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SYNCHRONIZATION SIGNALS IN PACKET SWITCHED NETWORKS: PARAMETER MONITORING AND MEASUREMENT

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In the present paper, measurement of the parameters of synchronization signals in IP/MPLS transport networks is considered. The results of measurements of synchronization signal instability indices for base station are presented. The basic principles for the development of the system for monitoring synchronization signals are considered.

Keywords: packet switched network (IP/MPLS network), synchronization signal, parameters of synchronization signals, measurement of the parameters of synchronization signals, monitoring of synchronization signals

Introduction

Because synchronization issues are crucial for modern IP/MPLS transport networks [1–4], enhancement of the role of synchronization network is the modern trend in the development of primary network, and this trend will continue in the immediate future [2]. Moreover, synchronization problems are related not only to primary network, but are important when developing access networks with consideration for various technologies and protocols embodied in the specific IP/MPLS network [2–4].

Measurement of parameters of reference signals as well as evaluation of their instability is a prerequisite for the solution of synchronization problems in electric communication networks.

The *aim* of the paper is to solve the following topical issue: measuring the parameters of synchronization network in IP/MPLS network, and real-time monitoring of these indices to provide for timely response to network emergencies.

Problem statement

Currently, in communication operator networks, more and more network segments are being deployed for communicating through IP/MPLS transport only. However, with increase in the number of devices (e.g., mobile communication base stations), synchronization problems should be considered on a systemic level rather than on case-by-case basis. To this is related some kind of local revolution in approach: arrival of some «critical mass» of users of synchronization signals in the IP/MPLS network results in the requirement for considering synchronization system as a separate component of electric communication system.

With the following increase in the number of digital devices, the concepts of the development and principles of control of synchronization network start being subjected to changes. Such system-based approach may be provided by measurement of the parameters of synchronization network.

Therefore, this work is devoted to the solution of the following topical problems:

1) Measuring the parameters of synchronization network in IP/MPLS network, and
2) Real-time monitoring of these indices.

Main part

In «Definition and Terminology for Synchronization Networks» [1], TIE (Time Interval Error), MTIE (Maximum Time Interval Error) and TDEV (Time Deviation) are the three parameters used as basic criteria for evaluation of quality of synchronization signals, but only TIE function is directly measured.

TIE is defined as the time deviation between the signal being measured and the reference clock. One can perform calculation of MTIE based on obtained TIE array.

MTIE is defined as the maximum peak-to-peak delay variation of a given synchronization signal with respect to an ideal synchronization signal within an observation time for all observation times of that length within the measurement period. Besides, performed is the calculation of TDEV (Time Deviation), which is described as «a measure of the expected time variation of a signal as a function of integration time» [1]. TDEV may provide information on spectral components of either phase or time noise of the signal.

Because, by definition, MTIE equals peak-to-peak delay variation of a given synchronization signal with respect to an ideal synchronization signal within a certain period, it provides for the detection of phase transients in synchronization signal. However, because of its sensitivity to phase transients, MTIE is inadequate to show the underlying noise of synchronization signal.

Random noise is better characterized by TDEV which is an RMS power estimator instead of a peak estimator. TDEV tends to remove transients in a synchronization signal, and is therefore a better estimator of the underlying noise processes [2]. It has been shown [5] that measurements may be taken at digital ports of terminal equipment (at Tributary E1) and directly at Ethernet port (for this purpose, such special meters as STA-61 (Spectracom) and Paragon-m (Oscilloquartz) have been developed recently).

