Power Matters

Time Interfaces

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Why do we need time?

- High accuracy
  - Wireless base stations
  - Mobile backhaul
- Lower accuracy
  - Delay measurements
  - Alarm messaging correlation between sites

Application Requirements for Time/Phase

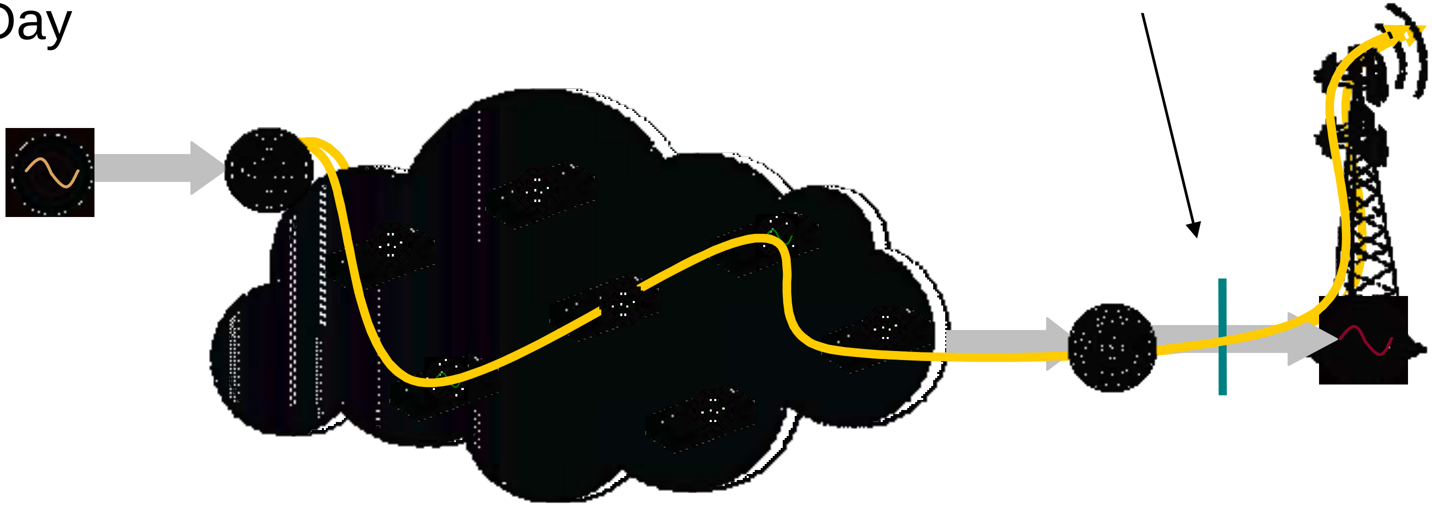
Application/Technology	Accuracy
CDMA2000	± 3 or ± 10 microseconds with respect to CDMA System Time
TD-SCDMA (NodeB TDD mode)	3 microseconds
WCDMA-TDD (NodeB TDD mode)	In TDD mode, the synchronization inputs shall not exceed 2.5 microseconds.
W-CDMA MBSFN	12.8 microseconds
LTE MBSFN	Values < +/- 1 microseconds
W-CDMA (Home NodeB TDD mode)	Microsecond level accuracy
WiMAX	The BS transmit reference timing shall be time-aligned with the 1pps pulse with an accuracy of ± 1 ms
LTE-TDD	3 or 10 microseconds depending on cell size
LTE-TDD to CDMA 1xRTT and HRPD handovers	± 10 microseconds with respect to CDMA system time
IP Network delay Monitoring	+/- 1 ms with respect to a common time reference (e.g. UTC)
Billing and Alarms	+/- 100 ms with respect to a common time reference (e.g. UTC)

