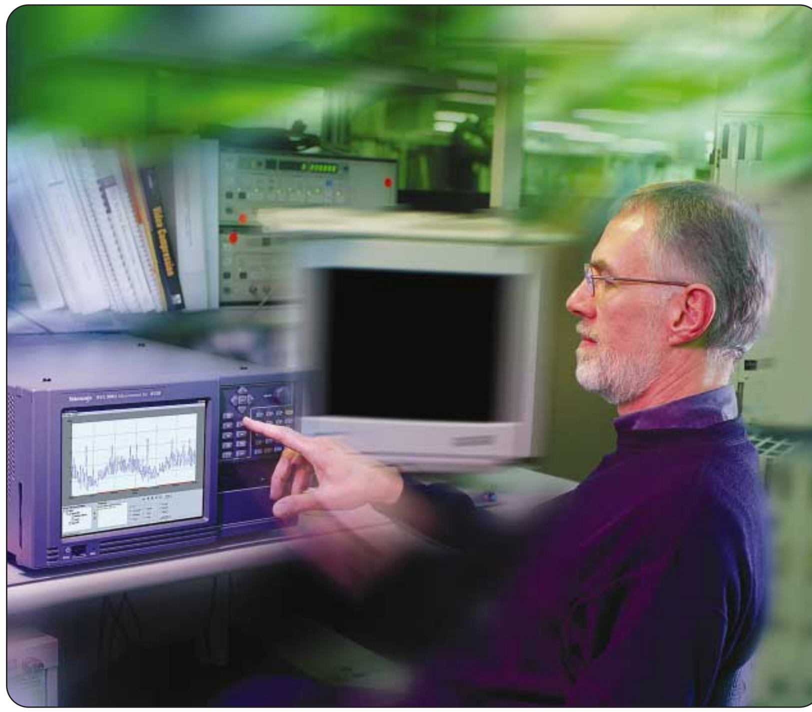
Using Triggered Video Capture to Improve Picture Quality



COMPUTING
COMMUNICATIONS
VIDEO

Assuring Picture Quality

Today's video transmission methods depend on compressed digital video to deliver the high-volume of video data required. This creates a need for an easy, reliable, consistent test method to guarantee Video Quality of Service to the end user.

What do terrestrial broadcasters, content providers, satellite and cable TV operators, and network operators have in common? The answer is on almost every television screen: they are all delivering compressed digital video to their customers.

Perhaps more importantly, they are all seeking ways to balance Video Quality of Service (VQoS) and bandwidth to extract maximum performance and revenue from their enterprises. The result is a broad demand for VQoS measurement and monitoring solutions that can:

- **Ensure reliable transmission with no downtime.** Reliable delivery of "the product" is of course essential to any business, including video transport. But how can reliability be sustained without taking systems out of service for maintenance and repair? VQoS monitoring can detect problems early and can help localize their source, guiding technical personnel toward a quick solution.
- **Support expected quality… or better!** Quantifiable picture quality measurements make it possible to document system performance over time, set measurable targets for improvement where necessary, and track the results of the quality control process.
- **Detect problems before they become customer complaints.** A small, barely-visible video problem can be the precursor to larger failures. 24-hour, 7 days per week monitoring, with appropriate alerts and follow-up, is the best way to ensure that all meaningful errors are captured and understood.
- **Allocate bandwidth efficiently.** Bandwidth allocation is the key to delivering the maximum content in the available bandwidth. Dynamic statistical multiplexing lets multiple channels share the same piece of the spectrum, giving more bandwidth to the most demanding content channels. This scheme requires constant and accurate monitoring of the allocation process, to ensure that each stream meets desired quality standards.

This application note will describe a methodology to help ensure the quality of the content in MPEG compressed video streams. The approach is straightforward and non-invasive, and because it is based on objective picture quality parameters, it delivers results that correlate closely with human visual response.

Continuous VQoS Monitoring Supports Picture Quality and Competitiveness

Providers and networks who can deliver more content and good quality at the same time have an immense advantage in competing for both viewers and advertisers. Compressed digital video is bandwidth-efficient, and has the technical potential to deliver quality images to viewers.

