Power Matters

Microsemi

Improving Synchronization Standards

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Agenda

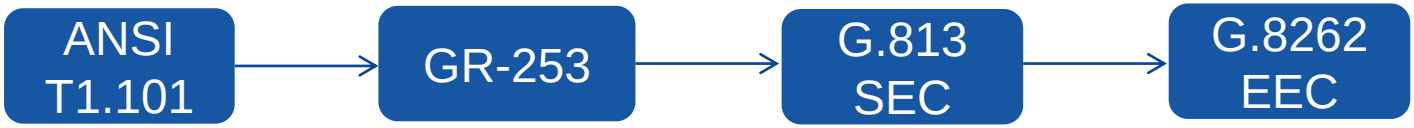
- Synchronization standards from user perspective
- Synchronous Ethernet G.8262
- Proposal for simple improvements G.8262+
  - Long term phase transients (holdover)
  - Short term phase transients

Synchronization standards

- Objective of standards is to clearly state what is needed, and not necessarily why it is needed.
- Standard is written by consensus between standard participants so requirements may not always be the most optimum solution—standard requirements are quite often compromise between conflicting interests.
- Telecom synchronization standards are built on 50 year synchronization history—Many standard requirements have long history for backward compatibility.

Synchronous Ethernet

- Synchronous Ethernet ITU-T G.8262 is closely based on SDH Equipment Clock ITU-T G.813 standard (almost carbon copy)-Why fix something which is not broken
- There are few requirements in G.8262 which are carried forward from old standard and which may not represent realty in the field.
  - Long term phase transients (holdover)
  - Short term phase transients

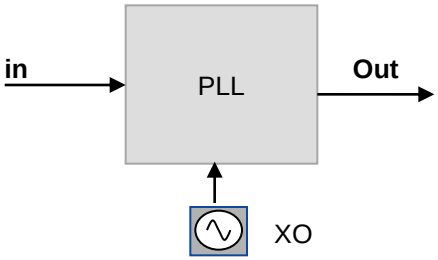


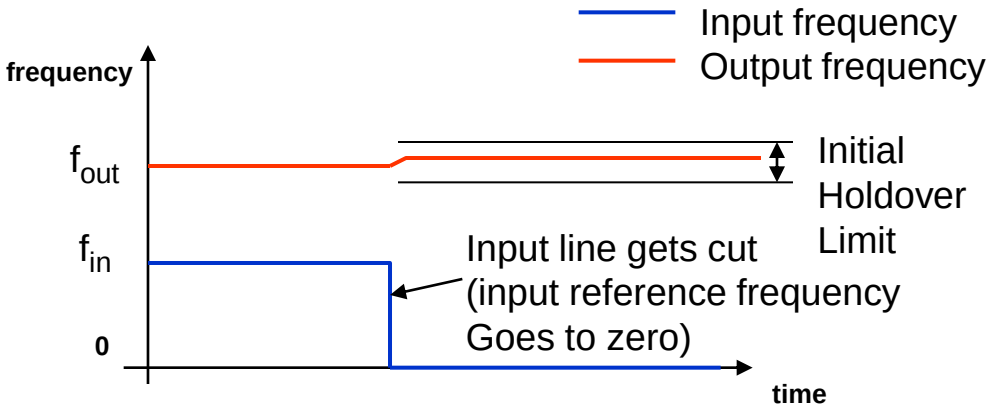
G.813 has many other dependencies but for the purpose of this presentation only relevant ones are shown

Long term phase transients

Long term phase transient (Holdover)

- Synchronizer constantly calculates the average frequency of the reference it is locked to, so that if the reference fails and none of the other references is available, the synchronizer goes into holdover mode where it generates output clock based on calculated average value. Holdover stability depends on resolution of the synchronizer averaging algorithm and on frequency stability of the oscillator used as synchronizer master clock.





Long term phase transient (Holdover) Cont.

$$DT(S) = \{(a_1 + a_2)\, S + 0.5\, b\, S^2 + c\} \quad [\text{ns}]$$

where:

a_1 = 50 ns/s (see Note 1);

a_2 = 2000 ns/s (see Note 2);

b = 1.16×10^{-4} ns/s^2 (see Note 3);

c = 120 ns (see Note 4).

