Application Note

# Isolating IP Video Issues with the JDSU T-BERD®/MTS-6000A and T-BERD®/MTS-8000

By Barry Constantine

## Introduction

Internet Protocol (IP)-based video networks present unique installation and troubleshooting challenges for service providers and telecommunication carriers. Unlike Layer 2/3 data services, the provider's workforce must be capable of monitoring and troubleshooting the service within the IP transport system. Troubleshooting video can be quite complex, but similar to many other network troubleshooting scenarios, isolating the source of the problem is critical to successful resolution.

This application note describes a methodology that streamlines the workflow to troubleshoot IP video problems within a carrier's IP transport network. It presents a generic, yet representative IP video network model to describe the troubleshooting workflow shown in Figure 1.

The video headend (VHE) is the facility that provides the national video source content for the carrier. The initial quality of a broadcast video program is established by items such as the content sources used, the compression algorithms implemented (Motion Picture Experts Group 2 or 4 [MPEG-2] or [MPEG-4], for example), the encoders used and various compression settings used by the encoders and transcoders in grooming the video or media streams. The VHE broadcast video content is distributed to multiple video serving offices (VSOs) through the VHE core IP network.

The network that connects the VHE to the multiple VSOs is referred to as the IP transport network. Within the VSO, the video is groomed for items such as local programming insertion, ad insertion, and then distributed to the consumer across the access network.

This application note focuses upon the troubleshooting workflow for the field technicians who are responsible for the IP transport network, although some of the workflow is also relevant for the IP portion of the VHE. It shows how to determine whether the video quality problem is related to the source or caused by the IP transport network itself. Isolating the source video and IP-network-related problems is fundamental to the diagnosis and can greatly optimize the time in verifying and troubleshooting the problem.

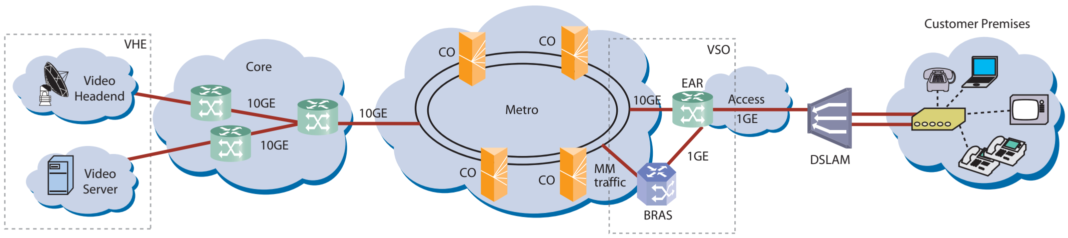


Figure 1 Representative IP Video Network

## Video Troubleshooting Workflow for the IP Transport Network

Figure 2 highlights the workflow for troubleshooting video problems in an IP transport network, featuring the JDSU T-BERD/MTS-6000A Multi-Services Application Module and T-BERD/MTS-8000 Transport Module Ethernet service testers. We will demonstrate step-by-step tester configuration along with representative results.

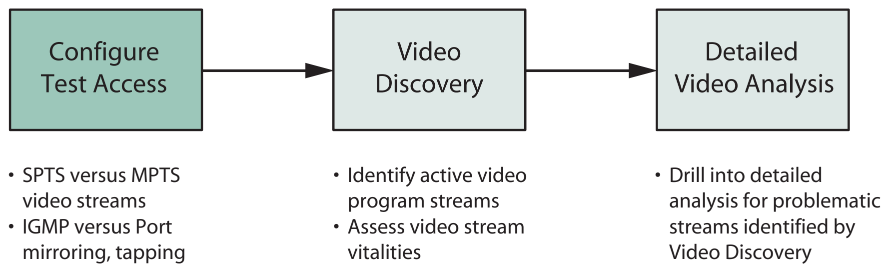


Figure 2 Video troubleshooting workflow—IP Transport Network

**Configure Test Access**

Video is encapsulated in a variety of ways into an IP stream. The MPEG stream is generally packetized into 188-byte transport packet streams and then encapsulated into an IP stream. The encapsulation is referred to as Single Program Transport Stream (SPTS) and Multiple Program Transport Stream (MPTS).

IP video networks distribute video using multicast IP and unicast IP streams. Broadcast video uses multicast IP throughout an IP network and Internet Group Management Protocol (IGMP) signaling to allow a set top box (STB) to join a video stream. Unicast IP video is used to transfer content from the video source to a particular STB. Video on Demand (VoD) service is an example of an IP unicast service. Unicast IP video can also be used to transfer content from the video source (VHE) to the distribution offices (VSOs).

The encapsulation (SPTS or MPTS) and the IP transmission type (multicast and unicast) must be configured properly on the T-BERD/MTS-6000A or T-BERD/MTS-8000 test tool, so that video streams can be accessed for analysis. The following subsections summarize the appropriate test configuration for encapsulation and IP transmission type of the video streams.

SPTS versus MPTS

The first step in the test access configuration process is to identify the manner (SPTS or MPTS) in which video streams are encapsulated, as Figure 3 illustrates.

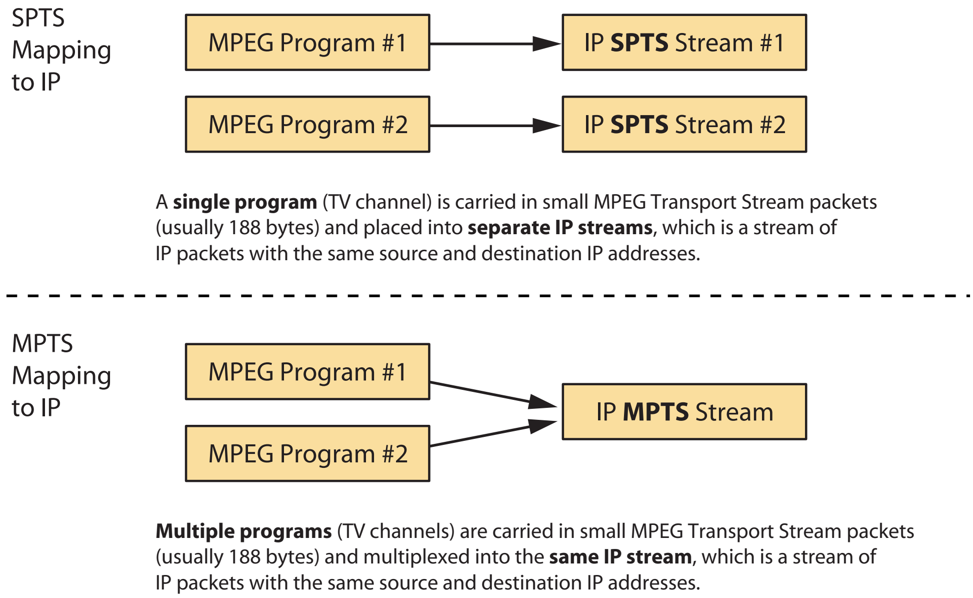


Figure 3 SPTS versus MPTS transport within IP

Some general *rules* regarding SPTS versus MPTS stream types:

– Multicast networks always use SPTS video streams.

