction
Coaxial cable	A centre wire, an insulator, then a conductive sheath or braid
Window line	Two wires side by side, held by an insulating ribbon
Open-wire line	Two conductors held at a uniform distance by insulating spreaders

Balanced and unbalanced

- A **balanced** line is made of **two parallel wires**.
- A line is **unbalanced** when **one conductor is connected to ground**: this is the case of coax.
- A **balun** connects **balanced** and **unbalanced** systems.

Where does the balun go?

- To feed a **dipole** with coax: **between the cable and the antenna**.
- Between **coax** and **window line**.
- Between an **antenna tuner** with an unbalanced output and a balanced line.

Source: ISED official question bank, Basic Qualification (section B-006).

B-006-003 Choosing cable and connectors

Why coax?

Coax is **usable in a wide variety of settings**: its shield makes it immune to a nearby **metal fence** or **icing**, unlike balanced lines.

- The best shielding: a **solid shield**.
- A **foam** dielectric means **lower loss**. To wind the cable on a toroid (common-mode choke), a **solid** dielectric avoids the centre conductor moving and shorting.

Connectors

Connector	Typical use
PL-259	RG-213 cable to an HF transceiver
SMA	Modern hand-held and its antenna
N	Moisture resistant
BNC	Low-power and test equipment

Clean and tighten connectors regularly to keep their **contact resistance** to a minimum.

Source: ISED official question bank, Basic Qualification (section B-006).

B-006-004 Transmission line loss

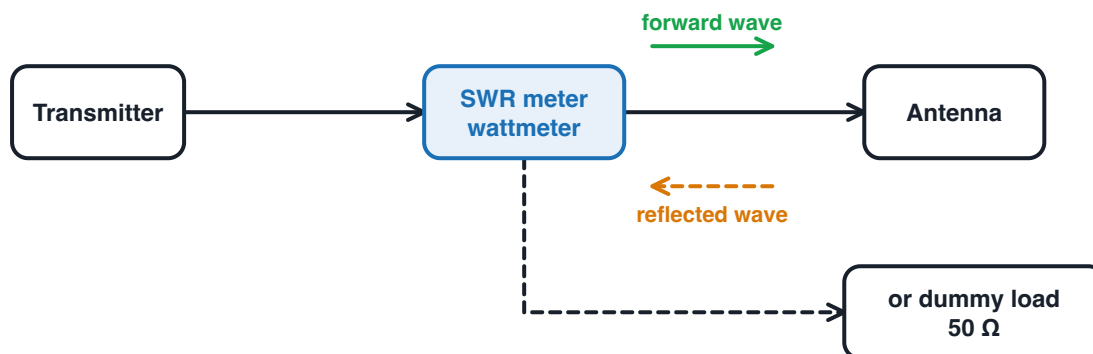
- Loss is expressed in **decibels per unit length**.
- It **increases with length**: going from 20 to 40 m increases the loss by **100%**. Shorten excess cable.
- It **increases with frequency**, due to internal line losses: RG-58 has **excess loss** on 70 cm.
- Replacing RG-213 with thinner RG-58: **less power radiated**.
- **Open-wire line** has the lowest loss on HF and can run at **high SWR** without excessive loss.

Source: ISED official question bank, Basic Qualification (section B-006).

B-006-005 SWR and standing waves

Standing waves

If the line impedance differs from the antenna's, some energy is reflected: **standing waves** appear and the **transfer of energy** to the antenna is **reduced**.



SWR = 1: antenna perfectly matched, no reflected wave

Measuring SWR and power

Reading the SWR meter

The SWR meter measures **forward and reflected voltage**.

Reading	Meaning
1:1	Best impedance match
Less than 1.5:1	Fairly good match
High	Open or short circuit in the antenna system
Erratic	Intermittent connection

- High SWR **increases line loss**.
- Line loss **lowers the reading** at the station: the reflected energy is attenuated on its way back.

The antenna analyzer

It shows the **SWR over a range of frequencies**: the tool for adjusting antenna length.

Source: ISED official question bank, Basic Qualification (section B-006).

B-006-006 Impedance matching

The principle

Power transfer is **maximum** when the load impedance **equals** the source impedance.

- If the antenna is matched to the line, **line length has no effect** on the match.
- To minimize line loss, match **at the junction between line and antenna**.

