Miracast Codec Timing
Application Note

Products:

- R&S®RTO
- R&S®RTE
- R&S®RTM2000
- R&S®HMO1002
- R&S®FSW
- R&S®FSV
- R&S®FSVR
- R&S®FSL
- R&S®FSC
- R&S®VTC
- R&S®VTE

This application note describes the configuration of a Miracast wireless video transmission system and how to measure the delay times between a smart phone or tablet (source) and a television / monitor (sink) display. The accompanying software for Windows 7/8/10, Mac OS X and MATLAB additionally allows to measure the delay until the video signal is transmitted over the air and optionally until it is available on the HDMI cable of an external Miracast receiver.

Note:

Please find the most up-to-date document on our homepage http://www.rohde-schwarz.com/appnote/1MA250.

This document is complemented by software. The software may be updated even if the version of the document remains unchanged

Application Note
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10.2015 – 1MA250_2e

ROHDE&SCHWARZ

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1 Introduction

High resolution video processing and replay has recently become available in smaller screen devices such as smart phones and tablets. The increasing demand for wireless video transmission to larger monitor and TV screens for presentations, video playback and especially gaming requires minimal delay time between the source device and the target display. The Miracast standard defined by the WiFi Alliance is used for demonstrating the measurement method introduced in this paper. Since these transmission techniques consists of various components, it is important to know how much each one of them influences the total delay time. This application note describes how to measure the delay of various stages in a Miracast transmission system manually and also automatically via an application software with this note.

The following abbreviations are used for the R&S® test equipment:

- The R&S®FSW, R&S®FSV, R&S®FSVR, R&S®FSL, R&S®FSC Spectrum Analyzers are referred to as FSx.
- The R&S®RTO, R&S®RTE, R&S®RTM2000 Digital Oscilloscopes are referred to as RTx.
- The R&S®HMO1002 Digital Oscilloscope is referred to as HMO1002.
- The R&S®VTE or R&S®VTC Video Analyzers are referred to as VTx.
- R&S® stands for Rohde & Schwarz GmbH & Co KG.

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2 Video over WLAN Transmission Standards

One transmission method suited for mobile phones is Miracast, a standard for wireless display defined by the WiFi Alliance. The WiFi Alliance is an association of several manufacturers for defining common requirements and ensuring platform independent communication. The specification contains all requirements that are necessary for the transmission and has been implemented in state of the art smart phones, media players, televisions and monitors.

A further transmission method is the Proprietary Standard Wireless Display by Intel, whereby a WiFi connection is made between a PC and a Wireless Display (WiDi). This additional monitor can be used to clone or expand the desktop. The measurement configuration for WiDi is the same as with Miracast and not explicitly mentioned in this application note.

The schematic of a Miracast transmission system is shown in Fig. 2-1.

