

# Communication over a TP cable



## Signal on a TP cable, shaping

Signal shaping is the main function of the TPEX -- Twisted-pair Ethernet Transceiver circuit. Original signal generated by the Manchester modulator is rectangular. Applying Fourier transform, we discover that it consists of a number of odd harmonics with non-neglectable amplitudes:

$$f(x) = \sin(x) + 1/3 \sin(3x) + 1/5 \sin(5x) + \dots$$

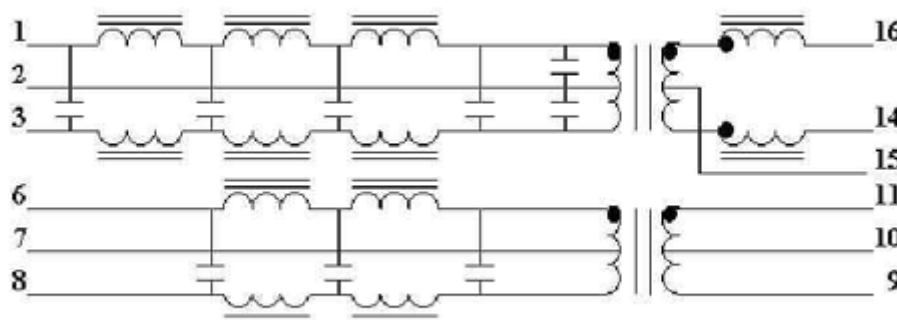
Converting the coefficients to dB, the level of 3rd harmonic is -4.77 dB and of 5th harmonic -7 dB. Such a suppression is clearly insufficient since harmonics carry no useful information and only cause unwanted noise. There are two ways of eliminating them:

- [Suppression of harmonics by filtration.](#)
- [Driving the line with a near-sine signal.](#)

### 1) Filtering harmonics

TP cable is driven through a hybrid filter/transformer, for example [20F001N](#) device. In the following picture, the filter is in the top part of the schematic. It is driven by symmetric rectangular signal connected to pins 1 and 3. TP line connects to pins 14 and 16.

#### Schematic:

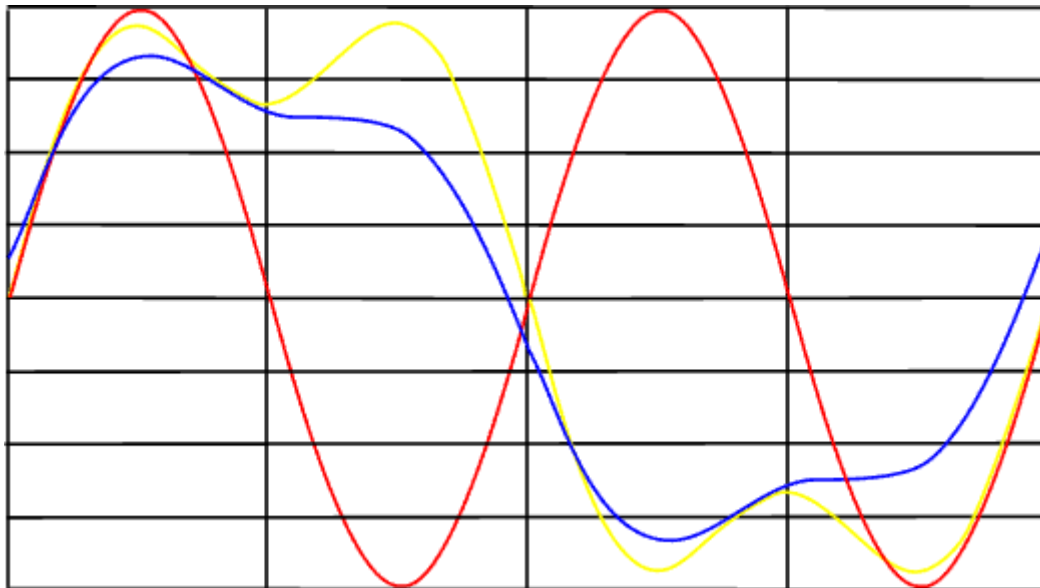


Cut-off frequency of this circuit is 17 MHz. Attenuation is shown in the following table:

