64-Channel
Real-Time
Transport Stream Analyzer
Controller

SW-4957

Device controller software for the
TS Analyzer

Software user guide, measurement guide
and device description
V 1.01

Contents

1. General information for using the CW-4957-type TS analyzer

The CW-4957-type 64-channel transport stream analyzer is a high-performance measuring instrument for measurements in digital television technology. The device is capable of simultaneous and continuous measurement of the characteristics in 60 IP and 4 ASI transport streams. The software used for reading out the measurement results of the device decides which features will be read out, displayed and/or stored. The manufacturer offers three options as follows:

- **Internet Interface** This Web-based User Interface (WUI) built in the device allows the computer user to read and display the measurement results either directly or via the Internet by connecting to the interface. In this mode, only a commonly used web browser software (Firefox, Internet Explorer, etc.) is required in the computer.
- **SW-4957 64-Channel Real-Time TS Analyzer Controller software** So far CableWord offered only Windows-based control software for its products. The Web-based interface in the devices of the latest generation (e.g. CW-4957) allows the users working with Linux or other operating system to communicate with the device. The SW-4957 software is designed for those who wish to use the previous years' traditions in the device. The features of the web interface and the SW-4957 are similar but not identical.
- **User-created software** CableWorld fully support those who want to write their own driver software. For creating the software the manufacturer provides the device instruction set and software source code to the user. The opportunities offered by the device are summarized in Chapter 2.

1.1. Using the Internet Interface (Web-based User Interface - WUI)

For using the Internet Interface, connect the Device Controller input of the TS Analyzer to the Ethernet output of the Internet Interface with the short UTP cable located in the box as shown in Figure 1.1.

Figure 1.1
Interconnecting the TS Analyzer and the computer via the Internet Interface

At the first installation connect the computer directly to the port of the device labeled Internet. The delivery states of the IP addresses in the units behind the connectors are as follows:

Connector	IP Address
● TS Analyzer Controller Input	**10.123.13.101**
● TS Analyzer Input	**10.123.13.102**
● Internet Interface Ethernet Output	**10.123.13.103**
● Internet Interface Internet Input	**192.168.10.10**

At the Internet connector the MAC Address is individual, can be used anywhere in the world wide web, at the other three connections the CableWorld auto MAC Address value is used. Connections to the Internet Interface can build contacts in 10 Base-T or 100 Base-T mode. At these two connectors use crossover cable for the direct connection between the computer and the connector, to the connection via switch straight cable should be used. The short UTP cable located in the box is "straight" design, in this connection the controller input of the TS Analyzer can accommodate to the cable.

After building up the links, start the installed web browser and enter that you want to join to IP address 192.168.10.10. Thereafter, the Internet Interface provides displaying the user interface of the device with TCP/IP connection. The appearing user interface provides configuring the device and displaying the measurement results. For further details you can get support through the 'Help'.

For the access to the CW-4957 type via the Internet the router at the location of the installation is to be configured to forward the incoming TCP/IP messages to the device. An example to set the router is shown in Figure 1.2. At remote access points, the (fixed) IP address at the location of the installation must be entered into the browser.

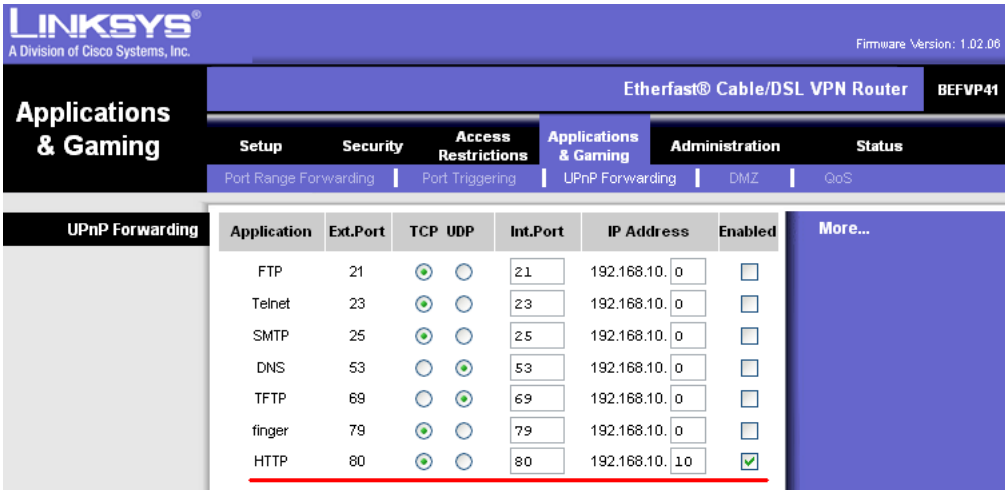


Figure 1.2

Configuring the router to reach TS analyzer via the Internet

1.2. Using the SW-4957 64-Channel Real-Time TS Analyzer Controller software

When using the SW-4957 software, connect the device control input directly with crossover cable, or through switch with straight cable to the computer. When the computer is able to build a Gigabit connection, then use a straight cable for the direct connection, too. The interconnection of the device and computer is shown in Figure 1.2. The control input is logically and physically independent from the measuring inputs. After installing, the SW-4957 software can be used normally on the system of CableWorld. The use of the software is described as divided into chapters.

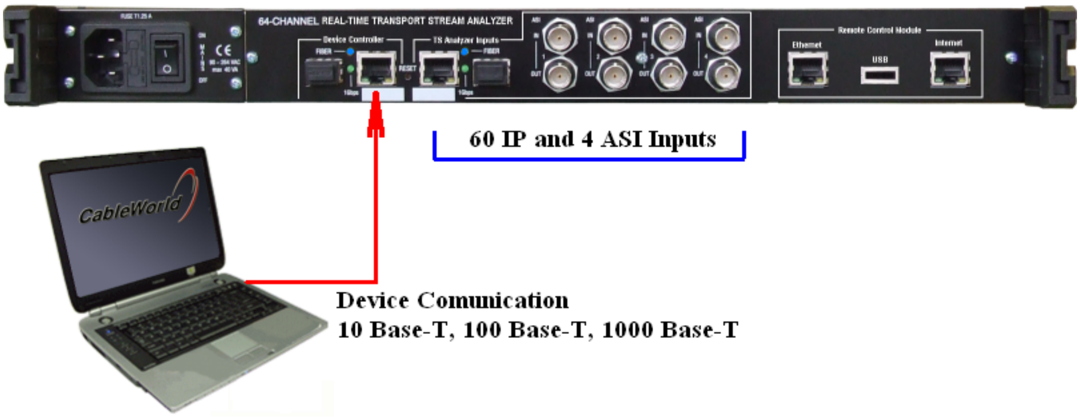


Figure 1.2
Interconnecting the device and the PC for using the SW-4957 software

1.3 The user's own software

The structure and instruction set of the CW-4957 type TS Analyzer is open, i.e. provide users with the opportunity to meet their needs by writing software. Chapter 2 describes the device's internal structure, the instruction set necessary to access the data can be downloaded from the www.bytestudio.hu website.

All products of CableWorld Ltd are of own development and constitute a uniform system. A number of descriptions can be found about using the Gigabit CW-Net system on the www.cableworld.hu web site. In the CableWorld system the software and the descriptions are available for free downloading and using. The frequently asked questions are answered on the website, video footage can be downloaded to help the use of the software.

2. The structure of the CW-4957 type 64-Channel Real-Time TS Analyzer

The CW-4957 type 64-Channel Real-Time Transport Stream Analyzer hadware comprises a large number of counter and storage circuits designed from FPGA. This fast circuits have the ability to simultaneously record 64 transport stream characteristics, but do not carry out eveluation. Evaluating the results is the task of an external processor in every version.

The Internet Interface is a built-in interface unit in the device, capable of reading out the measurement results and then transmitting them via the Internet to the user's computer. The Internet Interface builds up a TCP/IP connection to the user's computer and displays the results on the web interface (WUI) popular today. This solution has the advantage that the device anywhere in the world can be contacted, the disadvantage is that the speed the measurement results are displayed depends on the data rate of the Internet network. It is expected that the access via the Internet Interface will be the most popular access method for the users. Of course, the Internet Interface can be used to the direct connection without Internet.

When the SW-4957 software is used, the measurement results can quickly be forwarded to the user's computer via the local gigabit connection, but then the device can be accessed only from the points within the network. CableWorld tries to provide assistance through the SW-4957 software to users who wish to make their own software for performing and evaluation of the measurements. The manufacturer provides the SW-4957 software only as an additional service by the device.

The manufacturer is confident that after the discovery of the specific potential opportunities of the CW-4957 hardware, many people will undertake to write their own software to meet individual needs. For making the special user software CableWorld provides extensive technical support.

2.1. Timing in the TS Analyzer

The device's internal clock is a 64-bit counter, which is clocked at 200 MHz. At each measurement, this whole counter, or an intermediate part shows the current time. The finest resolution is 5 ns to ensure the accuracy of better than 50 ppm. The counter starts from the value 00...00, after turning on the power. The SETSYSTEMTIME instruction provides the counter operation in the same manner as the computer's clock. The Internet Interface and the SW-4957 software set the counter of the clock to the value corresponding to the milliseconds elapsed from 30 December 1899.

Since the Ethernet network and the Internet network are asynchronous, i.e. working regardless of time, the accuracy of the measurements is ensured that the current state of the internal clock is recorded with all measurement data, as well. Two 64-bit storages provide information about the time of stop and turn on of the measuring circuits.

2.2. Measuring the characteristics of the inputs

The device records the characteristics of the input signals in 64-bit counter-storage (hereafter counter only) circuits. The counters store the following characteristics:

- Number of Ethernet packets arriving at the IP input
- Number of Ethernet packets received with the Broadcast MAC Address
- Number of Ethernet packets received with the Multicast MAC Address
- Number of Ethernet packets received with the device's MAC Address
- Number of Ethernet packets in IPv4 format
- Number of Ethernet packets in IPv6 format
- Number of ARP packets
- Number of UDP/IP packets
- Number of TCP/IP packets
- Number of IGMP packets
- Number of packets in IPTV/UDP format
- Number of packets in IPTV/RTP format
- Number of RX Error events
- Number of input bytes for data rate measurement
- Number of CRC errors
- Total number of TS packets received at the ASI inputs

2.3. Measuring the input data rate and the data amount

The signals of the four ASI inputs are processed without filtering, but the packets of the IP input will be let through only if the IP Address and Port Number values match the values of a given input configuration. The counters assigned to the 64 inputs of the device indicate the number of the transport stream packets received at the given input since the start of the measurement or resetting the counters. In case of IP transmission these counters show the number of TS packets extracted from the UDP packets.

The data set read from the device shows the position of the 64-bit clock besides the state of the 64 counters. The input data rates can be calculated from the data of the data sets read at two different times (e.g. at a distance of 1 sec).

Using a larger time interval (e.g. 1 hour or 1 month) you can see, the total amount of data forwarded at the given input during this time.

2.4. Measuring the transport stream characteristics

The 64 transport streams will be analyzed first according to the PID values. The parameters are stored in the 4 × 64 = 256-bit counter group assigned to the PID values. Because in this test a very large amount of data must be treated, these counter groups are established in the SDRAM of the device. The size of the SDRAM is 128 Mbyte, the PID Analyzer occupies the first 1/8th part of this. The counters assigned to the PID values measure the following characteristics:

- Number of TS packets received with the given PID value (64 bits)
- Number of Continuity Counter errors considering the Adaptation Field (32 bits)
- Number of TS packets indicated as faulty by the Transport Error bit (16 bits)
- Number of the false sync bytes (16 bits)
- Date and time of the last error (32 bits)
- Maximum distance between two packets (32 bits)
- Indicating the packet Scrambled status (1 bit)
- Indicating the presence of the PCR (1 bit)
- Reserve indicators (2 bits)
- Reserve counter (28 bits)
- Last packet arrival time (32 bits) with this PID

When reading the status of the counters, it depends on the application software, what features of the data set will be displayed.

2.5. Measuring the Program Specific Information – PSI

In the device after the basic tests the majority of the TS packets will be discarded. The TS packets selected by programming for reading out the program specific information can be stored in a selected area of the SDRAM. For this purpose, half of the of SDRAM (64 MB) storage capacity is reserved. For each of the 64 transport streams the unit provides possibility of storing 32 TS packets each at 128 different PID values. The TS packets are stored in 256-byte blocks with 64-bit time stamps recording the arrival time. The 32-packet storages operate as FIFO systems, so always the last received 32 TS packets can be read out.

The Internet Interface and the SW-4957 software use the first part of the 128-piece memory for storing the PAT, CAT, SDT, NIT, etc. tables and the greater part for storing the PMT tables. The table contents are always evaluated and displayed on the user's computer after the read-out. The Internet Interface also forwards the TS packets to the user's PC via the TCP / IP connection.

The circuit collecting the PMT tables automatically on the basis of the PAT table data, is still under development when creating this description.

2.6. Measuring the TS packet arrival time

When transferring the transport stream over IP network most of the problems are caused by the jitter of the packet transmission. The jitter in the ASI and the IP line can be analyzed by examining the packet arrival times. The SDRAM stores the packet arrival times at the inputs in FIFO system, 8192 x 16-byte blocks for each input. In the 16-byte block the 8-byte timestamp and the first 8 bytes of packet data are stored. By the periodic data read-out the jitter of the data transmission can be represented with great accuracy.

