BHP BILLITON IRON ORE
NEWMAN TOWNSHIP ELECTRICITY SUPPLY

ANNUAL COMPLIANCE REPORT
2017/2018

REVISION B

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EXECUTIVE SUMMARY

BHP Billiton Iron Ore own and operate numerous iron ore mines located at the Pilbara region of WA. The township of Newman is located approximately 1,200km to the north of Perth; and the town's electricity network is owned, governed and operated by BHPBIO Supply Authority (BHPBIOSA).

In accordance with Western Australia Electricity Industry Code 2005 (the Code), the electrical supply authority must publish a report setting out the information described in Schedule 1 of the Code, in respect to each year ending on the 30th of June. This document, known as the A*nnual Compliance Report*, is to provide the full suite of information outlined in Schedule 1 of the Code, relating to the Network Quality and Reliability of Supply.

The methodology adopted to examine compliance/non-compliance with the Code utilizes two notable sources of information as follows:

1. Power quality data measured from the Newman 0.415kV network over a period of 7 calendar days or more; and
2. Outage data and other relevant information provided by the network operator (BHPBIOSA).

The Code is written in four Parts plus a reporting-requirements Schedule; as listed in the following:

3. *Part 1*: Preliminary information associated with term of reference.
4. *Part 2*: Quality and reliability standards (further partitioned into 4 *divisions*).
5. *Part 3*: Payment to customers for lack of regulatory adherence.
6. *Part 4*: Incidental duties as a Supply Authority.
7. *Schedule 1*: Information to be published in this report.

This Annual Compliance Report presents the relevant parts of the Code listed above; in particular:

- Power Quality criteria pertaining to Newman's distribution network (measured across 7 feeders supplying the town, of which 4 are connected to Town Substation and the remaining 3 are fed from South Town Substation); and
- The reportable requirements as outlined in Part 2 and Schedule 1 of the Code, for the 2017/18 Financial Year (FY).

With regards to the site measurements, the *average* values of electrical parameters were logged over a period of 7 days, at 10-minutes intervals. PQ indices were then calculated and found, in large, well within the limits stipulated by the Code. That is, the *averages* of the following parameters are proven to meet the Code's requirements:

- *Voltage Flicker (short- and long-term criteria);*
- *RMS Voltage Magnitude;*
- *Power System Frequency; and*
- *Voltage Total Harmonic Distortion (U-THD).*

The following minor compliance issues were however identified:

- The individual *Voltage Harmonic Distortions,* mostly for the feeders supplied from Town Substation. The magnitude of voltage's even harmonics (specifically 6th order) is found to occasionally exceed the limits set by AS 61000:2001, which in turn indicate the presence of unbalanced 3-phase loads with possible DC component in the network. This is not a problem of major concern at the present time (as observed for <2% of the measurements). However, should it further exacerbate in coming years, then mitigation measures may be required to ensure quality of supply.

- Short-term flicker events were found to have exceeded the limits set by 'the code' for TC2, TC3, TC4, STS2 and STS6 feeders. The frequency of occurrence of such exceedances constitutes a very small fraction (i.e, under 0.2%) of the total measurements period. Hence, it is not deemed of a practical concern at this stage and will only need to be monitored over the coming years.
- There are few voltage limit events in exceedance of the limits set by AS/NZS 3000:2007 for TC2 and TC4 feeders. The frequency of occurrence of the exceedances constitutes a very small fraction (i.e, under 0.2%) of the total measurements period. Hence, it is not deemed of a practical concern at this stage but needs to be monitored over the coming years.

Reportable parameters for Newman Township Electricity Supply over the 2017/18 FY (as outlined in the 'Schedule 1' of the Code) are presented below:

- *>12 hour interruptions*: No interruptions were recorded to have exceeded 12 hours.
- No *small use customer* was disconnected from the network more frequent than the Code's requirements (i.e., limit of 16 times).
- No complaints were received from customers during FY 2017/2018.
- Within the 2017/18 FY, an estimated total of $16M was invested by BHPBIOSA towards Newman network operations, maintenance and reinforcement works; to not only address the issues identified by the operator but also to improve the quality and reliability of supply.
- The key reliability indices are calculated as listed below:
    - *Customer Average Interruption Duration Index* (CAIDI) of 33 minutes – CAIDI is the average outage duration that any given customer experience (i.e., the average restoration time).
    - *System Average Interruption Frequency Index* (SAIFI) of 1.07 interruptions – SAIFI is the number of interruptions that the customers experienced.
    - *Average Service Availability Index* (ASAI) of 99.99% – ASAI is the perceived availability of the network to the customers.
    - *System Average Interruption Duration Index* (SAIDI) of 35 minutes – SAIDI is the average outage duration for each customer served.

In summary, the metering data collected from 14 locations throughout the Newman network indicate that the power quality is compliant with the requirements set in the code. With regards to the reliability of the supply, the overall network performance is deemed satisfactory when compared to the same indices for previous FY. As such, this report finds the reliability and quality of the supply for Newman Township network in compliance with the Code's requirements.

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1. INTRODUCTION

The township of Newman is located approximately 1,200km to the north of Perth; the town's electricity network is owned, governed and operated by BHP Billiton Iron Ore Supply Authority (BHPBIOSA). The network encompasses the township of Newman, Newman Airport, Capricorn Roadhouse, town water supply bore field, Mt Whaleback iron ore mine, and several smaller satellite mines in the adjacent areas.

At present, the township of Newman includes 2,385 registered premises comprised of a mixture of residential and commercial customers (compared to 2,395 customers for 2016/17 FY).

According to Western Australia Electricity Industry (Network Quality and Reliability of Supply) Code 2005 (the Code), an electricity distributor must prepare a report setting out the information described in Schedule 1 of the Code, in respect to each year ending on 30 June.

This Annual Compliance Report presents all information required by "Schedule 1 – Information to be published", relating to supply of electricity, for the period of 1st July 2017 to 30th of June 2018. Measurement information is based on sampled data and outlined in Section 6, whereas outage information is based on data provided by BHPBIOSA and outlined in Section 7.

The compliance statistical analysis has focused solely on Newman Township and the key infrastructure adjacent to the township. The electrical network supplying the BHPBIO mining operation and the surrounding mine leases have not been assessed in this report.

2. ASSUMPTIONS

The terminologies used throughout this compliance report are as defined in the Western Australia Electricity Industry (Network Quality and Reliability of Supply) Code 2005 (the Code).

The logging information gathered over the limited period is indicative of the performance of the network over the complete financial year (2017/2018 FY).

3. METHODOLOGY

The electricity supply compliance review entailed the following processes:

1. The temporary installation of PQ loggers at the beginning and end of the 11kV feeders emanating from the Town and Southtown Substations (a total of 14 loggers, 2 for each feeder were installed). Each PQ logger was installed on the low voltage (LV) side of pad-mounted transformers. The measuring period lasted between 8 and 10 days between February to April 2018. The PQ measurements were undertaken in accordance with AS 61000.4.30:2007, Annex A (Power Quality Measurements).
2. Interpretation and analysis of the logged PQ data using HIOKI 3196 & 3198 PQ Analysers.
3. The receipt of the following information from BHPBIOSA:
   - Network outage information for planned and forced outages for the Newman Township during the 2017/2018 FY as well as information on customer complaints.
   - Expenditure information as a consequence of network complaints or programs directed to improve reliability or power quality of the network.
4. Identification of any breaches of the Code's provisions and Electricity Act 1945.
5. Statistical analyses and review of network performance.
6. Preparation of a compliance report that fulfils the requirements outlined in the Code.

4. NEWMAN TOWNSHIP PQ MONITORING

4.1. PQ Device Specification

The equipment used to undertake the PQ logging were a mixture of the HIOKI 3196 and HIOKI 3198 PQ Analysers. The HIOKI 3198 is the updated iteration of HIOKI 3196 but both types of loggers are practically identical in terms of their features, functionality, and user interface.

The HIOKI device can measure multiple waveforms and transient events simultaneously using 4 voltage channels and 4 current channels per device. The device is compliant with AS61000-4-30 Ed 2 Class A, which specifies compatibility with industry standard PQ parameters (further information pertaining to the HIOKI 3196 and HIOKI 3198 is provided in Appendix A).

The measurements obtained for the loggers are then extracted and analysed with the accompanying analysis software (HIOKI 9624 V2.50).

4.2. PQ Devices

4.2.1. Locations and In-service Period

A total of 14 PQ loggers were deployed across 14 locations on the Newman TC1, TC2, TC3, TC4, STS1, STS2, and STS6 feeders. The installation locations and times are as listed in Table 1.

Figure 1 presents a colour-coded single line diagram of the 7 Newman township feeders. Hatched circles indicate the locations at which the PQ loggers were temporary located.

All loggers were installed on the LV (secondary) side of pad-mount transformers. Due to the difficulty and safety issues surrounding the installation the loggers on the LV side of pole-top transformer.

Table 1 | PQ Logger Locations

Zone Subs	Feeder Name	Start or End of Feeder	Substation Name	Date Installed	Date Removed
Township	TC1	Start	PS3	22/02/2018 12:17	02/03/2018 10:17
		End	PS68	14/02/2018 21:50	22/02/2018 08:40
	TC2	Start	PS10	23/02/2018 07:45	02/03/2018 10:05
		End	PS14	05/03/2018 14:07	15/03/2018 13:57
	TC3	Start	PS108	23/02/2018 08:14	02/03/2018 08:44
		End	PS69	05/02/2018 14:37	13/02/2018 12:37
	TC4	Start	PS125	05/02/2018 16:08	13/02/2018 11:48
		End	PS15	05/03/2018 12:23	15/03/2018 11:03
South Town	STS1	Start	PS94	22/02/2018 14:37	02/03/2018 13:07
		End	PS25	03/04/2018 12:10	14/04/2018 14:20
	STS2	Start	PS60	14/02/2018 08:53	22/02/2018 08:33
		End	PS70	03/04/2018 15:09	14/04/2018 16:07
	STS6	Start	PS127	03/04/2018 13:55	14/04/2018 13:05
		End	PS121	05/02/2018 17:40	13/02/2018 15:20

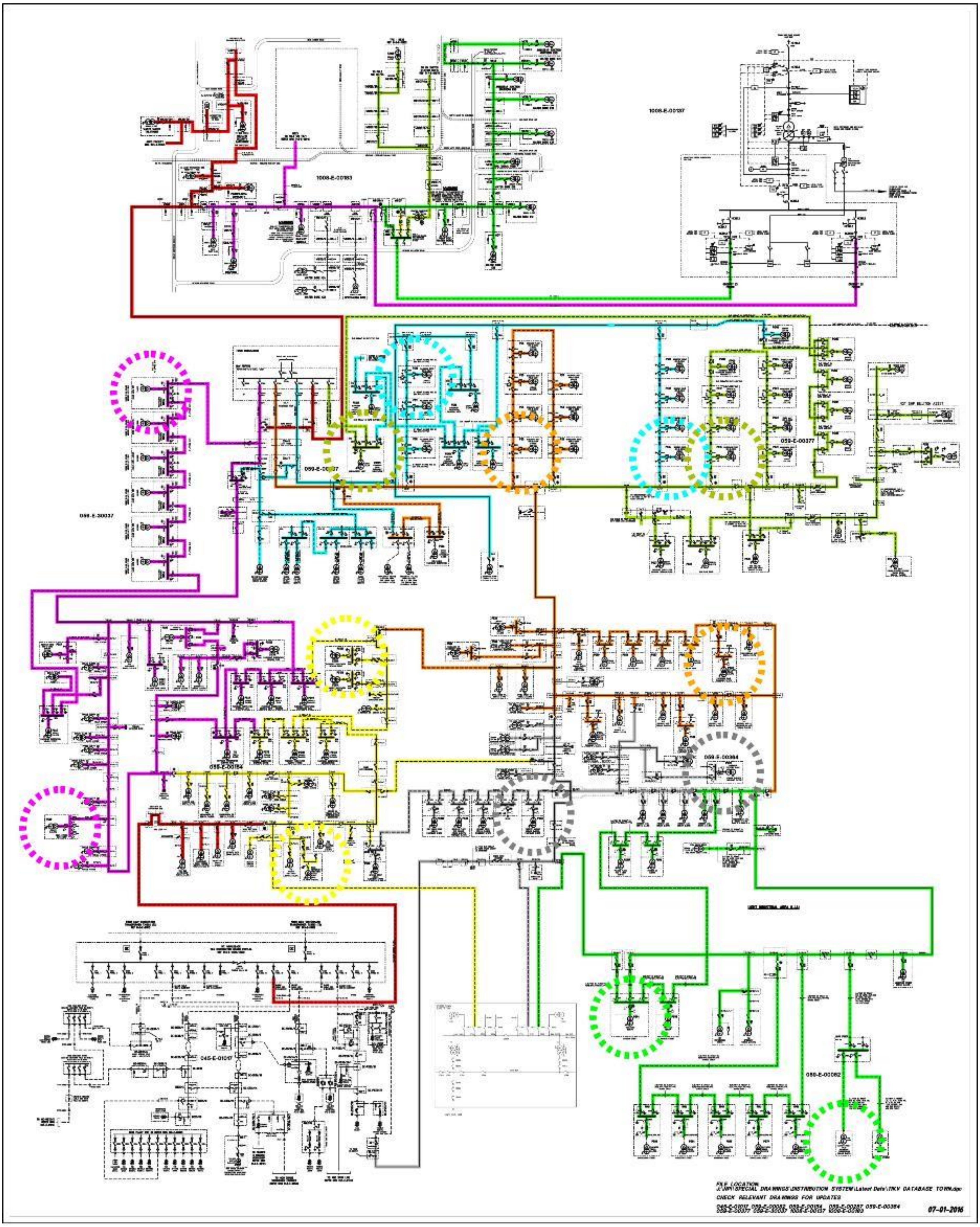


Figure 1 | Single line diagram of the Newman township (coloured circles indicate the location of PQ loggers)

4.3.PQ Device Setup

The setup of the PQ loggers was as per the relative HIOKI instruction manual.

As shown in the frequency and voltage time-based PQ plots in Appendix B , three values have been logged and plotted: the maximum RMS, the average RMS and the minimum RMS value over the recording interval. The recording interval setup in the PQ loggers was five minutes, with the exception of flicker which uses 10 minute intervals. That is, over the course of the in-service days the PQ loggers sampled various time-based parameters (e.g., Hz, U and I) at 5 minutes per sample; and at the end of every sampling interval the three RMS values where recorded.

Figure 2 is an extract from the HOIKI instruction manual depicting the sampling and interval-recording of maximum, average and minimum RMS values.

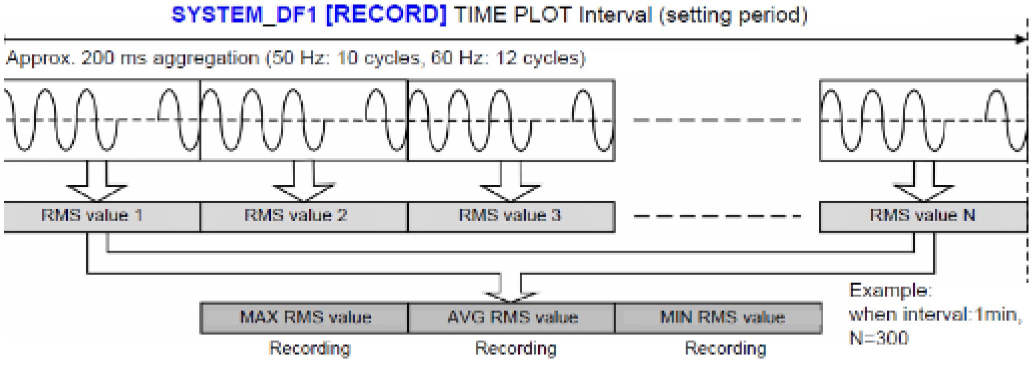


Figure 2 | Sampling and interval recording philosophy used in the Hioki PQ loggers (from Hioki Manual)

5. COMPLIANCE REQUIREMENTS

This section summarises the *Compatibility Levels* by which a 'Distributor's' electrical network is to comply with, as outlined by the Code.

5.1.Voltage Fluctuations

5.1.1. Flicker

The Code specifies that flicker shall comply with long- and short-term flicker 'compatibility levels' as per AS61000:2001. The compatibility levels are shown in Table 2, and are a measure of the voltage quality limits over a 10 minute and 2-hour interval for short- (*Pst*) and long-term (*Plt*) flicker.

Table 2 | Long & short-term flicker limits

Symbol	Value
Short Term - P_{ST}	1.0
Long Term – P_{LT}	0.8

5.1.2. Voltage Levels

In accordance with AS3000:2007 the voltage levels of the electrical network must be maintained at +10, -6% of the nominal supply voltage of 240V single-phase.

5.2.Frequency

The Code specifies the frequency fluctuation shall adhere to the Electricity Act 1945 with the level to be maintained at ±2.5% of 50Hz.

5.3.Voltage Total Harmonic Distortion

The Code specifies the voltage total harmonic distortion (U-THD) is to be kept under 8%. Individual odd and even harmonic components are not to exceed the figures shown in Table 3.

Table 3 | Harmonic Compatibility Level

Compatibility levels for harmonic voltages (in percent of nominal voltage)					
Odd harmonics (non-multiple of 3)		Odd harmonics (multiple of 3)		Even Harmonics	
Order (h)	Harmonic Voltage %	Order (h)	Harmonic Voltage %	Order (h)	Harmonic Voltage %
5	6	3	5	2	2
7	5	9	1.5	4	1
11	3.5	15	0.3	6	0.5
13	3	21	0.2	8	0.5
17	2	>21	0.2	10	0.5
19	1.5			12	0.2
23	1.5			>12	0.2
25	1.5				
>25	0.2 + 1.3(25/h)				

***Note** – Total harmonic distortion (THD): 8%*

5.4. Power Industry Reliability Indicators

As per Schedule 1, Clause 11 (a) to (d) of the Code, a number of reliability indicators (e.g. interruption durations and quantity of interruptions) are required to be reported. To achieve the Code's requirement, the following standard utility reliability indices have been used.

5.4.1. Customer Average Interruption Duration Index (CAIDI)

Customer Average Interruption Duration Index is defined as the sum of the duration of each customer interruption (in minutes) divided by the number of distribution customers served.

$$CAIDI_{Minutes} = \frac{\sum \text{Customer Interruption Durations}}{\sum \text{Customer Interruptions}} = \frac{\text{SAIDI}}{\text{SAIFI}}$$

5.4.2. System Average Interruption Frequency Index (SAIFI)

System Average Interruption Frequency Index is defined as the sum of the frequency of each sustained distribution customer interruption (in interruption events) attributable to the distribution system divided by the number of distribution customers served.

$$SAIFI_{Interruptions} = \frac{\sum \text{Number of Sustained DX Customer Interruptions}}{\text{Number of DX Customers Served}}$$

5.4.3. Average Service Availability Index (ASAI)

Average Service Availability Index is the percentage of time that the service is available to the networks' customers in a reportable year.

$$ASAI_{Percent} = 1 - \frac{SAIDI_{Hours}}{8760}$$

5.4.4. System Average Interruption Duration Index (SAIDI)

System Average Interruption Duration Index is defined as the sum of the duration of each sustained distribution customer interruption (in minutes) attributable to the distribution system divided by the number of distribution customers served.

$$SAIDI_{Minutes} = \frac{\sum \text{Sustained DX Customer Interruption Durations}}{\text{Number of DX Customers Served}}$$

6. Site Measurements (PQ Loggers Data)

The following sections describe the results and notable PQ events which have been recorded by the loggers for each of the 7 feeders.

6.1. Feeder TC1

The PQ logger at the start of the TC1 feeder was installed in the PS3 Callawa Way substation between 22/02/2018 and 02/03/2018, thus satisfying the 7 days minimum logging duration requirement.

The PQ logger at the end of the TC1 feeder was installed in the PS68 Capricorn Oval substation between 14/02/2018 and 22/02/2018, thus satisfying the 7 days minimum logging duration requirement. As shown in Figure 1 (orange feeder), TC1 originates from the Township substation. The TC1 feeder is a feeder that supplies a number of older distribution substations.

6.1.1. Flicker

The logged flicker data for the start and end of the TC1 feeder is shown from Figure 22 to Figure 24 and from Figure 25 to Figure 27 of Appendix B . There were no recorded flicker limit events causing the flicker level to breach the Code's limits (i.e. full compliance with the Code requirements).

6.1.2. Voltage

The logged voltage level data for the start and end of the TC1 feeder is shown from Figure 28 to Figure 3030 and from Figure 31 to Figure 33 in Appendix B , respectively. There were no recorded voltage limit events causing the voltage level to breach the Code's limits (i.e. full compliance with the Code requirements).

6.1.3. Frequency

The logged frequency data for the start and end of the TC1 feeder is shown in Figure 34 and Figure 35 of Appendix B . There were no recorded frequency limit events causing the voltage level to breach the Code's limits (i.e. full compliance with the Code requirements).

6.1.4. Voltage THD

The logged voltage THD level data for the start and end of the TC1 feeder are shown from Figure 36 to Figure 38 and from Figure 39 to Figure 41 in Appendix B There were no noted voltage limit events causing the voltage THD level to breach the Code's limits (i.e. full compliance with the Code requirements).

6.1.5. Harmonics

The logged harmonic data for the start and end of the TC1 feeder is shown in Figure 42 to Figure 45 and Figure 46 to Figure 49 in Appendix B , respectively.

A summary of non-compliant harmonics and the scale of non-compliances is shown in Figure 3 and Figure 4. It should be noted that the Power Quality measurements on the TC1 feeder given in the "W_APD05079 2016-2017 Annual Compliance Report" indicated that on a number of occassions, the 6^{th} harmonics of the voltage were found to exceed the limits set by AS/NZS 61000:2001 (i.e., larger than 0.5%).

The number of 6^{th} harmonic exceedances appears to have remained similar to that of the previous years measurements. However, the overall number of non-compliant even-harmonics appears to have increased this year with a multitude of 24th harmonics of the voltage also found to be in exceedance of the limits set by AS/NZS 61000:2001 (i.e., larger than 0.2%). Similar to the previous years' assessment, the even harmonic exceedances are attributed to unbalanced 3-phase loads, possibly with DC component, supplied from Town Substation [R Dugan *et al*, *Electrical Power Systems Quality* book, 3rd Edition, 2012]. The compliance issue is observed for <2% of the measurement period, hence of no major concern at the present but should it exacerbate in coming years, then mitigation measure (e.g., passive or active filters) are required to avoid undesirable consequences such as excessive neutral current, overheated installations, malfunction of protection devices and mis-operation or failure of electronic equipment.

Note that no non-compliant odd harmonics were observed during the logging period on the TC1 feeder, hence graphs depicting the non-compliant odd harmonics not presented.

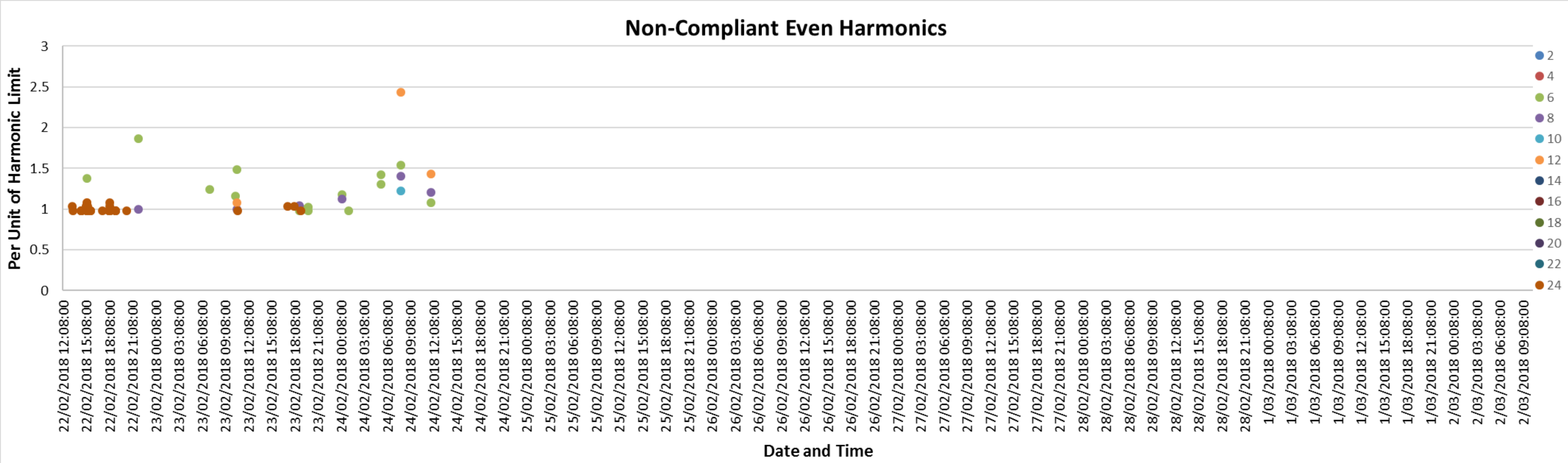


Figure 3 | TC1 feeder – Start – Non-compliant even harmonics

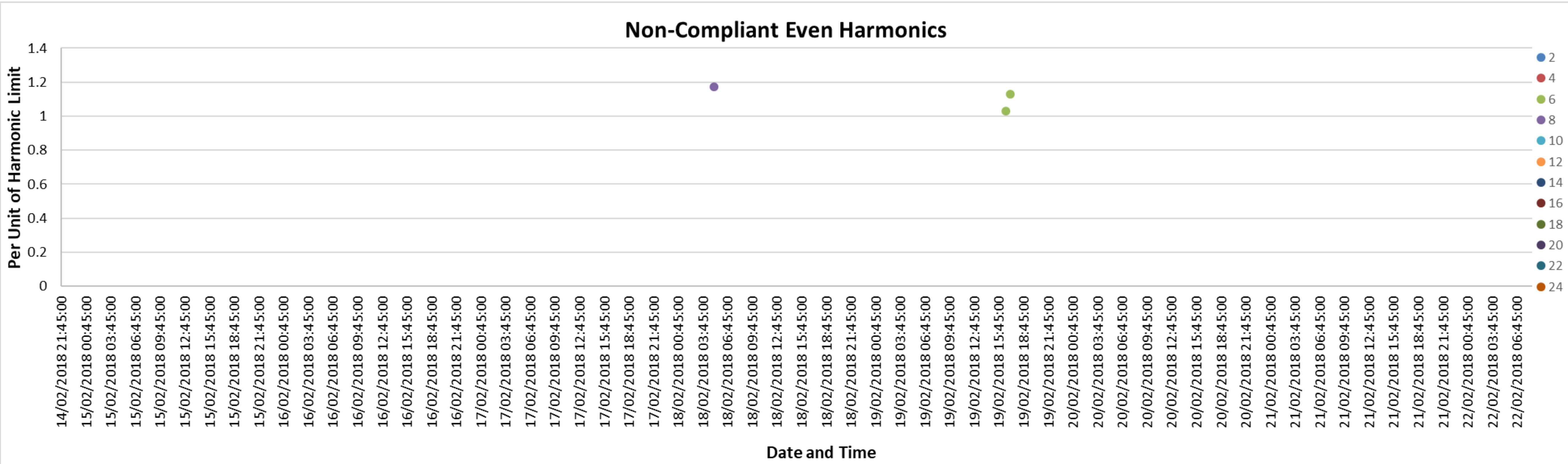


Figure 4 | TC1 feeder – End – Non-compliant even harmonics

6.2. Feeder TC2

The PQ logger at the start of the TC2 feeder was installed in the PS10 McLennan Drive substation between 23/02/2018 and 02/03/2018, thus satisfying the 7 days minimum logging duration requirement.

The PQ logger at the end of the TC2 feeder was installed in the PS14 Bondini Drive substation between 05/03/2018 and 15/03/2018, thus satisfying the 7 days minimum logging duration requirement. As shown in Figure 1 (cyan feeder), TC2 originates from the Township substation.

6.2.1. Flicker

The logged flicker data for the start and end of the TC2 feeder is shown in Figure 50 to Figure 52 and Figure 53 to Figure 55 of Appendix B , respectively.

Table 4 details the short-term flicker events found to be in exceedance of the limits set by 'the Code' including their respective magnitudes and affected phases. The frequency of occurrence of the exceedances constitutes a very small fraction (i.e., under 0.2%) of the total measurements period, hence of no practical concern at this stage.

Table 4 | Summary of Results - Short Term Flicker Events - Feeder TC2

Date & Time	Magnitude of Short Term Flicker (P_{st}) Events	
	Start of Feeder	End of Feeder
05/03/2018 18:26		R Phase – 1.08 W Phase – 1.08 B Phase – 1.08
14/03/2018 15:16		R Phase – 1.36 W Phase – 1.34 B Phase – 1.35

6.2.2. Voltage

The logged voltage level data for the start and end of the TC2 feeder is shown from Figure 56 to Figure 58 and from Figure 59 to Figure 61 of Appendix B , respectively.

Table 5 details the voltage limit events found to be in exceedance of the limits set by AS/NZS 3000:2007 including their respective magnitudes and affected phases. The frequency of occurrence of the exceedances constitutes a very small fraction (i.e., under 0.2%) of the total measurements period, hence of no practical concern at this stage.

Table 5 | Summary of Results - Voltage Events - Feeder TC2

Date & Time	Magnitude of Voltage Limit Events	
	Start of Feeder	End of Feeder
05/03/2018 18:21		R Phase – 221.05V W Phase – 220.39V B Phase – 222.09V
14/03/2018 15:11		R Phase – 221.58V W Phase – 220.79V B Phase – 222.09V

6.2.3. Frequency

The logged frequency data for the start and end of the TC2 feeder is shown in Figure 62 and Figure 63 of Appendix B , respectively. There were no recorded frequency limit events causing the voltage level to breach the Code's limits (i.e. full compliance with the Code requirements).

6.2.4. Voltage THD

The logged voltage THD level data for the start and end of the TC2 feeder is shown from Figure 64 to Figure 66 and from Figure 67 to Figure 69 in Appendix B , respectively. There were no noted voltage limit events causing the voltage THD level to breach the Code's limits (i.e. full compliance with the Code requirements).

6.2.5. Harmonics

The logged harmonic data for the start and end of the TC2 feeder is shown from Figure 70 to Figure 73 and from Figure 74 to Figure 77 in Appendix B , respectively.

A summary of non-compliant harmonics and the scale of non-compliances are shown in Figure 5 to Figure 6. The voltage's 6^{th} to 12^{th} even harmonics are observed to exceed their respective limits in a number of occassions. With respect to the previous reporting period (2016/17 FY), the compliance issue appears to have not exacerbated significantly, hence further investigation and monitoring is required in the coming years to ensure full compliance with the Code's requirements – refer to Section 6.1.5 for further details.

Note that no non-compliant odd harmonics were observed during the logging period on the TC1 feeder, hence graphs depicting the non-compliant odd harmonics not presented.

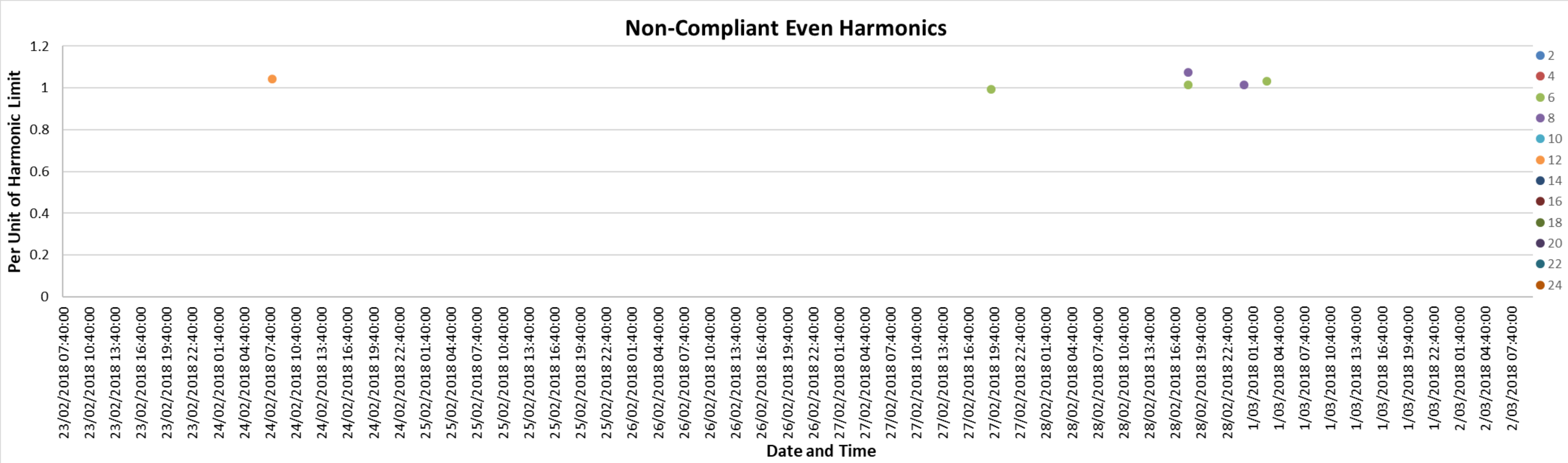


Figure 5 | TC2 feeder – Start – Non-compliant even harmonics

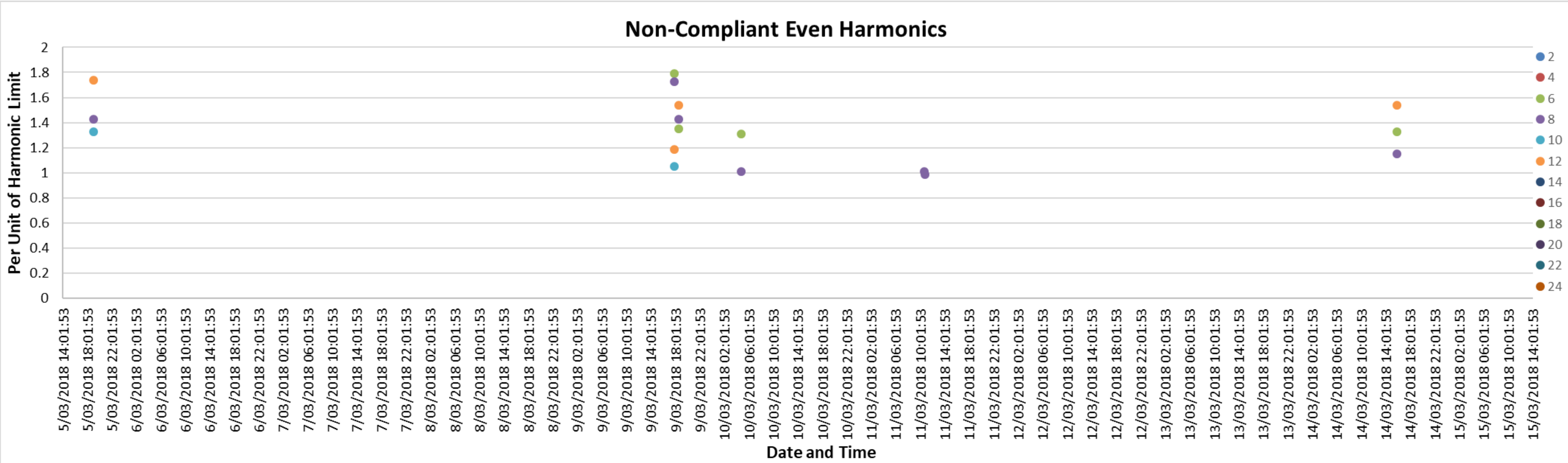


Figure 6 | TC2 feeder – End – Non-compliant even harmonics

6.3. Feeder TC3

The PQ logger at the start of the TC3 feeder was installed in the PS108 Less Tutt Drive substation between 23/02/2018 and 02/03/2018, thus satisfying the 7 days minimum logging duration requirement.

The PQ logger at the end of the TC3 feeder was installed in the PS69 Giles Avenue substation between 05/02/2018 and 13/02/2018, thus satisfying the 7 days minimum logging duration requirement. As shown in Figure 1 (purple feeder), TC3 originates from the Township substation.

6.3.1. Flicker

The logged flicker data for the start and end of the TC3 feeder is shown in Figure 78 to Figure 80 and Figure 81 to Figure 83 of Appendix B , respectively.

Table 6 details the short-term flicker events found to be in exceedance of the limits set by 'the Code' including their respective magnitudes and affected phases. The frequency of occurrence of the exceedances constitutes a very small fraction (i.e., under 0.1%) of the total measurements period, hence of no practical concern at this stage.

Table 6 | Summary of Results - Short Term Flicker Events - Feeder TC3

Date & Time	Magnitude of Short Term Flicker (P_{st}) Events	
	Start of Feeder	End of Feeder
12/02/2018 17:46		B Phase – 1.08

6.3.2. Voltage

The logged voltage level data for the start and end of the TC3 feeder is shown from Figure 84 to Figure 86 and from Figure 87 to Figure 89 of Appendix B , respectively. There were no recorded voltage limit events causing the voltage level to breach the Code's limits (i.e. full compliance with the Code requirements).

6.3.3. Frequency

The logged frequency data for the start and end of the TC3 feeder is shown in Figure 90 and Figure 91 of Appendix B , respectively. There were no recorded frequency limit events causing the voltage level to breach the Code's limits (i.e. full compliance with the Code requirements).

6.3.4. Voltage THD

The logged voltage THD level data for the start and end of the TC3 feeder is shown from Figure 92 to Figure 94 and from Figure 95 to Figure 97 in Appendix B , respectively. There were no noted voltage limit events causing the voltage THD level to breach the Code's limits (i.e. full compliance with the Code requirements).

6.3.5. Harmonics

The logged harmonic data for the start and end of the TC3 feeder is shown in Figure 98 to Figure 101 and Figure 102 to Figure 105 in Appendix B , respectively.

A summary of non-compliant harmonics and the scale of non-compliances are shown in Figure 7 to Figure 9. Given the temporary and random nature of the breaches, they are not deemed of any practical concern (i.e. not deemed as compliance issues).

Note that no non-compliant odd harmonics were observed during the logging period on the PS108 TC3 feeder (start), hence the graph depicting the non-compliant odd harmonics is not presented.

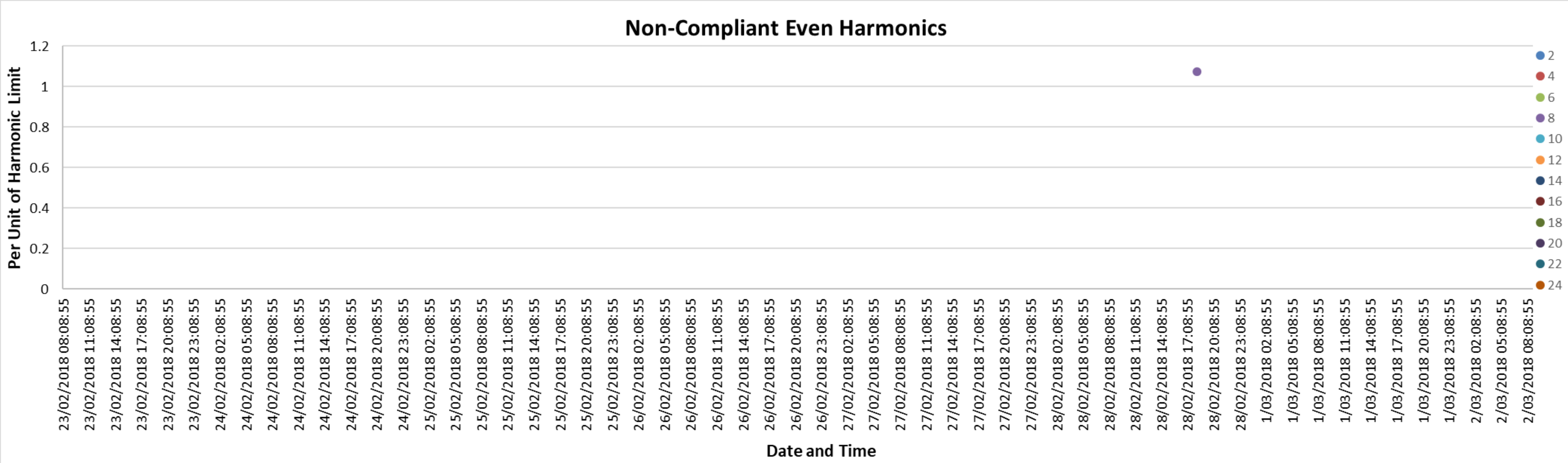


Figure 7 | TC3 feeder – Start – Non-compliant even harmonics

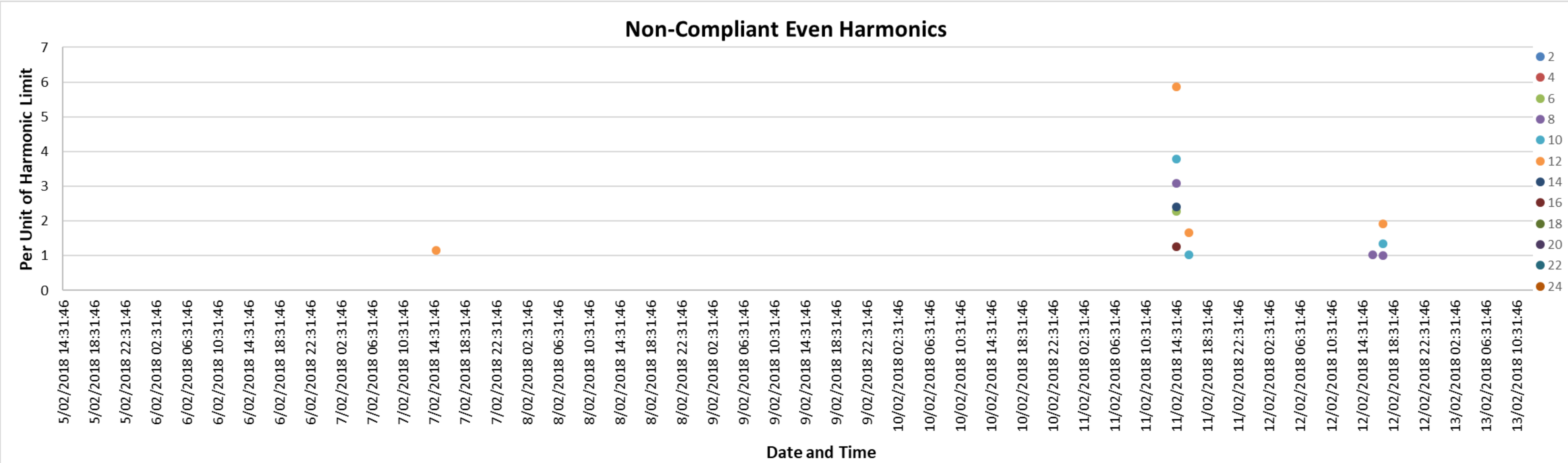


Figure 8 | TC3 feeder – End – Non-compliant even harmonics

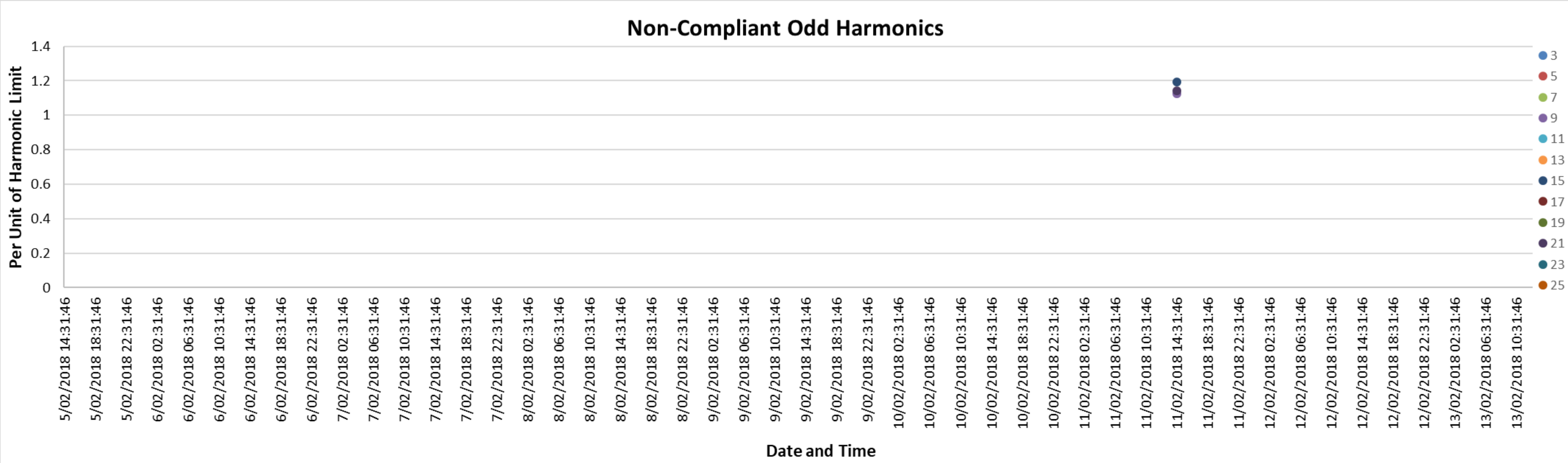


Figure 9 | TC3 feeder – End – Non-compliant odd harmonics

6.4. Feeder TC4

The PQ logger at the start of the TC4 feeder was installed in the PS125 Bubbacurry Loop substation and was installed between 05/02/2018 and 13/02/2018, thus satisfying the 7 days minimum logging duration requirement. The PQ logger at the end of the TC4 feeder was installed in the PS15 Karrawan Way substation and was installed between 05/03/2018 and 15/03/2018, thus satisfying the 7 days minimum logging duration requirement. As shown in Figure 1 (light-green feeder), TC4 originates from the Township substation.

6.4.1. Flicker

The logged flicker data for the start and end of the TC4 feeder is shown from Figure 106 to Figure 108 and from Figure 109 to Figure 111 of Appendix B , respectively.

Table 7 details the short-term flicker events found to be in exceedance of the limits set by 'the Code' including their respective magnitudes and affected phases. The frequency of occurrence of the exceedances constitutes a very small fraction (i.e., under 0.2%) of the total measurements period, hence of no practical concern at this stage.

Table 7 | Summary of Results - Short Term Flicker Events - Feeder TC4

Date & Time	Magnitude of Short Term Flicker (P_{st}) Events	
	Start of Feeder	End of Feeder
05/03/2018 16:02		R Phase – 1.09 W Phase – 1.09 B Phase – 1.09
14/03/2018 12:52		R Phase – 1.37 W Phase – 1.35 B Phase – 1.36

6.4.2. Voltage

The logged voltage level data for the start and end of the TC4 feeder are shown in Figure 112 to Figure 114 and Figure 115 to Figure 117 of Appendix B , respectively.

Table 8 details the voltage limit events found to be in exceedance of the limits set by AS/NZS 3000:2007 including their respective magnitudes and affected phases. The frequency of occurrence of the exceedances constitutes a very small fraction (i.e., under 0.2%) of the total measurements period, hence of no practical concern at this stage.

Table 8 | Summary of Results - Voltage Events - Feeder TC4

Date & Time	Magnitude of Voltage Limit Events	
	Start of Feeder	End of Feeder
05/03/2018 15:57		R Phase – 221.65V W Phase – 221.29V B Phase – 222.51V
14/03/2018 12:47		R Phase – 219.53V W Phase – 218.99V B Phase – 220.07V

6.4.3. Frequency

The logged frequency data for the start and end of the TC4 feeder is shown in Figure 118 and Figure 119 of Appendix B . There were no recorded frequency limit events causing the voltage level to breach the Code's limits (i.e. full compliance with the Code requirements).

6.4.4. Voltage THD

The logged voltage THD level data for the start and end of the TC4 feeder is shown from Figure 120 to Figure 122 and from Figure 123 to Figure 125 in Appendix B , respectively. There were no noted voltage limit events causing the voltage THD level to breach the Code's limits (i.e. full compliance with the Code requirements).

6.4.5. Harmonics

The logged harmonic data for the start and end of the TC4 feeder is shown from Figure 126 to Figure 129 and from Figure 130 to Figure 133 in Appendix B , respectively.

A summary of non-compliant harmonics and the scale of non-compliances is shown in Figure 10 and Figure 11.

It should be noted that the Power Quality measurements on the TC4 feeder given in the "W_APD05079 2016-2017 Annual Compliance Report" indicated that on a number of occassions, the 6th harmonics of the voltage were found to exceed the limits set by AS/NZS 61000:2001 (i.e., larger than 0.5%).

The number of 6th harmonic exceedances appears to have remained similar to that of the previous years measurements. However, the overall number of non-compliant even-harmonics appears to have worsened with a number of 12th harmonics of the voltage found to be in exceedance of the limits set by AS/NZS 61000:2001 (i.e., larger than 0.2%).Hence further investigation and monitoring is required in the coming years to ensure full compliance with the Code's requirements – refer to Section 6.1.5 for further details.

Additionally, note that no non-compliant odd harmonics were observed during the logging period on the TC4 feeder, hence graphs depicting the non-compliant odd harmonics have been omitted.

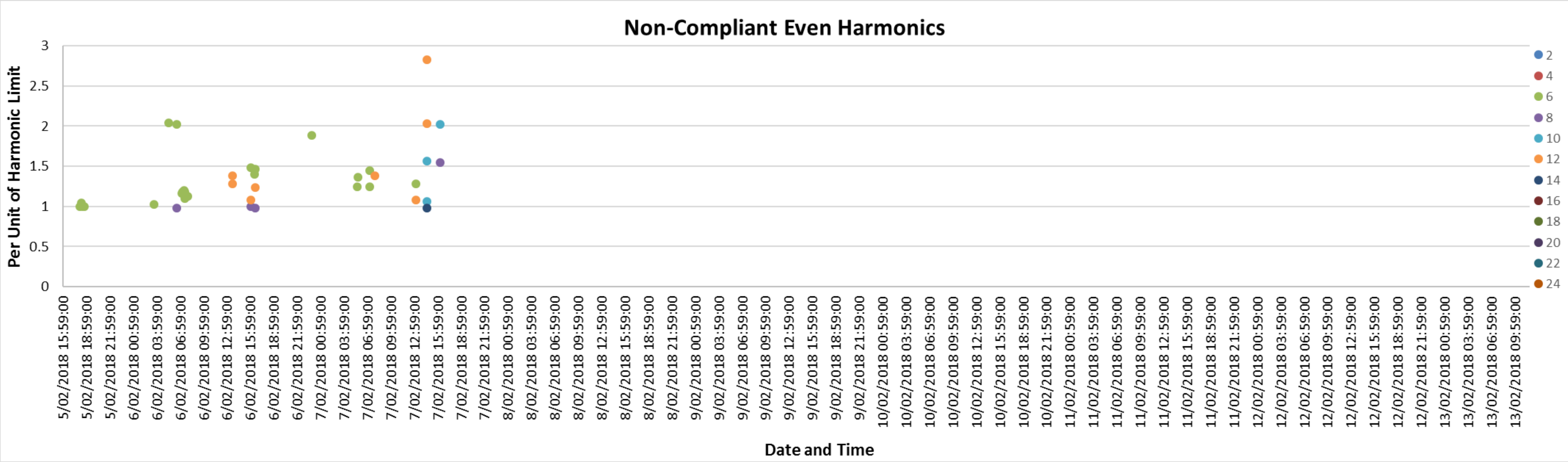


Figure 10 | TC4 feeder – Start – Non-compliant even harmonics

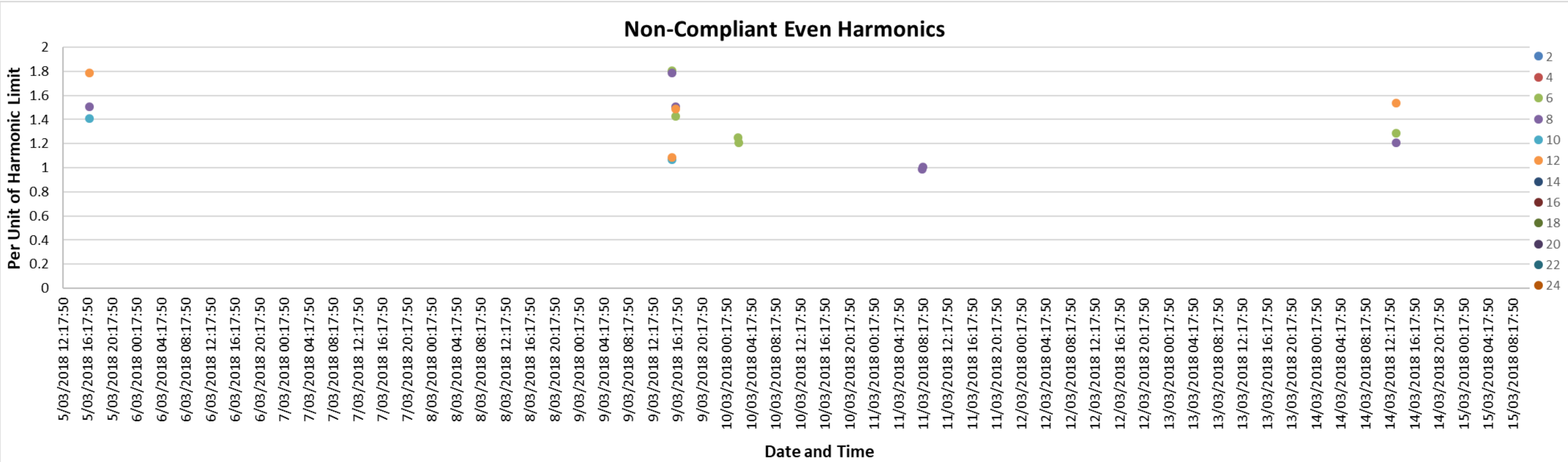


Figure 11 | TC4 feeder – End – Non-compliant even harmonics

6.5. Feeder STS1

The PQ logger at the start of the STS1 feeder was installed in the PS94 Pardoo Street substation between 22/02/2018 and 02/03/2018, thus satisfying the 7 days minimum logging duration requirement.