The antenna tuner

- It **matches the transceiver to a mismatched antenna system**, by **adding capacitive or inductive reactance**.
- Solid-state transceivers **reduce power automatically** when the mismatch is too great: the tuner lets them deliver **rated power**.
- Located **near the antenna feed point**, it gives **less line loss**.

The transformer

- It matches impedance over a **wide bandwidth**.
- An **end-fed half-wave** (EFHW) antenna, with very high feed point impedance, is matched to 50 Ω coax with a **transformer**.
- Folded dipole (about 300 Ω) on a 50 Ω line: $300/50 = 6:1$.

Source: ISED official question bank, Basic Qualification (section B-006).

B-006-007 Polarization and the isotropic antenna

Polarization

Polarization is set by the **orientation of the electric field** relative to the Earth's surface.

Polarization	Electric field	Examples
Horizontal	Parallel to the ground	Yagi with elements parallel to the ground
Vertical	Perpendicular to the ground	Half-wave or dipole mounted vertically, mobile whip

- Use the **same polarization** at both ends: a vertical signal is received at **higher strength** on a vertical antenna (for example a ground plane).
- By **ground wave**, a vertical wave **stays vertical**.

The isotropic antenna

A **hypothetical point source** radiating equally in all directions: its pattern is a **sphere**. It is the reference for gain (dBi).

Source: ISED official question bank, Basic Qualification (section B-006).

B-006-008 Wavelength and antenna resonance

Wavelength

Radio waves travel at the **speed of light**, about **300,000 km/s**: $\lambda = 300/F$.

- 25 MHz: **12 m**; 2 MHz: **150 m**.

Tuning an antenna

To...	You...
Lower the resonant frequency (3900 → 3600 kHz)	Lengthen the antenna, or add a series inductance
Raise the resonant frequency (3600 → 3900 kHz)	Shorten the radiating element

- **Insulators** at the ends of a wire antenna **limit its electrical length**.
- A **trap** is a **coil and capacitor in parallel**.

Source: ISED official question bank, Basic Qualification (section B-006).

B-006-009 Gain, directivity and bandwidth

Gain

- **Antenna gain** is the ratio of its radiated signal strength to that of a **reference antenna**.
- In **dBi** the reference is the **isotropic** antenna; in **dBd**, the dipole.
- A half-wave dipole has about **2.1 dB** of gain over isotropic: 4.1 dBi = **2.0 dBd**.
- In free space, the dipole radiates most **broadside**.

Parasitic elements

- A parasitic element is energized **by induction or radiation** from the driven element.
- Adding them increases **directivity**: the dipole becomes a Yagi.

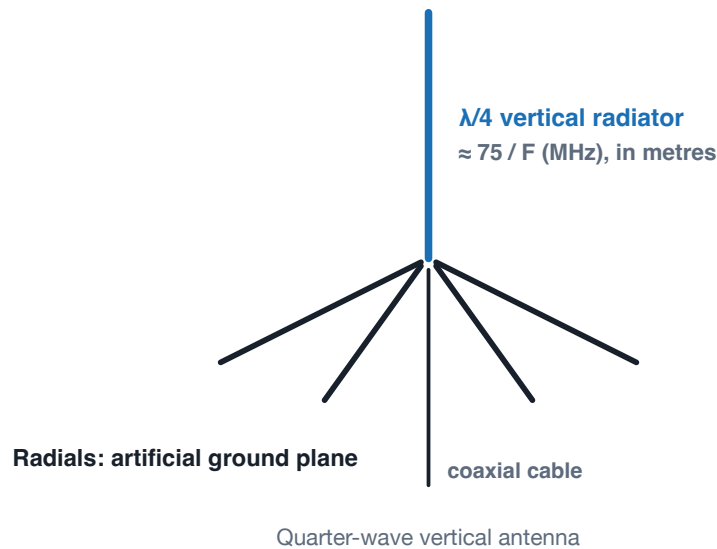
Element added	Radiation increases...
Slightly shorter (director)	From the dipole towards the new element
Slightly longer (reflector)	From the new element towards the dipole

Bandwidth

The **frequency range** over which the antenna performs well.

Source: ISED official question bank, Basic Qualification (section B-006).