But the efficiency of compressed video comes at a price. During MPEG compression, a certain amount of the original content is knowingly discarded. Video compression artifacts are the unpleasant reminders that the picture on the screen isn't a perfect reconstruction of the original. Some of these artifacts, such as "blockiness" (see Figure 1), can be easily seen and are very objectionable.

In addition to compression-related picture quality issues, there are other visible problems that must be controlled. Dropouts and other distortions arise from errors in encoders, decoders, multiplexers, and the transport network. Gaussian noise can be present in video entering compression encoders, as can satellite transmission transients. Material originated or processed in the analog domain, too, may exhibit noise or distortion.

In all of these cases, continuous monitoring of the video stream can support the VQoS that viewers demand, while ensuring the most efficient use of available bandwidth. Following are just a few of the applications that are driving content providers and networks toward a policy of 24-hours-a-day, 7 days per week monitoring of their digital video streams:

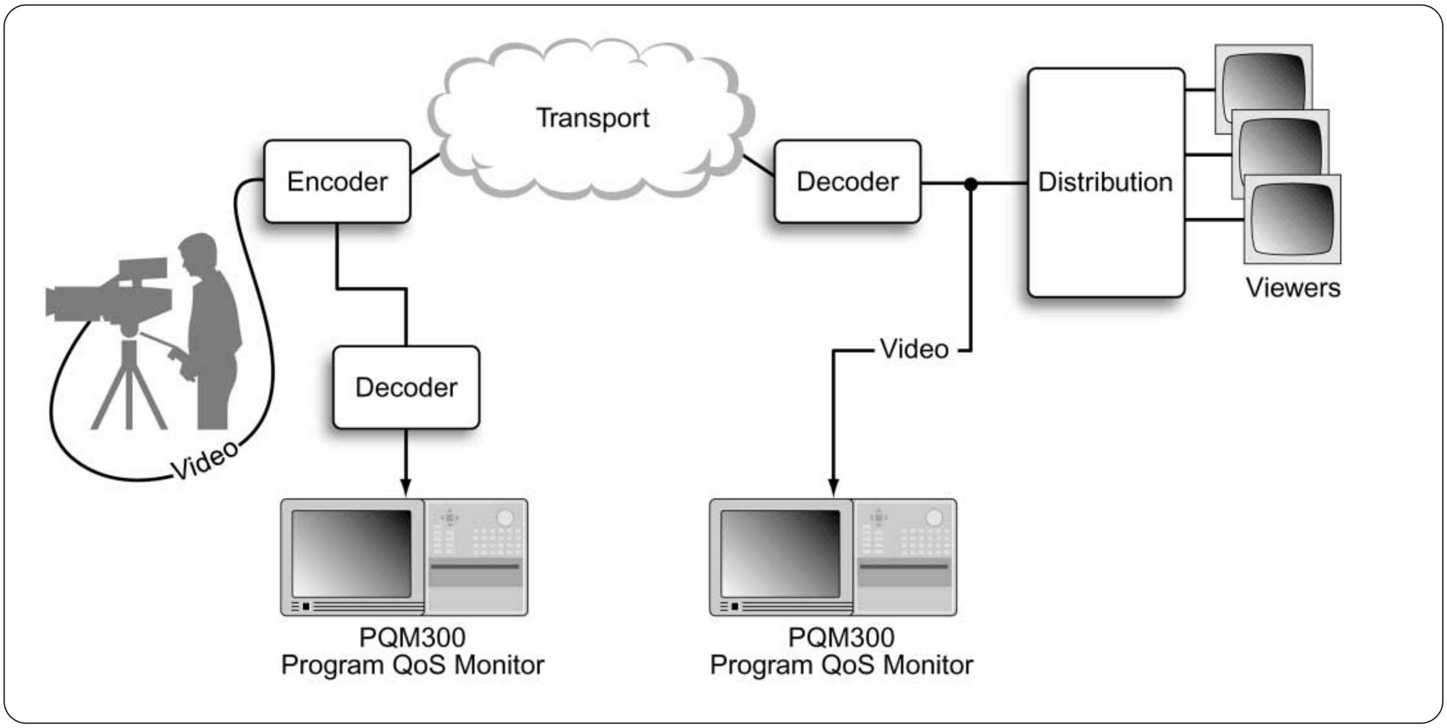
Figure 1. *"Blockiness" due to video compression.*

- Verifying quality of statistically multiplexed streams
- Verifying compliance with Service Level Agreements (SLA)
- Troubleshooting video transmission systems
- Increasing technical staff productivity and minimizing measurement errors

Monitoring Instrument Keeps Picture Quality in View

Fortunately there is an elegant solution for monitoring digital video streams, detecting errors, and logging the errors as well as the events that preceded and followed them.

