THE COMPUTER VNA ASSISTED MEASUREMENTS OF THE UTP CABLE TRANSMITTING WIDE RANGE FREQUENCY SIGNALS UP TO 100 MHZ

Marek Matusiak, Andrzej Cader

IT Institute, Academy of Management, Lodz, Poland
marek@matusiak.net, acader@swspiz.pl

Abstract

The paper describes some possibilities of the Unshielded Twisted Pair (UTP) cable as an universal signal transmitting line at the range of radiofrequencies from 0,1 to 100 MHz. Four pairs of the UTP in the subject of the impedance of the line with the different load were examined. The Vector Network Analyzer was used as a base measurement equipment [1,2]. Results are clearly shown using charts from the freeware IG-miniVNA computer program. The final experiments conclusion presents the UTP 5e category as a good general purpose transmitting line for universal 100 ohm impedance sources and loads [3].

Key words: VNA, VNA program, impedance measurement, UTP cable, transmitting line, computer measurement

1 Introduction

The Unshielded Twisted Pair (UTP) computer cable is accessible and quite cheap transmitting line type for computer networks. Four twisted pair is also good a opportunity to realize four parallel transmissions of any mode signals. The Vector Network Analyzer (VNA) offers a quick and accurate measurement of all important electrical parameters as: impedance magnitude and phase depending on frequency changes for two-ends electrical circuits.

The VNA is also useful to examine transmitting parameters of the line as a four-ends electrical circuit and find the cable attenuation for example. The method gives hundreds measurements per second for the setting frequency range [4].

2 Equipment and methods

Authors use the VNA hardware and software dedicated to aerial measurements. It is connected to the computer USB port and after the recognizing process by the operating system takes the virtual COM port for the control. The IG-miniVNA computer program commands the VNA and all transmitting and data collecting process as well.

Fig. 1. shows the VNA and the UTP cable connected to the port called "VNA". This port is dedicated to two-ends circuits and used especially for Return Loss (RL) and Phase (Ph). measurements. Other parameters, impedance magnitude, Standing Wave Ratio (SWR) are recalculated from RL and Ph [5].

$$RL = 10log\frac{P_R}{P_F} = 20log\frac{U_R}{U_F} - 20log\left|\frac{Z_L - Z_S}{Z_L + Z_S}\right| \ (dB)$$

$$SWR = \frac{U_{max}}{U_{min}} = \frac{1+\frac{U_R}{U_F}}{1-\frac{U_R}{U_F}}$$

where: P_R, P_F – reflected and forwarded power, U_R, U_F – reflected and forwarded voltage,
Z_L – load impedance magnitude, Z_S – source impedance magnitude
U_{max} – maximum voltage amplitude, U_{min} – minimum voltage amplitude

The impedance Z as a complex number is presented using equations:

$$Z = R + jX = |Z|(cos\varphi + jsin\varphi) = |Z|e^{-j\varphi}$$

where: R – resistance, X – reactance, $|Z|$ - impedance magnitude,
φ – circuit phase angle

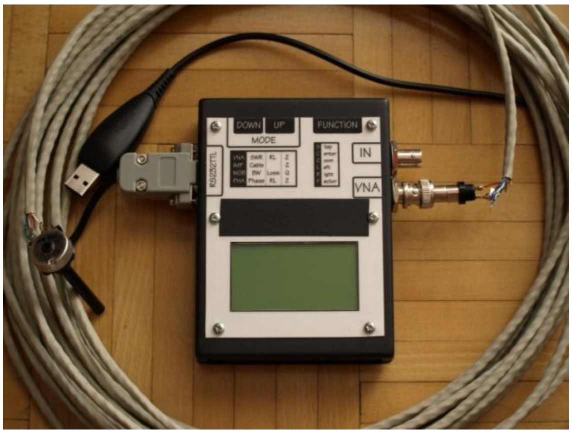


Figure 1. The VNA with UTP cable and the carbon variable resistor as the load

The next "IN" socket is connected to the opposite cable end for measurements of the cable transmitting parameters like the attenuation . The figure 2 presents the VNA principle as a schematic block diagram [6].

