COJOT
MORE THAN ONE WAVELENGTH

Increasing Wideband Antenna Performance With Active Matching

A White Paper

Executive Summary

Present wideband antennas, operating in the VHF and UHF frequency bands, are typically passively matched to achieve a reasonably good performance, with low enough VSWR (Voltage Standing Wave Ratio) levels, over a wider bandwidth. This White Paper presents an approach that allows optimizing the matching of wideband antennas more efficiently and without the trade-offs that come with passive matching methods.

The purpose of this paper is to make users and OEMs of radio frequency (RF) devices aware of the benefits that wideband antennas can provide when using active matching. It will describe how the overall performance of a RF system can be efficiently enhanced through COJOT's approach of using wideband antennas with active matching that can be operational within the VHF/UHF frequency ranges. The benefits of efficiency enhancement can include: improved antenna performance (extra range), better signal quality, reduced power consumption or smaller antenna designs.

There is a clear need for a smart approach that will provide additional benefits as well as an indispensable level of flexibility to users and OEM's of RF systems when keeping up with the demanding market requirements.

Introduction

Requirements in today's RF market are quite challenging and highly diversifying; devices for communication and electronic warfare applications become less obtrusive, technology more complex and better coverage and higher capacity is needed over an even wider bandwidth, while at the same time there is a strong need to reduce power consumption. Furthermore, multiple radio systems often co-exist on one platform, causing unwanted in-band interferences, especially at platforms where space is limited.

The antenna is a crucial element of the entire RF system, because it converts the radio amplifier's power to electromagnetic waves. To achieve a best possible transmission over a wide bandwidth, it would require that the antenna is ideally in tune over the entire frequency range that the antenna is supposed to work at. Naturally an antenna is however only in a narrow band in tune and the matching of a wideband antenna, to 50 ohm, is challenging. In order to obtain a VSWR level that is low enough, inductive or resistive components are often needed in the matching network. It means that trade-offs in performance have to be made, and the wider the frequency band is that a signal needs to be transmitted at, the more challenging an efficient matching actually becomes.

COJOT has developed a new type of active band switching for VHF/UHF wideband antennas that allows optimizing the matching more efficiently across a wide frequency range of interest. This technology can improve the antenna's overall performance and provides additional benefits for enhanced efficiency, including reduced power consumption and the option to use radiators of smaller physical size. In this approach the entire frequency range is split into smaller portions. Yes, this method is already widely utilized in modern communications within the HF bands, but there it is much simpler to implement. With modern tactical radio waveforms, in the VHF and UHF frequency bands, modulation techniques are more challenging. They commonly include techniques called frequency hopping, a method where the signal is rapidly switching among various frequency bands. In this technique the time to make the switch from one band to another is significantly shorter than the time that is required by HF devices. This difference makes it challenging, when tuning the matching of wideband antennas operating in the VHF/UHF bands.

The Principle of Active Matching

Active matching can provide remarkable performance enhancements especially for wideband VHF/UHF antennas, which have a relatively broad operating bandwidth. For example, the relative bandwidth of a 30-90 MHz antenna is almost 100 percent. Matching problems occur when these broadband antennas need to be matched to 50 Ohm impedance, with low enough VSWR (Voltage Standing Wave Ratio) levels throughout the whole operating bandwidth.

Figure 1 on the right illustrates for instance the impedance matching (to 50 ohm) of a typical VHF radiator, in the 30 – 150 MHz frequency range, that doesn't have any matching components. The blue line presents the matching of this VHF radiator and the red curve shows respectively the radiator's mismatching loss, i.e. when the antenna is in tune the mismatching loss is small and additional matching wouldn't be required (see two areas shaded in blue). As it can be seen, those areas are however rather narrow compared to the entire frequency band this antenna is supposed to work in.

