International Telecommunication Union

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

G.8271/Y.1366

Amendment 1
(08/2013)

SERIES G: TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS

Packet over Transport aspects – Quality and availability targets

SERIES Y: GLOBAL INFORMATION INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS AND NEXT-GENERATION NETWORKS

Internet protocol aspects – Transport

Time and phase synchronization aspects of packet networks

Amendment 1

Recommendation ITU-T G.8271/Y.1366 (2012) – Amendment 1

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Recommendation ITU-T G.8271/Y.1366

Time and phase synchronization aspects of packet networks

Amendment 1

Summary

Amendment 1 to Recommendation ITU-T G.8271/Y.1366 provides some improvements and updates as well as the following additional information:

- Details on the time synchronization interface
- Details on time-stamping granularity in the clause on the characteristics of the noise sources
- Details on the time error accumulations

History

Edition	Recommendation	Approval	Study Group
1.0	ITU-T G.8271/Y.1366	2012-02-13	15
1.1	ITU-T G.8271/Y.1366 (2012) Amd. 1	2013-08-29	15

FOREWORD

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The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

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As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at http://www.itu.int/ITU-T/ipr/.

Recommendation ITU-T G.8271/Y.1366

Time and phase synchronization aspects of packet networks

Amendment 1

1) Clause 2, References

Add the following reference:

[ITU-T G.703] Recommendation ITU-T G.703 (2001), *Physical/electrical characteristics of hierarchical digital interfaces*.

2) Clause 4, Abbreviations and acronyms

Replace

EEC Ethernet Equipment Clock

with

EEC synchronous Ethernet Equipment Clock

3) Clause 6, The need for phase and time synchronization

Update the final part of clause 6 as follows:

…

Based on Table II.1, it is possible to classify the applications into classes of requirements, as shown in Table 1 below.

<u>NOTE – In the case of mobile applications as described in Table II.1, the requirements are generally expressed in terms of phase error between base stations. In the case of a centralized master, the requirement could be expressed as ± half of the accuracy requirement applicable to the specific technology. Table 1 presents the requirement in this format in order to allow the analysis of time error budgeting as distributed from a PRTC towards the end application.</u>

Table 1 – Time and phase requirement classes

Level of accuracy	~~Range of~~Time error requirements (Note ~~2~~1)	Typical applications (for information)
1	~~1 ms –~~500 ms	Billing, alarms
2	~~5 µs –~~100 µs ~~(Note 1)~~	IP Delay monitoring
3	~~1.5 µs –~~5 µs	LTE TDD (large cell) ~~Wimax-TDD (some configurations)~~
4	~~1 µs –~~1.5 µs	UTRA-TDD, LTE-TDD (small cell) Wimax-TDD (some configurations)
5	~~x ns –~~1 µs ~~(Note 4)~~	Wimax-TDD (some configurations)
6	< x ns (Note 3~~4~~)	Location based services and some ~~Some~~ LTE-A features (Note ~~3~~2)

~~NOTE 1 – The most stringent requirement that is expected for IP monitoring has been chosen as limit for this class of requirements.~~

NOTE ~~2~~1 – The requirement is expressed in terms of error with respect to ~~the~~ an ideal reference.

NOTE ~~3~~2 – The performance requirements of the LTE-A features are under study~~ by 3GPP~~. For information purposes only, values between 500 ns and 1.5 µs have been mentioned for some LTE-A features. Depending on the final specifications developed by 3GPP, LTE-A applications may be handled in a different level of accuracy.

NOTE 3~~4~~ – The value for x is for further study.

This Recommendation deals mainly with the more stringent classes of requirements, indicated as levels of accuracy 4, 5 and 6 in Table 1.

4) Clause 8, Network reference model

Replace clause 8 with the following text:

8 Network reference model

Figure 4 describes the network reference model used to define the time and phase synchronization performance objectives.

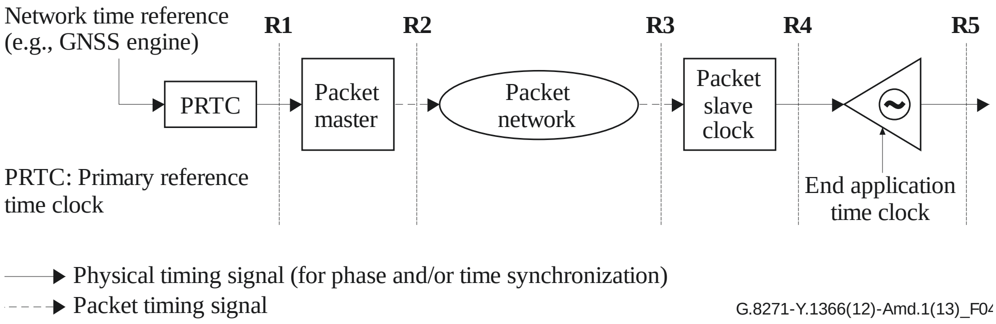

Figure 4 – Network reference model

The following reference points are defined. All the requirements related to these reference points are defined with respect to a common time reference, i.e., any recognized time reference such as GPS time.