The PQ logger at the end of the STS1 feeder was installed in the PS25 Laver Street substation between 03/04/2018 and 14/04/2018, thus satisfying the 7 days minimum logging duration requirement. As shown in Figure 1 (green feeder), STS1 originates from the South Town substation.

6.5.1. Flicker

The logged flicker data for the start and end of the STS1 feeder is shown from Figure 134 to Figure 136 and from Figure 137 to Figure 139 of Appendix B , respectively. There were no recorded flicker limit events causing the flicker level to breach the Code's limits (i.e. full compliance with the Code requirements).

6.5.2. Voltage

The logged voltage level data for the start and end of the STS1 feeder is shown from Figure 140 to Figure 142 and from Figure 143 to Figure 145 of Appendix B , respectively. There were no recorded voltage limit events causing the voltage level to breach the Code's limits (i.e. full compliance with the Code requirements).

6.5.3. Frequency

The logged frequency data for the start and end of the STS1 feeder is shown in Figure 146 and Figure 147 of Appendix B , respectively. There were no recorded frequency limit events causing the voltage level to breach the Code's limits (i.e. full compliance with the Code requirements).

6.5.4. Voltage THD

The logged voltage THD level data for the start and end of the STS1 feeder is shown from Figure 148 to Figure 150 and from Figure 151 to Figure 153 in Appendix B , respectively. There were no noted voltage limit events causing the voltage THD level to breach the Code's limits (i.e. full compliance with the Code requirements).

6.5.5. Harmonics

The logged harmonic data for the start and end of the STS1 feeder is shown in Figure 154 to Figure 157 and Figure 158 to Figure 161 in Appendix B , respectively.

A summary of non-compliant harmonics and the scale of non-compliances is shown in Figure 12. Given the temporary and random nature of the breaches, they are not deemed of any practical concern (i.e. not deemed as compliance issues).

Note that no non-compliant odd harmonics were observed during the logging period on the STS1 feeder. Similarly, no non-compliant even harmonics were observed on the start of the STS1 feeder, hence graphs depicting these non-compliant (odd or even) harmonics not presented.

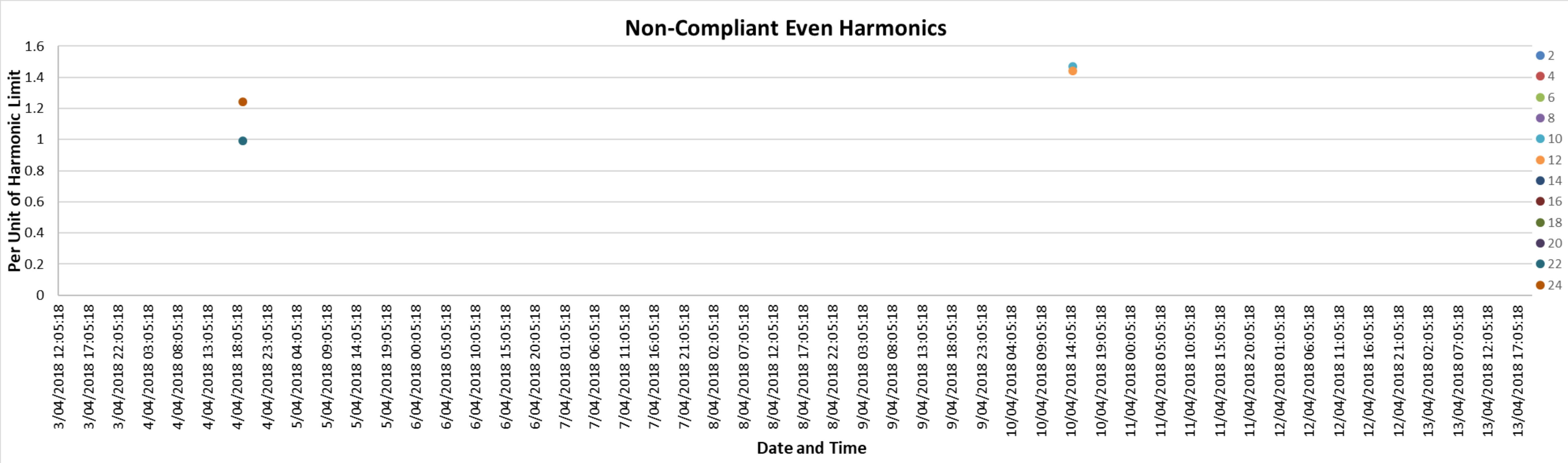


Figure 12 | STS1 feeder – End – Non-compliant even harmonics

6.6. Feeder STS2

The PQ logger at the start of the STS2 feeder was installed in the PS60 Forrest Avenue substation between 14/02/2018 and 22/02/2018, thus satisfying the 7 days minimum logging requirements.

The PQ logger at the end of the STS2 feeder was installed in the PS70 Jabbarup Crescent Park substation between 03/04/2018 and 14/04/2018, thus satisfying the 7 days minimum logging requirement. As shown in Figure 1 (grey feeder), STS2 originates from the South Town substation.

6.6.1. Flicker

The logged flicker data for the start and end of the STS2 feeder is shown from Figure 162 to Figure 164 and from Figure 165 to Figure 167 of Appendix B , respectively.

Table 9 details the short-term flicker events found to be in exceedance of the limits set by 'the Code' including their respective magnitudes and affected phases. The frequency of occurrence of the exceedances constitutes a very small fraction (i.e., under 0.1%) of the total measurements period, hence of no practical concern at this stage.

Table 9 | Summary of Results - Short Term Flicker Events - Feeder STS2

Date & Time	Magnitude of Short Term Flicker (P_{st}) Events	
	Start of Feeder	End of Feeder
19/02/2018 16:52		R Phase – 1.14 B Phase – 1.13

6.6.2. Voltage

The logged voltage level data for the start and end of the STS2 feeder is shown from Figure 168 to Figure 170 and from Figure 171 to Figure 173 of Appendix B , respectively. There were no recorded voltage limit events causing the voltage level to breach the Code's limits (i.e. full compliance with the Code requirements).

6.6.3. Frequency

The logged frequency data for the start and end of the STS2 feeder is shown in Figure 174 and Figure 175 of Appendix B , respectively. There were no recorded frequency limit events causing the voltage level to breach the Code's limits (i.e. full compliance with the Code requirements).

6.6.4. Voltage THD

The logged voltage THD level data for the start and end of the STS2 feeder is shown from Figure 176 to Figure 178 and from Figure 179 to Figure 181 in Appendix B , respectively. There were no noted voltage limit events causing the voltage THD level to breach the Code's limits (i.e. full compliance with the Code requirements).

6.6.5. Harmonics

The logged harmonic data for the start and end of the STS2 feeder is shown in Figure 182 to Figure 185 and Figure 186 to Figure 189 in Appendix B , respectively.

A summary of non-compliant harmonics and the scale of non-compliances are shown in Figure 13 to Figure 14. Given the temporary and random nature of the breaches, they are not deemed of any practical concern (i.e. not deemed as compliance issues).

Note that no non-compliant odd harmonics were observed during the logging period on the STS2 feeder, hence graphs depicting the non-compliant odd harmonics not presented.

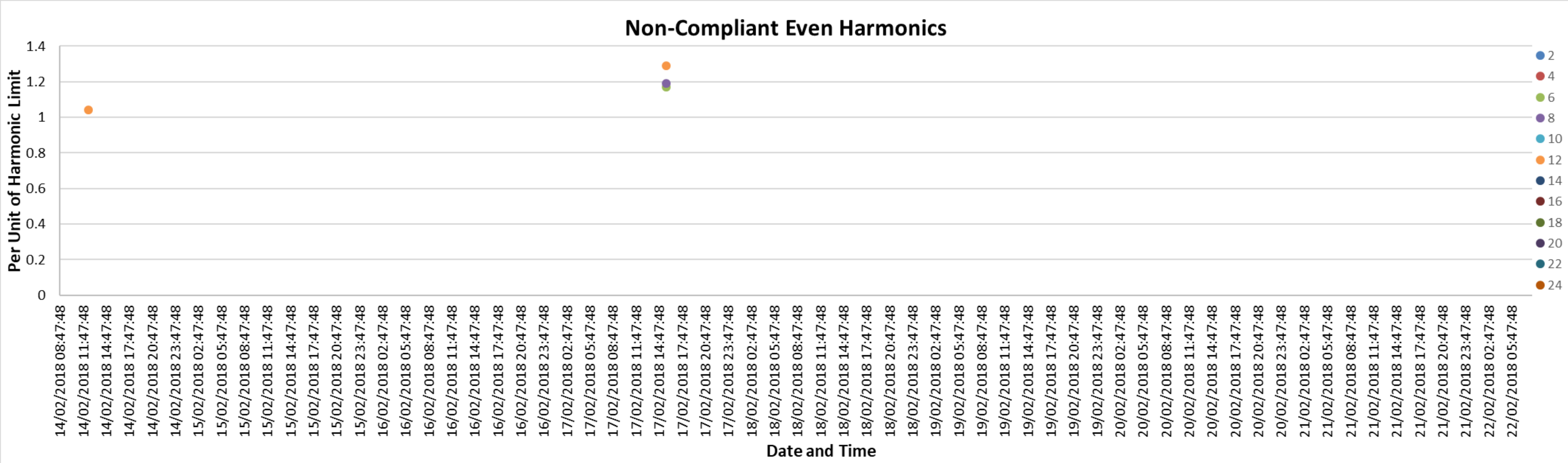


Figure 13 | STS2 feeder – Start – Non-compliant even harmonics

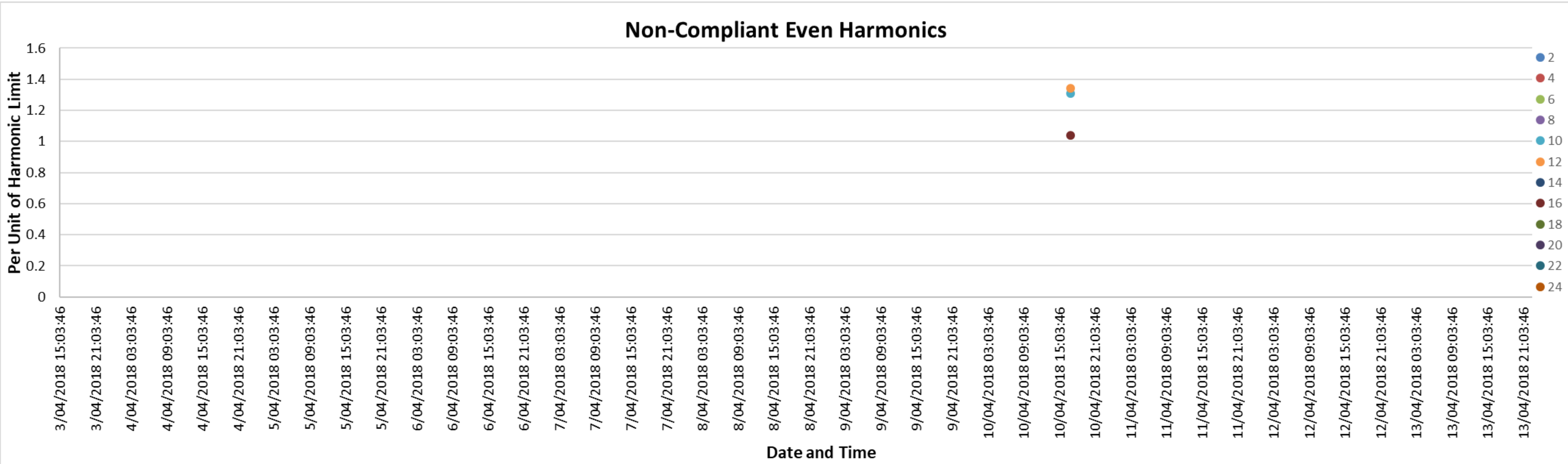


Figure 14 | STS2 feeder – End – Non-compliant even harmonics

6.7. Feeder STS6

The PQ logger at the start of the STS6 feeder was installed in the PS127 Water Treatment substation between 03/04/2018 and 14/04/2018, thus satisfying the 7 days minimum logging requirement.

The PQ logger at the end of the STS6 feeder was installed in the PS121 Newman Drive substation between 05/02/2018 and 13/02/2018, thus satisfying the 7 days minimum logging requirement. As shown in Figure 1 (yellow feeder), STS6 originates from the South Town substation.

6.7.1. Flicker

The logged flicker data for the start and end of the STS6 feeder is shown from Figure 190 to Figure 192 and from Figure 193 to Figure 195 of Appendix B , respectively.

Table 10 details the short-term flicker events found to be in exceedance of the limits set by 'the Code' including their respective magnitudes and affected phases. The frequency of occurrence of the exceedances constitutes a very small fraction (i.e., under 0.1%) of the total measurements period, hence of no practical concern at this stage.

Table 10 | Summary of Results - Short Term Flicker Events - Feeder STS6

Date & Time	Magnitude of Short Term Flicker (P_{st}) Events	
	Start of Feeder	End of Feeder
12/02/2018 20:20		B Phase – 1.10

6.7.2. Voltage

The logged voltage level data for the start and end of the STS6 feeder is shown from Figure 196 to Figure 198 and from Figure 199 to Figure 201 of Appendix B , respectively. There were no recorded voltage limit events causing the voltage level to breach the Code's limits (i.e. full compliance with the Code requirements).

6.7.3. Frequency

The logged frequency data for the start and end of the STS6 feeder is shown in Figure 202 and Figure 203 of Appendix B , respectively. There were no recorded frequency limit events causing the voltage level to breach the Code's limits (i.e. full compliance with the Code requirements).

6.7.4. Voltage THD

The logged voltage THD level data for the start and end of the STS6 feeder are shown in Figure 204 to Figure 206 and Figure 207 to Figure 209 in Appendix B , respectively. There were no noted voltage limit events causing the voltage THD level to breach the Code's limits (i.e. full compliance with the Code requirements).

6.7.5. Harmonics

The logged harmonic data for the start and end of the STS6 feeder is shown from Figure 210 to Figure 213 and from Figure 214 to Figure 217 in Appendix B , respectively.

A summary of non-compliant harmonics and the scale of non-compliances are shown in Figure 15 to Figure 17. Note that the 15th order harmonic components of the supply voltage exceeds the prescribed limit in a number of occassions, but this is not deemed of major concern as it occurs in less than 2% of the measurements period. Further investigation of the issue is recommended in coming years should the harmonic components continue to raise.

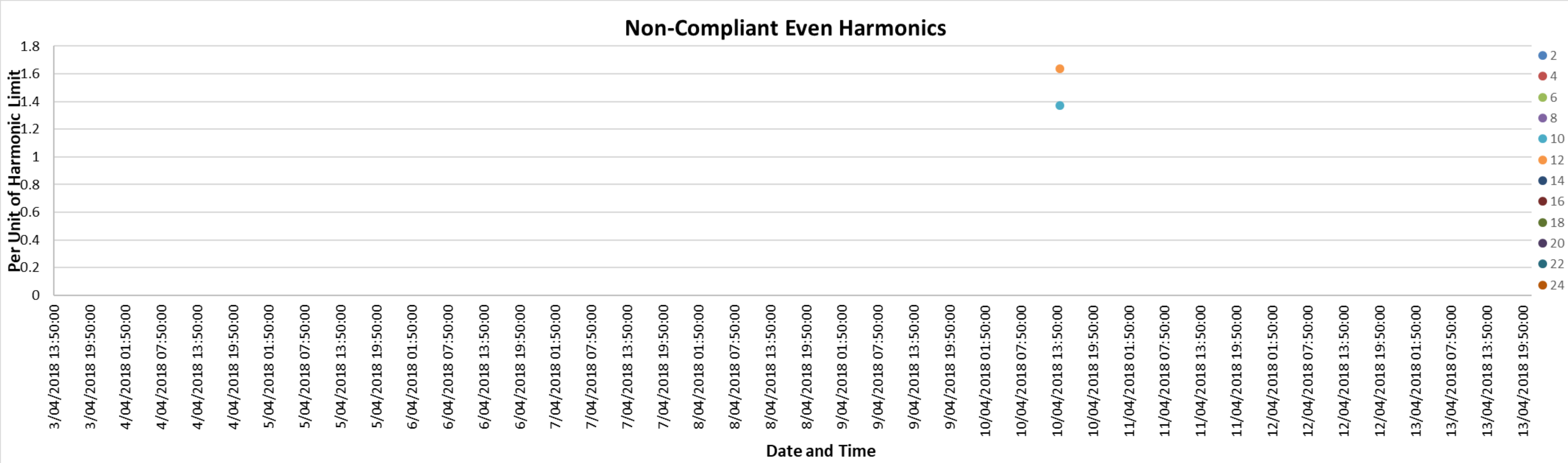


Figure 15 | STS6 feeder – Start – Non-compliant even harmonics

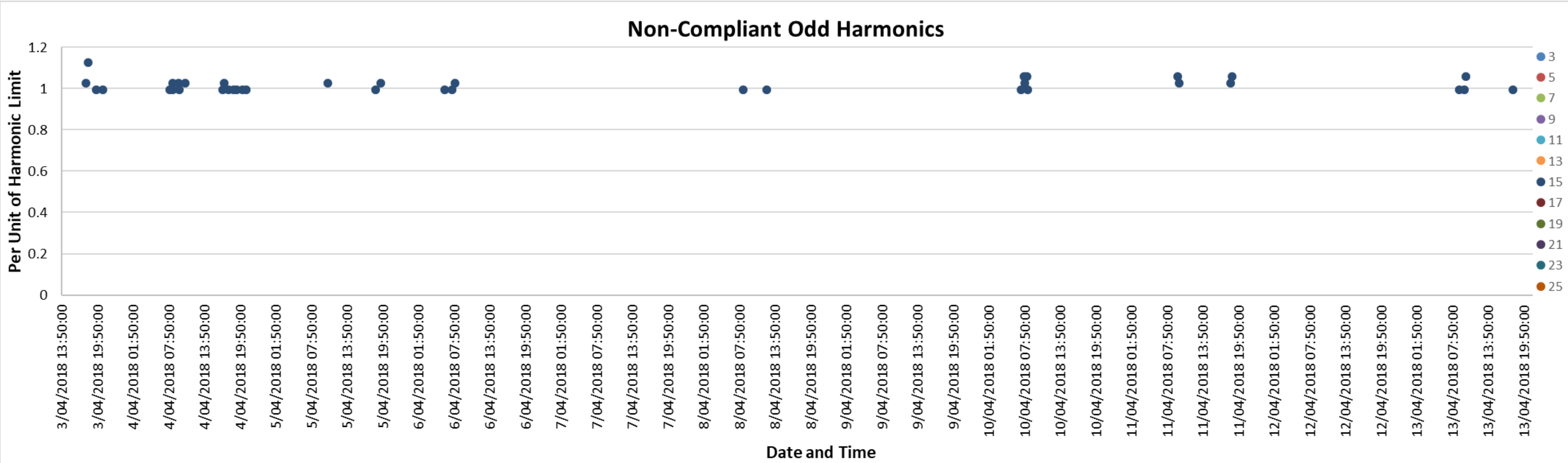


Figure 16 | STS6 feeder – Start – Non-compliant odd harmonics

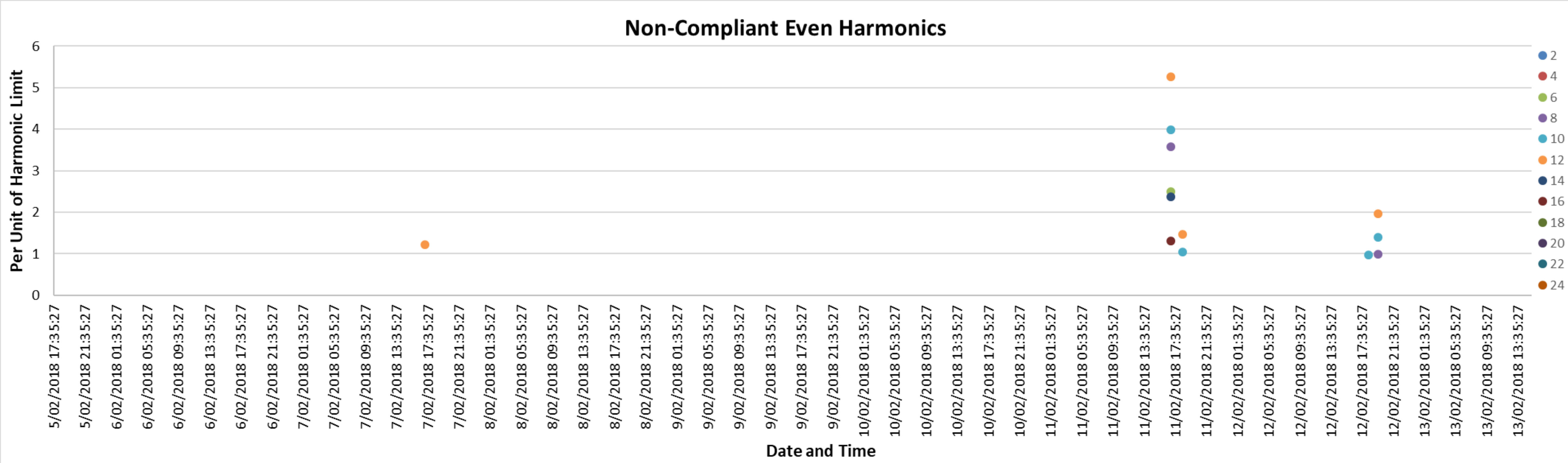


Figure 17 | STS6 feeder – End – Non-compliant even harmonics

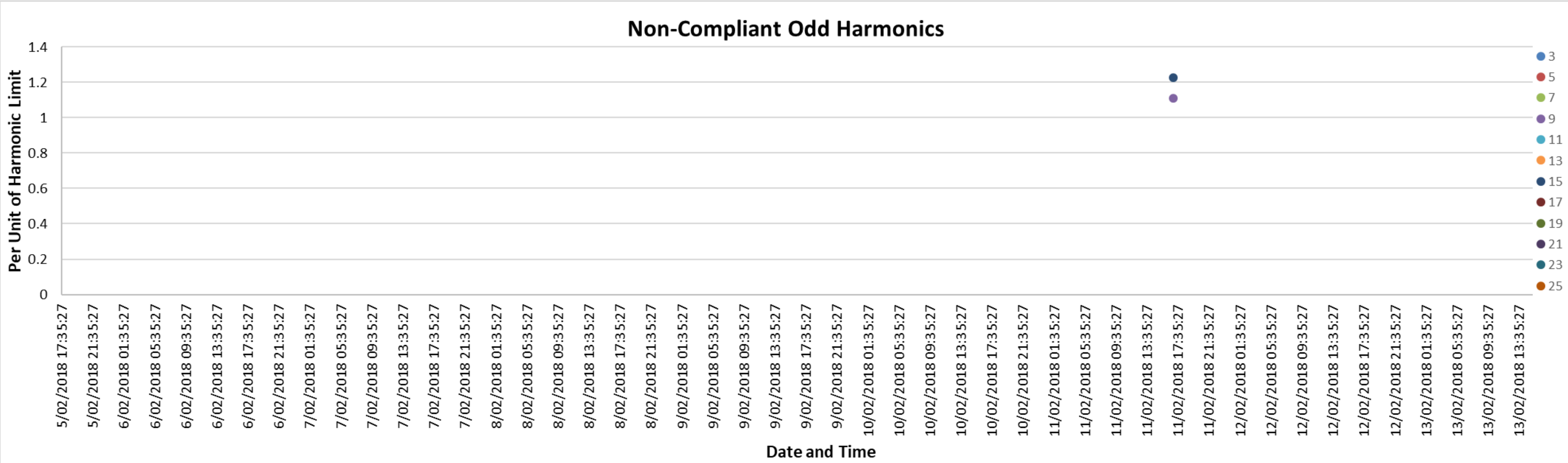


Figure 18 | STS6 feeder – End – Non-compliant odd harmonics

7. RESPONSE TO THE CODE REQUIREMENTS

This section contains all of the information required for compliance reporting as detailed in the Code "Schedule 1 - Information to be published" and "Part 2 – Quality and reliability standards".

7.1. Quality and Reliability Standards (Part 2)

7.1.1. Voltage Fluctuations (Part 2 Division 1 Quality Standards Section 6(2))

The voltage fluctuations (flicker) of electricity supplied must not exceed the compatibility levels for long-term and short-term flicker as described in Section 5.1.1.

The PQ logging results for 2017/18 FY indicate eight voltage fluctuation breaches on the township network during the logged periods. presents the results for the previous three reporting periods together with the 2017/2018 result.

Given the results presented in Table 11, a deterioration is observed over the 2017/18 FY with respect to the measurements of the years before. This needs to be monitored over the course of next year and if further decline in the quality of supply observed, then the source of the issues to be identified and mitigation measures to be considered.

Table 11 | Total number of breaches of voltage fluctuation compatibility levels

Description	Reportable Period			
	2014/2015	2015/2016	2016/2017	2017/2018
Total number of breaches of *Pst*	5	1	0	8
Total number of breaches of *Plt*	1	0	0	0

7.1.2. Harmonics (Part 2 Division 1 Quality Standards Section 7)

Within the Code, there are two measures for assessing the power quality of the Newman network. The two measures are:

1 Assessment of individual harmonics and a comparison of their magnitudes against the table in Part 2, Division 1, Section 7 of the Code; and

2 Assessment of the calculated Voltage Total Harmonic Distortion (U-THD) and a comparison of its magnitude with the Code's compliant value of 8%.

7.1.2.1. Individual Voltage Harmonics

Individual, non-compliant harmonics for each respective feeder are already presented in Section 6 (mostly of no practical concern at this stage due to very infrequent occurrence and also, the THD being well within the limit).

7.1.2.2. Voltage Total Harmonic Distortions

The voltage harmonic distortion levels of electricity supplied must not exceed the Voltage Total Harmonic Distortion (U-THD) of 8% stated in Part 2, Division 1, Section 7 of the Code.

Table 12 presents the results for the previous three reporting periods together with the 2017/2018 result. In the 2017/2018 period, zero events occurred where the *maximum* U-THD was greater than the 8% limit. The *average* of the U-THD was consistently well within the 8% limit.

Given the results presented in Table 12, a consistent supply is observed over the 2017/18 FY with respect to the measurements of the years before.

Table 12 |Total number of breaches of total harmonic distortion limit

Description	Reportable Period			
	2014/2015	2015/2016	2016/2017	2017/2018
Total number of breaches of Voltage Total Harmonic Distortion (U-THD)	1	0	0	0

7.1.3. Voltage Level Compliance (Part 2 Division 2 Quality Standards Section 8 Note (a))

The following information is not required as part of the reporting requirements of the Code. It has been included here to provide a more complete indication of the network power supply quality.

In accordance with AS3000:2007, the voltage levels of the electrical network must be maintained at +10, -6% the nominal supply voltage of 240V single-phase. As the voltage measurements are taken at the secondary (LV) side of the pad-mounted transformers located at the beginning and the end of each feeder supplying the township, the voltage level at the customer connection point would be lower than the logged results. The voltage drop due to customer's loads must be limited to 5% in accordance with AS3000. The lowest average voltage level recorded during the PQ logging period was 241V (start of TC3 feeders). Therefore, it is expected that the average voltage level at a customer's connection point will fall within the required range.

Table 13 presents the results for the previous three reporting periods together with the 2017/2018 result. In 2017/2018, there were four separate instances where the voltage level breached the voltage limits across one or more phases.

Given the results presented in Table 13, a deterioration is observed over the 2017/18 FY with respect to the measurements of the years before. This needs to be monitored over the course of next year and if further decline in the quality of supply observed, then the source of the issues to be identified and mitigation measures to be considered.

Table 13 | Total number of breaches of voltage level limits

Description	Reportable Period			
	2014/2015	2015/2016	2016/2017	2017/2018
Total number of breaches of voltage limits	2	0	0	4

7.1.4. Frequency Compliance (Part 2 Division 2 Quality Standards Section 8 Note (b))

According to the Electricity Act 1945 Section 25(1)(d), the frequency of electricity supplied must be maintained at ±2.5% of the frequency at 50 cycles per second. This information is not required as part of the reporting requirements of the Code. It has been included here to provide a more complete indication of supply PQ.

Table 14 presents the results for the previous three reporting periods together with the 2017/2018 result. For the 2017/2018 PQ logging period, there were zero instances where the frequency breached the required limits.

Given the results presented in Table 14, a consistent supply is observed over the 2017/18 FY with respect to the measurements of the years before.

Table 14 | Total number of breaches of frequency limits

Description	Reportable Period			
	2014/2015	2015/2016	2016/2017	2017/2018
Total number of breaches of frequency limits	1	0	0	0

7.2. Remedial actions taken for breaches of provisions (Schedule 1 Item 4 (b))

Newman BHPBIOSA is observed to have adopted a rather pro-active approach in establishing and executing asset replacement and improvement programs to sustain an improve power quality and reliability across Newman Township.

To ensure compliance to Australian regulations, BHPBIOSA have undertaken annual PQ logging on the 11kV supply feeders from both South Town and Township substations during the summer period. Improvements are implemented based on the PQ logging data results and complaints received from customers related to power quality issues.

Asset upgrades including:

- Major equipment upgrades at the Township Substation including the replacement of the two ageing 66/11kV power transformers and neutral earth resistors;
- Reconfiguration of supply from the NCC, bypassing Alinta Power Station;
- Proactive upgrade of an overhead section of low voltage powerline between poles 35/19 to 35/23 to an underground section to improve the safety to public within area due to lower height clearances on this section;
- Continuation of ad-hoc improvements as a result of investigations, e.g., replacement of ageing or defective pole top distribution transformers with pad-mount substations; and
- Budgeting and planning for the replacement of sections of HV overhead line with HV underground cabling within the Township of Newman, namely an upcoming project for the upgrade of a main road overhead crossing to prevent oversize loads accidentally connecting with the powerline.

In addition to the asset upgrade programs executed over the 2017/18 FY, BHPBIOSA has continued to improve their internal work processes, yielding improved reliability and quality of supply. A brief example of process improvement works completed or currently in progress includes the following:

- Content changes to the 2016 Inspection System Plan (ISP) due to the formal merge of the Department of Mines, Industry Regulation and Safety (DMIRS) and the former Building Commission and EnergySafety to form the new Building and Energy Division.
- Adoption of Photo-Voltaic (PV) inspections into the 2016 Inspection System Plan (ISP) and ISP Manual Documents;
- Undertaking an external audit of the 2016 Inspection System Plan; and
- Review and implementation of recent changes to Regulation 55 of the Electricity (Licensing) Regulations 1991.

7.3. Supply interrupted (Schedule 1 Item 5)

The provisions of The Code have the following requirements:

> *"The number of premises of small use customers the supply of electricity to which has been interrupted —*
>
> > *(a) for more than 12 hours continuously; or*
> >
> > *(b) more than the permitted number of times, as that expression is defined in section 12(1),*
>
> *and in the case of interruptions referred to in paragraph (a), the number of interruptions and the length of each interruption."*

7.3.1. Interruptions Exceeding 12 hours

There were no interruptions over 12 hours for small customers were recorded for 2017/2018 FY.

Table 15 | Total number of premises of small customers interrupted continuously for more than 12 hours

Description	Reportable Period			
	2014/2015	2015/2016	2016/2017	2017/2018
Total number of premises that experienced interruptions more than 12 hours	0	0	1	0

7.3.2. Frequent Interruptions

The permitted number of times a customer can be disconnected in the Newman Township is 16 interruptions as per Section 12 (1) (b) of the Code. Analysis of BHPBIOSA's outage logs presented in Table 16 indicates that the no customers were disconnected more than 16 times.

Table 16 | Total number of premises that experienced more than 16 interruptions

Description	Reportable Period			
	2014/2015	2015/2016	2016/2017	2017/2018
Total number of premises that experienced more than 16 interruptions	0	0	0	0

7.4. Number of complaints received (Schedule 1 Item 6 and Item 10)

According to Schedule 1, "complaint" means that a provision of Electricity Code 2005 Part 2; or an instrument made under Electricity Code 2005 Section 14(3), has not been, or is not being, complied with. For the reporting period, no complaints were made.

Table 17 presents the results for the previous three reporting periods together with the 2017/2018 result.

Table 17 | Total number of formal complaints lodged to BHPBIOSA

Description	Reportable Periods			
	2014/2015	2015/2016	2016/2017	2017/2018
Total number of formal complaints received	0	0	0	0

7.5. Complaints received in each discrete area (Schedule 1 Items 7 & 10)

The township of Newman is supplied from an integrated network and there are no discrete areas.

7.6. Total amount spent addressing complaints (Schedule 1 Items 8 & 10)

There has been no technical complaint over the 2017/18 FY that required BHPBIO's action.

7.7. Investments over 2017/2018 FY

Table 18 shows the total AUD amount spent in improving the supply quality and reliability and to cater for network expansion[1].

Table 18 | Total amount spent by BHPBIOSA in Network Improvements (indicative only)

Description	Reportable Periods			
	2014/2015	2015/2016	2016/2017	2017/2018
Total amount spent in dollars (AUD)	$16.90 million	$13.20 million	$16.00 million	$16.00 million

7.8. Number and Total amount of payments made (Schedule 1 Items 9 & 10)

This section outlines the total number of payments and the amount of those payments made by BHPBIOSA under Sections 18 and 19 of the Code. That is payment for failure to give the require notice of planned interruptions and payments for supply interruptions exceeding 12 hours. There were no supply interruptions of small customers being disconnected for over 16 times, and no recorded interruptions exceeding 12 hours. Table 1918 presents the results for the previous three reporting periods together with the 2017/2018 result.

Table 19 | Total number and amount of payments made under Sections 18 and 19

Description	Reportable Periods			
	2014/2015	2015/2016	2016/2017	2017/2018
Total number of payments	0	0	0	0
Total amount of payments (AUD)	0	0	0	0

[1] Figures presented are indicative only and may differ due to various factors including re-structuring works recently taken place in the network operation and maintenance team.

7.9. Reliability of Supply (Schedule 1 Item 11)

This section covers the requirements of Item 11 of Schedule 1 of The Code, as reproduced below:

1. *"For each discrete area —*

    (a) the average length of interruption of supply to customer premises expressed in minutes;

    (b) the average number of interruptions of supply to customer premises;

    (c) the average percentage of time that electricity has been supplied to customer premises; and

    (d) the average total length of all interruptions of supply to customer premises expressed in minutes."

In this report, the township of Newman is considered the *discrete area*. The BHP 2017/18 FY fault outage data presented within Appendix C has been applied in determining the parameters described above and presented further in the following sub-sections.

7.9.1. Average interruption (Schedule 1 Items 11 (a), 12 and 13)

The average length of interruption of supply to customer premises for the Newman township electrical network is measured in minutes over the course of the 2017/2018 FY, shown in Table 2019. Note that CAIDI index (33 minutes) has notably improved compared to the previous FY (53 minutes) and tracks well below the average of CAIDI recorded over the last 4 years (67 minutes).

Table 20 | The average length of interruption of supply to customer premises expressed in minutes (CAIDI)

Description	Reportable Period				
	2014/2015	2015/2016	2016/2017	2017/2018	Average
Average length of interruptions – CAIDI (minutes)	80	102	53	**33**	67

7.9.2. Average number of interruptions (Schedule 1 Items 11 (b), 12 and 13)

The average number of interruptions of supply to customer premises for the township of Newman over the course of the 2017/2018 FY is shown in Table 2120. Note that SAIFI index (1.07) has improved significantly compared to the previous FY (1.53) and tracks well below the average of SAIFI recorded over the last 4 years (2.12).

Table 21 | The average number of interruptions of supply to customer premises (SAIFI)

Description	Reportable Period				
	2014/2015	2015/2016	2016/2017	2017/2018	Average
Average supply interruptions – SAIFI (No. of Interruptions)	4.23	1.64	1.53	**1.07**	2.12

7.9.3. Average percentage of time electricity supplied (Schedule 1 Items 11 (c), 12 and 13)

The average percentage of time that electricity has been supplied to customer premises over the course of the 2017/2018 FY is shown in Table 2221. Note that ASAI index has marginally improved compared to the previous FY and tracks well with the average of ASAI recorded over the last 4 years.

Table 22 | The average percentage of time that electricity has been supplied to customer premises (ASAI)

Description	Reportable Period				
	2014/2015	2015/2016	2016/2017	2017/2018	Average
Average number of supply interruptions ASAI (Percentage of time connected)	99.94%	99.97%	99.98%	**99.99%**	99.97%

7.9.4. Average total length of all interruptions (Schedule 1 Items 11 (d), 12 and 13)

The average total length of all interruptions of supply to customer premises, expressed in minutes, is shown in Table 2322. Note that SAIDI index (35 minutes) has notably improved compared to the previous FY (81 minutes) and tracks well below the average SAIDI recorded over the last 4 years (155 minutes).

Table 23 | The average total length of all interruptions of supply to customer premises in minutes (SAIDI)

Description	Reportable Period				
	2014/2015	2015/2016	2016/2017	2017/2018	Average
SAIDI (minutes)	339	168	81	**35**	155

7.10. Percentile Values (Schedule 1 Items 14 and 15)

This section outlines the response to schedule 1 items 14 and 15 of the Code. An extract from the code requirements is shown below:

Item 14: *"For customer premises in each discrete area, an estimate of the 25th, 50th, 75th, 90th, 95th, 98th and 100th percentile values of —*

(a) the average length of interruption referred to in item 11(a);

(b) the number of interruptions; and

(c) the total length of interruptions."

Item 15: *"For each category of information in item 14(a), (b) and (c), a graph showing the distribution of customer premises across the range of that category."*

7.10.1. Percentile – Average Length of Interruption

As required by 'Schedule 1' of The Code, Table 2423 presents the CAIDI results on a percentile basis.

Table 24 | Percentile of the average length of interruption of supply to customer premises in 2017/2018

Description	Percentile						
	25th	50th	75th	90th	95th	98th	100th
Average Length of Interruption (CAIDI)	30	33	33	33	33	33	33

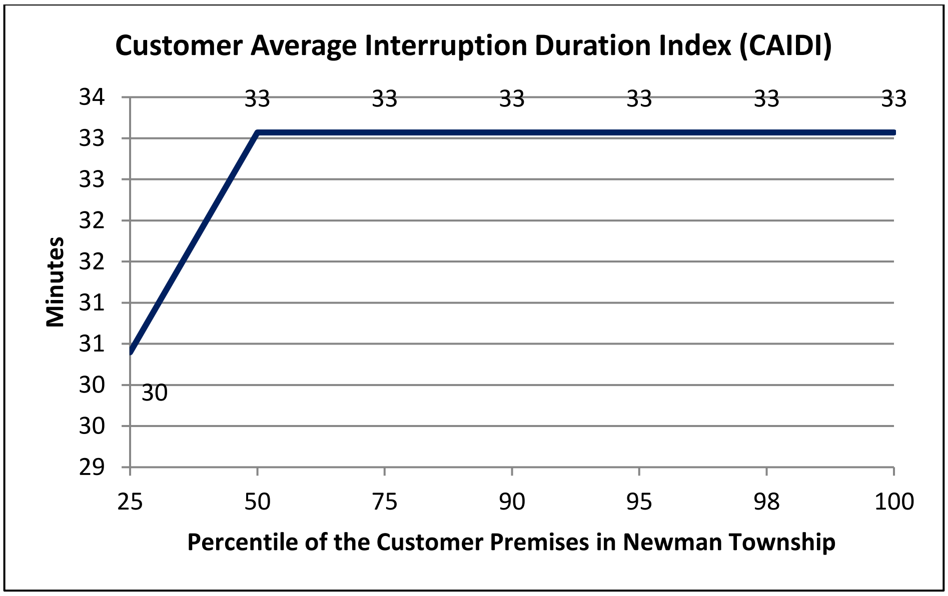


Figure 19 | The average length of interruption (minutes) of supply to customers over 2017/2018 FY

7.10.2. Percentile - Number of interruptions

As required by 'Schedule 1' of The Code, Table 2524 presents the SAIFI results on a percentile basis.

Table 25 | Percentile values of the number of interruptions in 2017/2018

Description	Percentile						
	25th	50th	75th	90th	95th	98th	100th
Number of interruptions (SAIFI)	0.77	1.07	1.07	1.07	1.07	1.07	1.07

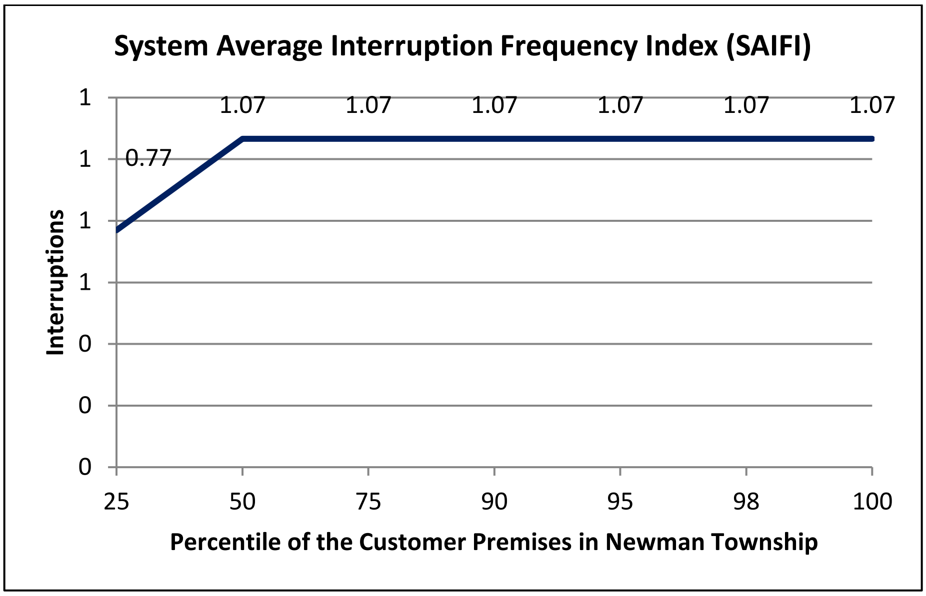


Figure 20 | Percentile graph showing the number of interruptions (SAIFI) in 2017/2018

7.10.3. Percentile - Total Length of Interruptions

As required by 'Schedule 1' of The Code, Table 2625 presents the SAIDI results on a percentile basis.

Table 26 | Percentile values of the total length of interruptions in 2017/2018

Description	Percentile						
	25th	50th	75th	90th	95th	98th	100th
Total lengths of interruptions (SAIDI)	23	35	35	35	35	35	35

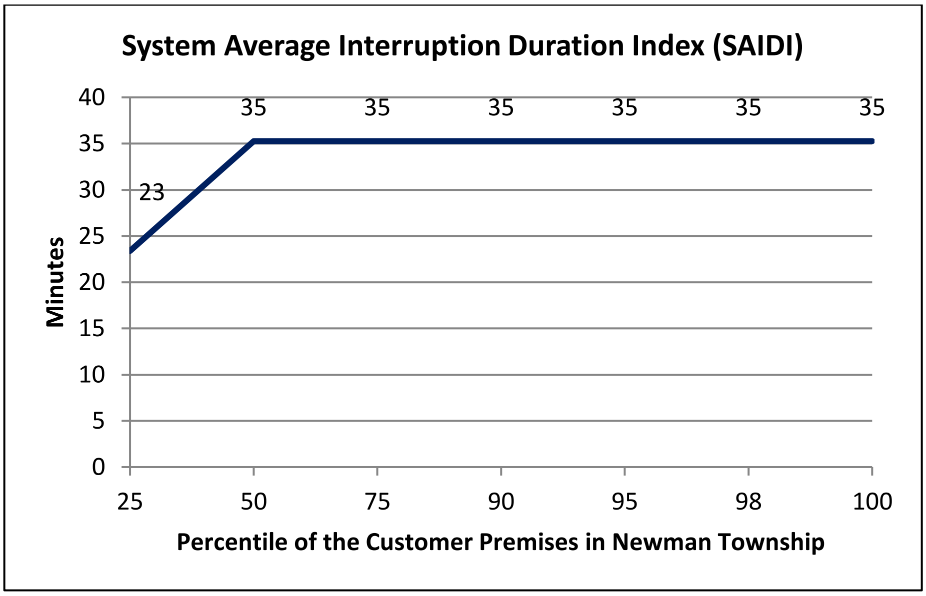


Figure 21 | Percentile graph showing the total length of interruptions (SAIDI) in 2017/2018

8. CONCLUSION

This report addresses all relevant parts pertaining to Newman's 11kV supply network and the reportable requirements as per Part 2 and Schedule 1 of the Code.

With regards to the PQ criteria, the *average* values of all electrical parameters logged over the monitoring period (1 week) were found well within the limits stipulated by the Code. That is, the *average* of the following parameters are proven to meet the Code's requirements:

- *Voltage Flicker (short- and long-term criteria);*
- *RMS Voltage Magnitude;*
- *Power System Frequency; and*
- *Voltage Total Harmonic Distortion (U-THD).*

The following minor compliance issues were identified:

- The individual *Voltage Harmonic Distortions* for the feeders. The magnitude of voltage's even harmonics (specifically 6th order) is found to occasionally exceed the limits set by AS 61000:2001, which in turn indicate the presence of unbalanced 3-phase loads with possible DC component in the network. This is not a problem of major concern at the present time (as observed for <1% of the measurements). However, should it exacerbate in coming years, then mitigation measures may be required to ensure quality of supply.

- Short-term flicker events were found to have exceeded the limits set by 'the code' for TC2, TC3, TC4, STS2 and STS6. The frequency of occurrence of the exceedances constitutes a very small fraction (i.e, under 0.2%) of the total measurements period. As such this does not constitute a major problem and will only need to be monitored over the coming years.

- Voltage limit events were found to be in exceedance of the limits set by AS/NZS 3000:2007 for TC2 and TC4 feeders. The frequency of occurrence of the exceedances constitutes a very small fraction (i.e, under 0.2%) of the total measurements period. As such this does not constitute a major problem and will only need to be monitored over the coming years.

Reportable parameters for Newman Township Electricity Supply over the 2017/18 FY (as outlined in the 'Schedule 1' of the Code) are presented below:

- *>12 hour interruptions*: No interruptions were recorded to have exceeded 12 hours.
- No *small use customer* was disconnected from the network more frequent than the Code's requirements (i.e., limit of 16 times).
- No complaints was received from customers during FY 2017/2018.
- Within the 2017/18 FY, an estimated total of $16M was invested by BHPBIOSA towards Newman network operations, maintenance and reinforcement works; to not only address the issues identified by the operator but also to improve the quality and reliability of supply.
- The key reliability indices are calculated as listed below:
  - *Customer Average Interruption Duration Index* (CAIDI) of 33 minutes – CAIDI is the average outage duration that any given customer experience (i.e., the average restoration time).

- *System Average Interruption Frequency Index* (SAIFI) of 1.07 interruptions – SAIFI is the number of interruptions that the customers experienced.
- *Average Service Availability Index* (ASAI) of 99.99% – ASAI is the perceived availability of the network to the customers.
- *System Average Interruption Duration Index* (SAIDI) of 35 minutes – SAIDI is the average outage duration for each customer served.

The metering data collected from 14 locations throughout the Newman network indicate that the power quality, *as so far as is reasonably practical*, is compliant with the Code. With regards to the Reliability of the Supply, the overall network performance is deemed satisfactory.

In summary, this report finds the reliability and quality of the supply for Newman Township network in compliance with the Code's requirements; however, there are areas that require the BHPBIOSA's attention and investment to ensure improved quality of electricity supply in the upcoming years.

APPENDIX A PQ Logging Device (HIOKI 3198)

HIOKI

POWER QUALITY ANALYZER PW3198

Power Measuring Instruments

Record and Analyze Power Supply Problems Simultaneously with a Single Unit

The New World Standard for Power Quality Analysis

Never Miss the Moment
- Detect power supply problems and perform onsite troubleshooting
- Do preventive maintenance to avert accidents by managing the power quality

CAT IV-600V Safety Standard
- Meets the CAT IV safety rating required to check an incoming power line
- Safe enough to measure up to 6,000Vpeak of transient overvoltage

Easy Setup Function with PRESETS
- Just select the measurement course, wiring, and clamps
- Automatic one-step setup based on measurement conditions

Compliant with New International Standards
- International power quality measurement standard IEC 61000-4-30 Edition 2 Class A
- High precision with a basic voltage measurement accuracy of 0.1%

CE

ISO 9001 JMI-0216 ISO14001 JQA-E-90091

www.hioki.com
HIOKI company overview, new products, environmental considerations and other information are available on our website.

The number of power supply problems is increasing as power systems are becoming more and more complicated - all due to the rising use of power electronics devices plus a growing installed base of large systems and distributed power supplies. The quickest way to approach these problems is to understand the situation quickly and accurately. The PW3198 Power Quality Analyzer is ready to effectively solve your power supply problems.

Troubleshooting

- ✔ Understand the actual power situation at the site where the problem is occurring (e.g., the equipment malfunction, failure, reset, overheating, or burning damage).
- ✔ Ideal for troubleshooting solar and wind power generation systems, EV charge stations, smart grids, tooling machines, OA equipment (e.g., computers, printers, and UPS), medical equipment, server rooms, and electrical equipment (e.g., transformers and phase-advancing capacitors).

Field Survey and Preventive Maintenance

- ✔ Perform long-term measurements of the power quality and study problems that are difficult to detect or that occur intermittently.
- ✔ Maintain electrical equipment and check the operation of solar and wind power generation systems.
- ✔ Manage the parameters with a control set point, such as a voltage fluctuation, flicker, and harmonic voltage.

Power (Load) Survey

- ✔ Study the power consumption and confirm system capacity before adding load.

Advanced Features for Safe, Simple, and Accurate Measurements

1 International Standard IEC61000-4-30 Edition 2 Class A

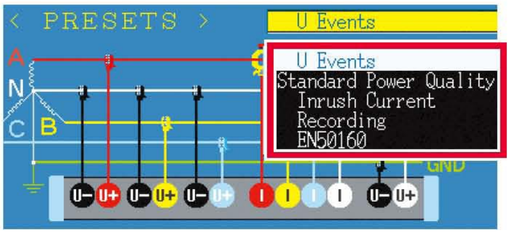
Class A is defined in the international standard IEC61000-4-30, which specifies compatibility with power quality parameters, accuracy, and standards to enable comparison and discussion of the measurement results of different measuring instruments.

The PW3198 is compliant with the latest IEC61000-4-30 Edition 2 Class A standard. The instrument can perform measurements in accordance with the standard, including continuous gapless calculation, methods to detect events such as dip, swell, and instantaneous power failure, and time synchronization using the optional GPS box.

2 CAT IV-600V Safety

The PW3198 is compliant with the measurement category CAT IV - 600V and can also safely test the incoming lines for both single-phase and three-phase power supplies.

3 Easy to set up - Just select the measurement course and the PW3198 will do the rest

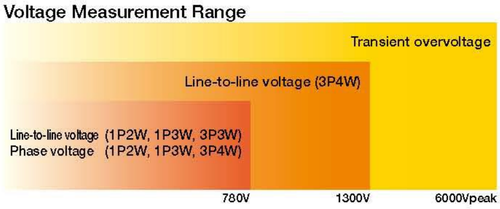


Simply choose the course based on the measurement objective and the necessary configurations will be set automatically.

U Events	Record voltage and frequency and detect errors simultaneously.
Standard Power Quality	Record voltage, current, frequency, and harmonic, and detect errors simultaneously.
Inrush current	Measure the inrush current.
Recording	Record only the TIME PLOT Data but do not detect errors.
EN50160	Perform measurements in accordance with EN50160.

