Bal-Un ed Un-Un

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Definitions

Bal-Un (Balanced-Unbalanced):
A device capable of balancing the currents flowing in a transmission line carrying unbalanced currents.

Choke:
A device capable of reducing common-mode currents (CMC) flowing in a transmission line.

Impedance Transformer:
A device capable of changing the impedance ratio between the input and output.

Un-Un (Unbalanced-Unbalanced):
A device that shares the reference potential between the input and output.

Bal-Un

There are two types of Bal-Un (Balanced-Unbalanced):

- Current Bal-Un is a device that balances (equalizes) the currents flowing through a transmission line, hindering common mode currents (CMC).

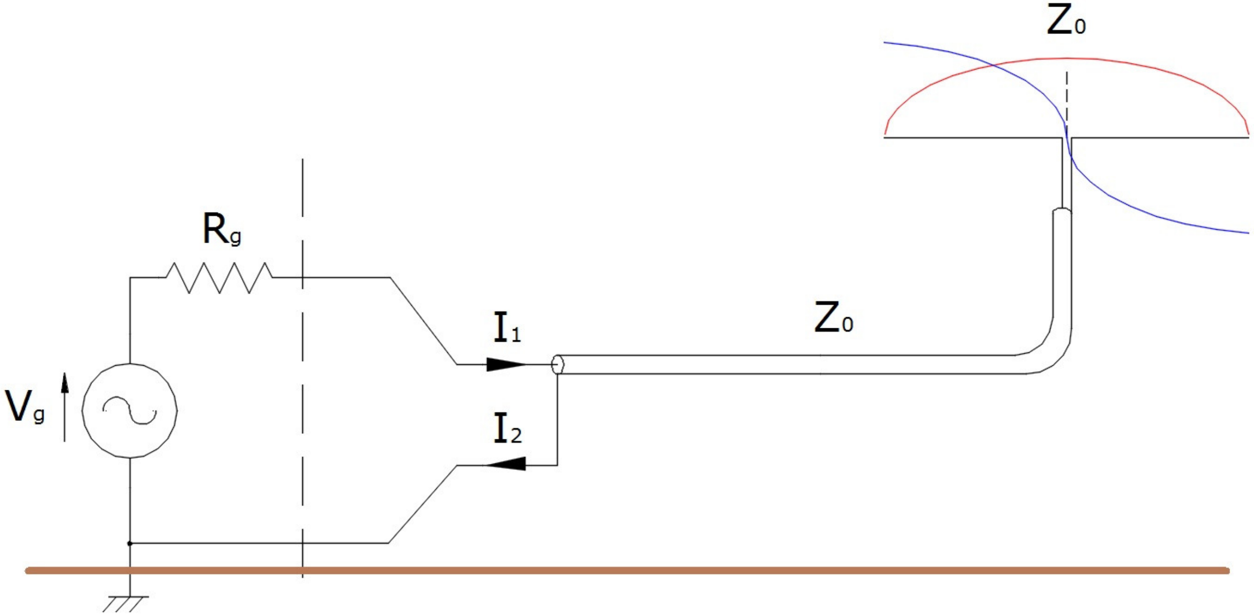
- Voltage Bal-Un balances the voltages at the output port. Balancing the voltages is not a sufficient condition to balance the currents as well. In fact, if the conductors on the balanced output do not see equal impedances towards the virtual zero potential, equal currents will not flow in the line, resulting in common mode currents (CMC).

Bal-Un

For us OM, is concerned with ensuring that the currents in the line are balanced because if they are not, it means that there are common mode currents (CMC) present. Consequently, the line will not be solely carrying differential currents (CMD).

$$I_D = \frac{I_1 + I_2}{2}$$

$$I_C = \frac{I_1 - I_2}{2}$$



Please note that common mode currents generate a magnetic field that extends beyond the transmission line as if it were a TX (transmitter) antenna.

