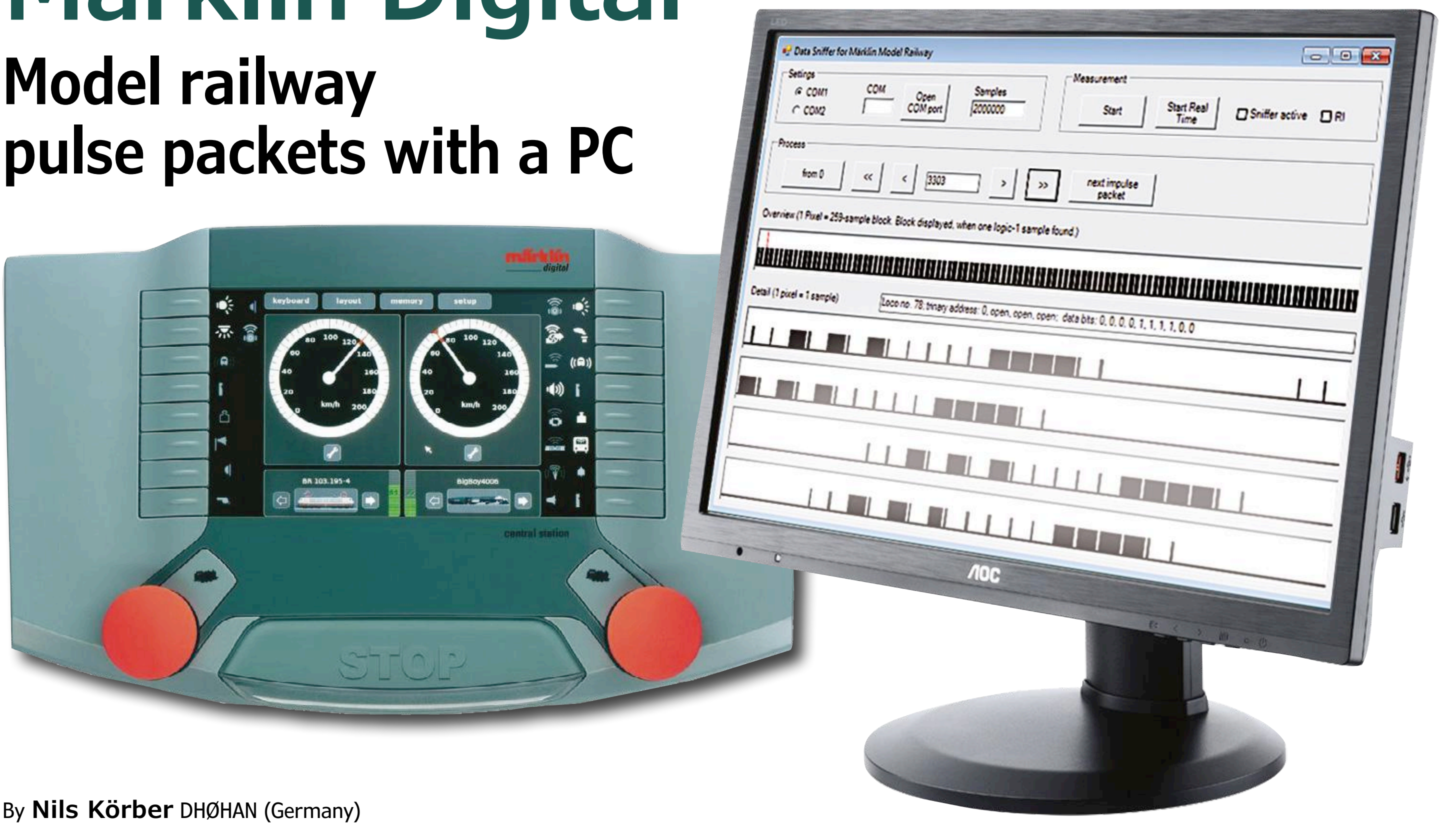
Datasniffer 2.0 for Märklin Digital

Model railway pulse packets with a PC



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It doesn't matter if they are generated by a DELTA-Control, Control Unit, Digital Railrunner, EEDTS-Pro or some other model railway controller, at the rails, all control signals in 'Motorola format' look pretty much alike. For testing and tracking down errors it helps if you can see these digital pulses live on a PC screen. In fact what you need is a Data Sniffer!

Those of you with a good memory may recognize the above header. The Data Sniffer (or Data Monitor) was first introduced in the May 2002 edition of Elektor. Thirteen years on, te software for that project is no longer compatible with the operating systems used on modern PCs. Welcome to the update!