2.7. Measuring the PCR

The PCR measurement and evaluation is a rather complicated task. The device collects the PCR data placed in the transport stream and stores them together with the time of receipt. For each of the 64 transport streams the SDRAM stores the PCR data in 128-kbyte blocks.

Each PCR data are stored with 16 bytes; the value of the PCR together with the PID and the time stamp. Always the last received 8192 PCR data can be read out from the SDRAM.

2.8. Analyzing the elementary streams

The remaining part of the SDRAM is divided into four 8-Mbyte blocks. In this stores the packets of the four selected elementary streams of the input streams can be collected. This storage system is also FIFO, the packets belonging to a given PID value are stored in 256-byte blocks together with the time stamps recording the arrival time.

These four storages provide possibility for the software for a thorough examination of the large tables (e.g. with many section NIT, EIT, etc.) as well as the characteristics of elementary streams.

2.9. Controlling the counter and measuring circuits

The clock built in the CW-4957 type analyzer starts at start-up from 00...00 value and keeps working. The current value can be modified at any time, the counter status can be adjusted to the local time. After the first power on the measuring circuits do not work, the Start Time value shows the start time of the operation. In case of saving the starting state, the device will continue to make measurements at the next power on. The Stop Time value indicates the stop of the measurement processes. The measurement processes can be stopped and then continued freely, when required.

The unit stores the measurement results only in RAM, so if the power fails, the previous values will be lost. The Internet Interface saves the measurement results set by configuration to SD card so that they will not be lost when the line voltage is off. When using other computer software (e.g. SW-4957) your computer must provide for backing up your data.

A part of the measurement circuits in the device must be programmed, the preset values can be saved. It depends on the application software if the settings are being saved. When the settings often change, backup is not practical because of the finite number of EEPROM storage write cycles (typically 100 000).

The data of the counter and measuring circuits can be deleted in small or large quantities. The possibilities to delete data depend on the software used.

The transport stream analyzer continuously processes the input signals. The process begins by examining the characteristics of the IP. This is followed by breaking down the Ethernet packets into TS packets. In the device the TS packets arriving at the IP input and the ASI inputs, get into a high speed (> 1.64 Gbps) serial packet processing unit, i.e. only one TS packet is being processed at a time. During the time of analysis the packets are stored in 256-byte sectors together with the time stamp containing the arrival time.

The filtering and breaking down of the packets and the locations of the analyses are shown in the block diagram of Figure 2.1.

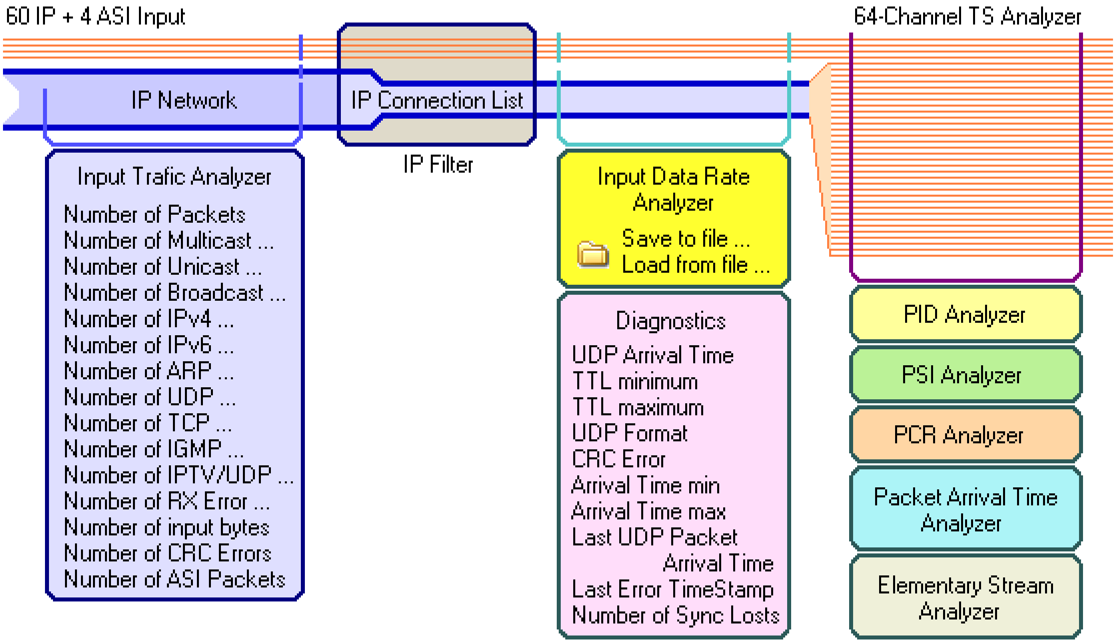


Figure 2.1
TS Analyzer measuring circuit schematic

3. Using the SW-4957 software

The installer exe of the SW-4957 type 64-Channel Real-Time TS Analyzer software can be found at the www.cableworld.eu. The software is free and can be used in Windows environment. When using Windows XP the use of the offered library is appropriate. When using Vista or Windows 7, the file writing is very limited, so if the computer is not used as an administrator, install the software to your documents.

For those who operate large systems, and work with two or more TS Analyzers, we suggest to copy the entire contents of the SW-4957 directory to produce an own directory for each device and run the exe file from there. With this solution, the settings and test results will not be mixed.

3.1. Getting started

After installation, click the icon to run the software. Click the **Configuration** line on the left menu selector, and the main controls establishing the link with the device become visible.

In the delivery state of the CW-4957 type TS analyzer, the IP address of the controller input is set to 10.123.13.101. The connection between the device and the PC via Ethernet network is correct, if crossover cable (CAT5 UTP) is used for the direct connections and straight cable for connections via switch. The connections of the modern computers can override these requirements, i.e. they may be able to interpret the modified cable wiring.

For gigabit connection a straight cable must be used, in which each of the 8 wire is connected. In most cases, users want to keep contact with several devices simultaneously, therefore the linking of the computer and the TS analyzer with straight cables through a Switch is shown in Figure 3.1. TS diagram of the king the illustrated example. For building gigabit connections for distances up to several meters the high-quality Series CAT5 UTP cable is adequate, however, for a greater distance the CAT6 cable is recommended. For professional systems the optical cable is recommended.

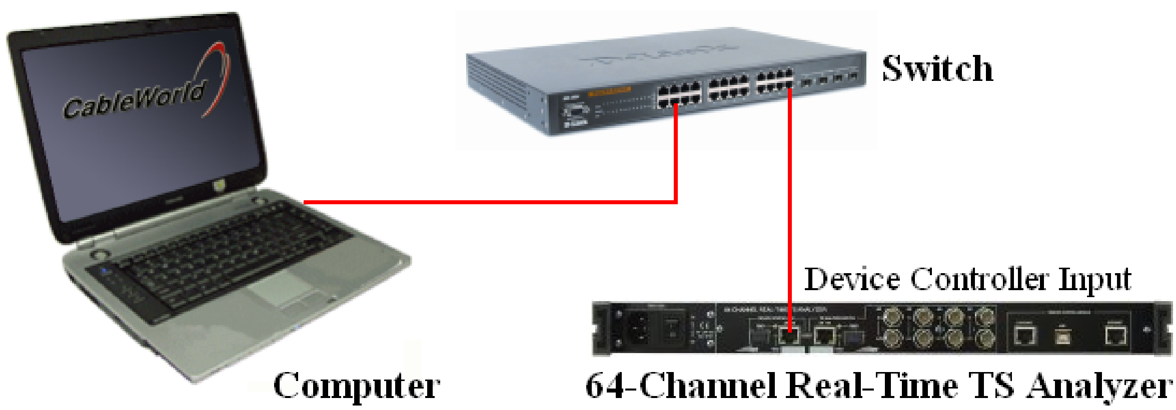


Figure 3.1

Connecting the PC and the TS Analyzer through switch

The device is ready within 1 minute after the power on, clicking the **Query** button, the software reads from the device's response the type, serial number and key settings (e.g. the IP address of the analyzer's input, the measurement is switched on, etc.). Clicking the submenus of the Configuration menu, the limited user interface will be displayed and the configuration panel (Device Settings), which is rarely needed can be made visible.

3.2. Modifying the device IP address

By clicking the **Configuration/Device Settings** menu the necessary user interface becomes visible. After entering the new IP Address the software prompts you to confirm the change. It is important to note that following the modification the device can only be achieved with the new IP address. Adjust your computer (IP Address, Netmask) and the software settings (IP Address, Use the CW-Net) to the new IP address as necessary.

3.3. Choosing the Port Number

In case of the TS analyzer the use of the Port Number differs from the solutions used in the previous CableWorld products. Transport stream can be sent to the TS Analyzer input in the full range, i.e. at each value from 0 to 65535. Transport stream must not get normally to the control inputs, only the instructions of the Internet Interface and the SW-4957 software. The SW-4957 software communicates with both inputs at Port 56947, therefore it is useful if this port will not be used for transmitting the TS. In case of the SW-4957 software the value of the Port used for communication can be modified in the SW4957a.ini file.

The analyzer unit can communicate with the user's home-made software and the Internet Interface to any Port number, however, it is useful for the communication to choose a Port number, where no TS transmission occurs.

The device can not be programmed through the analyzer input, from this input the device sends an answer only to the simplest query to verify the existence of the connection.

3.4. Default Gateway and Netmask

Setting these values is important only in highly sophisticated complex systems. If you need them, ask for help at cableworld@cableworld.hu

3.5. Device Controller Input Lock

After programming, the Device Controller input can be locked against unauthorised use. The unlocking will be made with a 16-character password. The unlocking can also be made with the rear panel Reset, but then the device loses the user's current settings and the factory default settings will be loaded.

In case of input lock the device sends a reply only to the commands Query, ARP and Ping. In case of the TS Analyzer the use of the lock function may be required only in special applications.

3.6. TS Analyzer Input Lock

The measuring input lock of the device can be set through the control input. In case of the lock of the measuring input, the device sends no reply to the Query, Ping and ARP commands. The Reset switch opens the lock of this input is, too.

In the TS analyzer applications the open measuring input condition is required if you want to examine transport streams with unicast transmission or to check remotely whether the measuring input of the device is connected to the IP network.

3.7. Reserve connection of the TS Analyzer Input and the Device Controller Input

First the device seeks to establish a connection through an optical line at both the control input and the measuring input. In the case, if that fails, it attempts to build a relationship through the UTP cable. The automatic transfer switch service also provides an opportunity to build the backup links. When both connection modes are established, in case of the break or other defect of the optical fiber, the device automatically switches to the copper connection.

3.8. Checking the link between the TS Analyzer and the PC

On the Configuration page after setting the IP address, press the Query button. When the connection between device and the computer is OK, the screen displays the device name, type and serial number, and you can see whether the measuring circuits are turned on. The answer shows the specific IP address where the analyzer input is set to.

Click the Query button on top of the user interface to send the query command to the TS analyzer input. The response received indicates that the input is connected. When the measurements are carried out in another network, no reply arrives to this query.

3.9. Setting the TS Analyzer clock

The clock in the CW-4957 type device shows the time elapsed since the power-on. Pressing the **Set Device Timer** button the SW-4957 software adjusts the TS analyzer clock to the computer clock, i.e. set the counter of the clock to the time elapsed since 30.12.1899. The Reset button resets the counter and again the time elapsed since 30/12/1899 can be seen. The Set Device Timer buttons placed on the Communication and the Device Settings pages have exactly the same effect. The software automatically adjusts the length of time while awaiting the answer 'Yes' confirming the setting.

3.10. The most important rule of using the TS Analyzer

The TS Analyzer can simultaneously perform a wide variety of measurements, however, these measurements should be prepared, i.e. the device must be programmed in advance. When using this device, the user must be always aware of the fact that, in which of the following three alternatives the adressed device operates:

- **Use as a general measuring equipment.** Getting started with the device should be initiated in this mode. This mode differs from the others only, that the device can be programmed freely. No need to fear that some test results are lost or become false of anything set incorrectly for a short or long time. The SW-4957 software usually supports this mode, because the user provided the opportunity to program the device without restriction.
- **Use as a system control/monitor equipment.** The carefully programmed TS Analyzer used with the system stores large amounts of unrepeatable test results. The program of such a device is allowed to modify with competence and due care to avoid data loss or generate confusion in the ongoing measurements. Using the SW-4957 software, the user must be careful that the intervention does not interfere with the running processes.

- **Using the device via the Internet Interface.** The Internet Interface constantly provides programming the TS Analyzer Module and saving the data periodically. Using the query mode the configuration is not possible to change, so the data can not be damaged. In the administrator mode there are limited options to change the settings, so its use is only recommended for the professional staff.

3.11. Using the Auto Query mode

The SW-4957 software is only able to carry out measurements with the device after making sure the correct communication and the measurement processes are in use in the device. The software will read this information from the reply sent the to the command Query. The query manually can start with the **Query – Read settings from Device** button. When the **Send Query automatically ...** checkbox is checked, after starting, the software will automatically query the device at the preset IP address allowing the user to begin the measurements immediately. The query results can be seen in the lower left corner of the GUI. In the event that the software starts and the device is not available (e.g. wrong IP address is set, the device is not turned on etc.) the query can be performed later by clicking Query.