B-006-010 Vertical antennas



Lengths

- Quarter wave below 30 MHz: $L \approx 71.3/F$ metres (the ISED sheet gives $71/F$). At 21.125 MHz: **3.37 m**.
- Half wave: $L \approx 150/F$ on VHF; at 223 MHz: **67 cm**.

Characteristics

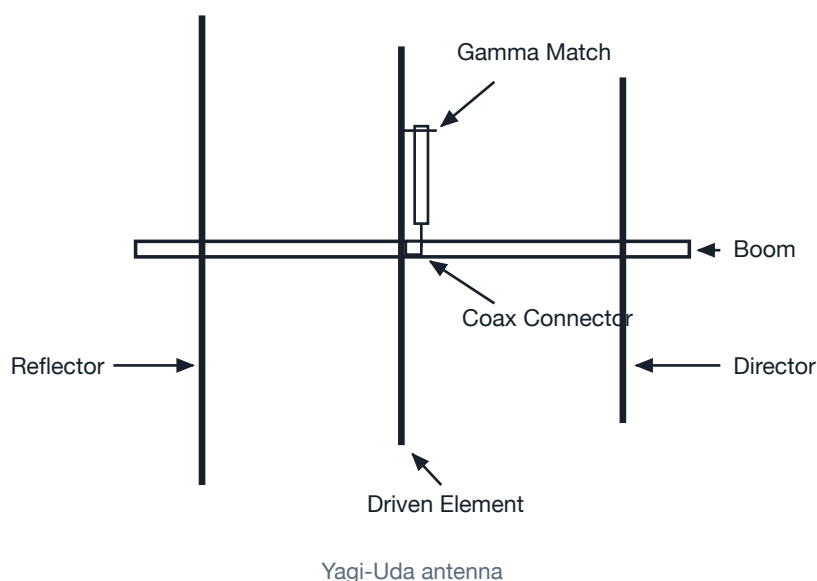
- A quarter-wave vertical on a car roof radiates **equally well in all horizontal directions**.
- For VHF or UHF mobile, a **5/8-wave** has **more gain** than a quarter wave.
- A **ground-plane** antenna is fed with **50 Ω coax**. Quarter-wave radials **sloping downward** bring its impedance close to **50 Ω**.
- A **ground-mounted** vertical needs a **wire ground system** (radials) to reduce ground losses.

Shortened antennas

A 2 m vertical on 80 m is too short: it shows **capacitive reactance**. A **series inductor** (loading coil) **tunes it out** and makes the antenna resonate.

Source: ISED official question bank, Basic Qualification (section B-006).

B-006-011 The Yagi antenna



Element lengths

Element	Approximate length	Example
Driven element	Half wave: $143/F$	14 MHz: 10.21 m
Director	About 5% shorter: $136/F$	21.1 MHz: 6.44 m
Reflector	About 5% longer: $150/F$	28.1 MHz: 5.34 m

Performance

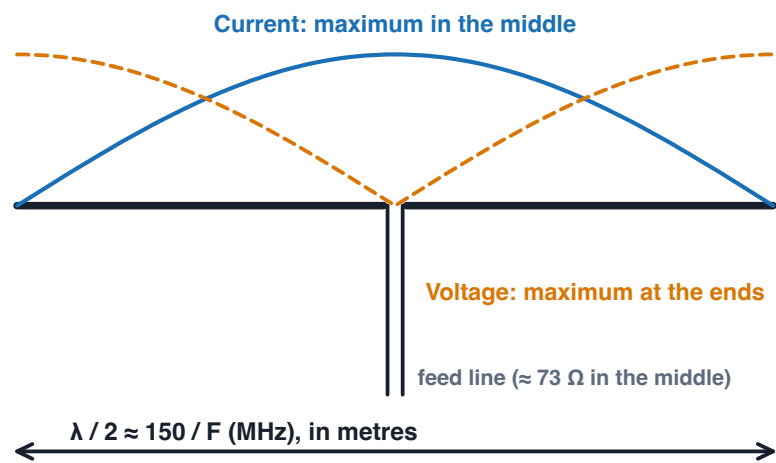
- A longer **boom** with more **directors**, or wider **element spacing**: **gain increases**.
- For a 3-element Yagi, spacing of about **0.20 wavelength** gives the best compromise between gain and front-to-back ratio.
- The **front-to-back ratio** compares power radiated forward with power radiated backward.
- **Thicker elements** widen the **bandwidth**.
- Two stacked Yagis gain about **3 dB**: 10 dBi → **13 dBi**.