The Tektronix PQM300 Program VQoS Monitor is an integrated tool that uses the PDI quality scale, which correlates closely with the Picture Quality Rating (PQR) scale when the errors in the video are MPEG blockiness errors. This technology has been proven to accurately reflect real viewers' reactions, minus the normal human tendency to



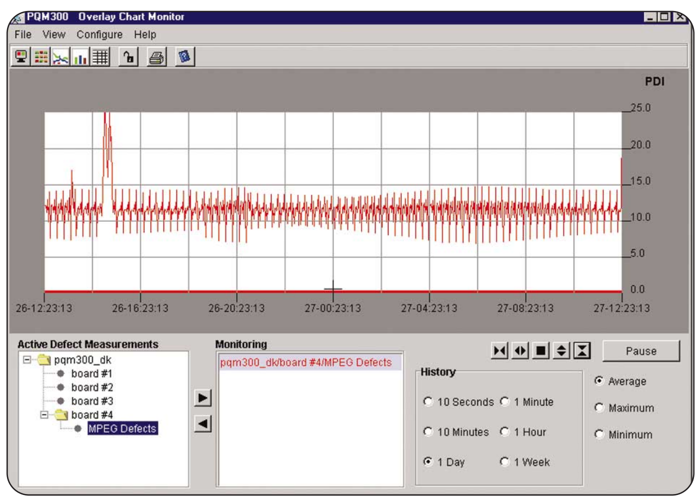
▶ ***Figure 2.*** *A basic VQoS monitoring setup.*

become bored, tired, or distracted. The PQA series is intended to minimize the need for "live" viewing trials, which are both costly and subjective.

The PQM300 is a single-ended instrument that requires no reference image to make its determinations. It examines the incoming video stream for MPEG compression artifacts such as blockiness, as well as detecting Gaussian noise (which sometimes occurs when there are analog elements in the transmission chain). The PQM300 also assists in the detection of frozen frames and loss of service. The instrument monitors up to eight channels simultaneously.

The PQM300 can be connected to monitor the video stream at any or many points in a network. Figure 2 depicts a typical installation that will be the basis for the discussion to follow.

Connected as shown in Figure 2, the PQM300 is a valuable tool for capturing the VQoS performance of a transmission system. It can accumulate error data for hours, days, or weeks and produce a graphical display of the result, as shown in Figure 3. This chart represents a one-day accumulation.



▶ ***Figure 3.*** *Quantitative Picture Quality Ratings measured by a PQM300.*

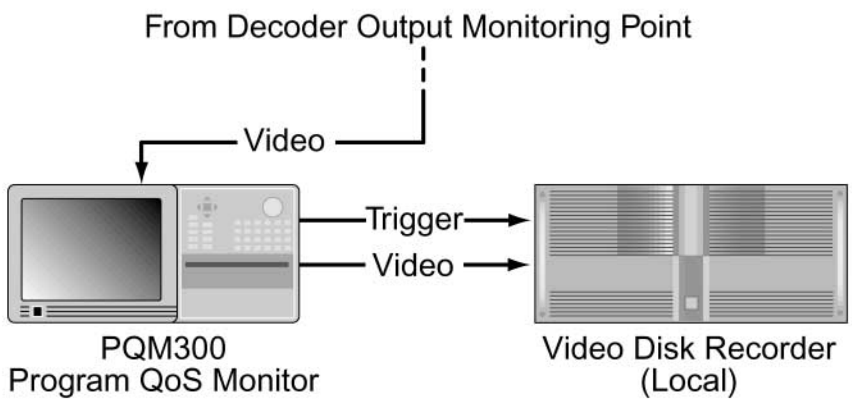


Figure 4. *Connecting the PQM300 to trigger video capture when errors are detected.*

Much like a strip chart recorder, the display plots hundreds or thousands of points. As the graph shows, there is a fairly consistent "background" error level punctuated by occasional spikes of much greater magnitude. Here the vertical scale is expressed in PDI units, with higher readings indicating poorer picture quality.