Reference: ITU-T G.8271 Draft

Client Time Interface

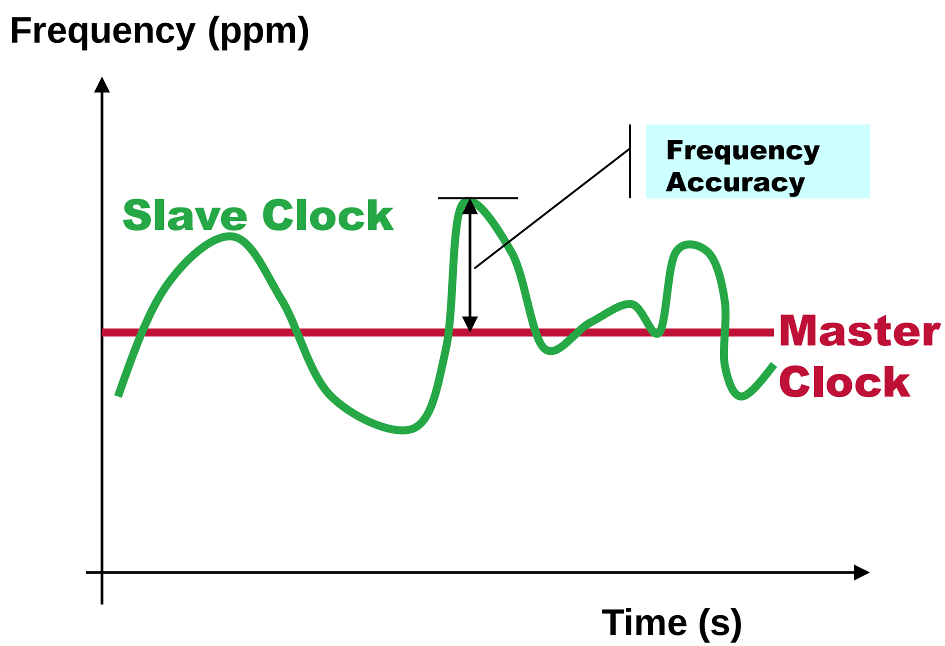
- Time boundary passes 3 types of information
  - Clock
  - Time Pulse / Frame Pulse
  - Time of Day
- May be used to transfer different types of timing information:
  - Frequency Accuracy (FFO)
  - Frequency (MTIE & TDEV)
  - Phase (Alignment/PPS)
  - Time of Day