– Source feeds (links that transport content) from the VHO to the distribution office typically are carried over unicast, MPTS streams.

– VoD service distribution (subscriber side) is always unicast and carried over SPTS streams.

Once the determination is made whether the video is SPTS or MPTS encapsulation, launch the T-BERD/MTS-6000A or T-BERD/MTS-8000 into the appropriate mode (SPTS Explorer/Analyzer or MPTS Explorer/Analyzer) and configure the physical test access.

### Test Access for Multicast IP Video

In a multicast IP video network, the fundamental concept is that a video stream is not sent in a unicast (point-to-point) manner between the source and receiver. Broadcast programming is sent to all VSOs; STBs join existing streams resulting in only the desired stream being sent over the Access network to the STB, which dramatically reduces the wasted network bandwidth that occurs when the same stream must be sent multiple times to multiple end points. Figure 4 shows a simplistic multicast-based video implementation. Note that the single source of video, or blue arrow from MPEG encoder #1, is only transmitted once (unicast) between the encoder and core backbone switch and then is multicast to the appropriate end points. This provides an overly simplistic example; however, in mainstream IP/video networks, the multicast source architecture is distributed geographically and is a complex network design.

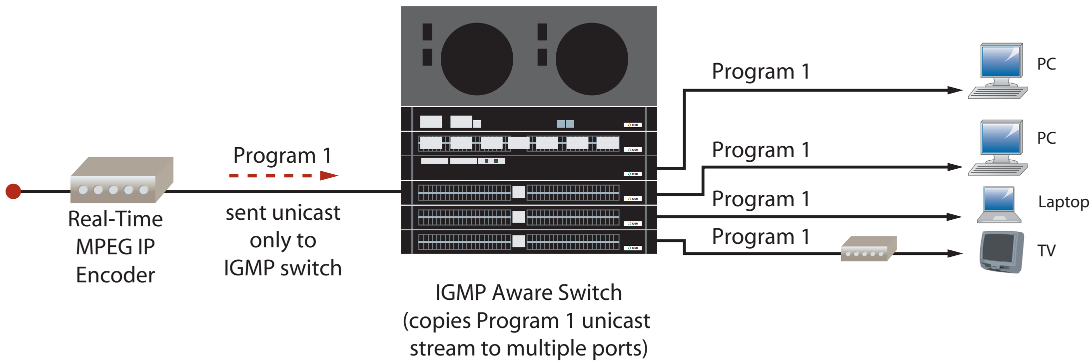


Figure 4 Typical Multicast-Based Network

For the IGMP end points to *join* the multicast stream, special IGMP signaling must occur between the end points and the multicast switches and routers. Each multicast stream is referred to as a group and generally corresponds to a video program such as ESPN or HBO.

For test equipment to monitor video streams in a multicast network, the test equipment must support the IGMP signaling protocol to join the multicast stream. Figure 5 shows a sample of the simple JDSU T-BERD/MTS-6000A or T-BERD/MTS-8000 setup screen that facilitates test access in a multicast network. The user simply selects the multicast stream to join from the Address Book or creates a new stream and then selects: *Join Streams*.

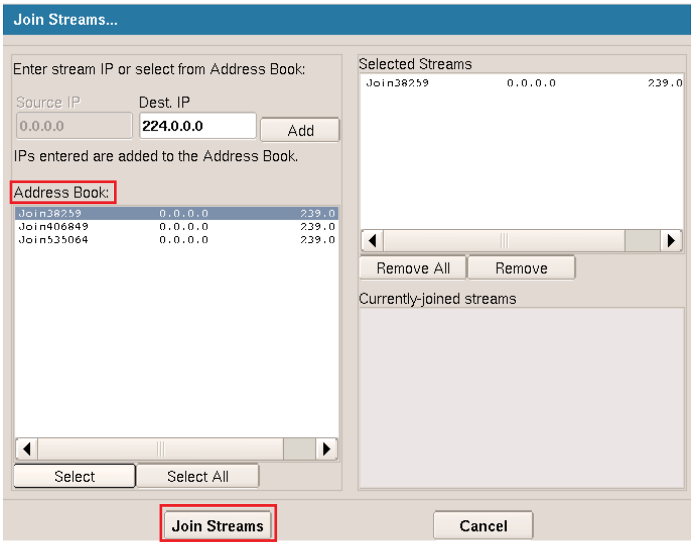


Figure 5 IGMP test access *Join* configuration screen

Once the appropriate IGMP Multicast IP address is entered, the T-BERD/MTS-6000A or T-BERD/MTS-8000 will successfully access the multicast video stream(s) and testing can proceed to the next step in the workflow: *Video Discovery*.

### Test Access fpr Unicast IP Video

Unicast IP streams, such as video source content transport to distribution offices or video on demand (VoD), do not use IGMP and they transport video programs in a Layer 2/Layer 3 (L2/L3) manner. Video streams are carried similarly to a traditional IP network using video distribution devices such as virtual local area networks (VLANs) or IP routing throughout the network.

To monitor the unicast streams, use *port mirroring* when an active elements such as a switch or router is present within the network. Many such active network devices have a spare port for test purposes and the video traffic can be copied or mirrored to this test port. A network engineer must administer proper router/switch configuration commands, such as Internetwork Operating System (IOS) commands, to copy the desired video link to the test port.

Once the unicast video streams are mirrored to a test port, the T-BERD/MTS-6000A or T-BERD/MTS-8000 can then successfully access the video stream(s) and the testing can proceed to the next step in the workflow: *Video Discovery*.

