Advanced C37.94™ Pass-Through Testing

In-Line Monitoring & Intrusive Testing with TX340s

Although IEEE C37.94™ is not new, this simple mode of low-rate optical point-to-point communication links has been gaining attention in the past few years. This is mostly due to Power Utilities migrating their core network from Time Division Multiplexing (TDM) to Packet Switched Network (PSN) architecture (e.g., Ethernet, MPLS, etc.) – all while trying to avoid triggering a major overhaul of their teleprotection monitoring and relay devices. Network Equipment Manufacturers (NEMs) have also been busy developing legacy line cards for their new utility-oriented switches and aggregation points, which are being deployed during this TDM-to-PSN transition.

Based on 2.048 Mbps line rate (same as E1), C37.94 was meant for direct point-to-point optical links to replace troublesome copper cables in their high-voltage environments. But in reality, the utilities' communication network first evolved into PDH, then to SDH/SONET. Different means were created to convert, multiplex and map C37.94 payloads into PDH/DSn and SDH/SONET, to be transported along other services, such as voice, data, video and even encapsulated Ethernet, over a Multi-Service (TDM) Transport Network. The optical-to-electrical C37.94-to-E1 conversion was either done by a separate add-on box or built into special line cards loaded into the PDH/DSn or SDH/SONET multiplexers.

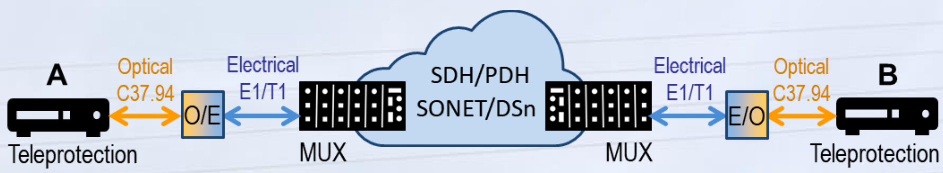

Figure 1. C37.94 over Multi-Service (TDM) Transport Networks using Optical-Electrical (E1/T1) converters.

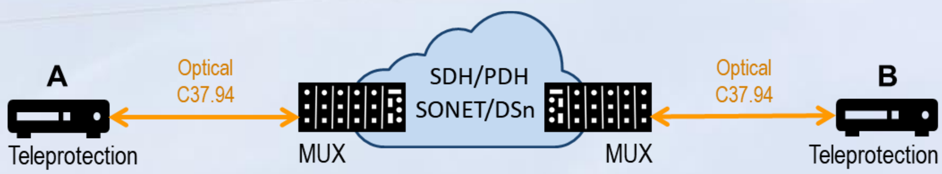

Figure 2. C37.94 over Multi-Service (TDM) Transport Networks using native line cards in the multiplexers.

Although Figure 2 looks like a cleaner solution, users have to depend on the information provided by the multiplexer to monitor links' health, but they differ from vendor to vendor. Because of this, some prefer the external converter approach in Figure 1, where testing, monitoring, troubleshooting, stressing and verification are easier at the E1/T1 level, since PDH tools or test sets are widely available.

Even though TDM networks are synchronous, transparent, predictable, extremely reliable and stable, and they allocate dedicated physical bandwidth to each client, it is hard to ignore the global trend of packetizing. Packet switched networks (PSN) have become the modern trend, whereas the external optical-electrical adapter approach is no longer practical. Some form of circuit emulation (CE) is used to transparently mimic C37.94 links across the packet network. The caveat is that PSNs are asynchronous in nature, bandwidth is shared, and end-to-end connections are "soft" or logical, not physical. This creates some levels of uncertainty and require certain techniques or technologies to compensate for packets' behavior. It also triggers the need for more testing to guarantee end-to-end transparency.