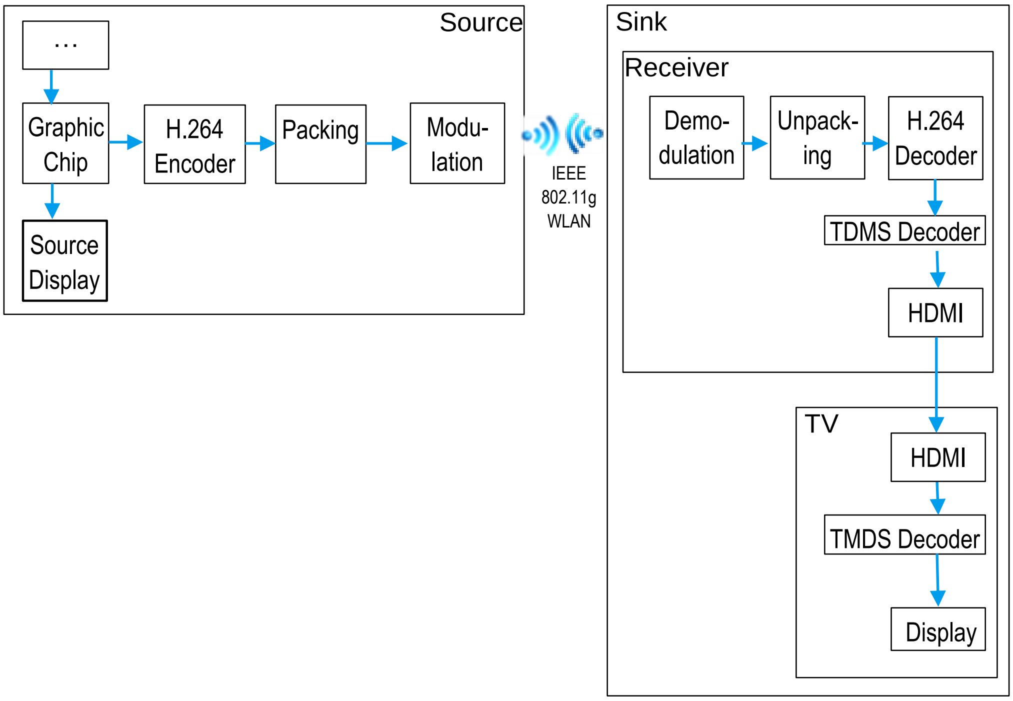

Fig. 2-1: Schematic of a Miracast video transmission system

Data is fed to a graphic chip which prepares it for the source display and also generates an image signal stream for further processing. This stream is sent to the H264 coder where the data rate of the image information is reduced. This is followed by multiple information packaging. These packets are transmitted on a 802.11 – series WLAN channel, typically via a WiFi module using OFDM. The image data stream is received at the sink’s WLAN module and unpacked in the following stage. The generated transport stream passes a H264 decoder which creates the original image content. The images are then coded by TDMS, which is the standard for transporting data via HDMI interfaces. From here the content reaches the TV monitor where it is TDMS decoded and finally displayed on the TV video panel.

The schematic does not contain all processes, such as video signal buffers between some of the stages. These buffers also contribute to the total delay.

3 Delay Measurement of Mobile Display → Transmission Path → TV Display

3.1 Measurement Configuration

This measurement configuration allows to measure the delay between the moment an image is available on the source (mobile) display, in the air and on the sink (TV) display. The measurement configuration is shown in Fig. 2-1.

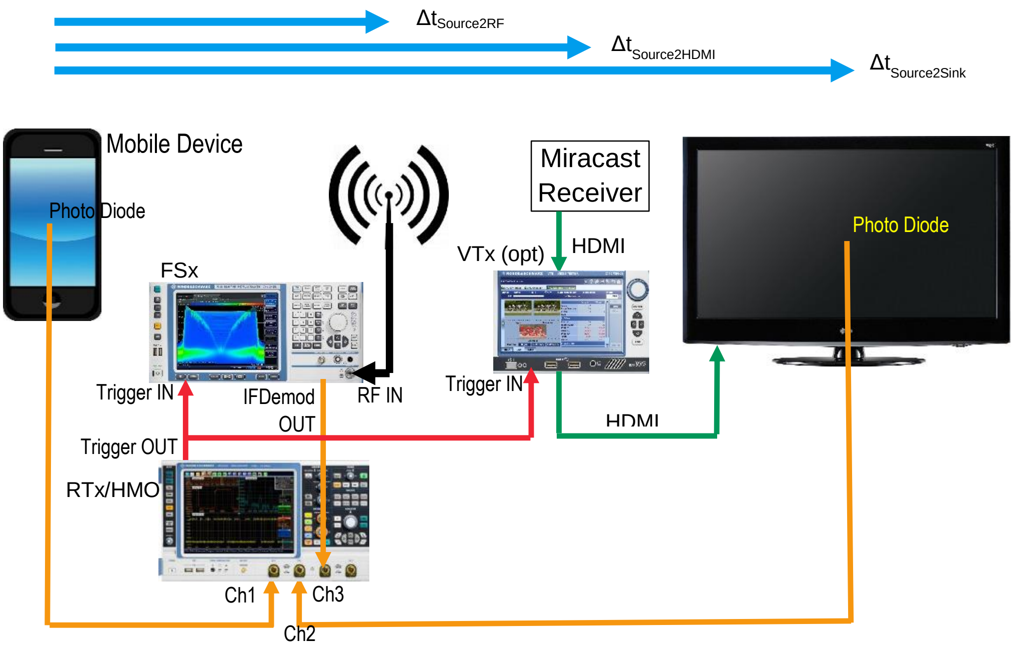

Fig. 3-1: Measurement Configuration for manual test

For this solution a smart phone with Android 4.2, Windows 8.1 and BlackBerry 10.2.1 or higher can be used. These operating systems support desktop mirroring according to the Miracast standard. In this example a mobile phone (source) connects to a Netgear Push2TV 2000 Miracast receiver which decodes the video signal and sends it to a television via High-Definition Multimedia Interface (HDMI). An optional VTx Video Analyzer can be used for determining the signal delay caused by the external Miracast receiver. There are photo diodes attached to the mobile phone and television display units which detect the frame change in the test video (see section 2.2). Any 4-channel oscilloscope e.g. RTO10x4, RTM2xx4, RTE2xx4 is desirable for manual evaluation because it can show all relevant waveforms simultaneously. Three input channels and the trigger output are needed. The delay between the rising slopes of both photo diodes is the latency of the whole system. Additionally, this measurement configuration also allows to detect frame changes in the RF signal. The spectrum analyzer (SA) is triggered by the scope's trigger output in a 500 ms (600 ms) time span before and after the trigger signal the FSx spectrum analyzer detects a change in the data rate.