- R1: PRTC output
- R2: Packet master clock output
- R3: Packet slave clock input
- R4: Packet slave clock output
- R5: End application output

NOTE 1 – In Figure 4 the packet master clock could correspond to a T-GM and the packet slave clock could correspond to a T-TSC (telecom time slave clock).

NOTE 2 – The performance studies under development are based on a full timing support in the network with hardware timestamping (e.g., T-BC in every node in the case of IEEE 1588-2008) with and without physical layer frequency synchronization support (e.g., synchronous Ethernet support).

The case of partial timing support is for further study.

The overall budget relates to measurement point 'R5' (i.e., the time error at R5 with respect to the common time reference).

'R1', 'R2', 'R3' and 'R4' define the other relevant measurement reference points and related network limits, that also indicate the budget of the noise that can be allocated to the relevant network segments (e.g., 'R1 to R3', 'R1 to R4', etc.).

NOTE 3 – Some specific access technologies may need to be considered in the network reference model in some cases. For instance, the packet network between points R2 and R3 can be composed in some cases of a transport part and an access part. Each part would then have its own phase/time budget. In other scenarios, the access segment can be positioned at point R4, between the packet slave clock, and the end application. The definition of network reference models considering the access technologies is for further study.

The measurement points that are of interest for a specific application may depend on where the network administrative domain borders apply.

Also, as described above, the measurement in some cases needs to be performed on a two-way timing signal, which would require a specific test set-up and metrics to be used.

The measurement set-up for two-way timing signals as well as the noise that can be added by the measurement test equipment is an item for further study.

Another possibility is to perform the measurement using an external dedicated output phase/time reference, such as a 1PPS interface. Annex A in this Recommendation provides guidance about this type of interface.

5) Clause A.1, ITU-T V.11 Interface

Replace clause A.1 with the following text:

A.1 1PPS ITU-T V.11 interface

The 1PPS time/phase interface uses a point-to-point ITU-T V.11 interface as specified in [ITU-T V.11] with an additional requirement on the rise/fall times of the 1PPS signal as defined in [ITU-T G.703]. This is needed to provide the accuracy required for the 1PPS signal.

This interface can be used for time synchronization distribution as well as for time measurement.

The interface is a balanced interface that can tolerate significant common mode noise.

The 1PPS interface consists of a balanced 100 ohm 1PPS differential signal that can be used to connect to the next time device or measurement equipment.

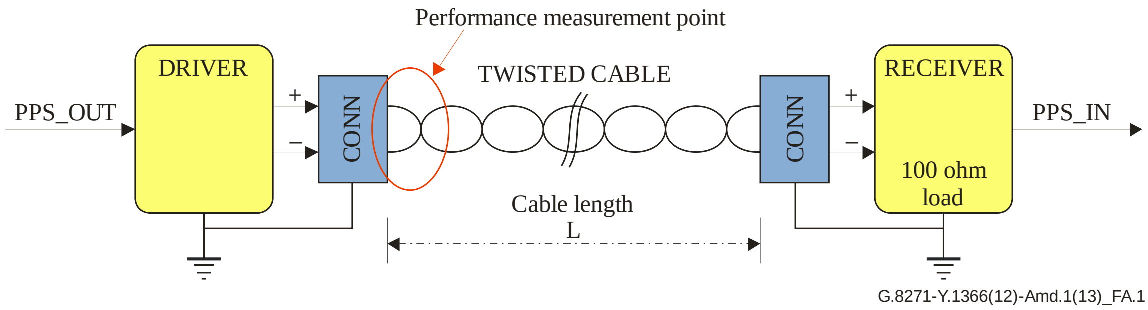

Figure A.1 – Balanced 1PPS V.11 interface

A.1.1 Interface signals

The signals of this interface are defined in this clause as follows:

- 1PPS_OUT+/1PPS_OUT-: This output signal pair indicates the significant event occurring on the leading edge of the signal and is generated by the time master.
- 1PPS_IN+/1PPS_IN-: This input signal pair indicates the significant event occurring on the leading edge of the signal and is used by the time slave.
- TX+/TX-: This output signal pair is used for a serial communication channel for transfer of time messages and status messages between the time master and the time slave.
- RX+/RX-: This input signal pair is used for a serial communication channel for transfer of messages between the time master and the time slave.

The connector is defined in [ITU-T G.703], which specifies the physical aspects of this interface. The protocol used on the serial communication channel is for further study.

The connection requires the use of a crossed cable that connects the signal pairs as specified in Table A.1.

Table A.1 – Cable connections

Connector A	Connector B
1PPS_OUT+/1PPS_OUT-	1PPS_IN+/1PPS_IN-
1PPS_IN+/1PPS_IN-	1PPS_OUT+/1PPS_OUT-
TX+/TX-	RX+/RX-
RX+/RX-	TX+/TX-
NOTE – Not all the signals in Table A.1 will necessarily be needed at the same time (e.g., one direction only might be sufficient in some cases). The backward direction of the messaging channel is for further study.	