3.12. Configuring the inputs

Configuring the inputs is the most important step in the TS Analyzer to operate. The data streams of the IP network can be assigned to the 60 IP inputs by loading the **IP Connection List** into the device. To edit the list, turn off the Read Only mode and then type the IP Address and Port Number values of the data streams to be analysed. The stream type can be set to **Multicast, Unicast** and **Disabled**. When giving the type the initial letter is enough to enter. In the comment column a name composed of 8 characters helps the identification of the streams.

While editing the list, press the **Compile** button often to see how the software interprets the earlier data. In the list, pressing the Enter key to create a new line is prohibited. The ASI inputs do not require configuration. The IP Connection List can be read back from the device, can be saved to a file and can be loaded from a file, too. The data can be edited in the ini-format file.

3.13. Calling the multicast streams

The TS Analyzer calls the multicast streams with IGMPv2 messages. The repetition time of the messages can be set on the Device Settings page. The proposed repetition time: IGMP Report Time = 150 to 200 sec.

3.14. Sending the unicast streams

The user has to provide sending the unicast streams. The automatic setting is supported by the device with the reply sent to the ARP message. The data necessary to manually configure can be read from the Device Settings page.

In unicast reception, if the switch cannot see the receiver for few minutes, it will transmits the stream on a broadcast basis. To eliminate this failure the TS Analyzer sends out ARP messages to the network with a programmable repetition time. The proposed repetition time: ARP Report Time = 130 to 180 sec.

3.15. Connecting the ASI input signals

The four ASI inputs do not require any configuration steps. The inputs are configured for loop-through, so the TS Analyzer can easily fit into any system without additional tools.

3.16. Measuring the characteristics of the transport streams

The use of additional units of the SW-4957 software and the measurement of the characteristics of transport streams are described in separate chapters.

4. IP Network Analyzer

The Ethernet network, or a fancy name, an IP network is capable of transporting Ethernet packets in large quantities. The design of the Ethernet packets on the physical layer is the same, but the data they deliver should always be interpreted according to the protocol used in drawing up the packets. In the network analysis both the type and number of Ethernet packets are examined.

The CW-4957 type Real-Time TS Analyzer classifies the Ethernet packets arriving at its input and then stores in 64-bit counters, how many packets of each type were received. The device stores the number of errors discovered and also the number of TS packets arriving at the ASI inputs during the test.

The SW-4957 software allows the analysis of the input data streams, recording and retrieving the characteristics over time on the following measurement pages:

- IP Network Traffic Analyzer
- Input Data Rate Analyzer
- IP Network Diagnostics

4.1. IP Network Traffic Analyzer

The IP Network Traffic Analyzer is one of the simplest page of the software, because it does not require any prior setting. The **Continue** and **Stop** buttons start and stop the measurement process. The software queries the current status of the counters built in the device in every second, and then calculates the data rate values, from the pieces between the two queries and the change in time. The graph represents the different types of data packets in packet/sec units. Below the graph the numeric value of the following features can be read:

- Actual IP input data rate, which is determined by counting the number of bytes received.
- Aggregated data rate of the four ASI inputs, which is determined from the number of TS packets received at the four inputs.
- Number of RX (reception error) errors detected at the IP input.
- Number of CRC errors detected at the IP input. The device verifies the correctness of the value of the 4-byte CRC, closing the Ethernet packet.

The ASI input data rate is determined from the numbers TS packets, so both the resolution and the size of the ± 1 digit measurement error is ± 1packet = ± 188 × 8 = 1504 bits.

The number of Ethernet packets and the input data rate are in a common database. The backups and read-backs performed on the Input Data Rate Analyzer page, also contain the data of the IP Network Traffic Analyzer.

4.2. Input Data Rate Analyzer

The continuous assessment of the 64 input data rates helps you solve a variety of errors. The Input Data Rate Analyzer module queries the state of the counters every second, and the graph shows the data rate values measured with the 1-second time gate. The measured data can be saved to file, then read back and verified later.

At using the data rate indicator click the selector on the left, to select the desired input to

be analyzed, then start the measurement by clinking the **Restart Real-Time Analyzer** button. The graph shows the instantaneous data rate continuously, and its min and max values. During the measurement you can switch to another input at any time and continue the test there. The graph can be zoomed, shifted, the measurement can be stopped, then resumed. To reset the default setting, use the **Clear** button.

When the measurement is stopped (**Stop** button), by clinking the **View Report** button the data of the 64 inputs and the IP Network Traffic Analyzer can be seen in text. The data of the text information display can be saved as a text file.

Checking the **Save to File** check box, at every 16th measurements the software adds the previous results to the **Input_DR.dat** file. The content of the file can be deleted, then a 0 size file can be found in the directory. The **Save to File** mode can be switched on and off as needed during the measurement.

Press the **View Stored Data** button, the contents of the **Input_DR.dat** file is loaded and then plotted with more than a hundredfold plotting speed. With the **Marker** and the mouse the stored data can be analyzed in detail later. When you want to plot the stored characteristics of another input, after selecting the input, the data should be loaded again. Figure 4.1 shows the measurement pages of the input characteristics.

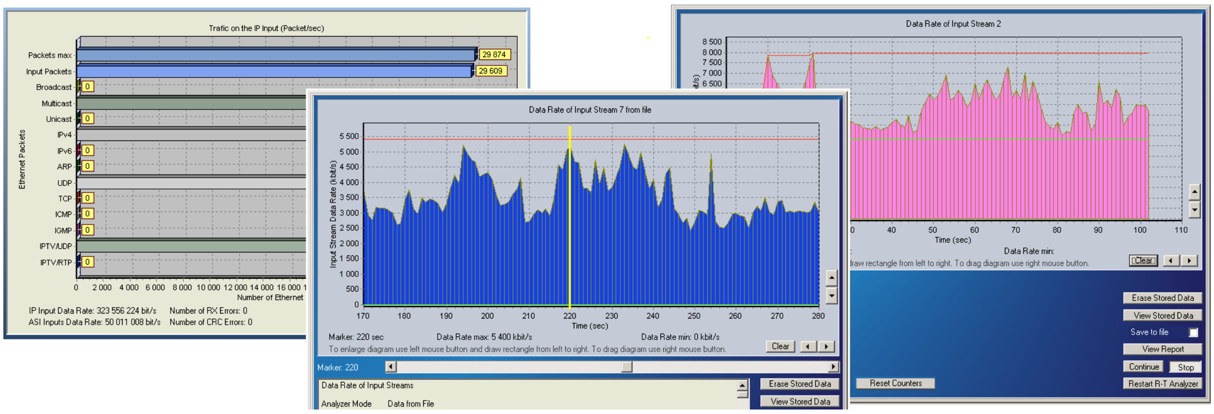


Figure 4.1
Test details of the characteristics of an IPTV system

In each case, the software uses the \IP_Anal\Input_DR.dat file for saving data. If this file is not found in the library, the data will not be saved. The amount of data tested is 1024 bytes per second, so the size of the file increases with 16 kBytes every 16th second. The software does not examine, whether the measurement happens continuously or intermittently. In the longer-term analyses the file size will significantly increase, the user must provide the file deletion by pressing the Erase Stored Data button.

To save the data stored, copy the file to your directory, then change the name to a name referring to the content. For information: the size of a 24-hour test file is 24 × 3600 × 1024 = approx. 88.5 Mbytes. At the read back the file is loaded in the computer RAM in one block, so it is advisable to divide the longer-term analyses into days. The file with the distinguished name can be loaded in using the Load Input Data Rate File from ... (*.dat) menu.

In the examination of the stored data, the text display shows the data for all the 64 inputs at the time indicated by the marker. The average speed is always calculated from the start (Start button) of the measurement, therefore, if the input signal is interrupted several times during its preparation, at the actual start of the measurement, press the Stop then the Start button and delete all the stored data. The Clear Counters button located below the graph, stops the test and clears only the counters used in the measurement. In most of the tests this is sufficient.

In the examination of the stored data, the IP Network Traffic page belonging to the time of the test is also displayed according the stored data.

4.3. IP Network Diagnostics

The IP Network Diagnostics measurement page is made for those who are interested in further information, so start more detailed examination to detect the transmission errors. Pressing the **Continue** button the computer starts a measurement cycle every 6 seconds, of which the following information will be displayed separately for each input.

- **Time to Live:** In order to ensure that IP packets do not circulate forever on the Internet by accident, a byte-sized counter is installed in the data packets. When a packet passes through a more intelligent network device (e.g. router), the device will reduce the value of the 'Time to Live' byte by one. When this counter value decreases to 0, the packet will be dropped. In large systems (e.g. telecommunications networks) in case of IP transmission, the value of the 'Time to Live' variable allows to recognize the route of the incoming data packet. The software displays the minimum and maximum values of the variable Time to Live. The products of CableWorld launch the UDP packets with a Time to Live value of 128.
- **Program Association Table - PAT:** Monitoring and indicating the presence of PAT.
- **Null Packets:** Indicating the presence of the null packets.
- **UDP Packet Format:** Displaying the format of the UDP packets.
- **Number of CRC Errors:** The errors of the 4-byte CRC closing the Ethernet packet, differ from the errors of the IP Network Traffic Analyzer, as here we can see the number of errors for each input separately, while there we could see the total number of errors.
- **Arrival Time min:** In case of continuous input signal, the minimum of the distances between the UDP packets is shown in the display. The distance is measured in ns, the resolution of the measuring circuit is ± 5 ns.
- **Arrival Time max:** The maximum value (similarly to the previous one) shows the largest measured time distance the between two UDP packets.
- **Last UDP Packet Arrival Time:** Recording the arrival time of the last UDP packet allows the very accurate measurement of the time of formation of defects and the switching of the streams, etc..
- **Last Error Time Stamp:** The measuring circuit records the time of the last synchronous error or the error in the continuity or the data transmission.

Some test results of the diagnostics page are shown in Figure 4.2. The measurement results can be saved as a text file, the measurement results can be supplemented by user comments at the end of the page.

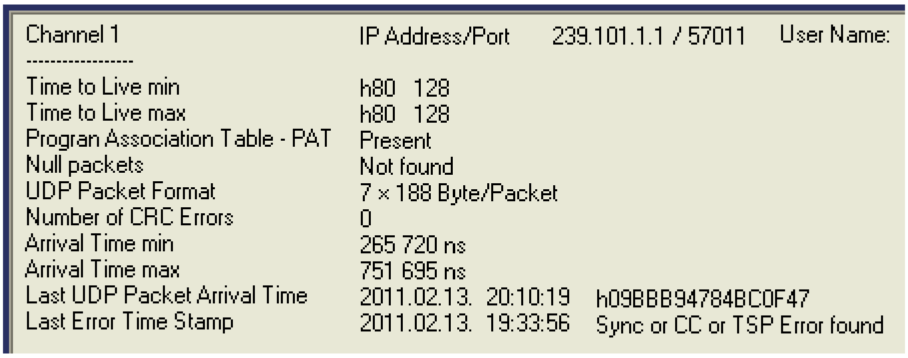


Figure 4.2
Measurement results of the IPTV stream on the IP Network Diagnostics page

In the first second of the test cycle, the software reads the status of the device counters, and then resets some of the counters. The measurement cycles are repeated every 5 seconds after the reset. Most of the data displayed (e.g. the presence of null packets, the presence of PAT, the UDP format, etc.) always show the measurement results of the last 5 seconds.

The software automatically resets some of the counters when the Auto Counter Reset checkbox is checked, depending on the measured characteristics. The automatic reset function can be turned off in case of specific tests (e.g. at observations longer than 5 seconds). By clicking the Reset Counters of Diagnostic Module button the user also can reset the counters, which are not included in the automatic reset system (e.g. the Last Error Time Stamp). The manual deletion warns the user to change the settings by stopping the measurement cycles, so the Continue button must be pressed to proceed. Following the reset, the measuring circuits start automatically, so by pressing the Continue button the user can see not the results of the last 5 seconds, but the results over the time since the reset. Using these possibilities the timed readout (Single Read) and the long-time measurements are also feasible.

The hexadecimal number shown after the value of Last UDP Packet Arrival Time is the System Time Stamp, which is multiplied by 5 shows the time in ns. The decimal data shows the same time in units of microseconds. The date is calculated from the values measured in ms by using the Windows API.

The Automatic Reset Counter process does not delete the stores of the Last UDP Packet Arrival Time and the Last Error Arrival Time.

5. Measuring the characteristics of the transport stream – PID Analyzer

After examining the input features the CW-4957 type 64-Channel Real-Time Transport Stream Analyzer breaks the data streams arriving from the 60 IP and the 4 ASI inputs down into 188-byte transport stream packets and examines them further according to the standards of the DVB system. The task of the PID (Packet Identifier) Analyzer is sorting the packets by PID and testing the sorted groups separately.

The CW-4957 type TS analyzer stores the information for each of the 8192 PID values in 32-byte buffers belonging to the PIDs. The first 8 bytes of the buffer are used for a counter, its status indicates the number of packets have been received with this PID value so far. The following 3 1/2 bytes are also a counter which counts the Continuity Counter errors appearing with the given PID value. The half byte (4 bits) before the beginning of this counter section stores the current value of the Continuity Counter until the next packet arrives. The next two counters have only a size of 2 bytes each and count the defective packets indicated by the Transport Error Indicator bit and count the sync errors.