Impedance Transformer

An impedance transformer is a transformer in every sense. Like all transformers, it can vary the ratio between voltage and current from the primary to the secondary while maintaining nearly the same power throughput.

mpedance transformers have: a primary winding, a magnetic circuit, and at least one secondary winding. The ratio between the primary turns n_P and the secondary turns n_S, squared, determines the transformation ratio of input impedance Z_P to output impedance Z_S:

$$\frac{Z_P}{Z_S} = \left(\frac{n_P}{n_S}\right)^2$$

Impedance transformers can have separate primary and secondary windings galvanically isolated, or they can be autotransformers with a common winding between the primary and secondary. In the latter case, there is no galvanic separation between the primary and secondary.

Autotransformers are also known as Un-Un transformers.

Choke

A choke is a device used to reduce common mode currents (CMC) flowing along the transmission line.

If common mode currents are completely blocked by the choke, only the differential mode currents will flow in the line, which, by definition, are balanced. That is, they are equal in magnitude and opposite in direction.

Therefore, if the choke is effective, it can be said to also function as a Bal-Un (Balanced-Unbalanced transformer).

Due to its configuration, a choke is not capable of impedance transformation, so its transformation ratio is always 1:1.

Un-Un

The Un-Un (Unbalanced-Unbalanced) is an impedance autotransformer with both the input and output sharing the same reference potential.
Un-Uns are primarily used to match the load impedance to that of the transmission line.
Un-Uns can perform impedance transformation both up and down but never with a 1:1 transformation ratio.
It's not the only way to achieve matching; there are other methods as well, but the Un-Un is the only one capable of doing so across various frequency bands. In practice, they are wide bandwidth devices.
The Un-Un does not possess any common mode current blocking properties.

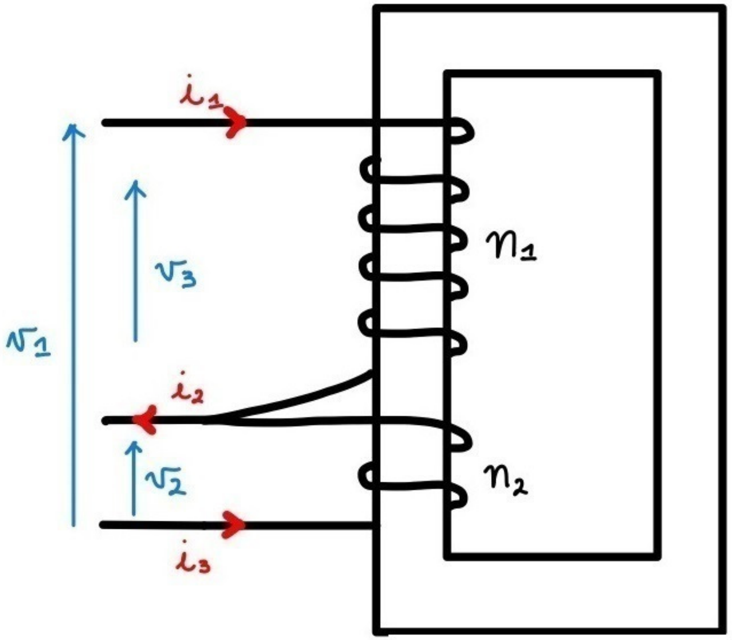
Impedance Autotransformer

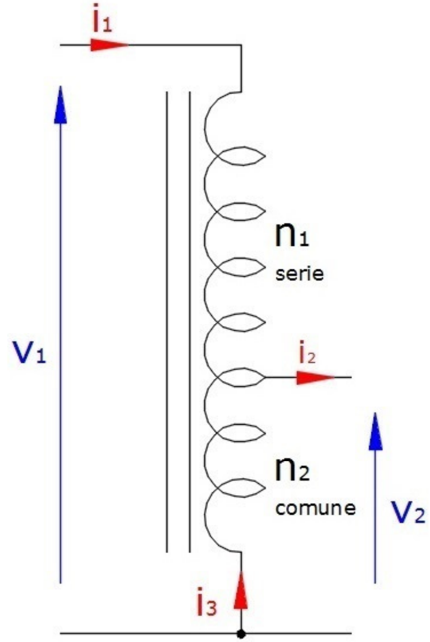
I'll open a parenthesis to explain the autotransformer more clearly because it is widely used in the amateur radio field. Autotransformers can be of two types:

- Step-down;
- Step-up.