**Video Discovery**

After properly configuring the test access, conduct a Video Discovery, which is a basic survey of the active video streams, and obtain a summary of stream health. Figure 6 highlights the uses of video discovery.

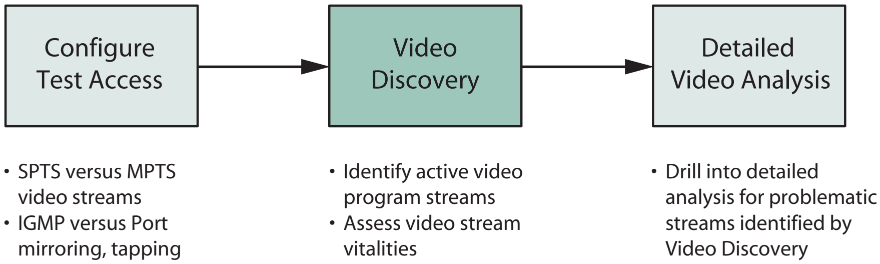


Figure 6 Using video discovery to identify active video streams and assess video vitalities

The goal of the Video Discovery step is to conduct a basic discovery of the video streams and explore the fundamental health of each identified stream. The JDSU T-BERD/MTS-6000A or T-BERD/MTS-8000 tester provides Video Explorer modes of test operation to simplify this basic video audit. Figure 7 shows the summary video screen of the T-BERD/MTS-6000A or T-BERD/MTS-8000 SPTS Explorer application.

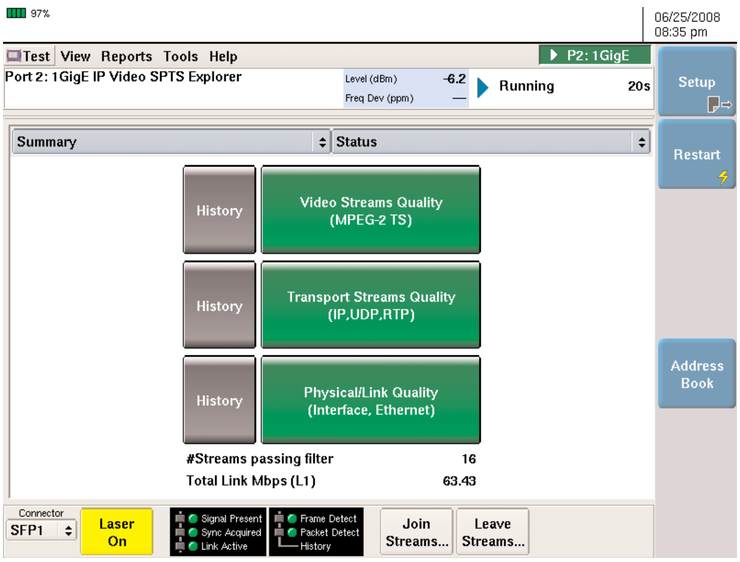


Figure 7 SPTS Explorer video summary screen

This summary screen provides a powerful dashboard interface that immediately draws attention to the layer that may be potentially causing video problems. In this example, all SPTS video streams on the link pass the video vitality test. In this mode of operation (SPTS Explorer), 512 SPTS streams (equivalent to 512 video programs) are automatically discovered and analyzed for basic integrity. In the MPTS mode, 32 MPTS streams (equivalent up to 512 video programs) are analyzed.

Clicking on any of the three layers (Video Streams Quality, Transport Streams Quality, or Physical/Link Quality) will display the appropriate results. These layers are hierarchical in that the lower layers should be analyzed first if problems display with yellow or red color coding. Physical/Link quality would be issues such as Ethernet FCS errors; Transport Layer might be Packet Loss type errors; and Video Streams Layer would include possible MPEG-related source issues.

For example, clicking on the Transport Streams Quality icon displays the transport-related results for all IP Video streams discovered on the link, as Figure 8 shows. Note important statistics such as Packet Loss and Packet Jitter (Pkt Loss, Pkt Jitter).

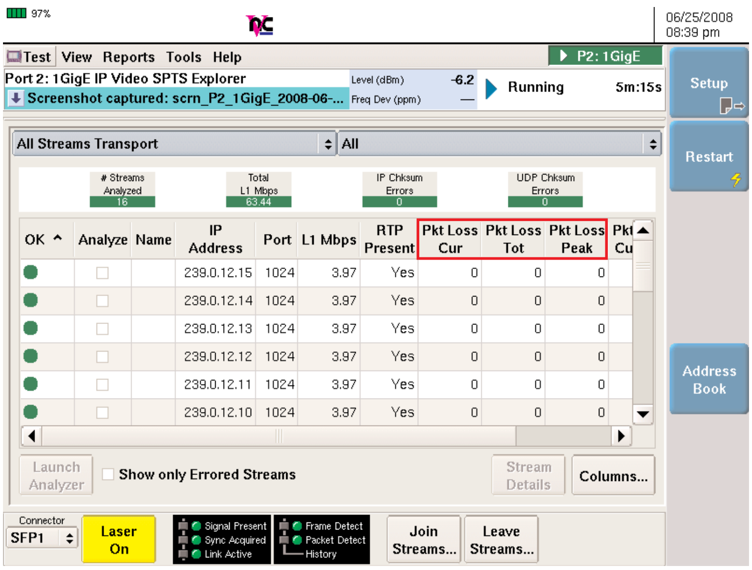


Figure 8 Transport stream quality: status and results

In a similar manner, clicking on the Video Streams Quality icon displays the results for video source content for all IP Video streams discovered on the link, as Figure 9 shows.

