Understanding Baluns

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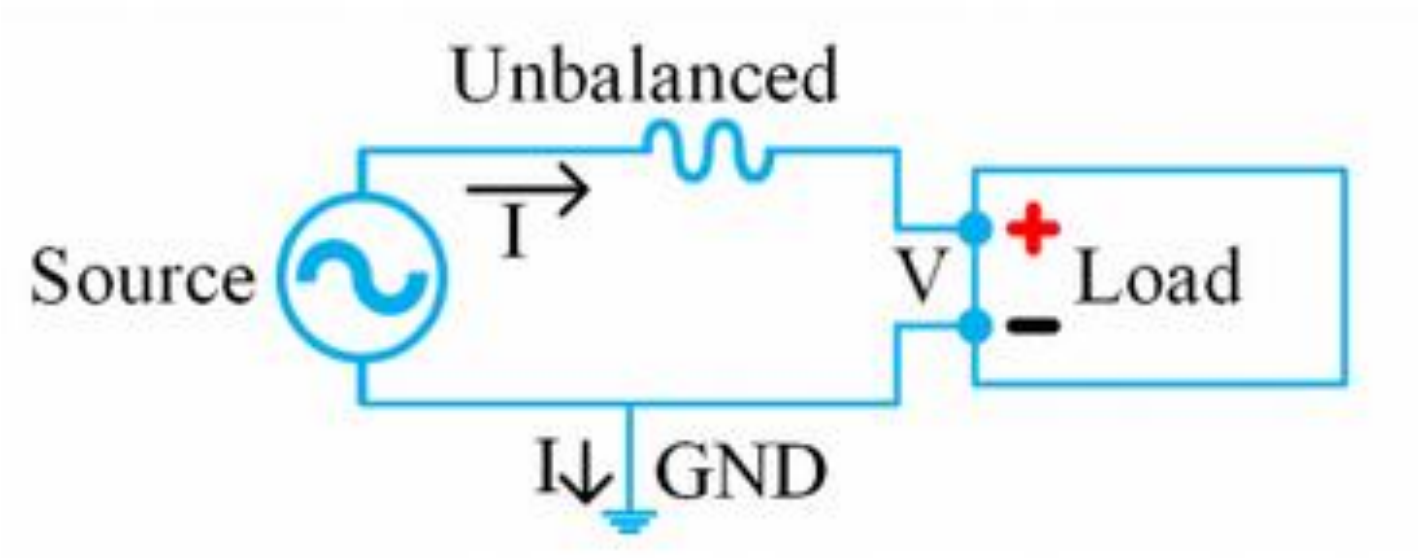
What is a Balun ??

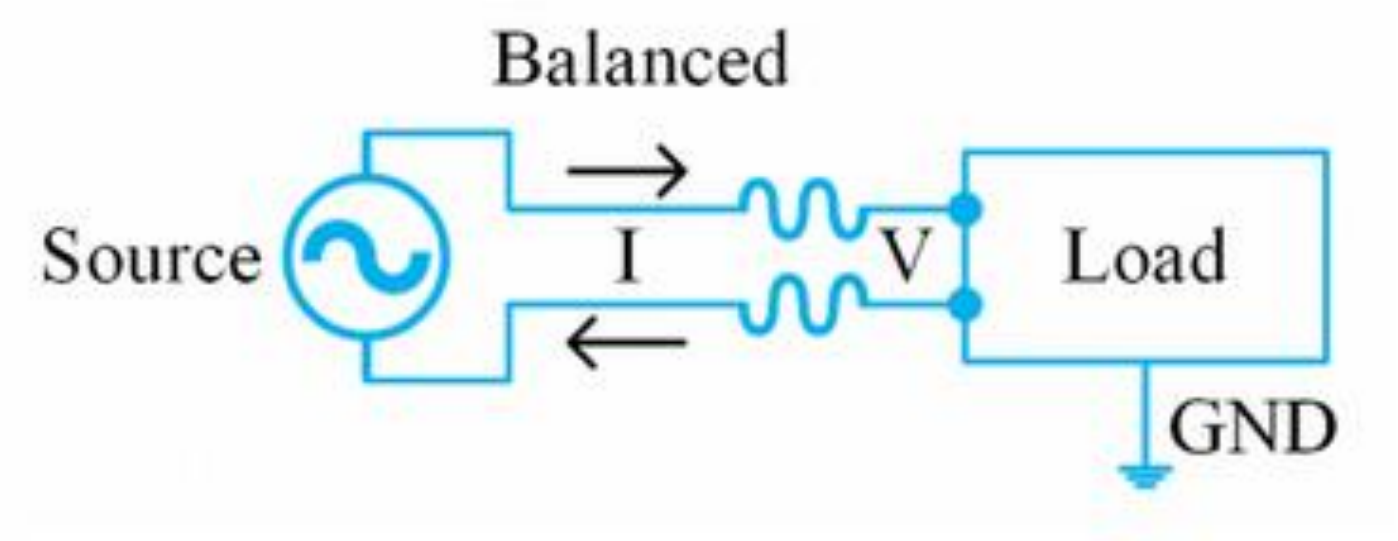
- A device for converting from an unbalanced system to a balanced system.
- Can also provide impedance matching, but not necessarily.
- What is meant by “balanced” and “unbalanced” systems and why do we differentiate between them ??