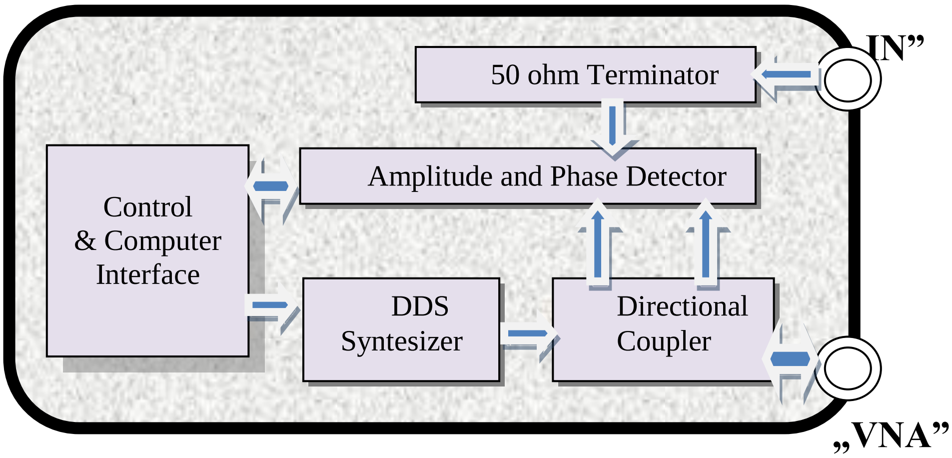


Figure 2. The VNA block diagram

The main author of the controlled program is Jean Luis Pages, the software works stable and quickly. The presented screenshot (Fig.3) was made during the calibration measurement of the terminator BNC resistor of 75 ohm. The upper curve presents the impedance magnitude from 0.1 MHz to 100 MHz and it is excellently flat. The phase angle has a very small values, a few degrees. Flat charts signalize the good resistance type of the load. When the reactance increases the impedance magnitude and phase curves change and present much variable.

Figure 3. The IG-miniVNA program interface by J.L.Pages and the calibration 75 ohm resistor

3 Results

Several transmitting lines and loads were experimental examined.

– 75 ohm terminator connected to the end of the 10 m length UTP transmitting line

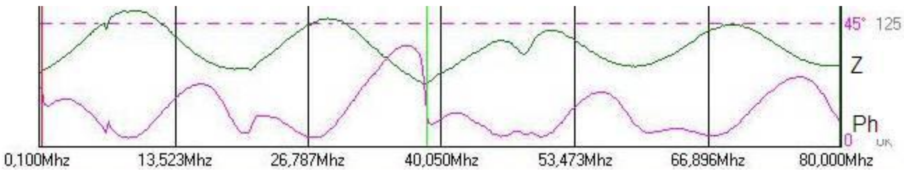


Figure 4. The Z magnitude and phase curves when 75 ohm resistor terminates 10 m UTP

Big changes signalize that the load is unmatched to the source and line impedance. The reflected wave and energy losses are automatically present in the transmission line.

– The 10 m UTP line closed in the end

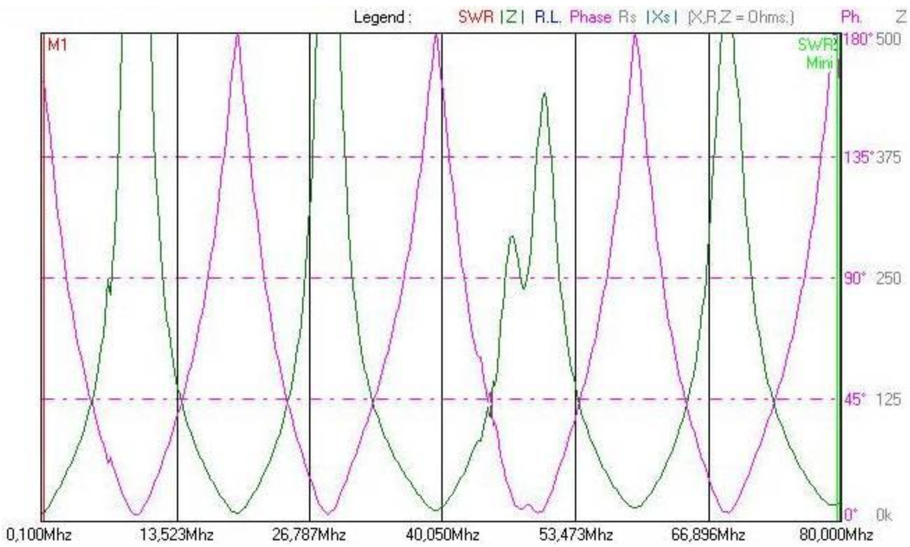


Figure 5. The case of the UTP 10 m line closed in the end

The load is extremely unmatched (at the impedance) to the line and the source.

– 100 ohm resistor connected to the 10 m UTP line

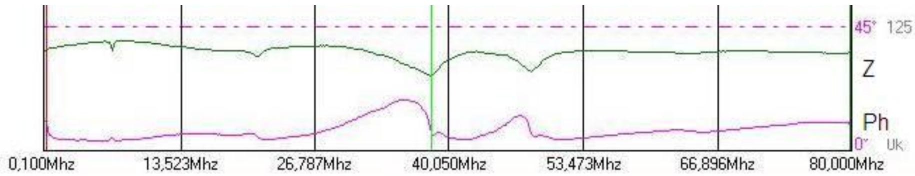


Figure 6. The Z magnitude and phase curves when 100 ohm resistor terminates 10 m UTP

Fig. 6. presents quite flat curves that load is well matched to the source and the line. Waves on curves signalize parts of the wavelength matched to the line.