On HF

- **Element traps** let one Yagi work on 20, 15 and 10 m.
- From 20 to 10 m, elements are **short enough** for rotatable high-gain antennas.

Source: ISED official question bank, Basic Qualification (section B-006).

B-006-012 The dipole and wire antennas



Half-wave dipole: current and voltage

The half-wave dipole

- Length: $L \approx 143 / F$ (the ISED sheet gives $142 / F$). At 28.150 MHz: **5.08 m**; at 3.75 MHz: **38.13 m**.
- Feed point impedance in free space: **73 Ω** .
- 3D pattern: a **torus** (donut) around the antenna. It radiates broadside: ends north-south → radiation mostly **east and west**.

Other wire antennas

Antenna	Advantage	Disadvantage
End-fed half wave (EFHW)	Multi-band operation	High impedance: needs a transformer
Trap antenna	Multi-band	May radiate harmonics more readily
Random wire	Simple	RF feedback in the station

Source: ISED official question bank, Basic Qualification (section B-006).

B-006-013 Loop antennas: quad and delta loop

- A **quad** is made of **two or more parallel four-sided wire loops**, each about **one wavelength** long.
- A **delta loop** with parasitic elements uses **triangular** loops of about one wavelength.
- A **horizontal loop** follows the same rule.

Loop length

$$L = \frac{306}{F}$$

Frequency	Length
21.4 MHz	14.30 m
14.3 MHz	21.40 m
28.7 MHz	10.66 m
7.15 MHz	42.80 m

Polarization

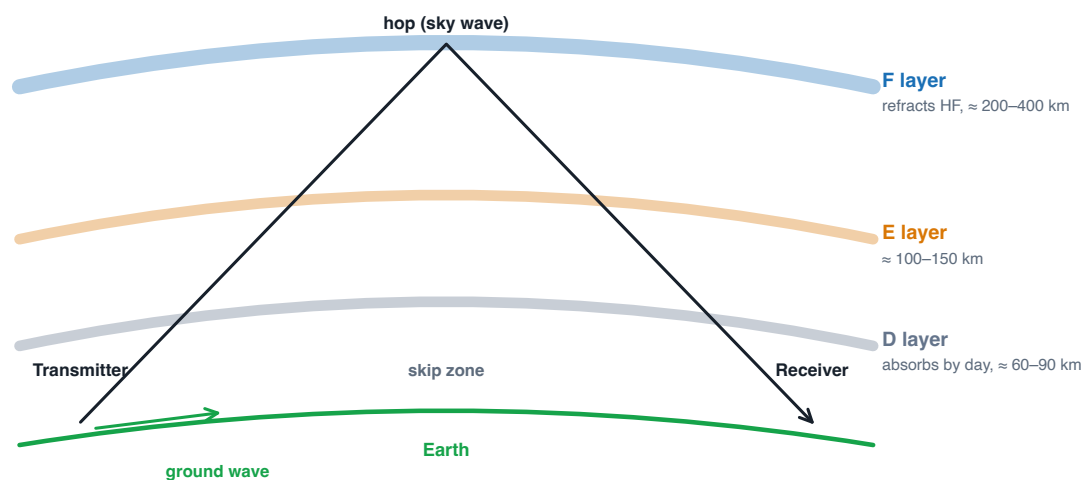
Feed point	Polarization
Centre of the bottom side, parallel to the ground	Horizontal
A side perpendicular to the ground	Vertical

A quad's drawback compared with a Yagi: it is **more susceptible to weather damage**.

Source: ISED official question bank, Basic Qualification (section B-006).

Radio Wave Propagation

B-007-001 Propagation modes



The ionosphere, ground wave and sky wave

Mode	Description
Line of sight	VHF between two nearby stations
Ground wave	Follows the Earth's surface and is directly affected by it; up to about 200 km by day on the lower HF frequencies; longest range on 160 m
Sky wave (ionospheric wave)	Goes up to the ionosphere, which returns it to Earth ; reaches beyond 4,000 km
NVIS (near vertical incidence sky wave)	Medium-range HF, even in difficult terrain

On VHF and up, the **radio horizon** is farther than the visual horizon because of **normal refraction in the troposphere**.

Source: ISED official question bank, Basic Qualification (section B-007).