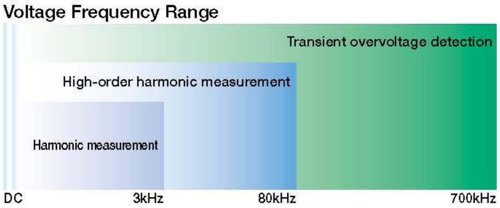
4 Highly Accurate, Broadband, Wide Dynamic Range Makes for Reliable Measurements

Voltage Measurement Range



Both low and high voltages can be measured in a single range.

Voltage Frequency Range



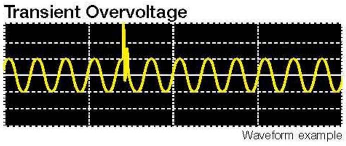
Wide range from DC voltage to 700 kHz

Basic Measurement Accuracy (50/60 Hz)

Voltage	±0.1% of nominal voltage
Current	±0.2% rdg. ±0.1% f.s. + Clamp-on sensor accuracy
Power	±0.2% rdg. ±0.1% f.s. + Clamp-on sensor accuracy

World's highest level of basic measurement accuracy. Extremely accurate voltage measurement without the need to switch ranges.

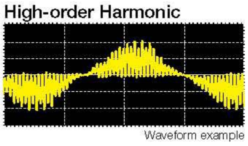
Transient Overvoltage



Waveform example

Transient overvoltage can also be measured in a range between the maximum 6,000 V and minimum 1 μs (2 MS/s).

High-order Harmonic



Waveform example

The PW3198 is the first power quality analyzer that can measure the high-order harmonic component of up to 80 kHz.

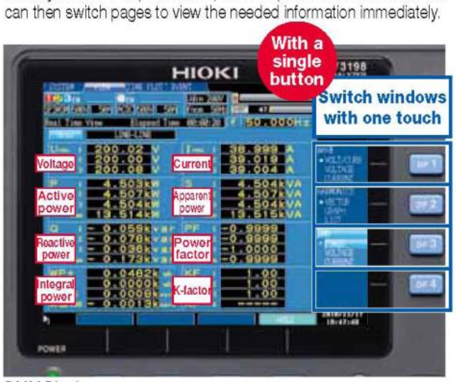
PW3198 Never Misses the Moment a Power Supply Failure Occurs

The PW3198 can measure all waveforms of power, harmonic, and error events simultaneously. When a problem occurs with the equipment or system on your site, the PW3198 will help you detect the cause of the problem early and solve it quickly. You can depend on the PW3198 to monitor all aspects of your power supplies.

Measure All Parameters at the **Same Time**

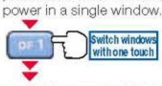
Acquire the Information You Need Quickly by Switching Pages (RMS Value)

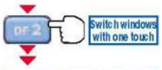
Just connect to the measurement line, and the PW3198 will simultaneously measure all parameters, such as power and harmonic. You can then switch pages to view the needed information immediately.



DMM Display

Display parameters such as voltage, current, power, power factor, and integral power in a single window.



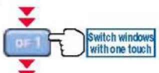


Waveform Display

Display the voltage and current waveforms on channels 1 to 4 one above the other in a single window.

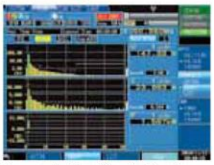
Vector Display

Display the measured value and vector of the voltage and current of each order harmonic.



4-channel Waveform Display

Display the voltage and current waveforms on channels 1 to 4 individually.

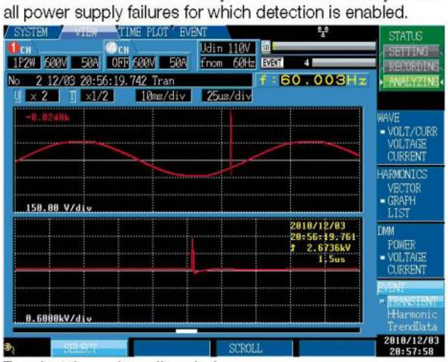


Harmonic Bar Graph Display

Display the RMS value and phase angle of harmonics from the 0th order to the 50th either in a graph or as numerical values.

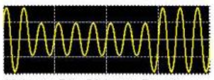
Reliably Detect Power Supply Failures (Event)

To detect power supply failures, measurement does not need to be performed multiple times under different conditions. The PW3198 can always monitor and reliably detect all power supply failures for which detection is enabled.



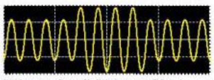
Transient Overvoltage (Impulse)

A transient overvoltage is generated by a lightning strike or a contact fault or closed contact of a circuit breaker and relay, and often causes a steep voltage change and a high voltage peak.



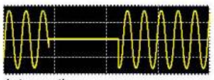
Voltage Dip (Voltage Drop)

Voltage drops for a short time as a result of large inrush current generated in the load by, for example, a starting motor.



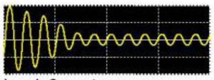
Voltage Swell (Voltage Rise)

A voltage swell is generated by a lightning strike or a heavily loaded power line being opened or closed, causing the voltage to rise instantaneously.



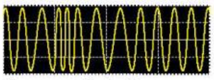
Interruption

The power supply stops instantaneously or for a short or long time because electrical power transmission is stopped as a result of a lightning strike, or because the circuit breaker is tripped by a power supply short circuit.



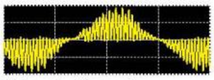
Inrush Current

A large current flows instantaneously at the moment electrical equipment, a motor, or similar devices are powered on.



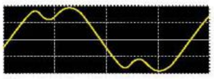
Frequency Fluctuations

An excessive increase or decrease of the load causes the operation of a generator to become unstable, resulting in frequency fluctuations.



High-order Harmonic

Voltage and current waveforms are distorted by noise components generated by a semiconductor control device or the like installed in the power supply of electronic equipment.



Harmonic

Harmonic is generated by a semiconductor control device installed in the power supply of equipment, causing distortion of voltage and current waveforms.

Unbalance

An increase or decrease in the load connected to each phase of the three-phase power supply or an unbalanced operation of equipment and devices causes the load of a particular phase to become heavy so that voltage and current waveforms are distorted, voltage drops, or negative phase sequence voltage is generated.

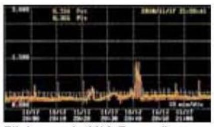
Simultaneous Recording of TIME PLOT Data and Event Waveforms

TIME PLOT Data — TIME PLOT Recording of All Parameters

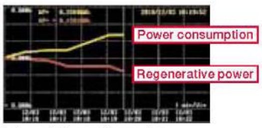
The PW3198 can simultaneously record 8,000 or more parameters, such as voltage, current, power, power factor, frequency, integral power, harmonic, and flicker, at the specified recording interval. The PW3198 never fails to capture the peak because it performs calculations continuously and records the maximum, minimum, and average values within the recording interval.

Trend Recording
(TIME PLOT Recording)

Harmonic Recording



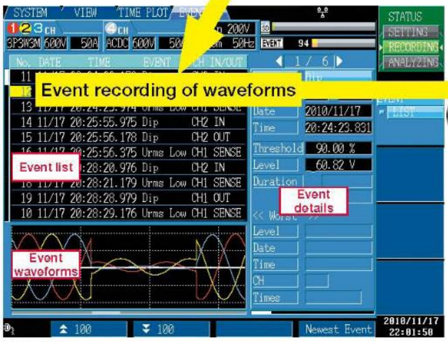
Flicker and ΔV10 Recording



Integral Power Recording

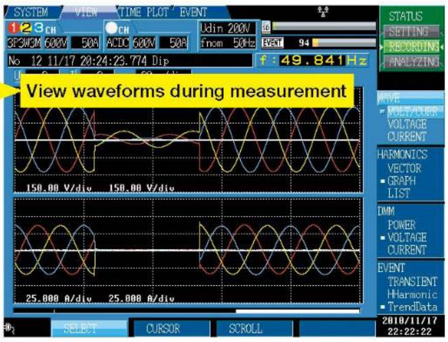
Event Waveforms — Capture up to 55,000 Instantaneous Waveforms of Power Supply Failures

The PW3198 can record up to 1,000 instantaneous waveforms of power supply failures (up to 55,000 when repeat recording is set to ON) while performing TIME PLOT recording.



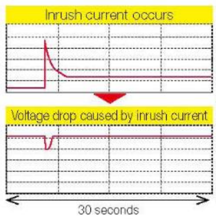
Event List

This list records instantaneous waveforms of power supply failures (events), such as a voltage drop or inrush current, along with the time or other information. Events are always monitored, regardless of the recording interval of the TIME PLOT recording.



Event Waveform

The PW3198 lets you view the instantaneous waveform (200 ms) of a power supply failure in the window.



RMS value changes over 30 seconds

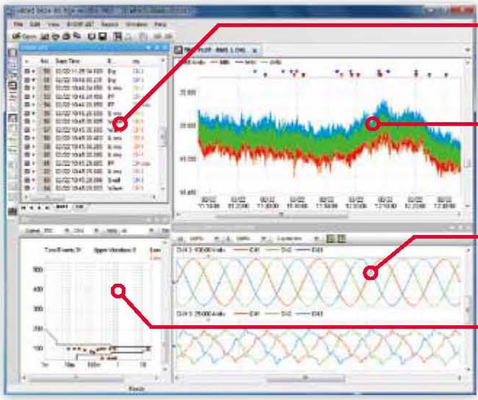
When a voltage drop or inrush current occurs, RMS value changes are recorded over 30 seconds simultaneously. This function can also be used to check the voltage drop caused by inrush current generated by the start of the motor.

Analyze Recorded Data with a PC Using Application Software 9624-50 PQA-HiVIEW PRO

Use Model 9624-50 PQA-HiVIEW PRO (version 2.00 or later) with a PC to analyze the data collected by the PW3198.

Viewer Function

Display and analyze the data recorded by the **PW3198 POWER QUALITY ANALYZER**.



Event List Window

Display a list of power supply failures (events) that occurred.

TIME PLOT Window

Display the TIME PLOT (recorded trend) data as well as changes in the voltage/current RMS values, harmonic, and many other parameters.

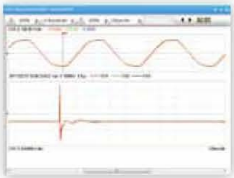
Event Waveform Window

Display the waveform of an event that occurred, plus the vector, harmonic, DMM, and instantaneous harmonic values.

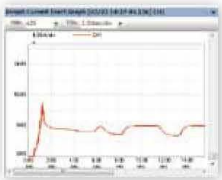
ITIC Curve Display Window

Analyze the ITIC (CBEMA) curve (tolerance curve) used in the power quality standards in the United States.

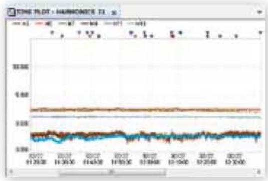
Status Window



Transient Waveform Window



Inrush Current Event Graph Window



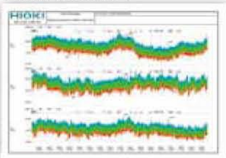
Harmonics TIME PLOT Window

Report Creation Function

Automatically and effortlessly create rich reports for compliance and record management.

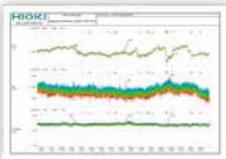
Report output items: Voltage/current RMS value fluctuation graph, harmonic fluctuation graph, inter-harmonics fluctuation graph, flicker graph, integral power graph, demand graph, total harmonic voltage/current distortion rate list, EN50160 window (Overview, Harmonic, Measurement Results Category), worst case, transient waveform, maximum/minimum value list, all event waveforms/detailed list, and setup list

Print Examples



RMS Value Voltage Fluctuations

All Event Detailed List



TIME PLOT Recording of Parameters

EN50160

Other Functions

CSV Conversion of Measurement Data

Convert data in the range specified in the TIME PLOT window into CSV format and then save for further processing. The 9624-50 can also convert event waveforms into CSV format. Open CSV data using any commercially available spreadsheet software for advanced data management and analysis.

Even Analyze Data Recorded with Models 3196 and 3197 PQAs

Data recorded with the HIOKI 3196 and 3197 Power Quality Analyzers can also be analyzed.

Download Measurement Data via USB/LAN

Data in the SD card inserted in the PW3198 can be downloaded to a PC via USB or LAN.

EN50160 Display Function

EN50160 is a power quality standard for the EU. In this mode, evaluate and analyze power quality in accordance with the standard. You can display the Overview, Harmonic, and Measurement Results Category windows.

9624-50 Specifications

Delivery media	CD-R
Operating environment	AT-compatible PC
OS	Windows XP, Windows Vista (32-bit), Windows 7 (32/64-bit)
Memory	512 MB or more

Useful Functions for a Wide Variety of Applications

Large Capacity Recording with SD Card

Data is recorded to a large capacity SD card. The data can be transferred to a PC and analyzed using dedicated application software. If your PC is not equipped with an SD card slot, simply connect a USB cable between the PW3198 and the PC. The PC will then recognize the SD card as removable media.

Repeat record	Recording period
OFF	Max. 35 days Reference value: ALL DATA (all items recorded), repeat recording OFF, and TIME PLOT interval 1 minute or longer)
ON	Max. 55 weeks (about 1 year) Reference value: ALL DATA (all items recorded), repeat recording ON (1 week x 55 times), and TIME PLOT interval 10 minutes or longer)

Simultaneously Measure Three-phase Lines and Grounding Wire

Apart from the main measurement line, you can also measure the AC/DC voltage on another line using Channel 4.

Yes! Simultaneously!

- Measure the primary and secondary sides of UPS
- Two-line voltage analysis
- Measure three-phase lines and grounding wire
- Measure neutral lines to detect short circuits
- Measure the input and output of a DC-AC converter for solar power generation

Remote Measurement Using HTTP Server Function

You can use any Internet browser to remotely operate the PW3198, plus download the data stored in the SD card using dedicated software (LAN access required).

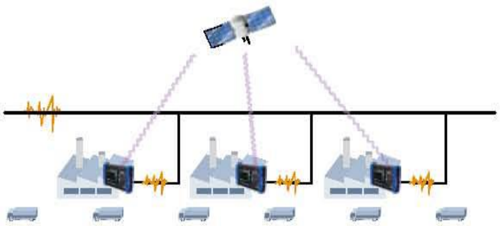
Conduct off-site remote control with a tablet PC using a wireless LAN router

An Assortment of Clamp-on Sensors Covers a Broad Range of Measurements

In addition to current sensors for measuring 100A AC, 500A AC, 1000A AC and 5000A AC rated currents, a 5A AC sensor is also available. In addition, HIOKI's CLAMP ON LEAK SENSORS enable you to accurately measure for leakage current down to the mA level, while the new CT969X-90 AC/DC Clamp On Sensors further widen applications by supporting DC current testing.

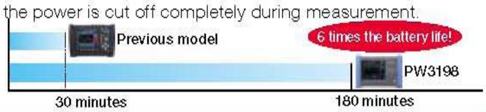
GPS Time Synchronization

The PW9005 GPS BOX lets you synchronize the clock on the PW3198 to the UTC standard time. Eliminate time differences between multiple PQAs and correctly analyze measurement data taken by several instruments.



Backup and Recovery from Power Failure

The PW3198 uses the new large capacity BATTERY PACK Z1003, enabling continuous measurement for three hours even if a power failure occurs. In addition, a power failure processing function restarts measurement automatically even if the power is cut off completely during measurement.



Other Measurement Applications

Flicker measurement

Measure flicker in conformance with IEC 61000-4-15 Ed2.

Phase voltage check for Δ connection

Use the Δ-Y and Y-Δ conversion function to measure phase voltage using a virtual neutral point.

400 Hz line measurement

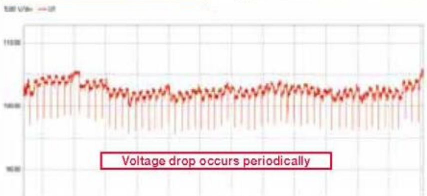
Measure at a power line frequency of 50/60 Hz as well as 400 Hz.

Power Quality Survey Applications

The power supply of the office equipment sometimes shuts down

Survey Objective
The power supply of a printer at the office shuts down even though it is not operated. Equipment other than the printer can also sometimes perform a reset unexpectedly.

Measurement Method
Setup is very easy. Just install the PW3198 on the site, and measure the voltage, current, and power. To troubleshoot, just select the clamp-on sensor and wiring, and then select the "U Events" course.



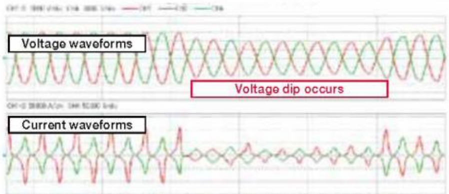
Voltage Fluctuation Graph

Analysis Report
No failure occurred during the measurement period, but a periodic voltage drop was confirmed. The voltage drop may have been caused by the periodic start and operation of the electrical equipment connected to the power supply line. **Equipment, such as a laser printer, copier, and electrical heater, may start themselves periodically due to residual heat. An instantaneous voltage drop is likely to have been caused by inrush current from equipment that consumes a large amount of power.**

Medical equipment malfunctions

Survey Objective
Replacing the equipment with a new one by the service provider did not improve the malfunction. A survey of the power supply was required to clarify the cause.

Measurement Method
Select the "U Events" course in the PW3198 in the same way as with the office equipment example.



Voltage and Current Waveforms at the Time Voltage Dip Occurs

Analysis Report
It was determined that a voltage dip (voltage drop) occurred and impacted the operation of the equipment. **If a voltage dip occurs every day on a regular basis, the probable cause is the start of a large air-conditioning unit, pump, heater, or similar equipment.**

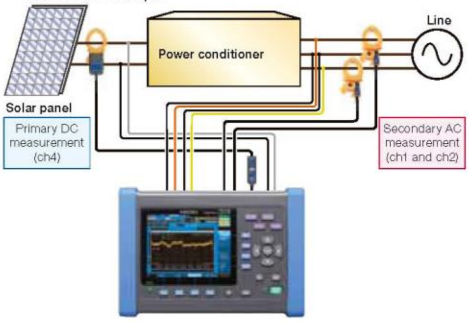
Surveying a Solar Power Generation System

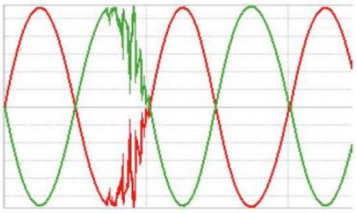
Survey Objective

- Maintain a solar power generation system and check its operation (verify the power quality)
- Troubleshoot (impact on the peripheral equipment, operation shutdown, etc.)

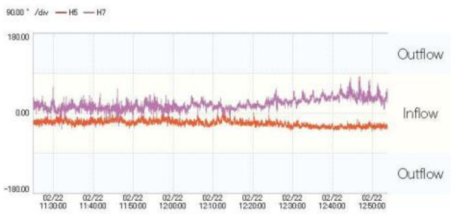
Measurement Method
Set up the PW3198 on the site and measure the voltage, current, and power. To survey the power quality, select the "Standard power quality measurement" course in the PRESETS menu. To measure the DC voltage, connect channel 4 to the primary side of the solar panel.

Connection Example





Example of Voltage Waveforms at the Time of Line Switching



Example of Determining Inflow or Outflow
(Inflow of 5th and 7th Order Harmonic)

Analysis Report
All parameters can be recorded simultaneously with a single measurement.

- Identify changes in the output voltage of the power conditioner
- Presence or absence of the occurrence of a transient overvoltage
- Frequency fluctuation important for system interconnection
- Identify changes in the harmonic voltage and current included in the output
- Power (AC), integral power (AC), etc.

PW3198 Specifications (Accuracy guaranteed for one year)

Measurement items

Voltage measurement items (TIME PLOT Recording)	RMS voltage Frequency DC voltage Harmonic voltage (0 to 50th order) Inter-harmonic voltage (0.5 to 49.5th) Total harmonic voltage distortion factor	Waveform voltage peak Frequency (1 cycle, 10-sec) IEC Flicker (Pst, Plt) Harmonic voltage phase angle (0 to 50th) High order harmonic voltage component Voltage Unbalance factor (Zero-phase /Negative-phase)
Current measurement items (TIME PLOT Recording)	RMS current Waveform current peak Harmonic current phase angle (0 to 50th) Harmonic current (0 to 50th) Inter-harmonic current (0.5 to 49.5th)	High order harmonic current component Total harmonic current distortion factor Current Unbalance factor (Zero-phase /Negative-phase) K factor DC current (when using compatible sensor)
Power measurement items (TIME PLOT Recording)	Active power Reactive power Apparent power Power factor	Harmonic power (0 to 50th) Harmonic voltage-current phase angle (0 to 50th) Active energy Reactive energy
EVENT measurement items (EVENT Recording)	Transient overvoltage Voltage swell Voltage dip Interruption Inrush current	Frequency fluctuations Voltage waveform comparison Timer External events
	Event detection using upper and lower thresholds available with other voltage, current and power measurement parameters (excluding Integrated power, Unbalance, Inter-harmonic, Harmonic phase angle, IEC Flicker)	

Input specifications

Measurement circuits	Single-phase 2-wire (1P2W), single-phase 3-wire (1P3W), three-phase 3-wire (3P3W2M, 3P4W2.5E) or three-phase 4-wire (3P4W) plus one extra input channel (must be synchronized to reference channel during AC/DC measurement)
Fundamental frequency of measurement circuit	50Hz, 60Hz, 400Hz
Input channels	Voltage : 4 channels (U1 to U4), Current : 4 channels (I1 to I4)
Input methods	Voltage : Isolated and differential inputs (channels not isolated between U1, U2 and U3; channels isolated between U1 to U3 and U4) Current : Insulated clamp-on sensors (voltage output)
Input resistance	Voltage : 4MΩ ±80kΩ (differential inputs) Current : 100kΩ ±10kΩ
Compatible clamp sensors	Units with f.s.=0.5V output at rated current input (f.s.=0.5V recommended) Units with rate of 0.1mV/A, 1mV/A, 10mV/A, or 100mV/A
Measurement ranges (Ch1 to Ch4 can be configured the same way; only CH4 can be configured separately)	Voltage measurement ranges

Voltage measurement items	Ranges
Voltage measurement	600.00V
Transient measurement	6.0000kV peak

PW3198 current ranges

Current sensor	Current range setting (A)
9660	100.00 / 50.000
9661	500.00 / 50.000
9667 (500A) *Discontinued	500.00 / 50.000
9667 (5kA) *Discontinued	5.0000k / 500.00
CT9667 (500A)	500.00 / 50.000
CT9667 (5kA)	5.0000k / 500.00
9669	1.0000k / 100.00
9694	50.000 / 5.0000
9695-02	50.000 / 5.0000
9695-03	100.00 / 10.000

Current sensor	Current range setting(A)
CT9691 (10A)	10.000 / 5.0000
CT9691 (100A)	100.00 / 10.000
CT9692 (20A)	50.000* / 5.0000
CT9692 (200A)	500.00* / 50.000
CT9693 (200A)	500.00* / 50.000
CT9693 (2kA)	5.0000k* / 500.00
9657-10	5.0000 / 500.00m
9675	5.0000 / 500.00m

*The full scale for each sensor is based on the specifications of the sensor in use, not the range setting on the PW3198.

PW3198 Power ranges
(automatically configured based on current range)

Current range	Power range (W / VA / var)
5.0000 kA	3.0000M
1.0000 kA	600.00k
500.00 A	300.00k
100.00 A	60.000k

Current range	Power range (W / VA / var)
50.000 A	30.000k
10.000 A	6.0000k
5.0000 A	3.0000k

Basic specifications

Maximum recording period	55 weeks (with repeated recording set to [1 Week], 55 iterations) 55 days (with repeated recording set to [1 Day], 55 iterations) 35 days (with repeated recording set to [OFF])
Maximum recordable events	55,000 events (with repeated recording on) 1000 events (with repeated recording off)
TIME PLOT data settings	TIME PLOT interval (MAX/MIN/AVG within each interval recorded) 1s, 3s, 15s, 30s, 1m, 5m, 10m, 15m, 30m, 1h, 2h, 150 cycle (at 50Hz), 180 cycle (at 60Hz), 1200 cycle (at 400Hz) Screen copy interval (screen shot at each interval saved to SD card) OFF, 5m, 10m, 30m, 1h, 2h Timer EVENT interval (200ms instantaneous waveform saved at each interval) OFF, 1m, 5m, 10m, 30m, 1h, 2h Time start and End OFF: Start recording manually ON: Start time and End time can be configured Repeated recording settings (maximum 55 iterations) OFF: Recording is not repeated 1Week: 55 weeks maximum in 1week segmentations 1Day: 55 days maximum in 1day segmentations Repeat time Daily Start time and End time can be configured when Repeated recording set to 1Day.
Recording items settings	Power (Small): Recording basic parameters P&Harm (Normal): Recording basic parameters and harmonics All Data (Full): Recording P&Harm items and inter-harmonics
Memory data capacity	Max. 32 GB with SD Card; only use of the HIOKI 2GB SD Memory Card Model Z4001 is guaranteed by HIOKI. *Contact your HIOKI representative for special order larger capacity cards that offer the HIOKI guarantee.*

PRESETS function	**U Events** : Record and monitor voltage elements and frequency, plus detect events **Standard Power Quality** : Record and monitor voltage and current elements, frequency, and harmonics, plus detect events **Inrush Current** : Measure inrush current (basic voltage measurement required) **Recording** : Record only trend data, no event detection **EN50160** : Measure according to EN50160 standards
Real-Time Clock function	Auto-calendar, leap-year correcting 24-hour clock
Real-time clock accuracy	±0.3 s per day (with instrument on, 23°C±5°C (73°F±9°F)
Power supply	**AC ADAPTER Z1002** (12 VDC, Rated power supply 100VAC to 240VAC, 1.7Amax, 50/60Hz) **BATTERY PACK Z1003** (Ni-MH 7.2VDC 4500 mAh)
Maximum rated power	15VA (when not charging), 35VA (when charging)
Continuous battery operation time	Approx. 180 min. [@23°C (@73.4°F), when using **BATTERY PACK Z1003**]
Recharge function	**BATTERY PACK Z1003** charges regardless of whether the instrument is on or off; charge time: max. 5 hr. 30 min. @23°C (@73.4°F)
Power outage processing	In the event of a power outage during recording, instrument resumes recording once the power is back on (integral power starts from 0).
Power supply quality measurement method	IEC61000-4-30 Ed.2 :2008 IEEE1159 EN50160 (using Model **PQA-HiVIEW PRO 9624-50**)
Dimensions	Approx. 300 W× 211 H × 68 D mm (11.81" W × 8.31" H × 2.68" D) (excluding protrusions)
Mass	Approx. 2.6 kg (91.7 oz.) (including battery pack)
Accessories	Instruction manual, Measurement guide, **VOLTAGE CORD L1000** (8 cords, approx. 3 m each: 1 each red, yellow, blue, and gray plus 4 black; 8 alligator clips: 1 each red, yellow, blue, and gray plus 4 black), Spiral Tube, Input Cable Labels (for identifying channel of voltage cords and clamp-on sensors), **AC ADAPTER Z1002**, Strap, USB cable (1 m length), **BATTERY PACK Z1003**, **SD MEMORY CARD (2GB) Z4001**

Display specifications

Display	6.5-inch TFT color LCD (640 × 480 dots)

External Interface Specifications

SD card Interface	Saving of binary data, Saving and Loading setting files, Saving and Loading screen copies Slot : SD standard compliant Compatible card : SD memory card/ SDHC memory card Supported memory capacity : Max. 32 GB with SD Card; only use of the HIOKI 2GB SD Memory Card Model Z4001 is guaranteed by HIOKI. *Contact your HIOKI representative for special order larger capacity cards that offer the HIOKI guarantee.* Media full processing : Saving of data to SD memory card is stopped
RS-232C Interface	Measurement and control using GPS-synchronized time (connecting GPS BOX) Connector : D-sub9pin Connection destination : GPS box (cannot be connected to computer)
LAN Interface	1. HTTP server function (compatible software: Internet Explorer Ver.6 or later, Remote operation application function, measurement start and stop control functions, system configuration function, event list function (capable of displaying event waveforms, event vectors, and event harmonic bar graphs) 2. Downloading of data from the SD memory card using the 9624-50 PQA-HiView Pro Connector : RJ-45 Transmission method : 10BASE-T,100BASE-TX
USB2.0 Interface	1. Recognizes the SD memory card as a removable disk when connected to a computer. *The instrument cannot be connected during recording (including standby operation) or analysis.* 2. Download data from the SD memory card using the 9624-50 PQA-HiView Pro *The instrument cannot be connected during recording (including standby operation) or analysis.* Connector : Series B receptacle Connection destination : Computer [WindowsXP, WindowsVista(32bit), Windows7 (32/64bit)]
External control interface	Connector : 4-pin screwless terminal block External event input : External event input at TTL low level (at falling edge of 1.0 V or less and when shorted) between GND terminal and EVENT IN terminal Min. pulse width: 30 ms; rated voltage: -0.5 V to +6.0 V External event output :

External event output item setting	Operation	Pulse width
Short pulse output	TTL low output at event generation between [GND] terminal and [EVENT OUT] terminal	Low level for 10 ms or more
Long pulse output	TTL low output at event generation between [GND] terminal and [EVENT OUT] terminal (No external event output at START event)	Low level for approx. 2.5 s
ΔV10 alarm	TTL low output at ΔV10 alarm between [GND] terminal and [EVENT OUT] terminal	Low level while alarm occurring ; reverts to high at data reset

Environment and safety specifications

Operating environment	Indoors, altitude up to 3000 m (measurement category is lowered to 600 V CAT III when above 2000m), Pollution degree 2
Storage temperature and humidity	-20 to 50°C (-4 to 122°F) 80% RH or less (non-condensating) (If the instrument will not be used for an extended period of time, remove the battery pack and store in a cool location [from -20 to 30°C (-4 to 86°F)].)
Operating temperature and humidity	0 to 50°C (32 to 122°F) 80% RH or less (non-condensating)
Dust and water resistance	IP30 (EN60529)
Maximum input voltage	Voltage input section 1000 VAC, DC±600 V, max. peak voltage ±6000 Vpeak Current input section 3VAC, DC±4.24V
Maximum rated voltage to earth	Voltage input terminal 600 V (Measurement Categories IV, anticipated transient overvoltage 8000 V)
Dielectric strength	6.88 kVrms (@50/60 Hz, 1 mA sense current): Between voltage measurement terminals (U1 to U3) and voltage measurement terminals (U4) 4.30 kVrms (1 mA@50/60 Hz, 1 mA sense current): Between voltage input terminal (U1 to U3) and current input terminals/interfaces Between voltage (U4) and current measurement terminals, and interfaces
Applicable standards	Safety EN61010 EMC EN61326 Class A, EN61000-3-2, EN61000-3-3

Measurement Specifications (For specifications when measuring 400Hz circuits, please inquire with your HIOKI distributor.)

- TIME PLOT : The MAX/MIN/AVG of each recording interval for each parameter are recorded.
- EVENT : When a power anomaly occurs, approx. 200ms instantaneous waveform is recorded.
- TRANSIENT : When a transient overvoltage is detected, the 2ms instantaneous waveforms before and after the occurrence (total 4ms) are recorded.
- FLUCTUATION : The RMS fluctuation 0.5s before and 29.5s after an event has occurred are recorded.
- HIGH-ORDER HARM : When a high order harmonic event occurs, the 40ms instantaneous waveform is recorded.

Transient overvoltage
TRANSIENT EVENT

Display items	For single transient incidents and continuous transient incidents Transient voltage value, Transient width For continuous transient incidents Transient period (Period from transient IN to transient OUT) Max. transient voltage value (Max. peak value during the period) Transient count during period
Measurement method	Detected from waveform obtained by eliminating the fundamental component (50/60/400 Hz) from the sampled waveform
Sampling frequency	2MHz
Measurement range, resolution	±6.0000kVpeak, 0.0001kV
Measurement bandwidth	5 kHz (-3dB) to 700 kHz (-3dB)
Min. detection width	0.5 μs
Measurement accuracy	±5.0% rdg.±1.0%f.s.

RMS voltage/ RMS current refreshed each half-cycle
TIME PLOT EVENT

Measurement method	RMS voltage refreshed each half-cycle : True RMS type, RMS voltage values are calculated using sample data for 1 waveform derived by overlapping the voltage waveform every half-cycle RMS current refreshed each half-cycle : RMS current is calculated using current waveform data sampled every half-cycle
Sampling frequency	200kHz
Measurement range, resolution	RMS voltage refreshed each half-cycle : 600.00V, 0.01V RMS current refreshed each half-cycle : Based on clamp-on sensor in use; see Input specifications
Measurement accuracy	RMS voltage refreshed each half-cycle : ±0.2% of nominal voltage (With 1.666% f.s. to 110% f.s. input and a nominal input voltage of at least 100 V) ±0.2%rdg.±0.08%f.s. (With input outside the range of 1.666% f.s. to 110% f.s. or a nominal input voltage of less than 100 V) RMS current refreshed each half-cycle : ±0.3% rdg.±0.5%f.s. + clamp-on sensor accuracy

Swell/ Dip/ Interruption
FLUCTUATION EVENT

Display item	Swell : Swell height, Swell duration Dip : Dip depth, Dip duration Interruption : Interruption depth, Interruption duration
Measurement method	Swell : A swell is detected when the RMS voltage refreshed each half-cycle exceeds the threshold in the positive direction Dip : A dip is detected when the RMS voltage refreshed each half-cycle exceeds the threshold in the negative direction Interruption : An interruption is detected when the RMS voltage refreshed each half-cycle exceeds the threshold in the negative direction
Range and accuracy	See RMS voltage refreshed each half-cycle

Inrush current
FLUCTUATION EVENT

Display item	Maximum current of RMS current refreshed each 1/2 cycle
Measurement method	Detected when the RMS current refreshed each 1/2 cycle exceeds the threshold in a positive direction
Range and accuracy	See RMS current refreshed each half-cycle

RMS voltage, RMS current
TIME PLOT EVENT

Display items	RMS voltage : RMS voltage for each channel and AVG (average) RMS voltage for multiple channels RMS current : RMS current for each channel and AVG (average) RMS current for multiple channels
Measurement method	AC+DC True RMS type (Current DC value: with release of new clamp-on sensor) RMS value calculated from 10 cycles (50 Hz) or 12 cycles (60 Hz)
Sampling frequency	200kHz
Measurement range, resolution	RMS voltage : 600.00V, 0.01V RMS current : Based on clamp-on sensor in use; see Input specifications
Measurement accuracy	RMS voltage : ±0.1% of nominal voltage (With 1.666% f.s. to 110% f.s. input and a nominal input voltage of at least 100 V) ±0.2%rdg.±0.08%f.s. (With input outside the range of 1.666% f.s. to 110% f.s. or a nominal input voltage of less than 100 V) RMS current : ±0.2% rdg.±0.1%f.s. + clamp-on sensor accuracy

Voltage waveform peak/ Current waveform peak
TIME PLOT EVENT

Display item	Positive peak value and negative peak value
Measurement method	Measured every 10 cycles (50 Hz) or 12 cycles (60 Hz) maximum and minimum points sampled during approx. 200 ms aggregation
Sampling frequency	200kHz
Measurement range, resolution	Voltage waveform peak : ±1200.0 Vpeak, 0.1V Current waveform peak : The quadruple of RMS current measurement range (Based on clamp-on sensor in use; See Input specifications)

Voltage waveform comparison
EVENT

Display item	Event detection only
Measurement method	A judgment area is automatically generated from the previous 200 ms aggregation waveform, and events are generated based on a comparison with the judgment waveform. Waveform judgments are performed once for each 200 ms aggregation.
Comparison window width	10 cycles (50 Hz), 12 cycles (60 Hz)
No. of window points	4096 points synchronized with harmonic calculations

Frequency cycle
TIME PLOT EVENT

Measurement method	Calculated as the reciprocal of the accumulated whole-cycle time during one U1 (reference channel) cycle
Measurement range, resolution	70.000Hz, 0.001Hz
Measurement bandwidth	40.000 to 70.000Hz
Measurement accuracy	±0.200 Hz or less (for input from 10% f.s. to 110% f.s.)

Frequency
TIME PLOT EVENT

Measurement method	Calculated as the reciprocal of the accumulated whole-cycle time during approx. 200ms period of 10 or 12 U1 (reference channel) cycles
Measurement range, resolution	70.000Hz, 0.001Hz
Measurement bandwidth	40.000 to 70.000Hz
Measurement accuracy	±0.020 Hz or less

10-sec frequency
TIME PLOT

Measurement method	Calculated as the reciprocal of the accumulated whole-cycle time during the specified 10s period for U1 (reference channel) as per IEC61000-4-30
Measurement range, resolution	70.000Hz, 0.001Hz
Measurement bandwidth	40.000 to 70.000Hz
Measurement accuracy	±0.010 Hz or less

Voltage DC value (ch4 only)

TIME PLOT EVENT

Measurement method	Average value during approx. 20ms aggregation synchronized with the reference channel (CH4 only)
Sampling frequency	200kHz
Measurement range, resolution	600.00V, 0.01V
Measurement accuracy	±0.3%rdg. ±0.08%f.s.

Current DC value (ch4 only; when using compatible sensor)

TIME PLOT EVENT

Measurement method	Average value during approx. 200ms aggregation synchronized to reference channel (CH4 only)
Sampling frequency	200kHz
Measurement range, resolution	Based on clamp-on sensor in use (with release of new clamp-on sensor)
Measurement accuracy	±0.5% rdg.±0.5%f.s. + clamp-on sensor accuracy

Active power/ Apparent power/ Reactive power

TIME PLOT EVENT

Display items	Active power : Active power for each channel and sum value for multiple channels. Sink (consumption) and Source (regeneration) Apparent power : Apparent power of each channel and its sum for multiple channels No polarity Reactive power : Reactive power of each channel and its sum for multiple channels Lag phase (LAG: current lags voltage) and Lead phase (LEAD: current leads voltage)
Measurement method	Active power : Measured every 10 cycles (50 Hz) or 12 cycles (60 Hz) Apparent power : Calculated from RMS voltage U and RMS current I Reactive power : Calculated using apparent power S and active power P
Sampling frequency	200kHz
Measurement range, resolution	Depends on the voltage × current range combination; see Input specifications
Measurement accuracy	Active power : ±0.2% rdg.±0.1%f.s. + clamp-on sensor accuracy Apparent power : ±1 dgt. for calculations derived from the various measurement values Reactive power : ±1 dgt. for calculations derived from the various measurement values

Active energy /Reactive energy

TIME PLOT

Display items	Active energy : WP+ (consumption), WP- (regeneration); Sum of multiple channels Reactive energy : WQLAG (lag), WQLEAD (lead); Sum for multiple channels Elapsed time
Measurement method	Measured every 10 cycles (50 Hz) or 12 cycles (60 Hz) Integrated separately by consumption and regeneration from active power Integrated separately by lag and lead from reactive power Integration starts at the same time as recording Recorded at the specified TIMEPLOT interval
Sampling frequency	200kHz
Measurement range, resolution	Depends on the voltage × current range combination; see Input specifications
Measurement accuracy	Active energy : Active power measurement accuracy ±10 dgt. Reactive energy : Reactive power measurement accuracy ±10 dgt.

Power factor /Displacement power factor

TIME PLOT EVENT

Display items	Displacement power factor of each channel and its sum value for multiple channels
Measurement method	Power factor : Calculated from RMS voltage U, RMS current I, and active power P Displacement power factor : Calculated from the phase difference between the fundamental voltage wave and the fundamental current wave Lag phase (LAG: current lags voltage) and Lead phase (LEAD: current leads voltage
Sampling frequency	200kHz
Measurement range, resolution	-1.0000 (lead) to 0.0000 to 1.0000 (lag)

Voltage unbalance factor/ Current unbalance factor (negative-phase, zero-phase)

TIME PLOT

Display items	Voltage unbalance factor : Negative-phase unbalance factor, zero-phase unbalance factor Current unbalance factor : Negative-phase unbalance factor, zero-phase unbalance factor
Measurement method	Calculated using various components of the three-phase fundamental wave (line-to-line voltage) for three-phase 3-wire (3P3W2M, 3P3W3M) and three-phase 4-wire connections
Sampling frequency	200kHz
Measurement range	Voltage unbalance factor : Component is V and unbalance factor is 0.00% to 100.00% Current unbalance factor : Component is V and unbalance factor is 0.00% to 100.00%
Measurement accuracy	Voltage unbalance factor : ±0.15% Current unbalance factor : —

High-order harmonic voltage component/ High-order harmonic current component

HIGH-ORDER HARM TIME PLOT EVENT

Display items	For single incidents and continuous transient incidents High-order harmonic voltage component value High-order harmonic current component value For continuous incidents High-order harmonic voltage component maximum value High-order harmonic current component maximum value High-order harmonic voltage component period High-order harmonic current component period
Measurement method	The waveform obtained by eliminating the fundamental component is calculated using the true RMS method during 10 cycles (50 Hz) or 12 cycles (60 Hz) of the fundamental wave
Sampling frequency	200kHz
Measurement range, resolution	High-order harmonic voltage component : 600.00V, 0.01V High-order harmonic current component : Based on clamp-on sensor in use; See Input specifications
Measurement bandwidth	2kHz (-3dB) to 80kHz (-3dB)
Measurement accuracy	High-order harmonic voltage component : ±10%rdg. ±0.1%f.s. High-order harmonic current component : ±10% rdg.±0.2%f.s. + clamp-on sensor accuracy

Harmonic voltage/ Harmonic current (including fundamental component)

TIME PLOT EVENT

Display items	Select either RMS or content percentage; From 0 to 50th order
Measurement method	Uses IEC61000-4-7:2002.
Comparison window width	10 cycles (50 Hz), 12 cycles (60 Hz)
No. of window points	4096 points synchronized with harmonic calculations
Measurement range, resolution	Harmonic voltage : 600.00V, 0.01V Harmonic current : Based on clamp-on sensor in use; see Input specifications
Measurement accuracy	See measurement accuracy with a fundamental wave of 50/60 Hz When using an AC-only clamp sensor, 0th order is not specified for current and power

Total harmonic voltage/ Total harmonic current distortion factor

TIME PLOT EVENT

Display items	THD-F (total harmonic distortion factor for the fundamental wave) THD-R (total harmonic distortion factor for the total harmonic including the fundamental wave)
Measurement method	Based on IEC61000-4-7:2002; Max. order: 50th
Comparison window width	10 cycles (50 Hz), 12 cycles (60 Hz)
No. of window points	4096 points synchronized with harmonic calculations
Measurement range, resolution	0.00 to 100.00%(Voltage), 0.00 to 500.00%(Current)
Measurement accuracy	—

Harmonic power (including fundamental component)

TIME PLOT EVENT

Display item	Select either RMS or content percentage; From 0 to 50th order
Measurement method	Uses IEC61000-4-7:2002.
Comparison window width	10 cycles (50 Hz), 12 cycles (60 Hz)
No. of window points	4096 points synchronized with harmonic calculations
Measurement range, resolution	Depends on the voltage × current range combination; See Input specifications
Measurement accuracy	See measurement accuracy with a fundamental wave of 50/60 Hz (When using an AC-only clamp sensor, order 0 is not specified for current and power)

Measurement accuracy with a fundamental wave of 50/60 Hz

Harmonic input	Measurement accuracy
Voltage (At least 1% of nominal voltage)	Specified with a nominal voltage of at least 100 V Order 0: ±0.3%rdg.±0.08%f.s. Order 1+: ±5.00%rdg
Voltage (<1% of nominal voltage)	Specified with a nominal voltage of at least 100 V Order 0: ±0.3%rdg.±0.08%f.s. Order 1+: ±0.05% of nominal voltage
Current	Order 0: ±0.5%rdg.±0.5%f.s. +clamp-on sensor accuracy Order 1 to 20th: ±0.5%rdg.±0.2%f.s. +clamp-on sensor accuracy Order 21 to 50th: ±1.0%rdg.±0.3%f.s. +clamp-on sensor accuracy
Power	Order 0: ±0.5%rdg.±0.5%f.s. +clamp-on sensor accuracy Order 1 to 20th: ±0.5%rdg.±0.2%f.s. +clamp-on sensor accuracy Order 21 to 30th: ±1.0%rdg.±0.3%f.s. +clamp-on sensor accuracy Order 31 to 40th: ±2.0%rdg.±0.3%f.s. +clamp-on sensor accuracy Order 41 to 50th: ±3.0%rdg.±0.3%f.s. +clamp-on sensor accuracy

Harmonic voltage phase angle/ Harmonic current phase angle (including fundamental component)

TIME PLOT

Display item	Harmonic phase angle components for whole orders
Measurement method	Uses IEC61000-4-7:2002.
Comparison window width	10 cycles (50 Hz), 12 cycles (60 Hz)
No. of window points	4096 points synchronized with harmonic calculations
Measurement range, resolution	-180.00° to 0.00° to 180.00°
Measurement accuracy	—

Harmonic voltage-current phase angle (including fundamental component)

TIME PLOT EVENT

Display item	Indicates the difference between the harmonic voltage phase angle and the harmonic current phase angle. Harmonic voltage-current phase difference for each channel and sum (total) value for multiple channels
Measurement method	Uses IEC61000-4-7:2002.
Comparison window width	10 cycles (50 Hz), 12 cycles (60 Hz)
No. of window points	4096 points synchronized with harmonic calculations
Measurement range, resolution	-180.00° to 0.00° to 180.00°
Measurement accuracy	1st to 3rd orders : ± 2° +clamp-on sensor accuracy 4th to 50th orders: ±(0.05° × k+2°) +clamp-on sensor accuracy; (k: harmonic orders) Specified with a harmonic voltage of 1 V for each order and a current level of at 1% f.s. or greater.

Inter-harmonic voltage and inter-harmonic current

TIME PLOT

Display item	Select either RMS or content percentage; 0.5 to 49.5th orders
Measurement method	Uses IEC61000-4-7:2002.
Comparison window width	10 cycles (50 Hz), 12 cycles (60 Hz)
No. of window points	4096 points synchronized with harmonic calculations
Measurement range, resolution	Inter-harmonic voltage : 600.00V, 0.01V Inter-harmonic current : Due to using clamp-on sensor; See Input specifications
Measurement accuracy	Inter-harmonic voltage (Specified with a nominal voltage of at least 100 V) : At least 1% of harmonic input nominal voltage: ±5.00% rdg. <1% of harmonic input nominal voltage : ±0.05% of nominal voltage Inter-harmonic current : Unspecified

K Factor (multiplication factor)

TIME PLOT EVENT

Measurement method	Calculated using the harmonic RMS current of the 2nd to 50th orders
Comparison window width	10 cycles (50 Hz), 12 cycles (60 Hz)
No. of window points	4096 points synchronized with harmonic calculations
Measurement range, resolution	0.00 to 500.00
Measurement accuracy	—

Instantaneous flicker value

TIME PLOT

Measurement method	As per IEC61000-4-15 User-selectable from 230 Vlamp/120 Vlamp (when Pst and Plt are selected for flicker measurement)/4 types of Ed2 filter (230 Vlamp 50/60 Hz, 120 Vlamp 60/50 Hz)
Measurement range, resolution	99.999, 0.001

ΔV10 Flicker

TIME PLOT

Display items	ΔV10 measured at one minute intervals, average value for one hour, maximum value for one hour, fourth largest value for one hour, total (within the measurement interval) maximum value
Measurement method	Calculated values are subject to 100 V conversion following gap-less measurement once each minute
Measurement range, resolution	0.000 to 99.999V
Measurement accuracy	±2% rdg.±0.01 V (with a fundamental wave of 100 Vrms [50/60 Hz], a fluctuation voltage of 1 Vrms, and a fluctuation frequency of 10 Hz)
Threshold	0.00 to 9.99V alarm output is generated when the reading for each minute is compared to the threshold and found to be greater

IEC Flicker

TIME PLOT

Display items	Short interval flicker Pst, long interval flicker Plt
Measurement method	Based on IEC61000-4-15:1997 +A1:2003 Ed1/Ed2. Pst is calculated after 10 minutes of continuous measurement and Plt after 2 hours of continuous measurement
Measurement range	0.0001 to 10000 P.U. broken into 1,024 segments with a logarithm
Measurement accuracy	Pst ±5% rdg. (Specified within range 0.1000 to 20.000 using IEC61000-4-15 Ed1.1 and IEC61000-4-15 Ed2 Class F1 performance test.)
Flicker filter	Select 230 V lamp Ed1, 120 V lamp Ed1, 230 V lamp Ed2, or 120 V lamp Ed2.

14

Clamp-on sensors specifications (Options)

Clamp-on sensor	CLAMP ON SENSOR 9694	CLAMP ON SENSOR 9660	CLAMP ON SENSOR 9661
Appearance			
Primary current rating	5A AC	100A AC	500A AC
Output voltage	10mV/A AC	AC 1mV/A AC	AC 1mV/A AC
Measurement range	See input specifications		
Amplitude accuracy *	±0.3%rdg.±0.02%f.s. *	±0.3%rdg.±0.02%f.s. *	±0.3%rdg.±0.01%f.s.*
Phase accuracy *	±2° or less *	±1° or less *	±0.5° or less *
Maximum allowable input*	50 A continuous *	130 A continuous *	550 A continuous *
Maximum rated voltage to earth	CAT III 300Vrms		CAT III 600 Vrms
Frequency characteristics	±1.0% or less for 66Hz to 5kHz (deviation from specified accuracy)		
Cord length	3m (9.84ft)		
Measurable conductor diameter	Max.φ15mm (0.59")		Max.φ46mm (1.81")
Dimensions, Mass	46W(1.81")×135H(5.31")×21D(0.83")mm, 230g(8.1oz.)		78W(3.07")×152H(5.98")×42D(1.65")mm, 380g(13.4oz.)

*: 45 to 66Hz

Clamp-on sensor	CLAMP ON SENSOR 9669	FLEXIBLE CLAMP ON SENSOR CT9667
Appearance		
Primary current rating	1000 A AC	500A AC, 5000A AC
Output voltage	0.5mV/A AC	500 mV AC f.s.
Measurement range	See input specifications	
Amplitude accuracy *	±1.0%rdg.±0.01%f.s. *	±2.0%rdg.±0.3%f.s. *
Phase accuracy *	±1° or less *	±1° or less *
Maximum allowable input*	1000 A continuous *	10000 A continuous *
Maximum rated voltage to earth	CAT III 600Vrms	CATIII 1000 Vrms CATIV 600 Vrms
Frequency characteristics	Within ±2% at 40Hz to 5kHz (deviation from accuracy)	±3dB or less for 10 Hz to 20kHz (within ±3dB)
Cord length	3m (9.84ft)	Sensor to circuit: 2m (6.56ft) Circuit to connector: 1m (3.28ft)
Measurable conductor diameter	Max. φ55 mm(2.17"), 80 (3.15")x20(0.79") mm busbar	Max. φ254mm(10")
Dimensions, Mass	99.5W (3.92") x 188H (7.40") x 42D (1.65") mm, 590g (20.8 oz.)	Circuit box: 35W (1.38") x 120.5H (4.74") x 34D (1.34") mm, 140 g (4.9 oz.)
Power supply	—	LR6 alkaline battery x2, AC Adapter (option) or external 5 to 15 V DC power supply
Options (sold separately)		AC ADAPTER 9445-02 (universal 100 to 240VAC ,9V/1A output for USA) AC ADAPTER 9445-03 (universal 100 to 240VAC ,9V/1A output for Europe)

*: 45 to 66Hz

Clamp-on sensor	CLAMP ON SENSOR 9695-02	CLAMP ON SENSOR 9695-03
Appearance		
Primary current rating	50A AC	100A AC
Output voltage	10mV/A AC	1mV/A AC
Measurement range	See input specifications	
Amplitude accuracy *	±0.3%rdg.±0.02%f.s. *	±0.3%rdg.±0.02%f.s. *
Phase accuracy *	Within ±2° *	Within ±1° *
Maximum allowable input*	130 A continuous *	130 A continuous *
Maximum rated voltage to earth	CAT III 300Vrms (insulated conductor)	
Frequency characteristic	Within ±2% at 40Hz to 5kHz (deviation from accuracy)	
Cord length	CONNECTION CORD 9219 (sold separately) is required.	
Measurable conductor diameter	Max. φ15mm (0.59")	
Dimensions, Mass	51W(2.01")×58H(2.28")×19D(0.75")mm , 50g(1.8oz.)	
Options (sold separately)	CONNECTION CORD 9219 (Cord length:3m (9.84ft)	

Note: CONNECTION CORD 9219 (sold separately) is required.
*: 45 to 66Hz


CONNECTION CORD 9219

Clamp-on AC/DC sensor	AC/DC CLAMP ON SENSOR CT9691-90 (CT9691 bundled with the CT6590)	AC/DC CLAMP ON SENSOR CT9692-90 (CT9692 bundled with the CT6590)	AC/DC CLAMP ON SENSOR CT9693-90 (CT9693 bundled with the CT6590)
Appearance			
Includes	CT9691 x1, CT6590 x1	CT9692 x1, CT6590 x1	CT9693 x1, CT6590 x1

CT9691,CT9692,CT9693 (Clamp sensor) specifications

	CT9691	CT9692	CT9693
Primary current rating	100A AC/DC	200A AC/DC	2000A AC/DC
Maximum input range (RMS value)	100Arms continuous*	200Arms continuous*	2000Arms continuous*
Maximum rated voltage to earth	CAT III AC/DC 600V		
Frequency band	DC to 10 KHz (-3dB)	DC to 20 KHz (-3dB)	DC to 15 KHz (-3dB)
Cord length	2m (6.5 ft)		
Measurable conductor diameter	35 mm (1.38") or less	33 mm (1.30") or less	55 mm (2.17") or less
Dimensions, Mass	53W(2.09") x 129H(5.08") x 18D(0.71") mm, 230g (8.1 oz.)	62W(2.44") x 167H(6.57") x 35D(1.38") mm, 410g (14.5 oz.)	62W(2.44") x 195H(7.72") x 35D(1.38") mm, 500g (17.6 oz.)