– The 220 ohm resistor connected to the 10 m UTP line

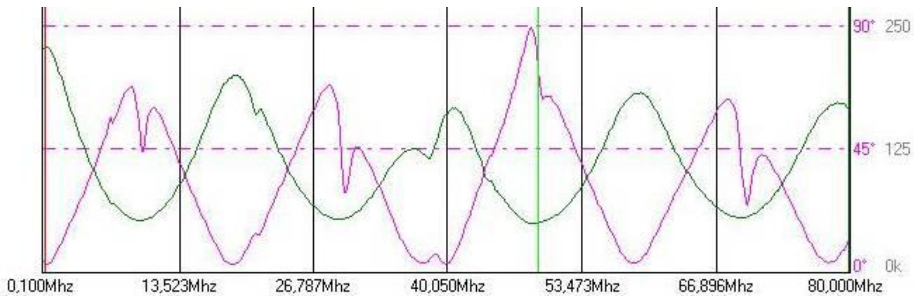


Figure 7. The Z magnitude and phase curves when 220 ohm resistor terminating 10 m UTP

The figure shows waves of the Z magnitude and the phase angle. The load resistor is significantly bigger than the impedance of the transmission line and the source.

– The 100 ohm resistor connected to the 10 m UTP line, rest twisted pairs closed

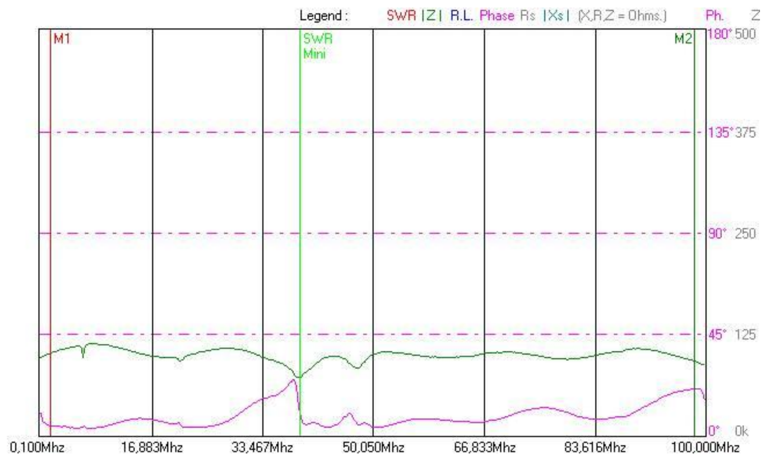
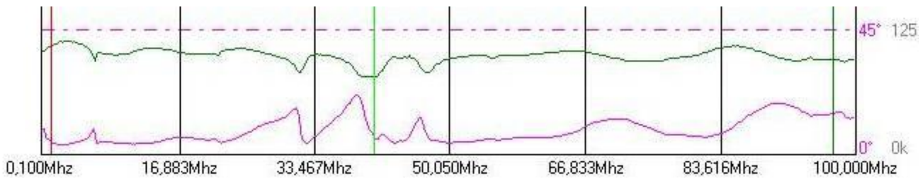


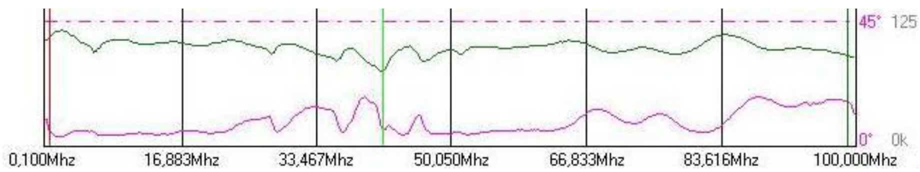
Figure 8. One UTP pair loaded 100 ohm with the closed rest 3 pairs presence

The differences between Fig. 7 and Fig. 8 are invisible. That is a good prognostic for an independent transmission process in all UTP pairs.

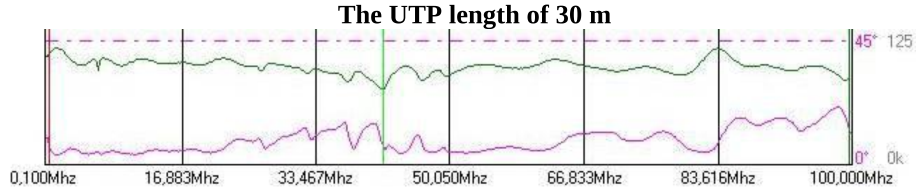
– UTP increasing length to: 2x10 m, 3x10 m and 4x10 m. The load: 100 ohm.



The UTP length of 20 m



The UTP length of 30 m



The UTP length of 40 m

Figure 9. Charts present UTP lengths of 20, 30 and 40 meters with 100 ohm resistor loads

Additional waves in the Z and Phase curves are observed at the frequency range about 25-50 MHz probably because of connections to the next 10 m length UTP pairs.

4 Conclusions

There were completed a few experiments with the UTP computer cable of the 5e category. Conclusions are presented below:

- The VNA computer impedance measurements are very quick and sufficiently correct.
- The measurement calibration is very easy and precise.
- The impedance magnitude is very near 100 ohm and constant in the wide range of the frequency up to 100 MHz.
- Additional 10 m length segments connected to the parts measured before do not change main electrical parameters.
- Not connected cable pairs do not change parameters of the measured main pair.
- The measured UTP cable is a very useful medium for any electrical signal with the source and load near 100 ohm impedance at 100 MHz frequency range.
- The investigated cable is a good solution for any electrical signals up to 100 MHz for a balanced and unbalanced transmission lines as well.

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