Time transfer interface



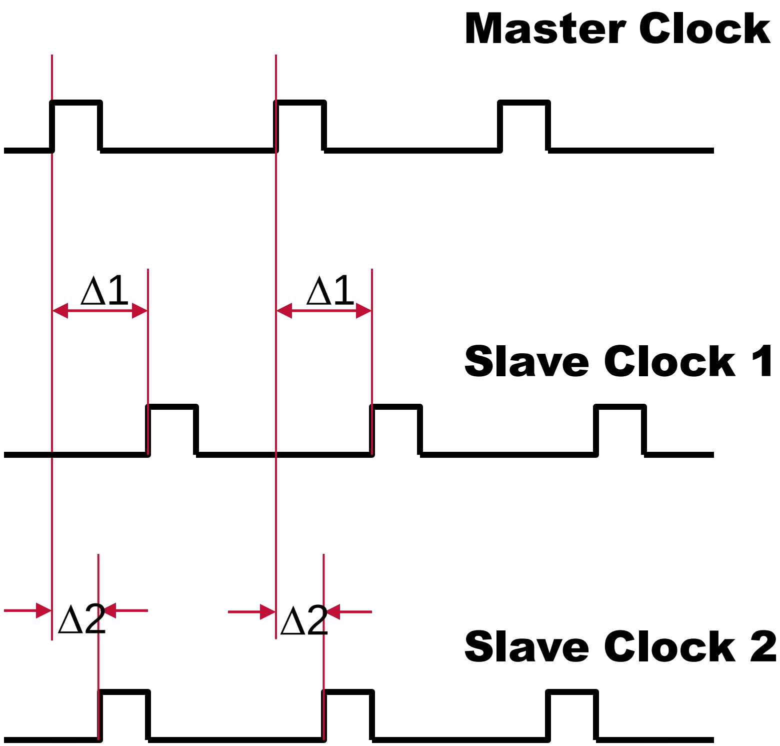
Timing Technology: Frequency Accuracy

- Frequency accuracy (FFO) is the difference in frequency between the server clock and the recovered client clock over a time interval
- Frequency targets
  - ± 32 ppm for Stratum 4 & 4E
  - ± 4.6 ppm for Stratum 3 & 3E
  - ± 50 ppb for GSM & WCDMA-FDD
  - ± 100 ppb for Home NodeB



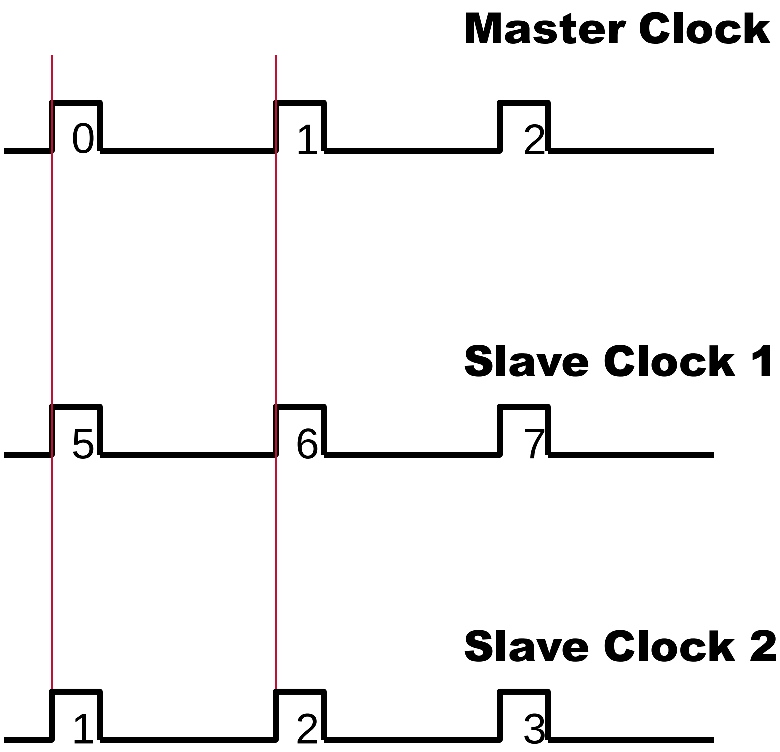
Timing Technology: Wander (Frequency)

- TIE, MTIE and TDEV
- Phase accuracy is the measurement of the change in phase of the recovered client in comparison with the server clock over a time interval.
- Phase targets for traffic interface
  - 18 µs MTIE for E1 from ITU-T G.823
  - 18 µs MTIE for T1 from ANSI T1.403
  - < 18 µs MTIE for E1/T1 from ITU-T G.8261
- Phase targets for synchronization interface
  - 2 µs MTIE for E1 from ITU-T G.823
  - 1 µs MTIE for T1 from ANSI T1.101