Unbalanced system



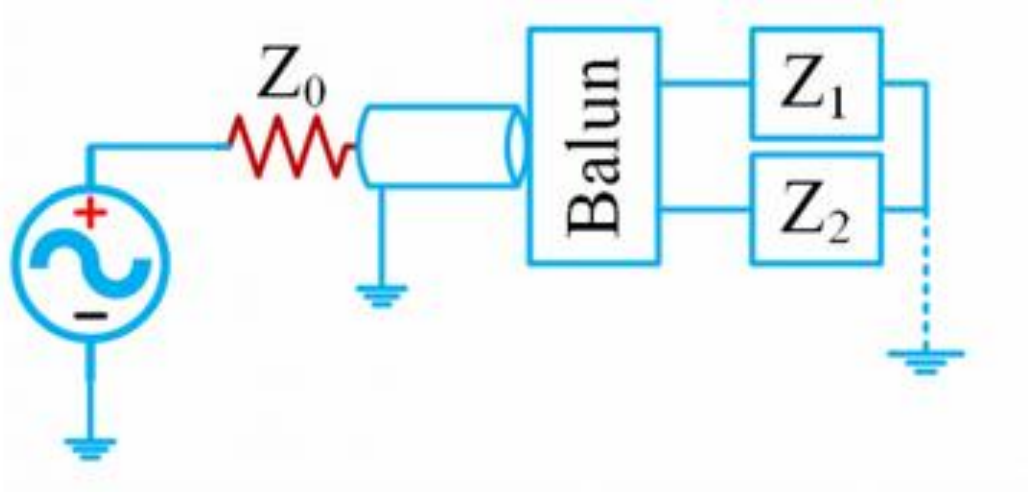
- Coaxial systems
- Microstrip lines

Balanced system



- Twin wire line
- Twisted pair line
- Ethernet cabling
- Audio applications

Use of Balun to Convert Unbalanced to Balanced



- Balun interfaces balanced to unbalanced
- Coax input to a push-pull amplifier

Balanced or Unbalanced Systems

- Balanced and unbalanced are useful in different contexts.
- Coax (unbalenced) is useful on shielded and screened systems and is convenient in RF systems.
- Many antennas are inherenently balenced, eg the dipole.

Balanced Systems

- Antennas – Diploes
- Push-pull amplifiers
- Twin wire systems – even audio!
- Mixers – balanced
- Instrumentation – differential inputs
- Open wire lines – Twin line