Some background and the concept

The control protocol used by Märklin digital model train controllers has already been pretty well covered (in the Elektor May 1999 edition for example) so there's no need to go over the theory in detail and we will just concern ourselves with the basics: The data is transmitted in the form of pulse packets which contain 18 individual pulses or 9 pulse pairs. The signal voltage levels on the rails are approximately −15 V and +15 V, the exact levels are dependent on the type of control unit you are using and the loading on the system which is dependant on the number of connected units.

Depending on circumstances a single pulse is interpreted as a bit while a pulse pair is interpreted as a 'trit' (trinary bit). Their logic value corresponds to the mark/space ratio of the pulses i.e. their pulse width. A typical data stream seen on the rails consists of bits and trits, for example:

Bit '0'
6 µs at +15 V, 182 µs at -15 V

Bit '1'
182 µs at +15 V, 26 µs at -15 V

Trit '0'
26 µs at +15 V, 182 µs at −15 V
26 µs at +15 V, 182 µs at −15 V

Trit '1'
182 µs at +15 V, 26 µs at –15 V
182 µs at +15 V, 26 µs at –15 V

Trit 'open'
182 µs at +15 V, 26 µs at –15 V
26 µs at +15 V, 182 µs at –15 V

In old Motorola format a complete pulse packet is made up of four trits which defines the locomotive address, one trit for the function and four trits for engine speed and direction of travel. The new Motorola format replaces the last four trits by eight bits giving information for speed, direction and four functions f1, f2, f3 and f4. The pulse packet therefore still retains the same length i.e. approximately 3.75 ms.

For the Data Sniffer to read the signal present on the rails from the digital train controller requires a level shifter circuit to reduce the signal level before it can be connected to the PC's serial interface. The data sniffer program samples the input signal at quite a high sample rate and stores the results during the measurement window which lasts for a few seconds. At the end of the measurement window the measured states are evaluated and then shown in detail on the PC display.

The measurement accuracy is dependant on the speed and consistency of the sampling rate. Here we must take into account some limitations (read more on this in 'Software'). Assuming we have a constant sampling rate we need to sample the waveform twice within the shortest pulse width of 26 µs to be sure that it has been detected. This gives us a minimum sampling rate of around 83.5 kHz. This rate should be achievable with a fairly up to date PC even with Windows running. The author's PC uses an Intel Pentium clocked at 2 GHz which, under Windows 7 is able to achieve a sample rate of 160 kHz. PCs with higher specs will get even better rates and more reliable measurements.

The Hardware: one voltage divider

The control signals present on the rails are input to the PC via the serial interface port. The signal level can be in excess of 15 V so we use a simple voltage divider network (**Figure 1**) consisting of just two resistors valued at 4.7 kΩ. This reduces the signal levels so that they are compatible with the RS232C/V.28 standard.
For the serial interface the RI (Ring Indicator) and GND (Ground) connections are used. On a 25-way sub-D connector RI is connected to pin 22 and GND to Pin 7, for a 9-way sub-D-connector RI connects to pin 9 and GND to pin 5. The two-wire cable to the PC can be relatively long without causing any problems it is only important to observe the correct polarity of the two wires. On Märklin layouts the 'B' connection goes to the middle rail.

Note that with the PC connected, the power supply to the rails is no longer floating but is earthed via the GND connection at the PC. If this arrangement is not compatible with other circuitry you have installed on your layout it will be necessary to use a mains isolator with them in order to isolate them for the power controller.

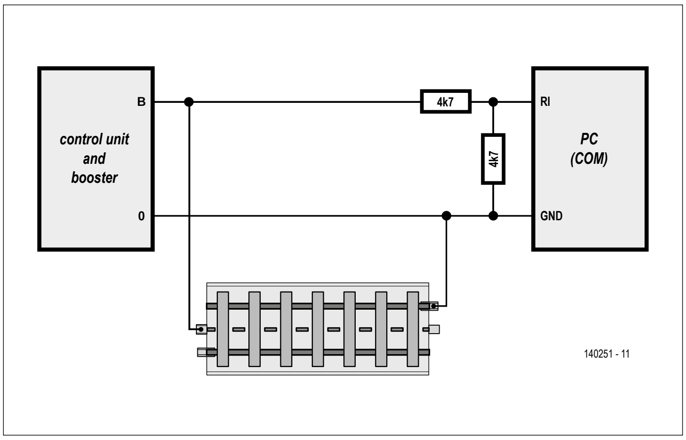

Figure 1. The train controller and PC working together.