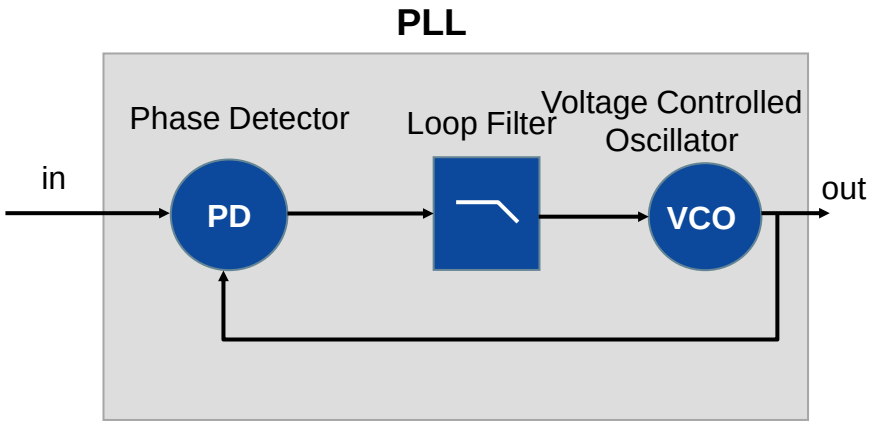
NOTE 1 – The frequency offset a_1 represents an initial frequency offset corresponding to 5×10^{-8} (0.05 ppm).

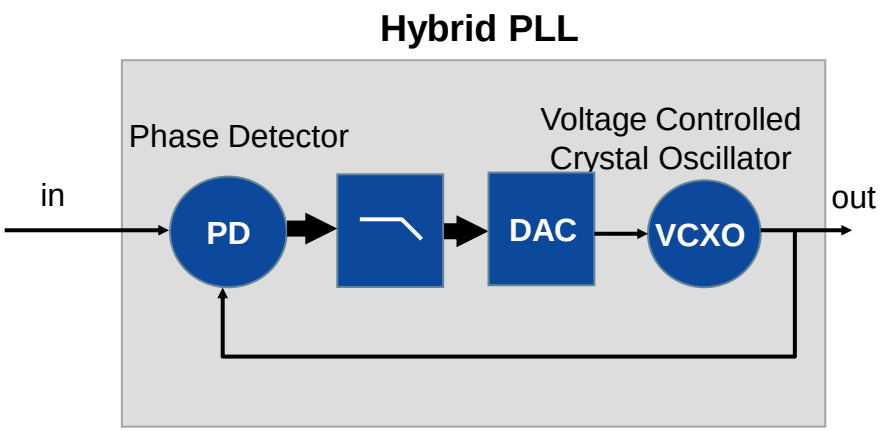
NOTE 2 – The frequency offset a_2 accounts for temperature variations after the clock went into holdover and corresponds to 2×10^{-6} (2 ppm). If there are no temperature variations, the term a^2S should not contribute to the phase error.

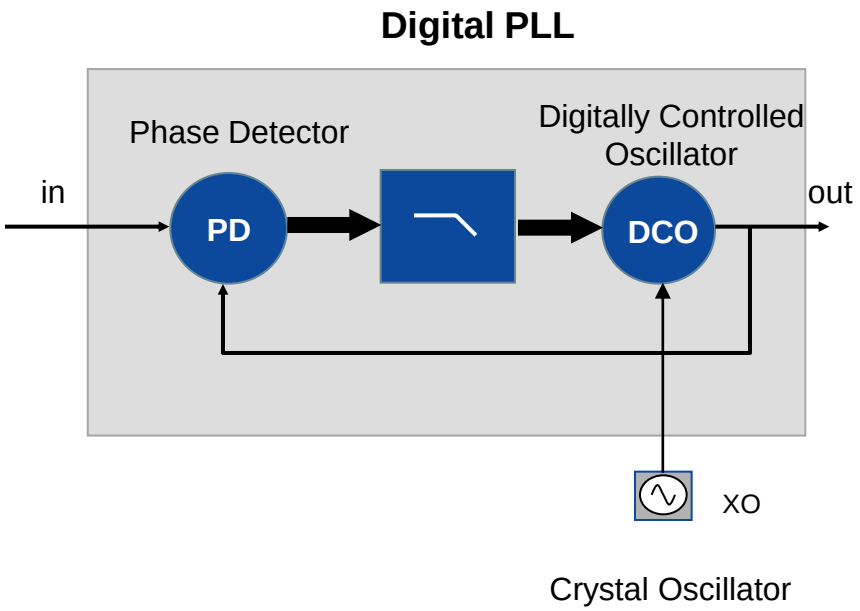
NOTE 3 – The drift b is caused by ageing: 1.16×10^{-4} ns/s^2 corresponds to a frequency drift of 1×10^{-8}/day (0.01 ppm/day). This value is derived from typical ageing characteristics after 10 days of continuous operation. It is not intended to measure this value on a per day basis, as the temperature effect will dominate.