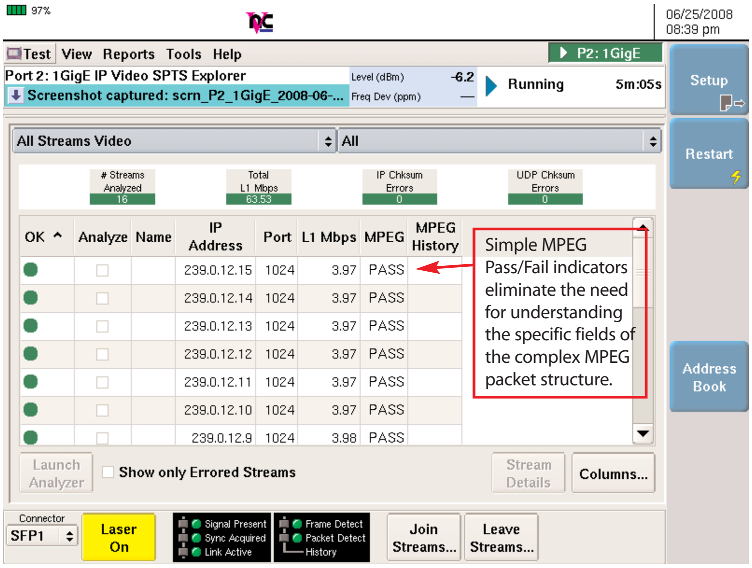


Figure 9 Video streams quality: status and results

Video discovery represents the first stage in the overall troubleshooting process. The intent is to quickly identify video streams on the link and to direct the user correctly with respect to focusing on the appropriate layer and stream(s) for a detailed analysis.

**Detailed Video Analysis**

Figure 10 shows the workflow for a detailed analysis and resolution. The next step in the troubleshooting workflow lets the user conduct deeper analysis into a very comprehensive set of results, including TR101-290 for the MPEG layer, Loss Distance/Period (RFC3357), and media delivery index (MDI) for the Transport layer; as well as many other stream and Program Identifier (PID)-based results.

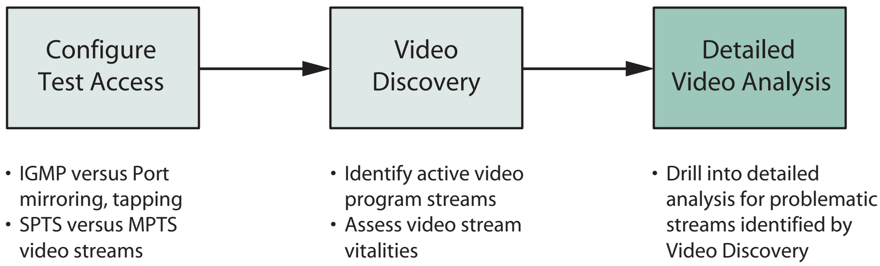


Figure 10 Detailed video analysis for problematic streams

Up to this point, the Video SPTS Explorer audited the link and identified the video streams contained within it. The SPTS Analyzer is then launched to conduct a detailed analysis of either the selected streams discovered by the SPTS Explorer, or to analyze all streams on the link directly.

To simplify the user experience, the SPTS Analyzer User Interface is presented in a very consistent manner with a Status screen similar to the one shown in Figure 11 and the All Streams (Complete) screen similar to the one shown in Figure 12.

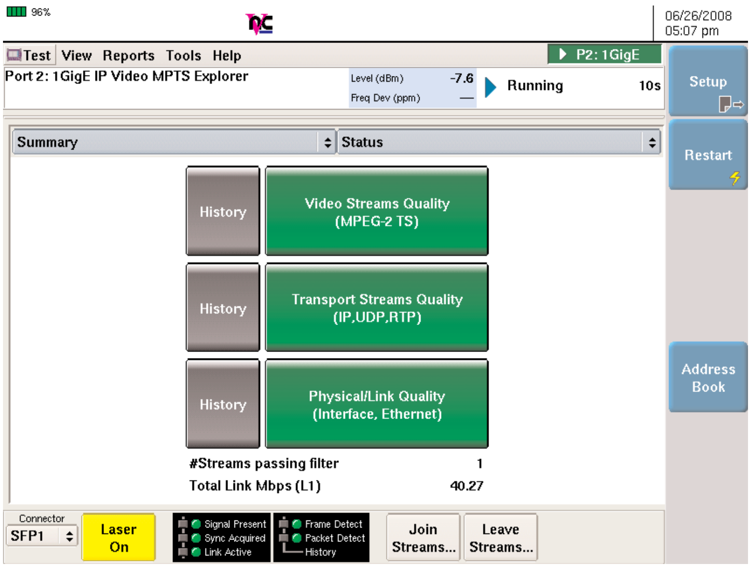


Figure 11 SPTS Video Analyzer summary screen

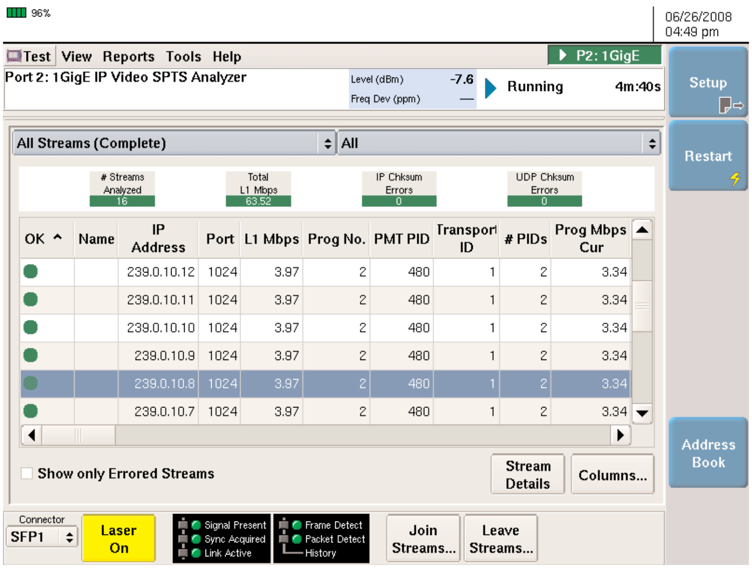


Figure 12 SPTS Video Analyzer, all streams—complete (video and transport layers)

The Analyzer mode provides more in-depth results than does the Explorer mode, because it merely scans for problems, whereas the Analyzer mode solves them. The Explorer and Analyzer modes provide many statistics and results in custom displays. Appendixes A and B provide the complete list of results for both the Explorer and Analyzer functions.

In addition to robust results per stream, the Analyzer functions let the user drill into the MPEG streams and analyze the PIDs. Advanced users can examine items such as Program Tables, Video PIDs, and Audio PIDs to verify MPEG bit rates and various TR101-290 errors per PID. Figure 13 provides an example of a deeper analysis into the PID level.