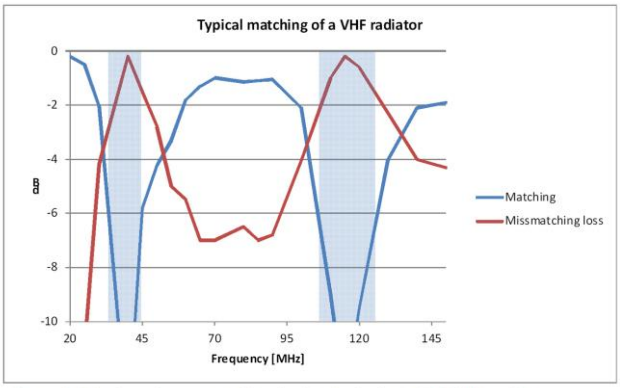


Figure 1 - The impedance matching (to 50 ohm) of a typical VHF radiator

Traditionally the matching of such a wideband antenna is accomplished with inductive or resistive components that are accompanied by considerable mismatching losses. This is illustrated in figure 2, which shows in a simplified view the typical mismatching loss of a wideband antenna that is matched with passive components. In this example, the maximum VSWR level is set to 1:3, which is quite a typical requirement in communication applications. It can be seen that wideband matching with passive components is generally determined by the weakest frequency area. The antenna's overall performance is significantly affected, as for example areas where the antenna is naturally in tune can't be fully exploited. This shortcoming can be avoided through antennas that use tunable matching.

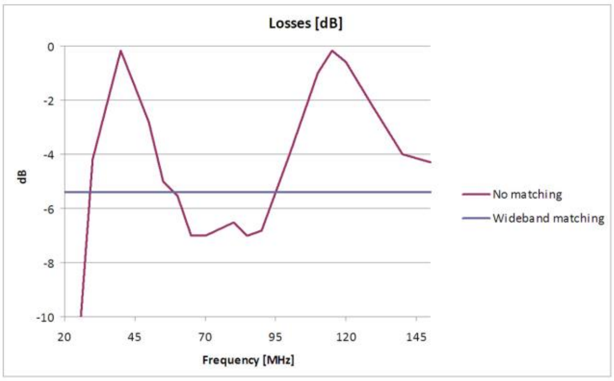


Figure 2 - Typical mismatching loss of a wideband antenna matched with passive components, compared to a VHF radiator without any matching

The basic idea of active band switching is to split the frequency band into smaller slots and match each of these slots separately. This way those areas where the antenna is naturally in tune can be fully obtained, the antenna's overall performance be improved and valuable additional benefits be gained.

Figure 3 represents the simplified principle of a wideband antenna with active band switching technology. The given block diagram shows the antenna's active matching unit, consisting of a control unit and several narrow band antenna matching units (AMU) that are used to separately match the given frequency slots. The RF signal sent from the radio to the antenna is routed to the relevant AMU to match the frequency slot of interest. This type of communication between the radio and the antenna is constantly made and based on the control signal from the radio.

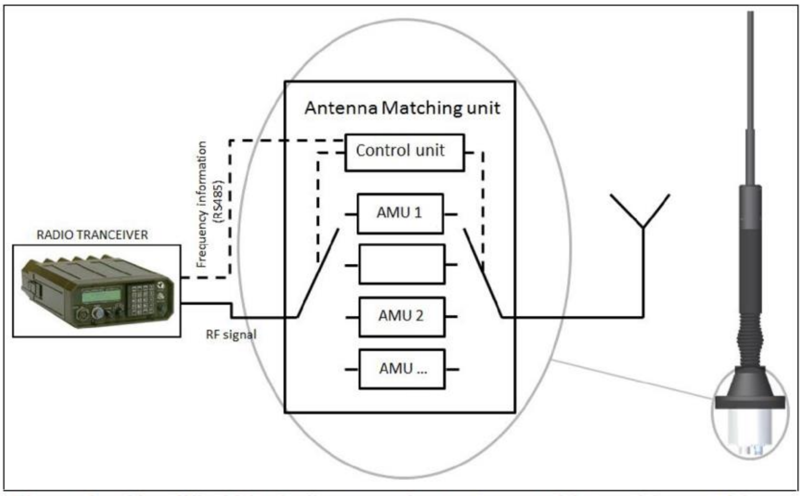


Figure 3 – Simplified block diagram of an antenna with tunable matching

With the help of modern PIN diodes and a well-designed communication between the radio and the antenna the required tuning time can be reduced to an optimal minimum. So that for example, in applications where frequency hopping is used, the switching between matching units is capable of keeping up with spontaneous frequency changes that are initiated by the radio's control signal.

The bandwidth of those various matching units is designed in a way that also modern wideband waveforms can be supported.