NOTE 4 – The phase offset c takes care of any additional phase shift that may arise during the transition at the entry of the holdover state.

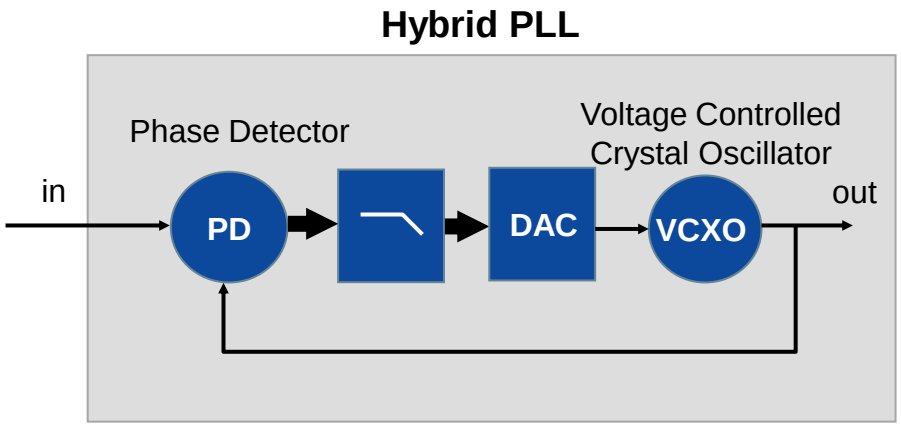
Common holdover implementation





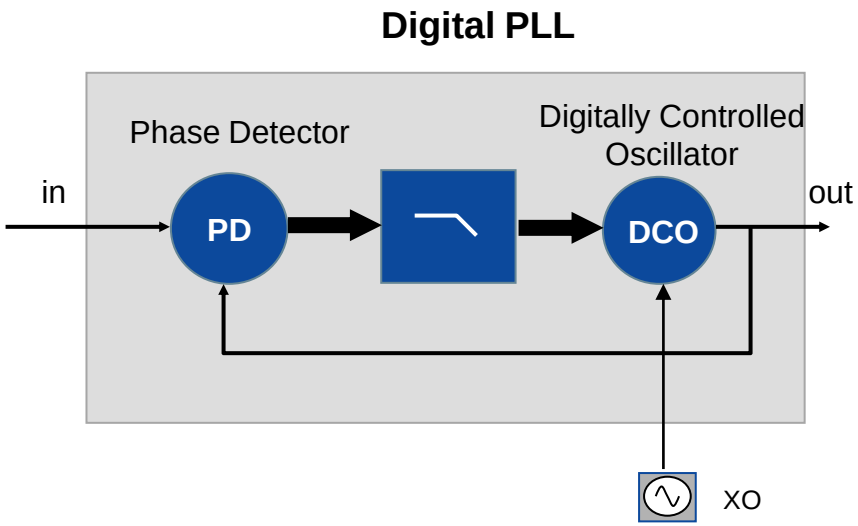


Common holdover implementation Cont.



- For VCXO (OCVCXO) with +/-20ppm range and 10 bit DAC resolution is 40ppm/1024 = 39ppb
- Holdover accuracy is than +/-19.5ppb
- When you add margin for inherent DAC inaccuracies you get to +/-50ppb
- With 16 bit DAC (very common today) one could get accuracy of +/-0.3ppb

Common holdover implementation Cont.



Frequency generated by DCO is:

—

Where:

control word from low pass filter

frequency of crystal oscillator

size of accumulator in bits

For 24 bit accumulator (high end in late 80^{s}) step size is —

Holdover accuracy is than +/-28ppb

Nowadays accumulators with 32, 48 and 64 bit are used. For example 32 bit accumulator provide better than 0.2ppb accuracy