Oscilloscope settings:

Horizontal Scale	= 100 ms / div
Horizontal Position	= 0 s
Vertical Scale	= 100 mV / div
Vertical Position	= -2 DIVisions
Trigger	= Normal
Trigger Source	= Channel 1
Trigger Output	= Triggered by Channel 1
Trigger Slope	= Pos. Edge
Trigger Level	= 32 mV (only for RTx)
Trigger Reference Point	= 60 %
Coupling Channel 1	= DC 50 Ω
Coupling Channel 2	= DC 50 Ω
Coupling Channel 3	= AC 50 Ω

Spectrum Analyzer settings:

Center Frequency	= e.g. 2.421 or 5.149 GHz (same as WiFi channel)
Resolution Bandwidth (RBW)	= 40MHz (measure complete channel)
Trigger Mode	= external
Trigger	= -500 ms (-600 ms with HMO)
Sweep Time	= 1 sec. (1.2 sec with HMO)
Span	= Zero Span (amplitude vs. time)

The transmitted data in 802.11g specified systems appears as bursts vs. time. With low data rates the distances between bursts are larger than with high data rates. The frame change immediately increases the transmission's data rate which can be observed on the oscilloscope by connecting the IF/Video DEMOD output (configured as video output) of the spectrum analyzer to an oscilloscope input. Now, all 3 signals can simultaneously be displayed on the oscilloscope (see Fig.3-2).