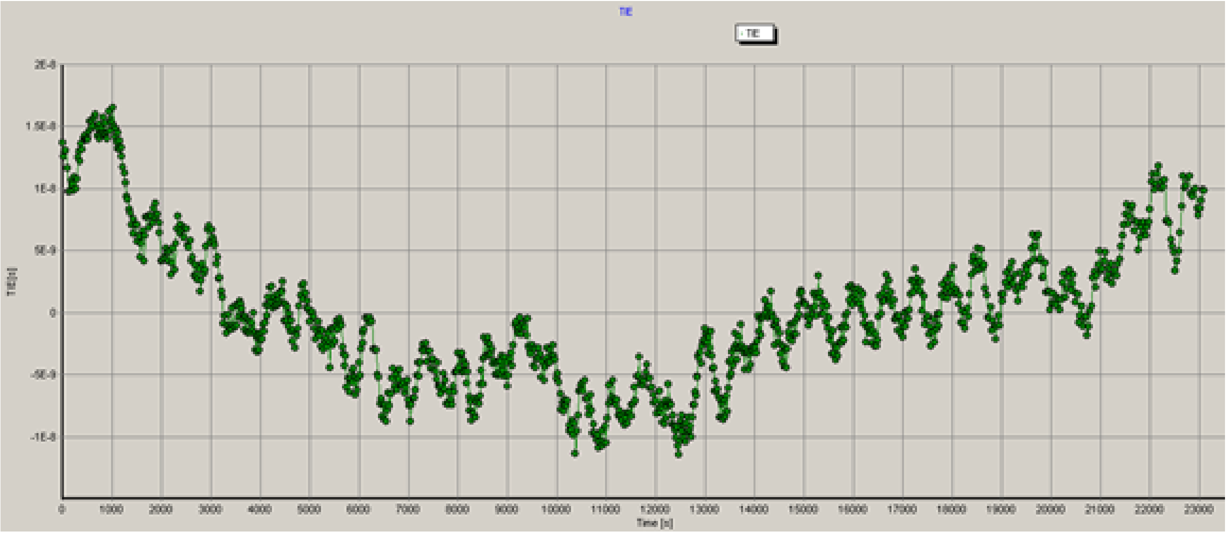
Measurement Example

Measurements of frequency stability parameters were performed in IP/MPLS network at the level of PE-router with three retransmissions for synchronization of mobile communication base station connected through IP. As the reference frequency for IP/MPLS network, use was made of a clock net signal transmitted through SDH (Synchronous Digital Hierarchy) network. Sources of clock signal were cesium oscillators and GPS-receivers distributed over the network. From PE Level, the signal can be distributed to the lower levels (e.g., to P Level), and, correspondingly, can be used for synchronization of the base unit.

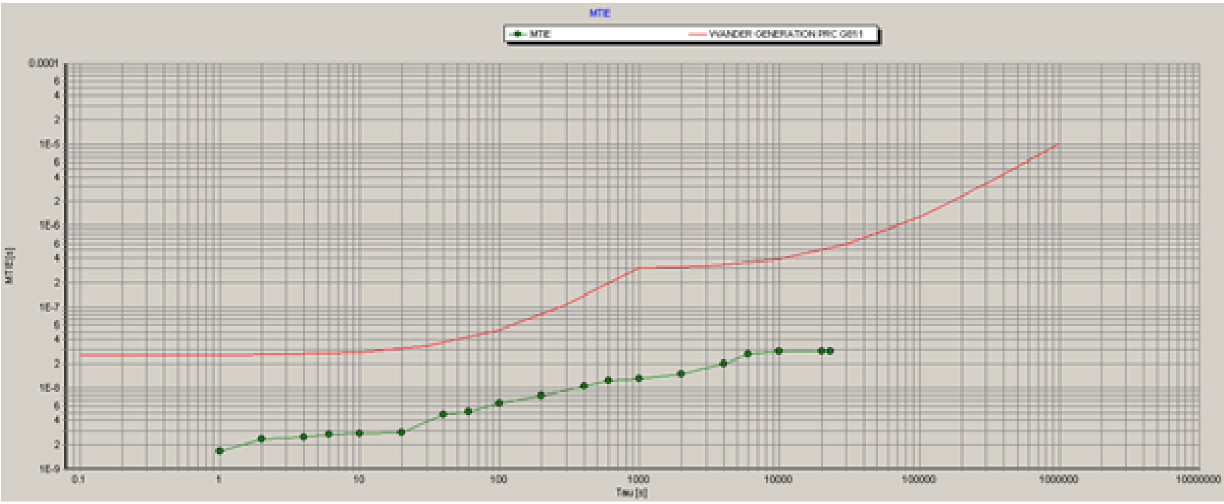
MTIE and TDEV mask in accordance with the ITU-T Requirements G.811 (timing requirements of primary reference clocks) is shown in Figs. 1(b) and 1(c), respectively. MTIE and TDEV were calculated based on directly obtained TIE values (see Fig. 1(a)).

The signal is suitable for a base station, because its daily stability is better than 5×10^{-8}.