Four bytes store the time of the last error found with the given PID value. The time of the last error will be modified by the circuits controlling the sync byte (Sync Error), monitoring the continuity of data (Error CC) and the transmission errors (Error TSP), when necessary. The time stamp is stored in a reduced resolution, it shows the time of the errors up to two weeks ago and with 1 ms time resolution.

In the 32-byte block, 4 bytes indicate the maximum time distance between the packets arriving with the given PID value, with the display capability of between 2 weeks and 1 ms time presented previously. The CRC error counter is three and a half-bytes and the last packet arrival time of the given PID value is stored in 4 bytes.

The four flag bits built in the storage unit give the following infomation:

- Indicating the occurrence of the encrypted status, that is, information whether there were encrypted packets among the packets arriving with the given PID value – in the examined time interval – based on data read from the packet header.
- Indicating the encrypted status at the time of the examination
- Indicating the occurrence of the PCR with the given PID value
- Reserve (Transport Priority bit)

Simultaneously with the data read-out of the storage units the System Time Stamp is also read out, so that two different time reading allows for very accurate determination of the data rate.

On selecting the PID Analyzer menu item of the SW-4957 software, a text field appears on the screen. On clicking the **Refresh Channel Data Base** button, after a few seconds the data stream report of the selected channel appears in text. After the button is pressed, the software reads the channel database from the device twice about 1 second apart and will prepare the report from this. The user can supplement the report with text, and can save it in a text file. The lines selected from the clipboard (Ctrl-C), the measurement results can be copied. After repairing, the user can delete the existing number of errors; on clicking the **Erase Channel Data Base** button, the 8192 stores of 32 bits each of the channel can be deleted.

The PID analyzer displays the data only in the PID values, where the number of packets is greater than zero. The data rate is calculated from the differences of the packet numbers and times measured at two consecutive readings, so the speed of the computer and the IP network do not affect the measured value. After the data rate value expressed in kbit/s units the numbers of the different errors and the last state of the Continuity Counter are shown.

The result of the examination of the encrypted status and the indication of the presence of the PCR are entered in the second data block.

The numbers can be read in the third block of data allow the calculation of special characteristics (e.g. amount of data transmitted). The last packet arrival time helps uncover the location and time of the error.

Displaying the last error time helps the repair processes. Measuring the maximum time distance between packets gets an important role in detecting intermittent transmission errors during the IP transmission.

Consider changing the channel number you want, do not forget to update the data. After reading the database, the software reads the times from the device, which may be necessary for the various calculations. For example, if we want to calculate how is the average data rate the packets were have received so far, then divide the number of packets by the (length of the) time interval from the Start to the current time. In this test the time interval is about 100 ms longer, since the Device Time was read out only after the read-out from the database. Absolutely accurate data are obtained when the measurement is started by pressing the Start button, and then later (even several days later) is stopped by the Stop button, and the Start-Stop Time interval is used to calculate the data rate.

Note that deleting the channel database is very useful in many cases (e.g. observing the errors), but not appropriate for all the measurements. Starting and stopping the measurements with the Start-Stop button provides high measurement accuracy, there are times when this is required, however, the operation also affects the data of the other 63 channels that are not under test in the same time. The user is to define the tasks required for the test, taking into account the tests that are in progress in the other channels of the measuring device. During installation and testing of the device, it is practical to try as many measurement procedures as possible, in order that in the case of the normal operation we can be aware of the effects of the single operations (deleting counters, deleting SDRAM, configuring the measuring circuits, etc.).

6. Analysing the Program Specific Information – PSI Analyzer

The detailed analysis of the data streams of the 64 inputs - for example, analyzing the contents of the tables – requires a very large computer. The amount of data generated during the analysis is so large that its evaluation is not simple for the user. The CW-4957 type TS Analyzer collects the packets constituting the tables in 128 packet buffers for each input.
The packet storages are 32 x 256 bytes in size and operate in ring-buffer mode, so allow viewing always the 32 last received packets. Besides the 188-byte packet data, the packet arrival time is also stored, so the table repetition time, the order of releasing the tables, etc., can be clearly observed, as well. The packets to be stored in the 128 buffers can be filtered by PID and also by the value of the Table Id or the Service Id. The SW-4957 software uses these options as follows:

6.1. Configuring the PSI Analyzer

Configuring the 128 units manually, it would be a difficult and laborious task, so first of all, the software offers the possibility of the automatic configuration. In the absence of the input signal, the first eight units of the 128 storage units are set to collect the PAT, CAT, NIT-actual, SDT-actual, BAT, TDT-TOT, EIT, MIP. Clicking the auto configuration button the software reads the PAT table and sets the following storages to collect the PMTs included. The storage units from 119 to 128 are programmed to collect less frequently used tables, but if the number of PMTs is greater than 110, they will be overwritten.

In normal applications, first configure the inputs (Load IP Connection List) and then actually connect the input signals. After starting the measurements with the start button, entering the **PSI Analyzer Configuration** page gives the opportunity to configure the PSI Analyzer. The **Load Channel Configuration** button of the PSI Analyzer Programmer can be used for configuring just the selected channel, the **Load Ch 1...64 Configuration** button is for configuring all the 64 channels in series (the time required for configuration is about 1 min). Both configuration processes are designed not to disturb the other ongoing measurements (the counters and the storage will not be erased).

The best solution is to press the **One Touch Device Configuration** button, as in this case the software automatically deletes the storages, collects the PAT samples and restarts the measurement processes. The current PSI configuration can be displayed by clicking the **View PSI Analyzer Configuration** button (the configuration can not be read out of the device, the displayed setting shows the data stored in the computer).

In the absence of input signal or with measurements stopped the PSI Analyzer can not be configured automatically! The Edit menu provides options to configure manually.

6.2. Displaying the components of the transport stream, plotting the TS Tree

The graphic form displaying the program-specific information is plotting the components of the transport stream in a tree structure, so most users want to see it first. Entering the common page of the **PSI Configuration - TS Tree**, select the input to be analysed first (if you have not already done so, configure the PSI Analyzer) and then press the **Refresh PSI Analyzer Packets** button. As a result, the software reads the packets in the 128 stores of the PSI Analyzer and then plots the structure of the TS.

Since the 128 storages opreate in ring buffer mode - that is always show the last 32 packets of the table - a false picture can be obtained if the content of the transport stream has changed in the meantime (for example, some tables are disabled). To get the latest data, delete the data of the 128 stores and then ask for the update. Following the deletion, it must be taken into account that some tables are rarely repeated, i.e., reading immediately after the deletion, it is not sure that there is already a new table in the storage. As an example, the NIT table is transmitted every 5 to 10 seconds, or the TDT-TOT tables are transmitted around every 30 to 60 seconds. In a well-functioning system these problems do not occur, after the update always the tree structure of the real state can be seen.

Alternating the analyzer pages the TS Tree helps the user's job, that it is never updated automatically, it helps study the details by keeping the version opened by the user. The **Table Packet Analyzer** page and the **Table Section Analyzer** page make it possible to study the data of the TS Tree down to the smallest details.

6.3. Displaying the packets of the tables – Table Packet Analyzer

As we have seen, the program specific information can be analyzed by reading 128 × 32 TS packets from the TS Analyzer for each input. In practice, there is a number of tasks, where in addition to displaying the tree structure, the byte-level analysis of the information-bearing packets or monitoring the data arrival of the packets become necessary. The Table Packet Analyzer is an opportunity to analyse this 128×32 packets in detail.

Using the Table Packet Analyzer assumes that the configuration of the PSI Analyzer has already been done when viewing the TS Tree. If not, go back and configure the PSI Analyzer.

Clicking the **Refresh PSI Analyzer Packets** button, all the data of the 128×32 storage will be read and the data packets will be represented according to the format used last. The **View Packets of Sample** button shows the contents of the 128×32 storage without any selection.

Clicking the View PAT, CAT, SDT, NIT Actual, etc., buttons the selector shows only the selected packets, the rest is not visible. In the case of the PMT, by entering the serial number of the table, one may jump to the desired packets . The serial number is the same as the serial number in the PAT.

In Extended PSI Analyzer Mode the packets of the less frequently used tables (SDT Other, NIT Other, etc.) can be displayed on the screen.

With the Data and Packet Format controls the format to display the bytes (hexa-decimal, decimal, character) can be set and the data of the packets can be distinguished with colors. Distinguishing the header, section, etc. by colors, especially helps the data analysis of the larger, more complex tables.

The time data next to the packets show the arrival times of the packets compared to the first packet arrival time. The first packet arrival time is the Time Base date, which is readable in date format in the lower note field. Where the ms time resolution is not enough, there the arrival time after the 188^{th} byte can be used, expressed in nanoseconds.

Clicking any of the packets the PID value will be displayed automatically and the software also will show which packets arrive with this PID.

The 128×32 TS Packets collected by the PSI Analyzer can be saved into file and further analyzed with other software. At the blocks of the store, where no packet was received after the deletion, the packets will be filled only with bytes with value of h00, starting with h47.

6.4. Displaying the contents of the tables – Table Section Analyzer

Using the Table Section Analyzer assumes that the configuration of the PSI Analyzer was already completed when viewing the TS Tree. If not, go back and configure the PSI Analyzer and then after some waiting, ask for updating the database. Click one of the buttons next to the text display to select the table of which the content is to be analyzed.

The Section Analyzer analyzes the contents of the table down to the smallest details, it checks the CRC, lists the contents of the section and measures table repetition time. Asking for updating the data repeatedly, the analyzer will show the contents of the newly arrived sections. The analysis of very large databases (for example, 50 to 100 PMT tables) can take up to several seconds, wait patiently for the end of the process and do not start the new analyzing processes. The measurement results are displayed in text, can be saved in text file or copied to the clipboard to transfer to other applications.

It is also true in the case of the Section Analyzer, that if packets are not arriving with some PID value just now, asking for an analysis, the contents of packets received earlier or the random data content of the SDRAM after power on can be viewed. By deleting the packets – click Erase PSI Analyzer Packets button – it is easy to resolve this situation. When studying the TS analyzer and during the installation process, use more often the **Erase PSI Analyzer Packets** button.

Studying the measurement results of the Section Analyzer, if you do not agree with the data processing, go back to the packet analyzer and watch, from which packets the analyzer read out this result.

The table repetition time is determined from the 32-packet sample. The software looks for two identical beginnings of sections in the sample, and displays the difference of their arrival times. The correctness of the measurement can be checked manually by going back to the packet analyzer. Clicking the Section button on the Table Packet Analyzer page graphically shows the order of releasing the tables from the remultiplexers. In case of irregular packet release, different table repetition time values can be measured every time.

The PSI Analyzer database can be saved into file and loaded from file. The file contains the data read directly from the SDRAM. The file size is 1 Mbyte per channel (128 × 32 × 256). The file is great for writing and running a specific analyzing software, however, the TS Reader or similar widely used software can not process that format. For the latter software an appropriate file format can be obtained by using the 'Save TS Sample as... (*. ts)' menu. The *.ts format contains only the 188-byte packets, without the time and additional data.

The manual configuration of the PSI Analyzer is a difficult task, but it paves the way for a number of specific tests to be performed. The configuration steps: save the current settings using the 'Edit\Save PSI Channel Configuration as ...' menu, edit the created *.ini file, load back the modified settings. The code information necessary for the modification is included at the beginning of the file.

In the Create and Save Channel TS Report as ... (*.srp) menu the PSI Analyzer offers an opportunity to create a TS Report from the channel data stream, which is required to configure the remultiplexers of CableWorld. Clicking the menu, in the first step the software asks for the name of the file, then run the analyzer modules of the PSI Analyzer. In the second step, it reads the data of the PID Analyzer and as a result, it creates the TS Report to be saved.

7. TS Packet Arrival Time Analyzer

The analysis of TS packets arrival time is particularly needed for IP transmission systems, as the data transmission happens regardless of time, i.e. in asynchronous manner. The difficulty for the measurement and evaluation of arrival times stems from the fact that a very large amounts of data are to be processed simultaneously. With an average MPTS stream 20,000 to 30,000 packets arrive per second, storing and processing of these data is not straightforward.

The CW-4957's hardware is capable of collecting the arrival times correctly, even at the maximum data rate, however the continuous reading and processing of these requires a very powerful computer. The measuring circuit records the arrival time for each TS packet with accuracy of ±5 ns. The arrival time data block stored in the SDRAM is created from the 8-byte timestamp and the first 8 byte of the packet. The structure of the 16 bytes is shown in figure 7.1. The SDRAM can store up to 8192 arrival times for each input and provides the possibility of continuous measurement in ring buffer mode.

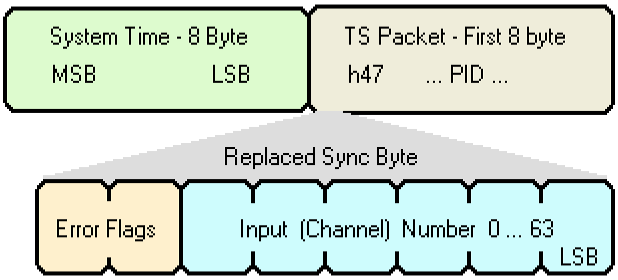


Figure 7.1
Data block structure storing the packet arrival time

The SDRAM read-out is repeated at a rate corresponding to the value of the Sampling Time set by the SW-4957 software, so it depends on the data rate of the stream, whether continuous or sampling type analysis happens. The software automatically discards the data has already been read out, so the analysis will be continuous at smaller data rates. The periodic data gaps are shown in the graphs graphically. Turning on the save into file, the data will be stored in 2-Mbyte units in the files named \ArrTime\ Atxxxxxx.dat. The serial number put in the file name will be incremented by the software automatically . The user must be especially careful that in a continuous analysis the amount of data stored is increasing very quickly and easily exceeds the value above the GByte. The saving into file should be set only if it is absolutely necessary. Sometimes it is practical to delete unnecessary files.