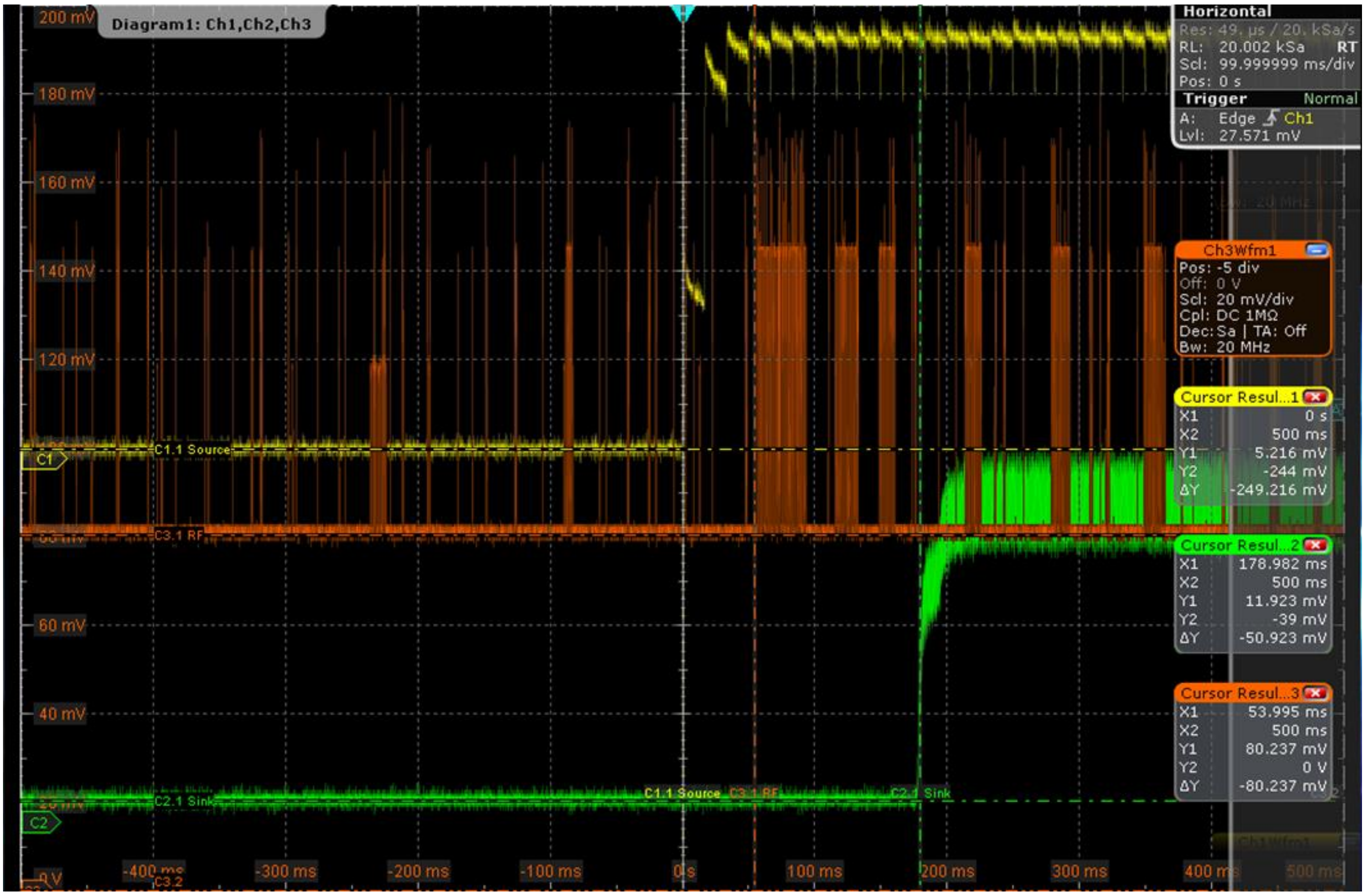

Fig. 3-2: Mobile → air → TV delay

C1.1 Source corresponds to the output of the photo diode on the smart phone display. It shows an abrupt rise of voltage level indicating a frame change.

C2.1 Sink represents the voltage of the photo diode on the TV. It is obvious from the screen shot that the signal is quite noisy. This noise is caused by the jitter of the background lighting of the TV. Despite of the noise, it is possible to detect the level rise caused by the frame change and set a marker at that point. The time difference between both slopes can be determined with the oscilloscope's cursors. In this case

Δt = C2.1_X1 – C1.1_X1 = 178.982 ms – 0 ms = 178.982 ms

C3.1 RF corresponds to the spectrum analyzer's IF output signal. It represents the data rate transmitted over the air. The moment when the peak density increases can easily be identified and measured with the C3.1_X1 cursor. The latency between source display and the RF transmission can be read directly

Δt = C3.1_X1 – C1.1_X1 = 53.995 ms – 0 ms = 53.995 ms

3.2 Video Test Signal

The transmitted test video Cut NoiseColorCW720p1_5sek.asf contains two different scenes and is 1 second long (see Fig. 3-3).

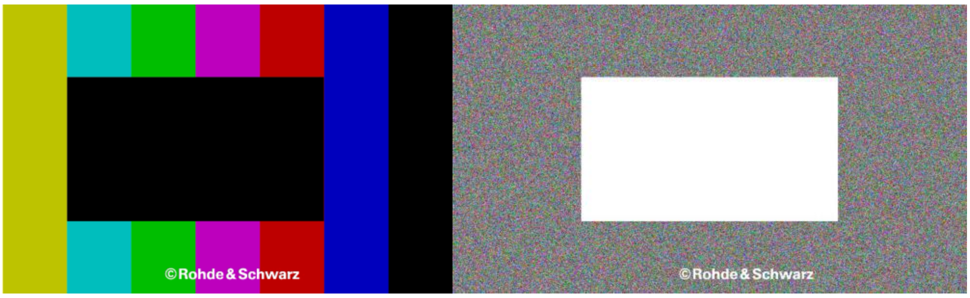

Fig. 3-3: Two different scenes of the test video

One scene is a static test picture with a black rectangle in the middle and the other is a noisy picture with white rectangle. This video is a handy tool for the delay measurements because it aids in generating the required slopes. The photo diodes mentioned in section 3.3 are directed to the rectangle. When the test frame changes from the still one with the black rectangle to the noisy one with the white rectangle, the photo diode level increases. The change from the still to the noisy frame also increases the data rate due to video compression, here H.264. Motionless scenes are transmitted with smaller data rate. The change from still picture to noisy scene results in an instantaneous increase of data rate.

The video player used on the smart phone must be capable of playing the video in an endless and seamless loop for obtaining best measurement results.

3.3 Photo Diode Schematic

The following schematic in Fig. 3-4 shows a possible photo diode circuit. The photo diode TSL 254 requires 6V voltage which can be supplied by a DC power supply or 4 AA batteries. The power supply should be of better quality to avoid additional noise. A 100 kΩ potentiometer can be used to calibrate the output voltage.

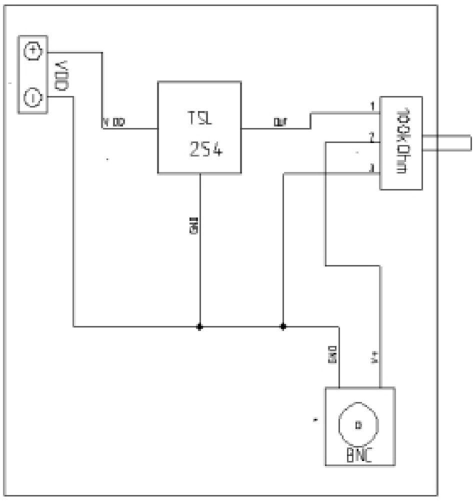

Fig. 3-4: Photo Diode Schematic

The photo diode can be fitted into a small case with felt pieces to protect the mobile device and TV screens. The light of the screen is emitted through the hole towards the photo diode.