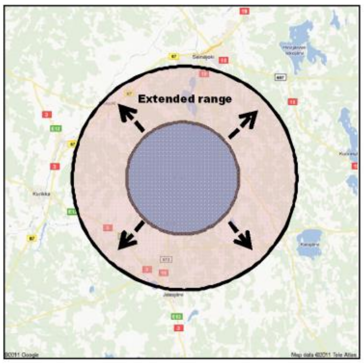
This approach can be used for the development of VHF/UHF wideband manpack/handheld and vehicle antennas that operate particularly within the 25 – 512 MHz frequency range. COJOT has been able to achieve the following performance attributes, in this case related to an antenna that was developed for the 30 – 90 MHz frequency range:

- In average 3 dB better gain compared to a passively matched antenna of similar size
- Channel bandwidth approximately 10 MHz enabling spread spectrum technologies still to be used
- Switching speed < 10 us. Total switching speed including the communication (transmit, receive, acknowledge) with the radio < 30 us.
- Power consumption of the matching unit only about 5 W (depends on required transmission RF -power tolerance)

Benefits

Wideband antennas that use active matching overcome the shortcomings of traditional passive matching methods. Active band switching enables to remarkably improve the antenna's overall performance and allows moreover taking into consideration the additional useful opportunities that this technology offers, i.e. its potential to considerably reduce power consumption and its capability to achieve with a smaller sized radiator a performance, which is similar to that of a longer, passively matched radiator.

Here are in brief the versatile and useful benefits that COJOT's active antennas, for the VHF and UHF bands, can provide over a traditional RF system equipped with passive antennas:

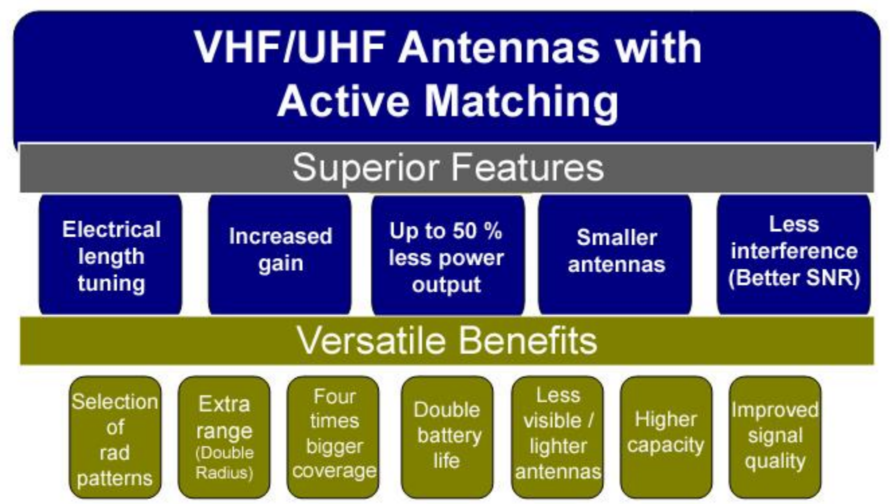


1. **Better coverage and extended range**
   - Achieves in average 3 dB better gain (equals 6 dB enhancement if implemented to transmit and receive) → Doubles the cell radius and makes cell coverage FOUR times bigger.

2. **Reduced power consumption**
   - Requires less transmission power for achieving the same coverage that the current passive antenna provides.
   - Having to achieve 3 dB less gain means in return 50% less transmit power → Doubles battery life of current radio amplifier devices and enables to reduce the size of cooling systems used in future radio amplifiers.

3. **Smaller antenna design**
   - Similar gain can be achieved with shorter radiators → Smaller antennas can be used in vehicle applications and lighter and more compact antennas in manpack/handheld applications.

4. **Better signal quality and higher capacity**
   - Higher out-of-band interference rejection as the antenna is operational at only a small area of the complete frequency range at this time → Better signal to noise ratio



Efficiency enhancements that COJOT's active VHF / UHF antennas can provide

About COJOT

COJOT is specialized in Wideband Antennas in the 20 – 6.000 MHz frequency range. Its products are globally used in military and public safety markets. COJOT is a privately held company headquartered in Espoo, Finland.

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