The evaluation of TS packet arrival times at the ASI inputs is clear, it does not require special explanation. At the IP input the 7 TS packets arrive at high speed and after arriving the CRC indicating the end of the packet the TS packets are present in the RAM simultaneously. The CW-4957 hardware shows the actual arrival time at the first packet, at the following 6 packets the value arising from the transmission speed of IP will be added to it (e.g. 188×8×1 ns = 1504 ns). In the example shown in Figure 7.2 Packet44 is the first TS packet of the UDP packet. The following 6 TS packets were received in the same UDP packet. The difference can be read is 1 to 2 microseconds and arises from rounding the value of 1.504 microseconds. The Packet51 already arrived in the following UDP, its distance from the previous UDP is 1933+2+1+2+1+2+1=1942 microseconds.

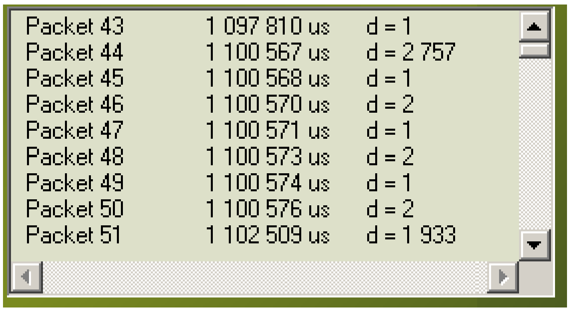


Figure 7.2
The arrival time of packets in case of 1000Base-T (detail). The arrival time shows the distance from the start of the sample, the "d" shows the distance between the two packets.

The upper graph of the TS Packet Arrival Time Analyzer illustrates a way of drawing the TS packets arriving at the same time, that the 2nd, 3rd, etc. packets are drawn in different colors over the previous ones. The details are shown in Figure 7.3.

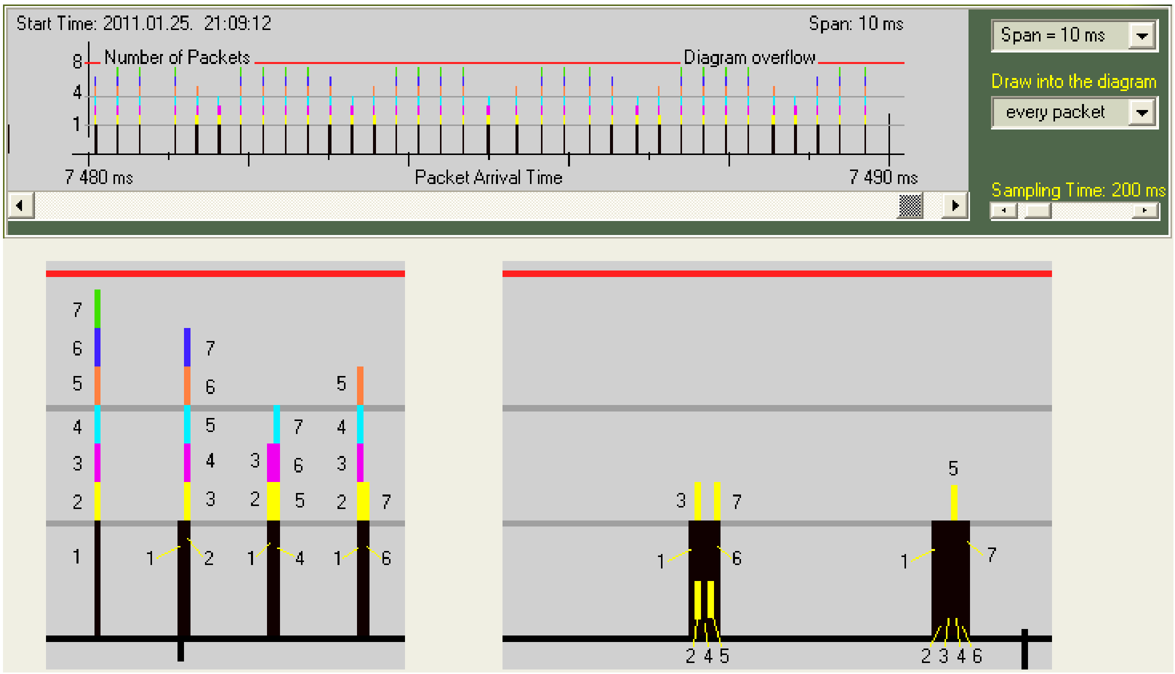


Figure 7.3
Plotting of packets, if more packets should be plotted to the same time

The drawing and the evaluation process can be simplified, if the data are rarefied and only every 7th, 10th, 100th or one thousandth arrival time data are processed. The graph illustrating the differences between TS packet arrival times is of great importance in transmission of CBR streams over the IP network , because clearly shows if the network data transmission capacity is temporarily reduced.

Displaying the arrival times in text format requires a huge computer capacity, therefore it should be turned on only at small amounts of data and manual testing. Displaying the several thousand lines even in this case requires seconds.

The graphic and text displays within the sample show only the data of the position indicated by the upper scrollbar in the range defined by the Span, so remember to modify the two parameters, if you do not see the expected patterns!

During a few hour or day test the amount of TS Packet Arrival Time data is so large that it can be evaluated only with a software written for this purpose. The best solution is, if the data are read out directly from the CW-4957 device. An acceptable solution is, if the files with compressed data written to file by the SW-4957 software are processed. The structure of the AT1.dat ... ATn.dat file used for saving the data, starting with the first byte is as follows:

- 8 bytes (LSB-MSB) – position of the next empty location (around the end of file)
- 8 bytes – Time Stamp with 5 ns resolution in LSB-MSB position
- 8 bytes – Time Stamp with 5 ns resolution but in MSB-LSB position
- 8 bytes – Reserve
- 4 bytes – The arrival time data in LSB-MSB position, up to the empty position continuously. The first sample is always a value of 0, the data are given in microseconds.

The display possibilities of the TS Packet Arrival Time Analyzer are shown in Figure 7.4, where the measurement results of the ASI input signal with data rate of permanent 38 Mbit/s are illustrated.

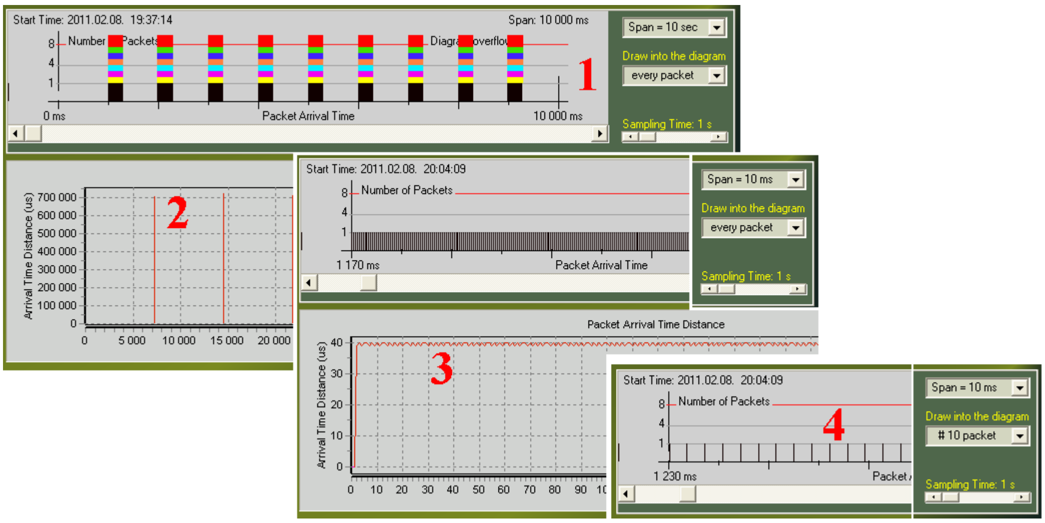


Figure 7.4
Testing the packet arrival times of ASI input signals

Explanation for evaluating the recordings in Figure 7.4:

1. The sampling rate of one second makes it possible to test the one third of the TS packets, the power of the computer used (P4/2.8), does not allow more frequent data readout and processing. The red rectangle appearing on top of the columns indicates that the overflow line has been exceeded, i.e. the presence of one or more packets is not being represented.
2. Examining the distance of the arrival times, after 8100 samples a value of 700 ms is displayed at the place where there are no data on arrival times. This peak value is periodically repeated, and if your computer can not handle this high speed, it may be even greater. This value can also increase when saving to file.
3. Magnifying the graph, i.e. reducing the test range to 10 ms (Span = 10 ms), the packets become visible one at a time and show that the distance between them is approx. 40 microseconds.
4. For the thorough analysis the spacing of the packets is also possible, if only every 10th packet is displayed. In IP transmission, displaying the data of the 7th packets would be useful, if the UDP packet contains 7 TS packets.

8. Analyzing the PCR

In the digital television systems, the transmitter side compression and the reception side recovery processes are synchronized with a 27 MHz oscillator. The task of the PCR inserted in the transport stream is to ensure the accurate tracking of the two 27 MHz oscillators. The PCR data shows the current status of the counter connected to the oscillator on the transmitter side. The oscillator frequency of the receiver side is correct, if the state of the counter connected to it, has the same value.

After rearranging the packets (e.g. remultiplexing or IP transmission) the inserted PCR data seems corrupted, because the PCR inserted in the packet gets to a new place in time, but it shows the data corresponding to its old location. On the transmitter side the accuracy of inserting the PCR is ±500 ns, defined by the standard (ISO / IEC 13818-1), in the process of remultiplexing it can be impaired to ± 25 microseconds (ISO / IEC 13818-9), without any particular problem.

The accuracy of the PCR has a prominent role when on the reception side a PAL signal must be produced, as the PCR ensures the accuracy of the PAL color subcarrier according to the standard. The significance of PCR in the purely digital systems is significantly reduced, that is several orders of magnitude higher PCR failure may be tolerated.

In the world of the PCR it is easier to navigate, if you know that in a 40 Mbps stream the transmission time of bytes is 200 ns, so shifting the PCR by one packet causes a PCR error of 188 × 200 = approx. 40 microseconds.

The CW-4957 Real-Time Transport Stream Analyzer collects the PCR data of the 64 inputs at each input in a ring buffer for storing 8192 data. The stored 16-byte data comprise the PCR value, the PID value of the packet, the state of the input packet counter and the arrival time (in 5 ns resolution).

At the time of the query the SW-4957 software reads out the data of the 8192 buffers, then sorts them according to PID. At the SPTS streams more than 8,100 PCR status can be seen, at the MPTS streams this number is shared by the PCR PID values. For example, in the case of 8 different PCR data streams, approx. 1000 PCR values belong to one stream, so with 25-ms repetition time the development of PCR is shown in a 40-second sample taken back from the sampling. In case of SPTS, the visible sample size is 320 seconds, i.e. more than 5 minutes.

The PCR data readout on clicking the **Single Read PCR ...** button is single, on clicking the **Real-Time ...** button is repeated every two seconds. On clicking the Stop button the repetitive readout can be stopped, the current data and the **PCR Analyzer Report** can be saved to files, as well.

Repetition Time: The PCR repetition time is measured with accuracy of 5 ns, but the software displays only resolution of 1 ms. The report comprises the min and max values and the average value, as well.

PCR Accuracy: The measurement of the PCR accuracy according to the method in Figure 8.1 is as follows: the software determines a data rate from the number of packets and compares the current PCR value to this. As illustrated in the figure, if the PCR2 slips 'dt' over

time, then this error appears as +dt/2 error in the first test and as -dt/2 in the second test. Since this analysis considers the steady flow of bytes, clearly shows the course of PCR data of the ASI signals and data streams stored in files. In the case of IP transmission, it can only be considered correct, if after resetting the clock can provide the same flow rate.

Note: The flow rate is determined from data of the first and the last PCR, so the final PCR error value is always 0, i.e. It lies on the horizontal axis. Because of this, in a continuous test the curve plotted in the graph moves up and down, while keeping the distance between the PCRs.

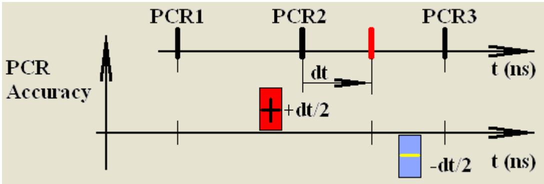


Figure 8.1
Measurement principle of PCR Accuracy

PCR Overall Jitter: At starting the PCR Overall Jitter measurement a clock will be started, which operates independently of the transport stream and the incoming PCR data will be analyzed in comparison to this. The procedure and the error interpretation is illustrated in Figure 8.2.

