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APPLICATION NOTE 4896

Frequently Asked Questions About Maxim's Time-Division Multiplexingover Packet (TDMoP) Techniques

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Abstract: This application note provides a series of frequently-asked questions (FAQs) and answers that can be used to better understand Maxim's time-division multiplexing over packet (TDMoP) techniques and products.

Introduction

This application note focuses on Maxim's TDMoP product line. The article provides a series of frequently-asked questions (FAQs) and answers that can be used to better understand TDMoP techniques, modes, and terms. The products featured here include the DS34T10x, DS34S10x, or DS34S132. The DS34T10x comprises the DS34T101/DS34T102/DS34T104/DS34T108. The DS34S10x comprises the DS34S101/DS34S102/DS34S104/DS34S108.

Packet Protocols

What Is a TDM Pseudowire (PW)?

A TDM PW is a standardized type of packet used to pass a TDM data stream through a packet-switched network. The PW creates a tunnel (delivery method) through the packet switch network (PSN). A PW not only passes the data, but can also pass the timing associated with the data. The most complex part of the process is accurately recreating the timing of the originating TDM data stream so that the recovered TDM data stream is not constantly speeding up and slowing at levels that would exceed the required jitter/wander limits.

What Is the Primary Difference Between a CES PW Payload and SAT PW Payload?

The circuit emulated service over a packet-switched network (CESoPSN) and structure-agnostic TDM over Packet (SAToP) protocols define how the data of a T1/E1 line is carried in a PW packet payload.

The CES method is used to carry Nx64 (i.e., fractional) T1/E1 signals. The CES payload byte aligns the T1/E1 data and specifies where each byte is carried in the PW packet payload. The framing pattern of the T1/E1 signal is commonly terminated and not forwarded by the CES PW. For a T1 line, the CES payload carries 24 bytes of data (the 193rd, framing bit, is not included). For an E1 line, the CES payload carries 31 bytes of data because the first framing byte is not included. This technique enables packet processing circuits to monitor more easily, and allows the CES method to modify the data as the packet is forwarded through a PSN. If one were to look at a captured/stored CES packet on a protocol analyzer, it would be possible to identify each byte according to its position within the payload section (e.g., "this is DS0 #17."). The CES payload size is programmed according to how many frames and how many DS0 timeslots (64kbps units) are carried in the payload.

The SAT method is used to carry full T1/E1 frames. The SAT payload does not identify the location of the T1/E1 bits. If one were to look at a captured/stored SAT packet on a protocol analyzer, it would not be possible to determine the purpose/use of any of the SAT payload bits except to say that it is "one of the T1/E1 bits." The SAT method is only used to carry the entire data stream from a TDM port. The data stream may not even include a T1/E1 framing signal (e.g., 1.544Mbps high-level data link control, HDLC). The SAT payload size is programmed as a byte count (e.g., 256 bytes per payload). The SAT method is not affected by the 193-bit-per-frame T1 signal because it does not identify where each T1 frame starts and stops.

Why Are There Multiple PW Header Types (MEF-8, MPLS, UDP/IP, L2TPv3, IPv4, and IPv6)?

The PW header type is chosen to match the network capability, such as for a Multiprotocol Label Switching (MPLS) network. Some end-user networks do not specify what PW header is used. Other networks require that the TDM PW packets use a particular PW header type. Maxim's TDMoP devices can generate these above-mentioned PW headers.

What Is the AAL1 (ATM Adaption Layer 1) PW Used for?

This protocol is only supported by the DS34T10x and DS34S10x families of TDMoP devices. It is useful when the device is used in an ATM network. For example, some parts of the mobile network currently use ATM switches. The AAL1 PW protocol uses a format that mimics the AAL1 cell format so that the payload can be more easily translated between ATM cells and PW packets.

Operations

What Does High-Level Data Link Control (HDLC) Have to Do with TDMoP?

T1/E1 lines often carry a mixture of pulse code modulation (PCM) and HDLC on different DS0s. The user has two options with HDLC data: either ignore the fact that the data carries HDLC coding and forward it in the same way that PCM is forwarded when using a TDM PW; or decode the HDLC data stream, removing all of the idle characters and HDLC coding, and forward the remaining data at the Ethernet port using an HDLC PW when not using a TDM PW. The HDLC PW differs from the TDM PWs because there is no timing associated with the HDLC PW packets. HDLC PW packets are only transmitted when an HDLC packet exists on the T1/E1 line. If the HDLC data stream is mostly idle characters (e.g., on/off hook signaling for a single telephone), then the HDLC PW can be more efficient. Otherwise use of the TDM PW is recommended.

How Many Bytes Should I Include in the Payload?