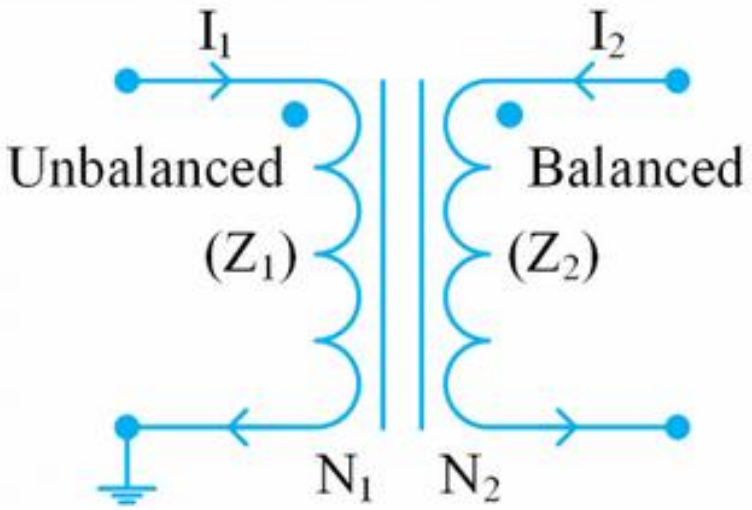
Unbalanced Systems

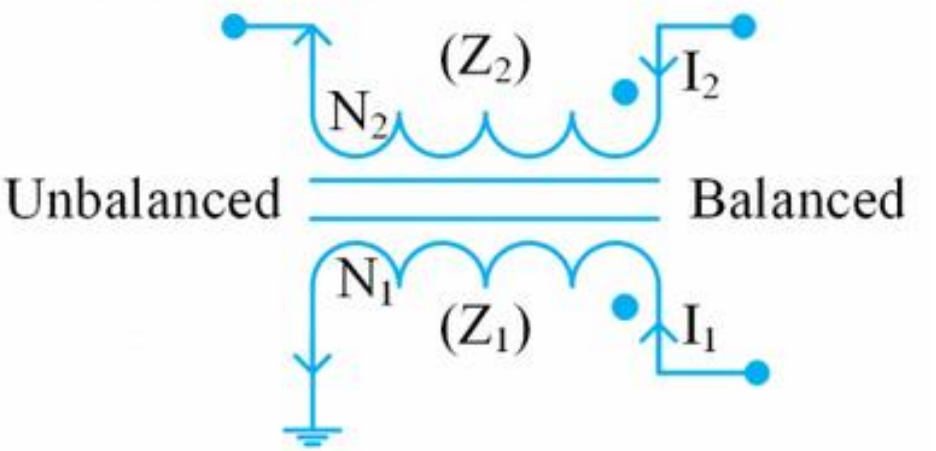
- Antennas – End fed
- Monopoles
- Coax lines and connectors
- Convenient for screening and casing
- Shutting out noise and shielding
- Most test equipment is coax based

Different Forms of Baluns

- One difficulty producing a general treatment of this topic is the many forms baluns can take!!
- Coax baluns, transformer baluns, auto-transformer baluns, ferrite toroidal baluns, microstrip baluns, current baluns and voltage baluns to name a few!
- Conceptually the transformer balun and its derivatives is probably the easiest to start with!
- Move on to look at other implementations.

Transformer Baluns





- Sometimes referred to as voltage and current baluns.
- Current baluns are also called choke baluns.

Impedance Transformation

- Step up and step down impedance transformation is easy with transformer baluns.
- Fairly large setup up/step down impedance changes possible .
- Impedance ratio depends on the square of the turns ratio.

Some Practical Implementations

- Most baluns for HF involve the use of some ferrite cores eg: rods, toroids, binocular or clip-on all are suitable in different situations.
- Simplest is to form a coil in the feed line at the feed point to form choke balun. This can be either on a core or air-spaced.
- Eliminates common mode currents in feed line and forces the dipole to be balanced.

Choice of Ferrite Cores

- Want a high permeability (μ) as possible and must not be lossey.
- Permeability tends to fall off with frequency
- Very high μ materials tend to be lossey so it is a compromise.
- Can check out random ferrite cores with a VNA just by winding a few turns of wire on them and checking that the impedance is inductive and out around the edge of the Smith Chart!!

Why baluns are helpful on Dipoles.