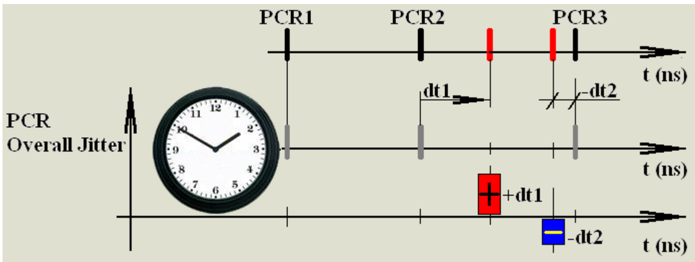


Figure 8.2
Measurement principle of PCR Overall Jitter

At measuring the Overall Jitter the speed of the original PCR clock and our clock do not match, hence the resulting curve will be steep, depending on the degree of difference. By switching on the Time Correction the difference between the clocks (which is very small) can be corrected. The PCR Overall Jitter illustrates well the characteristics of IP transmission. The three curves displayed by the software when testing the signal of the DVG test generator, are shown in Figure 8.3.

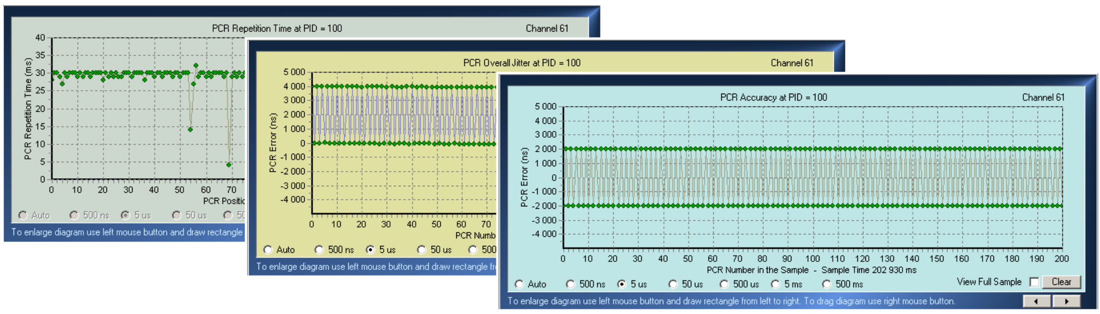


Figure 8.3
Diagrams of PCR repetition time, PCR Overall Jitter and PCR Accuracy

Common errors:

- The PCR Analyzer always scans a long time. After turning on, changing or connecting the transport stream, it takes several minutes until the several thousand samples will be collected. The current lack of data is not the fault of the device. The displayed curve always shows the events in the last minutes.
- The feature of the Ring Buffer is, that in case of interrupting or changing the stream, the SDRAM stores the final results of the measurements for a long time. The former data can be removed by deleting the SDRAM. During the test the continuous shifting of the curve to left indicates that more and more data arrive, i.e. there is input signal.
- The SW-4957 software allows shifting the continuous tests to the middle or end of the sample. The software stores the offsets, use the **Clear** button to reset the graph. Unchecking the box Full Sample, the setting is ineffective until the first **Clear**.

9. Analyzing the Elementary streams, using the TS Packet Collector

The CW-4957-type transport stream analyzer has four programmable sampling unit. Using the four sampling unit, samples can be taken from any of the 64 inputs with PID filtering or filtering off. Each sampler can store max. 2,768 TS packets (32,768×188 = 6,160,384 bytes) besides storing the arrival time simultaneously. The store can operate:

- In Start-Stop mode (the storage shuts down automatically when the unit is full).
- In Ring Buffer mode (After reaching the upper limit the storage continues at the starting address, that is always the last received 32,000 packets can be read from the storage unit).

The special feature of the four sampling unit is, that allows gathering the packets of different terms from the same input signal, as well. For example, the total TS can be collected in the storage unit of one sampler, while the packets of PID=100 and 200 can be collected in the second and third sampling units, as well.

When using the SW-4957 software, the **Packet Collector Selector** can help to set, which sampling unit you want to program or use. After selecting the unit, enter the number of the input from which the sample is to be taken, in the box named **Channel**. When the PID is given, the unit will only collect packets of that PID value. The PID filter is turned off by deleting the numbers. At PID filtering off, the inscription 'All PIDs' appears in the box. In most cases we do not need 32 thousand packets, namely much less is sufficient for the analysis. The number of packets written in the **Sample Size** box determines the amount of read outs, the collecting goes on apart from this. The data written to the boxes are processed, just after hitting the **Enter** key. The data entry fields are shown in Figure 9.1.

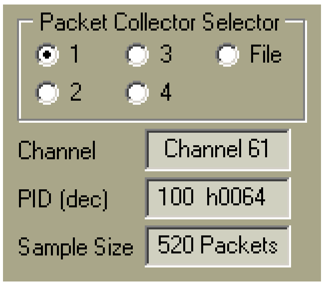


Figure 9.1
Configuration boxes of TS packet collecting

The data programmed into the device, and the mode of collecting data can be read by clicking the **Read Settings from Device** button. The total storage of the sampler can be deleted with the **Erase Selected Ring Buffer** button. Reading back the settings, affects only the state of the Start and Stop buttons, the data will be displayed in a separate box, the read-back does not change the data of Figure 9.1.

The device does not store the previous settings, the settings will be programmed by pressing one of the two Start buttons. On pressing the **Start** button, the device puts the packets from the first address of the SDRAM, then arriving at the end of the area stops collecting the packets. In this mode, the readout starts from the first address and lasts to the value specified by the Sample Size. The start of the readout will always stop collecting the packets. Repeated readings give always the same result unless you press the Start button in the meantime.

On pressing the **Start the Ring Buffer Mode** button the collection starts in the same way, but reaching the last address the storage continues at the starting address, that is, the earlier packets are overwritten again and again. During the readout the collection will be stopped and the software reads out the last received quantity of packets according to the

Sample Size. The packets read from the device will be saved in the \TSsample\Sample1(... 4).ts file. The file always contains the data of the last sample.

The TS sample is first displayed in tabular form. The byte format is adjustable. In the column before the sync bytes the arrival time of the packets can be read in units of ms. Who need more accurate data, those can find the arrival time in units of ns after the column of 188 bytes. The display mode is shown in Figure 9.2. The software saves the 8-byte time stamps (MSB ... LSB) of the arrival times in the \Tssample\Sample1(...4) file and then reads from there.

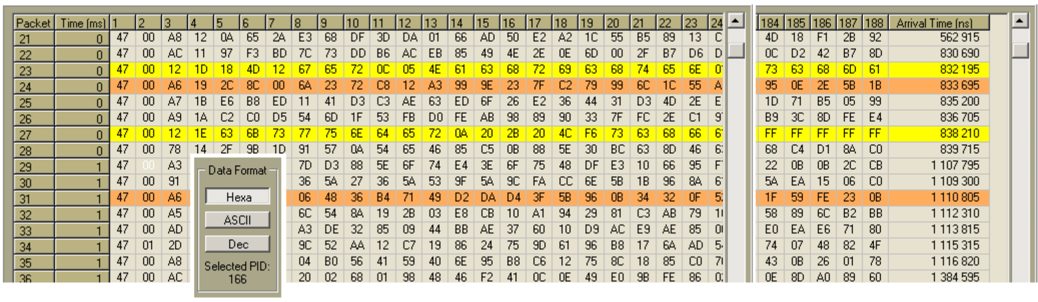


Figure 9.2

Table containing the packet arrival times

The orientation in the table data is helped by the packet selector with coloring the packets in the tables and displaying the PID value of the selected packet. The packet selector can be switched on and off by clicking the rows of the table as follows:

- Click any packets, the PID value will be displayed
- Click one of the 2nd, 3rd and 4th bytes, the related packets (where the value of the PID is the same) will be marked with the same color.
- Click the 1st byte (h47), the tables will remain marked, the marking of the related packets will be deactivated.
- Click the 5th byte and above, the color marking will be off.

The four sampling circuits of the CW TS-4957 Real-Time Analyzer allow the usual sampling of the streams and also the collection and observation of packets that appear rarely, in unexpected times. The ring buffer mode allows sampling the end of the data streams turned off or removed, that is, it is possible to view the events before the trigger time. The SDRAM contains the input number and a few bits (flag) of error occurrence in the place of the sync byte, therefore the TS Collector does not allow to study the synchronous error.

Besides viewing the sample, the SW-4957 software ensures by saving the sample to file (**Save Collected TS Packets as ... (*. ts)** menu), that the user can analyze the sample with further software also available. The previously saved sample can be loaded back using the **Load Collected TS Packets as ... (*. ts)** menu. When the software finds also the *.tst file containing the time data beside the sample, the arrival time data of the packets loaded back will also appear.

It is scheduled, that the later versions of the SW-4957 software will be extended with modules for the further analysis of the sample.

10. Measurement guide to analyzing digital television systems

The analog video signal analysis was simple. An oscilloscope was used to observe the amplitude of the sync and the luminance signal, and if it was OK (0.3 V and 0.7 V) a big mistake could not happen. In digital technology, determining the adequacy of the transport stream is not so simple task. The transport stream analyzer is capable of measuring many parameters, but the measured values become useful only if we can interpret them. In this guide we wish to help those who are already using the digital television technology, but have no skill in debugging and evaluating the features.

10.1. Characteristics of the input signals

In digital television the picture and sound data are transmitted in the transport stream. The transport stream is a sequence of bytes, which is divided into packets for transmission. The transport stream arrives at the device mostly via IP network or ASI line.

The feature of the IP network is, that via this network the transport stream does not arrive at the device input by itself. In order that the transport stream could arrive at the device input, different messages are to be sent to the network, and the data packets of the IP network should be established in accordance with the assigned protocols. Another important feature of the IP network is, that the transmission of data packets via the network is not bound to time and may suffer more or less delay here or there.

The characteristic of the ASI transmission is, that the data stream is delivered to the input of the device, if the BNC plug of the coaxial cable is connected to the device. In this transmission no delays are expected, and the data format is rarely a problem.

10.2. Analyzing the input signal arriving from the IP network

For analyzing the transport stream transmitted via IP network it should be achieved that the data stream to be analyzed could arrive at the input of the assigned device. Whether or not the computer or the CW-4957 type TS analyzer is essential to use, the test to be done is the same.

The feature of the multicast data stream is, that it can be called by multiple users. Using your computer the software and the operating system together ensure sending IGMP messages necessary to call the stream. The CW-4957 TS analyzer after loading the IP Connection List will begin calling the data streams. The device knows from this list, which data streams are to be analyzed, which data streams it should call.

A unicast data stream is sent only to one client at a time, it is not seen by other units of the network. When you want to analyze transport stream in unicast transmission, the sending side of the device is to be programmed to send the data stream to the input of the TS Analyzer. The sending station sends ARP message to the network in order to find the destination, for example the input of the TS analyzer. Everyone gets the message, but only the TS analyzer will respond to it, as it was searched in the message. With the MAC Address read from the answer the sender can achieve that only the TS Analyzer can receive the data stream from the sender afterwards.

As you can see, the analysis of data streams transmitted over an Ethernet network is quite

difficult. It is not physically possible to look into all data packets, so first the TS analyzer provides information on what data streams arrive at its input. By analyzing the input data stream the following information can be got:

- **Input data rate**: The number of bytes arriving at the input and the input data rate calculated from it, show the input load. When we see that the input load exceeds the 90% of the nominal value (e.g. 1000 Mbit/s with 1000Base-T), no longer can we be sure that sometimes there is no packet loss due to overloading. A packet loss causes the picture and sound getting stuck or the full stop of the decoders. The bit rate measured in bytes always gives accurate information on the input load. The speed measured as the number of Ethernet packets (frame rate) is useful in special tests and troubleshooting.
- **Distribution of packets according to the MAC Address:** The Ethernet packets can arrive at the TS analyzer input with multicast, unicast and broadcast MAC address. Viewing the ratio of these we can make sure that the packets arrive according to this expectation. In debugging, you can see if unnecessary packets arrive, or the required packets are not received. The arrival of redundant packets is a typical case, when due to incorrect configuration of the network the switch broadcasts a data stream.
- **IPv4/IPv6:** The current data packet format transmitted over the IP network is IPv4, the IPv6 is being implemented. The distribution shows the ratio of these. Currently the TS analyzer is able to process only data packets according to the IPv4, so the presence of those according to IPv6 is unnecessary.
- **Number of ARP packets:** The ARP (Address Resolution Protocol) messages querying the MAC Address are sent by broadcast, so they arrive at the TS Analyzer input, too. ARP messages are sent repeatedly by the source, which should send out the transport stream in unicast mode, but it does not know the MAC Address of the destination. In this case, the number of ARP messages per second can be more than one and they are repeated until the destination sends a reply to this. As an example, the user can see from this that a device should be turned on. According to the standard during unicast transmission of TS the receiver needs not send messages to the network. Major problem is that if the receiver does not send a message, then after a few minutes its MAC address will be deleted from the switch MAC table. To solve this problem in CableWorld products the receiver can be configured to send an ARP message periodically (e.g. in every one or two minutes) to indicate for the switch that it is present in the network. Monitoring the number of ARP messages can verify if this feature is turned on.
- **Number of UDP messages:** The transport stream is transmitted in UDP messages, so at the input of the TS Analyzer the UDP messages should be in significant majority.
- **Number of TCP messages:** The TCP messages must not appear at the TS Analyzer input.
- **Number of ICMP messages:** In the ICMP (Internet Control Message Protocol) messages the errors can be seen mostly. Destination Unreachable messages are displayed on the network, if the transport stream can not be delivered, for example a computer can not receive them. The products of CableWorld send no ICMP messages to the network.
- **Number of IGMP messages:** The normal multicast transmission works with the sequence of IGMP messages. The total absence of messages refers to bad settings. In correct operation a few messages per minute can be indicated, too many messages refer to incorrectly configured network devices (switches, appliances).
- **Number of IPTV/UDP messages:** In IPTV services, from the transport stream packets

we insert typically 1 to 7 TS packets into a UDP packet. The number and the number per second provides information on the UDP packages arriving in this format.