B-007-002 The ionosphere and its regions

- The ionosphere is formed by **solar radiation**, mostly **ultraviolet**, ionizing the outer atmosphere.
- Ionization is **highest at midday** and **lowest shortly before dawn**.

Region (layer)	Position	Role
D	Closest to the Earth	Absorbs low frequencies by day; least useful for long distance
E	Just below the F region	Hops up to about 2,000 km
F	Highest; splits into F1 and F2 by day	F2 is best for long distance, because it is the highest

By day, **160 m** and **80 m** are mostly short-range bands, because of **D region absorption**.

Source: ISED official question bank, Basic Qualification (section B-007).

B-007-003 Skip and the skip zone

Skip

- Skip is caused by **refraction** in the ionosphere.
- **Skip distance** is the **minimum** distance reached by a signal after one trip to the ionosphere.

Region	Maximum single-hop distance
E	2,000 km
F2	4,000 km

- Beyond that (Europe at 5,000 km), **multi-hop** is needed; at the midpoint, the Earth's surface **reflects** the wave back up.
- Skip distance **increases** with a **lower** radiation angle or a **higher** region; it **decreases** with a higher angle (simple geometry).

The skip zone

The area between the end of the **ground wave** and the point where the **first ionosphere-refracted wave** returns: too far for one, too close for the other.

Source: ISED official question bank, Basic Qualification (section B-007).

B-007-004 Absorption, fading and polarization

Daytime absorption

By day, low HF frequencies crossing the **D region** are **absorbed**: that is why distant 160 m and AM broadcast stations are heard only at night.

During a **sudden ionospheric disturbance** (SID), try a **higher frequency band**.

Fading

- A signal arriving by **several paths** (for example one hop and two hops) gives **phase differences**: its strength varies, that is **fading**. Multipath also causes **phase distortion**.
- In a city on 2 m, moving less than a metre can make signals from different paths **cancel**.
- **Selective fading** comes from phase differences between components of the same transmission; it is more pronounced at **wide bandwidths**.

Polarization

Refraction, reflection and **Faraday rotation change the polarization**. On HF the ionosphere changes it: the receiving antenna's polarization matters little there, unlike on VHF and UHF.

Source: ISED official question bank, Basic Qualification (section B-007).

B-007-005 The sun and the solar cycle

- **Solar radiation** influences all radiocommunication beyond ground wave and line of sight; the sun affects **all frequencies**, to varying degrees.
- Day to day, its **electromagnetic and particle radiation** is what matters.
- The ionosphere's ability to refract HF depends on the **amount of solar radiation**.

Sunspots

- **The more sunspots, the greater the ionization.**
- The average sunspot cycle lasts **11 years**: the main cause of cyclical changes in HF propagation.
- With high sunspot numbers, frequencies **up to 40 MHz and higher** become usable for long distance.

Solar flux

- **Solar flux** is the radio frequency energy emitted by the sun.
- The **solar-flux index** is a measure of solar activity taken at a **specific frequency** (2800 MHz, at Penticton, British Columbia).

Source: ISED official question bank, Basic Qualification (section B-007).

B-007-006 MUF, critical frequency and band choice

Term	Definition
Critical frequency	The highest frequency a region returns at vertical incidence
Maximum usable frequency (MUF)	The highest frequency that will reach a given destination
Optimum working frequency	Slightly lower than the MUF; the best for long range

- Below the MUF, waves are **bent back to Earth**.
- The MUF varies with the **radiation received from the sun**: it **rises** as UV increases during the day.
- Communication between continents can exceed the local critical frequency because the signal enters the ionosphere **at an oblique angle**.
- To know if 10 m is open to Europe: listen for **10-metre beacons**.

Bands and timing

- **20 m** gives worldwide propagation by day **at any point in the solar cycle**.
- **Summer daytime** is the worst time for **160 m and 80 m** beyond ground wave.

Source: ISED official question bank, Basic Qualification (section B-007).

B-007-007 VHF propagation: troposphere, sporadic E and aurora

The troposphere

- **Tropospheric bending** lets you reach stations **farther away** on 2 m; this is the **tropospheric wave**.
- Average range: about **800 km**. Beyond that, **tropospheric ducting**, caused by a **temperature inversion**.

Sporadic E

- **Patches of dense ionization** at E-region height.
- It most often opens **6 m** for long distance; sky-wave propagation on 6 m depends mostly on the **E region**.