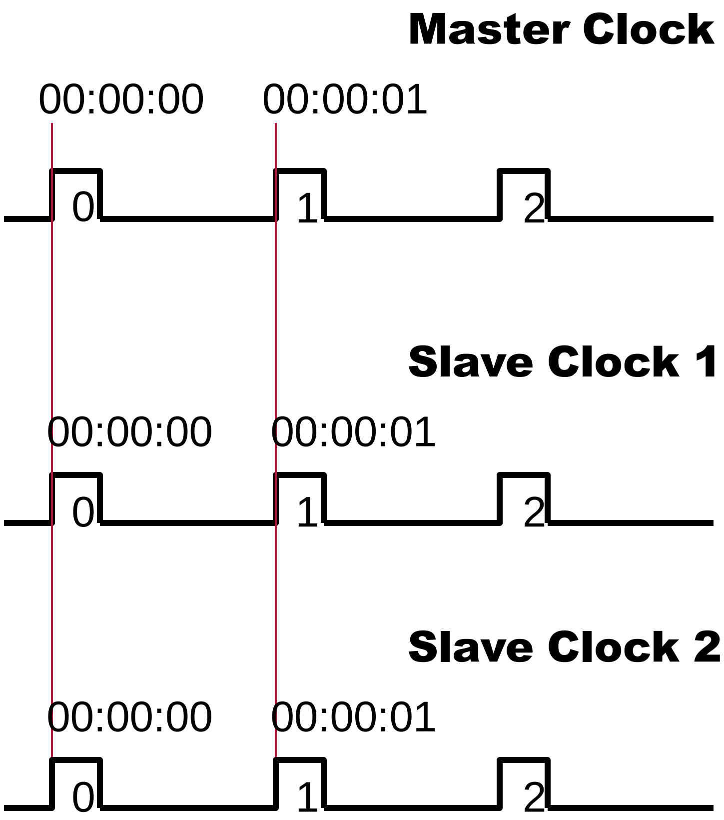
Timing Technology: Phase

- Alignment and PPS
- Phase alignment is in addition to phase lock. Phase alignment also referred to as Latency Correction.
- Phase alignment has
  - Bounded phase offset between server clock and recovered client clock
  - Bounded phase offset between different recovered client clocks
- Phase alignment requires bi-directional mechanism
- Phase alignment targets
  - ± 1.25 µs for WCDMA-TDD
  - ± 3 µs for CDMA2000, CDMAone
  - ± 1 µs for WiMAX



Timing Technology: Phase (Time of Day)

- Time of Day or Same Time is in addition to Phase Alignment.
- Time of Day is the ability to distribute the specific time of day in terms of year, month, day, etc. from the server clock to the clients.
- Time of Day normally requires a 1 PPS or 1 Hz signal at both the server and clients
- Time of Day targets
  - UTC/GMT time
  - GPS replacement

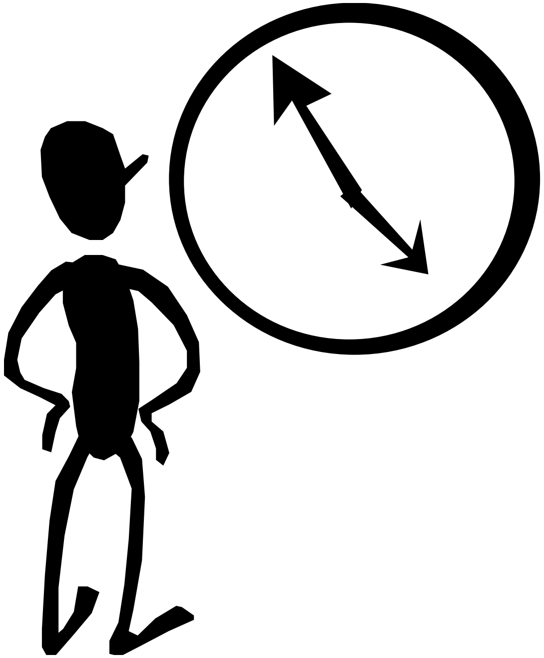


New Concepts for Phase/Time Transfer

- Coherency
  - Common time/frequency source
  - Different network for time and frequency
- Phase "holdover"
- One-way versus two-way methods

Challenges of the Time Interface

- Cabling types
- Maintaining accuracy of phase/time signal
- Compatibility with existing systems