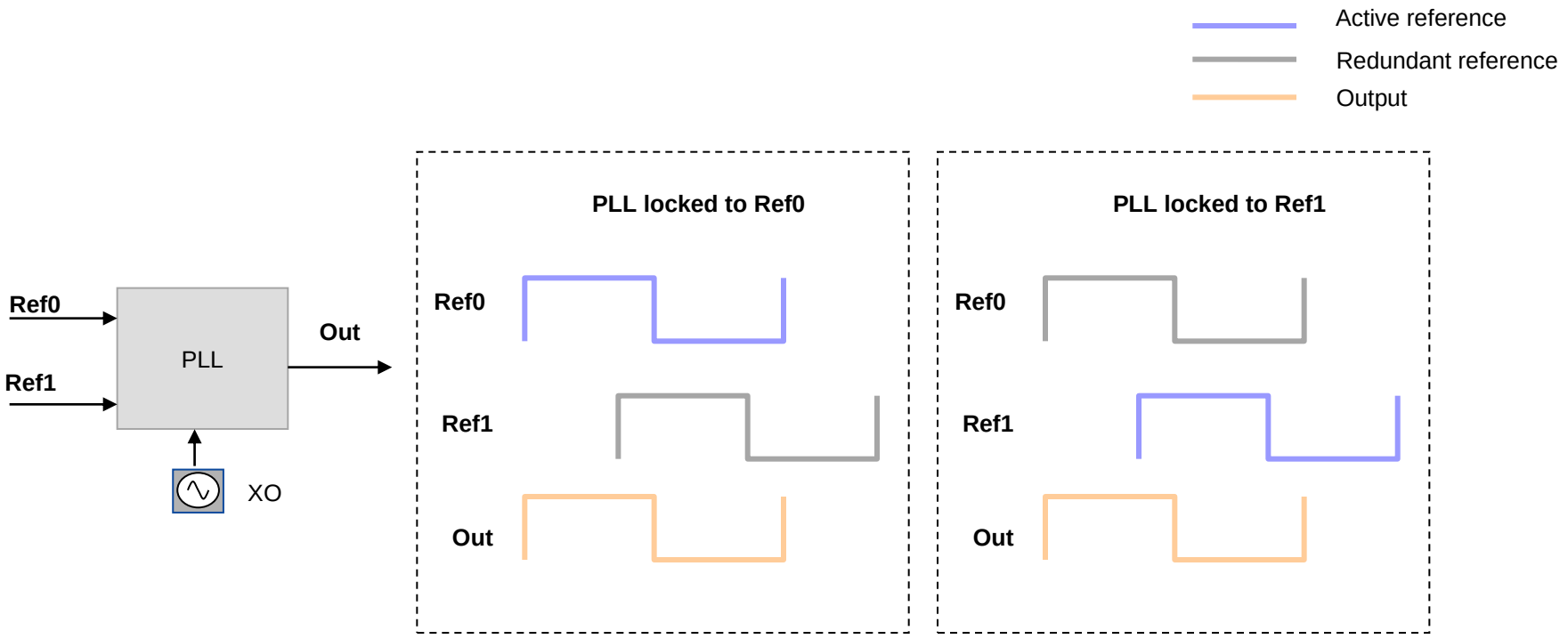
Common holdover implementation Cont.

- During the last 15 years all MSCC Network Timing devices and devices from other vendors have initial holdover accuracy better than 0.5ppb.