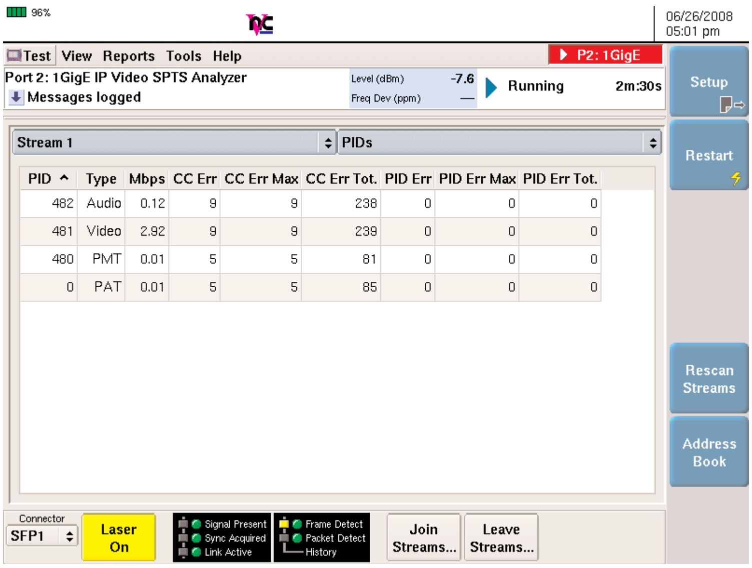


Figure 13 SPTS Analyzer deeper analysis to PID view on a stream

The deeper PID analysis view provides the content type per PID, such as video, audio, tables, and statistics per PID. The Mbps column summarizes the bandwidth of each PID. Figure 13 easily shows that the video stream is a 2.92 Mbps Standard Definition (SD) stream and the Audio is 128 kbps. TR101-290-type metrics such as CC Errors and PID Errors indicate possible source content issues with the stream itself.

Now that the workflow steps have been described, the next section provides two representative troubleshooting scenarios and explains how to apply the video troubleshooting workflow to each.

## Example Troubleshooting Scenarios

This section demonstrates the process of isolating video problems between IP transport-related issues and video source issues. The Video Explorer and Analyzer modes of the JDSU T-BERD/MTS-6000A and the T-BERD/MTS-8000 network testers will be used for each example scenario.

**Video Degradation due to IP Transport Network**

In this scenario, the transport network engineer/technician within the VSO is notified that certain video programs are received with poor quality at customer locations. The JDSU T-BERD/MTS-6000A or T-BERD/MTS-8000 analyzer is connected to the network via IGMP, and the SPTS Explorer (described in the subsection on Video Discovery, page 6) provides the Video Discovery shown in Figure 14.

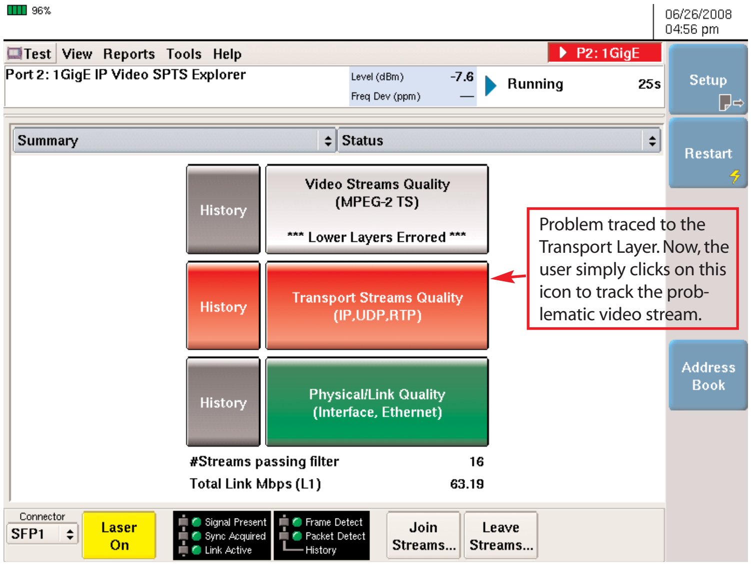


Figure 14 Video Discovery points to transport stream quality issue

From the SPTS Explorer summary screen, the user receives an alert that a problem exists at the transport streams layer. Simply clicking on the Transport Streams Quality icon, the user can view a summary of the SPTS streams at this layer. The user then selects the Show only Errored Streams option to filter the summary view and show only the stream(s) experiencing transport layer problems, as Figure 15 illustrates.

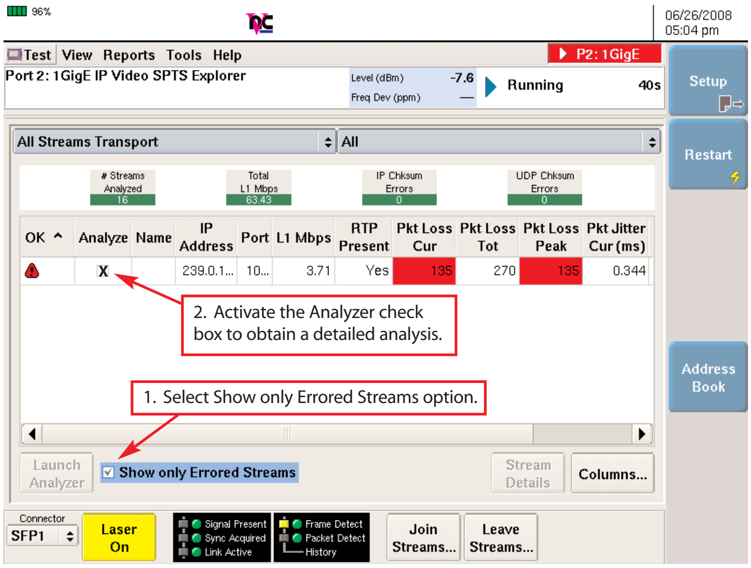


Figure 15 Video Discovery: Filter to errored stream

The Video SPTS Explorer has quickly audited the link, identified the problem layer (Transport), and filtered to the problematic stream, where the SPTS Explorer identifies the issue as Packet Loss. Users can now perform detailed analysis by simply selecting the Analyze option for that stream to launch the SPTS Analyzer.