Aurora

- Auroral activity occurs at **E-region height**.
- In the northern hemisphere, point the antenna **north**.
- **CW** is the most reliable mode: it is readable even when distorted.

Source: ISED official question bank, Basic Qualification (section B-007).

B-007-008 Scatter

Scattering redirects parts of the wave in **many directions**.

Ionospheric scatter (HF)

- It lets you hear **weak signals from the skip zone**.
- Signals are **weak** (only a small part of the energy is scattered) and **distorted** (several paths).
- Recognize it by weak, distorted signals **near the MUF**.

Tropospheric scatter (VHF/UHF)

It comes from **small variations** in density and water vapour in the **lower atmosphere**, and reaches beyond the radio horizon.

Meteor scatter

Meteor trails are most effective from **30 to 100 MHz**, especially on **6 m**.

Source: ISED official question bank, Basic Qualification (section B-007).

Interference and Suppression

B-008-001 Overload, desensitization and intermodulation

Receiver overload

- Caused by a **very strong signal** from a nearby transmitter.
- Recognize it when the interference is **the same whatever frequency** you transmit on, or on **all bands**.
- For a TV overloaded by an HF transmitter: a **high-pass filter** at the TV.

Desensitization

A very strong nearby transmitter makes a receiver deaf: at Field Day, the 20 m CW station ruins reception at the 20 m SSB station; two mobiles very close together no longer hear the repeater.

Intermodulation

Two or more strong signals **mix**, in the receiver or outside it, and produce interference on another frequency.

- A VHF hand-held on an outdoor gain antenna hears unwanted signals and noise: **receiver intermodulation**.
- Cure: a **suitable filter** at the receiver.
- Example: 92.5 MHz (FM station) – 14 MHz = 78.5 MHz, in channel 5; a **high-pass filter** at the TV fixes it.

Source: ISED official question bank, Basic Qualification (section B-008).

B-008-002 Audio rectification

Audio rectification happens in a device **with no RF circuits** (stereo, public address system): a junction rectifies the signal picked up by the wiring.

Transmission	What is heard
SSB	Distorted speech
CW	On-and-off humming or clicking

- The signal is heard **across the whole tuning range** of a broadcast receiver, or **whatever the volume** of a stereo: audio rectification.

Cures

- **Coils on ferrite cores** on the cables (wind speaker leads **around a ferrite core**).
- **Shorten** the speaker leads.
- For a telephone: a **plug-in RFI filter** close to the device.
- With an off-centre-fed (OCF) antenna: a **common-mode choke** on the transmission line.

Source: ISED official question bank, Basic Qualification (section B-008).

B-008-003 Spurious emissions and key clicks

Spurious emissions

- Signals sent **outside the band** you are transmitting in.
- A hand-held interfering with a nearby frequency is probably producing them.
- Operating without the **cover and shielding** may produce them.

Intermodulation

The creation of **new, unwanted frequencies** when signals interact in a **non-linear device**.

Key clicks (CW)

Where	Cause
Local interference	The making and breaking of the circuit at the key
Heard far away, wide bandwidth	Too sharp rise and decay times : poor waveform shaping

Check the **keying filter** first, then the later stages.

Parasitic oscillations

An **unwanted** oscillation in an amplifier or oscillator, caused by **unwanted positive feedback**, **above or below** the transmitter frequency.

Source: ISED official question bank, Basic Qualification (section B-008).

B-008-004 Harmonics and splatter

Harmonics

A **harmonic** is an unwanted signal at a **multiple** of the fundamental (operating) frequency. It may interfere with other stations.

Example	Explanation
Heard on 21.375 MHz while transmitting on 7.125 MHz	3×7.125 : third harmonic
Interference at 56 MHz	2×28 : second harmonic of a 10 m transmission
Only TV channel 3 (60 to 66 MHz) affected while on 15 m	$3 \times 21 \text{ MHz} \approx 63 \text{ MHz}$