CT6590 (SENSOR UNIT) specifications

	CT6590		
Range when combined with sensor (H/L selectable)	H range : 100A AC/DC f.s. L range : 10A AC/DC f.s.	H range : 200A AC/DC f.s. L range : 20A AC/DC f.s.	H range : 2000A AC/DC f.s. L range : 200A AC/DC f.s.
Sensor combination Output rate	H range : 1mV/A L range : 10mV/A	H range : 1mV/A L range : 10mV/A	H range : 0.1mV/A L range : 1mV/A
Sensor combination measurement range	See input specifications		
Sensor combination accuracy (Continuous input)	±1.5%rdg.±1.0%f.s. (DC ≤ f ≤ 66 Hz)	±1.5%rdg ±0.5%f.s. (DC ≤ f ≤ 66 Hz)	±2.0%rdg ±0.5%f.s. (DC) ±1.5%rdg ±0.5%f.s. (45 ≤ f ≤ 66Hz, I ≤ 1800A) ±2.5%rdg.±0.5%f.s. (45 ≤ f ≤ 66Hz, 1800A<I ≤ 2000A)
Sensor combination accuracy (Phase)	±2deg. (DC < f ≤ 66 Hz)	±2deg. (DC < f ≤ 66 Hz)	±2deg. (45Hz ≤ f ≤ 66 Hz)
Cord length	1m (3.3ft)		
Dimensions, Mass	36W(1.42") x 120H(4.72") x 34D(1.34") mm (excluding protruding parts), 166g(5.8 oz.) (including batteries)		
Power supply	LR6 alkaline battery x2, optional AC adapter, or 5 V to 15 VDC external power		
Options (sold separately)	AC ADAPTER 9445-02 (universal 100 to 240VAC , 9V/1A output/for USA) AC ADAPTER 9445-03 (universal 100 to 240VAC , 9V/1A output/for Europe)		

*: Derating according to frequency

Clamp-on leak sensor	CLAMP ON LEAK SENSOR 9657-10	CLAMP ON LEAK SENSOR 9675
Appearance		
Primary current rating	10A AC (Up to 5A on Model PW3198)	
Output voltage	100 mV/A AC	
Measurement range	See input specifications (Cannot be used to measure power)	
Amplitude accuracy *	±1.0%rdg.±0.05%f.s. *	±1.0% rdg.±0.005%f.s. *
Residual current characteristics	Max. 5mA (in 100A go and return electric wire)	Max. 1mA (in 10A go and return electric wire)
Effect of external magnetic fields	400A AC/m corresponds to 5mA, Max. 7.5mA	
Maximum rated voltage to earth	CATIII 300Vrms (insulated conductor)	
Cord length	3m (9.84ft)	
Measurable conductor diameter	Max. φ40 mm (1.57")	Max. φ30 mm (1.18oz")
Dimensions, Mass	74W(2.91")x145H(5.71")x 42D(1.65)mm, 380g(13.4oz.)	60W(2.36")x112.5H(4.43")x 23.6D(23.6")mm, 160g(5.6oz.)

*: 45 to 66Hz

Options

CE

Current measurement (see P.14 -15 Clamp-on sensors specifications for details)

CLAMP ON SENSOR (Load current, AC)

9694
5A AC, φ15mm(0.59")

9661
500A AC, φ46mm(1.81")

CT9667
500A AC/ 5000A AC (selectable),
φ254mm (10"),
Power supply: LR06 alkaline battery
or AC ADAPTER 9445-02/03 (sold separately)

9660
100A AC, φ15mm(0.59")

9669
1000A AC, φ55mm(2.17"),
80(3.15")×20(0.79")mm busbar

9695-02 (50A AC)
9695-03 (100A AC)
φ15mm (0.59"), CONNECTION CORD 9219 is required (sold separately)

CONNECTION CORD 9219
For connecting 9695-02, 9695-03
Cord length : 3m (9.84ft)

CLAMP ON AC/DC SENSOR (Load current, AC/DC)

CT9691-90
100A AC/DC / 10A AC/DC (selectable),
φ35mm(1.38")
Power supply:
LR6 alkaline battery
or AC ADAPTER 9445-02/03
(sold separately)

CT9692-90
200A AC/DC / 20A AC/DC (selectable),
φ33mm(1.30")
Power supply:
LR6 alkaline battery
or AC ADAPTER 9445-02/03
(sold separately)

CT9693-90
2000A AC/DC / 200A AC/DC (selectable),
φ55mm(2.17")
Power supply:
LR6 alkaline battery
or AC ADAPTER 9445-02/03
(sold separately)

The CT9691-90, CT9692-90, and CT9693-90 represent the respective clamp sensor bundled with the CT6590 Sensor Unit.

CLAMP ON ADAPTER

9290-10
CT ratio 10:1, AC1000A,
φ55mm(2.17"),
80(3.15")×20(0.79")mm busbar,
Cord length : 3m(9.84ft)

CLAMP ON LEAK SENSOR (Leak Current)

Cannot be used to measure power

9657-10
10A AC (Up to 5A on Model PW3198),
φ40mm(1.57"),

9675
10A AC (Up to 5A on Model PW3198),
φ30mm(1.18"),

Voltage measurement

WIRING ADAPTER
PW9000
For 3P3W WIRING

WIRING ADAPTER
PW9001
For 3P4W WIRING

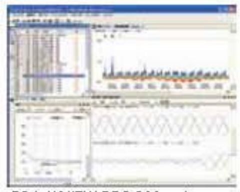
Reduce voltage cords for easy wiring

MAGNETIC ADAPTER 9804-01 (red)
MAGNETIC ADAPTER 9804-02 (black)
Magnetic tip for use with the standard Voltage Cord L1000
(generally compatible with M6 pan screws)

Red and black adapters sold separately.
Purchase the quantity and color appropriate for your application.
(Example: 3P3W - 3 adapters; 3P4W - 4 adapters)

GRABBER CLIP
9243
For use with the standard Voltage Cord L1000

Application software



PQA-HiVIEW PRO 9624-50
Use Model 9624-50 PQA-HiVIEW PRO (version 2.00 or later) with a PC to analyze the data collected by the PW3198.

Case

CARRYING CASE
C1001
Soft case
450W× 345W× 210Dmm
(17.7"W× 13.6"H× 8.3"D)
3.4kg (120oz.)

CARRYING CASE
C1002
Hard case
413W× 595W× 265Dmm
(16.3"W× 23.4"H× 10.4"D)
5.7kg (201oz.)

Clock synchronization

GPS BOX PW9005
To synchronize the PW3198 clock,
Accessory: Connection cable set

POWER QUALITY ANALYZER PW3198
(Bundled accessories)
SD MEMORY CARD 2GB Z4001,
VOLTAGE CORD L1000, AC ADAPTER Z1002,
BATTERY PACK Z1003, Instruction manual,
Measurement guide, Strap, USB cable (Approx. 1m in length)

POWER QUALITY ANALYZER PW3198-90

(Set with PQA HiVIEW PRO 9624-50 and bundled accessories)

IMPORTANT

Use Model PQA-HiVIEW PRO 9624-50 (version 2.00 or later) with a PC to analyze the data collected by the PW3198.

Bundled accessories

Voltage Cord L1000
8 cords, approx. 3 m each:
1 each red, yellow, blue, and gray plus 4 black;
8 alligator clips: 1 each red, yellow, blue, and gray plus 4 black

AC ADAPTER Z1002
Power supply for the PW3198
100V AC to 240V AC

SD MEMORY CARD 2GB
Z4001

IMPORTANT

Use only the SD Card Z4001 sold by HIOKI.

BATTERY PACK Z1003
(Ni-MH, 7.2 V/4500mAh)

●Combination example: For three-phase 4-wire circuits containing leak current

PW3198-90	+	9661 × 3	+	9675	+	PW9001	+	C1001
POWER QUALITY ANALYZER PW3198 set with PQA HiVIEW PRO 9624-50		CLAMP ON SENSOR (500A)		CLAMP ON LEAK SENSOR		WIRING ADAPTER		CARRYING CASE

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All information correct as of Sep. 5, 2012. All specifications are subject to change without notice.

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APPENDIX B PQ Logging Data for 2017/2018 FY

Please refer to the following pages.

TC1 Feeder – Flicker, Voltage, Frequency, and Harmonics

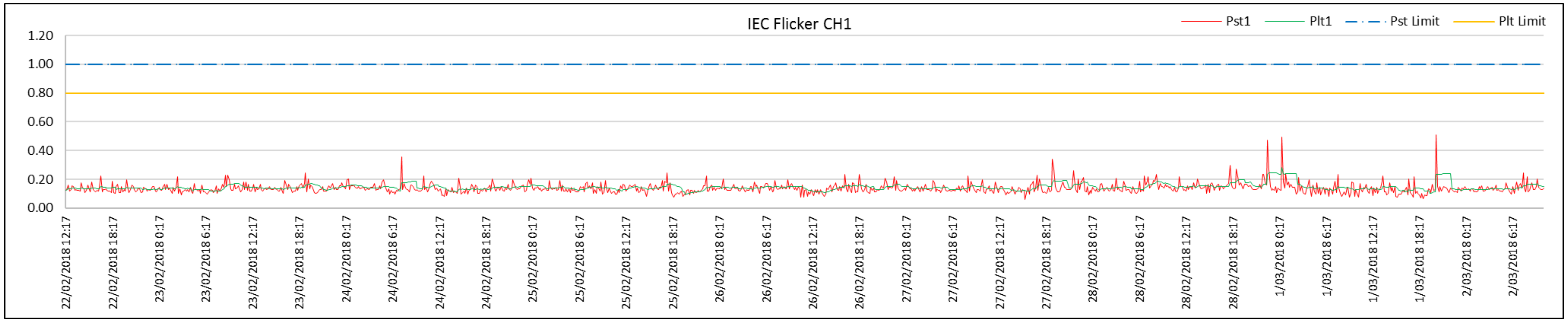

Figure 22 | TC1 - start of feeder – flicker measurements (Red Phase)

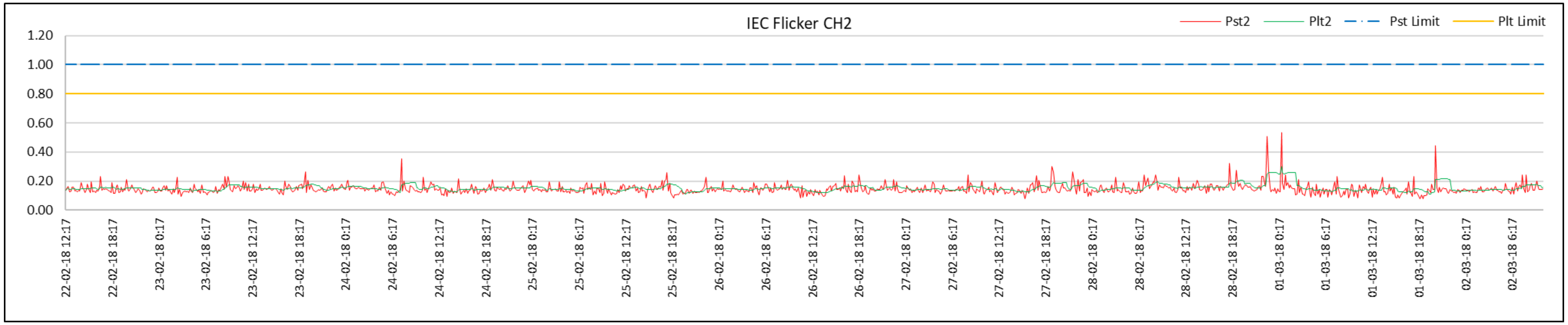

Figure 23 | TC1 - start of feeder – flicker measurements (White Phase)

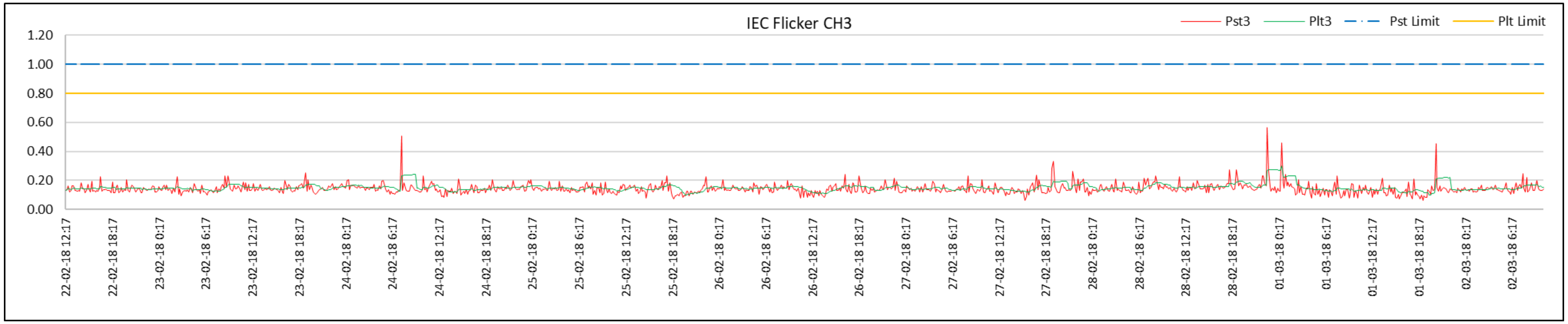

Figure 24 | TC1 - start of feeder – flicker measurements (Blue Phase)

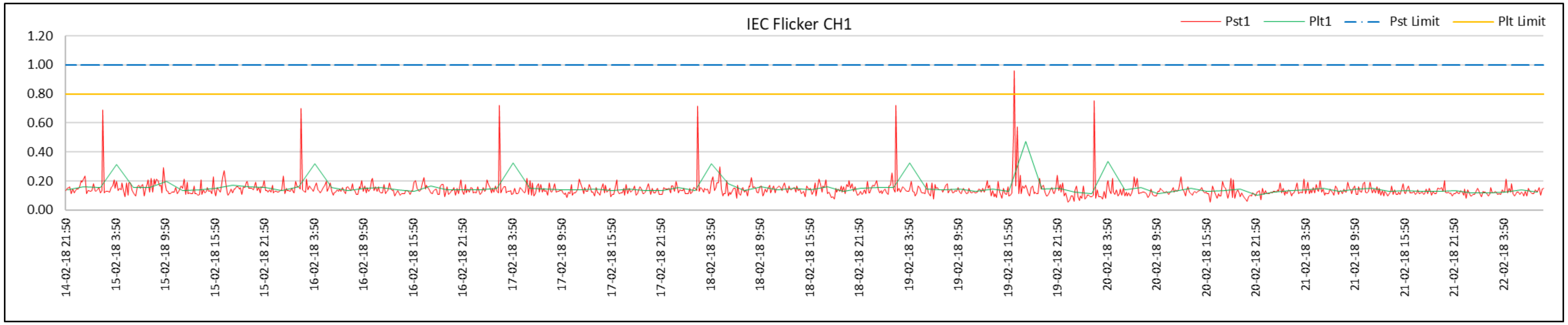

Figure 25 | TC1 – end of feeder – flicker measurements (Red Phase)

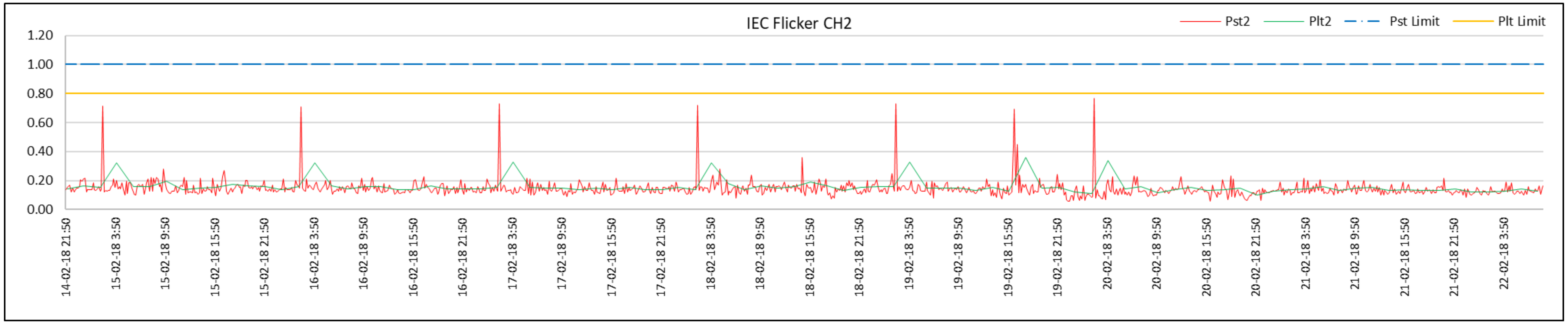

Figure 26 | TC1 - end of feeder – flicker measurements (White Phase)

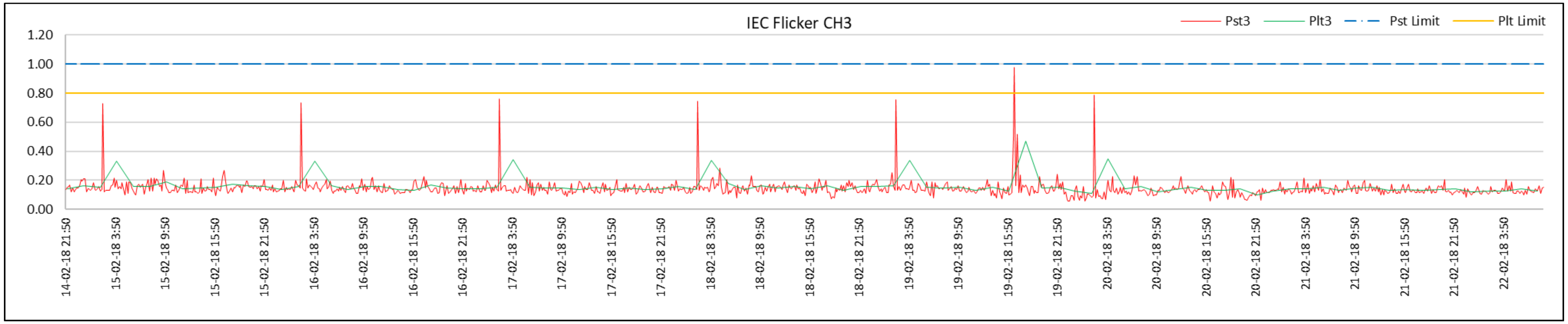

Figure 27 | TC1 - end of feeder – flicker measurements (Blue Phase)

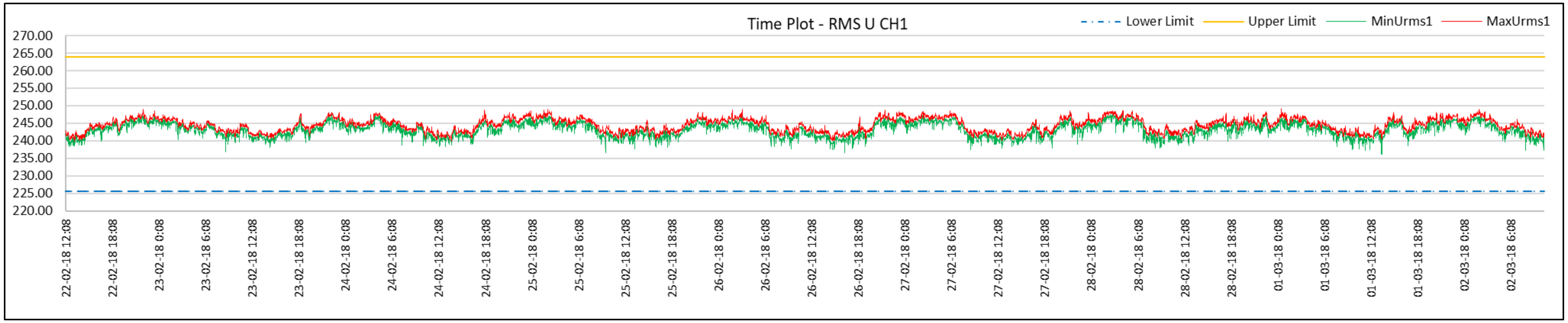

Figure 28 | TC1 - start of feeder – voltage measurements (Red Phase)

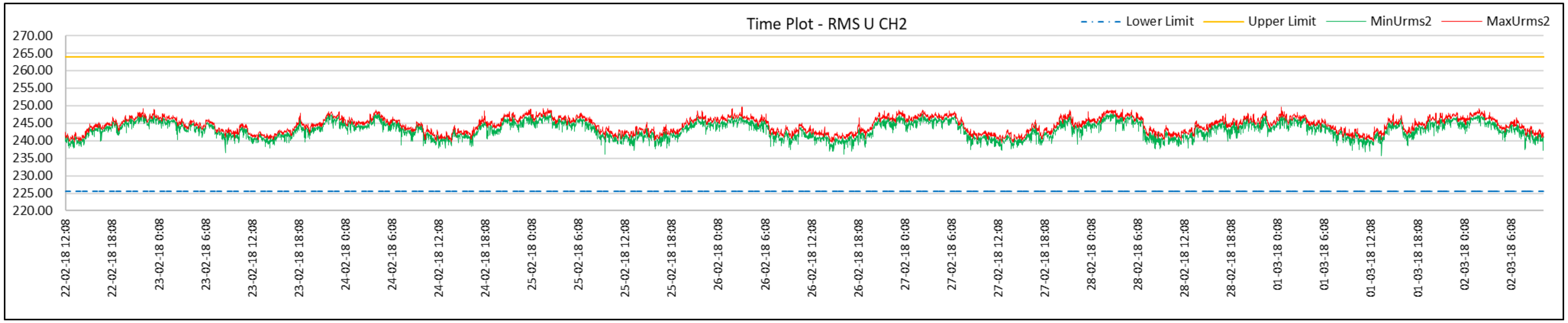

Figure 29 | TC1 - start of feeder – voltage measurements (White Phase)

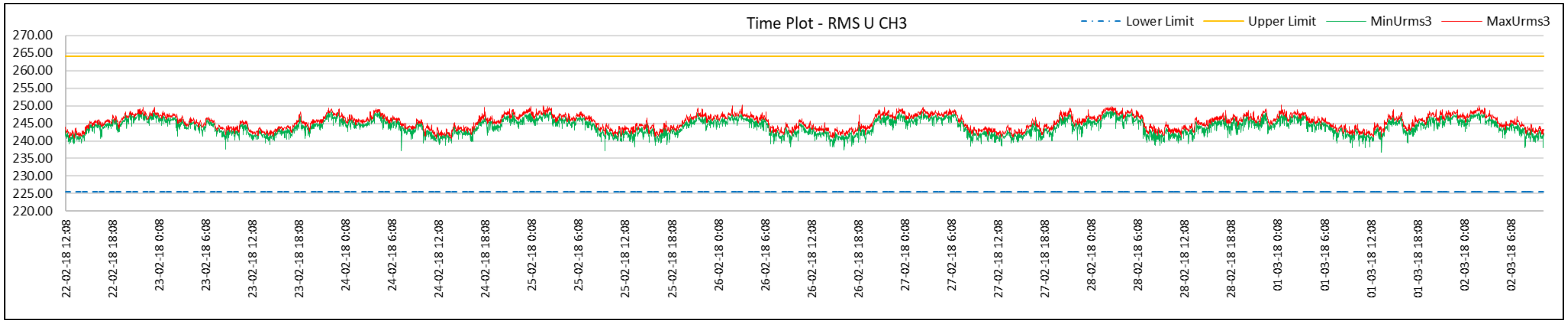

Figure 30 | TC1 - start of feeder – voltage measurements (Blue Phase)

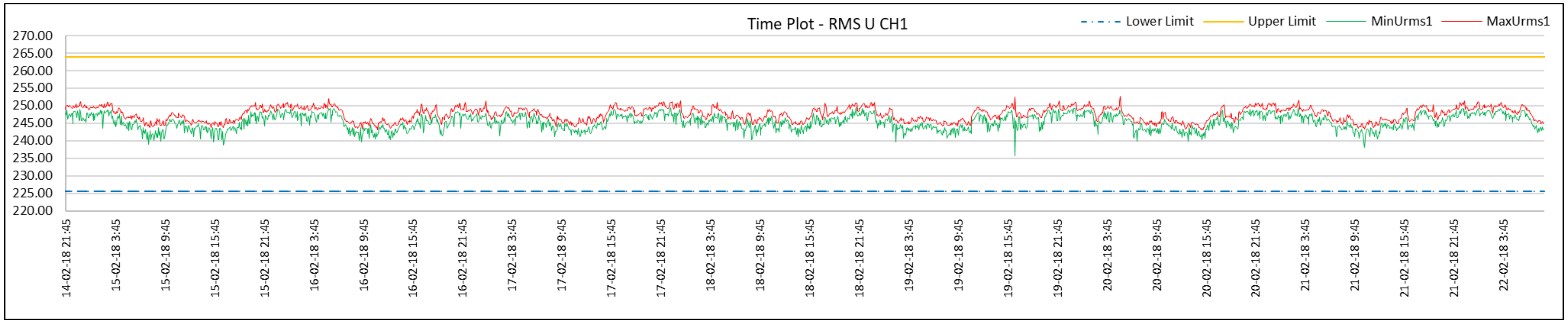

Figure 31 | TC1 - end of feeder – voltage measurements (Red Phase)

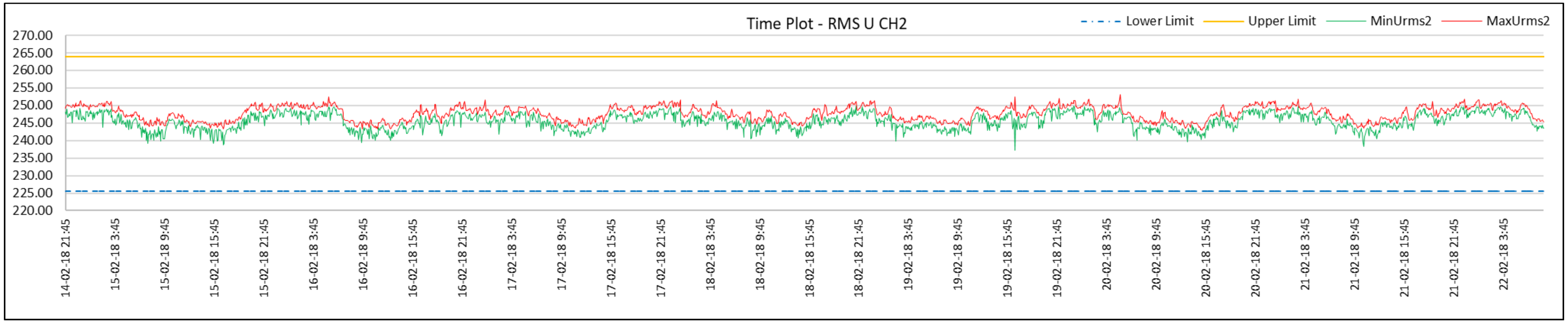

Figure 32 | TC1 - end of feeder – voltage measurements (White Phase)

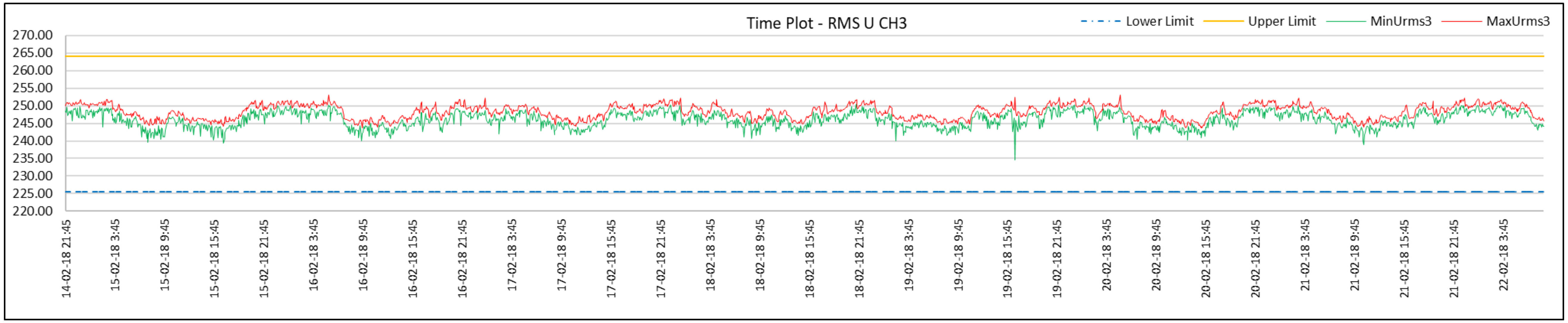

Figure 33 | TC1 - end of feeder – voltage measurements (Blue Phase)

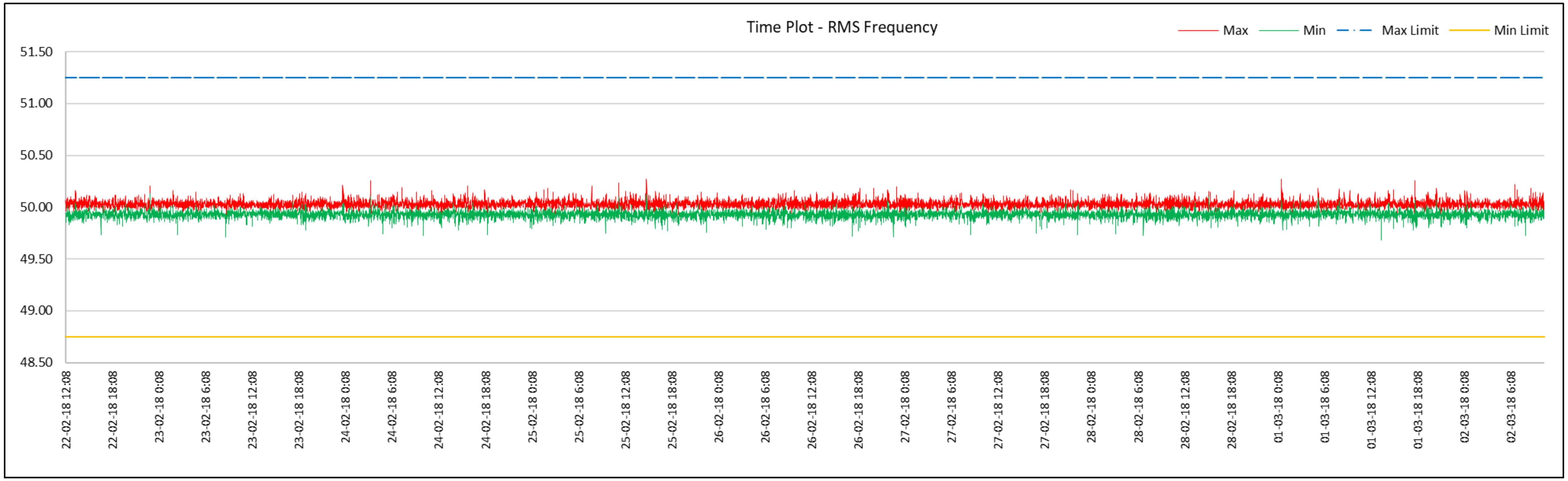

Figure 34 | TC1 - start of feeder – frequency measurements

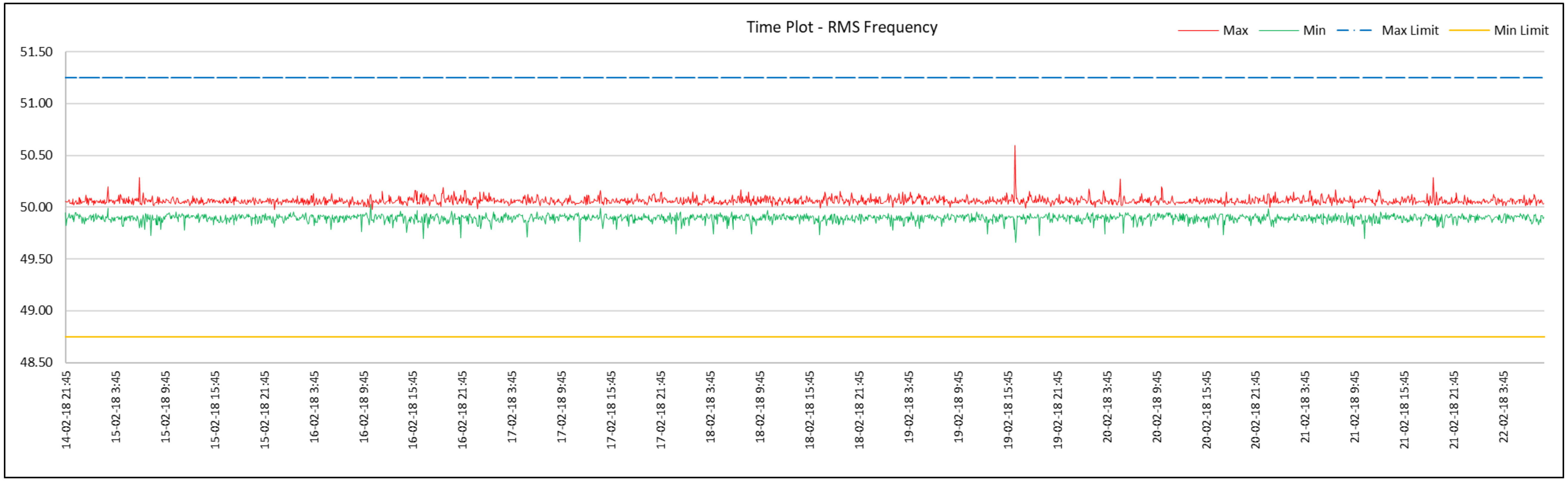

Figure 35 | TC1 - end of feeder – frequency measurements

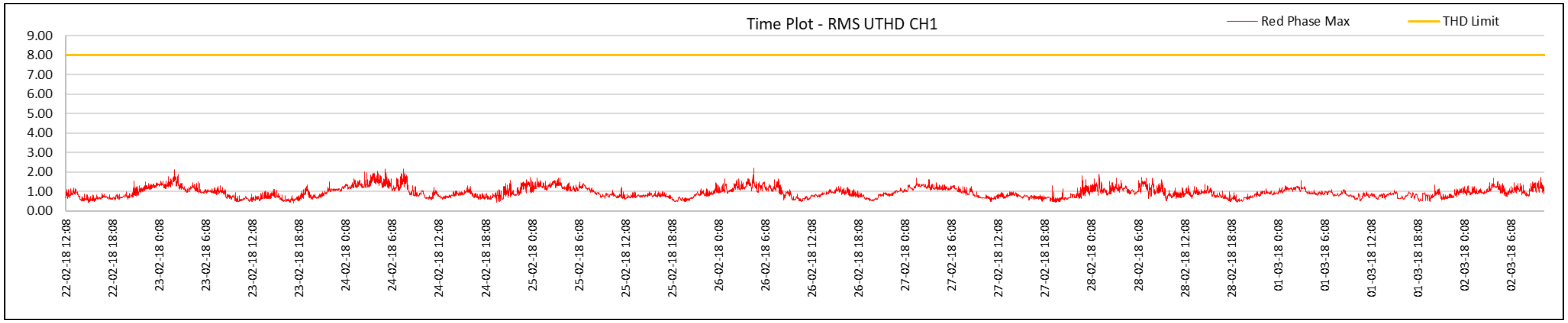

Figure 36 | TC1 - start of feeder – voltage THD measurements (Red Phase)

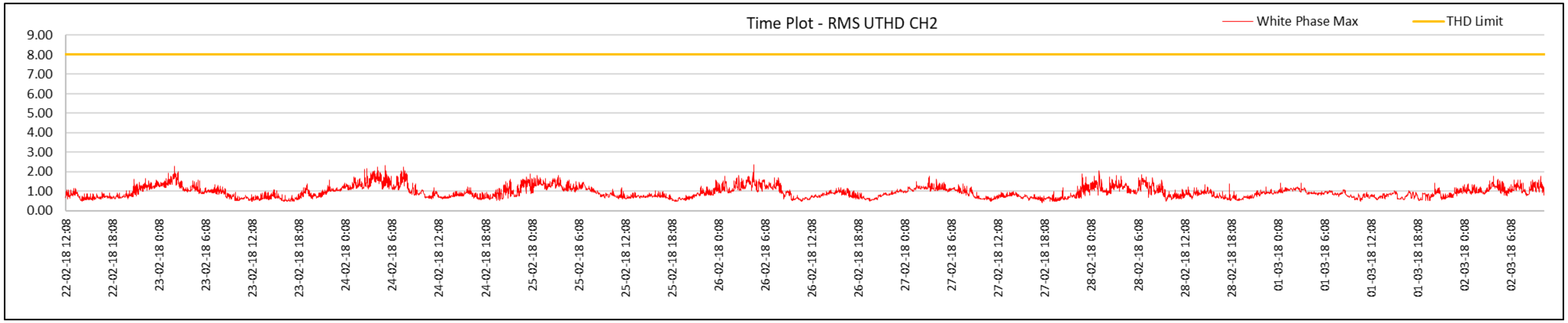

Figure 37 | TC1 - start of feeder – voltage THD measurements (White Phase)

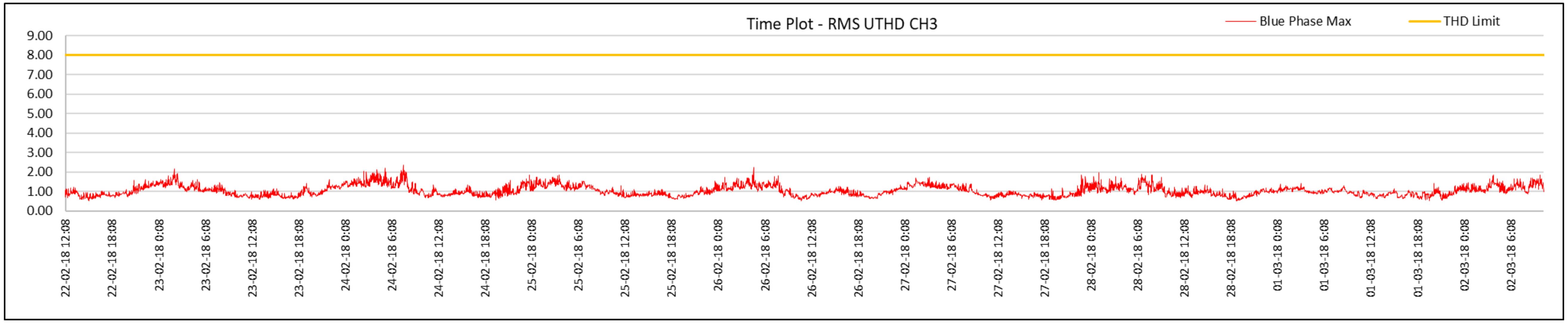

Figure 38 | TC1 - start of feeder – voltage THD measurements (Blue Phase)

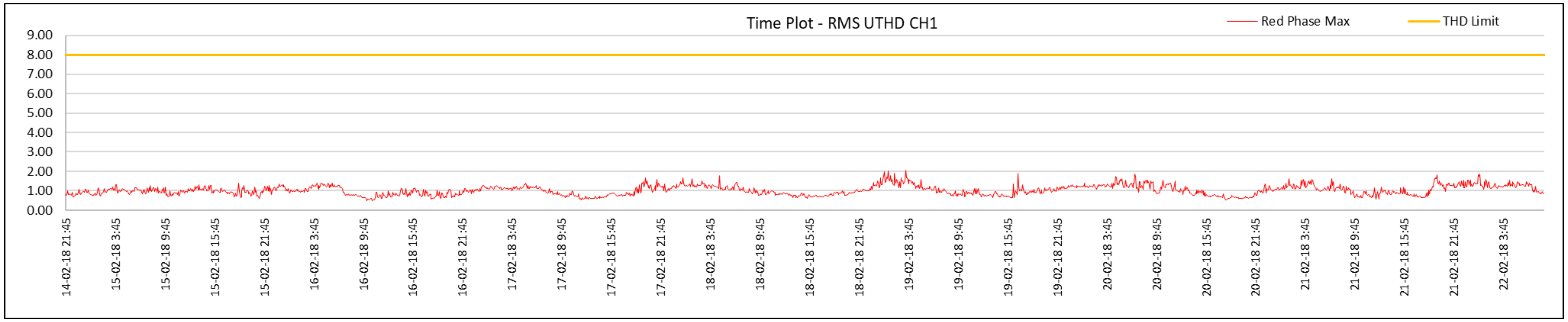

Figure 39 | TC1 - end of feeder – voltage THD measurements (Red Phase)

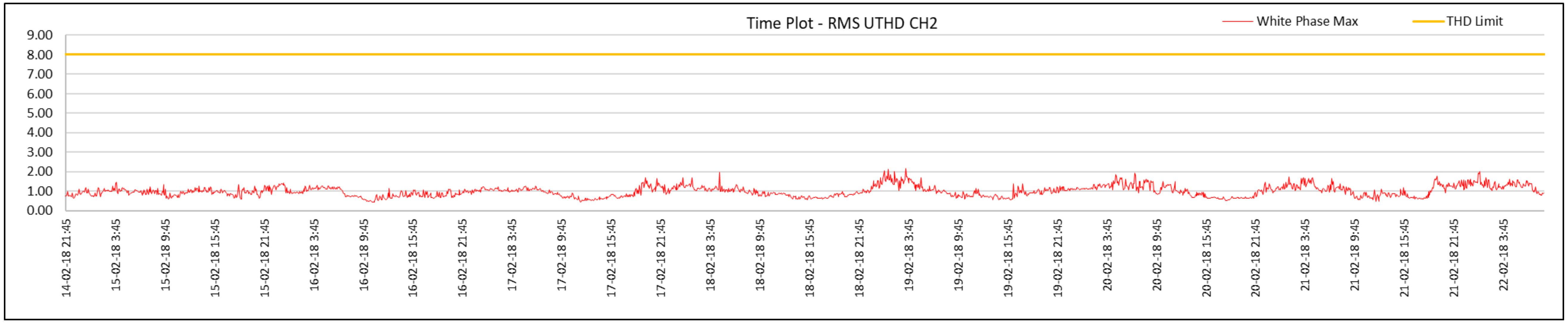

Figure 40 | TC1 - end of feeder – voltage THD measurements (White Phase)

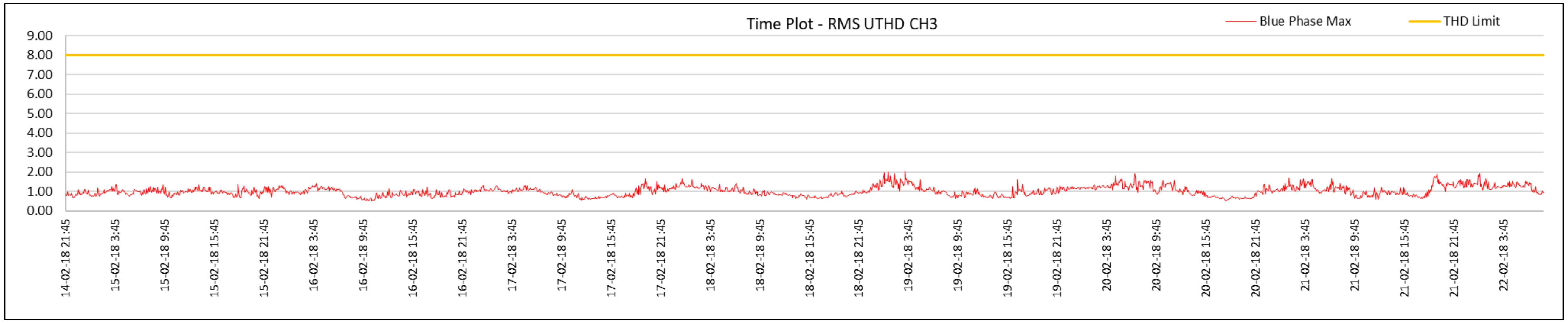

Figure 41 | TC1 - end of feeder – voltage THD measurements (Blue Phase)

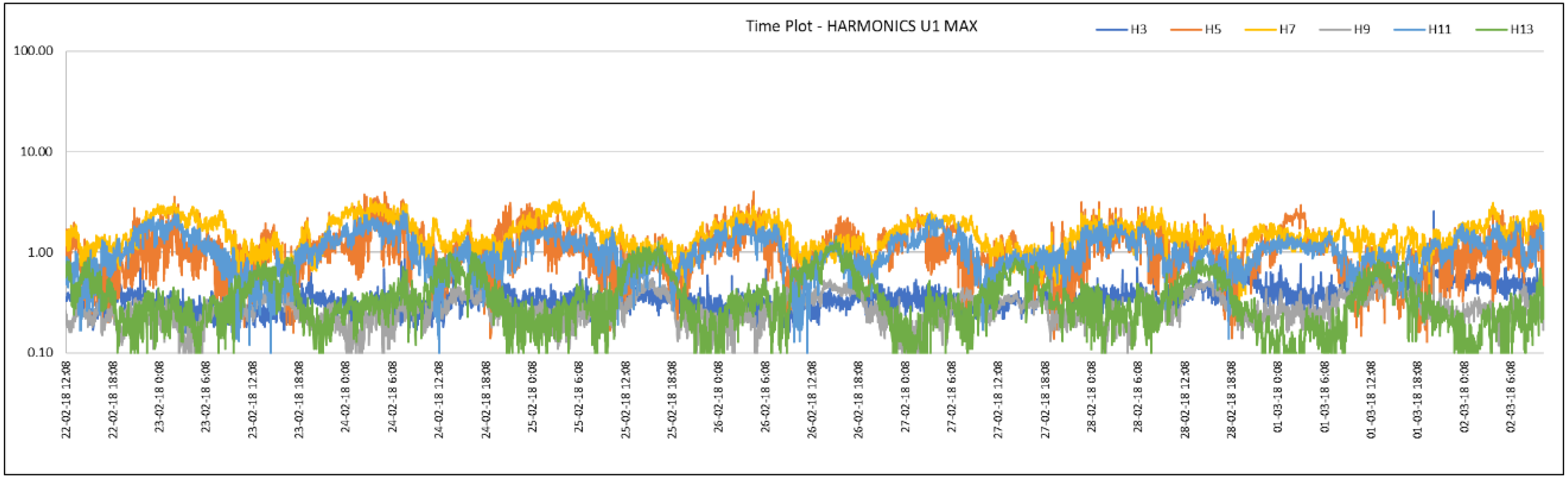

Figure 42 | TC1 – start of feeder – 3rd to 13th (odd) harmonics (Red Phase)

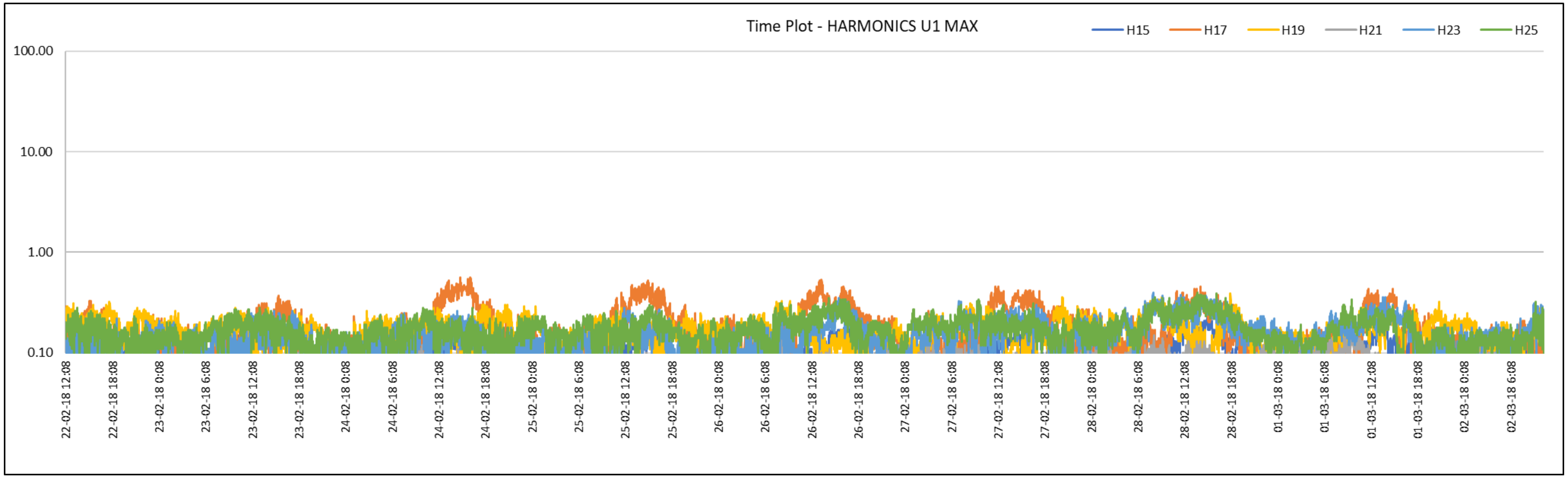

Figure 43 | TC1 – start of feeder – 15th to 25th (odd) harmonics (Red Phase)

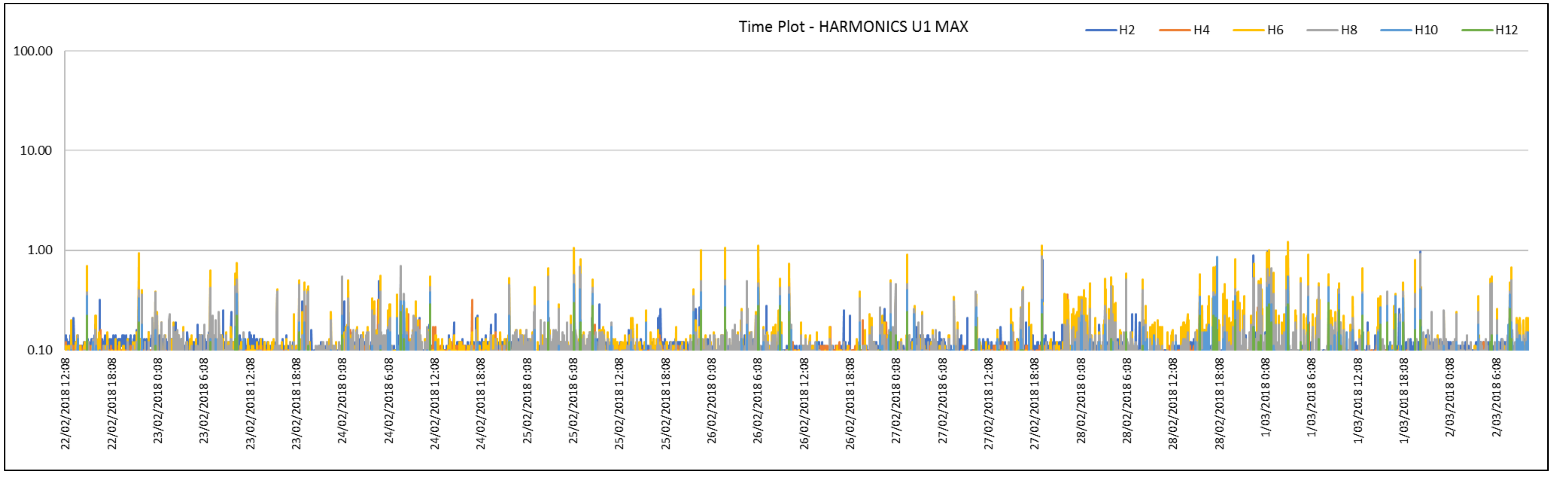

Figure 44 | TC1– start of feeder – 2th to 12th (even) harmonics (Red Phase)