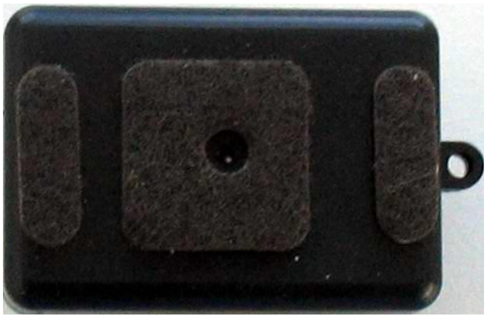

Fig. 3-5: Photo diode front casing

Fig. 3-6: Photo diode rear casing

On the rear of the casing mount a connector for the power supply and a BNC connector for the output voltage. A mounting screw for a microphone stand may also be fitted.

4 Measurement Automation

4.1 Why Automation?

It is error prone, less repeatable and more time consuming to manually configure the devices, tweak the cursor positions and document the test results. Therefore a MATLAB® script and program installers for Windows 7/8/10 and Mac OS X 10.x accompany this application note, allowing to set various device configurations, run multiple tests, display results via graphical user interface (GUI) and save them for further processing.

4.2 Performing the Measurement

4.2.1 Hardware Configuration

The hardware configuration used is nearly the same as the one in Fig. 3-1, with the difference that the demodulated RF signal can be measured directly with the spectrum analyzer, making the connection from the IF/Video-Demod output to channel 3 of the oscilloscope obsolete. In this case a 2 channel oscilloscope is sufficient.

The HDMI output of the Miracast receiver can alternatively be connected to the VTE for determining the signal delay between the mobile (source) and Miracast receiver.

Test software for various environments (Windows 7/8/10, Mac OS X 10.x, MATLAB® R2013) can be downloaded from the application note site. They run on the remote control computer which is connected to the instruments via LAN, USB or GPIB.

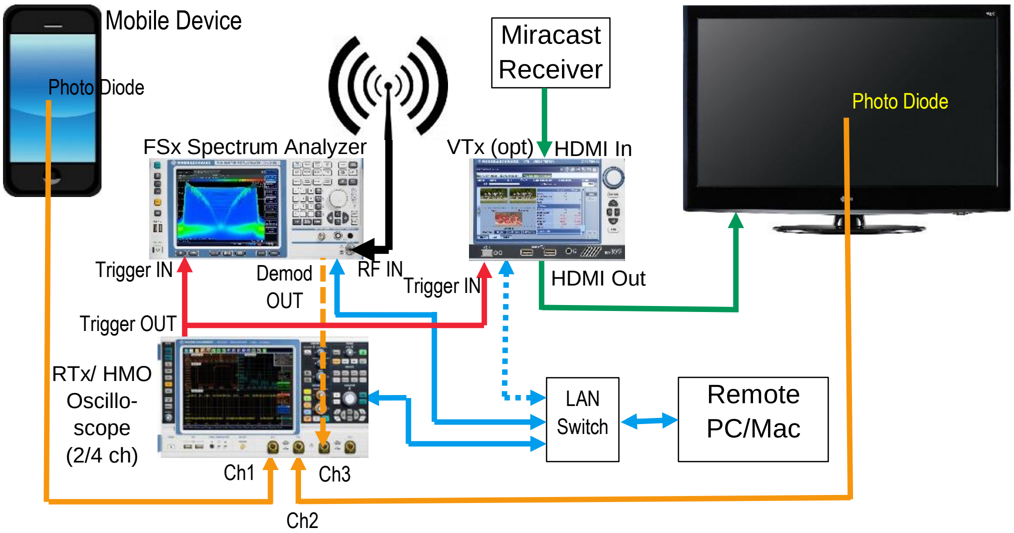

Fig. 4-1: Hardware configuration for automated tests

4.2.2 Software Configuration

For Windows 7/8/10 download and install MiracastCodecTiming_1.0.x.exe for 32-bit and MiracastCodecTiming64_1.0.x.exe for 64-bit. For Mac OS X 10.x download and install MiracastCodecTimingMc_1.0.x.dmg. These applications additionally require a current VISA runtime driver to be installed.

For the MATLAB® script unzip MiracastCodecTiming_1.0.0_Matlab.zip. It requires MATLAB® (R2013a and higher) with the Instrument Control Toolbox TMTool, a current VISA runtime driver, and the RsScope, HMO and RsSpecan VXIpnp x86 or x64 drivers to be installed.