The PQM300 allows you to set PDI thresholds that reflect the error levels specified in your SLAs and/or VQoS policies. When the instrument detects a threshold crossing, it logs and timestamps the event, and takes other actions as described below.

The PQM300 is designed to show you how many errors are detected, their severity, and when they occurred. The PQM300 can also help you take the next step in tracking down the cause of the problem.

Triggered Video Capture

The PQM300, when it detects an error that exceeds the user-specified threshold, responds with an alarm indication that is viewable on the instrument's display screen. Color-coded icons on the display (green for normal operation, red for current errors, and yellow for historical errors) indicate the status of each of the eight video streams coming into the instrument.

For the purposes of troubleshooting and VQoS characterization, the PQM300 can also take additional alarm-related actions:

1. Issue an SNMP message to trigger a local external video disk recorder, such that the recorder captures a passage of video surrounding the error event.
2. Send an SNMP message via the Internet (TCP/IP) to a remotely connected video disk recorder equipped with user-created software that receives and acts on the message.
3. The instrument can also activate a relay closure when an error is detected, or sound an audible alarm.

The first two actions are forms of triggered capture. The PQM300 does not itself record video, but it offers a means of capturing the actual video content surrounding an error event. The PQM300's triggering features ensure that only the content of interest is actually stored in a permanent record.

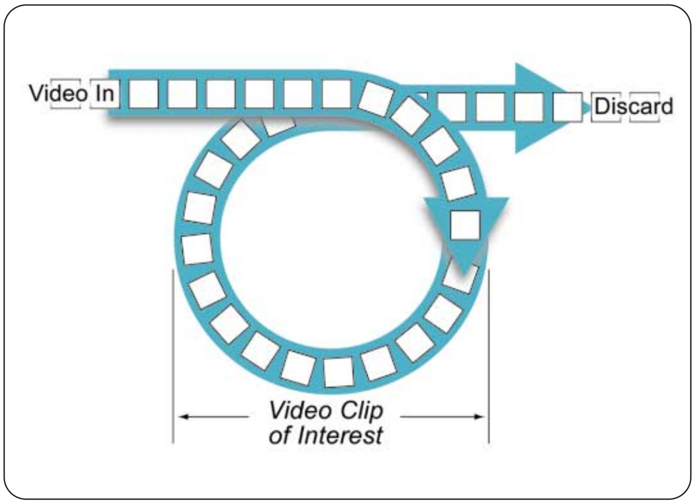


Figure 5. *The video recorder circulates a loop of video until it receives a trigger command from the PQM300.*

That record resides in a high-quality video disk recorder such as the Grass Valley Group ProfileXP Media Platform. The unit is connected as shown in Figure 4 to continuously record a loop of the incoming video (the actual recording time is arbitrary). Note that the video signal passes through the PQM300 on its way to the recorder.

Within the video disk recorder, the oldest material is discarded as new frames come in, as shown in Figure 5. This first-in, first-out process goes on until an error notification – the trigger signal – comes in from the PQM300.