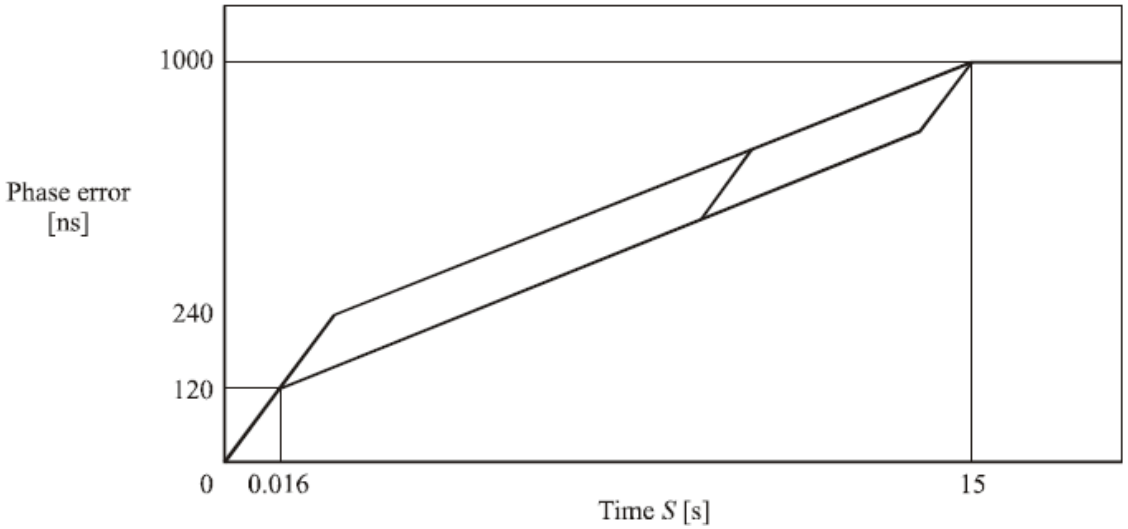
Short term phase transients

Short term phase transients

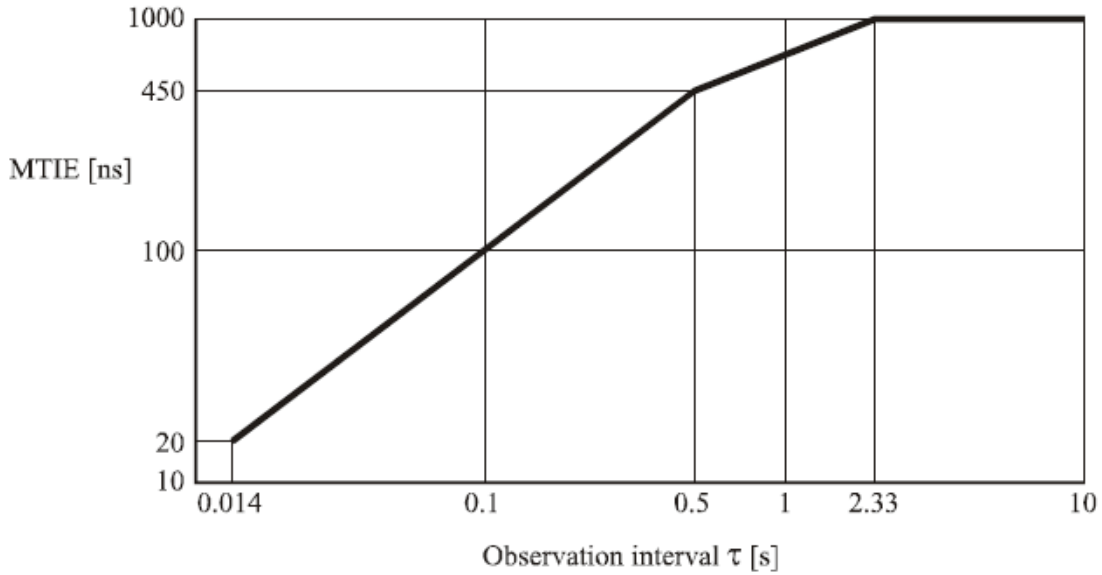
- During the reference rearrangements (reference switch), output phase should not experience sudden phase movement regardless of the phase offset between references.



Short term phase transients (G.8262) Cont.