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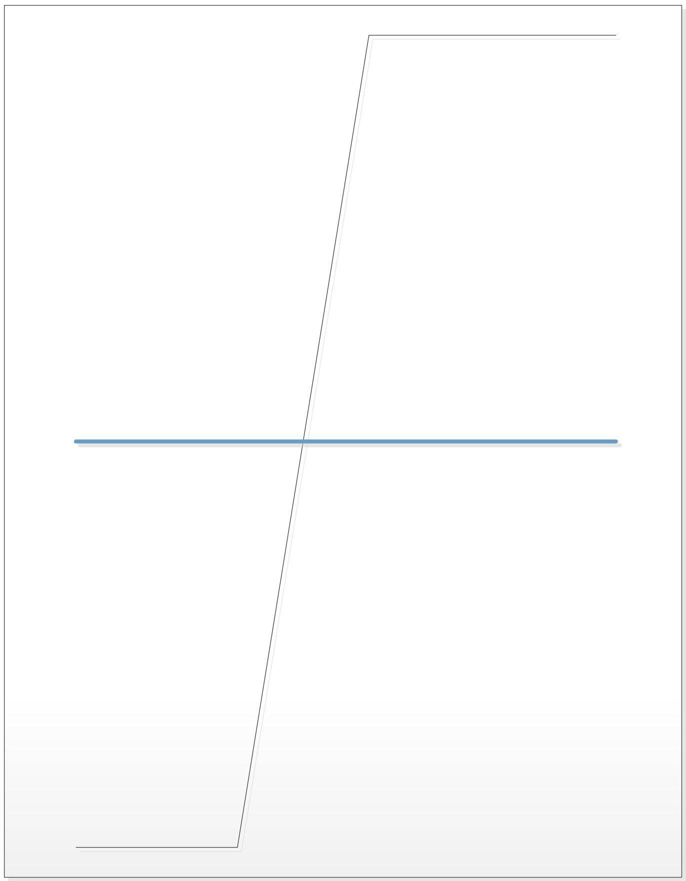
Working Environment Cabling

- Distance
  - Within a building
    - May need to go between floors
    - Less than 200 m (~700 ft)
  - Within a cabinet
    - Less than 1m (~3 ft)
- Cabling types
  - Twisted pair (DS1/Voice wiring)
  - Coax
  - Ethernet
    - Unshielded twisted pair

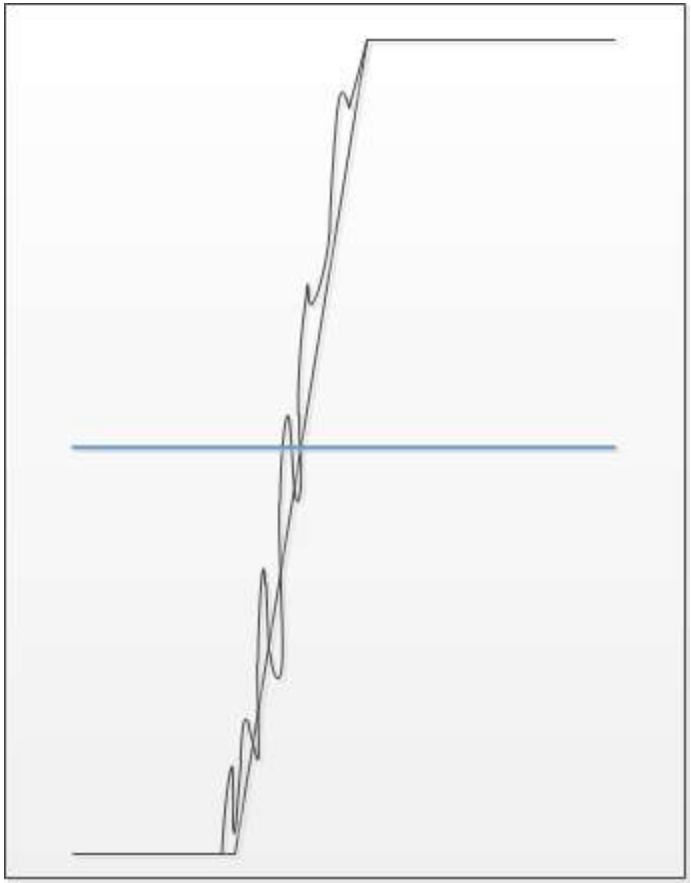
Working Environment
Problems with noisy clock signals - 1