Once the SPTS Analyzer is launched, the user can perform deeper analysis of the problematic stream. In this case, the high-level packet loss was observed and the detailed analysis provided standards based upon Loss Distance/Period (RFC3357) and MDI metrics, as Figure 16 shows.

### Summary of Distance/Loss Period and MDI Metrics

Video networks incur intermittent packet loss caused by impulse noises and other impairment sources that can be recovered by re-transmission or forward error correction (FEC) recovery mechanisms; however, each has its limitations. Two things affect the overall ability of the recovery mechanisms: the number of consecutive lost packets that can be recovered, or the number of *good* packets between a loss event.

RFC3357 defines a combination of two metrics to assess loss pattern metrics: Loss Distance and Loss Period. Loss Distance measures the difference in sequence numbers of two loss events, where *loss event* is defined as the loss of one or more packets in a row. *Loss Period* is the length of a single loss event, or the number of lost packets between two successfully received packets. Note that both of the loss metrics require that the video be carried over Real-Time Transport Protocol (RTP) (versus MPEG over User Datagram Protocol [UDP]).

MDI is a simpler and less robust method to derive loss metrics on a video stream. MDI does not consider the distance between lost packets and does not provide a correlation as robust as the resulting video quality. MDI may score a stream as poor quality in the loss domain, yet the loss distance (or distribution) may be such that the retransmission or FEC mechanisms can correct the loss.

JDSU supports both Loss Distance/Period (RFC3357) and MDI metrics, but advises end users to provide more weight to the Loss Distance/Period metrics than the MDI metrics as a more accurate indicator of video quality. One exception to this would be MPEG over UDP (versus RTP) implementations; MDI metrics are at the packet level and can be computed for MPEG over UDP.

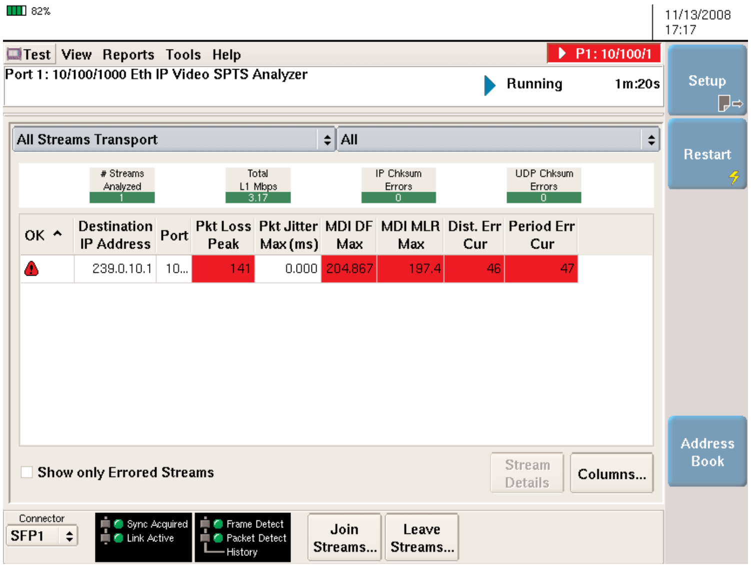


Figure 16 Detailed video analysis of the problematic stream

Figure 16 shows the analyzer with the Distance Loss and Period Loss flagged as having exceeded the threshold (as well as MDI metrics). The Distance and Period Loss metrics indicate that transport layer issues are causing packet loss that could adversely affect video quality (even in networks with recovery mechanisms). Possible causes are possibly link congestion or misconfigured router prioritization queues. These alarm color thresholds are configurable (yellow and red) as well as the columns displayed to the user.

To summarize this example scenario, the user could quickly determine that the poor video quality was due to transport layer issues and could provide industry standard Loss Distance/Period (RFC3557) and MDI metrics to measure the degree of transport degradation. Possible next steps would be to isolate the transport layer segment at fault, such as relocate the tester to different network segments.

**Video Degradation due to MPEG Source Content Issues**

The next scenario presents source video content issues occurring and the SPTS Explorer (from the subsection on Video Discovery, page 6) displaying the Video Discovery shown in Figure 17.

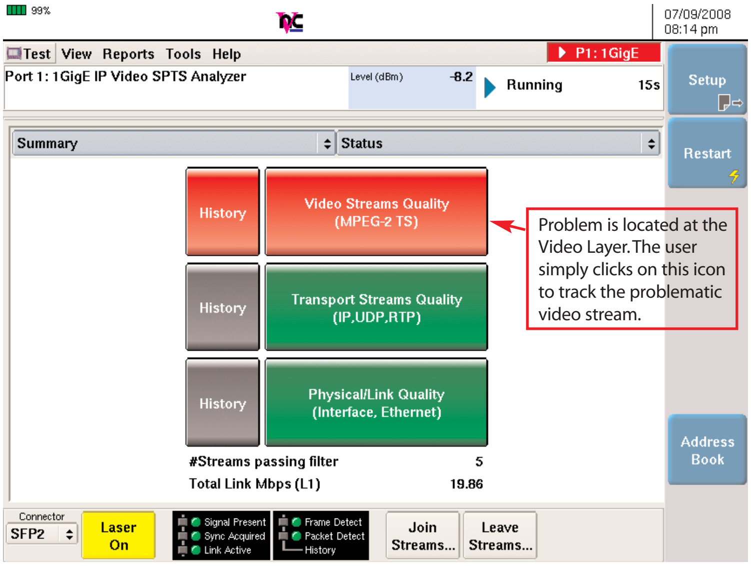


Figure 17 Video Discovery points to Video Streams Quality issue

From the SPTS Explorer summary screen, the user receives an alert that a problem exists at the video streams layer. Simply clicking on the Video Streams Quality icon, the user can view a summary of the SPTS streams at this layer. The user then selects the Show only Errored Streams option to filter to the summary view and show only the stream(s) experiencing video layer problems, as Figure 18 illustrates.

The SPTS Explorer has identified the MPEG layer as the issue. Users can now perform detailed analysis by simply selecting the Launch Analyzer option for that stream to launch the SPTS Analyzer.

Once the SPTS Analyzer is launched, the user can perform deeper analysis of the problematic stream. In this case, the SPTS Explorer originally flagged it as an MPEG layer issue. Now, upon deeper analysis, the Analyzer reveals the problem as the Continuity Counter (CC) and PMT Errors within the MPEG transport stream, as Figure 19 shows.