- A dipole is inherently a balanced load.
- A resonant half-wave dipole has an impedance of around 75 Ohms so near match to 50 Ohms.
- One reason for balun is that coax is inherently unbalanced. When feeding an antenna we want the currents in the inner and outer conductor to be equal an opposite so there is no stray field outside of the coax.
- Unbalanced currents tend to flow in the outer surface of the coax cable and produce a external e/m field which can distort the radiation pattern of the dipole and produce spurious resonances.

Skin effect in Coax

- Remember high frequency currents tend to flow in the surfaces of conductors.
- In coax the currents flow in the surface of the inner conductor and the inner surface of the outer conductor (screen).
- Want to minimise outer surface currents in a “feeder” as these provide “unbalance”.

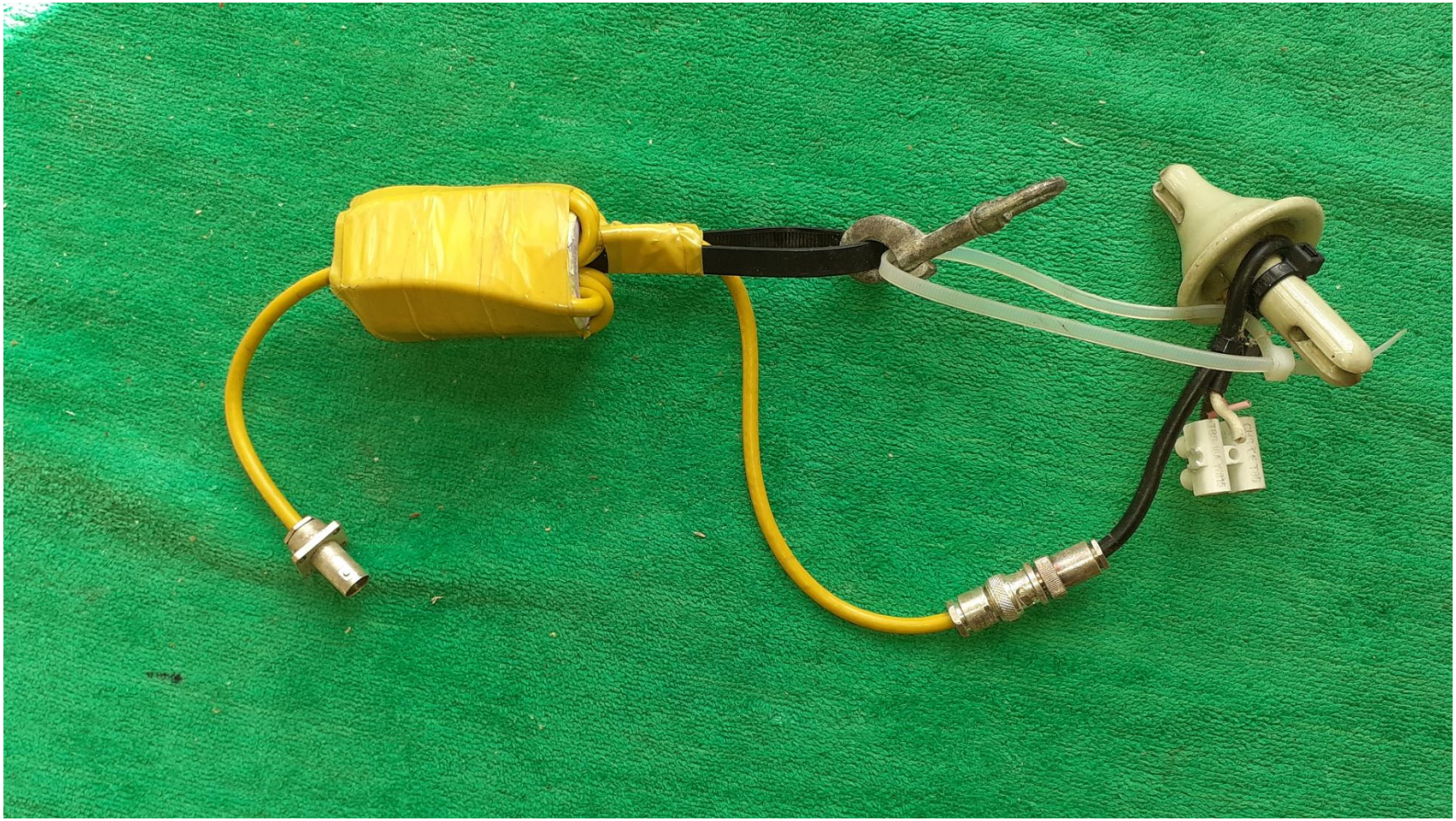
Some Practical Implementations

- There is a wide variety of formats and construction methods.
- Wide frequency range is desirable in baluns for HF operation.
- Some types entail use of transmission line stubs and are inherently narrowband., eg the Pawsey stub balun.