- **Number of IPTV/RTP messages:** When the RTP (Real Time Protocol) format is used, besides the TS packets the UDP packet contains additional information. The measuring circuit of this format will be developed in a later version.
- **Number of RX Error events:** In case of defective functioning of the IP network even incorrect Ethernet packets can arrive at the TS analyzer input. If it operates correctly, this number is zero, and after fixing the problem this number is no longer growing.

10.3. Analyzing the IP input signals after input filtering

By programming the IP Connection List we determine for the 60 IP inputs of the TS analyzer, at which input with what IP Address and Port Number values the arriving Ethernet data packets will be transferred. After filtering we talk about only transport stream per input; the input unit of the device reads the TS packets from the UDP packet and sends out only these. The SW-4957 software identifies the data stream arriving at the **Input 1** input as **TS 1** signal regardless of its content, and so on. The transport stream level examination provides information first about the transmission characteristics as follows:

- **Number of CRC errors:** The Ethernet packets contain 4-byte CRC closing for disclosing the transmission errors. The CRC errors in the data packets of the transport stream transmitted over the IP network give information on the quality of the IP transmission between the transmitter and receiver side. In case of faulty cables, connectors and interface circuits, the total number of CRC errors is increasing, and the number of errors detected per second is not zero. In a well-functioning system, the number of CRC errors is very low, in 10 Base-T, 100Base-T and optical transmission is typically zero. The reliability of Gigabit transmission over UTP cable is much worse than listed above, so the appearance of defects is expected mostly in the 1000Base-T connection. The Gigabit transmission over UTP cable is considered to be good from the value 1×10^{-12} BER (Bit Error Rate). The transport streams arrive typically passing through different routes of the IP network, so some of the TSs may arrive without CRC error, while others arrive with errors. The distribution of errors will help you find the location of the faulty transmission section. Note: The Ethernet packet CRC errors are not to be confused with CRC error on the PSI tables!
- **Monitoring the TTLmin and TTLmax values:** To ensure that the Ethernet packets do not circulate indefinitely in case of malfunction of the IP network, the TTL (Time To Live) variable is incorporated into the data packets with values between 0 and 255. The routers always reduce the value of the variable by one, and drop the packets with the value of TTL = 0. By watching the TTL value at the TS analyzer input we can determine whether the data packets circulated between the routers much or little before they arrived at the analyzer input. Monitoring the TTL is important only in large networks. CableWorld products launch the UDP packets with value TTL = 128.
- **Packet Format:** At UDP packet processing the TS analyzer indicates, that how many (1 to 7) TS packets are in the UDP packet. This measurement result helps to process unknown data streams (e.g. broadcasts of sports events), but sometimes also play a significant role in debugging.

- **Arrival Time:** The TS analyzer stores the arrival time of the input data packet received last. The arrival time is important for debugging. This data helps to determine, when the failure of the IP line or the sending device has been occurred.
- **Last Error Time Stamp:** The TS Analyzer watching the mistakes, also records the time of the error detected last.

10.4. Analyzing the ASI input signals

The errors of the TS packets arriving at the ASI input can only be disclosed by a more detailed examination, and there are no communication messages at the input. So when testing the ASI input signals, the TS analyzer measures only the total number of TS packets arriving at the four inputs. The measured data help to find out whether the input signals are nearly all right. The data rates of the ASI inputs measured separately can be found in the test results of the transport streams. The values of the Arrival Time and the Last Error Time Stamp can be read out at the ASI signals, too.

10.5. Analyzing the transport stream

The TS analyzer brakes the Ethernet packets down into TS packets and analyzes them formally together with the ASI input packets. In this study, you can get information as follows:

- **Sync error:** In the DVB system, each packet begins with sync byte with value h47. The number of sync errors shows in how many cases there were deviations from this value. It is very common that the signal processing devices rewrite the sync byte value, regardless of the arriving values, so the majority of sync errors arise in the transmission path. In the data stream of rate 38-Mbit/s, 38 / 8 = 4.75 Mbytes per second arrive. Calculating with 188-byte packets approx. 25000 sync bytes are received per second. At laboratory conditions, and in professional systems the daily and weekly measurement intervals are usually error-free. In the satellite and terrestrial reception a few sync error may occur daily, but the system corrects it and causes no confusion for the subscribers. Where several sync errors occur per hour, there you should look around more carefully, there is something not working correctly, there is something not configured correctly. During the IP transmission the location of the sync byte is defined within the data packet. The data packet processing circuits automatically write a value of h47 to this places, so during the IP transmission sync errors occur very rarely.
- **Sync Loss:** In the digital technology if only one or two sync errors are next to each other, the system will automatically improve. The case of 3 to 5 sync errors is already considered as sync loss, then you must restart the request for the sync byte. The sync loss typically causes the picture and sound getting stuck for a short period or stop working. In well-functioning systems sync loss typically does not occur. In satellite and terrestrial reception the atmospheric disturbances cause sync loss, but in most cases they can not be prevented. In small systems switching over the programs (e.g. relay TS switch) is almost always associated with sync loss. Since in the IP transmission the sync error is created only in special cases, it is practically impossible to meet the sync loss. With the standard structure of the data packet (e.g. 7 TS packets / UDP packet) the loss of the UDP packet causes no sync error or sync loss. As we will see, the loss of UDP packets will appear in the continuity error indicated by the Continuity Counter.

- **Continuity Counter Error:** For indicating the TS packet loss a four-bit (0 to 15) counter is incorporated in the fourth byte of the TS packet. The counter name: Continuity counter. This counter is set independently of the others by the device sending with the given PID, so the continuity or CC error always belongs to a given PID. When during the transmission (e.g. in IP network) entire TS packets are lost and sync error or sync loss is not observed, yet the displayed picture or sound will be wrong. In a normally functioning system CC error is not possible. If the data stream is interrupted by pulling out the connector, due to the uncertain breakdown of the contacts one or more CC errors occur. When plug in, errors occur again. If the data stream is interrupted once, the number of CC errors will increase only by one. In case of the CC errors the number of errors always should be examined in comparison with the former situation. If the number of errors does not change now, right now there is no packet loss. If the number of errors increased in the last hour, unknown number of packets were lost. In a TS containing more than one programs, it is possible that one of the CC program is faulty and the other is not. In case of a TS compiled from multiple sources, from the CC error it can also be concluded, where the errors occur. For example, if CC error is only in the sports program broadcast over IP, then the errors occur in the IP line. The CC errors graphically indicate the malfunction in the satellite, terrestrial receivers and the ASI lines. The special case of CC errors is the PID collision, when (with remapping operation) two streams are being forwarded to the same PID. This error is indicated by the rapid increasing of the number of CC errors.
- Data Transmission Error, TSP Error: In data stream transmitted via high-frequency modulators and demodulators errors can occur much easier, as if it would be transmitted via a copper wire. In QPSK, QAM, OFDM, etc. modulators error correction circuitry (e.g. Reed-Solomon error correction) are incorporated to correct the errors. In the event if so many errors are produced that the error correction circuitry can no longer correct them, in the second byte of the TS packet the error correction circuit sets the MSB bit to (a value of) 1. This bit's name is Transport Error Indicator and it indicates that some data may be defective in the given packet. In a well-functioning system these bits are 0, the packets are intact. In the satellite and terrestrial reception we meet this error typically at the time of large snowfall and torrential rains. In wire transfer, in case of (QAM) amp overdrive, intermodulation distortion and similar system errors we can see the TSP bit set to 1 in greater or lesser number. The steady increase in the number of errors TSP Error indicates that the bug is still there. When the number of errors is not zero, but it is not increasing, it can be concluded that there was some disturbing fact in the past.

The number of errors for the Sync Error, the CC Error and the TSP Error is important within the transport stream PID values and the transport stream as a whole. So, for the 64 input streams the CW-4957 TS Analyzer counts these errors first broken down into transport streams, and then the PID analyzer counts the same number of errors by the PID values. From the data by TS, it can be quickly determined whether a more detailed examination is needed, the fault location may often be inferred from the data by PID. The data by PID are usually used only in the debugging process.

10.6. Analyzing the transport stream by PID

The identification in the packet header (**P**acket **Id**entifier) shows, to which data stream (e.g. video, audio, etc.) the given packet belongs to. We can see from the distribution of packets by PID value, whether the required data streams are there in the transport stream. Remember, that the PID values read from the PSI tables give guidance for the receivers, but the transport stream analysis means more, we are curious about the real state. In the course of the analysis it should also be discovered, if there are secret or unnecessary packets in the transport stream. The CW-4957 TS analyzer continuously monitors all the packets arriving at the 64 inputs, and records at which input, with what PID value and possible error they arrive. The measurement results of the analysis by PID can be used in the following ways:

- **Number of packets received with the same PID:** The PID analyzer assigns one 64-bit counter to each of the 8192 PID values. The counter-zero status indicates, that no packet has been received with this PID, a number greater than zero shows the number of packets received since the power on or the reset of the counter. Simultaneously with reading out the number, we will also get the state of the internal clock, so two consecutive readouts allow you to calculate the data rate. In case of VBR streams, the instantaneous data rate depends largely on the size of the time gate (e.g. 100 ms or 1 sec), in which the measurement is carried out. The hardware allows for the implementation of the extremely short (1 ms) time gate, too. The curve plotted in the cyclical read-out provides information about the changes of data rates of the VBR streams. Service providers are increasingly interested in, whether the amount of data they have paid, actually has been transmitted in the VBR stream. From the number of packets the daily, weekly, monthly averages can be calculated exactly. The 64-bit counter counts the number of packets, so the device is able to perform the measurement correctly for a very long time interval even with HD broadcasts.
- **CC Error:** The TS level CC Error counter is 32-bit, the PID level counter is only 28-bit. The additional 4 bits always show the current status of the Continuity Counter. The PID level CC errors are very useful in the process started to find the places of the errors. Remember, that the rapid rise in the number of CC errors in most cases is due to PID collision (we send two streams – PID remapping – to the same PID values).
- **TSP Error:** The PID level TSP Error counter is 16-bit, its value is of great importance, when it is growing in the course of examination.
- **Sync Error:** The PID level Sync Error counter is 16-bit, the value is significant, when it is growing in the course of analysis or the stored number is of little value.
- **Scrambled Packet – scrambled status indicator:** In the analysis by PID, the hardware indicates with one bit, if the "Scrambled Packet" signal occurred with the given PID value. This indication is important in the analysis of deeper level.
- **Indicating the presence of PCR:** In the analysis by PID, the hardware indicates with one bit, if the PCR timestamp occurred with the given PID. This indication is important only in the analysis of deeper level.
- **Last Packet – arrival time:** The hardware stores the arrival time of the last packet for every PID. This data is important when the broadcasting breaks up or in the case of complex programs (turning on local program, starting night program, etc.) when monitoring and recording the switching time.

- **Last Error – time stamp:** Recording the time of the last error occurred with the given PID value serves for determining the quality features, proving the error-free interval.
- **Max Distance – between two packets:** The longest time distance measured between two packets is important in troubleshooting and proving the transmission imperfections (temporary line disconnection, line overload) particularly in the IP transmission.

The use of the test results by PID is twofold. As we have seen, from one part of the measurement results useful information can be obtained on the transmission characteristics, the other part of the test results gives useful information about the content of the transport stream. Viewing the numbers of packets measured at the 8192 PID values and so the values of the data rates calculated from those looks complicated, but mostly it is essential. The assessment is made easier, as most of the software do not indicate those PID values in the table, with which no packets have been received.

The transport stream is built using typically 50 to 200 "stable" data stream. When we can see in the PID table, that the TS has many different PID values, and there are many of the PID values in which only a few packets were received, the failure of a particular case we are facing with. This special phenomenon is caused during the transmission, when within the packets the bits carrying the value of the PID fail, so the PID value changed and the receiving side receives the packet. Due to the random failures the modified PID values can also occur sporadically. Of course, where this packet is missing from the data stream, there the number of CC errors increases. In circuit failures or in parallel transfer the connector and/or cable failures, the location of the error can be inferred from the more detailed analysis of the PID values.

In a well-functioning system, the table of the PID values and within this the data rates are very important for the highly experienced professionals. Try to gain experience as to what is the role of the most important PID values. For example:

- The most important table is the PAT. It is received with PID = 0, in the absence of this the receivers do not work.
- The SDT table comprises the name of the programs and is transmitted with PID = 17, in the absence of this the majority of receivers are not able to store the program features. In the absence of SDT the signal processing devices designed to be too smart (e.g. remultiplexers, TV receivers) do not work either.
- Search the EPG in the TS only if the arrival of packets can be seen with PID = 18.