Software

The Data Sniffer program 2.0 was written using the free Microsoft Visual Basic 2008 Express. The Dynamic Link Library RSCOM.dll was used to provide access to the serial interface. It was written by Burkhard Kainka whose name regular readers will recognize. It can also be downloaded for free from the Internet.

The user interface

The user interface shown in **Figure 2** is divided into five areas:

• Settings
When the port COM2 or COM1 is available the Data Sniffer will automatically select the port at start up. Alternatively you can use the *Open COM port* button to select the port. The number of samples used for the measurement can be defined here.

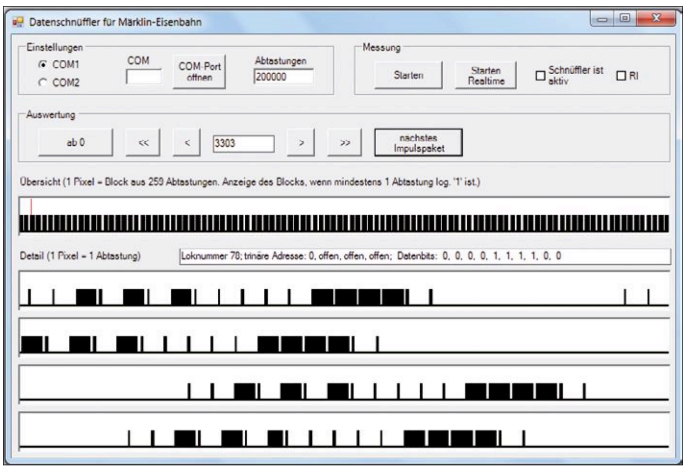

Figure 2. The Data Sniffer program user interface.

Measurement accuracy stands or falls on the sampling rate

• Measurement
The *Start* button begins measurement. The *Start Real Time* also begins a measurement but this time the activity of other Windows processes are suppressed by masking their interrupts so that the measurement accuracy is improved with a more consistent sample rate. While the measurement is active the *Sniffer Active* box will display a tick. Between measurements the state of the RI input is sampled and displayed in the RI field.

• Process
The buttons available in this area control the detailed data display region. The number of the displayed packet is also shown here. A special feature is the *next pulse packet* button: This button positions the detail window over the next pulse packet (actually, just before it) and evaluates the information contained therein. The results are displayed as text in the Detail window above.
• Overview
The complete measurement is shown here with samples arranged in blocks. A block will be displayed when a 1 (corresponding to a 15 V level) is detected in the block. In addition a red cursor shows where the section shown in detail begins.

• Detail
The Detail display in the lower half of the display shows the sampled data values in four contiguous windows. The first displayed sample can be selected using buttons in the 'Process' field. There are always 3088 samples displayed.
Figure 2 shows a pulse packet in old Motorola-Format for Locomotive number 78. The data bits shown 0000111100 or data trits 00110 indicate that *function* is off and the *speed* value is *6*. In this case the displayed region begins with sample 3303 from a total of 200,000 samples.

Features and system requirements

In order to get reliable measurements it will be necessary to select the *Start Realtime* option. This will mask disturbances from other Windows processes. During the time that measurements are made it is advisable to avoid other interactions with the PC also, such as moving the mouse.

The Data Sniffer program is available as a complete VB2008 setup. This means that there is no need to install Visual Basic in the PC; all you will need is Microsoft .NET-Framework which comes pre-installed in most modern computers. You will need RSCOM.dll [3], which you can store in the Data Sniffer folder or in your computer's Windows system folder (i.e. C:\Windows\System32). The DLL registration will usually be taken care of in the background but sometimes it will be necessary to register it manually.

Should you want to take a closer look at the program or make changes if necessary you can install Visual Basic 2008 Express Edition or higher and open the VB2008 project.
The source code and compiled program of the Data Sniffer are available for free download from Elektor's web site [4].
The Data Sniffer requires a PC with a free serial interface port, preferably COM1 or COM2. Alternatively you can use a standard 'USB 2.0 to RS232 serial' adapter cable of which there are numerous examples available on a popular online auction site for less than five Euros. A computer with a built-in serial interface has the advantage of a higher data sampling rate.
The system is compatible with Microsoft Windows XP, Vista, 7 or 8.

NB: Supply power for the model engines can either be floating (no connection to ground potential) or grounded via one of the outside rails (not the center rail!). ⏮

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Web Links & Literature:

[1] Data Monitor for Märklin Model Railway Systems, Elektor May 2002

[2] Digital Control for Model Trains, Elektor May 1999

[3] RSCOM.dll: www.elektronik-labor.com/RS232/RSCOM.zip

[4] www.elektormagazine.com/140251

[5] The author's homepage: www.koerber-home.de