The Collins Balun

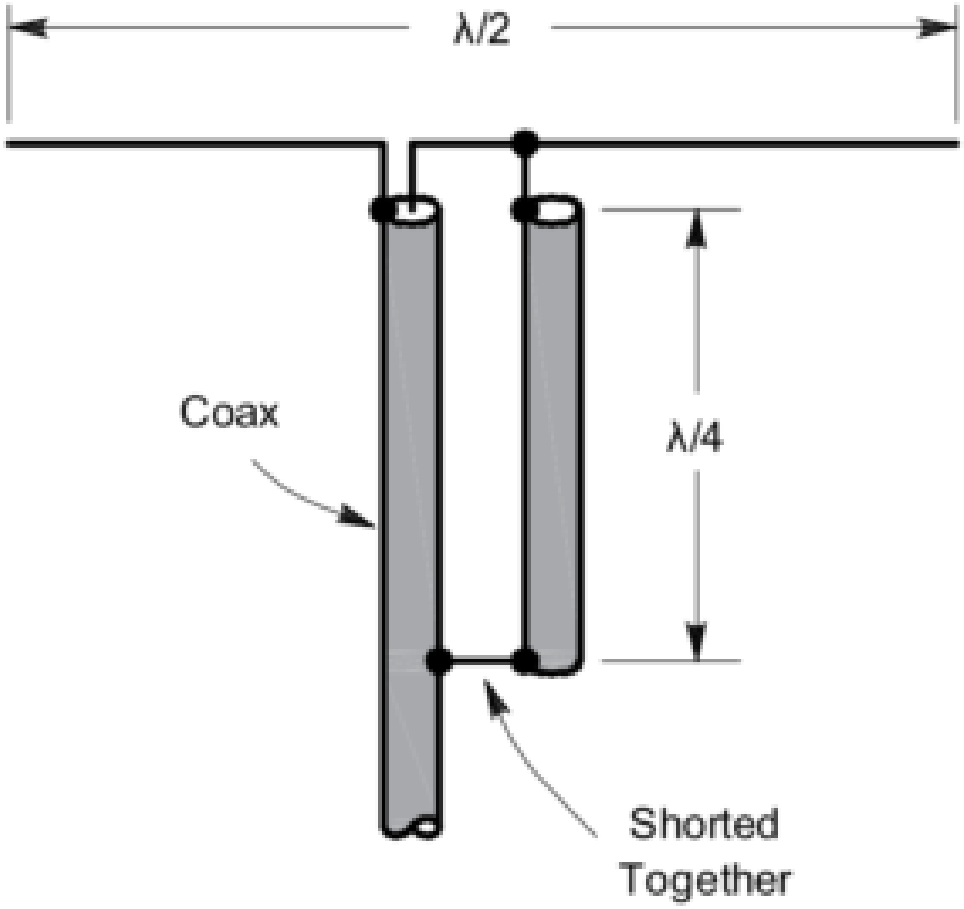
Ferrite Ring Coaxial Balun

Another Implementation (homebrew!!)