- All clock signals have a rise time/fall time
  - Depends on driver, cabling and receiver
- Receiver uses a certain threshold

Problems with noisy clock signals - 2

- Noise on clock
  - Jitter on frequency
  - Random error in phase instant
- Need selected interface to work at all cable lengths and receiver types



Serial Interfaces

- TIA/EIA RS-232 (single ended)
- TIA/EIA RS-422/RS-485 (differential)
  - Common Mode Range
    - RS-422 has range of +/-3 V
    - RS-485 has range of -7 to 12 V
  - RS-485 meets all RS-422 requirements and allows longer line lengths
- ITU-T V.11 – Compatible with RS-422

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Commonly used interfaces

- Frequency
  - Clock
  - DS1/E1
  - SONET/SDH
- Phase pulse
  - 1 PPS (and other pulse rates)
- Time-of-day over serial
  - NMEA-0183
- Combined Phase and serial time-of-day
- Frequency/Phase/Time-of-day
  - NTP
  - PTP
  - IRIG
  - PTTI

Frequency

- Different ways to provide high speed clock
  - 1/5/10 MHz, sine wave, 1 Vrms into 50 ohm (13 dBm), 0V centered over BNC
    - Normally 10 MHz
    - 0V-crossing point of sine wave against PPS rising edge is sometimes seen
  - G.703-13 2.048 MHz E1 sync interface clock, over BNC
    - Very common on 2G/3G base stations for sync input port
  - E1/T1, HDB3/B8ZS, all-ones or carrying traffic, over BNC or RJ-48c
    - Very common on 2G/3G base stations for traffic input ports
    - Traffic carrying ports may be assumed to be unreliable
    - Most, but not all, can tolerate traffic mask as filter down to 16 or 50 ppb
  - SyncE, Ethernet, RJ-45 or optical
    - Likely a traffic carrying port rather than a dedicated sync port
  - Composite Clock, 64 kbit/s
    - Not seen much outside USA
    - Not seen on base stations generally

Time Pulse / Frame Pulse

- Different ways to provide time pulse
  - PPS, 2.5V or 5V, TTL, Active High, Rising Edge Aligned over BNC
    - Very popular
    - Pulse width 100 ns – 200 ms
  - ESEC/PP2S
    - Same as PPS, but for some CDMA systems
  - PPM, PPD, PPH
    - Same as PPS, but lower rate
  - PPS over RS-422/RS-232 (DB9/DB25/RJ-45)

Two-way Interfaces

- Two-way packet
  - 1588 packets over IP/Ethernet link
    - for 4G base stations that are 1588-aware
  - NTP packets over IP/Ethernet link
    - normally legacy base stations used for billing & alarms
- Other two-way methods - DTI/UTI (ITU-T J.211)
    - Used in the cable industry
    - Not used in mobile backhaul

Serial Time Stamp

- ASCII-based time code
  - Implied clock instant
  - Proprietary (i.e. from Motorola GPS)
  - NEMA 0183
    - Example sentence: $GPGGA, Time, Lat, N, Long, W, Quality, Num of Sat, Precision, Altitude, M, Height, M,, Checksum
- General items in messages
  - Time stamp
    - Full date
    - Seconds since epoch
  - Status of GPS receiver
    - Locked, unlocked, error conditions
    - Number of satellites
    - Different status messages may be needed for other receivers of other GNSS systems