4.2.3 MATLAB® Instrument Drivers

The *.zip file also contains MATLAB® R - instrument drivers (instr_FSX.m, instr_HMO.m, instr_RTX.m and instr_VTx.m). In case you install a future driver versions, it is necessary to generate MATLAB® R - instrument drivers by executing the command **makemid ('driver',' filename')**. Enter the VXIpnp driver name for 'driver' and any name for 'filename'. This must be performed for the FSx Spectrum Analyzer and RTx or HMO Oscilloscope and VTx Video Analyzer.

4.2.4 Running the Measurement GUI

The MATLAB® script can be started by double clicking on the Main.m file.

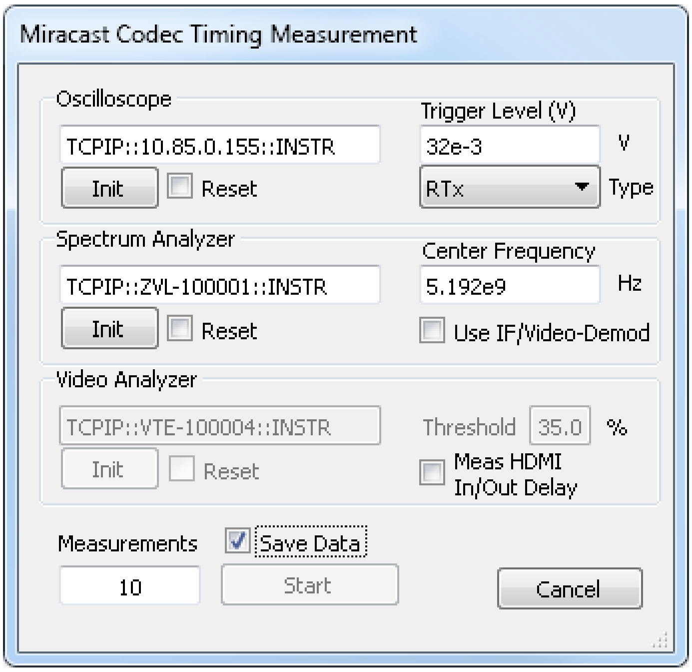

Fig. 4-2: Measurement GUI

Enter a valid **VISA RESOURCE DESCRIPTOR** in the Oscilloscope, Spectrum Analyzer and Video Analyzer edit lines, for instance TCPIP::RTO-200159::INSTR (<Interface Type>::<Instrument Name or IP address>::INSTR). The <Interface Type> can be TCPIP (LAN), GPIB0/1 (GPIB).

INIT – Resets and configures the according instrument. If **HMO1002** is selected in the oscilloscope menu and **INIT** has been pressed with **RESET** checked, it is necessary to turn ON the oscilloscope's trigger output (AUX OUT BNC connector) manually by pressing the **UTIL** button (**VERTICAL** key field) → **PAGE1/2** → **ACQ. TRIGGER EV.**

READY – Is checked, when the device is initialized and configured.

TRIGGER LEVEL – Required voltage level of the first photo diode to trigger the RTx oscilloscope (not required for HMO).

TYPE – Select **RTX** or **HMO1002** oscilloscope.

CENTER FREQUENCY – The RF frequency of the used WiFi channel, e.g..5.192 GHz.

USE IF/VIDEO-DEMOD – When checked, the demodulated RF signal is measured with the channel 3 of the oscilloscope instead of the spectrum analyzer.

MEASURE HDMI DELAY – When checked, it enables to measure the delay at the HDMI output of the Miracast Receiver (obsolete for receivers integrated in the TV) with a VTx AV analyzer. Its External Start Trigger is set to Positive Slope.

THRESHOLD – Should be set to a value between the lowest and the highest AVG. PICTURE LEVEL. In this example 22.0% ≤ Threshold ≤ 47.5%. The default value is 35.0%.