It is almost always important to minimize latency. The latency is directly affected by the payload size, so the payload size is usually set as small as the equipment bandwidth will allow. It is worth noting that the PW bandwidth becomes increasingly less efficient as the payload size is reduced. In some cases, the TDMoP device operates in a system that uses specific timing constraints. For example, some mobile systems use low-bit-rate voice encoding techniques that process voice data in 8ms blocks. This kind of system can benefit from a PW payload size that equates to 8ms of voice data. Other systems can be very sensitive to latency and require that the latency not exceed 1ms. There is no standardized rule for latency. When Maxim TDMoP devices generate packets, the maximum size of the data and the padding field is 1500 bytes. If the payload to be transported is less than 46 bytes, then padding is used to bring the frame size up to the minimum length. A minimum length Ethernet frame is 64 bytes from the destination address field through the frame check sequence.

Can TDM PWs Be Used to Implement a Telecom DS0 Cross-Connect?

Yes. A TDMoP device can be used to implement portions of a synchronous DS0 cross-connect. All data streams must be synchronized to each other, and many of the functions must be implemented externally to the TDMoP device (e.g., telephony signaling). If ACR is used to synchronize remote endpoints, then the system will be susceptible to systematic PDV which can cause the device not to meet the wander mask. The clock-recovery settling time will also be an issue with this systematic PDV. Only customers with expert knowledge in the design of this equipment type should attempt this application. Maxim does not have the expertise to analyze, solve, or support this type of system.

Clock Recovery Timing Modes

What Is Differential Clock Recovery (DCR)?

The clock recovery algorithm in DCR uses real-time transport protocol (RTP) timestamps. The sending side uses a high-accuracy clock to generate timestamps that identify when each packet is transmitted. The receiving side must have access to the same/common clock (frequency, e.g., GPS timing) and use the difference between each received RTP timestamp to regenerate the T1/E1 timing. A common clock reference is available for use by public network equipment at nearly every public network node. DCR timing recovery is primarily influenced by the accuracy of the common clock. As long as the common clock is a high-quality source (e.g., a Stratum 3 clock), DCR will provide better timing recovery than adaptive clock recovery (ACR).

What Is Adaptive Clock Recovery (ACR)?

ACR timing recovery is based on the rate at which packets are received. It does not use an RTP timestamp. Although Maxim's TDMoP products can generate an RTP in the ACR method, this RTP is not part of the clock recovery algorithm. Since the network between the two PW endpoints adds a constantly changing delay to the transmission of each packet, the ACR technique can be affected by the packet delay variation (PDV). The constantly changing network delay affects when the packet is received. The complex DSP timing recovery algorithm filters out high-frequency PDV. However, some systems can introduce a systematic PDV with frequencies that are too slow to be practically filtered out (example systems include GPON and EPON). Systematic PDV can result in a higher than expected timing wander, and the ACR techniques cannot guarantee Stratum 3-quality clock stability under these conditions. The degraded performance is caused by the PDV, not by the clock-recovery implementation. As long as there is no systematic PDV issue, the ACR technique can be expected to meet the Stratum 3 jitter/wander requirements.

The ACR technique does not require a common timing source at both PW endpoints and, therefore, may be perceived as an easier and cost-effective implementation. However, the ACR technique still requires a high-quality clock at both ends like an oven-controlled crystal oscillator (OCXO) or a specialized temperature-compensated crystal oscillator (TCXO). Most public network equipment is located at network nodes that have a stratum-level network timing source. In these cases using network timing can be more practical and cost efficient, while also providing better timing performance.

In adaptive mode for low-speed interfaces (up to 4.6MHz), an on-chip digital PLL (clocked by a 38.88MHz clock in the DS34T10x and DS34S10x devices derived from the CLK_HIGH pin, and clocked by a 155.52MHz clock in the DS34S132 derived from the REFCLK pin) synthesizes the recovered clock frequency. The frequency stability characteristics of the CLK_HIGH or REFCLK signal depend on the wander requirements of the recovered TDM clock. For applications where the recovered TDM clock must comply with G.823/G.824 requirements for traffic interfaces, typically a TCXO can be use as the source for the CLK_HIGH or REFCLK signal. For applications where the recovered clock must comply with G.823/G.824 requirements for synchronization interfaces, the CLK_HIGH or REFCLK signal typically must come from an OCXO.

Definitions

What Does Operations, Administration & Maintenance (OAM) Mean?

For a T1/E1 Line, OAM generally means T1/E1 alarms, performance monitoring (PM), and loopback that are communicated with the T1/E1 framing pattern. PW alarm OAM is communicated using the L-bit and R-bit in each PW packet header. The TDMoP device also enables an external CPU to send and receive virtual circuit connectivity verification (VCCV) and Metro Ethernet Forum (MEF) OAM message/packets at the Ethernet interface. These message/packets are independent of the TDM PW packets. PW VCCV OAM can be used for functions like PW connection setup, PM, and maintenance. MEF OAM is an Ethernet protocol that can include IEEE® 802.1ag and other specialized Ethernet OAM functions (e.g., connection continuity checking).