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Time stamp with clock

- Gives time code for instant defined by 1 PPS clock
- Advantages
  - Accuracy of 1 PPS clock pulse
  - Flexibility of serial time code protocol
- Examples
  - IRIG-B over 5V TTL BNC (primarily DCLS, but also AM)
    - IEEE 1344-1995 has extensions to IRIG-B
  - AFNOR NFS-87-500

Other Time Formats - IRIG

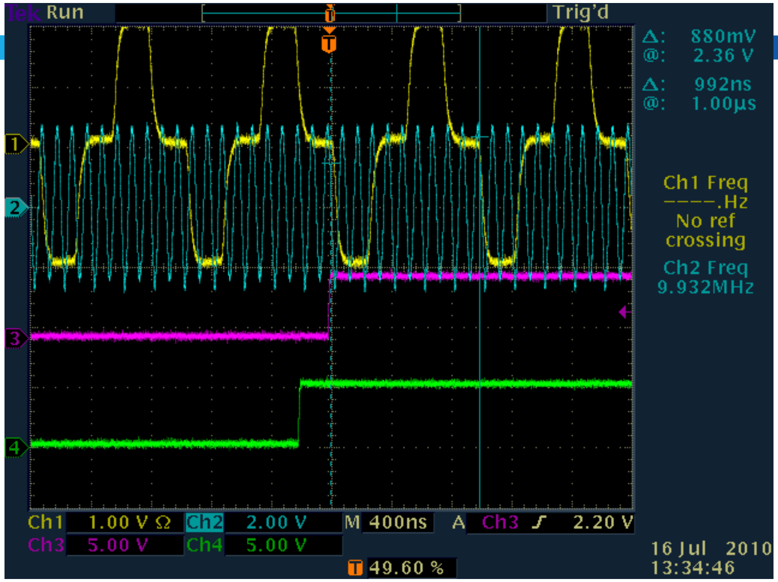
- Pulse rates
  - 1 pulse per minute to 10,000 pulses per second
- Form
  - DC Level Shift (DCLS)
  - Amplitude modulation
    - Carrier frequency (selected values from 100 Hz to 1 MHz)
  - Manchester modulation
- Time representation
  - Binary Coded Decimal – Time of Year (BCD_{TOY})
  - BCD_{Year}
  - Straight binary second (0 to 86,400)
    - 86,400 seconds = 24 hours

Other Time Formats – PTTI

- 1 PPS
  - 50 Ohm coax
  - Amplitude of 10 V
  - Rise time of less than 50 ns
  - Pulse width of 16 – 30 microseconds
- 2-wire balanced with 100 Ohm termination
  - BCD Time Code sent after the 1 PPS pulse
  - Voltage of 0 to 5.5 V (DC)
- Timing fault information (status)
  - 50 Ohm coax

Example Time Interfaces

- Channel 1 - E1 (G.703)
- Channel 2 - 10 MHz
- Channel 3 - 1 PPS
- Channel 4 - IRIG



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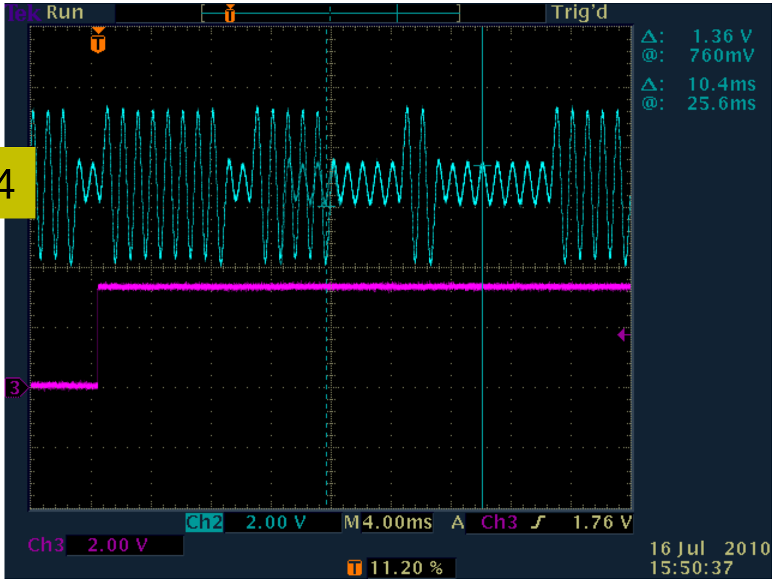