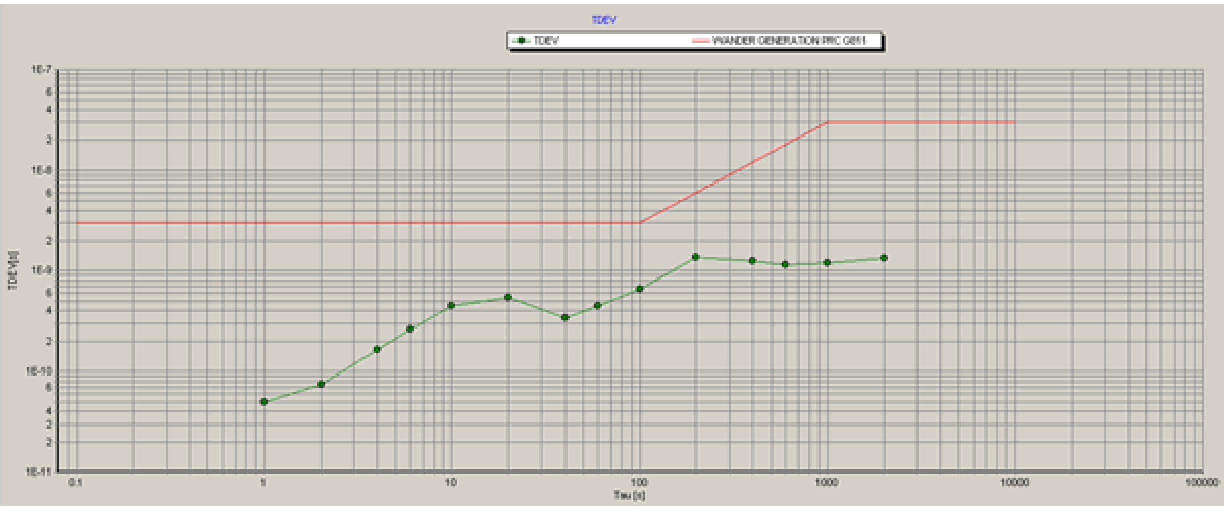
Strictly speaking, there is no requirement for synchronization as such for network core and aggregation level. However, when implementing an IP/MPLS network and performing station-by-station deployment of a great number of base stations with IP interfaces in large networks, a problem related to synchronization between old base stations and remaining islands of conventional TDM (Time Division Multiplexing) transport network may occur. Therefore, there may take place a transfer of synchronization signal from IP/MPLS cloud to separate SDH sections, and directly to base stations themselves through organization of separate E1 streams. Interestingly, that, in such a case, traffic and signal data may be transferred in a similar way to (1) minimize time and cost when implementing transfer to packet networks and (2) make the very process of upgrade (or change) of base stations for those with IP interface more flexible.



a



b



c

Fig. 1. Measurements of stability parameters: a — time interval error (TIE); b — Maximum Time Interval Error (MTIE) and c — Time Deviation (TDEV)

When deploying and operating a synchronization network within IP/MPLS transport network, it becomes necessary to develop a synchronization signal monitoring system. The latter system must depend neither on the number of equipment manufacturers nor on the number of sources of synchronization signal. It is proposed to perform continuous measurement of TIE values for the signals from several primary sources with respect to each other, and, based on gradually accumulated data, to calculate MTIE and TDEV values at predetermined time intervals.

The number of signals to be compared should be at least three; it will provide for identification of abnormal signal based on majority decision. For this purpose, software-and-hardware complexes are developed to become the backbone of monitoring system. In this case, the meters may be represented by the above-mentioned state-of-the-art measurement devices to be installed stationary within the network.

Unlike synchronization of classic digital networks, the measurement points within IP/MPLS networks may be of more variable locations due to flexibility of IP-based configuration [3, 4].

Therefore, based on continuous monitoring, it is possible to decide which of the three signals is out of the norms defined by the masks of ITU-T requirement G.811. To calculate MTIE and TDEV values, firstly, TIE data arrays accumulated; then, the results will be produced at definite time intervals.