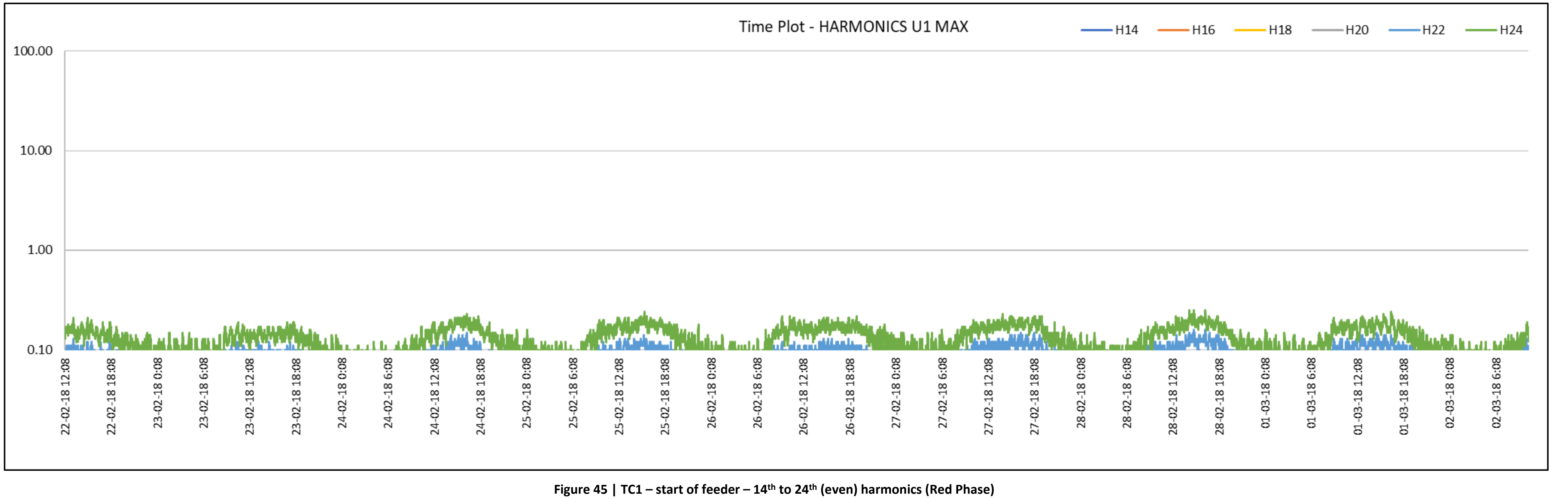

Figure 45 | TC1 – start of feeder – 14th to 24th (even) harmonics (Red Phase)

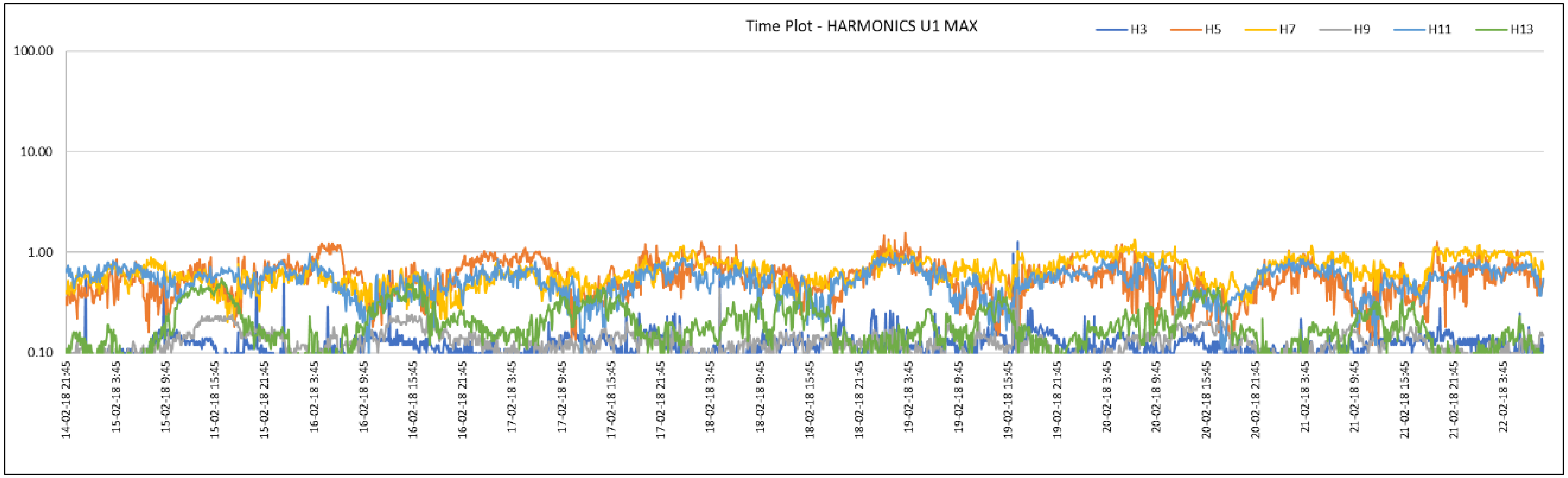

Figure 46 | TC1 – end of feeder – 3rd to 13th (odd) harmonics (Red Phase)

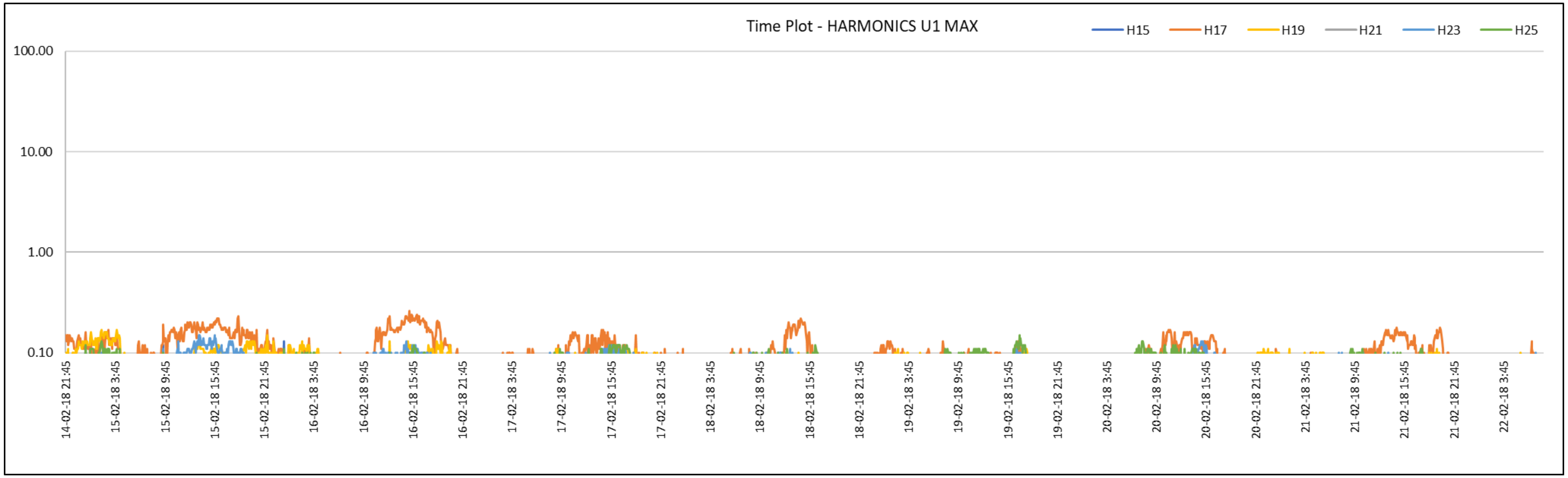

Figure 47 | TC1 – end of feeder – 15th to 25th (odd) harmonics (Red Phase)

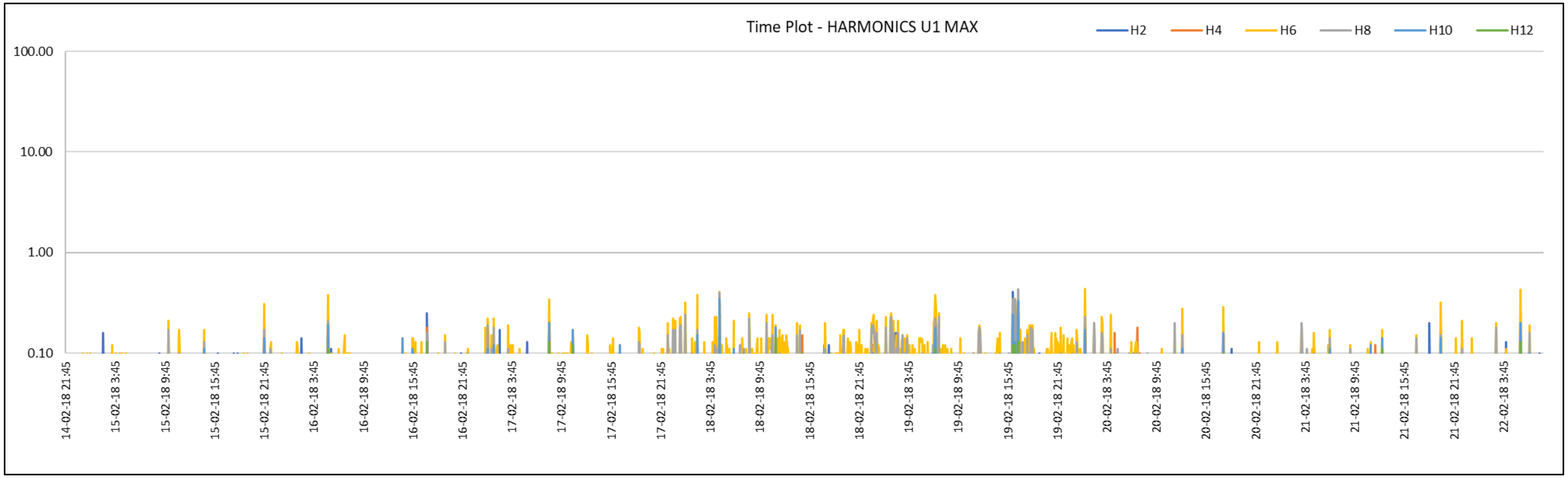

Figure 48 | TC1– end of feeder – 2th to 12th (even) harmonics (Red Phase)

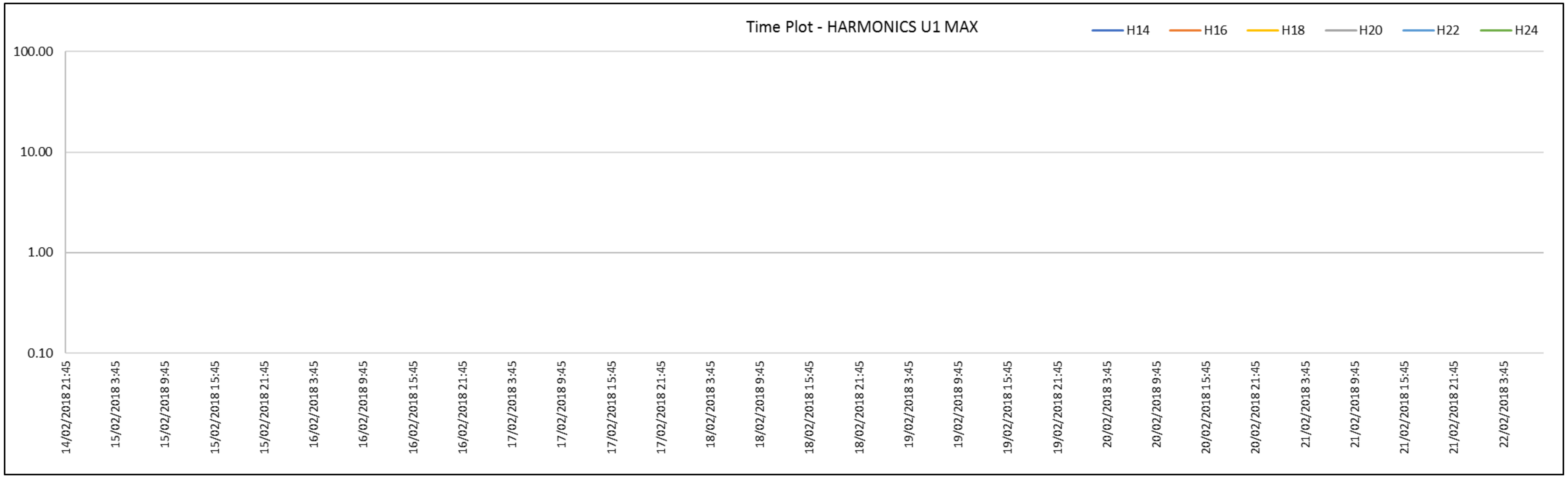

Figure 49 | TC1 – end of feeder – 14th to 24th (even) harmonics (Red Phase)

TC2 Feeder – Flicker, Voltage, Frequency, and Harmonics

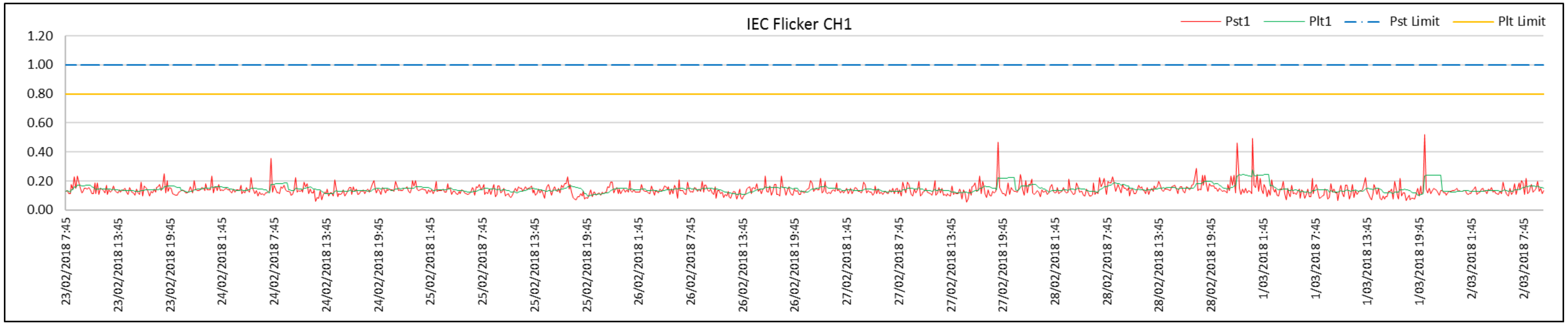

Figure 50 | TC2 - start of feeder – flicker measurements (Red Phase)

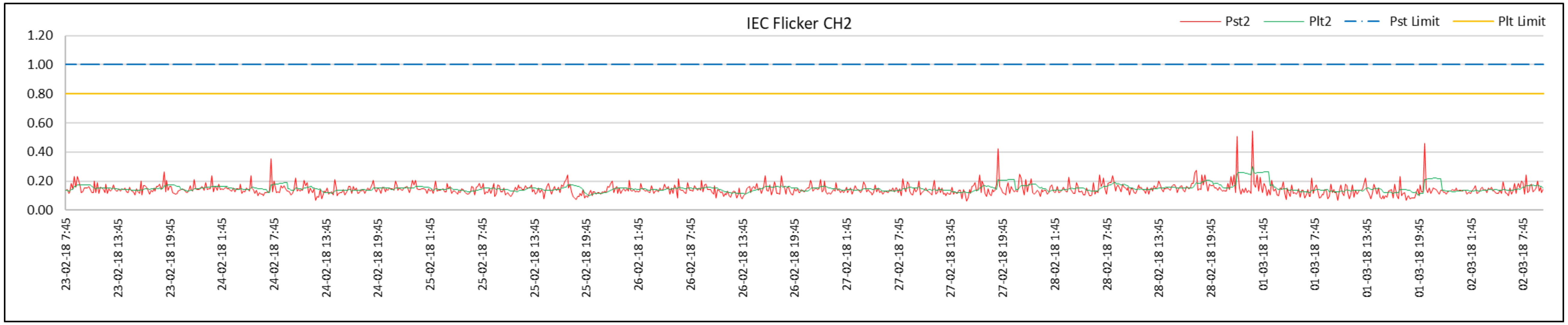

Figure 51 | TC2 - start of feeder – flicker measurements (White Phase)

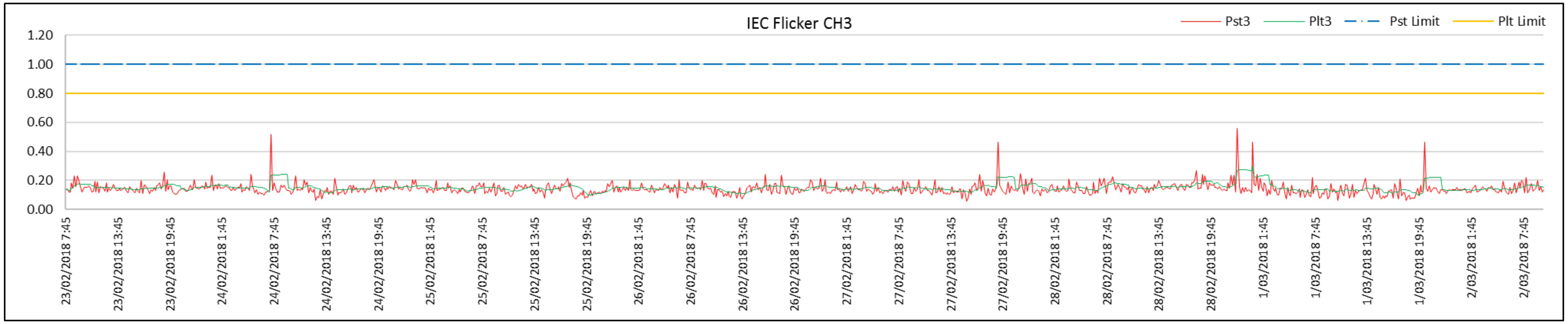

Figure 52 | TC2 - start of feeder – flicker measurements (Blue Phase)

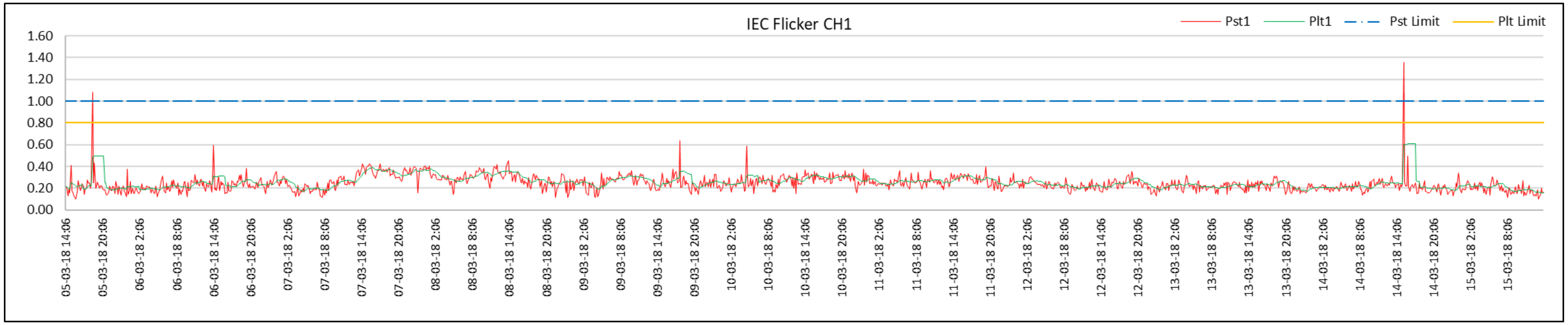

Figure 53 | TC2 – end of feeder – flicker measurements (Red Phase)

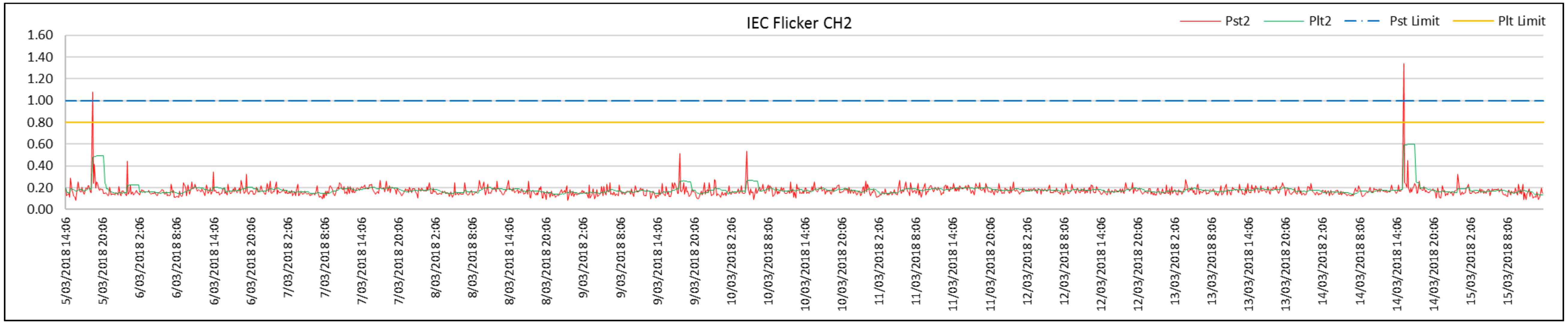

Figure 54 | TC2 - end of feeder – flicker measurements (White Phase)

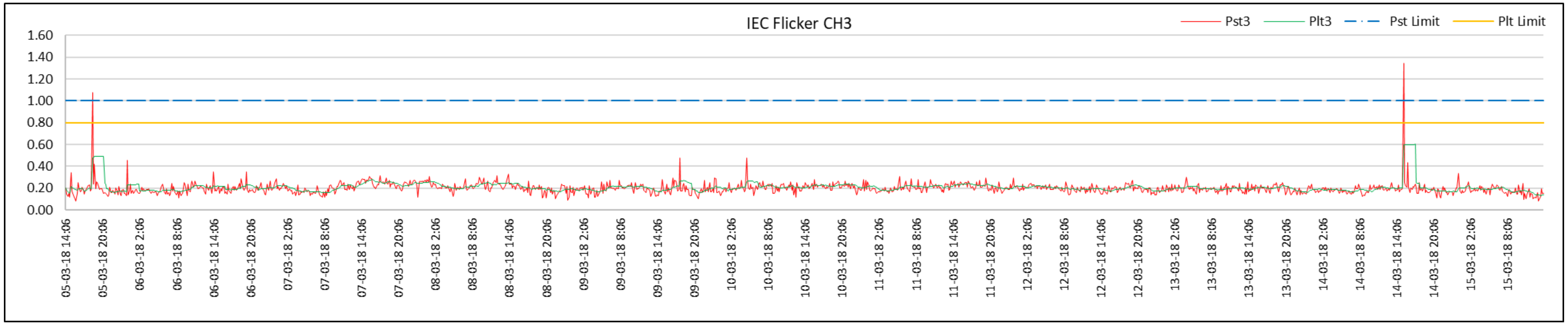

Figure 55 | TC2 - end of feeder – flicker measurements (Blue Phase)

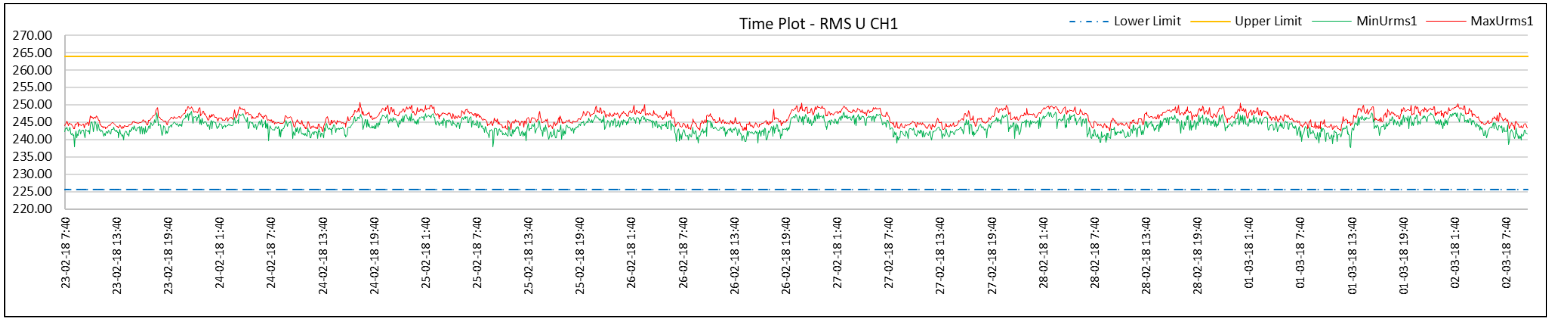

Figure 56 | TC2 - start of feeder – voltage measurements (Red Phase)

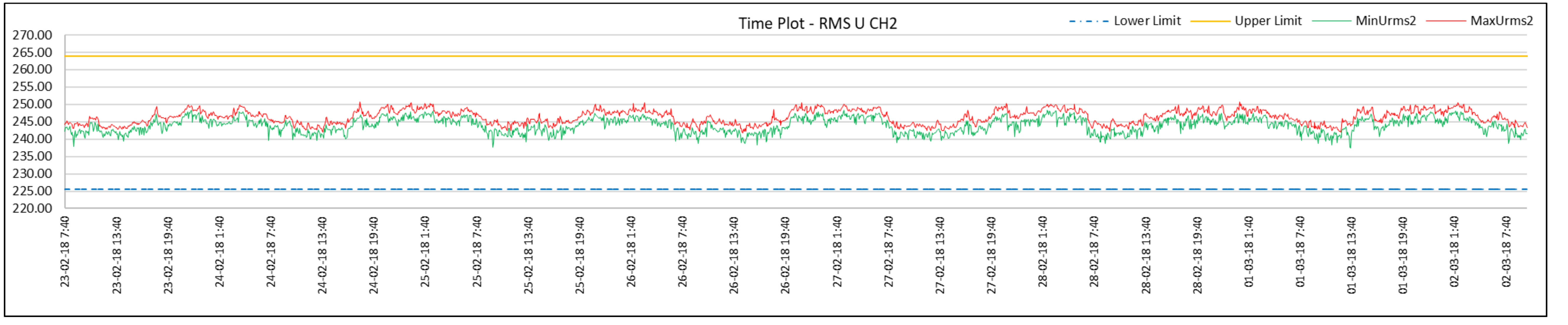

Figure 57 | TC2 - start of feeder – voltage measurements (White Phase)

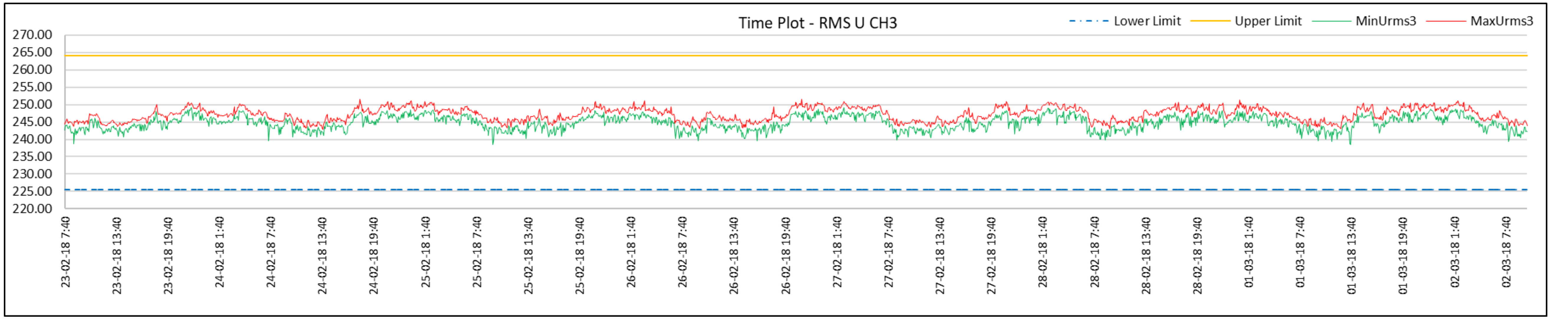

Figure 58 | TC2 - start of feeder – voltage measurements (Blue Phase)

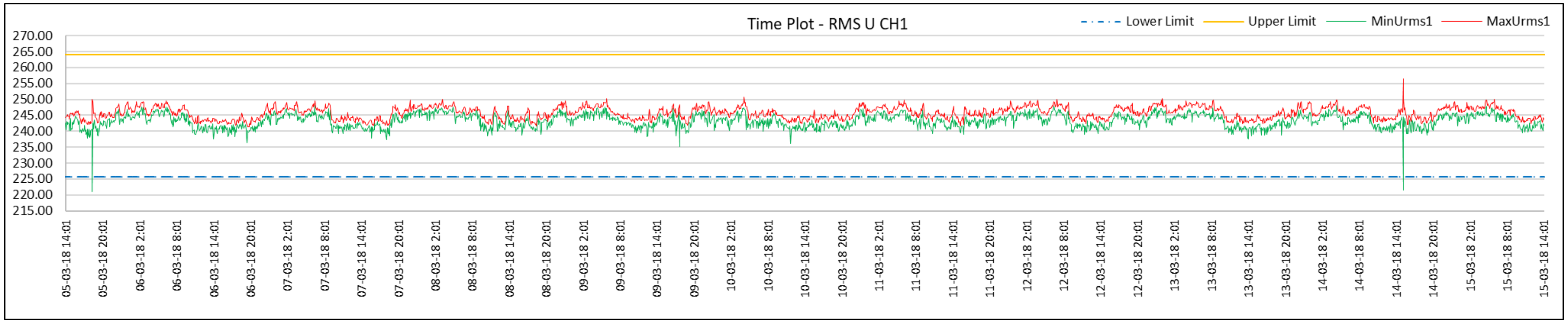

Figure 59 | TC2 - end of feeder – voltage measurements (Red Phase)

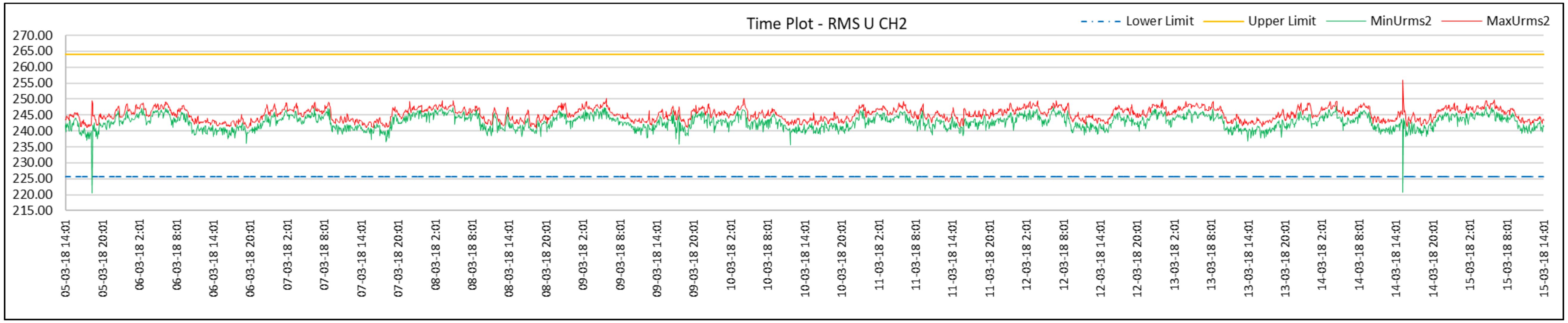

Figure 60 | TC2 - end of feeder – voltage measurements (White Phase)

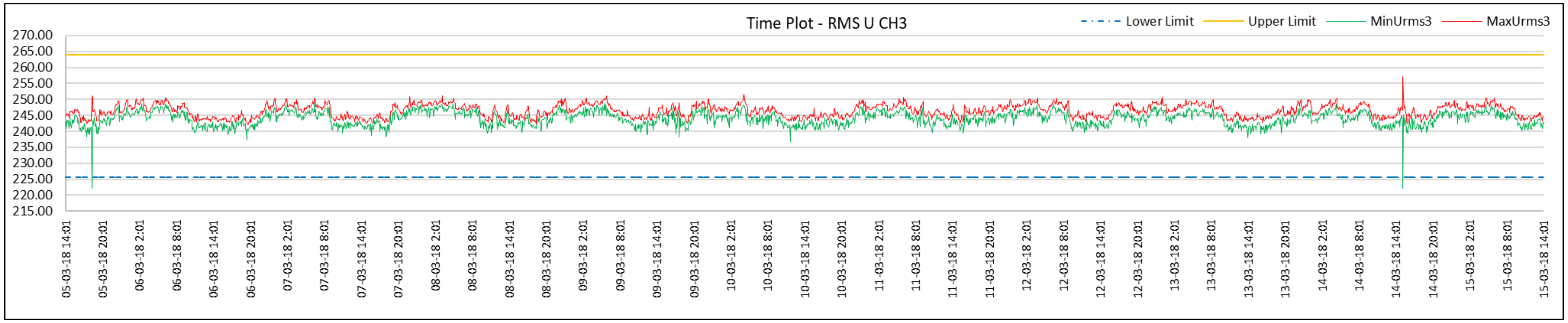

Figure 61 | TC2 - end of feeder – voltage measurements (Blue Phase)

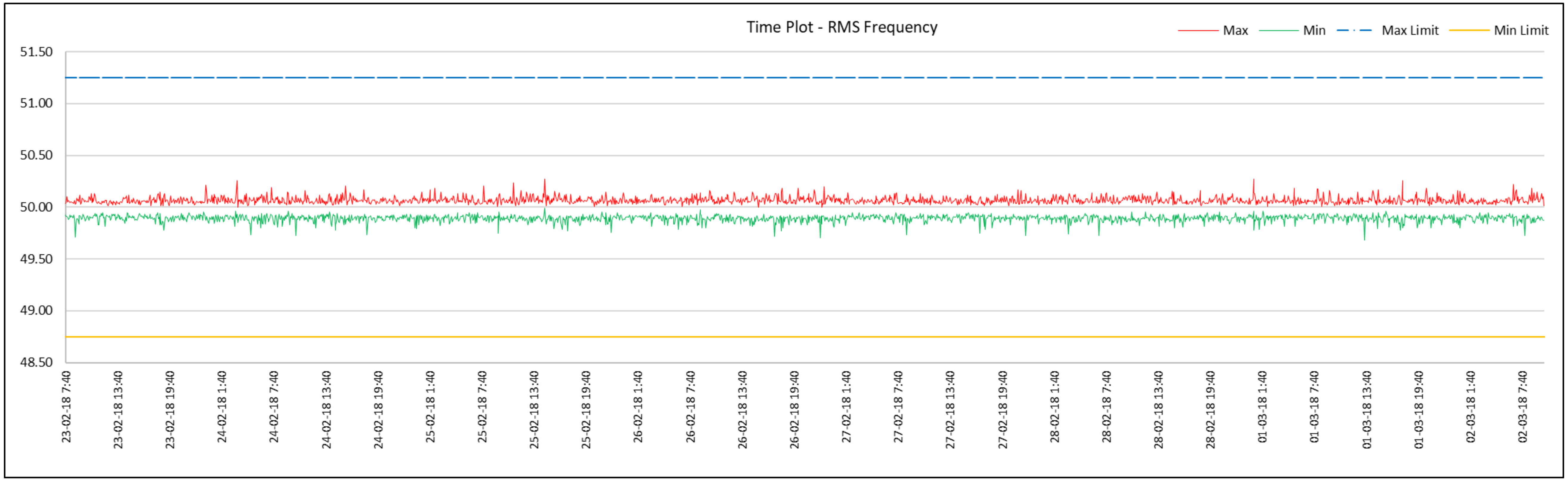

Figure 62 | TC2 - start of feeder – frequency measurements

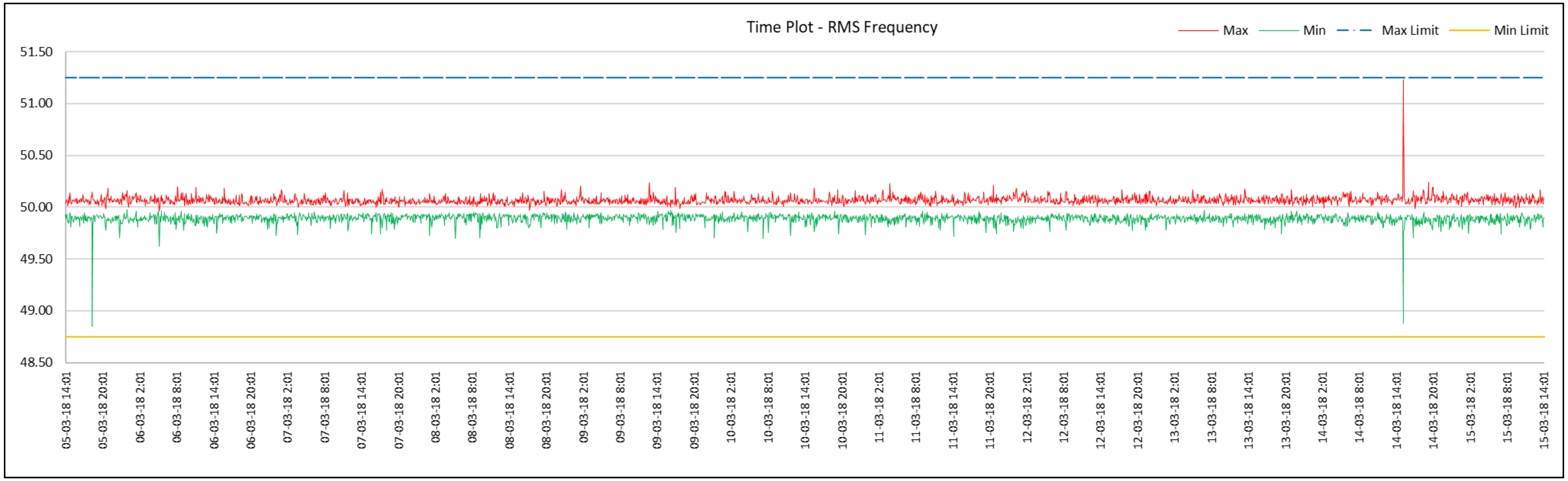

Figure 63 | TC2 - end of feeder – frequency measurements

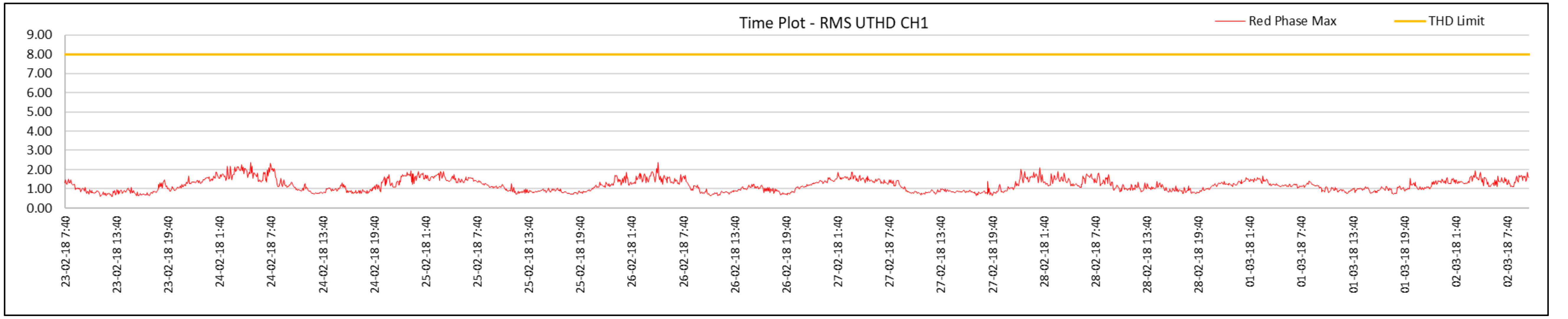

Figure 64 | TC2 - start of feeder – voltage THD measurements (Red Phase)

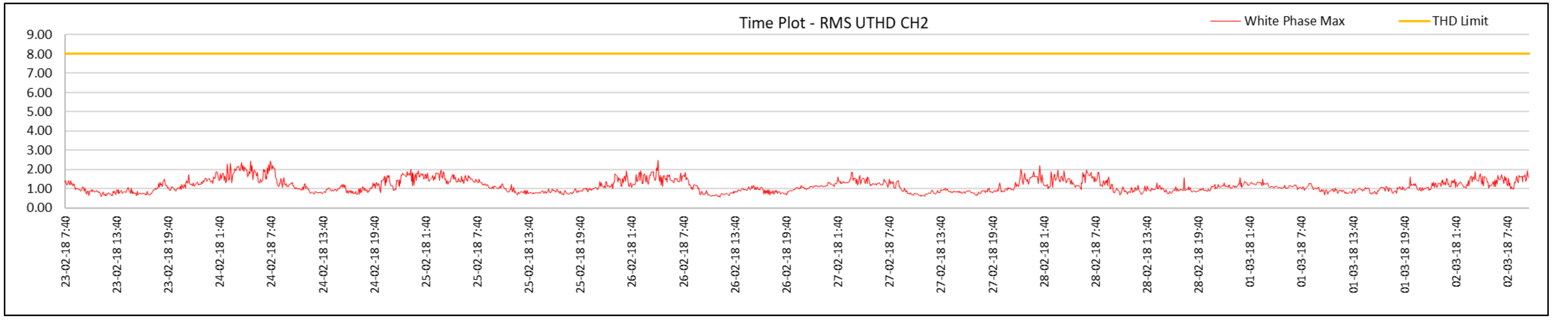

Figure 65 | TC2- start of feeder – voltage THD measurements (White Phase)

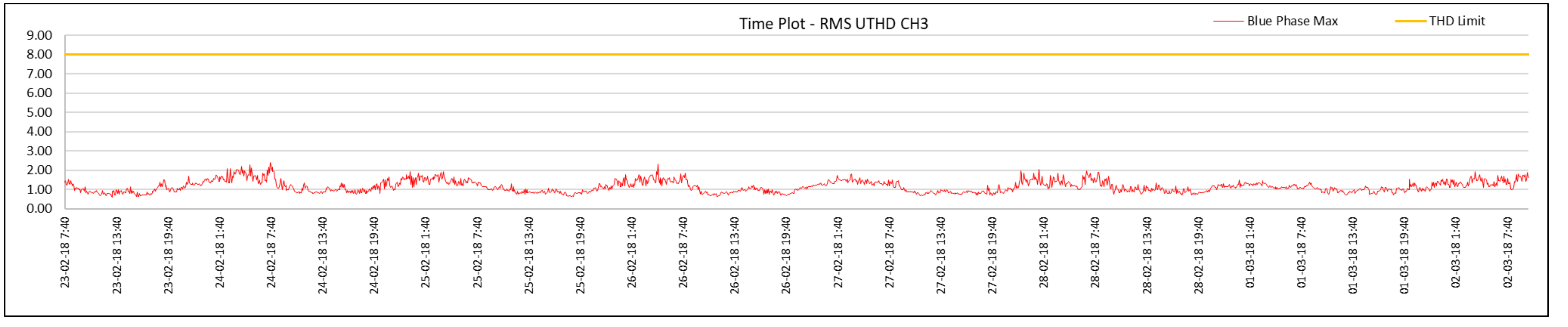

Figure 66 | TC2 - start of feeder – voltage THD measurements (Blue Phase)

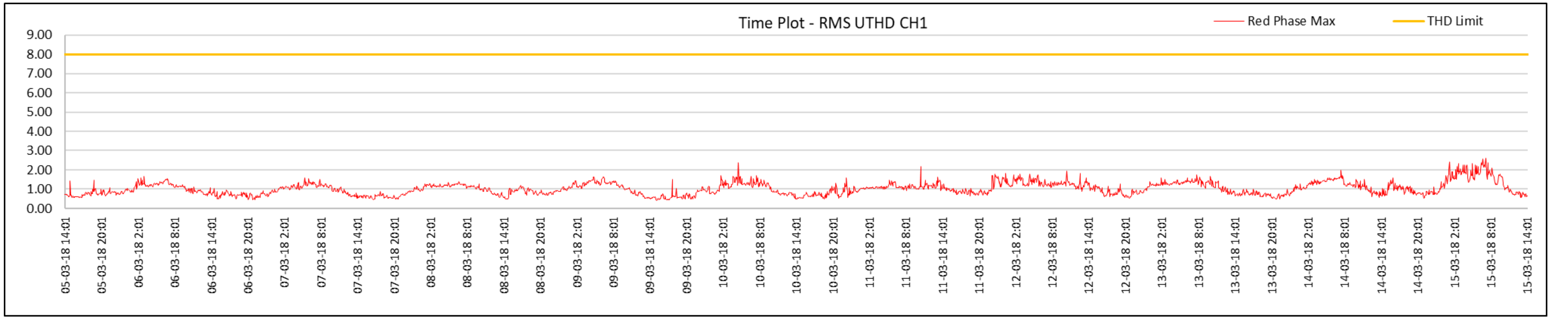

Figure 67 | TC2 - end of feeder – voltage THD measurements (Red Phase)

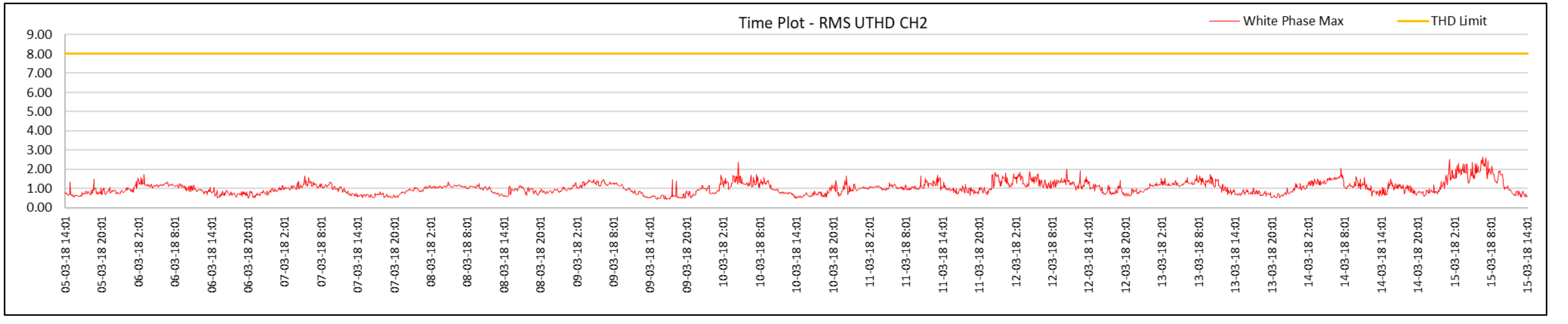

Figure 68 | TC2 - end of feeder – voltage THD measurements (White Phase)

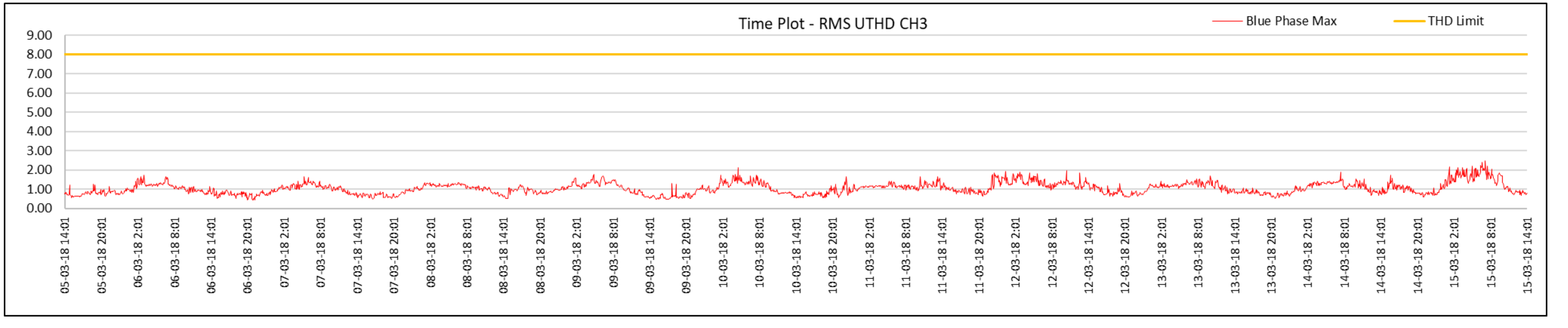

Figure 69 | TC2 - end of feeder – voltage THD measurements (Blue Phase)

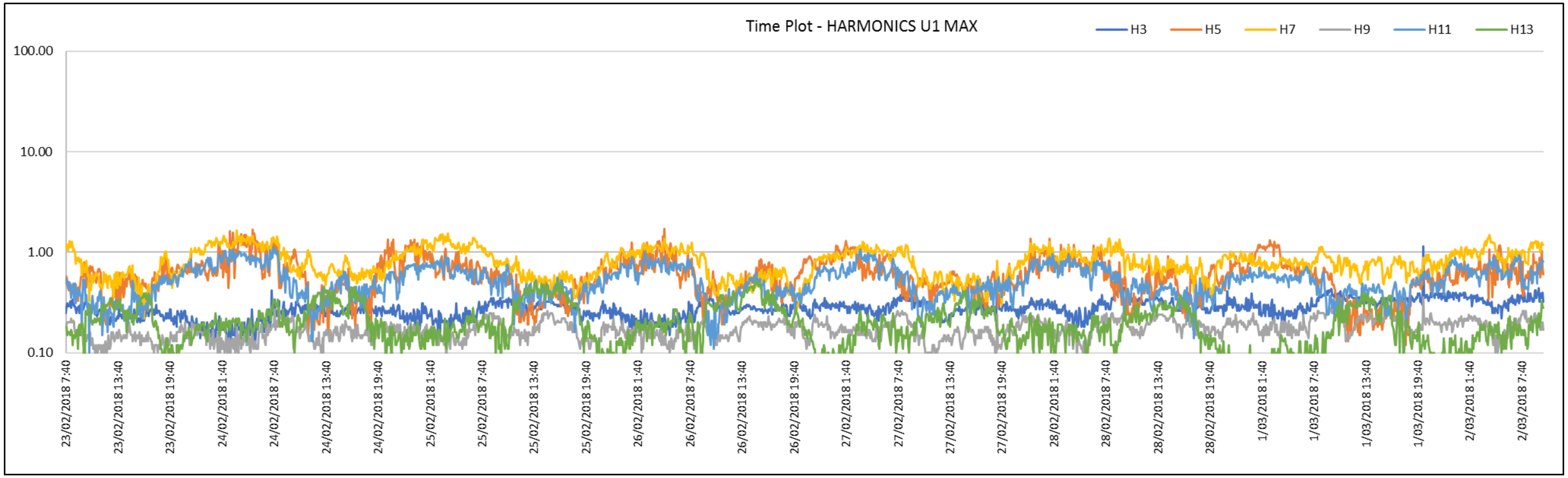

Figure 70 | TC2 – start of feeder – 3rd to 13th (odd) harmonics (Red Phase)

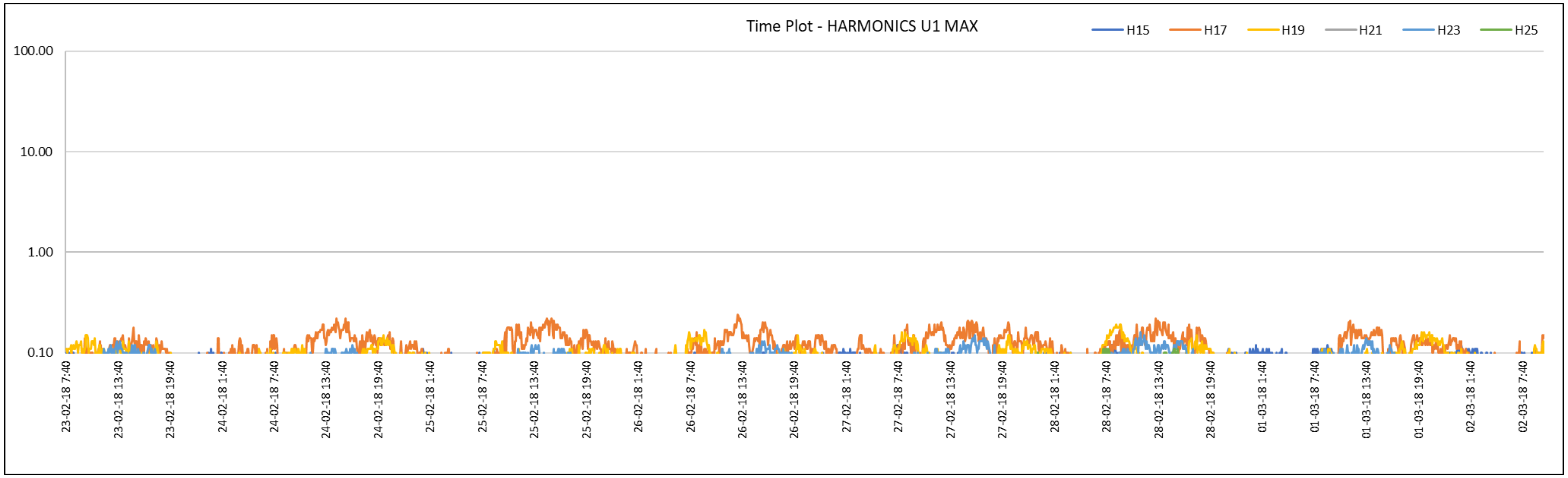

Figure 71 | TC2 – start of feeder – 15th to 25th (odd) harmonics (Red Phase)

