

A Preview of the Matching Networks and Phasing Course



Course Description

At the heart of any AM transmission system is any number of matching networks that are used to impedance match the antenna to the transmission line and transmitter and provide proper inter-element current phasing. These networks, composed of mica and vacuum capacitors and plated coils that often “sing” with modulation, are the stuff of mystery. Many capable broadcast engineers who have not previously dealt with these components and networks approach them with some trepidation, as they have for decades been the realm of the consulting engineer, things not to be touched if at all possible. While there is wisdom in leaving a working system alone, any engineer responsible for the care and feeding of an AM transmission facility should understand the networks therein.

The purpose of this course is to give the student a good overall understanding of the various types of networks used in an AM transmission system, the situations in which each might be used and calculating the leg values thereof. It also discusses the phase budget for a phasing and coupling system and the use of power divider and phasing networks therein.

Course Content

- Matching, L and Tee Networks Practical Considerations for Matching Networks
- Phase Shifting Networks and Power Dividers
- Phase Budget
- Network, Divider and Shifter Designs
- Multi-Mode Systems

SBE Recertification Credit

The completion of a course through SBE University qualifies for 1 credit, identified under Category I of the Recertification Schedule for SBE Certifications.

Enrollment Information

SBE Member Price: \$80
Non-Member Price: \$115

Matching, L, and Tee Networks

Matching Networks

A vertical radiator, whether it is a simple non-directional radiator or an element of a multi-tower directional array, presents a complex impedance to the source feeding it. Transmission lines are used to couple the RF from the transmitter output to the antenna, and coaxial transmission lines have a characteristic impedance based upon, among other things, the diameter and spacing of the inner and outer conductors. The modern coaxial transmission lines commonly used in AM antenna systems typically have a characteristic impedance of 50 ohms.

The most efficient power transfer occurs when the impedance of the load matches the impedance of the source.

To properly and efficiently couple RF from the transmission line to the antenna, the impedance of the load must be transformed or "matched" to the impedance of the transmission line. The most efficient power transfer occurs when the impedance of the load matches the impedance of the source. In

addition to maximizing power delivery from source to load, VSWR bandwidth is significantly impacted by the source-load match. VSWR bandwidth, in turn, affects the audio bandwidth and thus the quality of the demodulated audio.

Ideally, not only should the impedance of the load be matched to the impedance of the source, but the orientation of the load should also be correct. This is defined as a symmetrical arrangement of reduced resistance with equal but opposite reactance on either side of carrier. A Smith chart display of such an idealized load is shown in Figure 1.1. This orientation applies at the output of the transmitter power amplifier. Additional phase shifts in combining networks and filters will often result in the ideal orientation being considerably different at the transmitter output.

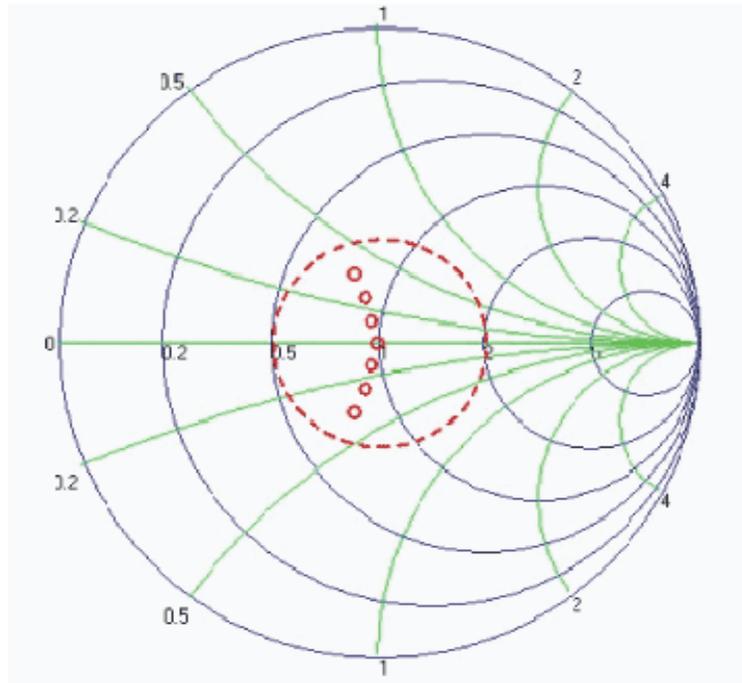


Figure 1.1 - localized load orientation

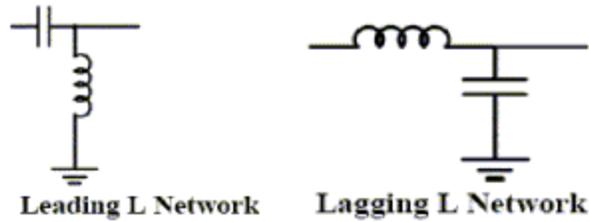
The phase shift characteristic of the matching network is often used to properly rotate and orient the load. The individual leg reactances and reactance "slopes" are often used to properly shape the load.

In in-band on-channel (IBOC) digital systems, which employ 25 carriers in the 5 to 15 kHz range on either side of the analog carrier, bandwidth is even more important.

In the simplest of situations, wherein the resistance of the antenna is 50 ohms, all that may be needed is a reactive component of an equal value and opposite sign of the antenna reactance to "tune out" the reactance of the antenna. This would leave only the resistive component of the antenna impedance, thus presenting a "match" to the transmission line.

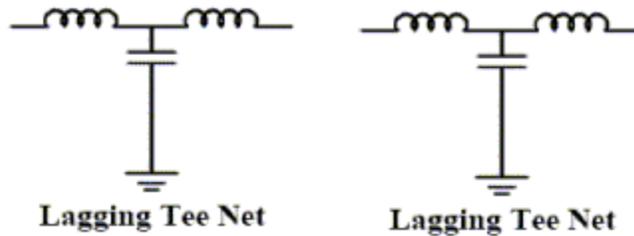
Seldom do such situations occur, however. A typical radiator will exhibit a complex base or driving point impedance that has a resistance of some value other than 50 ohms along with a reactance. It is thus necessary to use a matching network to transform the resistance to 50 ohms and eliminate the reactance. This can be done with any of several types of networks: L, Tee or Pi. Pi networks are seldom used in AM antenna systems. L networks are well-suited to use in some non-directional antennas where the phase shift through the network is not as important. Tee networks are useful where control of phase is necessary in addition to impedance transformation.

A matching network will either advance (lead) the phase of the current through it or retard (lag) it. The configuration of leading and lagging L networks is shown below:



Notice that the identifying characteristic of a leading L network is a capacitor on the input. Conversely, the identifying characteristic of a lagging L network is an inductor on the input.

The configuration of leading and lagging Tee networks is shown below:



Notice that in its simplest form as shown here, the identifying characteristic of a leading Tee network is an inductive reactance in the shunt leg. Conversely, a capacitive reactance in the shunt leg denotes a lagging configuration. These arrangements usually correspond to the opposite reactances in the series legs. In many cases, however, for the purpose of canceling inductive reactances in the load or input or for other reasons, there may be a combination of inductors and capacitors in the series arms of a practical Tee network. As such, it can be hard to identify whether such a network is a leading or lagging net by the series elements alone. The sure-fire way of identifying a Tee network is by the components in its shunt arm as noted above.