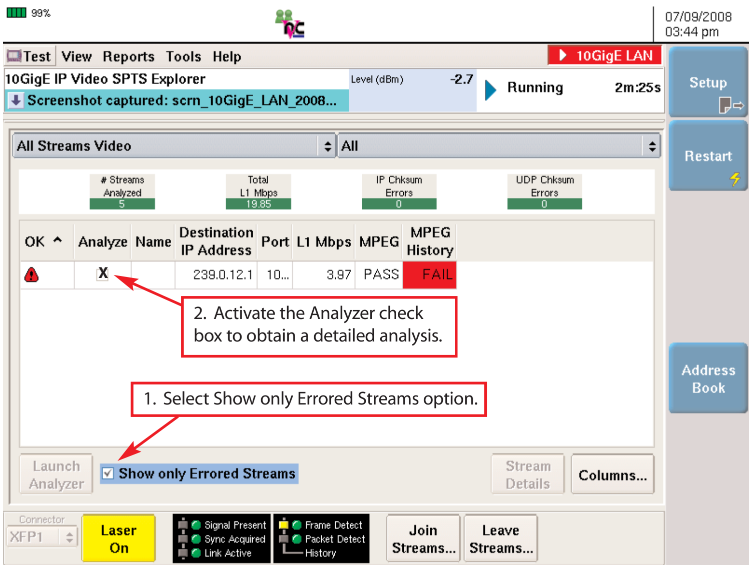


Figure 18 Video Discovery: Filter to errored stream

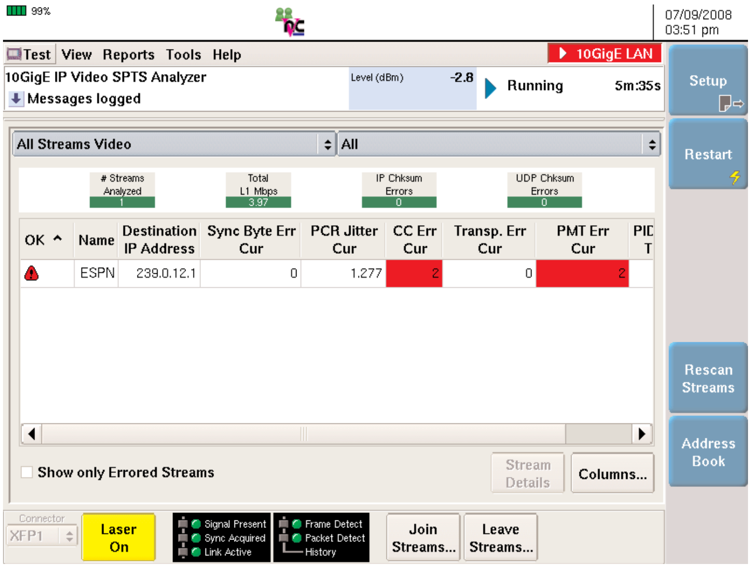


Figure 19 Detailed video analysis reveals CC and PMT errors within the MPEG stream

To summarize this example scenario, the user could quickly determine that the poor video quality was due to MPEG video layer issues and could identify the specific problems within the MPEG transport stream. Further analysis would lead the user to video source issues within the VHO or equipment that alters the video content within the VSO, such as ad insertion or local weather insertion.

## Conclusion

Troubleshooting video is quite complex, but similar many other network troubleshooting scenarios, isolating the source of the problem is key to successful resolution. This paper described a methodology for streamlining the workflow when troubleshooting IP video problems within the IP transport network, as illustrated in Figure 20. It also shows how using the T-BERD/MTS-6000A or T-BERD/MTS-8000 can significantly reduce the time between troubleshooting the problem and finding a resolution.

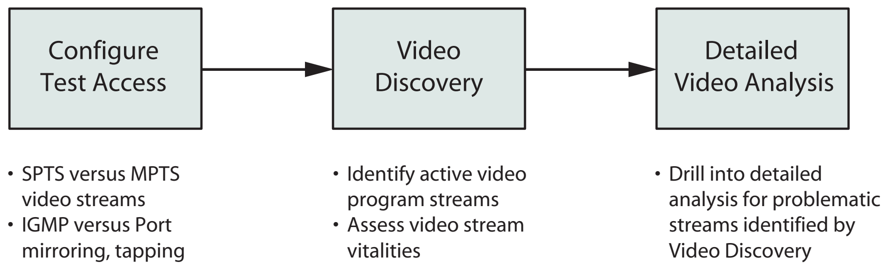


Figure 20 Video troubleshooting workflow—IP Transport Network

The following JDSU products offer capabilities for turning up and troubleshooting video. Links provided below lead to product pages located on the JDSU Website:

**JDSU T-BERD/MTS-8000 Transport Module**

http://www.jdsu.com/products/communications-test-measurement/products/a-z-product-list/tb-8000transport.html

http://www.jdsu.com/products/communications-test-measurement/products/a-z-product-list/mts-8000transport.html

**JDSU T-BERD/MTS-6000A Multi-Services Application Module**

http://www.jdsu.com/products/communications-test-measurement/products/a-z-product-list/multi-services-application-module-for-t-berd-mts-6000a-platform.html

**JDSU HST-3000 Handheld Services Tester**

www.jdsu.com/one

The following links reference other useful testing-related application notes and white papers located on the JDSU Website:

**White Paper: Fundamentals of Ethernet**
http://www.jdsu.com/product-literature/fundethernet_wp_acc_ae.pdf

**White Paper: Understanding Ethernet and Fibre-Channel Standard-Based Test Patterns**
http://www.jdsu.com/product-literature/ethernetfc_wp_acc_tm_ae.pdf

**White Paper: Verifying Metro Ethernet Quality of Service**
http://www.jdsu.com/product-literature/metroetherqos_wp_acc_tm_ae_0706.pdf

**Poster: Carrier Ethernet Service Testing**
http://www.jdsu.com/product-literature/metroethernet_POSTER120606_FINAL.pdf

## Appendix A: JDSU T-BERD/MTS-6000A and JDSU T-BERD/MTS-8000 *Video Explorer* Results

– All Video Explorer results are on a per stream basis (per PID is a function of the Analyzer mode)