Another parameter used to assess synchronization quality should be mentioned. Packet Delay Variation (PDV) characterizes IP/MPLS network load level depending on packet delay. In classic digital networks, this parameter is absent because of the very nature of these networks. PDV value should not exceed 50 ms; otherwise, synchronization signal stability parameters will be out of the norms defined by the masks of ITU-T requirement G.811 [2]. This fact has been confirmed by MTIE and TDEV measurements at the pilot section of synchronization network in IP/MPLS network.

PDV parameter is measured with special meters STA-61 (Spectracom) and Paragon-m (Oscilloquartz) and may represent an operating parameter in the synchronization network monitoring system being developed for IP/MPLS transport network.

Conclusions

In the present work, the following conclusions and results were obtained:

1) With increase in the number of devices, synchronization problems should be considered on a systemic level rather than case-by-case basis, i.e., arrival of some “critical mass” of users of synchronization signals in the IP/MPLS network results in the requirement for considering synchronization system as a separate component of electric communication system.

2) With increase in the number of digital devices, the concepts of the development and principles of control of synchronization network start being subjected to changes. Such system-based approach may be provided by measurement of the parameters of synchronization network.

3) TIE, MTIE and TDEV are the three parameters used as basic criteria for evaluation of performance of synchronization signals. This work presents the results of practical measurements. Besides, there has been established a relationship between synchronization quality and network load level using PDV index.

4) In this paper, we addressed the issues of the development of synchronization network monitoring system in IP/MPLS transport network. This system must depend neither on the number of equipment manufacturers nor on the number of sources of synchronization signal. A full-blown monitoring system, if available, will provide for timely response to network emergencies.

References

1. Рекомендация ITU-T G.810 «Терминология сетей синхронизации»
2. Mills, D.L. Computer Network Time Synchronization : the Network Time Protocol / D.L. Mills. — Boca Raton, FL : CRC/Taylor & Francis, 2006. — 286 p.
3. Вакась, В.И. Синхронизация базовых станций при внедрении технологий IP-сетей / В.И. Вакась, И.П. Черняк // Материалы 21-й Международной крымской конференции «СВЧ-техника и телекоммуникационные технологии» (КрыМиКо’2011), 12–16 сент. 2011 г., Севастополь. — Севастополь: Вебер, 2011. — С. 374–375.
4. Вакась, В.И. Комбинирование методов обеспечения синхронизацией базовых станций от разных иерархических уровней сети с коммутацией пакетов / В.И. Вакась, Н.В. Федорова // Материалы 22-й Международной крымской конференции «СВЧ-техника и телекоммуникационные технологии» (КрыМиКо’2012), 10–14 сент. 2012 г., Севастополь. — Севастополь: Вебер, 2012. — С. 320–321.
5. Вакась, В.И. Практические аспекты синхронизации сетей IP/MPLS [Текст] / В.И. Вакась, Н.В. Федорова // Зв’язок. — 2013. — № 1. — С. 23–27.

СИГНАЛИ СИНХРОНИЗАЦІЇ У МЕРЕЖАХ З КОМУТАЦІЄЮ ПАКЕТІВ. КОНТРОЛЬ І ВИМІР ЇХ ПАРАМЕТРІВ

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Розглянуто проведення вимірювань параметрів сигналів синхронізації в транспортних мережах IP/MPLS. Представлені результати вимірювань показників нестабільності сигналу синхронізації для базової станції. Розглянуто основні принципи створення системи моніторингу для сигналів синхронізації.

Ключові слова: мережа з комутацією пакетів (мережа IP/MPLS), сигнал синхронізації, параметри сигналу синхронізації, вимірювання параметрів сигналу синхронізації, моніторинг сигналу синхронізації

СИГНАЛЫ СИНХРОНИЗАЦИИ В СЕТЯХ С КОММУТАЦИЕЙ ПАКЕТОВ. КОНТРОЛЬ И ИЗМЕРЕНИЕ ИХ ПАРАМЕТРОВ

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Рассмотрено проведение измерений параметров сигналов синхронизации в транспортных сетях IP/MPLS. Представлены результаты измерений показателей нестабильности сигнала синхронизации для базовой станции. Рассмотрены основные принципы создания системы мониторинга для сигналов синхронизации.

Ключевые слова: сеть с коммутацией пакетов (сеть IP/MPLS), сигнал синхронизации, параметры сигнала синхронизации, измерение параметров сигнала синхронизации, мониторинг сигнала синхронизации