Maxim's TDMoP products support the following three types of OAM packets:

1. **UDP/IP-specific OAM packets**: match between the packet's bundle identifier and one of the values (up to eight different) configured in the OAM ID configuration registers.
2. **VCCV OAM packets (in-band performance monitor)**: a 1- to 16-bit value is created according to the combination of the control_word_oam_mask_n configuration register and the control_word_oam_value configuration register. An OAM packet is identified when there is a match between this value and the control word (31:16) bits. Such a match is taken into account only when

the OAM_ID_in_CW bundle configuration bit is set.

3. **MEF OAM packets**: match between the packet Ethertype and the Mef_oam_ether_type configuration register.

What Does Time-Division Multiplexing (TDM) PW Timing Mean?

TDM PW timing is an abstract term meaning that a PW carries timing information for the originating T1/E1. A complex DSP algorithm is used to reconstruct/recover the TDM timing at the far-end PW endpoint. Timing can be recovered from a PW by monitoring the received packet rate (e.g., by ACR) or by monitoring RTP timestamps that are included in each received packet (e.g., by DCR). Some applications do not use PW clock recovery, but instead use local receive T1/E1 timing (loop timing) or use a local system clock (system timing).

What Is a Real-Time Protocol (RTP) Timestamp?

An RTP timestamp provides a 32-bit value that is used by the DCR technique and indicates the relative timing between successively transmitted packets. The RTP timestamp also indicates when a packet is transmitted. This method excludes the PDV that results as a packet is forwarded though a network.

What Is an OAM Timestamp?

An OAM timestamp can be attached to a OAM packet generated by a central processing unit (CPU). These OAM packets are independent of the TDM PW packets. The OAM timestamp can be used at a far end (receiving end) PW endpoint to identify when a packet was transmitted. Use of the OAM timestamp is outside of the scope of the TDMoP device; the CPU determines how OAM timestamps are used.

What Is a Local Timestamp?

The TDMoP device adds a local timestamp value to each packet that is received and forwarded to the CPU. In some applications it is beneficial for the CPU to know when the packet was received. Use of the local timestamp is outside of the scope of the TDMoP device; the CPU determines how local timestamps are used.

Conclusion

These IETF PWE3 SAToP/CESoPSN/HDLC-compliant TDMoP devices provide the interworking functions required for translating TDM data streams into and out of TDMoP data streams for L2TPv3/IP, UDP/IP, MPLS (MFA-8), and Metro Ethernet (MEF-8) networks. Maxim's TDMoP devices also meet the jitter and wander timing performance required by the public network (i.e., ITU G.823, G.824, and G.8261). Up to 32 TDM ports can be translated into as many as 256 individually configurable PWs for transmission over a 100Mpsp/1000Mbps Ethernet port. One high-speed E3, T3, or STS-1 stream can also be transported transparently over IP, MPLS, or Ethernet networks with only DS34T10x or DS34S10x devices. Each TDM port's bit rate can vary from 64kbps to 2.048Mbps to support T1/E1 or slower TDM rates. PW interworking for TDM-based serial HDLC data is also supported. A built-in time-slot assignment (TSA) circuit can combine any group of time slots (TSs) from a single TDM port into a single PW. The TDMoP devices' high level of integration provides the perfect solution for high-density applications. The devices minimize cost, board space, and time to market. Ideal applications include the followings:

- TDM circuit emulation over PSN
- TDM over cable
- TDM leased-line services over PSN
- TDM over wireless
- TDM over BPON/GPON/EPON

Cellular backhaul
- HDLC-encapsulated data over PSN
- Multiservice over unified PSN

If you have further questions about TDMoP products or any other aspects of using Maxim telecom products, please contact the Telecom Products applications support team. You will need to join Maxim's Member Center. After completing the membership sign-up process, please submit the support request online. The support-request form can be accessed using the Communications and Timing Support.

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Related Parts		
DS34S101	Single/Dual/Quad/Octal TDM-Over-Packet Transport Devices	Free Samples
DS34S102	Single/Dual/Quad/Octal TDM-Over-Packet Transport Devices	Free Samples
DS34S104	Single/Dual/Quad/Octal TDM-Over-Packet Transport Devices	Free Samples
DS34S108	Single/Dual/Quad/Octal TDM-Over-Packet Transport Devices	Free Samples
DS34S132	32-Port TDM-over-Packet IC	Free Samples
DS34T101	Single/Dual/Quad/Octal TDM-Over-Packet Chip	Free Samples
DS34T102	Single/Dual/Quad/Octal TDM-Over-Packet Chip	Free Samples
DS34T104	Single/Dual/Quad/Octal TDM-Over-Packet Chip	Free Samples
DS34T108	Single/Dual/Quad/Octal TDM-Over-Packet Chip	Free Samples

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