20 MHz	7 dB
25 MHz	19 dB
30 MHz	32 dB
40 MHz	35 dB

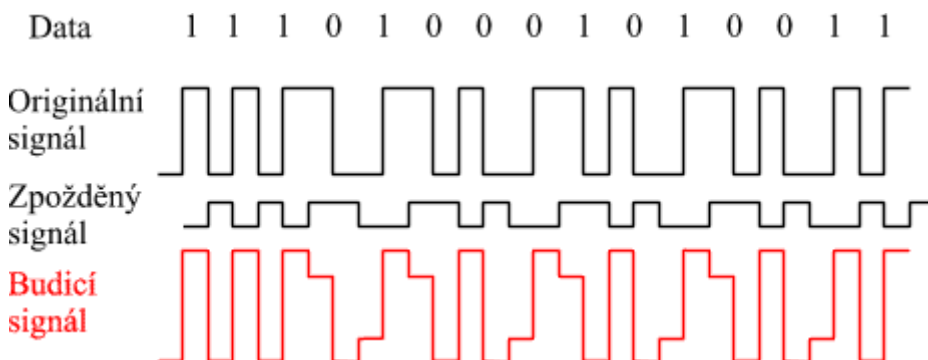
Attenuation of higher frequencies is about 25 dB. This filter solves the problem only partially. Signal coming into this filter has two main frequency components depending on the data being

transmitted. If a sequence 11 or 00 is transmitted, the modulation frequency is 10 MHz. However, if 01 or 10 is transmitted, the modulation frequency of this sequence is only 5 MHz! Such a signal will pass through the above filter with the third harmonic intact, obtaining the yellow-colored signal at the output.

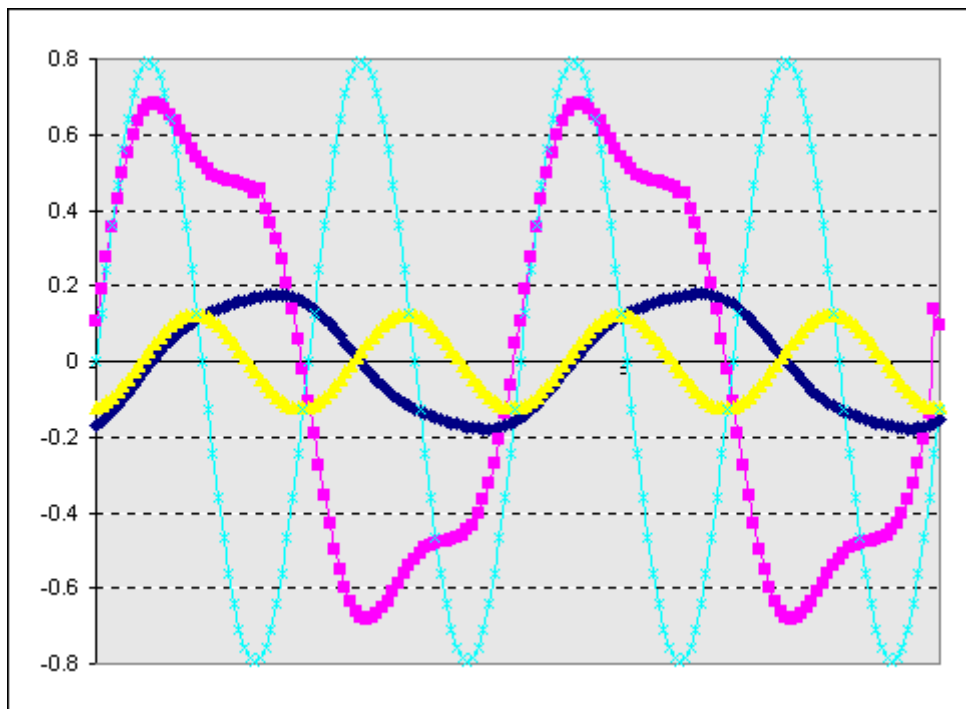


(filtered signal: **10 MHz** / **5 MHz** / **corrected 5 MHz signal**)