This depends on where the series winding is placed in relation to the common winding. The autotransformer is very cost-effective because, for the same power throughput, it uses less magnetic material and smaller conductors.
This allows for lower losses, fewer parasitic elements, and wider bandwidths.
Autotransformers almost always have an unbalanced output, except in some cases where the series winding is split into two identical halves that are connected in series at the two ends of the common winding.

Step-Down Impedance Autotransformer

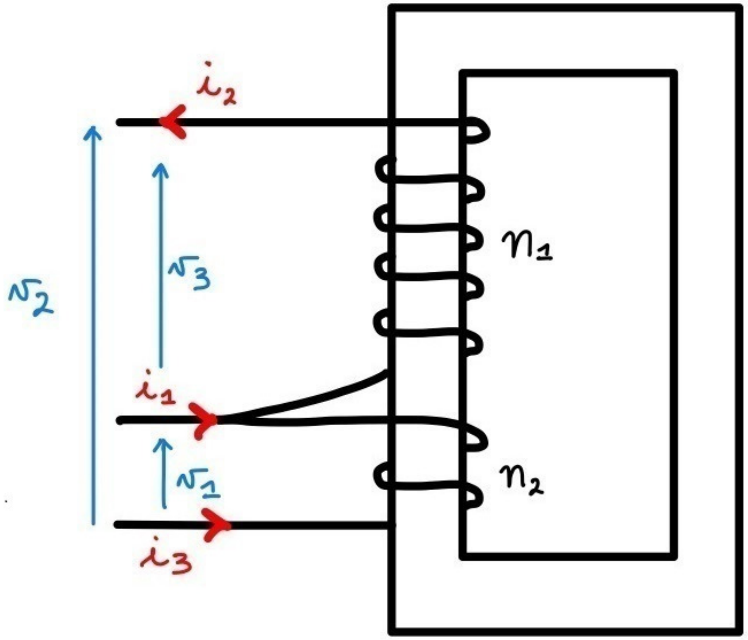


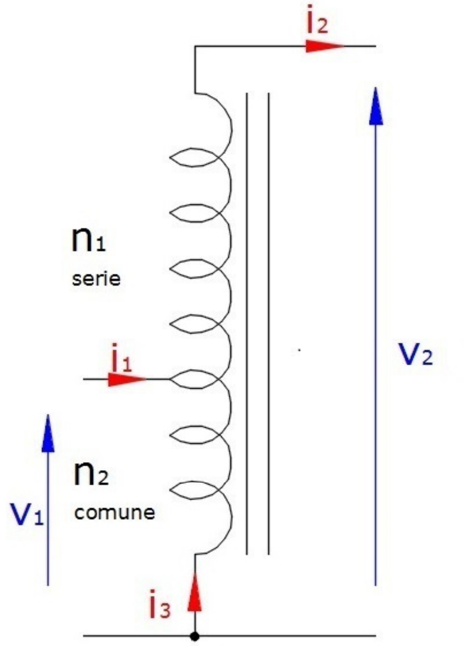


$$N = \frac{n_2}{n_1 + n_2} \qquad v_2 = \frac{n_2}{n_1 + n_2} v_1 \qquad v_3 = v_1 - v_2$$

$$i_3 = \frac{n_2}{n_1} i_1 \qquad i_2 = \frac{n_1 + n_2}{n_2} i_1 \qquad Z_2 = \left(\frac{n_2}{n_1 + n_2}\right)^2 Z_1$$

Step-Up Impedance Autotransformer





$$N = \frac{n_1 + n_2}{n_2} \qquad v_2 = \frac{n_1 + n_2}{n_2} v_1 \qquad v_3 = v_2 - v_1$$

$$i_3 = \frac{-n_2}{n_1 + n_2} i_1 \qquad i_2 = \frac{n_2}{n_1 + n_2} i_1 \qquad Z_2 = \left(\frac{n_1 + n_2}{n_2}\right)^2 Z_1$$