A.1.2 Automatic cable delay compensation (optional)

The 1PPS ITU-T V.11 interface can optionally support automatic cable delay compensation. The enhanced 1PPS ITU-T V.11 interface adds support for automatic cable and ITU-T V.11 transceiver compensation using a feedback loop that allows the time master to measure the round-trip delay of the 1PPS signal and compensate for the path delay when generating the 1PPS signal.

The 1PPS signal is initially generated by the timing master at the 1-second boundary, T1. This signal is delayed through the cable before it arrives at the timing slave. The 1PPS signal is looped back at the slave and sent to the time master. The time master captures the time of reception of the 1PPS signal from the time slave, T2, and measures the round-trip delay as the time since the generation of the 1PPS signal.

Assuming that the path is symmetrical, the time master calculates the mean cable delay as: (T2 – T1)/2 and either compensates for the cable delays by advancing the 1PPS signal by the mean cable delay or alternatively informs the time slave about the mean cable delay through the ITU-T V.11 serial communication channel so that the slave can perform the compensation.

The protocol used on the serial communication channel is for further study.

The time slave performs a loopback of the 1PPS signal at some point after the ITU-T V.11 transceiver.

6) Clause A.2, 1PPS 50 Ω phase synchronization measurement interface

Replace clause A.2 with the following text:

A.2 1PPS 50 Ω phase synchronization measurement interface

The 1PPS interface consists of an unbalanced 50-ohm 1PPS signal that can be used to connect to measurement equipment (see Figure A.2).

The physical characteristics of this interface are defined in [ITU-T G.703].

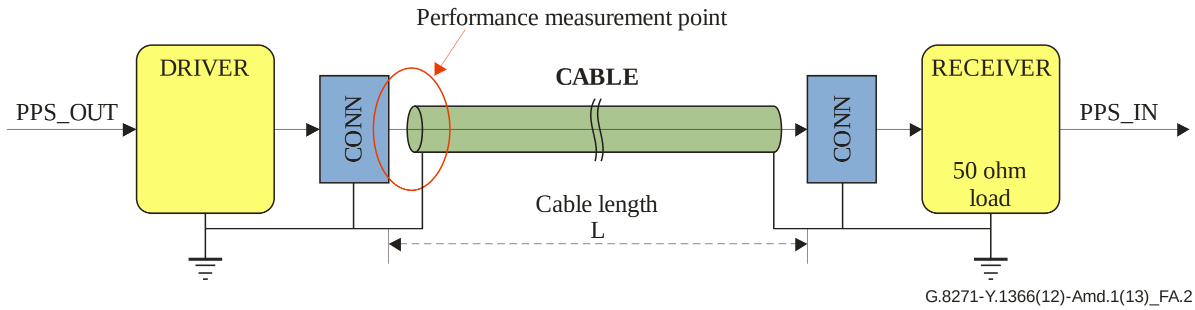

Figure A.2 – Unbalanced 1PPS 50 Ω measurement interface

The system must compensate for the internal delays in the system to ensure that the 1PPS signal timing is met at the edge of the box.

The measurement equipment is expected to compensate for the delays associated with the interconnection of the 1PPS interface.

7) Clause I.6, Derivation of delay asymmetry

Add the following note at the end of clause I.6:

"NOTE 4 – Asymmetry compensation is required at the start-up of the network as well as after any event that may change the characteristics of the asymmetry (e.g., after network rearrangements)."

8) New clause I.7.3 (Timestamping granularity)

Replace clause I.7.3 with the following text:

I.7.3 Timestamping granularity

The timestamping granularity depends on the rate of the timestamping clock. The timestamping granularity error is limited in extent by $T_{ts,rx}$, the increment in the timestamp counter at the receiver:

$$0 \leq e_{ts} < T_{ts,rx} \tag{I-10}$$

If the timestamping clock rate at the receiver is an integer multiple/submultiple of the rate at the sender then the beating effect may be observed and the error e_{ts} is almost static and cannot be reduced by the low-pass filtering inherent in phase-locked loops. If the rates are relatively prime then the error e_{ts} is randomized and is well modelled as white noise (flat spectrum).

This noise source is applicable to time-of-arrival measurements at the packet master and packet slave. The same model may apply for the time-of-departure measurements.

9) New clause I.8, Time error accumulation in a chain of clocks

Add the following new clause:

I.8 Time error accumulation in a chain of clocks

The total time error can be viewed as the sum of a constant time error component and a dynamic time error component.

NOTE – It is assumed that frequency offset and drift components are not present; therefore, only random components are included in the dynamic time error.

These two components have different characteristics in terms of modelling and accumulation. See Appendix IV of [b-ITU-T G.8271.1] for further details.

10) Bibliography

Add the following entry to the bibliography:

[b-ITU-T G.8271.1] Recommendation ITU-T G.8271.1/Y.1366.1 (2013), *Network limits for time synchronization in packet networks*.

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