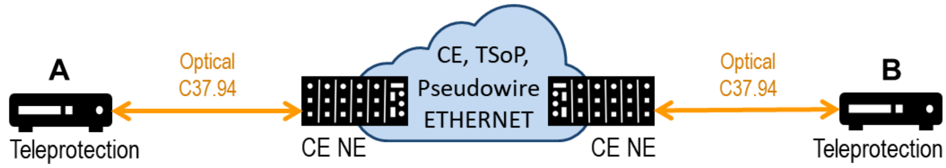

Figure 3. C37.94 over Hybrid Multi-Service (PSN) Transport Networks using native circuit emulation (CE) cards in the access switch.

The Need for Active Pass-through Testing

Normally, we do not advocate for the use of active pass-through equipment in-line with live links and users' traffic. But in this case, with the simplicity of C37.94, the temporary nature of such tests and much quicker setup (compared to adding protective monitor points), the benefits outweigh any potential risks. Keep in mind that the application is for construction, link activation, troubleshooting and lab tests. Nonetheless, be cautious as the in-line test set acts as a repeater, and any problems caused by optical power or attenuation issues may be masked. Thus, check for proper signal levels and transceivers' health first.

VeEX® has offered passive bi-directional monitoring for many years, on cases where splitters can be added as protective monitoring points that tap into the signals and monitor live traffic frequency, framing, alarms or errors. But this is not always possible with C37.94. By customer request, VeEX has developed and introduced its Advanced C37.94 Pass-Through Monitor test mode option (499-05-863) with intrusive Error Injection. It takes advantage of the dual SFP test ports available in the TX340s test set, acting as an active repeater. The test mode option provides direct access to the traffic in both directions and allows some level of manipulation. Being in the middle allows it to act as a monitoring as well as a simple impairment generator capable of stressing certain parameters on the links, line card, network equipment (multiplexer of switch), CE, and PSN or TDM.

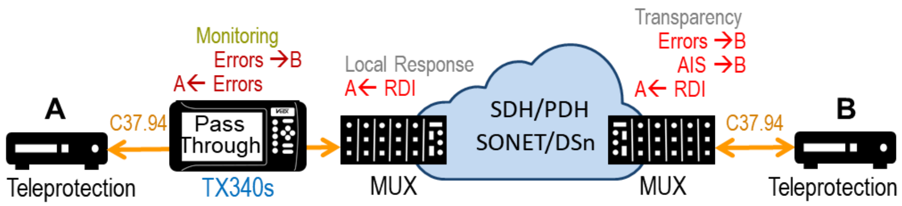

Figure 4. C37.94 intrusive pass-through testing in Multi-Service (TDM) Transport Networks.

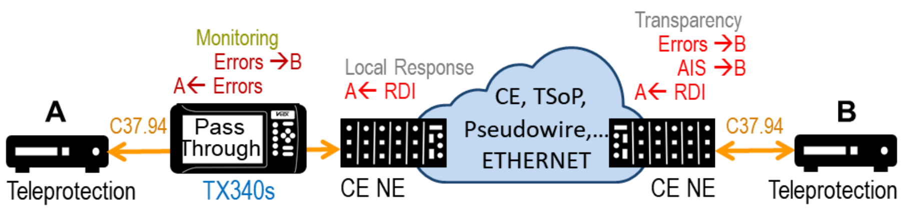

Figure 5. C37.94 intrusive pass-through testing in Hybrid Multi-Service (PSN) Transport Networks.

Utilities and NEMs labs use the Pass-through Monitoring and Intrusive Error Injection to validate their network architecture designs and guidelines, as well as evaluate, benchmark, and verify compatibility among different vendors during the implementation phase. This ensures that all the pieces work together seamlessly and transparently. This is valid in the TDM network approach and even more so when moving into the PSN transport/core. The same functionality is then used by construction crews to verify that all connections and settings are correct, that the system works as intended, as well as by maintenance technicians for troubleshooting purposes.

The test set can send C37.94 errors or alarms in either direction to verify proper responses from the neighboring network elements, the CE adaptation layers, far end devices, as well as verifying proper transparency across the PSN.