This signal is not very suitable for further processing. Since it is difficult to make a filter that would pass 10 MHz and sufficiently attenuate 15 MHz, it is necessary to reshape the signal before filtering. Signal is reshaped as shown, yellow color shows filtered signal. The reshaping is achieved by subtracting about 20% of the signal from Manchester coder delayed by 50 ns. Resulting signal is shown in the following figure.



Another reason for signal reshaping are the properties of the TP cable itself. Since it is mostly capacitive and is driven from output impedance of about 100 Ohms (necessary for termination), it exhibits some "persistence" caused by charging and discharging of the cable. After passing through the cable, the signal looks like:



filtered output signal **10 MHz** (data 1111 or 0000) / **5 MHz** (data 0101), signal at the end of cable  
**10MHz** / **5 MHz**

► [Equivalent circuit and further details](#)

## 2) Driving the line with a near-sine signal.

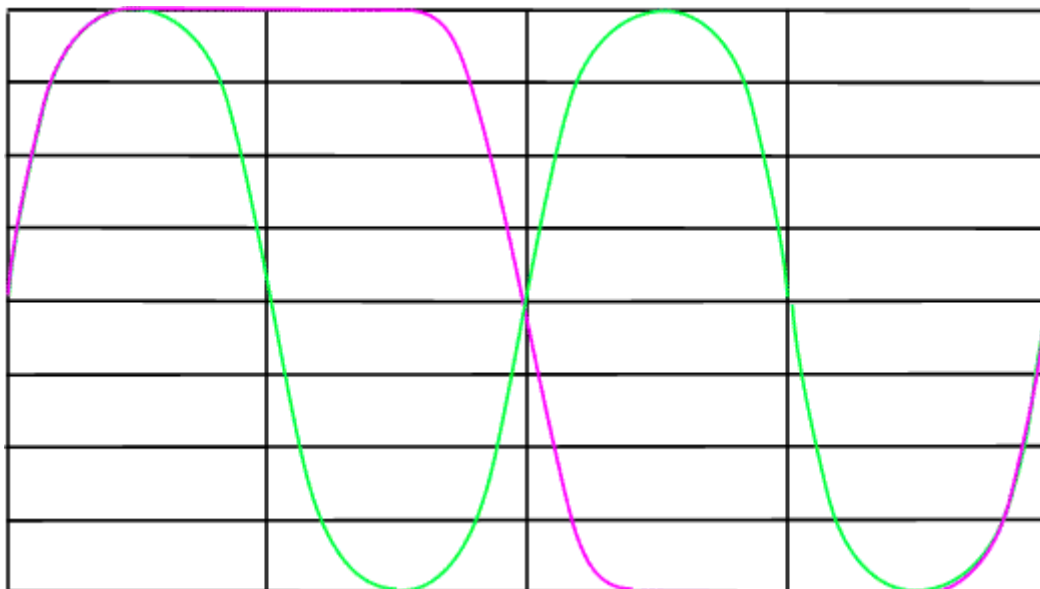
First hint of signal shaping is the method used in communication over [coaxial cable](#). Signal edges have rising/falling times modified to 25 ns. Rectangular signal is converted to trapezoidal, consisting of a number of odd harmonics:

$$f(x) = \sin(x) - \frac{1}{9} \sin(3x) + \frac{1}{25} \sin(5x) - \frac{1}{49} \sin(7x) + \dots$$

Converting to dB, level of 3rd harmonic is -9.5 dB and of 5th harmonic is -14 dB. This is twice as much attenuation compared to the rectangular signal but it is still not enough.