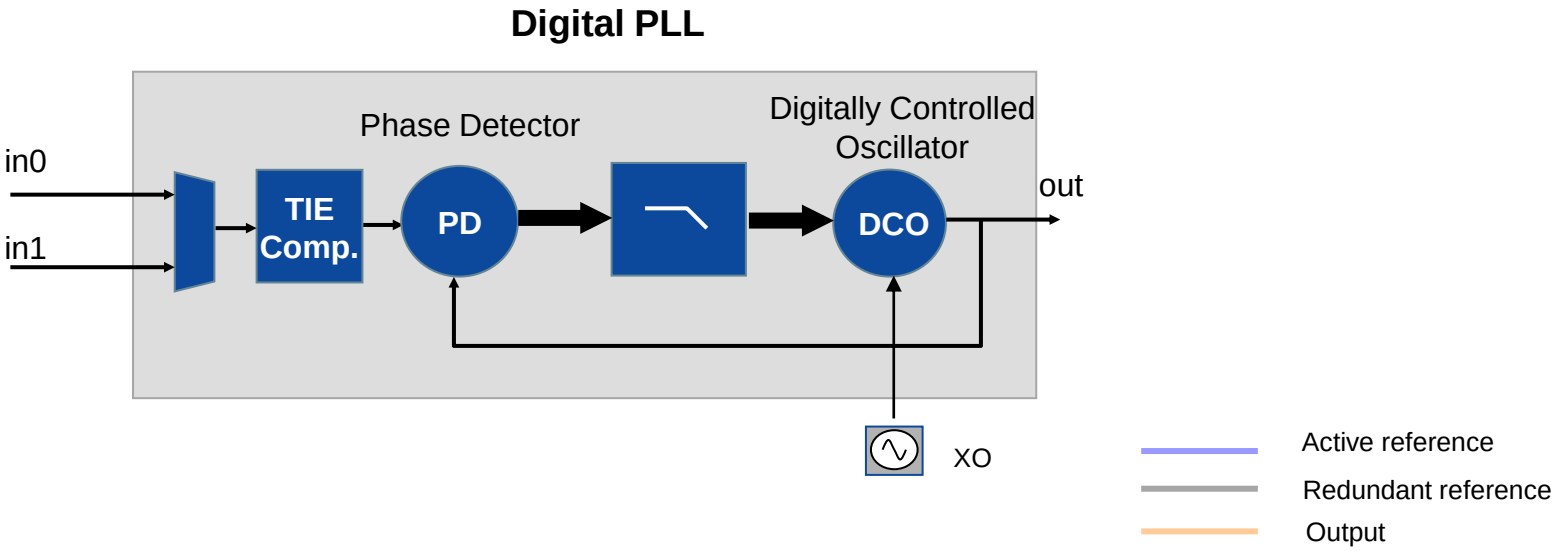


Option 1 (EU)



Option 2 (NA)

Handling of short term phase transients



Short term phase transients Cont.

- This requirement goes back to 80s (T1.101). At that time all synchronization solutions were made from discrete components (off the shelf logic) and clock frequencies were typically 10MHz and lower.
- For the last 15 years all MSCC (formerly Zarlink) Network PLLs, and PLLs from other vendors have phase transient of sub 10ns and quite often sub 1ns (at least 100 times below the stanard limit!)
- It is similar for custom (FPGA) solutions because internal sampling clock is at least 100MHz

Who could benefit from the change

Application	Frequency (ppb)	Phase (µs)	Time (µs)	Reference Document
CDMA	±50		±3 (Traceable & Synchronous to UTC)	TIA/EIA-95-B [53]
CDMA2000	±50		±10 (>8hrs) when external timing source disconnected ±3 (Traceable & Synchronous to UTC)	3GPP2 C.S0002-E v2.0 [54] C.S0010-C v2.0 [56]
GSM	±50 ±100 (pico BS)			ETSI TS 145.010 [54]
UMTS-FDD (WCDMA)	±50 (Wide area BS) ±100 (Medium range BS) ±100 (Local area BS) ±250 (Home BS)	12.8 (MBSFN-3GPP Release 7/8)		3GPP Frequency: TS 25.104 [64] MBSFN:TS 25.346 [66]
UMTS-TDD (WCDMA)	±50 (Wide area) ±100 (Local area) ±250 (Home eNB)	±2.5 ±1 (between Macro eNB and Home eNB)		3GPP Frequency: TS 25.105 [65] Phase: TS 25.402 [67] Home eNB: TR 25.866 [69]
TD-SCDMA	±50	±3		3GPP TS 25.123[63]
LTE (FDD)	±50 (Wide area) ±100 (Local area) ±250 (Home eNB)	CDMA handover and Synchronized E-UTRAN GPS time ±10 (> 8hours) when external timing source disconnected		3GPP Frequency: TS 36.104 [72] Time: TS 36.133 [73]
LTE (TDD)	±50	≤ 3 (small cell) ≤ 10 (large cell) CDMA handover and Synchronized E-UTRAN: ±10 (> 8hours) when external timing source disconnected		3GPP Frequency: TR36.922 [75] Phase & Time: TS36.133 [73]
LTE-A	±50 (Wide area) ±100 (Local area) ±250 (Home eNB)	≤ ±1.5 or lower, depending on service High accuracy needed for Location Based Services		Summarized in MBH IA Ph3 Sync TimePhase

Summary

- Network PLLs in field have more than 100 times better short term stability than requested by G.8262 standard.
- Network PLLs in field have more than 100 times better initial holdover accuracy than requested by G.8262 standard.
- New variant of G.8262 could be generated (G.8262+) to add these changes
- Majority of equipment in the field would be compatible to this standard.
- These changes would reduce requirement for synchronization devices in base stations and it would simplify IEEE1588 slave devices where IEEE1588 is used in tandem with Synchronous Ethernet.

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End