Test Setup & Results

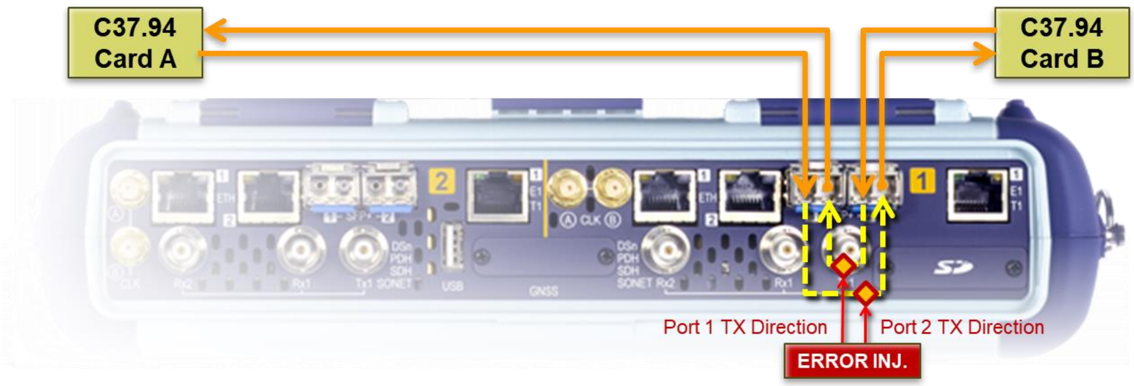

Figure 6. External connections, internal pass-through routing (yellow) and Error/Alarm Injection capability.