Clip-on Ferrites Make Useful Baluns

Pawsey Stub Balun

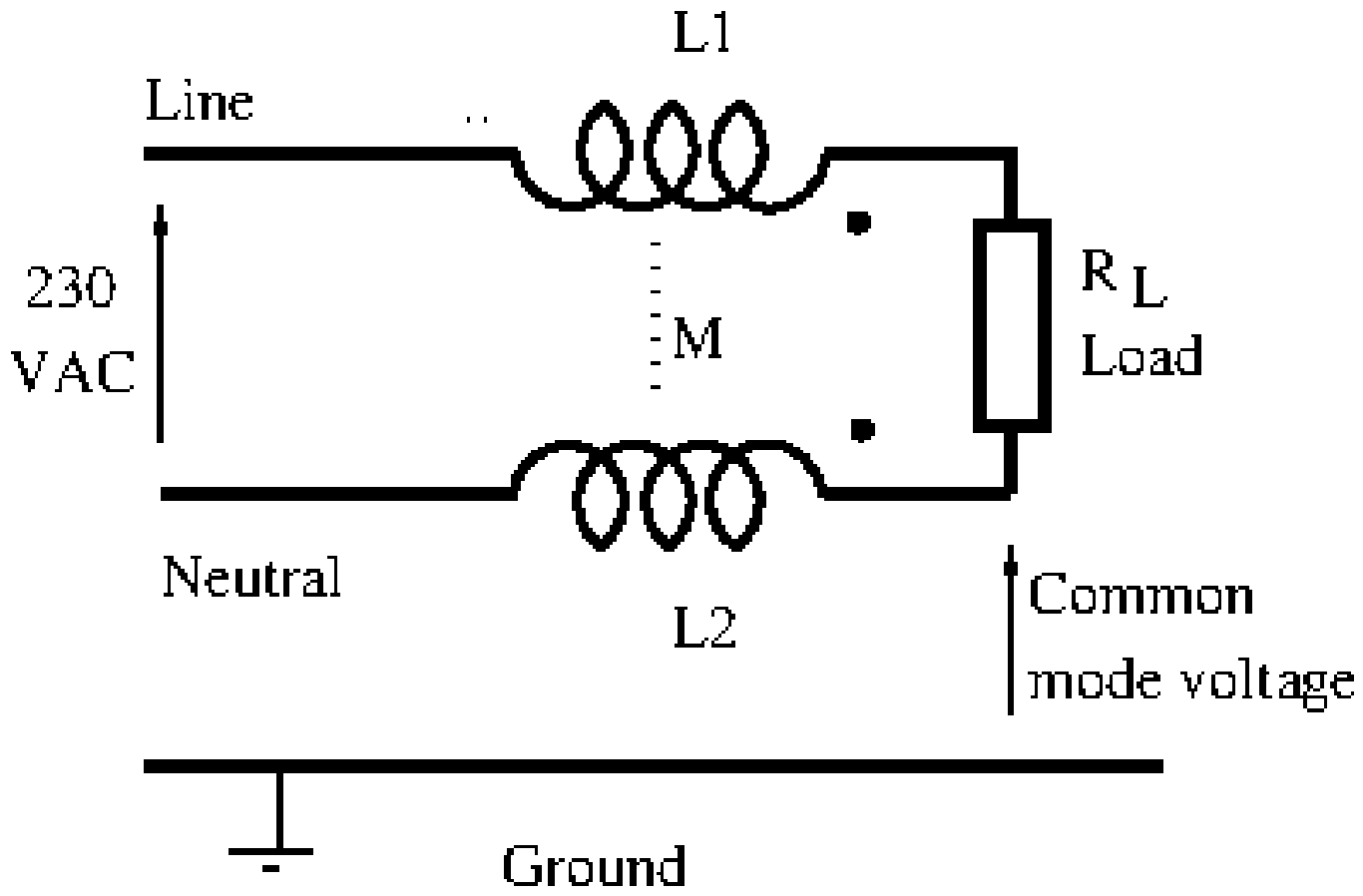


Wire Baluns

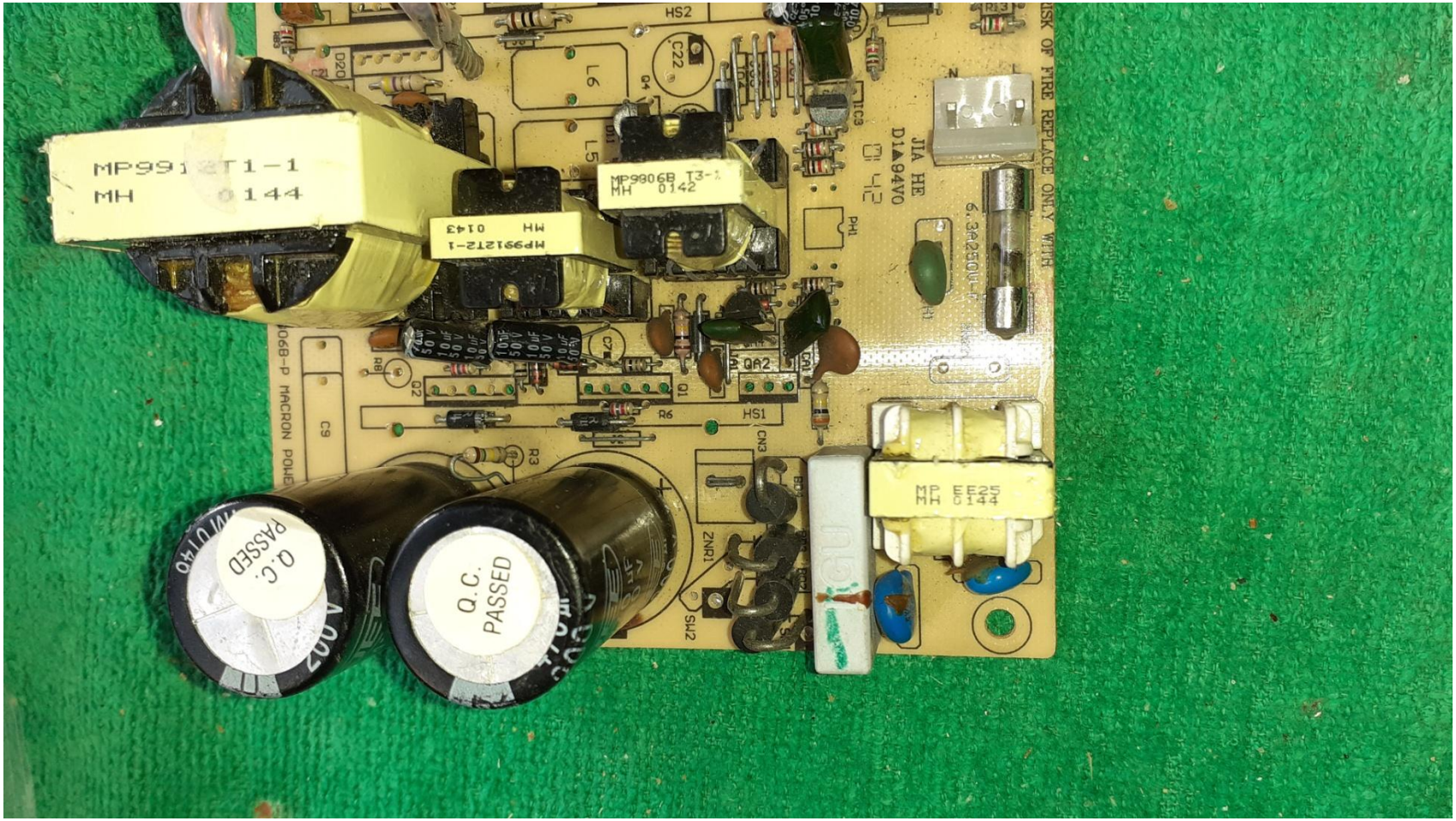
- One useful contruction technique is to wind multi-filar wires onto ferrite cores to give step-up/step-down impedance matching.
- Bifilar windings give 4:1 impedance change.
- Trifilar windings give 9:1 impedance change.
- Quadrifilar windings 16:1 impedance change.
- Useful for feeding high impedance antennas eg half-wave end-feds.

And Finally Other Applications of the Balun Concept

- The common mode choke in SMPS



SMPS Input Common Mode Choke



Further reading.

- ARRL handbook
- RSGB handbook
- “Transmission Line Transformers”, Jerry Sevick, W2FMI, https://www.okdxf.eu/files/Noble Publishing-2001-Transmission Line Transformers, 4ed.pdf
- Available on the internet

Any Questions ?