More difficult to evaluate the data bit rate, but it's good to know that the tables are transmitted at low data rate (n kbit/s). The audio bit rates can be measured in the order of 10 and 100 kbit/s, now the values of the video bit rates mostly vary (VBR) and typically range as follows:

- MPEG-2 / SD programs 2.5 to 4 Mbit/s,
- MPEG-2 / HD programs up to 20 Mbit/s,
- MPEG-4 / SD programs 1.5 to 3 Mbit/s,
- MPEG-4 / HD programs typically under 6 to 10 Mbit/s.

The EPG data rate is highly variable, typically depends on the service concept. In many streams, packets containing the EPG can hardly be found, while in others, 1 to 2 Mbit/s data rate is provided for transmitting the EPG.

Representing the video stream data rates on a graph illustrates well the operation of the statistical remultiplexer depending on the content of the program. For this purpose it is useful to view the values of the time diagram and the picture simultaneously. The time diagram of the data streams of tables carries information about the operation of the remultiplexers and similar devices only for people with a deeper technical knowledge.

10.7. Program Specific Information – PSI analysis

For operating the receivers, also different data streams are required in the transport stream for carrying the information and control. They are collectively known as program-specific information, which are delivered in standard table structures to the receivers. The analyzing process mainly deals with, whether these data are sent for the receiver in the appropriate form, and it considers that analyzing the tables gives special opportunity to analyze the failures.

The data bytes within the packets can have arbitrary values, so it is difficult to tell whether they retain their original value during the transmission, or their value may change, that is defective. Since the structure of tables is defined, it was possible locating a 4-byte CRC error detector at the end of the table. Watching these 4-byte CRC values at the receiving side we can get sample type images, whether there was a change in data in transit. In the case if each CRC is wrong there, do not look for the failure as the data error, but make sure that entering the CRC value is correct on the sending side.

The tables inserted in the transport stream vary in length and often the amount of data to be transmitted does not fit into one packet. In order to transmit larger amounts of data the contents of the tables were broken down into sections. One table may consist of a maximum of 256 sections, the length of the sections can not be longer than 1020 bytes. The sections are numbered from 0 to 255, with the exception of the EIT (EPG) table, which can be four times larger than the length of the section and the numbering do not have to be continuous. In case of the commonly used tables the short section can be transmitted in a single packet, the largest section is 1024 bytes (with CRC) and can be transmitted in 6 TS packets.

10.8. Designing the test module for the tables in the CW-4957 TS Analyzer

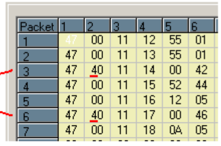
The number and size of tables built in the transport stream continues to grow, they deliver a large amount of information that can not be monitored continuously. The CW-4957 TS analyzer hardware stores the packets filtered by PID, Table Id and Service Id in 128 Ring Buffer units per input. Each Ring Buffer is able to store 32 TS packets, it stores the content and the arrival time of the packets, too. The Ring Buffer principle ensures, that in the buffer we can see always the last 32 packets received. After reading out the 32 packets, the software running on the PC is responsible for compiling the section and evaluating the data.

The packets of the very large tables do not fit the 32-packet Ring Buffer, for these one of the large Ring Buffers should be used. Since there are only four 8-Mbyte Ring Buffers in the device, the real time analysis is provided only for the data streams selected by the user. The Ring Buffer read out is fast, so the hardware also provides the possibility for the software to analyze all packets in real time, if the speed of your computer allows it.

10.9. Compiling the section to analyze the tables

The first step of analyzing the table is the compilation of the sections. Examining the table header the Payload Unit Start Indicator bit shows, that the read-out where to start. Figure 10.1 shows the meaning of the bits cut out of the standard description, next to it in the header of the packets the initial packets are marked (Payload Unit Start Indicator = 1) for the SDT tables.

sync_byte	**8**	**bslbf**
transport_error_indicator	**1**	**bslbf**
payload_unit_start_indicator	**1**	**bslbf**
transport_priority	**1**	**bslbf**
PID	**13**	**uimsbf**
transport_scrambling_control	**2**	**bslbf**
adaptation_field_control	**2**	**bslbf**
continuity_counter	**4**	**uimsbf**



Packet	1	2	3	4	5	6
1	47	00	11	12	55	01
2	47	00	11	13	55	01
3	47	40	11	14	00	42
4	47	00	11	15	52	44
5	47	00	11	16	12	05
6	47	40	11	17	00	46
7	47	00	11	18	0A	05

Figure 10.1

Packet Header in the standard and in practice

Reading the front of the section the Section Number shows the number of the section in the series, the value of the Last Section Number shows the total number of sections in the series. The data named Section Length shows the number of packets from which the data should be used to build the section. Using the 32-packet Ring Buffer system the entire section can be assembled for sure, if the table consists of 16 or fewer packets. In case of large tables, the amount of tables required to assemble the sections can also be collected with repeated readout.

11. Transport stream operational test, configuring the error messages

The CW-4957 type 64-Channel Real-Time TS Analyzer is suitable for the detailed engineering analysis of the 64 input signal characteristics and the continuous monitoring and indication of input signal errors that occur during operation. Entering the **ETSI TR 101 290 Analysis – Alarm Settings** page the table shows the data of the streams assigned to the inputs, read from IP Connection List. The user must specify, which parameters and what error values should generate error messages. The recommended configuration steps are as follows:

a. Click the squares of the column **Tested** to check the input signals you want to monitor. A click will always reverse the checking. The software will send out error messages only about the errors detected in the rows containing the inscription “Yes”.

b. The next configuration step is to check, which parameters of the input stream should be monitored. Where an “X” symbol can be seen in the “A” (Analized**)** column, the software will monitor the value of the given parameter continuously. The enter and delete of the symbol is done by mouse-click. A click always reverses the checking.

c. The third configuration step is to set the limits, where the error signal should appear. Click **View Alarm Settings** to see the current settings and limits. The software stores the alarm settings and limits in the Limit290.ini file, click **Restart** to load the content of this file.

Click **View Alarm Settings** to see and change the current settings and limits as needed. Then click **Apply and Save Alarm Settings** to validate and save the changes. Important: These settings are specially protected, can be saved only here and are not saved in the **Save Settings** and **Save Settings and Exit** operations.

Using the **Save as ...** and the **Load from ...** menus the alarm settings can be saved under any name and loaded from anywhere. After the loading click **Apply and Save Alarm Settings** to activate the loaded values. The **Edit/Load default Limits and Settings for Alarm Platform** menu is useful if you want enter many hundreds of limits on the basis of the manufacturer's limits. After modifying the limits click **Restart** to restart the scanning process.

The CW-4957 type TS Analyzer continuously monitors and stores the parameters of the 64 input streams. The SW-4957 software cyclically reads out and evaluate the stored data. The user can set the **Repetition Time** of the readout and evaluation cycles. The recommended value is a few seconds. This value can be smaller when monitoring smaller number of parameters. When monitoring many parameters simultaneously, the repetition time should be chosen large enough to perform the tests during this time. If the software cannot complete the required tests during the set repetition time, it automatically increases the set value and indicates the rate of increase.

In the SW-4957 software the analysis of the TS parameters was designed according to the ETSI TR 101 290 recommendation as follows:

1.1. Sync Lost

The sync loss can be observed primarily at the ASI outputs of high-frequency demodulators. The error is mostly caused by the changes of the transmission medium (storms, snowfall). It is practical to send an error message, if using a 10-second scanning cycle the number of errors exceeds 3 to 5.

When the reception is lost, there is no sync loss. In IP transmission the sync loss is very rare, it occurs only with special circuit faults, so not suitable for indicating problems during normal operation.

1.2. Sync Error

Synchronous errors typically result from data errors. More than two consecutive sync errors cause loss of sync, too. So, often the number of sync errors is twice as many as the sync losses.

It is important to note, that in IP transmission, due to the standardized data structure of the UDP packet no sync errors and sync losses occur in practice. The sync error can be used for indicating problems during normal operation, but only with limits.

1.3. PAT Error

Today, the advanced equipment of digital technology rarely provide false PAT tables. In the SW-4957 software, the counters of the

- false Table Identifier and
- scrambled PAT

events are intended mostly to implement the TR 290 recommendations. Monitoring of these events is recommended only in special cases.

1.4. Continuity Counter Error

The number of CC Errors indicates well in the ASI and IP transmission systems, if any breaks occur in the data transmission. In this place the SW-4957 software indicates all the CC errors measured on different PID values, so the short break of the stream causes less number of errors in the SPTS stream and higher number of errors in the MPTS stream. According to our experiences in the CC error analysis, setting the limit between 10 and 100 gives a good solution, but do not shrink to enter the value above 100, if it looks appropriate.

1.5. Table Error - lack of tables and streams

Monitoring the PMT tables according to TR 290 is a very large and difficult task for the hardware, so the SW-4957 software performs a modified analysis. Enter the PID value to be examined in the column 1.5. This analysis will generate an error message, if no packets arrive with the given PID during the tested period. Since the PID value can be given freely, the analysis can be programmed to monitor any tables or elementary streams. Default setting: PID=0 (monitoring the presence of PAT).

1.6. PID Error - monitoring the number of packets received on the PID

The A PID Error analysis monitors the number of incoming packets of the PID set in the column 1.5. Enter a number as a limit. The software sends out an error message, if the number of packets received in the test interval is less than this value.

2.1. Transport (TSP) Error

The error correcting circuit of the demodulator sets the Transport Error Bit to "1", to indicate if it failed to correct all the errors in the packet. The number of these errors characterizes well the quality of the transmission path. The software sends an error message if the number of errors in the tested time interval exceeds the value specified by the user. The proposed limit: 10 ... 100.

2.2. CRC Error - Data transmission error

The CRC placed at the end of the tables provides the sampling test of the packet data errors. A software error message indicates if in the test period the number of errors in the PAT, SDT and NIT tables exceeds the set limit.

On the basis of the ETSI TR 101 290 recommendations CableWorld composed 6 additional measurements, which can be used well to indicate the errors occurring in digital systems. These measurements can be found in the columns labelled with CW-1.1 ... CW-1.6.

CW-1.1. Input Data Rate min - Monitoring the lower limit

The software sends an error message if the input data rate in the tested time period was below the specified limit. The test can be used well for indicating operational anomalies of modulators and demodulators with a fixed data rate.

CW-1.2. PID Scrambled

The input data of this test is a PID value. The software sends an error message, if the two bits in the packet header indicate the "Scrambled" status. This test can be used to indicate the operational problems of CAMs.

CW-1.3. PID CC Error - Monitoring on a given PID

The software sends an error message, if the number of CC errors on the PID set in the CW-1.2. exceeds the specified limit number. The test is made to display faults in elementary streams.

CW-1.4. PID Data Rate min - Monitoring Elementary stream data rate

The software sends an error message, if the data rate of the stream on the PID set in the CW-1.2. is below the set limit. This measurement has primarily been designed to detect faults in the transmission of VBR streams.

CW-1.5. PID distance - Maximum distance between packets

The software sends an error message, if the distance between the packets transmitted on the PID set in CW-1.2. exceeds the set limit. The test circuit uses a resolution of 1 ms and can indicate a distance of a few hours. The final break of the packet sequence does not generate an error signal. This test can indicate the uneven data transmission on the IP network.

CW-1.6. PID Appear - Elementary Stream appears

The software sends an error message, if a packet arrives on the PID specified in the column. This test was made for special applications (e.g. indicating arrival of streams and messages).

Additional information:

Clicking Restart automatically clears the counters, storages of the TS analyzer and and starts a new testing process. In the first step of the new process the stored settings and limits will be loaded. As most of the measurements need two test results (e.g. data rate measurement or the number of errors in the monitored time period), the measured values and the alarms appear only after the second cycle, that is not an error to wait several seconds for the first data to appear.

On the Alarm Settings page, during the measurement process you can switch to viewing the limits, so it is possible to compare the measurement data and the limit values.

The Stop and Continue buttons can be used to stop and continue the testing process, but in this case the software increases the interrupted test period with the duration of the stop period, i.e. the number of errors per unit time increases. Using these features new measurements can be performed, e.g. monitoring the VBR bitrate in a few minute time span.

The measurement time increases proportionally with the number of the required measurements. It is true that the software is able to perform many measurements, but you get a more useful, more transparent supervisory system, if you do not ask measurement data from the software needlessly.

On the table of the Alarm Settings page all the measurement results are shown. The Alarm Report page shows only the results over the limit. The features Sync Lost, Sync Error, CC Error, TSP Error and Input Data Rate are measured and displayed in every cycle regardless of the settings.

The cycle time value can be changed at runtime, but the new value will not be saved.

12. TS analyzer configuration in one step

The transport stream analyzer installation requires, that the user knows the structure and operation of the device, and then configure its units before taking measurements. The One Touch Device Configurator page helps these tasks.

The user's task before using the One Touch Device Configurator:

- Preparing the IP Connection List. This list should specify the streams to be analyzed.
- Setting the IP address of the device, i.e. the software must be given the IP address of the device to be configured.

After starting the configuration process, the software sets the TS analyzer clock, clears all counters and storage units, samples the input signals and accordingly configures the PSI analyzer, etc. The final step of the configuration process is starting the measurement processes; clicking Start. After completing the configuration, you can choose freely from the different measurements.

Users familiar with the device, can leave some steps to shorten the configuration process, as desired.

13. Frequently Asked Questions

14. Remarks, comments, further information

We are pleased to receive at cableworld@cableworld.hu comments and remarks related to our devices and software, which we may take into consideration at further developments. Further information on the application of our products can be requested at the same address.

CableWorld Team