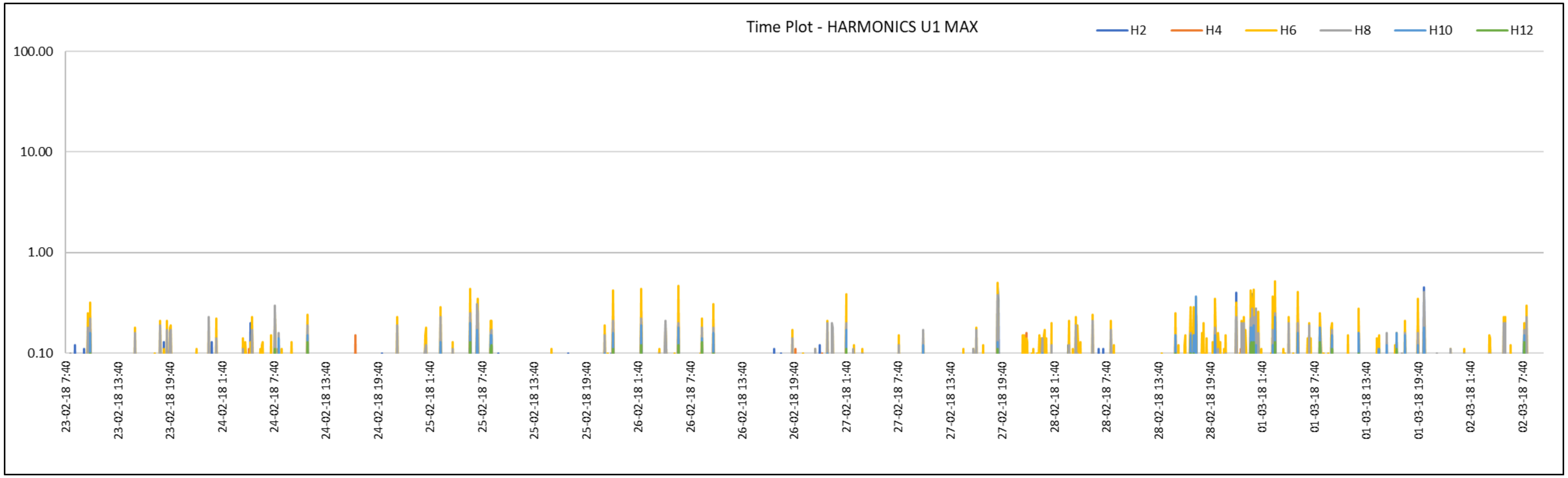

Figure 72 | TC2– start of feeder – 2th to 12th (even) harmonics (Red Phase)

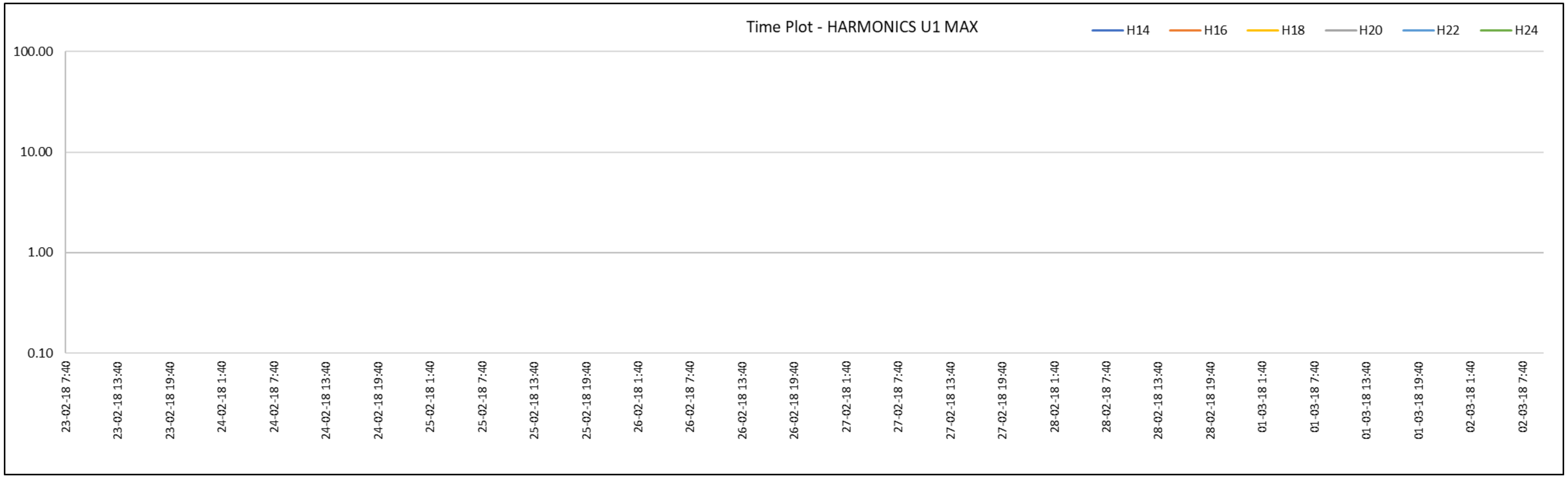

Figure 73 | TC2– start of feeder – 14th to 24th (even) harmonics (Red Phase)

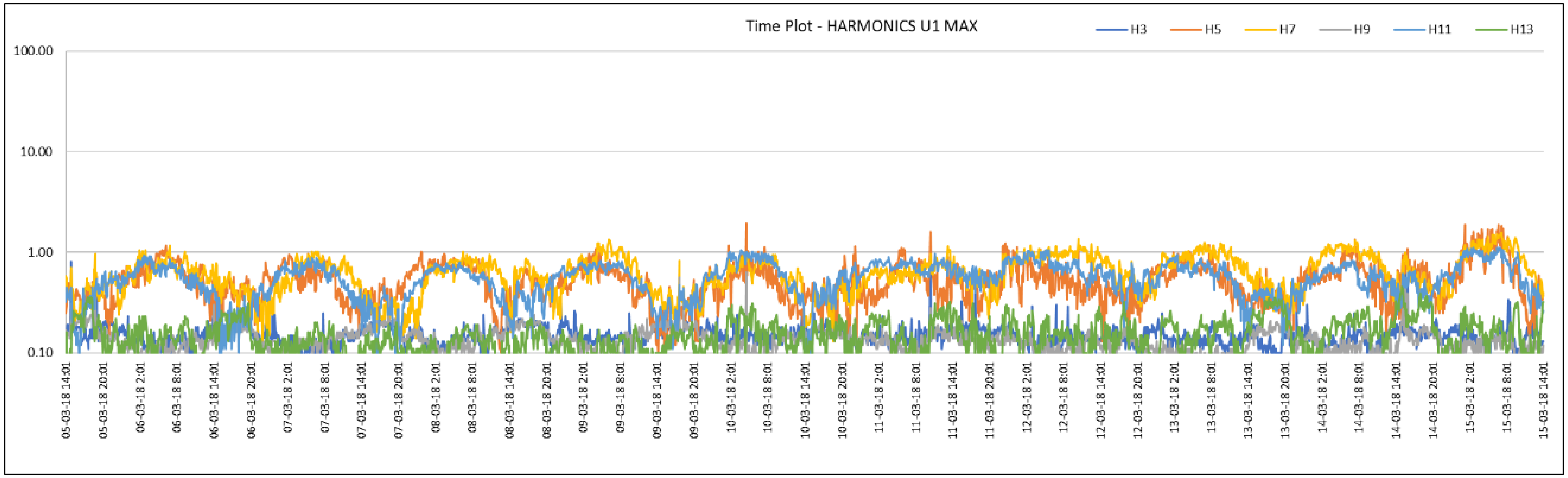

Figure 74 | TC2 – end of feeder – 3rd to 13th (odd) harmonics (Red Phase)

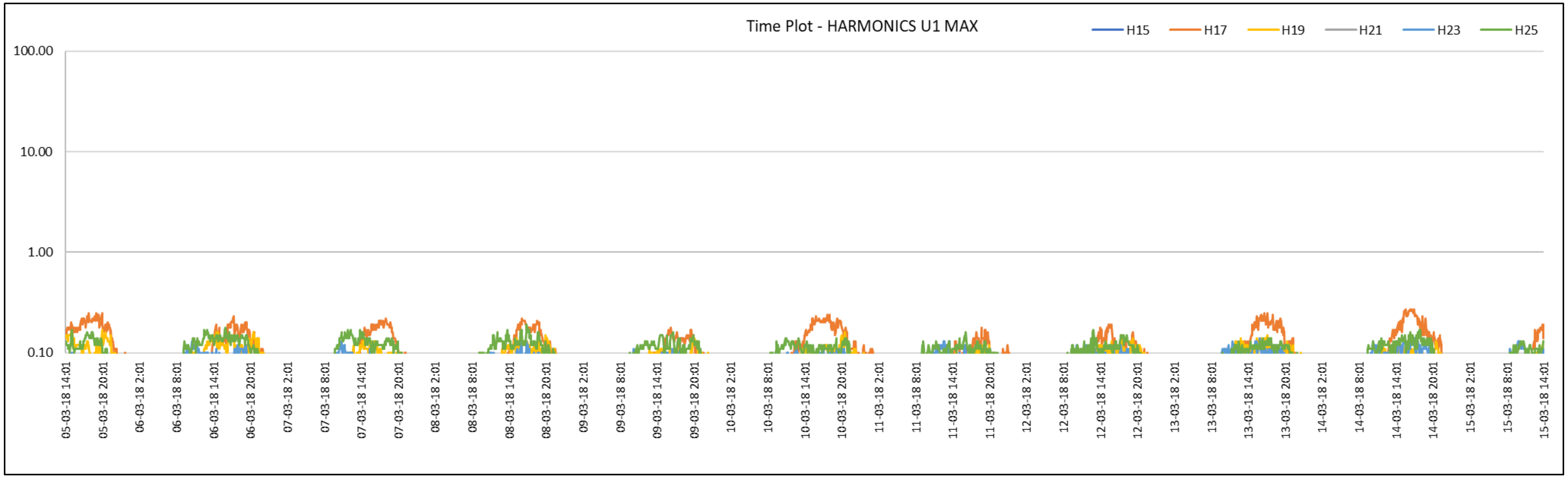

Figure 75 | TC2 – end of feeder – 15th to 25th (odd) harmonics (Red Phase)

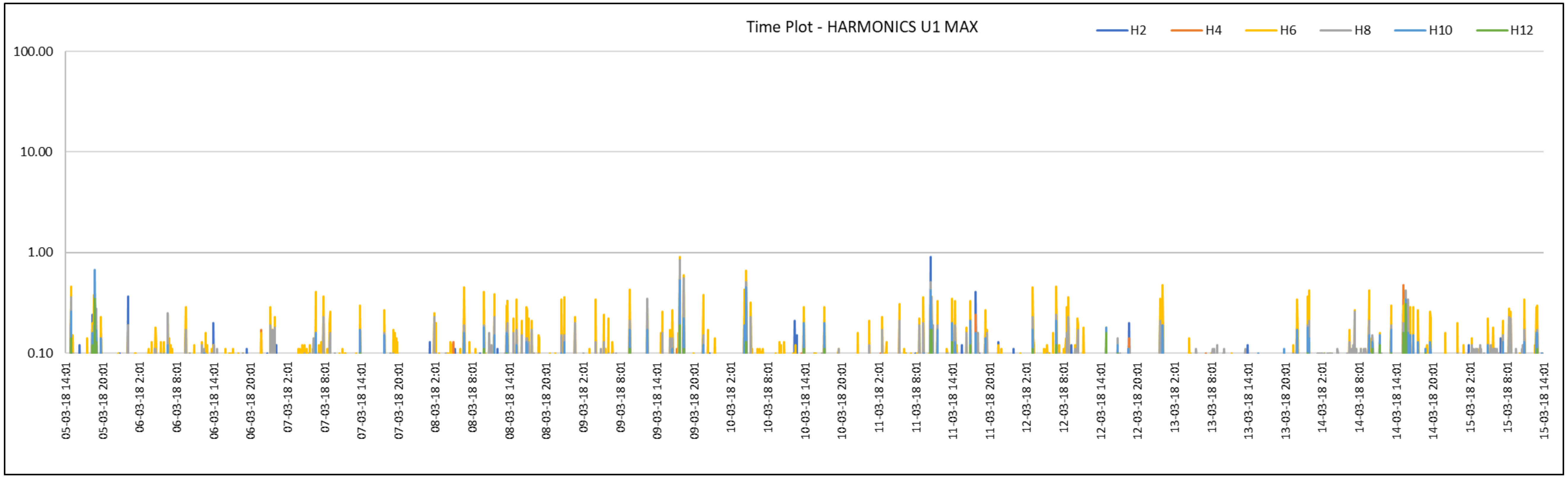

Figure 76 | TC2– end of feeder – 2th to 12th (even) harmonics (Red Phase)

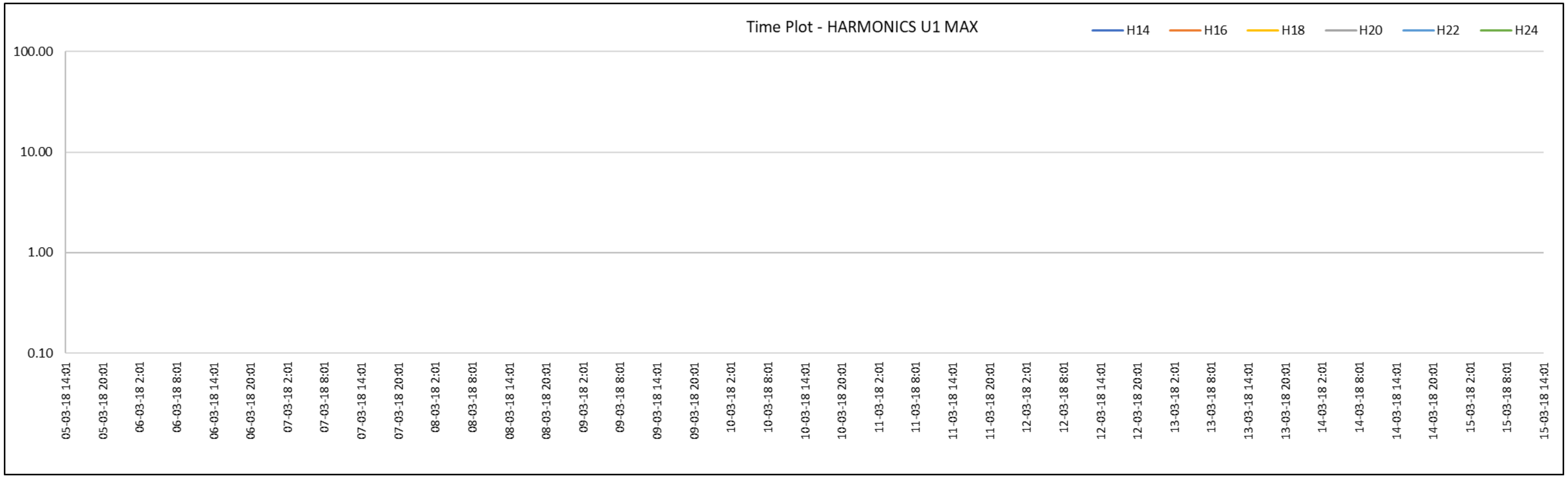

Figure 77 | TC2 – end of feeder – 14th to 24th (even) harmonics (Red Phase)

TC3 Feeder – Flicker, Voltage, Frequency, and Harmonics

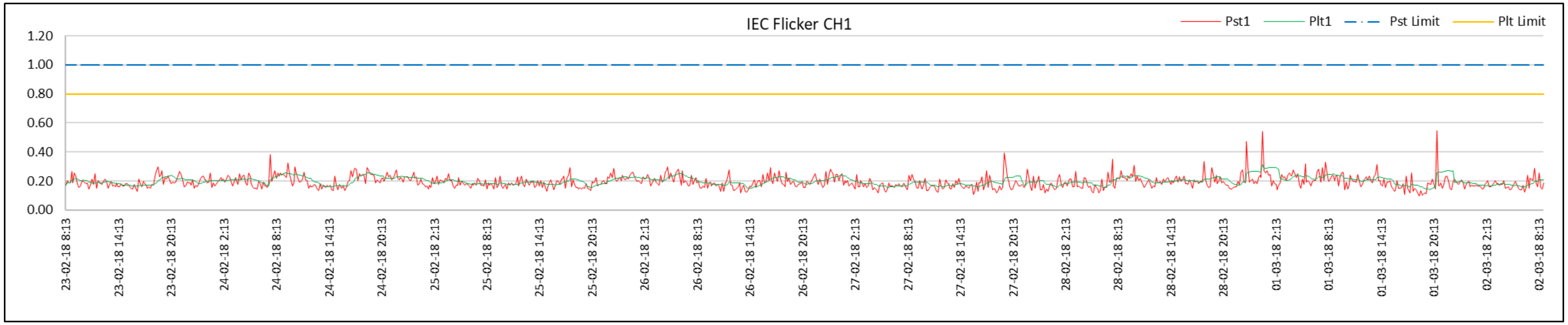

Figure 78 | TC3 - start of feeder – flicker measurements (Red Phase)

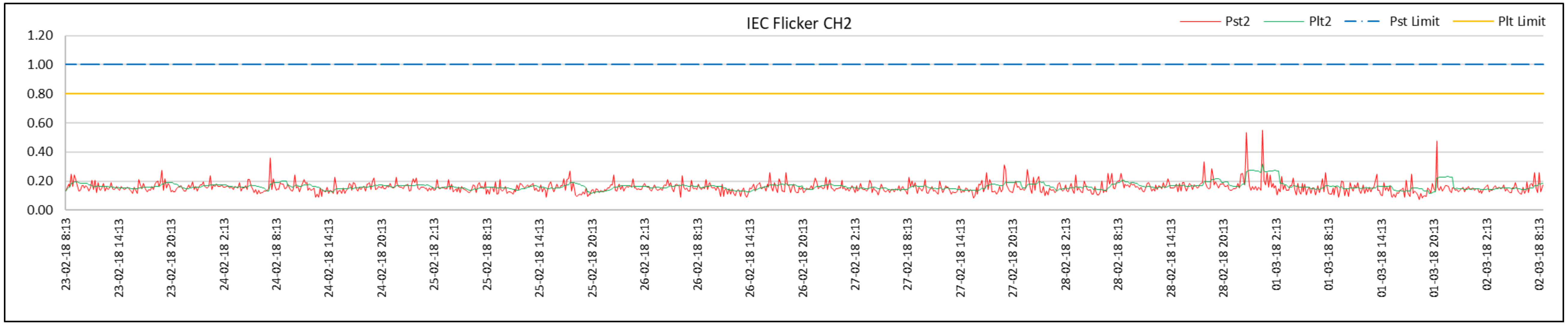

Figure 79 | TC3 - start of feeder – flicker measurements (White Phase)

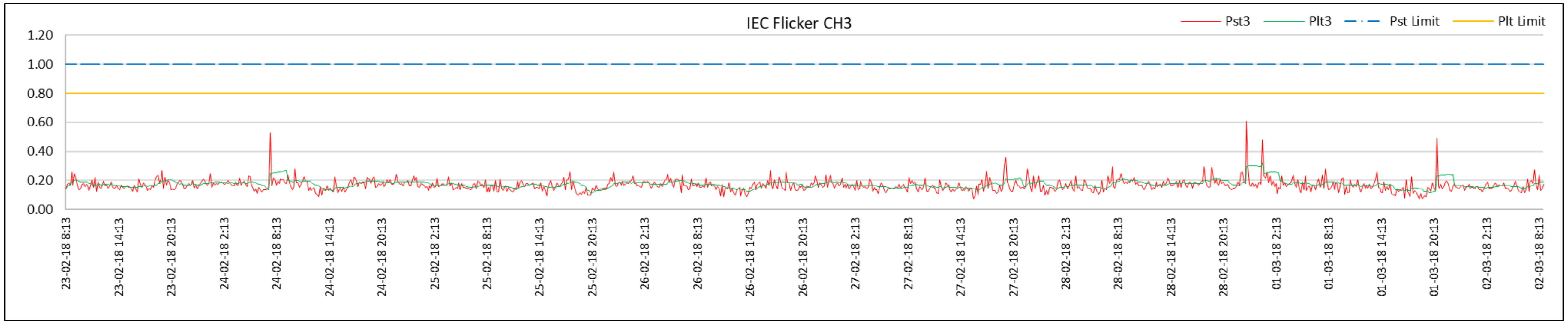

Figure 80 | TC3 - start of feeder – flicker measurements (Blue Phase)

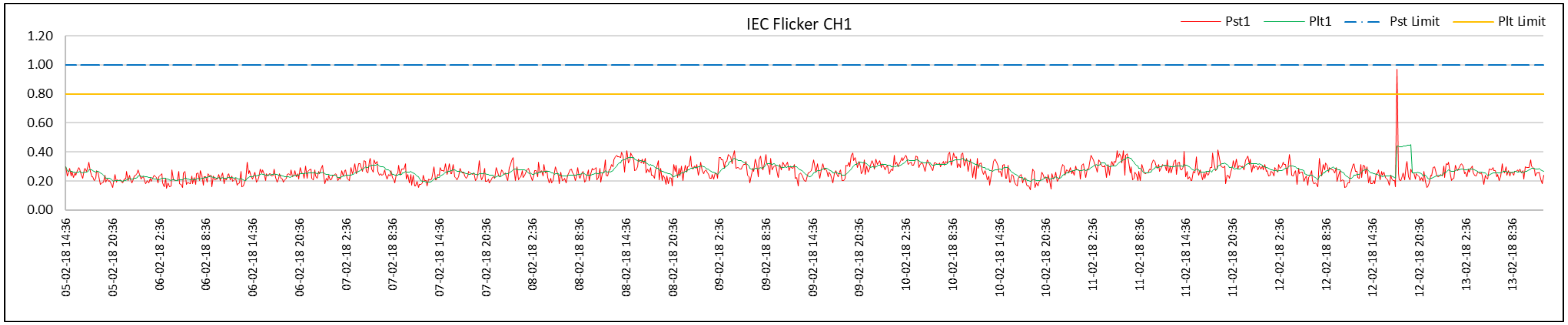

Figure 81 | TC3 – end of feeder – flicker measurements (Red Phase)

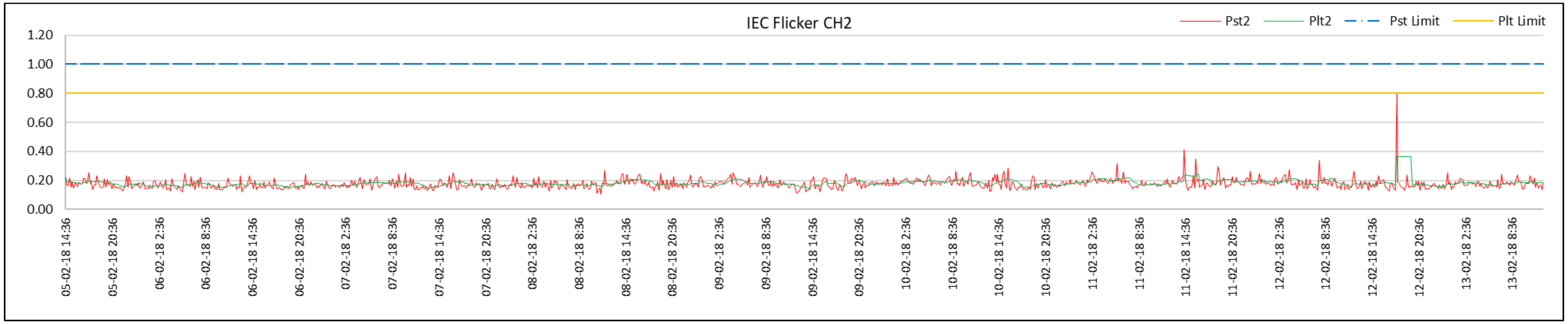

Figure 82 | TC3 - end of feeder – flicker measurements (White Phase)

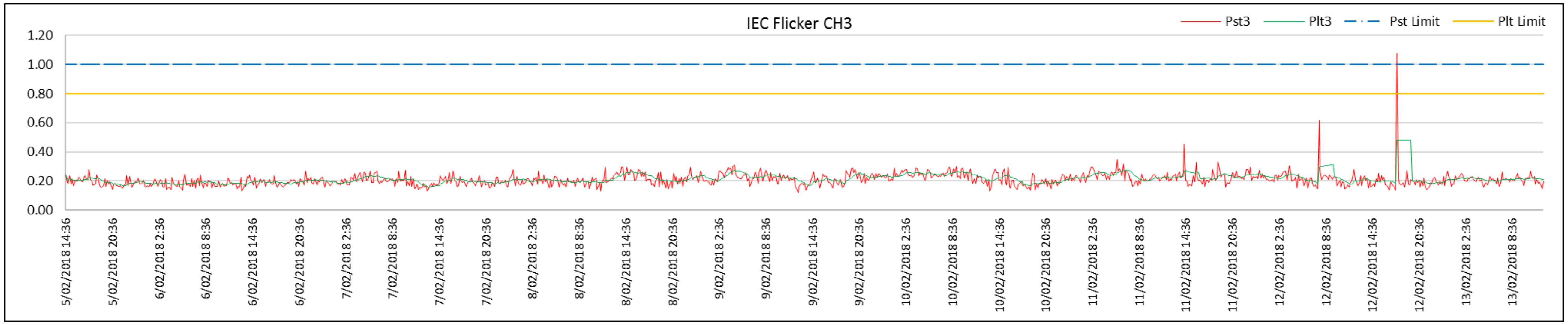

Figure 83 | TC3 - end of feeder – flicker measurements (Blue Phase)

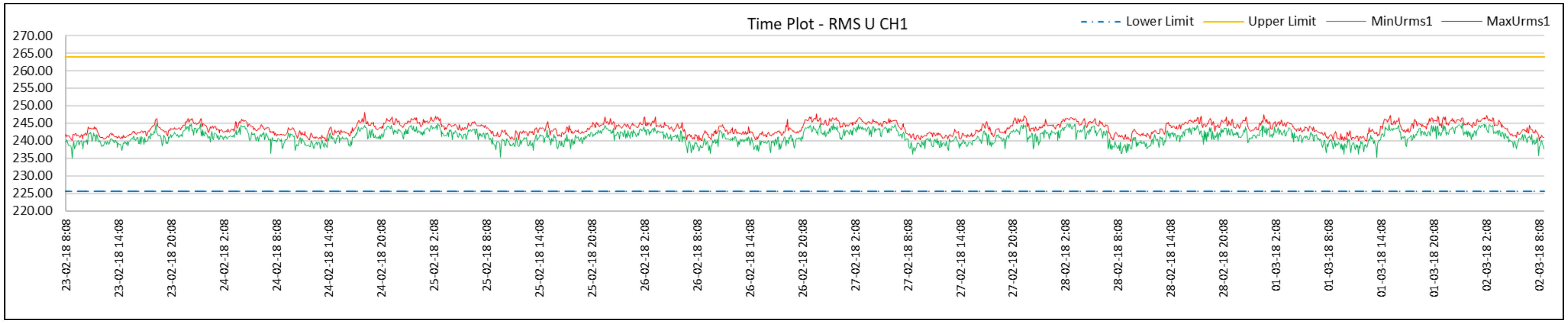

Figure 84 | TC3 - start of feeder – voltage measurements (Red Phase)

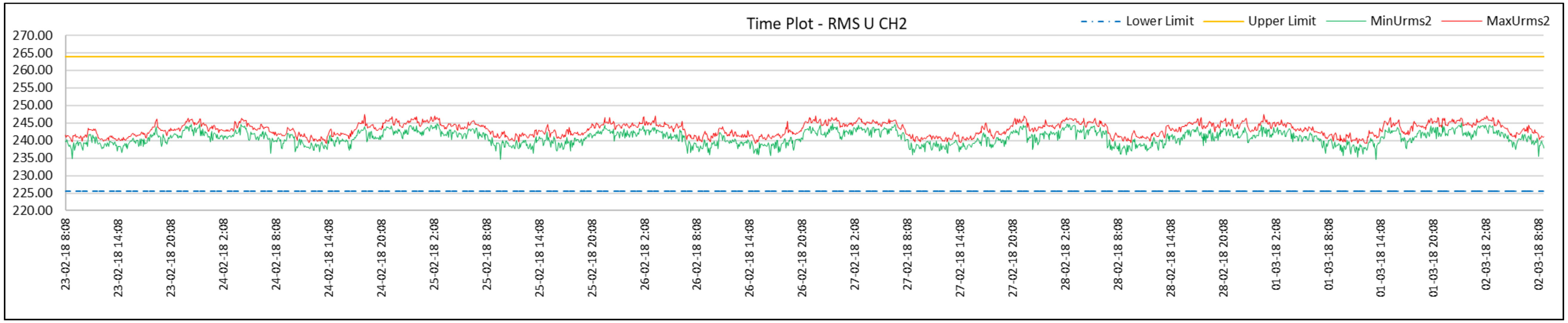

Figure 85 | TC3 - start of feeder – voltage measurements (White Phase)

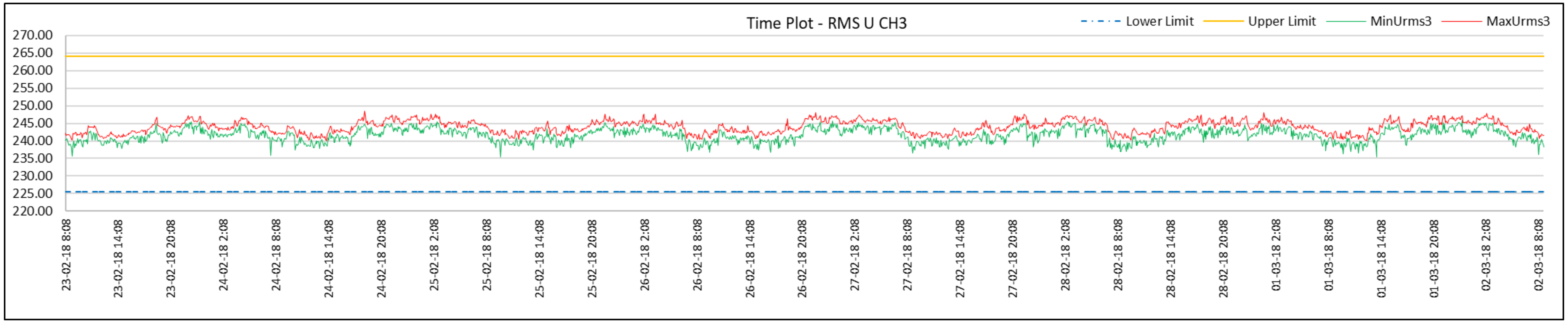

Figure 86 | TC3 - start of feeder – voltage measurements (Blue Phase)

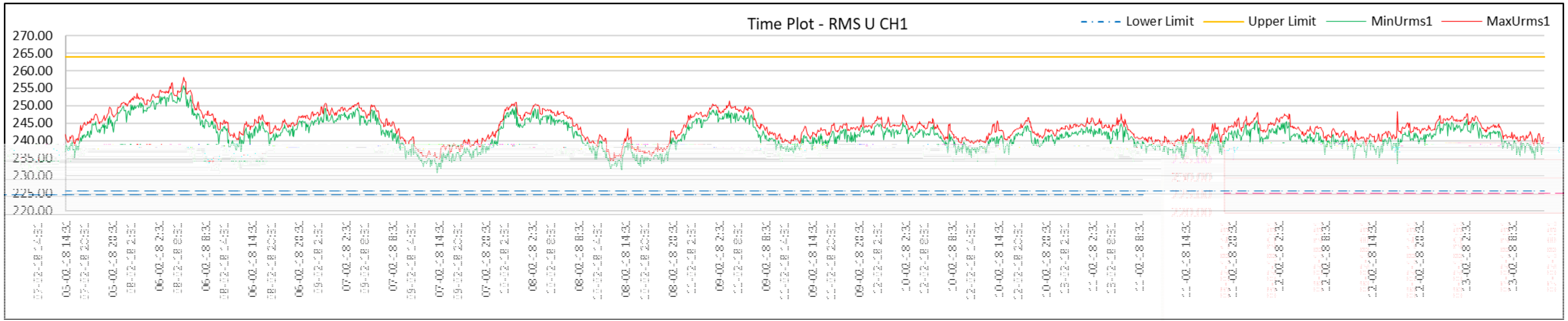

Figure 87 | TC3 - end of feeder – voltage measurements (Red Phase)

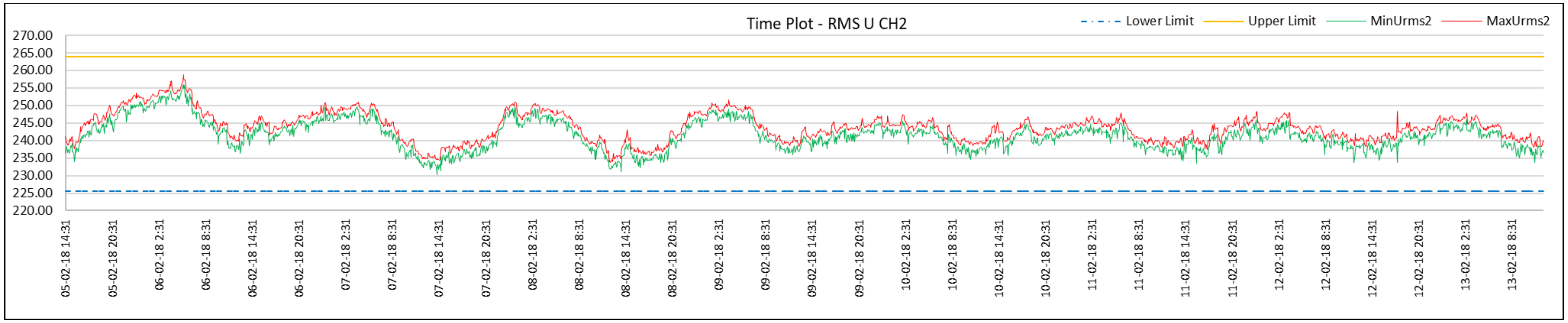

Figure 88 | TC3 - end of feeder – voltage measurements (White Phase)

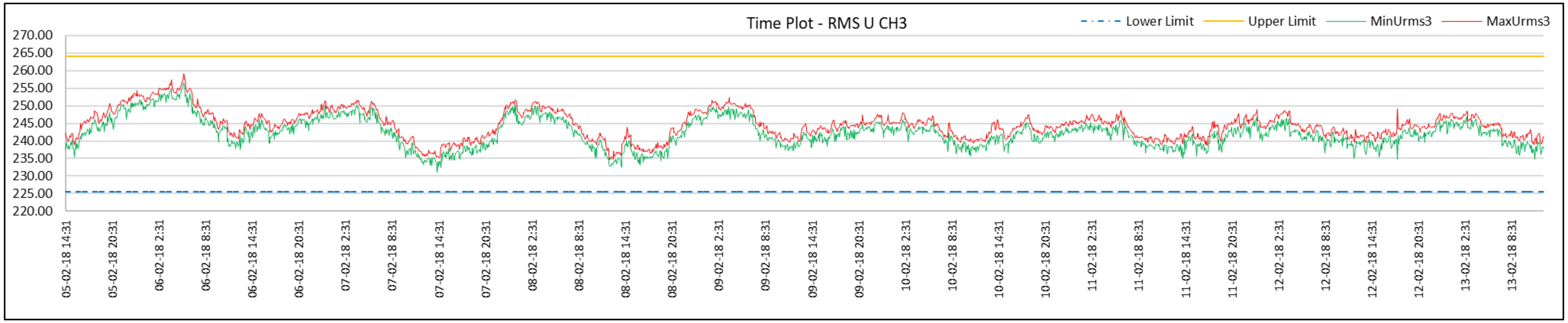

Figure 89 | TC3 - end of feeder – voltage measurements (Blue Phase)

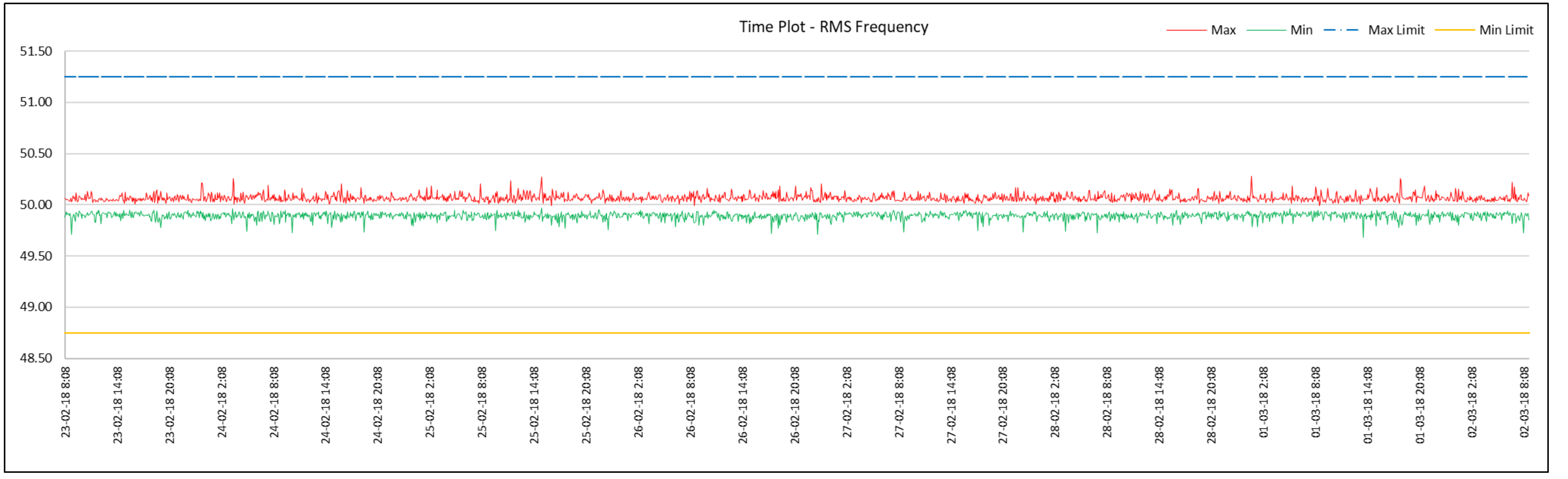

Figure 90 | TC3 - start of feeder – frequency measurements

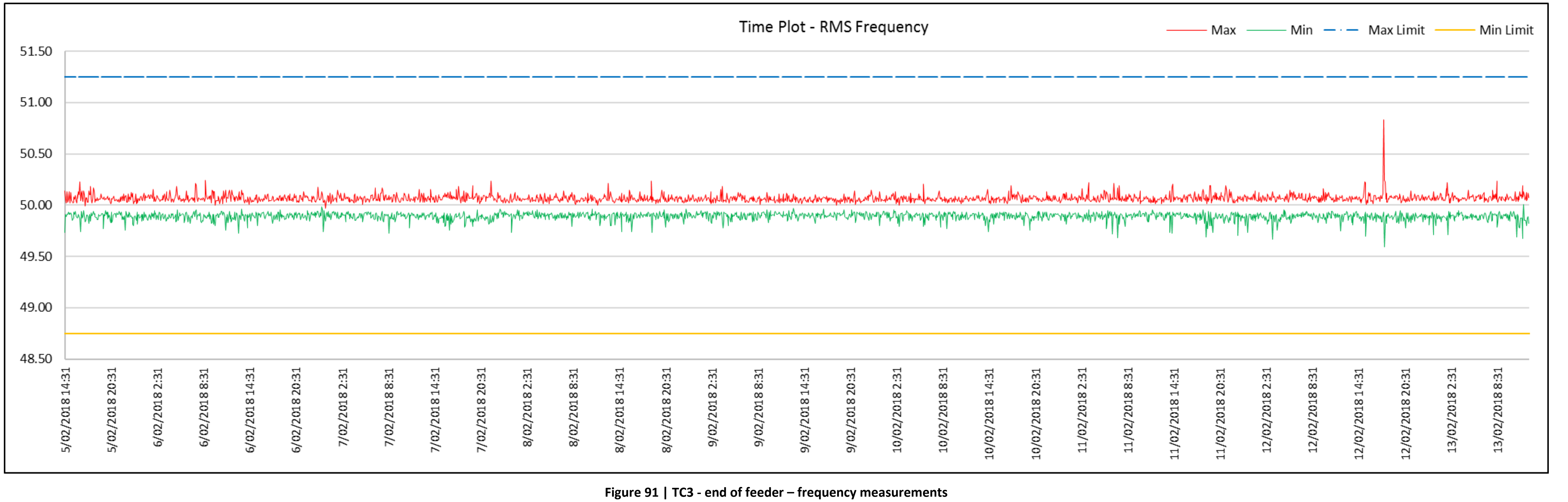

Figure 91 | TC3 - end of feeder – frequency measurements

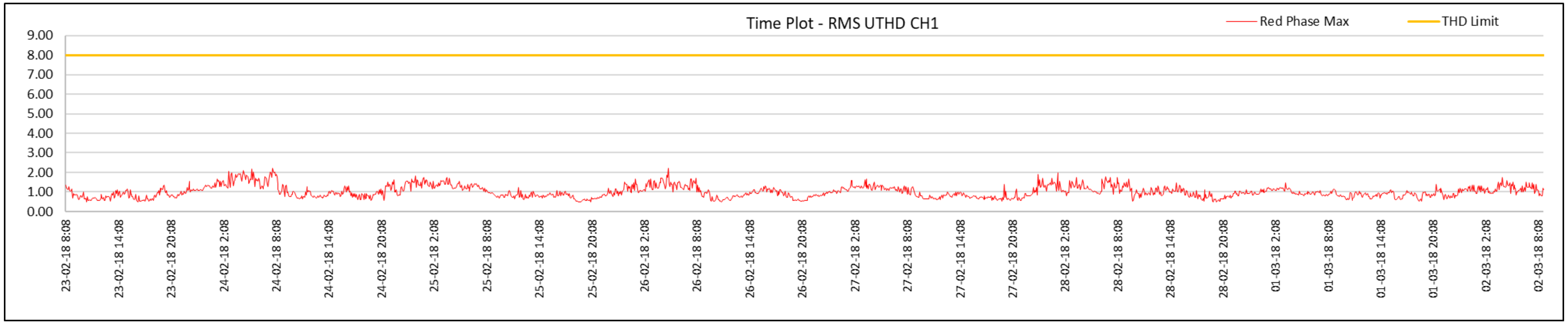

Figure 92 | TC3 - start of feeder – voltage THD measurements (Red Phase)

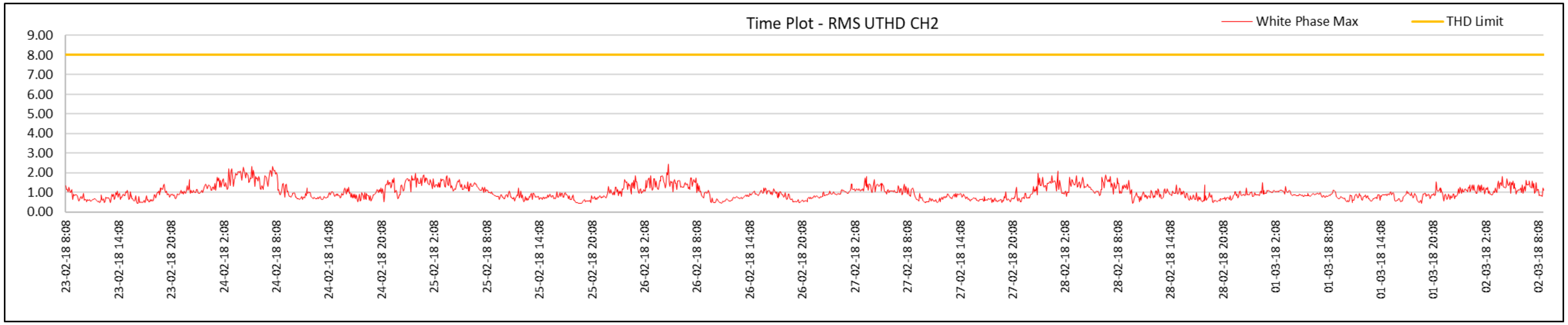

Figure 93 | TC3- start of feeder – voltage THD measurements (White Phase)

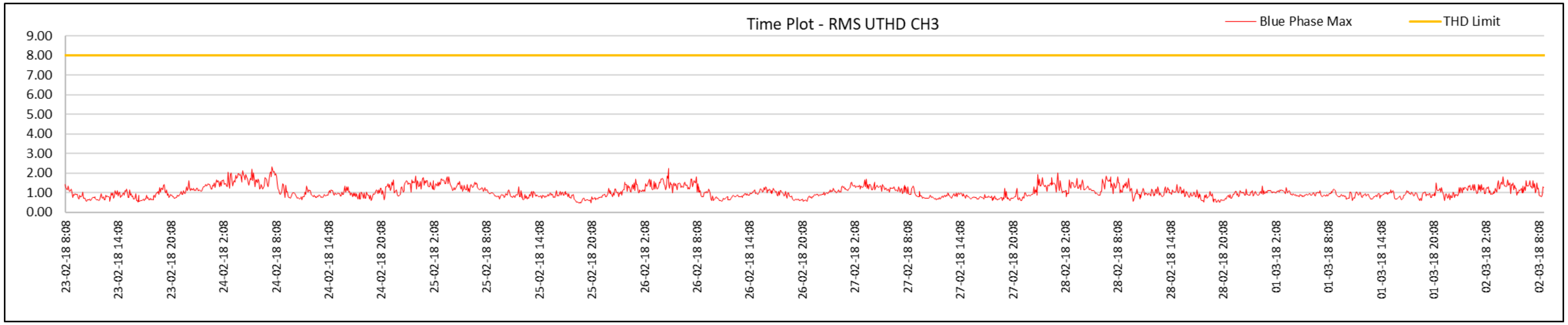

Figure 94 | TC3- start of feeder – voltage THD measurements (Blue Phase)

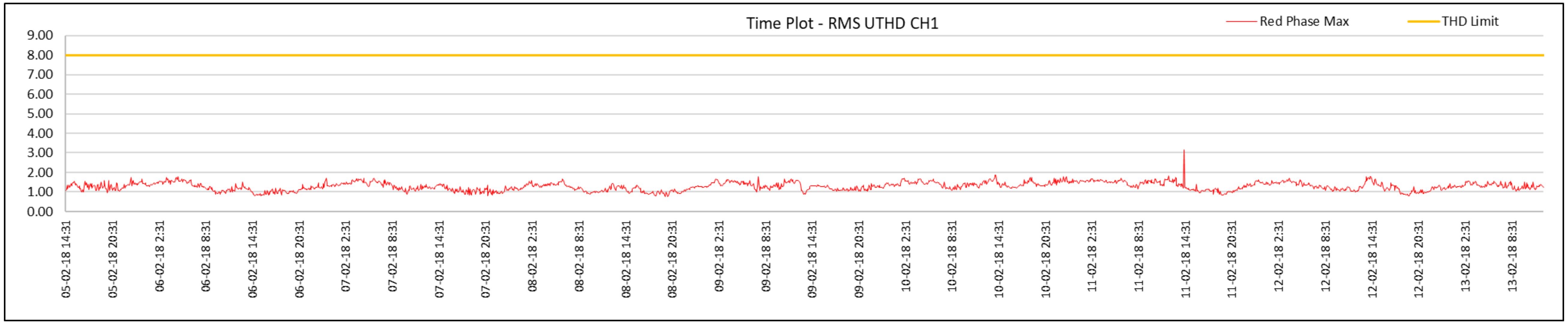

Figure 95 | TC3 - end of feeder – voltage THD measurements (Red Phase)

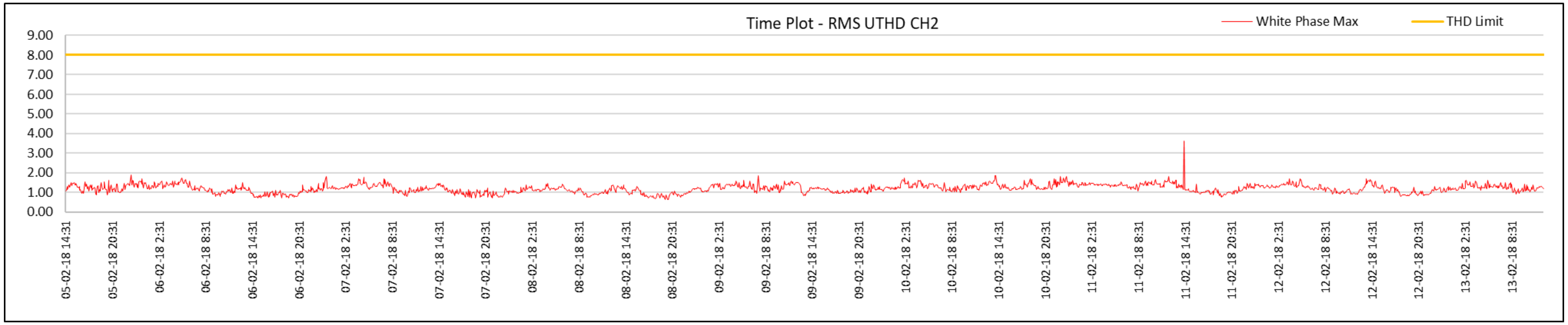

Figure 96 | TC3 - end of feeder – voltage THD measurements (White Phase)

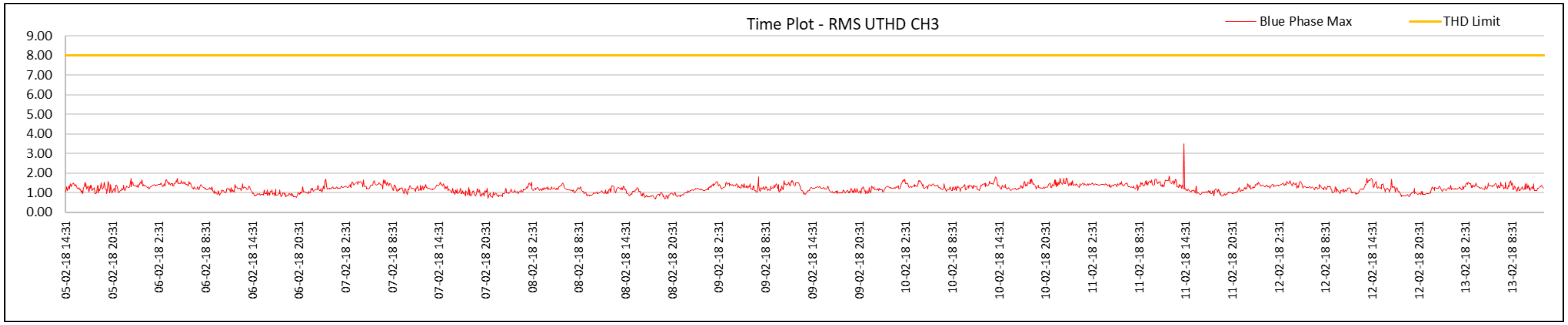

Figure 97 | TC3 - end of feeder – voltage THD measurements (Blue Phase)

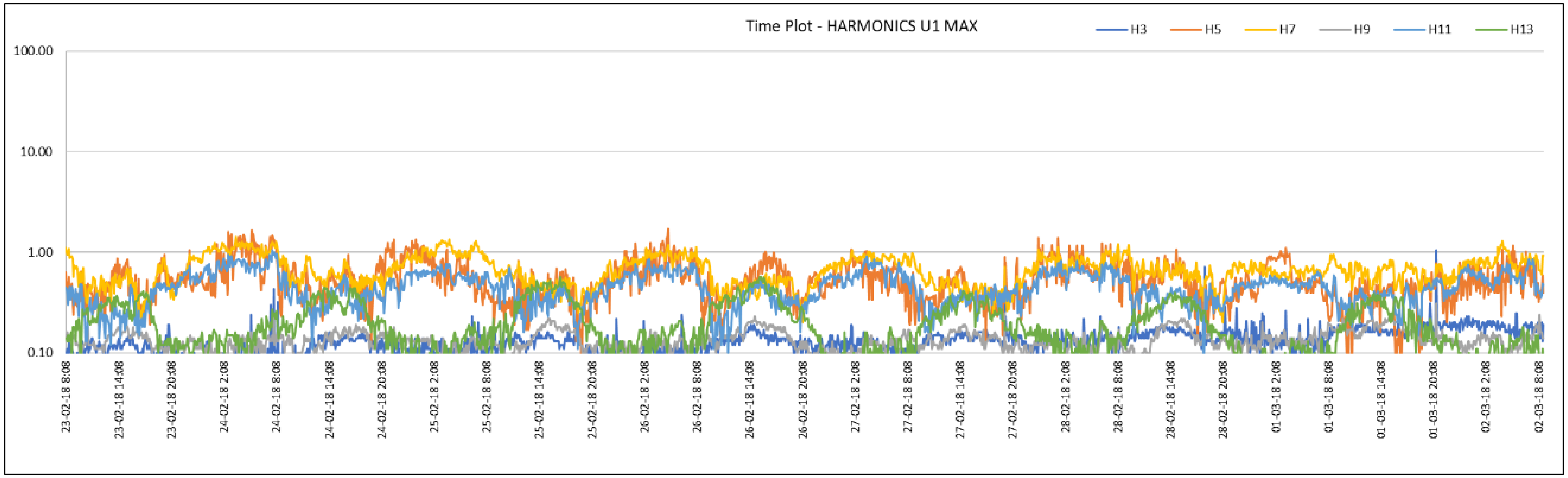

Figure 98 | TC3 – start of feeder – 3rd to 13th (odd) harmonics (Red Phase)