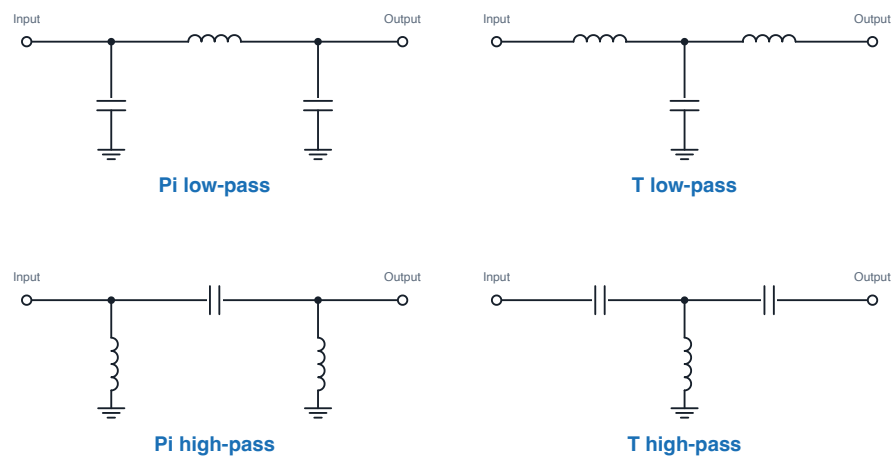
- A common cause: **overdriven stages** (excessive drive).

Out-of-band and splatter

- **"Out-of-band" emissions** are energy transmitted **just outside** the necessary bandwidth.
- **Splatter** comes from **overmodulating**.
- On SSB, **flat topping** comes from **excessive microphone gain**.

Source: ISED official question bank, Basic Qualification (section B-008).

B-008-005 Filters against interference



Series inductor = low-pass; series capacitor = high-pass

LC filters

Filter	Effect	Use
Low-pass	Attenuates above cut-off (for example 40 MHz)	AC line filter; low-cost software defined receiver picking up higher-frequency stations
High-pass	Attenuates below cut-off (for example 60 MHz)	TV overloaded by HF
Band-pass	Attenuates above and below a range	Field Day receivers; 2 m station overloaded by land mobile transmitters
Band-reject	Removes a band	31 m broadcast station between 40 m and 30 m
Notch	Attenuates one frequency, passes all others	Strong signal very close to the receive frequency

A filter's impedance must match the line, to **avoid unwanted reflection**.

Source: ISED official question bank, Basic Qualification (section B-008).

Formulas

The formulas of the ISED reference sheet (allowed during the examination), then the ones used in the question calculations.

ISED reference sheet

Quantity	Formula
Frequency (MHz) from wavelength (m)	$F = \frac{300}{\lambda}$
Wavelength (m) from frequency (MHz)	$\lambda = \frac{300}{F}$
Delta or quad loop (total length, m)	$L = \frac{306}{F}$
Half-wave wire (m)	$L = \frac{142}{F}$
Quarter-wave wire (m)	$L = \frac{71}{F}$
Ohm's law	$E = I \times R; I = \frac{E}{R}; R = \frac{E}{I}$
Power	$P = I \times E; I = \frac{P}{E}; E = \frac{P}{I}$
Resistances in series	$R_t = R_1 + R_2 + \dots$
Resistances in parallel	$\frac{1}{R_t} = \frac{1}{R_1} + \frac{1}{R_2} + \dots$
Capacitors in parallel	$C_t = C_1 + C_2 + \dots$
Capacitors in series	$\frac{1}{C_t} = \frac{1}{C_1} + \frac{1}{C_2} + \dots$
Inductances in series	$L_t = L_1 + L_2 + \dots$
Inductances in parallel	$\frac{1}{L_t} = \frac{1}{L_1} + \frac{1}{L_2} + \dots$

Other useful formulas

Quantity	Formula
Power from current or voltage	$P = I^2 \times R = \frac{E^2}{R}$
Two resistors in parallel	$R_t = \frac{R_1 \times R_2}{R_1 + R_2}$
RMS value of a sine wave	$E_{RMS} = 0.707 \times E_{peak}$
Ratio in decibels (power)	$dB = 10 \log \frac{P_2}{P_1}$
Efficiency	$\eta = \frac{P_{out}}{P_{in}}$
FM bandwidth (Carson's rule)	$B = 2 \times (\Delta F + f_{audio})$
Local oscillator above the signal	$f_{LO} = f + IF$

Decibel landmarks

dB	Power ratio
3 dB	× 2
6 dB (one S unit)	× 4
10 dB	× 10
20 dB	× 100

Source: ISED, Reference material for the Basic Qualification (2025).

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