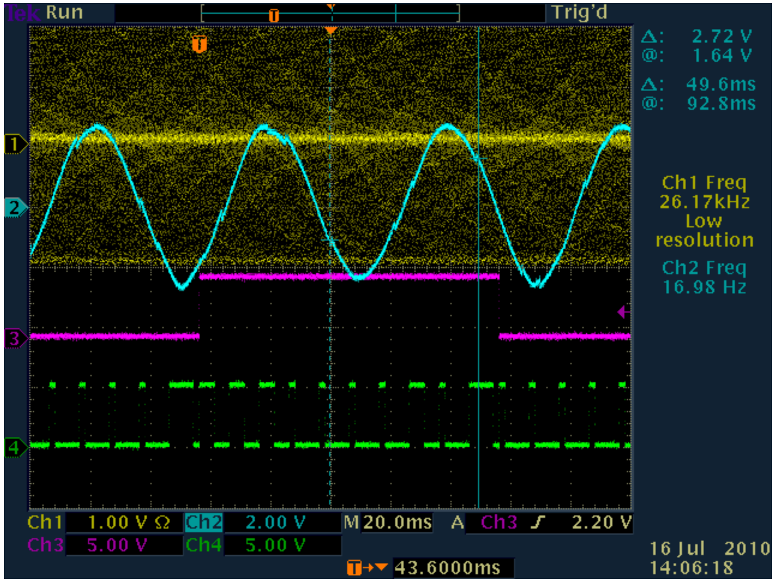

PTP as Time Interface

- Embedded PTP Clients allow manufacturers flexibility with internal architectures
- Defined interface with other equipment
  - Telecom profile for frequency – G.8265.1
  - Future telecom profile for time/phase – Proposed
- Easily testable using a probe or portable client at same point in network
- Flexibility to use the same hardware interface for different architectures
  - Local PRTC with PTP interface
  - PRTC from different location via BC

Long Term Solution – Embedded PTP Clients

- Need embedded PTP clients in all end equipment
- Leverage work on Boundary Clock in the network
- Internal processing of time and frequency information much easier problem to solve

Summary of Interfaces

Protocol	Physical layer	Standards	Frequency Transfer	Phase/Time Transfer
PTP	Copper or Optical	IEEE 1588 and 802.3	Yes	Yes
Serial time stamp formats	RS-422 or RS-232	Multiple	No	Yes
Serial and 1 PPS clock	V.11/RS-422	Company proprietary standards	Yes*	Yes
IRIG	Copper cable or coax	Yes	Yes	Yes
PTTI	Copper cable and coax	Yes	Yes	Yes
DTI	Copper cabling	Cable industry	Yes	Yes

Future of Time Interfaces

- Many interfaces work for the near term depending on the application
- Embedded PTP client should be the long term goal

Questions?

Selected Reference Documents

- ANSI/TIA/EIA-422-B Electrical Characteristics of Balanced Voltage Differential Interface Circuits, September 2005.
- IRIG Standard 200-04, IRIG Serial Time Code Formats, September 2004.
- ICD-GPS-060, GPS User Equipment (Phase III) Interface Control Document for the Precise Time and Time Interval (PTTI) Interface, 12 February 2002 (CAGE Code 3D619).
- NMEA 0183, Standard for Interfacing Marine Electronic Devices, Version 4.00, November 1, 2008.
- Telcordia GR-378-CORE, Generic Requirements for Timing Signal Generators, Issue 4, December 2010.