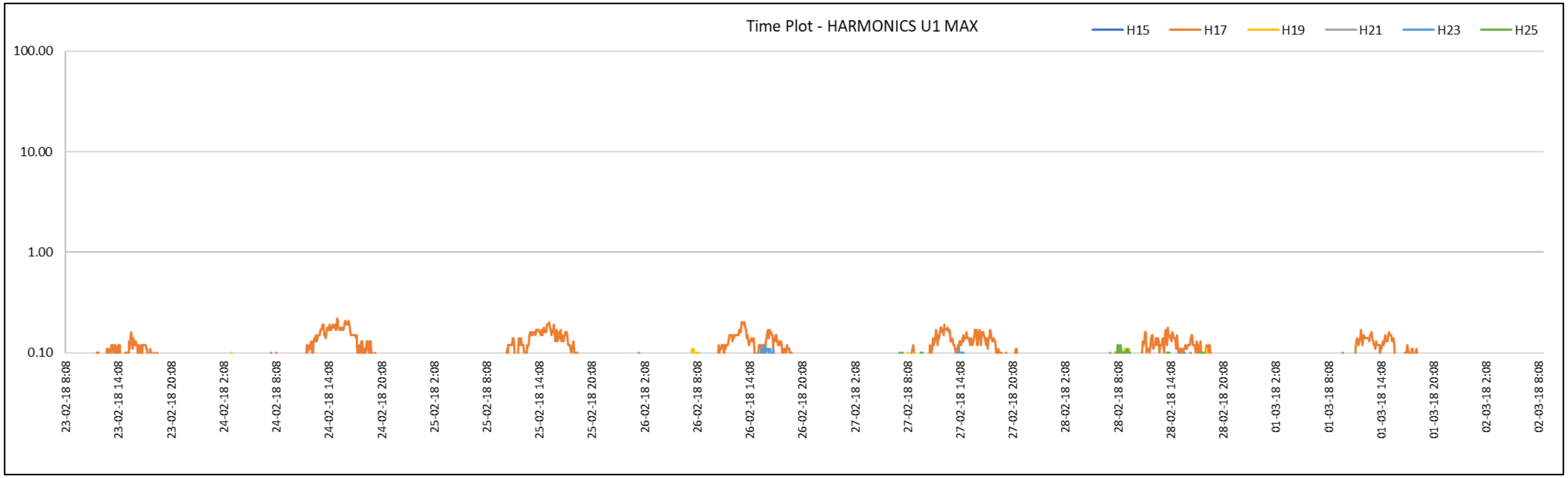

Figure 99 | TC3 – start of feeder – 15th to 25th (odd) harmonics (Red Phase)

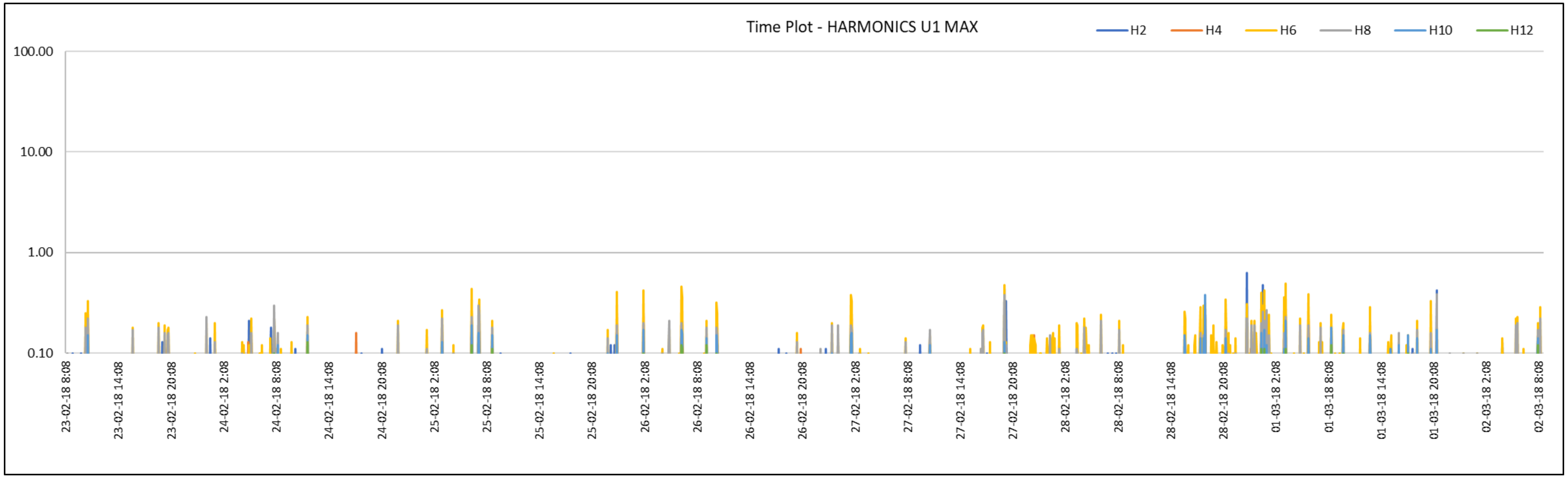

Figure 100 | TC3– start of feeder – 2th to 12th (even) harmonics (Red Phase)

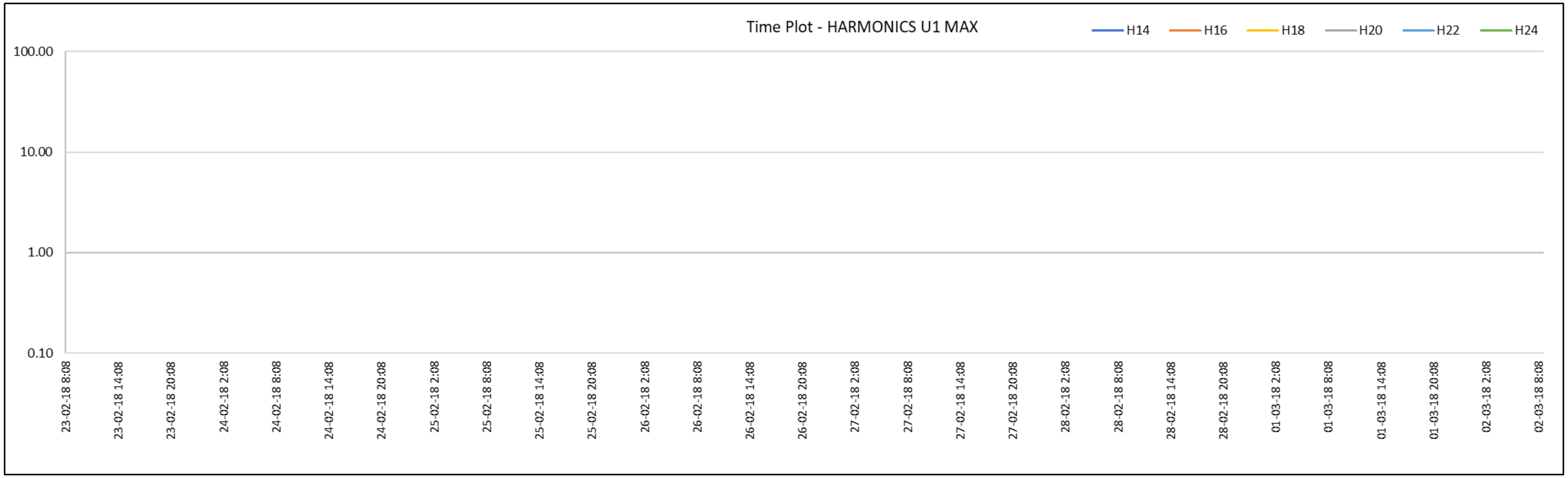

Figure 101 | TC3– start of feeder – 14th to 24th (even) harmonics (Red Phase)

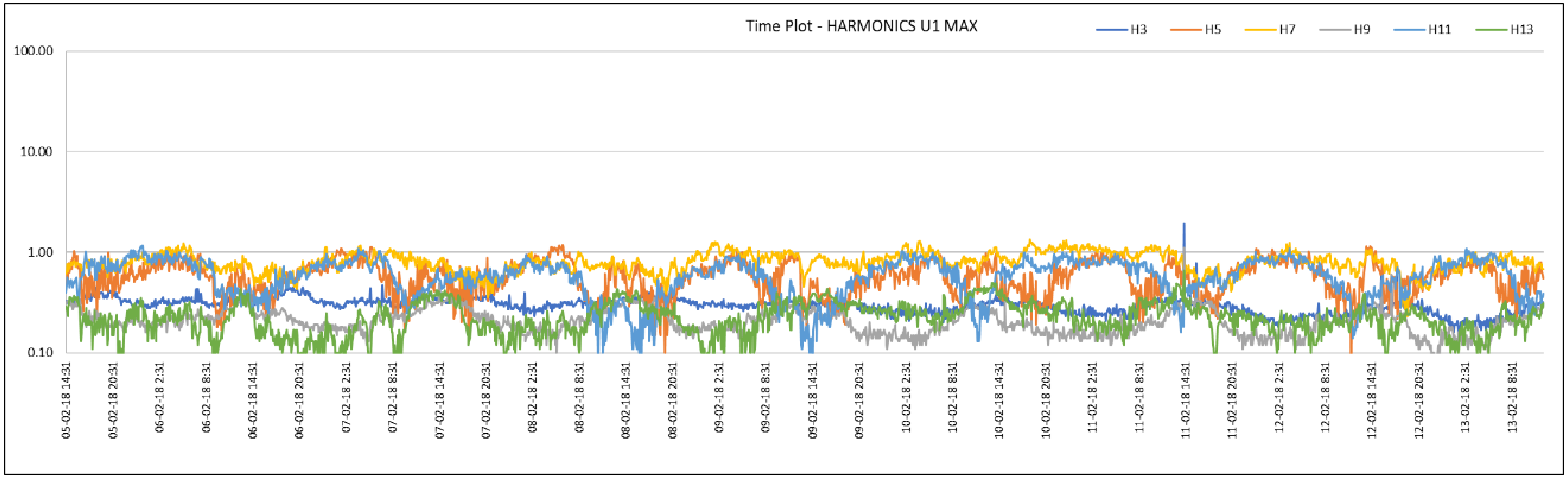

Figure 102 | TC3 – end of feeder – 3rd to 13th (odd) harmonics (Red Phase)

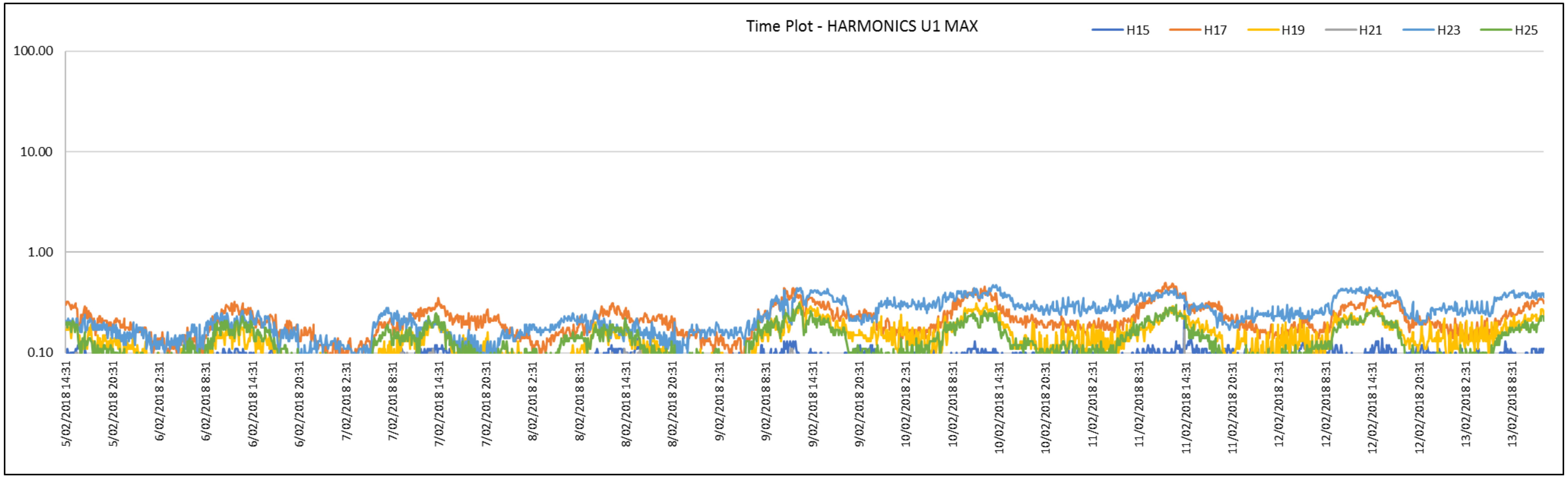

Figure 103 | TC3 – end of feeder – 15th to 25th (odd) harmonics (Red Phase)

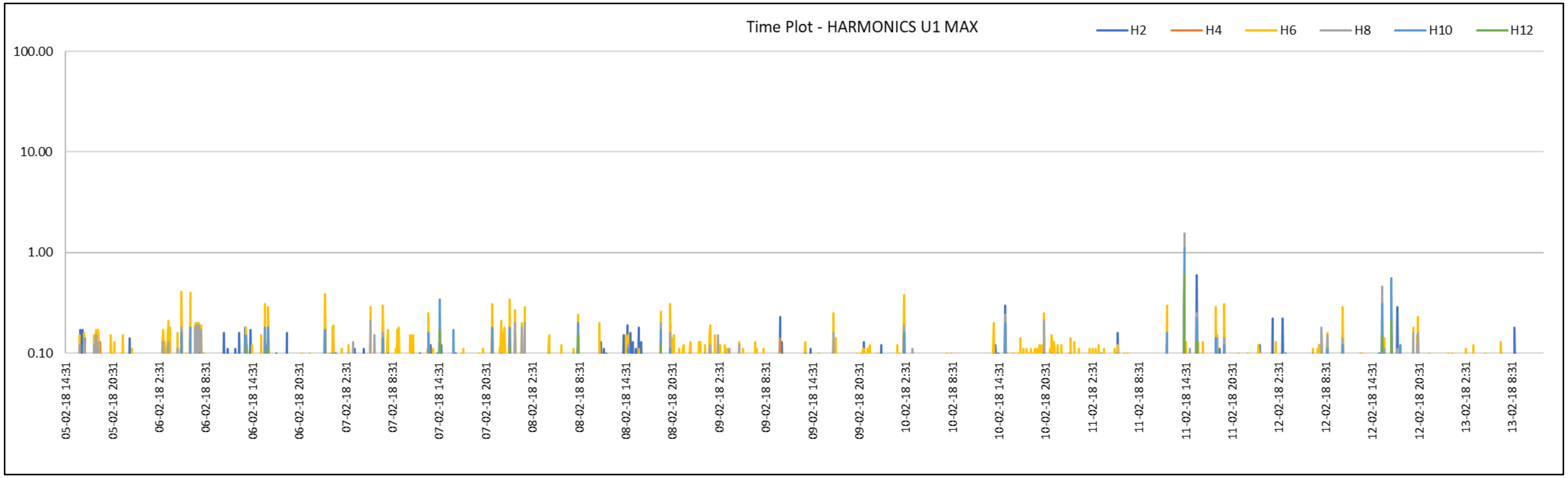

Figure 104 | TC3– end of feeder – 2th to 12th (even) harmonics (Red Phase)

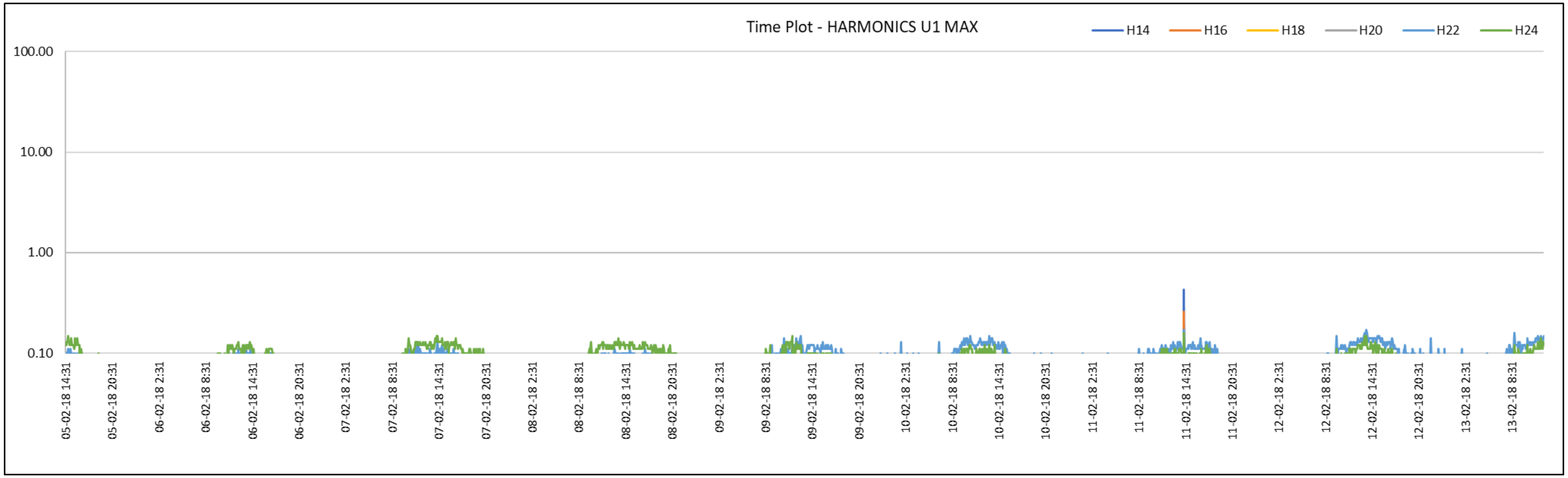

Figure 105 | TC3 – end of feeder – 14th to 24th (even) harmonics (Red Phase)

TC4 Feeder – Flicker, Voltage, Frequency, and Harmonics

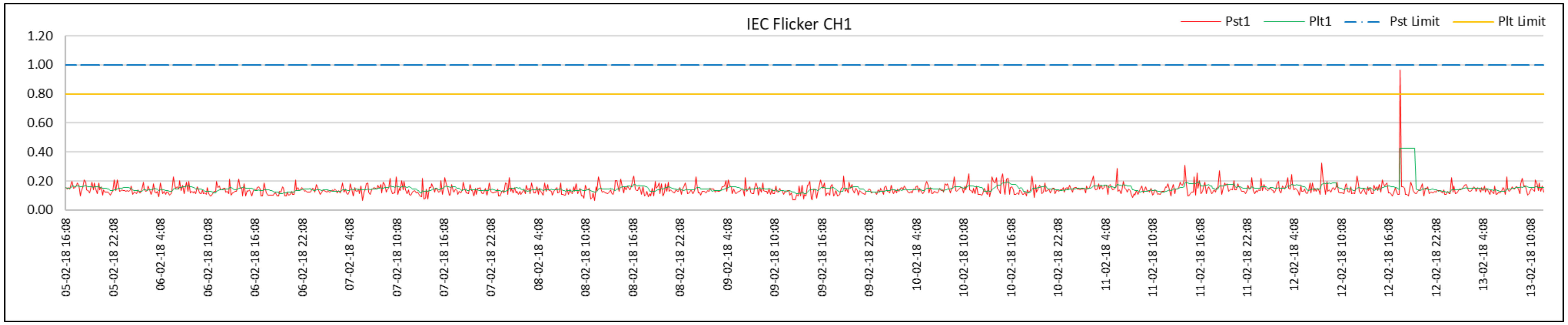

Figure 106 | TC4 - start of feeder – flicker measurements (Red Phase)

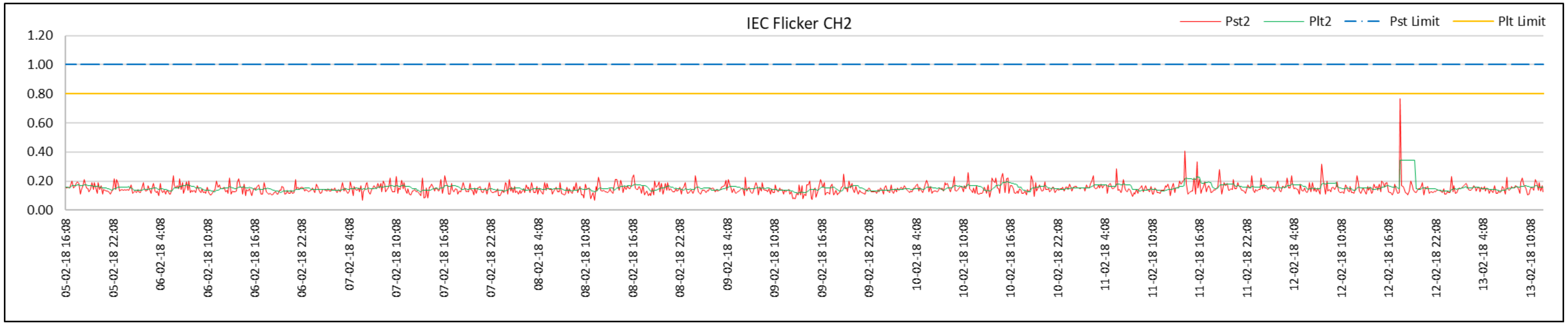

Figure 107 | TC4 - start of feeder – flicker measurements (White Phase)

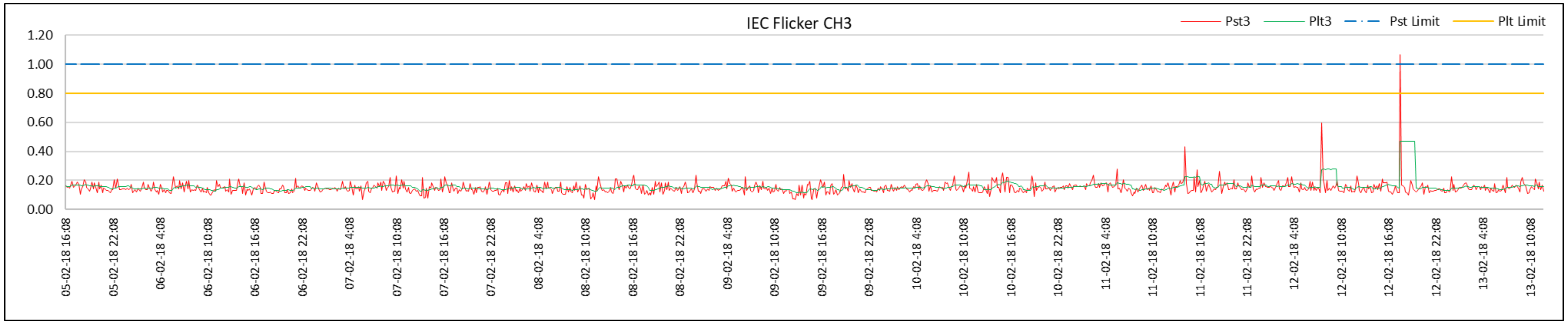

Figure 108 | TC4 - start of feeder – flicker measurements (Blue Phase)

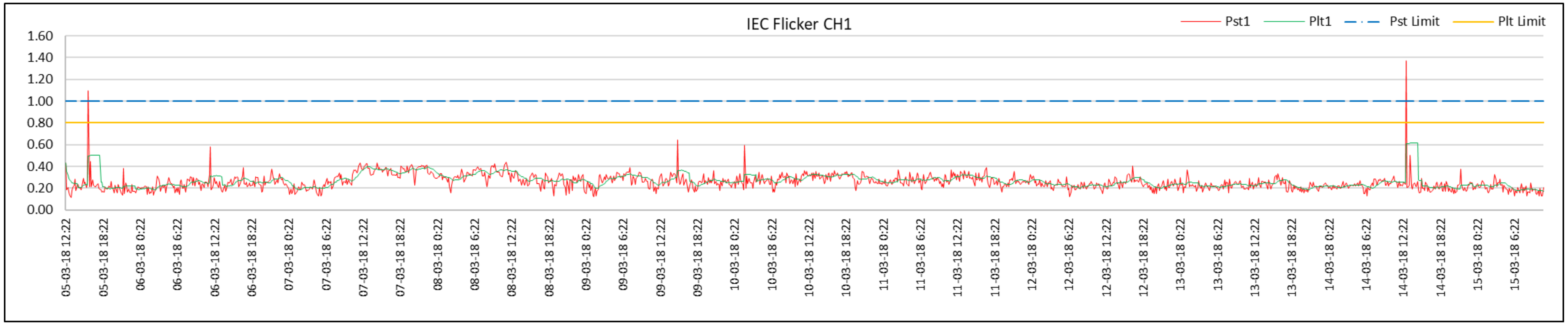

Figure 109 | TC4 – end of feeder – flicker measurements (Red Phase)

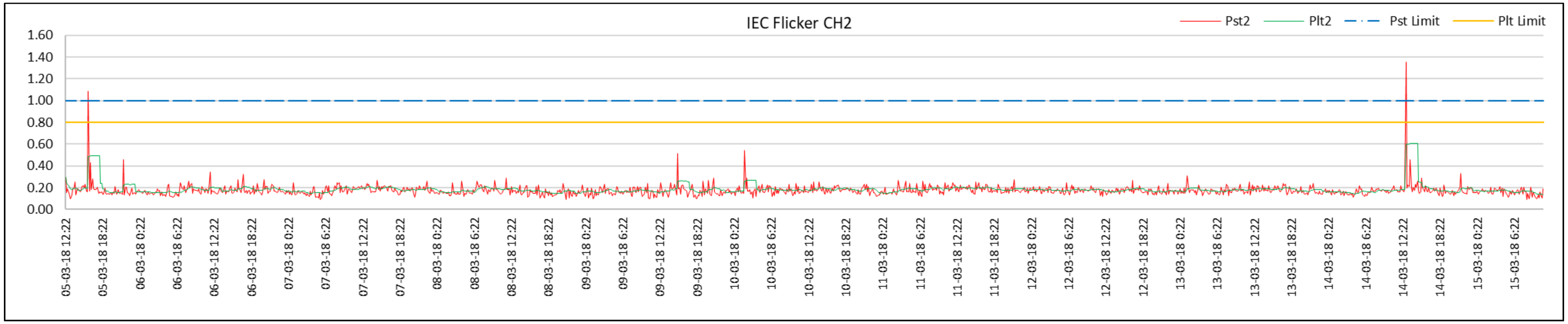

Figure 110 | TC4 - end of feeder – flicker measurements (White Phase)

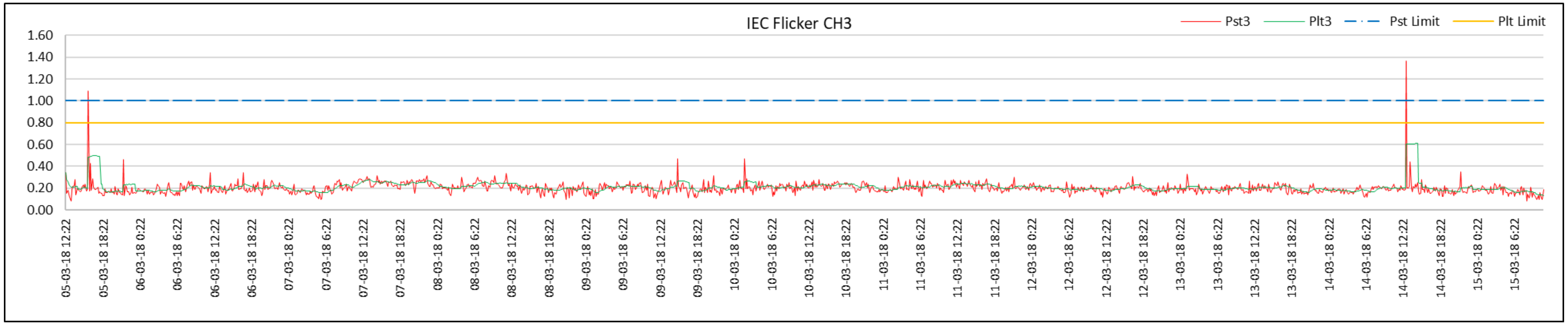

Figure 111 | TC4 - end of feeder – flicker measurements (Blue Phase)

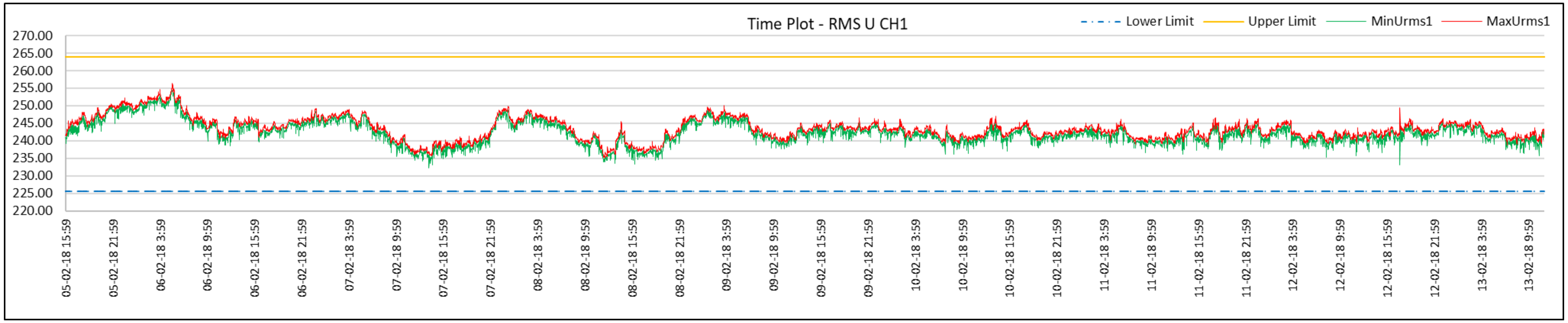

Figure 112 | TC4 - start of feeder – voltage measurements (Red Phase)

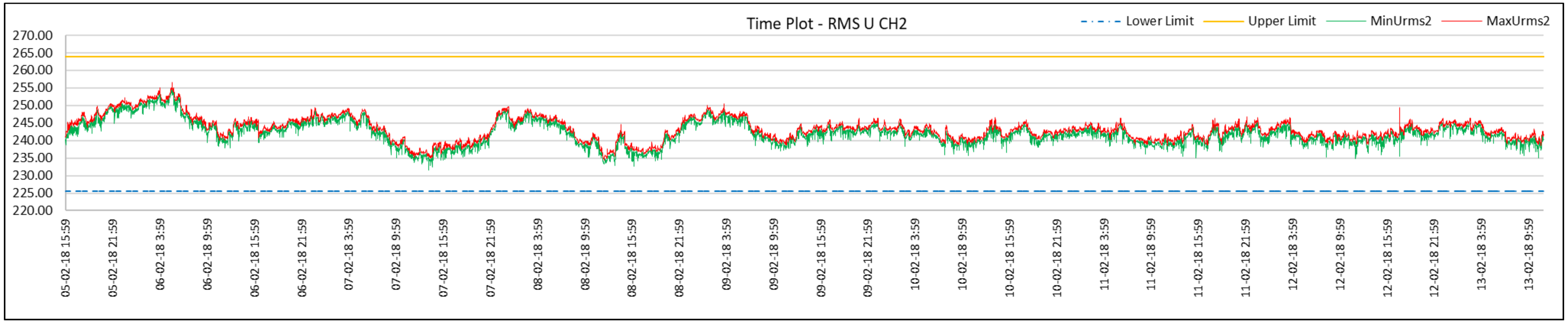

Figure 113 | TC4 - start of feeder – voltage measurements (White Phase)

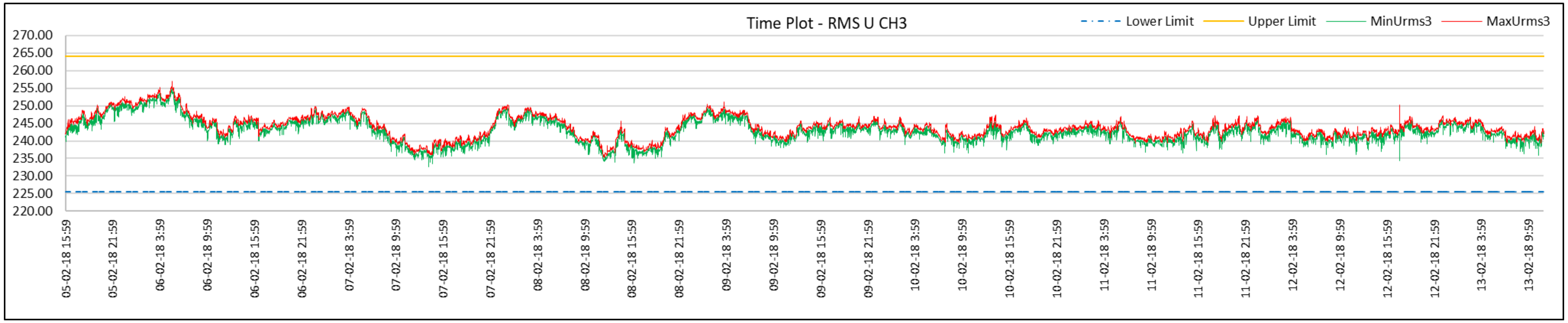

Figure 114 | TC4 - start of feeder – voltage measurements (Blue Phase)

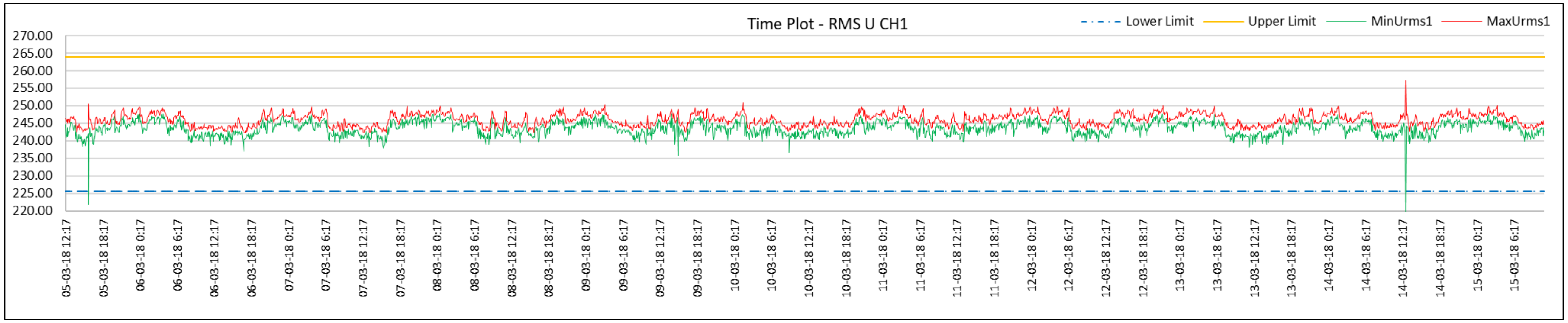

Figure 115 | TC4 - end of feeder – voltage measurements (Red Phase)

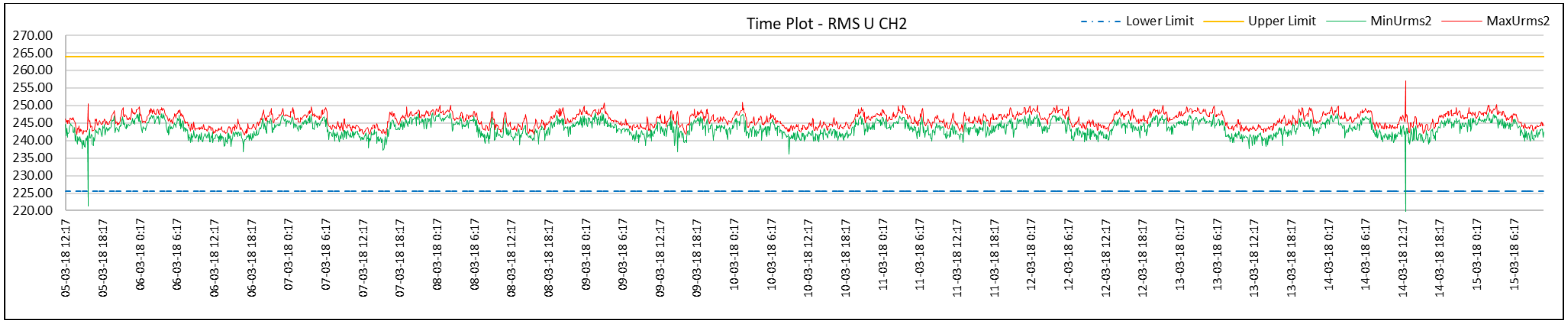

Figure 116 | TC4 - end of feeder – voltage measurements (White Phase)

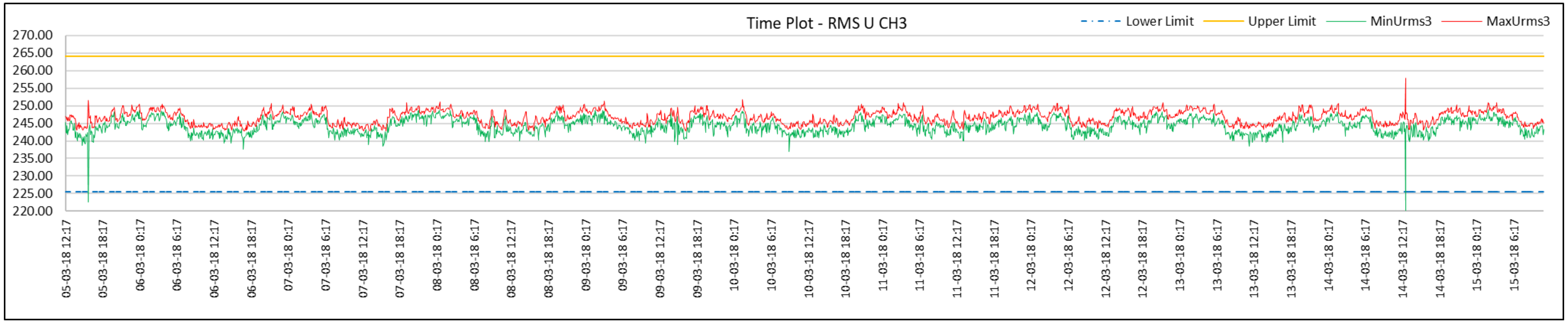

Figure 117 | TC4 - end of feeder – voltage measurements (Blue Phase)

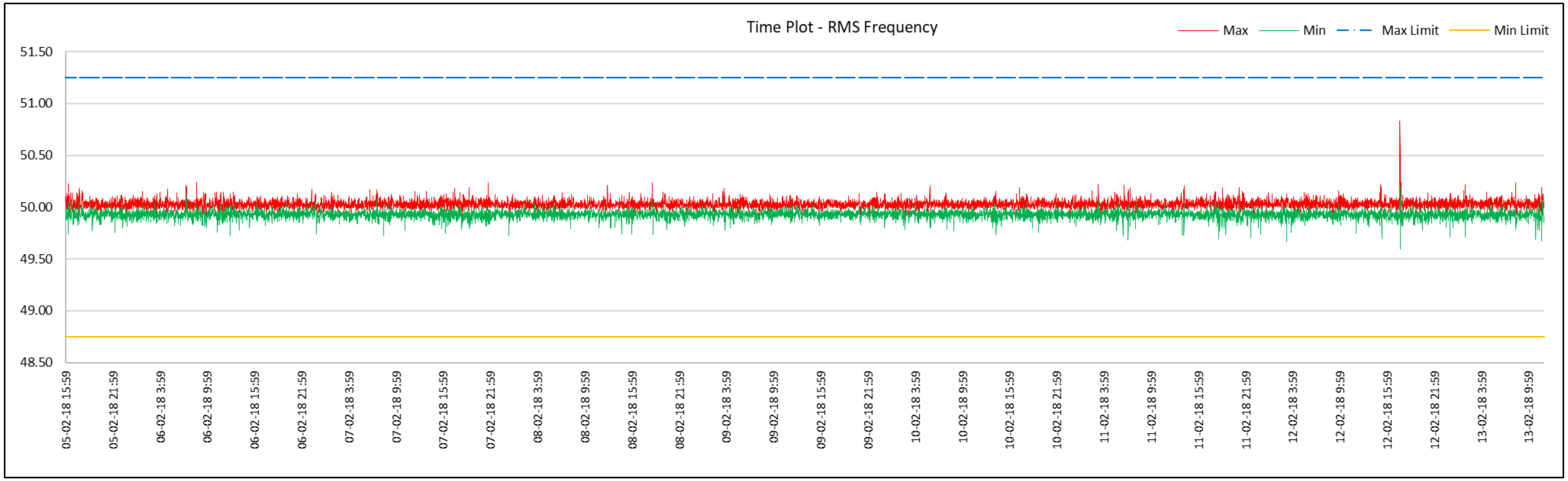

Figure 118 | TC4 - start of feeder – frequency measurements

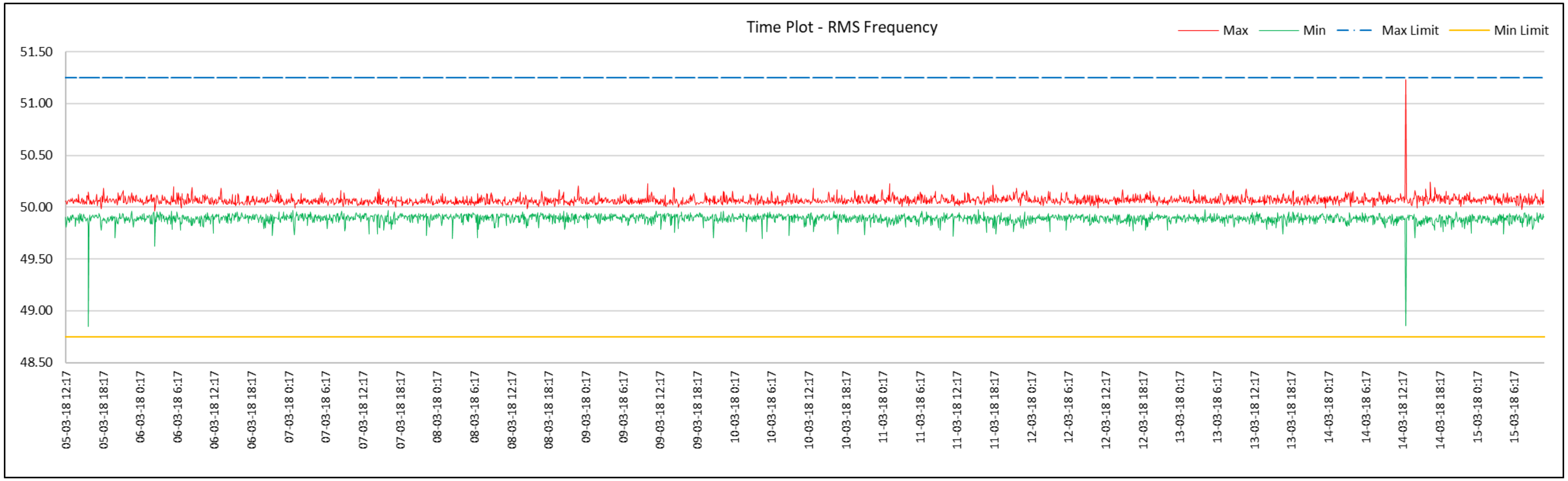

Figure 119 | TC4 - end of feeder – frequency measurements

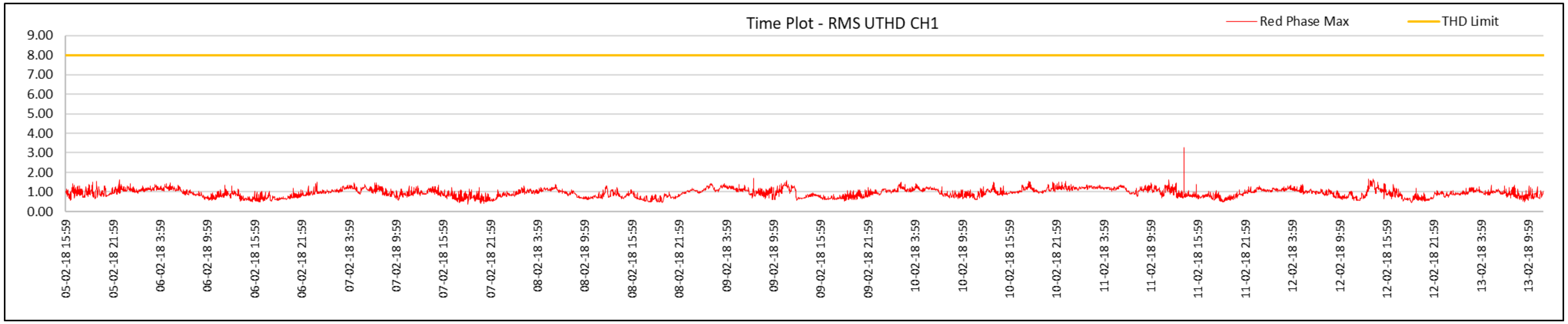

Figure 120 | TC4 - start of feeder – voltage THD measurements (Red Phase)

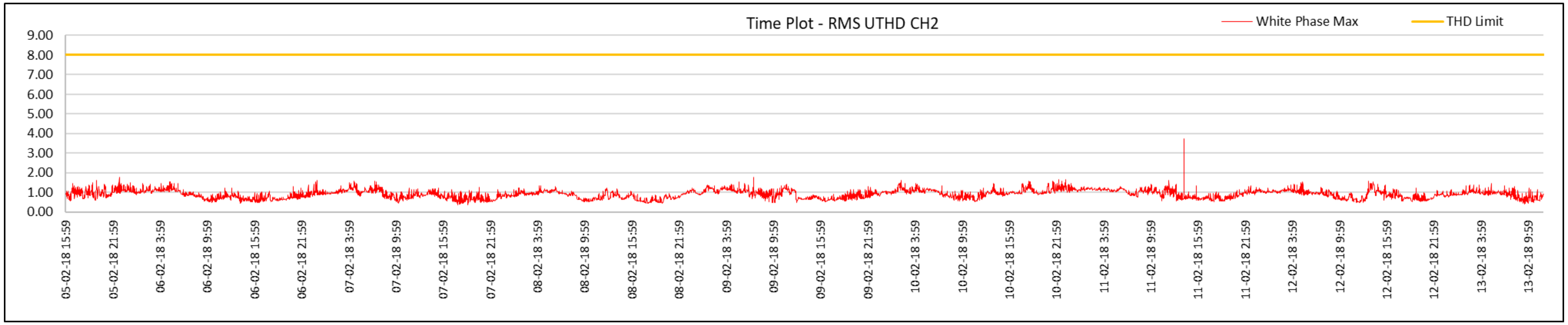

Figure 121 | TC4- start of feeder – voltage THD measurements (White Phase)

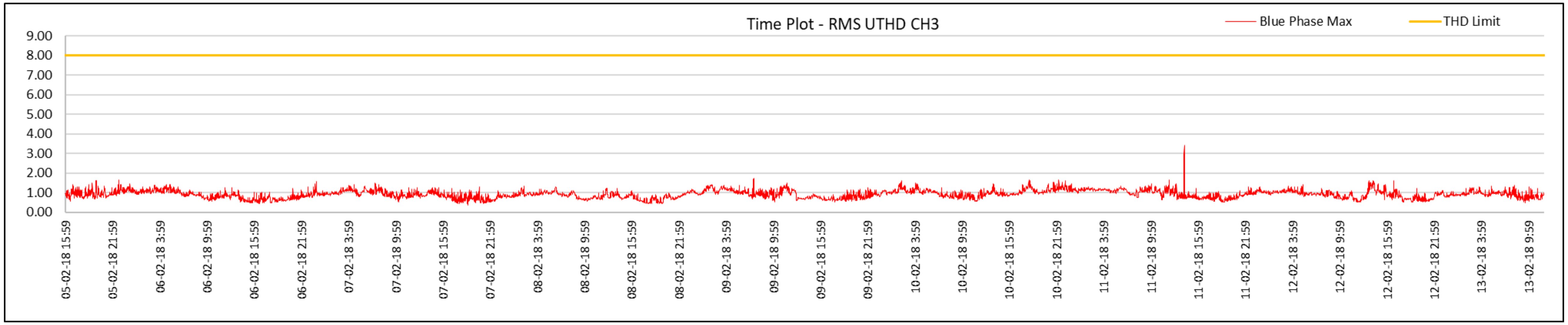

Figure 122 | TC4 - start of feeder – voltage THD measurements (Blue Phase)

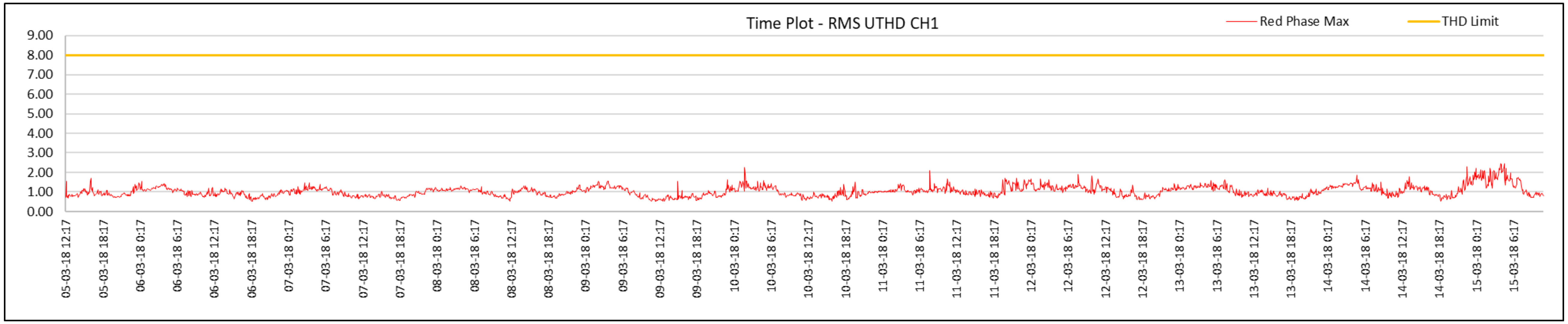

Figure 123 | TC4 - end of feeder – voltage THD measurements (Red Phase)

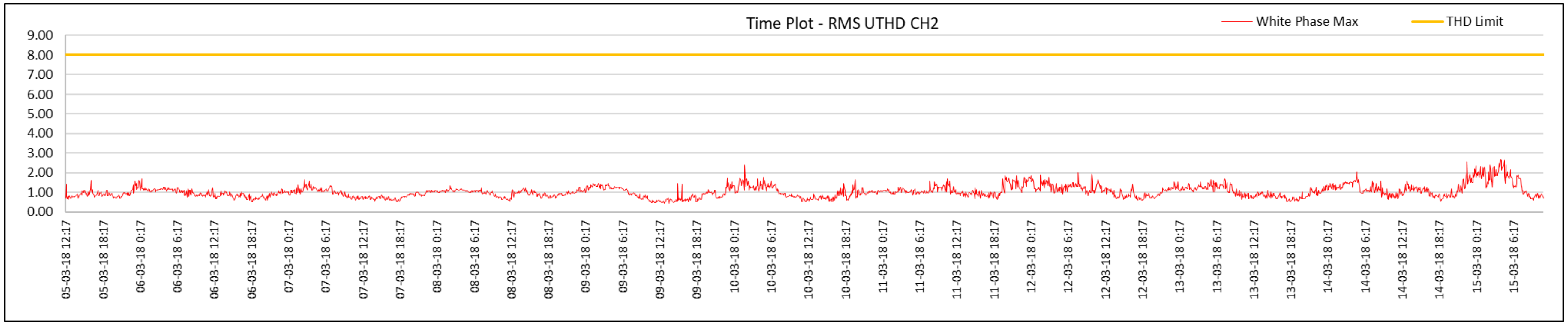

Figure 124 | TC4 - end of feeder – voltage THD measurements (White Phase)