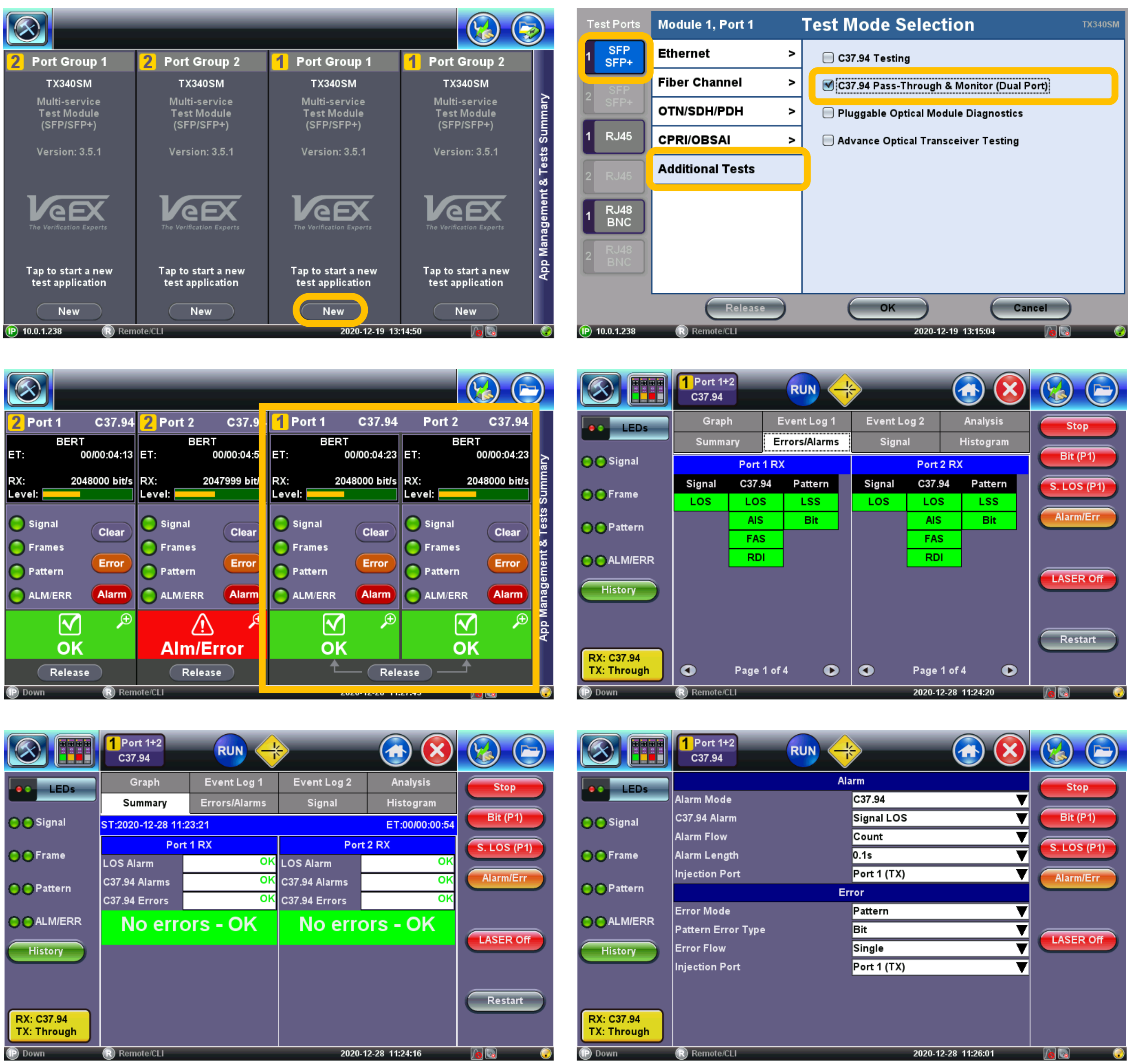

Figure 7. Sample setup, results and alarm/error generation screens from TX340s.

Monitoring Applications

- Measure Errors, Error Rate thresholds.
- Report Alarms and defect indicators.
- Frequency Offset (inaccuracy) and transparency of circuit-emulated links across the asynchronous packet network. Verify that clock settings of edge switches and teleprotection muxes/terminals/cards are correct.
- Data alignment and time slot realignment.
- Service disruption effects from APS events.
- Quick setup compared to adding attenuated monitoring points (any signal attenuation would change the test conditions and link behavior).
- Simultaneous side-by-side visibility in both directions.

Intrusive Impairment Generation

- Alarm Generation: LOS, LOF, AIS, RDI (Yellow).
- Error Injection: Frame Errors, Bit (Test Sequence) Error.
- Verify proper network response to simulated errors and alarms. Isolate problems by testing in each direction.
- Verify network response to high bit error rates (BER) to validate stablished thresholds and network response.
- Verify end-to-end transparency for alarm and defect indication signals.
- Induce APS events to verify network recovery settings.
- Frequency Offset generation (in terminal mode) to verify proper clock transparency and recovery functionalities and pulling range.

Other Important C37.94 Link Tests

- GNSS-assisted One-way delay (OWD) to identify end-to-end latency asymmetries and validate that existing delays are constant. If no access to satellite signal is available, point-to-loopback Round Trip Delay (RTD) is used as an alternative.
- Output Jitter and Wander measurements, to verify that packet delay variation in the PSN does not affect the links. The limits were introduced in IEEE Standard C37.94™-2017.
- Check Automatic Protection Switching (APS) time or Service Disruption Time (SDT), to verify that rerouting (due to network impairment or failure) doesn't affect the circuit-emulated links in unpredictable ways.
- Of course, out-of-service end-to-end Bit Error Rate Testing (BERT) to confirm link transparency and stability under different packet traffic loads,

Ordering Information

The Advanced C37.94 Pass-Through functionality is available as a software option for the TX300s platform with TX340s module.

- 499-05-662 IEEE C37.94 Optical Interface Testing (requires dedicated SFPs and ST/BFOC cables).
- 499-05-863 Advanced C37.94 Dual-port Monitor & Pass-Through with Error injection.
- 499-05-856 IEEE C37.94 Jitter and Wander. Includes Jitter Measurement, Jitter Generation and Wander Measurement.

About VeEX

VeEX Inc., a customer-oriented communications Test and Measurement company, develops innovative test and monitoring solutions for next generation telecommunication networks and services. With a blend of advanced technologies and vast technical expertise, VeEX products address all stages of network deployment, maintenance, field service turn-up, and integrate service verification features across copper, fiber optics, CATV/DOCSIS, mobile 4G/5G backhaul and fronthaul, next generation transport network, Fibre Channel, carrier & metro Ethernet technologies, WLAN and synchronization.

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