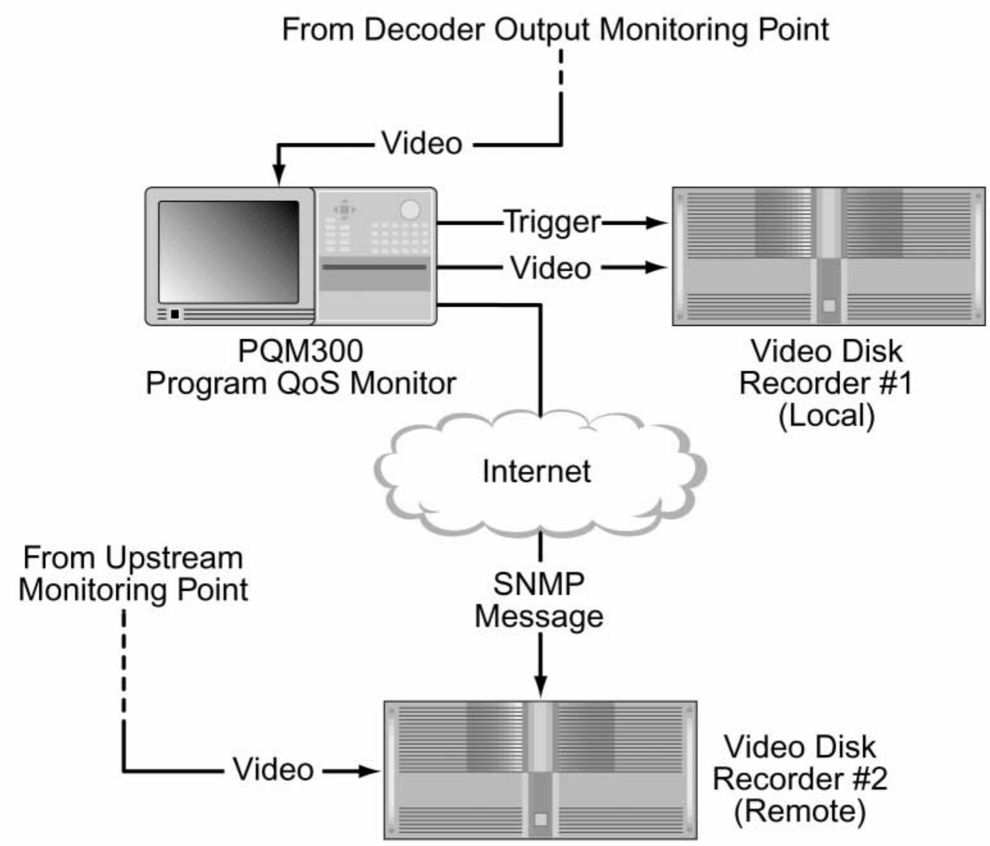
When the recorder receives the trigger, it continues recording the loop for another few seconds, then "freezes" the material that is in the loop. It then timestamps the whole package and stores it in a permanent file on the disk.

The result? Now you have a segment of video content that is known to contain a defect of some kind. Moreover, you know when (in absolute time) that defect occurred. Therefore, it is possible to correlate the spikes from the PQM300 error display with actual, viewable events. You can see the nature and degree of the defect.

The video information is efficiently stored because you, the user, choose the amount of time that is captured as well as the magnitude of the defect that causes a trigger to occur. Using the triggered capture technique, you can accumulate video defect files for days or weeks without exceeding the capacity of the recorder.

Expanding the System

As explained earlier, the PQM300 is a single-ended system. It determines picture quality based on fixed internal standards rather than comparing images to a reference signal (that is a job for the Tektronix PQA300, a laboratory-quality analysis system). However, thanks to its ability to send an SNMP message when it detects an error, the PQM300 can assist network-wide monitoring and troubleshooting efforts.



▶ ***Figure 6.*** *Triggered video capture can span multiple points in the network.*

Figure 6 shows a basic hookup involving a PQM300 and two video disk recorders. The PQM300 is at the receiving end of the transmission chain; here it is connected to the decoder output, as shown earlier. The local disk recorder captures defective video after its transit through the network.

A second video recorder is connected upstream, at the opposite end of the transmission chain. The two recorders may be in the same building or on two different continents. The remote recorder captures the video signal before it is encoded and before its passage through the network. Like the local recorder connected to the PQM300, it circulates a loop of video.

When the PQM300 detects an error, it issues a local trigger command and sends an SNMP message simultaneously via the Internet. With appropriate user-written software, this SNMP message triggers the remote video recorder to freeze the video segment. Note that the two recorders need not be synchronized with each other. Each machine stores a timestamp with the captured content, so it is possible to identify every segment by its absolute time reading.

The SNMP message can drive multiple video recorders connected at various points in the transport stream. This makes it easy to localize the source of picture quality problems, and to see exactly where cumulative signal degradation begins to become objectionable.

The TCP/IP connection from the PQM300 to the Internet is not limited to SNMP messages only. The PQM300 can also send error data files and other information to a central management console for evaluation (optional; not shown in illustrations).

Summary

The Tektronix PQM300 Program VQoS Monitor is a proven tool for real-time monitoring of compressed digital video streams. Combining the error detection power of the PQM300 with the video capture capability of one or more hard disk video recorders creates a powerful 24 hour, 7 days per week monitoring system. This system can provide both quantitative error readings and the actual video that contained the errors. It is an effective solution to support today's aggressive VQoS strategies and bandwidth-allocation schemes such as statistical multiplexing.

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