If the TP cable is to be driven through a hybrid transformer only, e.g. Valor ST7011, [Pulse PE-65745](#), [YCL 16PT-41](#), ... it is necessary to use a near-sine shaped driving signal. Filtering or shaping circuits are usually integrated into output drivers. For example, this method is used in [CS8900](#). Besides analog solutions, filtering can be implemented in two possible ways:


















- Signal is generated with a table and a D/A converter. Used e.g. in [LXT901/907](#) which uses a 5-bit D/A operating at 70 MHz.
- Signal is reshaped with a FIR filter. Used e.g. in [MTD907](#), which contains a 16-point FIR filter operating at 160 MHz. The following figure shows an example of the filter effect:



The signal shown was obtained by passing a rectangular 10/5MHz signal through a Blackman FIR filter. Although the spectrum is satisfactory, it is necessary to compensate for TP cable characteristics, so the reshaping mentioned at the end of [paragraph 1](#) is also applied.

## References

---

-  [Excel sheet for experiments with harmonics filtering](#)
-  [Excel sheet for experiments with a Hamming FIR filter](#)
-  [Excel sheet for experiments with a Blackman FIR filter](#)
-  [Excel sheet for experiments with cable capacity](#)
-  [The Scientist and Engineer's Guide to Digital Signal Processing, Second Edition](#)
-  Dr. Ing. Hans-Jochen Bartsch, Handbook of Mathematical Formulas [Czech edition], Praha SNTL 1983, 832 pages.
-  [Allied Telesyn International CentreCOM Micro Transceivers AT-MX10, AT-MX20, AT210](#) (2 pg.) [\[local copy\]](#)
-  [am79C98 Twisted-Pair Ethernet Transceiver \(TPEX\)](#) (22 pg.) [\[local copy\]](#)
-  [am79C100 Twisted-Pair Ethernet Transceiver Plus \(TPEX+\)](#) (24 pg.) [\[local copy\]](#)
-  [CS8900 High-Integrated ISA Ethernet Controller](#) (132 pg.) [\[local copy\]](#)
-  [CS8900A Product Data Sheet](#) (128 pg.) [\[local copy\]](#)
-  [AN073 - Magnetic Manufacturers for Networking Product Applications](#) (12 pg.) [\[local copy\]](#)
-  [LXT901/907 Universal 10BASE-T and AUI Transceivers](#) (40 pg.) [\[local copy\]](#)
-  [LXT902 Ethernet Twisted-Pair Media Attachment Ethernet Twisted-Pair Media Attachment Unit](#) (40 pg.) [\[local copy\]](#)
-  [LXT908 Universal 3.3V 10BASE-T and AUI Transceiver](#) (40 pg.) [\[local copy\]](#)
-  [MTD213 Ethernet Interface Adapter](#) (12 pg.) [\[local copy\]](#)
-  [MTD214 Ethernet Encoder/decoder and 10BaseT Transceiver with](#)

[Built-in Waveform Shaper](#) (11 pg.) [\[local copy\]](#)



[MTD907 Ethernet Encoder/decoder and 10BaseT Transceiver with Built-in Waveform Shaper](#) (14 pg.) [\[local copy\]](#)



[10BaseT Network Components, with filter](#) (6 pg.) [\[local copy\]](#)



[10BaseT Network Components, without filter](#) (4 pg.) [\[local copy\]](#)



[LAN Isolation Transformer Catalog](#) (10 pg.) [\[local copy\]](#)



[16PT-xx YCL 10 Base T Coupling Transformers](#) (3 pg.) [\[local copy\]](#)

---

[Web51 description](#) [News](#) [FAQ](#) [ORDER FORM](#) [DOWNLOAD](#) [Links](#)

---



---

(c)Copyright 2000 - 2002, HW server & Radek Benedikt  
[Web51@HW.cz](mailto:Web51@HW.cz), [Web51.HW.cz](http://Web51.HW.cz)