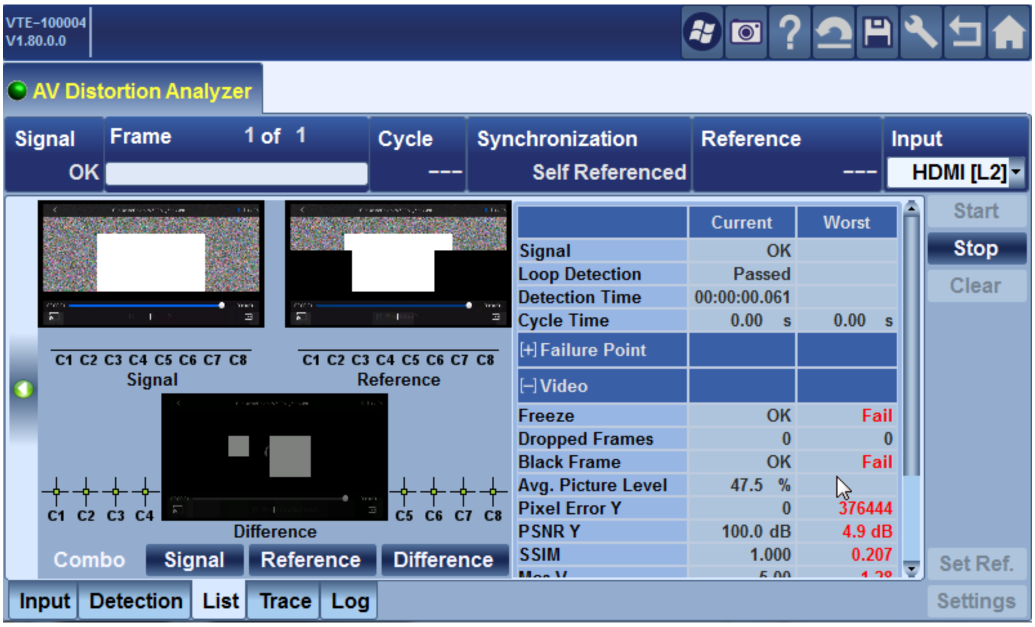

Fig. 4-3: Determine Threshold from Avg. Picture Level

SAVE DATA – Saves measured delay results in milliseconds and the 3 curves (src, rf and snk) for each measurement in double binary format . The number of samples is file size / 8.

- Gets current date & time <DateTime> = "**YYYY-MM-DD_HH-MM-SS_**"
- Saves **<DATETIME>_RESULTS.TXT** e.g. 5 measurements (in ms) with **MEAS HDMI** ON.

  Source2RF Delay: 36.6305 36.6200 37.6335 36.6295 36.6310

  Source2RF Mean: 36.8289

  Source2HD Delay: 6.124 6.201 5.999 6.350 6.110

  Source2HD Mean: 6.1565

  Source2Snk Delay: 175.746 177.104 176.500 174.692 175.223

  Source2Snk Mean: 175.853

- Saves **i** (= 5) times
  - **<DateTime>_<i>_src.bin**
  - **<DateTime>_<i>_rf.bin**
  - **<DateTime>_<i>_snk.bin**

START – Performs the delay measurements <**MEASUREMENT**> times and displays the result of the first measurement.