– Up to 512 SPTS and 32 MPTS streams can be discovered with these results reported

| Result Name | Definition | Programmable Alarm Threshold? |
|---|---|---|
| OK | Summary of all alarms (i.e., packet loss and MPEG layer alarms) | Yes, dependent upon configured thresholds for the various alarms which comprise "OK" |
| Name | The user-assigned program name for the video stream | N/A |
| IP Address | Unicast or multi-cast IP address of the MPEG Transport Stream (TS) | N/A |
| Port | UDP port of the MPEG TS | N/A |
| L1 Mbps | Bandwidth (including Layer 1/2) of the MPEG TS | N/A |
| MPEG | Represents a "PASS or "FAIL" indicator of the Continuity Error and Sync Byte Error thresholds | No |
| MPEG History | Provides PASS/FAIL historical indication over the entire test duration | No |
| RTP Present | Active when the MPEG is encapsulated in UDP/RTP | N/A |
| Pkt Loss (Cur, Tot, Peak) | Statistical numbers of IP layer packet loss (only valid for RTP-encapsulated MPEG) | Yes |
| Pkt Jitter (Cur, Max) | IP layer jitter measurements per each MPEG TS | Yes |

## Appendix B.1: JDSU T-BERD/MTS-6000A and JDSU T-BERD/MTS-8000 *Video Analyzer* Results – Per Stream

– For the Video Analyzer mode, up to 16 SPTS streams and 1 MPTS stream can be analyzed
– This corresponds up to a total of 256 number of PIDs

| Result Name | Definition | Programmable Alarm Threshold? |
|---|---|---|
| OK | Summary of all alarms (i.e., packet loss, MPEG layer alarms, MDI) | Yes, dependent upon configured thresholds for the various alarms which comprise "OK" |
| Name | The user-assigned program name for the video stream | N/A |
| IP Address | Unicast or multi-cast IP address of the MPEG Transport Stream (TS) | N/A |
| Port | UDP port of the MPEG TS | N/A |
| L1 Mbps | Bandwidth (including Layer 1/2) of the MPEG TS | N/A |
| PMT PID | Represents the Program Identification number (PID) for the Program Map Table (PMT) | N/A |
| Transport ID | Indicates the Transport ID for the MPEG TS | N/A |
| # PIDs | The number of PIDs with the MPEG TS | N/A |
| Prog Mbps (Cur, Min, Max) | The bandwidth of the program contained with the SPTS or MPTS stream (bandwidth at the MPEG TS layer) | N/A |
| RTP Present | Active when the MPEG is encapsulated in UDP/RTP | N/A |
| Pkt Loss (Cur, Tot, Peak) | Statistical numbers of IP layer packet loss (only valid for RTP-encapsulated MPEG TS) | Yes |
| Pkt Jitter (Cur, Max) | IP layer jitter measurements per each MPEG TS | Yes |
| OoS (Cur, Tot, Max) | Out of Sequence packets (valid for RTP-encapsulated MPEG TS) | No |
| Dist Err (Cur, Tot, Max)[1] | Number of distance errors (difference in RTP sequence numbers | No |
| Min Loss Dist[1] | Minimum number between sequence numbers during loss event | No |
| Period Err (Cur, Tot, Max)[2] | Number of lost packets (RTP sequence number related) between successfully received packets | No |
| Max Loss Period[2] | Maximum number of lost packets between successfully received packets | No |
| Sync Losses (Cur, Tot, Max) | Declares Sync Loss when two consecutive sync bytes (0x47) go undetected. Declares Sync when five consecutive sync bytes are detected. | No |
| Sync Byte Err (Cur, Tot, Max) | Number of MPEG Sync bytes not equal to "0x47" | Yes |
| MDI DF (Cur, Max) | Media Delivery Index (MDI) Delay Factor (DF) which is metric derived from IP packet jitter | Yes |
| MDI MLR (Cur, Max) | Media Deliver Index (MDI) Media Loss Ratio (MLRDF) which is metric derived from IP packet loss (for MPEG over RTP) | Yes |
| PCR Jitter (Cur, Max) | Measurement of MPEG TS jitter (versus IP jitter) | Yes |
| CC Err (Cur, Tot, Max) | Number of MPEG Continuity Counter (CC) errors; this is the number of out-of-sequence CC | Yes |
| Transp Err (Cur, Tot, Max) | Number of Transport Error fields set in the MPEG TS header | Yes |
| PAT Err (Cur, Tot, Max) | Number of times the PAT PID does not occur at least every 0.5 s | Yes |
| PMT Err (Cur, Tot, Max) | Number of times the PMT PID does not occur at least every 0.5 s | Yes |
| PID Err (Cur, Tot, Max) | Number of times the PID (not PAT or PMT) does not occur at least every 0.5 s | Yes |

[1]Per RFC-3357, "Loss Distance" measures the difference in sequence numbers of two loss events, with a "loss event" being the loss of one or more packets in a row
[2]Per RFC-3357, "Loss Period" is the length of a single loss event, that is, the number of lost packets between two successfully received packets

## Appendix B.2: JDSU T-BERD/MTS-6000A and JDSU T-BERD/MTS-8000 *Video Analyzer* Results – Per PID

| Result Name | Definition | Programmable Alarm Threshold? |
|---|---|---|
| PID | Identifies each individual PID number | N/A |
| Type | Denotes the type of PID (video, audio, or data) | N/A |
| Mbps | Bandwidth of each individual PID (i.e., 2.5 Mbps for SD video and 128 kbps for audio) | N/A |
| CC (Cur, Tot, Max) | Number of MPEG Continuity Counter (CC) errors (out-of-sequence) | Yes |
| PID Err (Cur, Tot, Max) | Counts of the occurrences when the a PID (not PAT or PMD) does not occur at least every 0.5 s | Yes |

**Test & Measurement Regional Sales**

| NORTH AMERICA | LATIN AMERICA | ASIA PACIFIC | EMEA | www.jdsu.com/test |
|---|---|---|---|---|
| TEL: 1 866 228 3762 | TEL: +1 954 688 5660 | TEL: +852 2892 0990 | TEL: +49 7121 86 2222 | |
| FAX: +1 301 353 9216 | FAX: +1 954 345 4668 | FAX: +852 2892 0770 | FAX: +49 7121 86 1222 | |


 December 2008 30162591 000 1208 IPVIDEOISSUES.AN.ACC.TM.AE