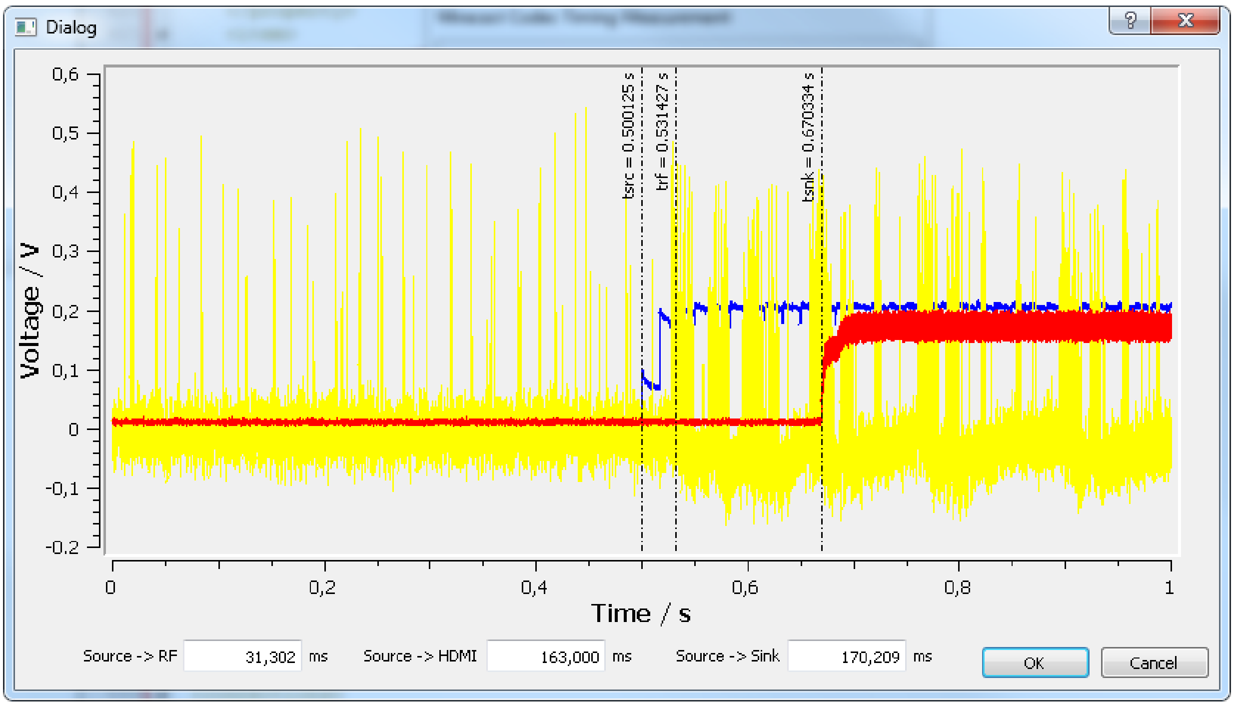

Fig. 4-4: Measurement Result Window

5 Ordering Information

Ordering Information		
Digital Oscilloscope		
R&S®RTO1002	600 MHz, 10 GSa/s, 20/40 MSa, 2 channels	1316.1000.02
R&S®RTO1004	600 MHz, 10 GSa/s, 20/80 MSa, 4 channels	1316.1000.04
R&S®RTO1012	1 GHz, 10 GSa/s, 20/40 MSa, 2 channels	1316.1000.12
R&S®RTO1014	1 GHz, 10 GSa/s, 20/80 MSa, 4 channels	1316.1000.14
R&S®RTO1022	2 GHz, 10 GSa/s, 20/40 MSa, 2 channels	1316.1000.22
R&S®RTO1024	2 GHz, 10 GSa/s, 20/80 MSa, 4 channels	1316.1000.24
R&S®RTO1044	4 GHz, 10 GSa/s, 20/80 MSa, 4 channels	1316.1000.44
R&S®RTE1022	200 MHz, 5 GSa/s, 10/20 MSa, 2 channels	1326.2000.22
R&S®RTE1024	200 MHz, 5 GSa/s, 10/40 MSa, 4 channels	1326.2000.24
R&S®RTE1032	350 MHz, 5 GSa/s, 10/20 MSa, 2 channels	1326.2000.32
R&S®RTE1034	350 MHz, 5 GSa/s, 10/40 MSa, 4 channels	1326.2000.34
R&S®RTE1052	500 MHz, 5 GSa/s, 10/20 MSa, 2 channels	1326.2000.52
R&S®RTE1054	500 MHz, 5 GSa/s, 10/40 MSa, 4 channels	1326.2000.54
R&S®RTE1102	1 GHz, 5 GSa/s, 10/20 MSa, 2 channels	1326.2000.62
R&S®RTE1104	1 GHz, 5 GSa/s, 10/40 MSa, 4 channels	1326.2000.64
R&S®RTE1152	1.5 GHz, 5 GSa/s, 10/20 MSa, 2 channels	1326.2000.72
R&S®RTE1154	1.5 GHz, 5 GSa/s, 10/40 MSa, 4 channels	1326.2000.74
R&S®RTE1202	2 GHz, 5 GSa/s, 10/20 MSa, 2 channels	1326.2000.82
R&S®RTE1204	2 GHz, 5 GSa/s, 10/40 MSa, 4 channels	1326.2000.84
R&S®RTM2022	200 MHz, 2.5/5 GSa/s, 10/20 MSa, 2 channels	5710.0999.22
R&S®RTM2024	200 MHz, 2.5/5 GSa/s, 10/20 MSa, 4 channels	5710.0999.24
R&S®RTM2032	350 MHz, 2.5/5 GSa/s, 10/20 MSa, 2 channels	5710.0999.32
R&S®RTM2034	350 MHz, 2.5/5 GSa/s, 10/20 MSa, 4 channels	5710.0999.34
R&S®RTM2052	500 MHz, 2.5/5 GSa/s, 10/20 MSa, 2 channels	5710.0999.52
R&S®RTM2054	500 MHz, 2.5/5 GSa/s, 10/20 MSa, 4 channels	5710.0999.54
R&S®HMO1002	50 MHz, 1 GSa/s, 1 MSa, 2 Channels	5800.2825.02
Spectrum Analyzer		
FSCx	9 kHz to 6 GHz	1314.3000.0x
FSLxx	9 kHz to 18 GHz	1300.2502.xx
FSVxx	10 Hz to 40 GHz	1307.9002.xx
FSVRxx	10 Hz to 40 GHz	1311.0006.xx
FSWxx	2 Hz to 67 GHz	1312.8000.xx
Video Analyzer		
R&S®VTE	Video Test Center	2115.7400.02
R&S®VTC	Video Tester	2115.7300.02
R&S®VT-B2350	MHL Analyzer/Generator Module	2115.7622.06
R&S®VT-B2360	HDMI Analyzer Module 225 MHz (optional)	2115.7616.06
R&S®VT-B2361	HDMI Analyzer Module 300 MHz (optional)	2115.7639.06
R&S®VT-B360	HDMI Generator Module (optional)	2115.7500.06

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