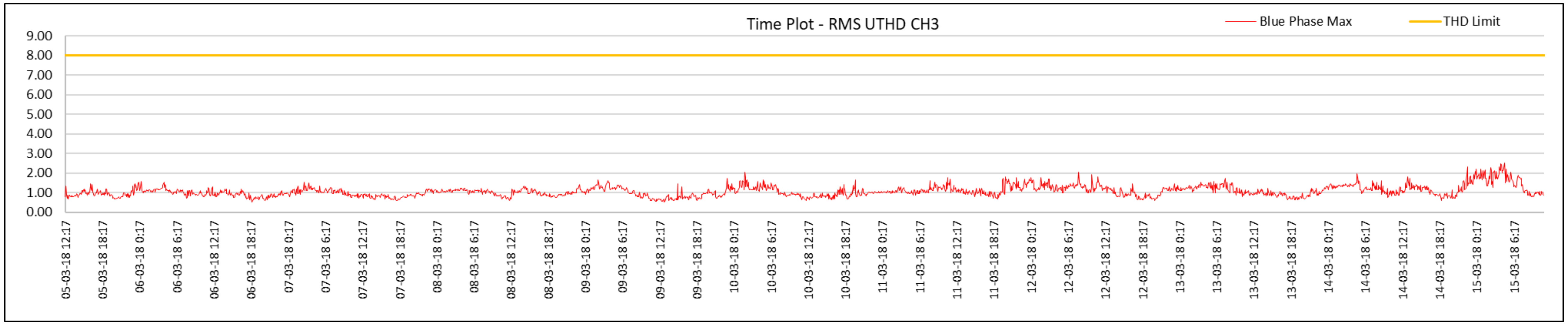

Figure 125 | TC4 - end of feeder – voltage THD measurements (Blue Phase)

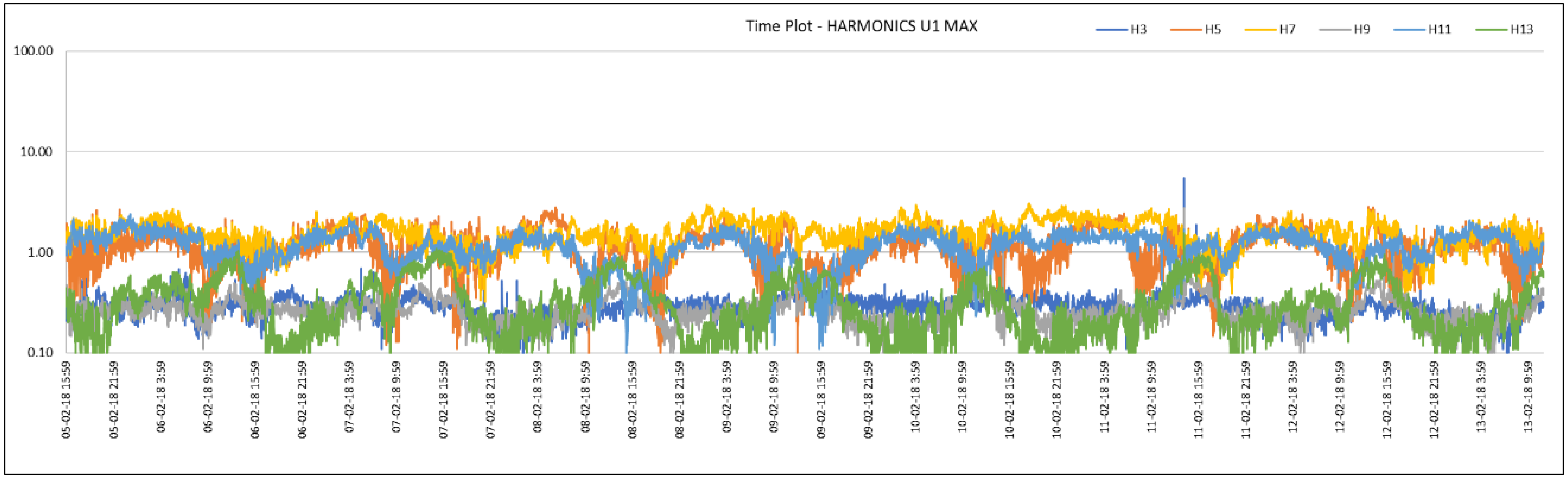

Figure 126 | TC4 – start of feeder – 3rd to 13th (odd) harmonics (Red Phase)

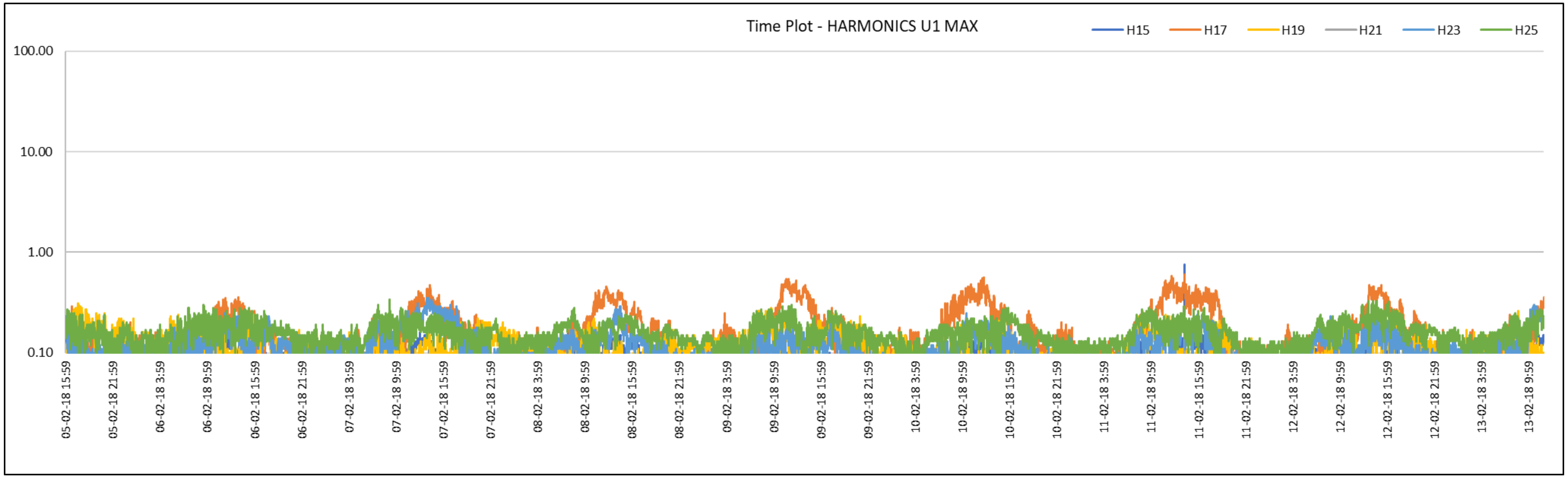

Figure 127 | TC4 – start of feeder – 15th to 25th (odd) harmonics (Red Phase)

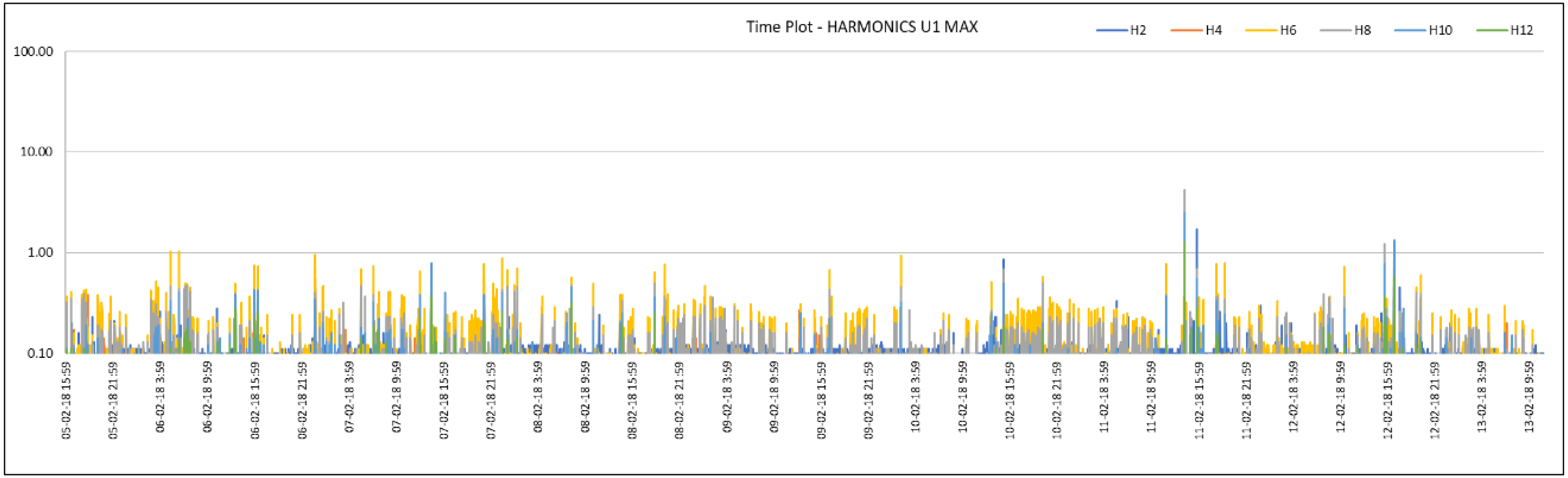

Figure 128 | TC4– start of feeder – 2th to 12th (even) harmonics (Red Phase)

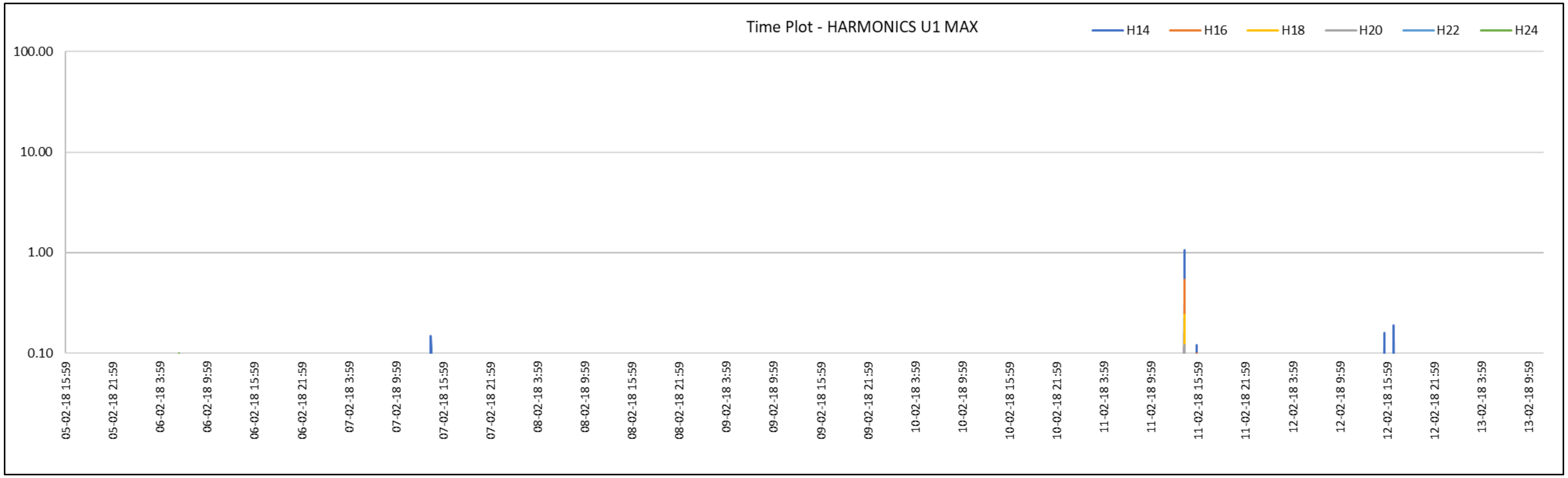

Figure 129 | TC4– start of feeder – 14th to 24th (even) harmonics (Red Phase)

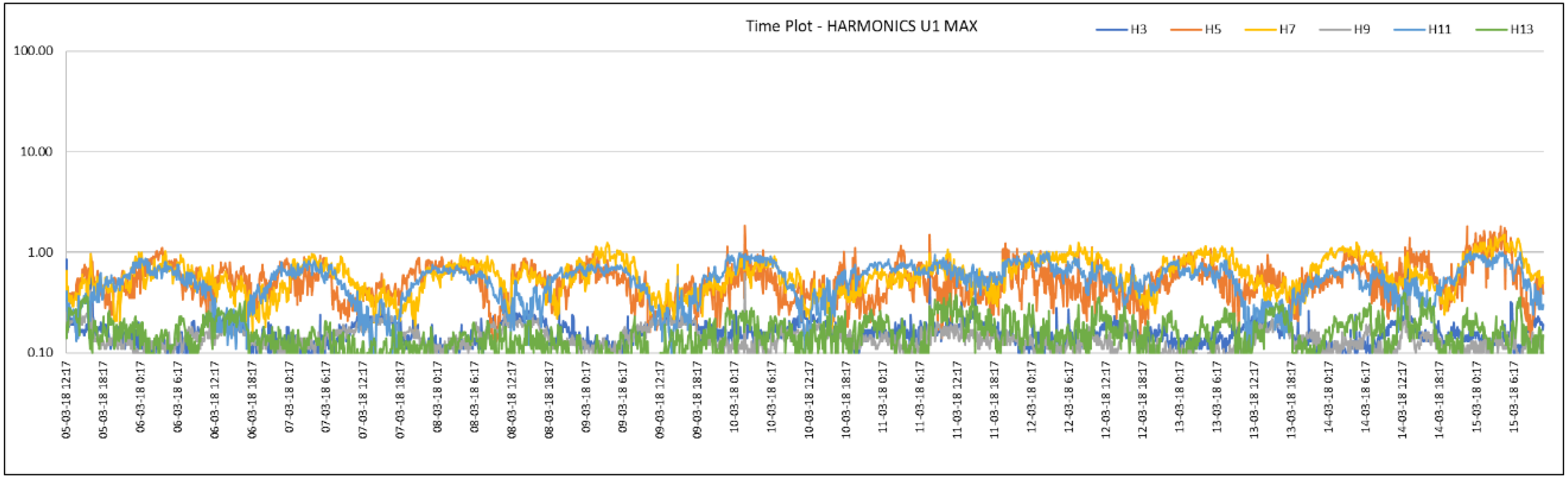

Figure 130 | TC4 – end of feeder – 3rd to 13th (odd) harmonics (Red Phase)

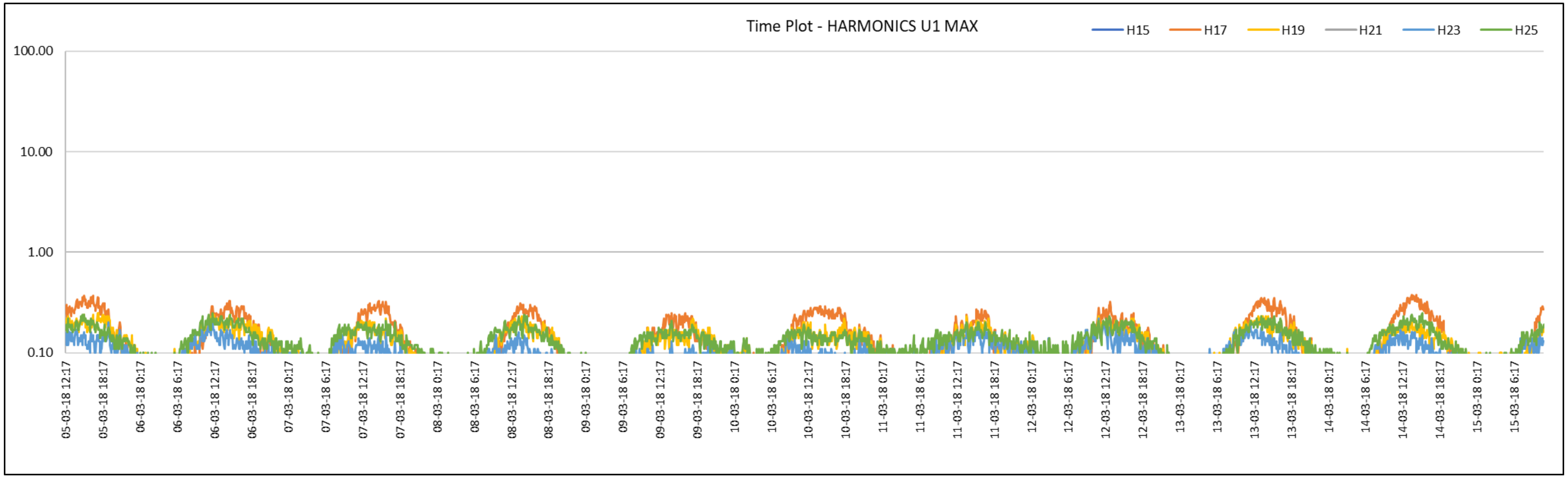

Figure 131 | TC4 – end of feeder – 15th to 25th (odd) harmonics (Red Phase)

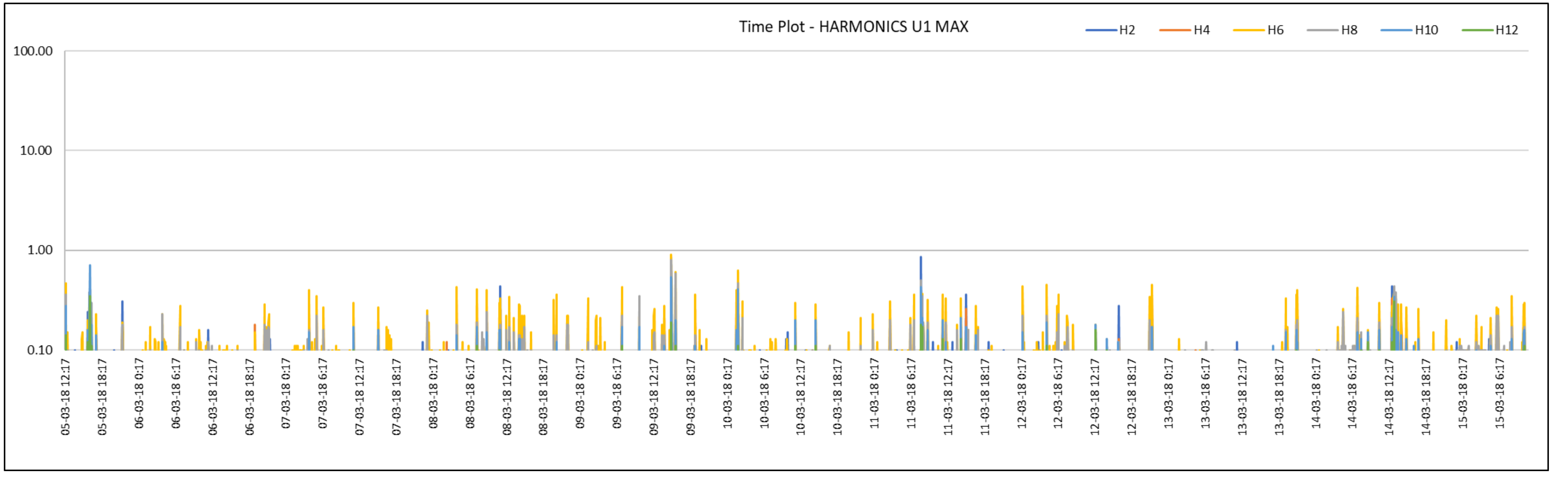

Figure 132 | TC4 – end of feeder – 2th to 12th (even) harmonics (Red Phase)

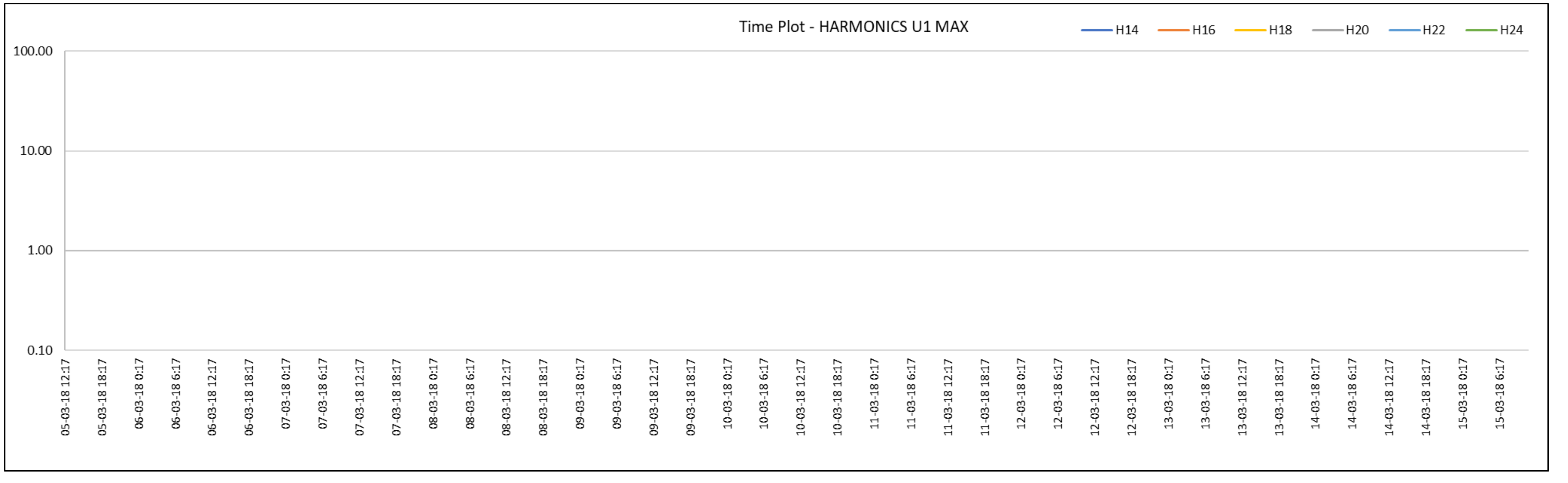

Figure 133 | TC4 – end of feeder – 14th to 24th (even) harmonics (Red Phase)

STS1 Feeder – Flicker, Voltage, Frequency, and Harmonics

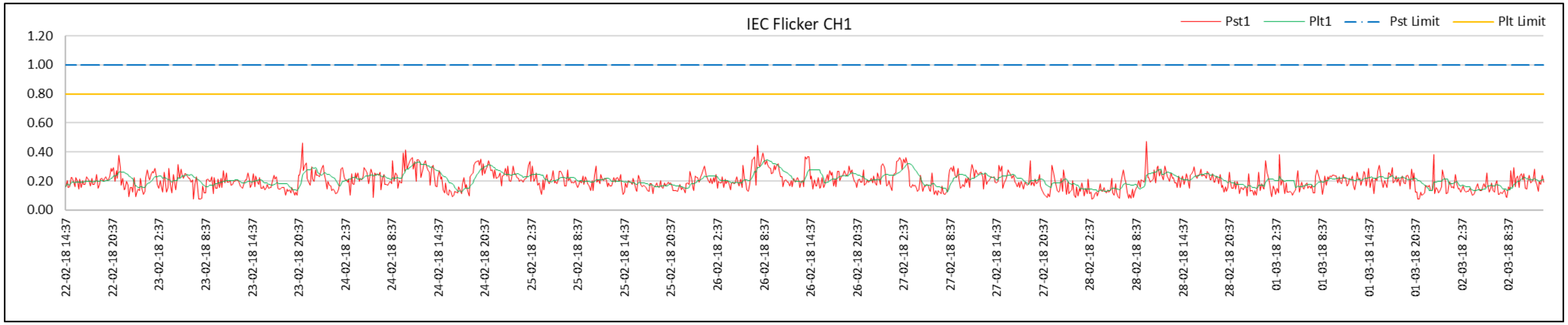

Figure 134 | STS1 - start of feeder – flicker measurements (Red Phase)

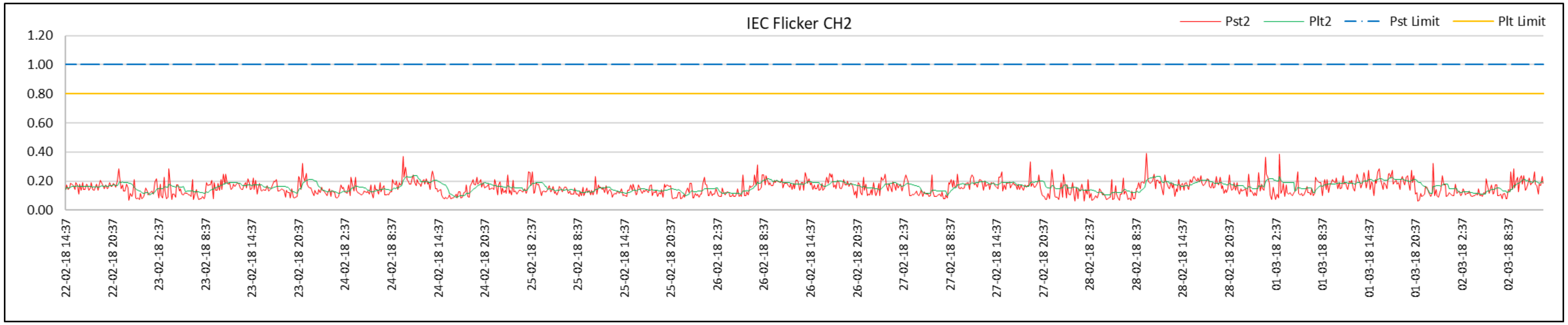

Figure 135 | STS1 - start of feeder – flicker measurements (White Phase)

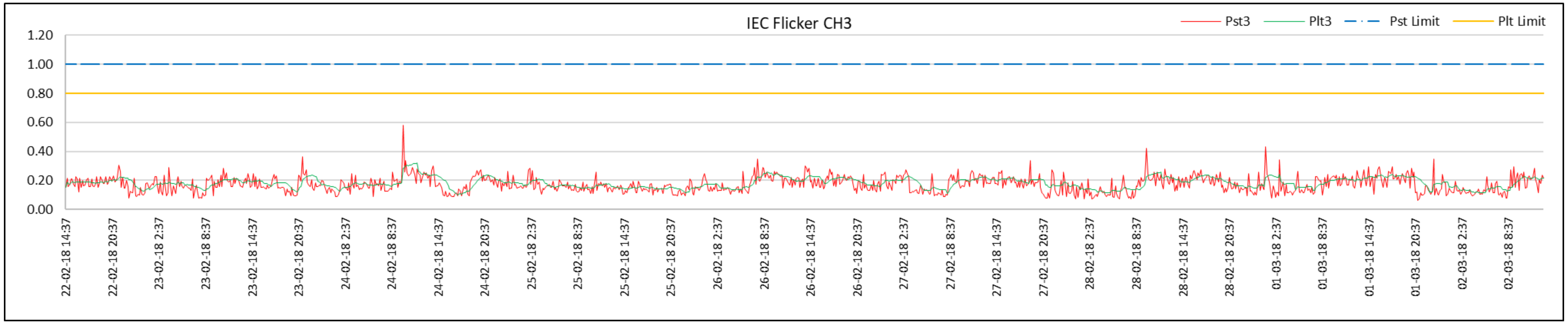

Figure 136 | STS1 - start of feeder – flicker measurements (Blue Phase)

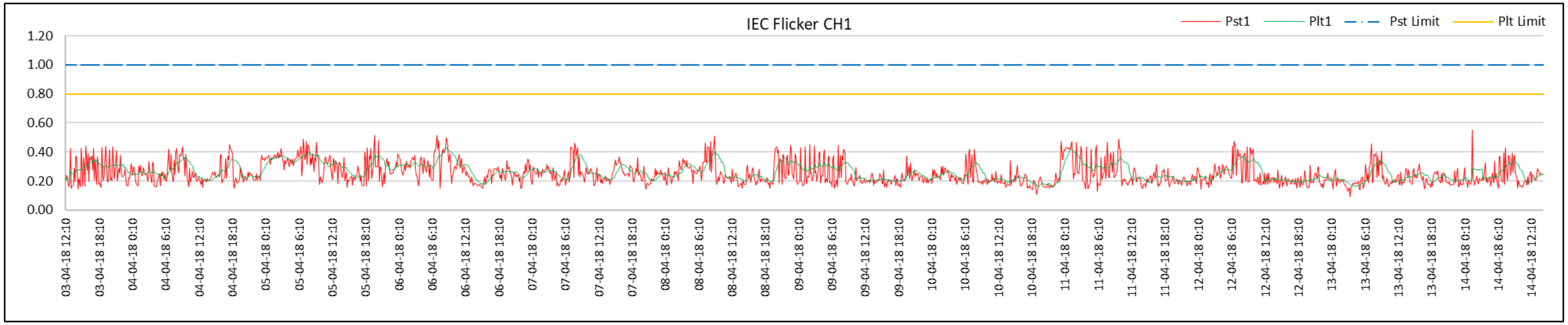

Figure 137 | STS1 – end of feeder – flicker measurements (Red Phase)

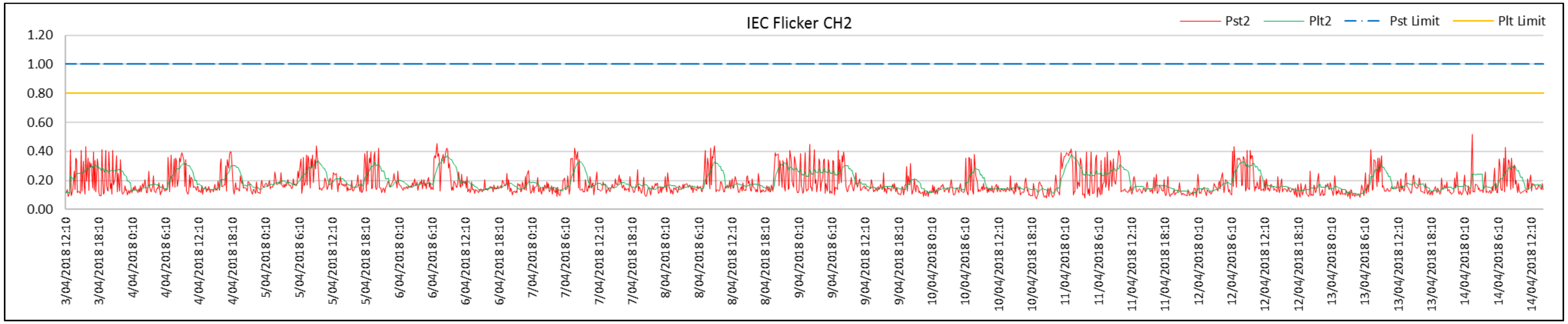

Figure 138 | STS1 - end of feeder – flicker measurements (White Phase)

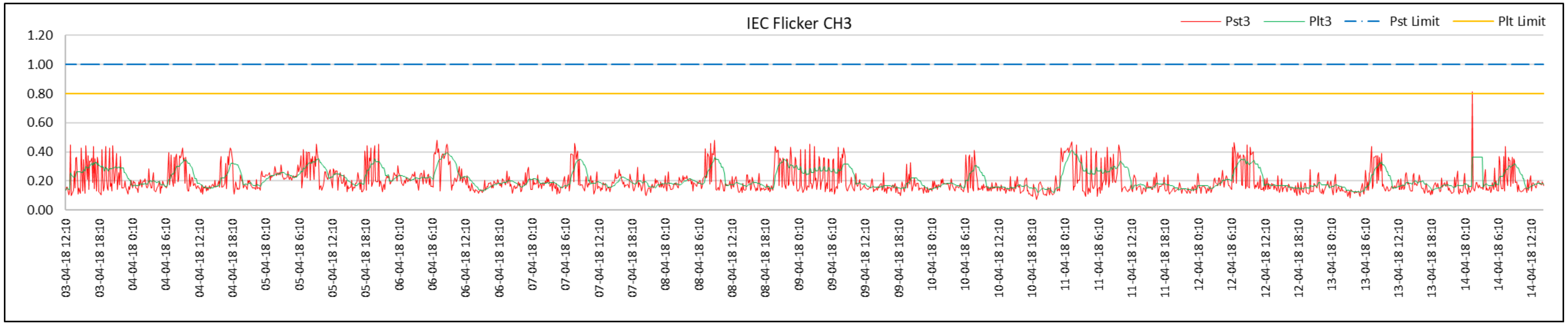

Figure 139 | STS1 - end of feeder – flicker measurements (Blue Phase)

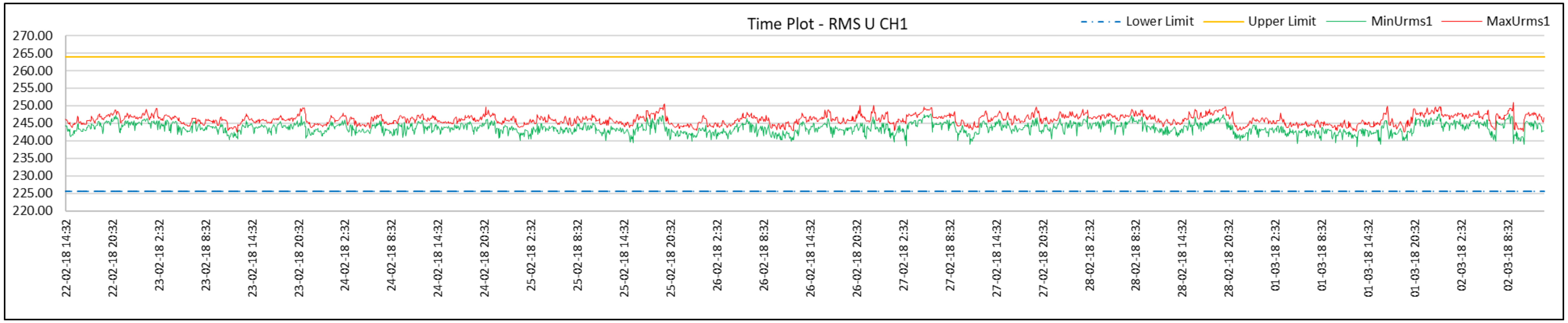

Figure 140 | STS1 - start of feeder – voltage measurements (Red Phase)

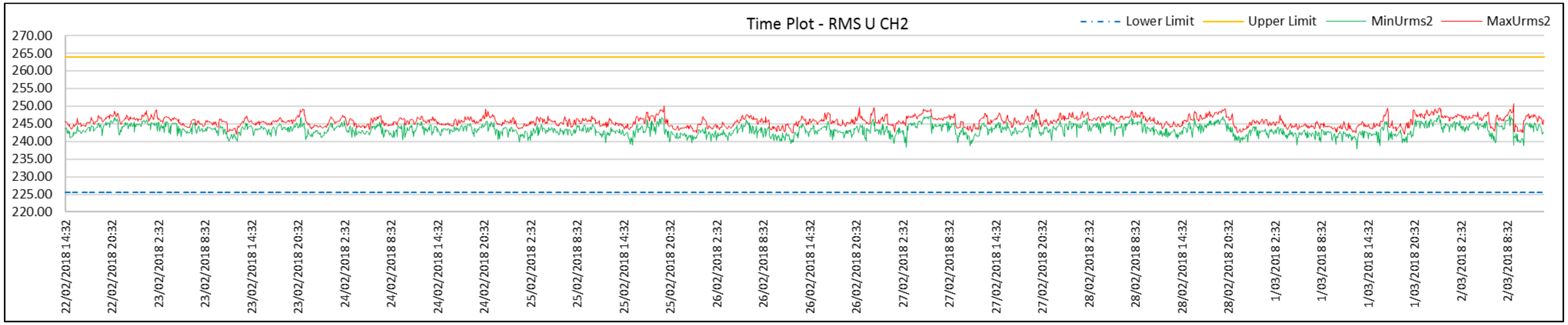

Figure 141 | STS1 - start of feeder – voltage measurements (White Phase)

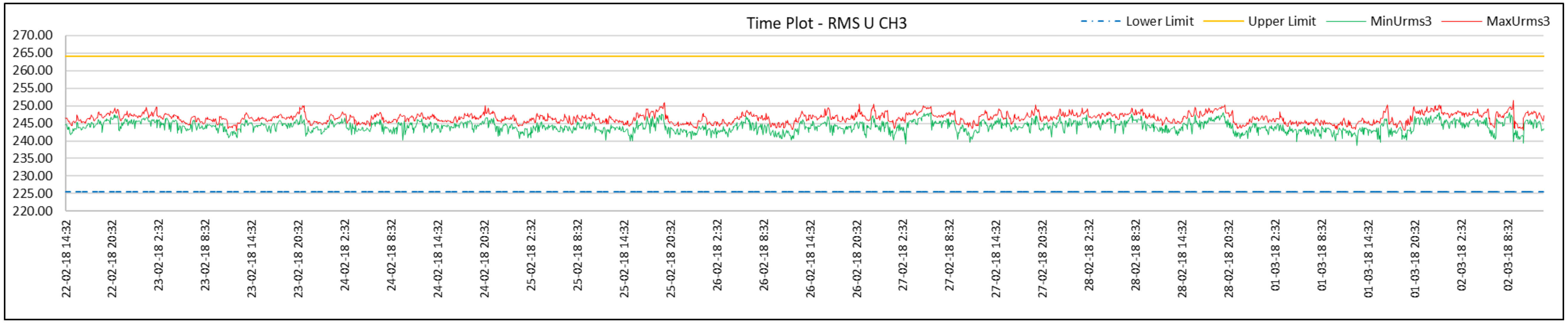

Figure 142 | STS1 - start of feeder – voltage measurements (Blue Phase)

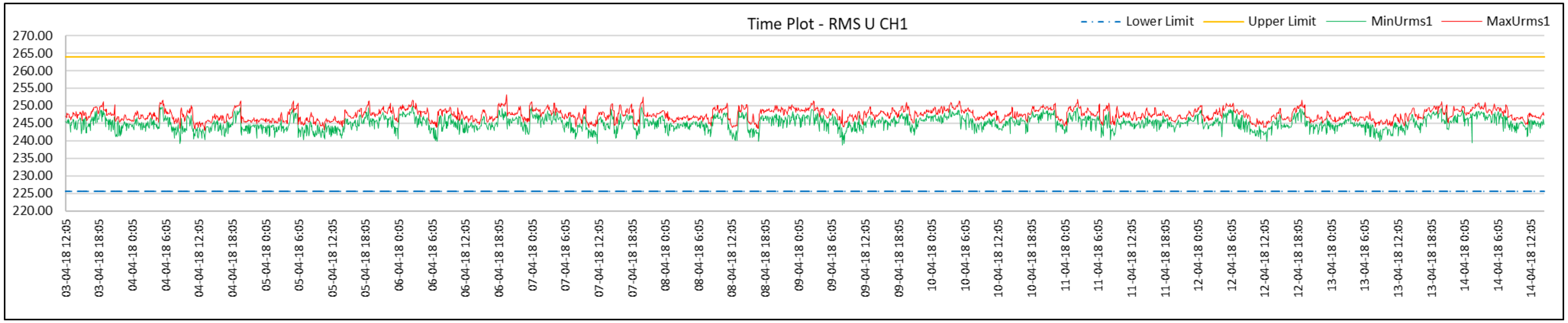

Figure 143 | STS1 - end of feeder – voltage measurements (Red Phase)

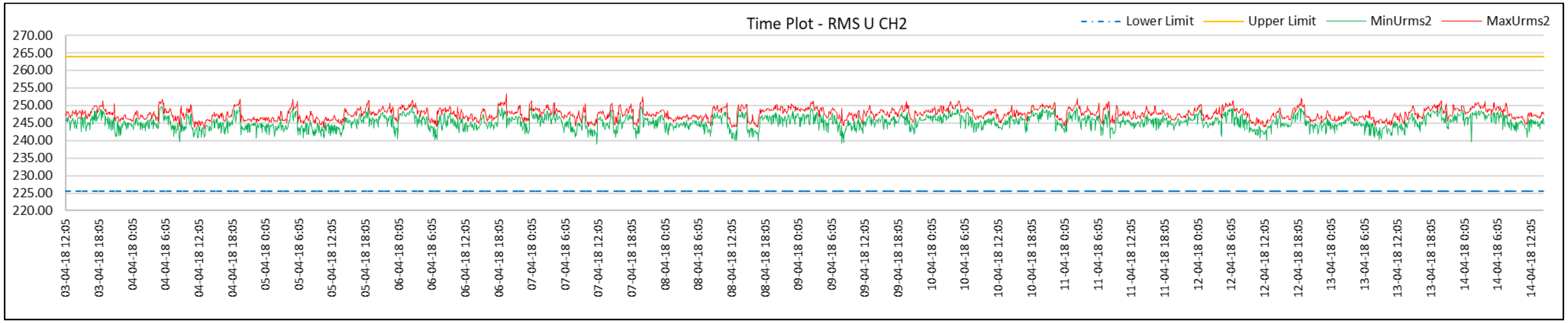

Figure 144 | STS1 - end of feeder – voltage measurements (White Phase)

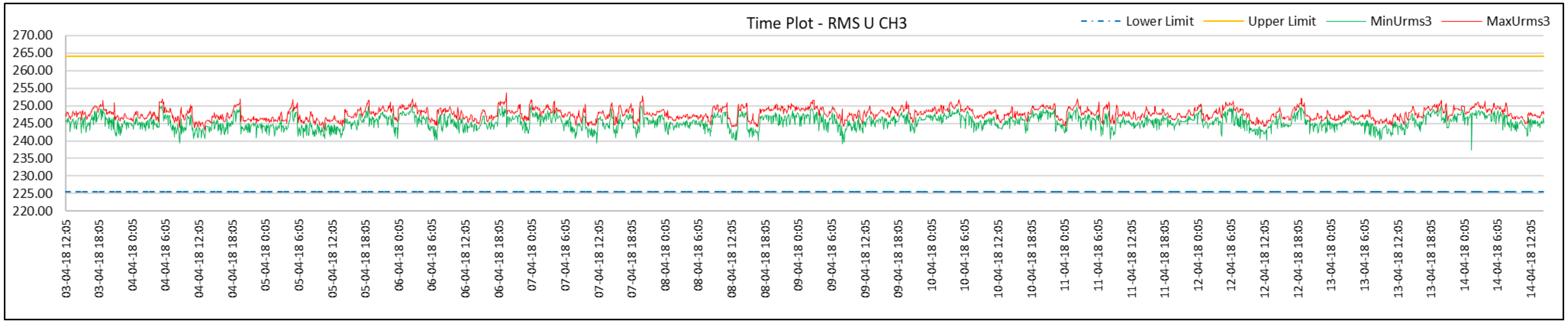

Figure 145 | STS1 - end of feeder – voltage measurements (Blue Phase)

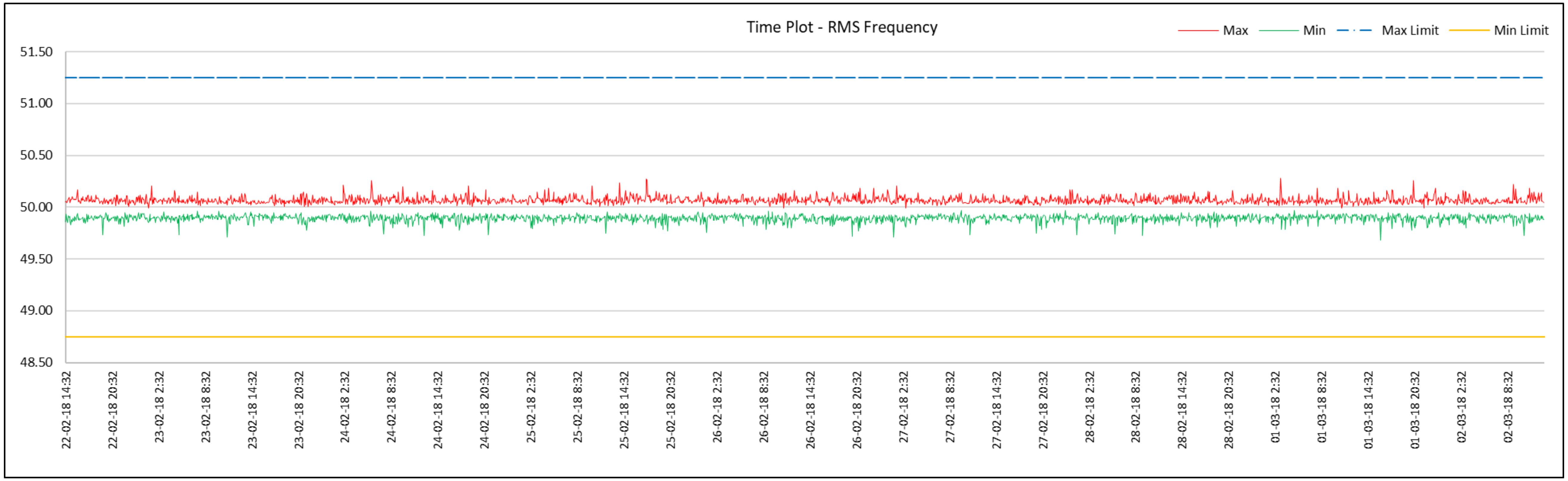

Figure 146 | STS1 - start of feeder – frequency measurements

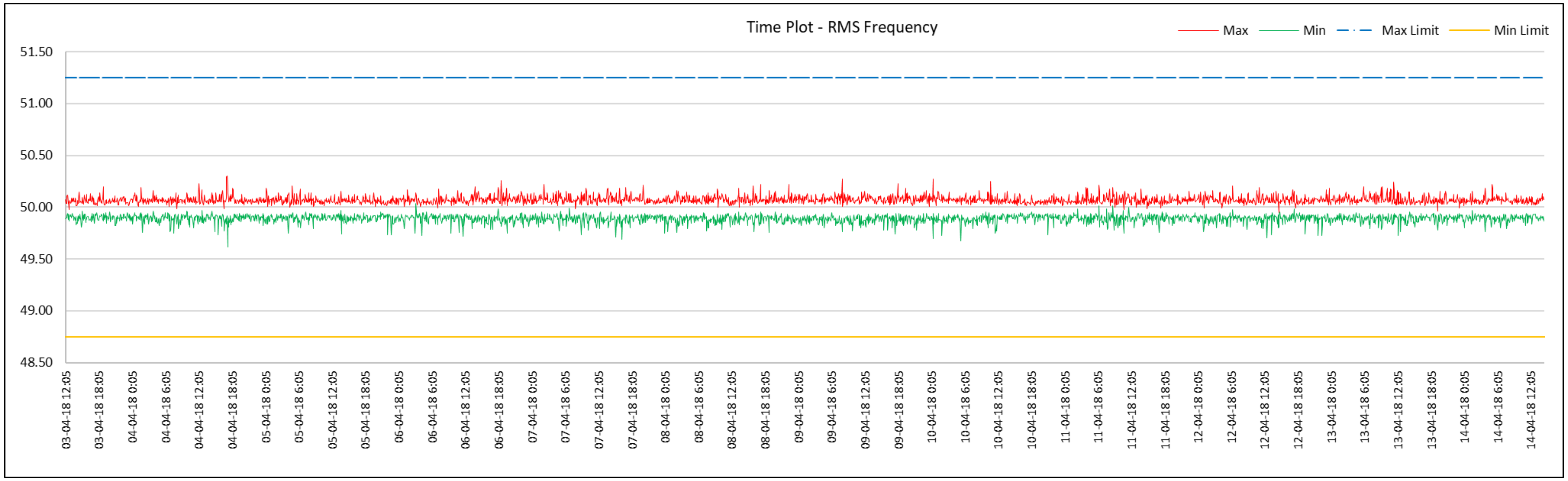

Figure 147 | STS1 - end of feeder – frequency measurements

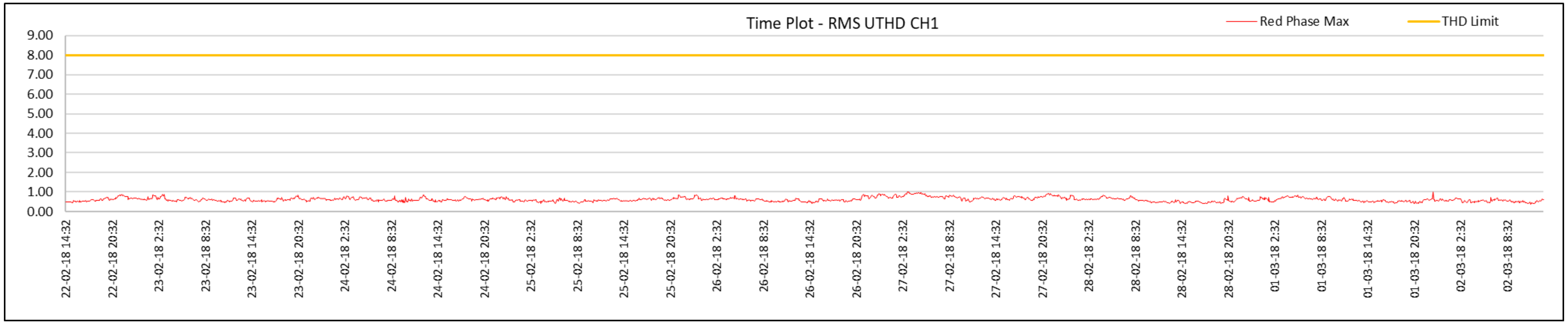

Figure 148 | STS1 - start of feeder – voltage THD measurements (Red Phase)

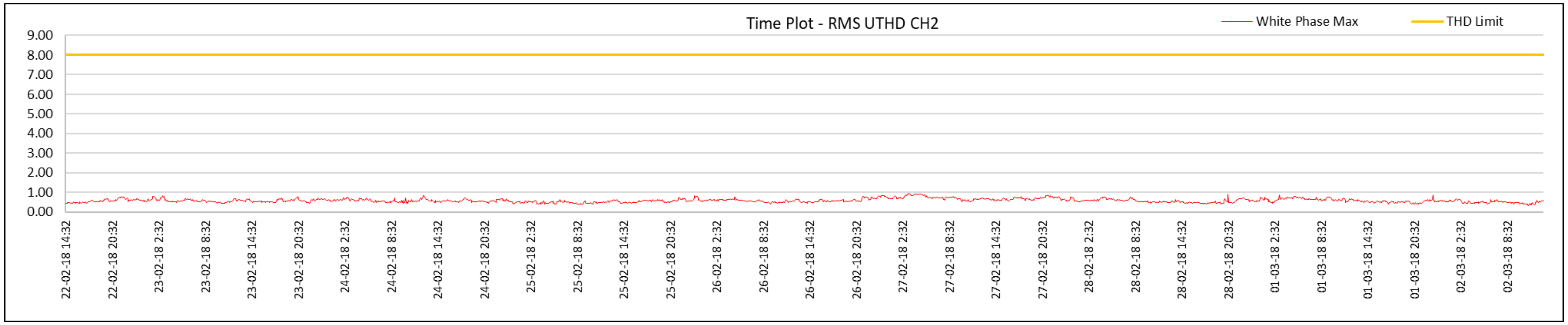

Figure 149 | STS1 - start of feeder – voltage THD measurements (White Phase)

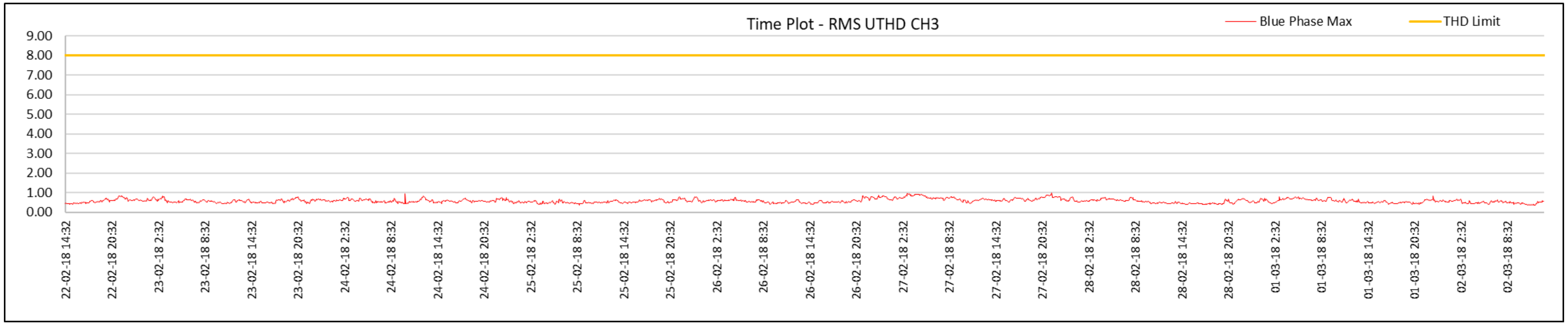

Figure 150 | STS1 - start of feeder – voltage THD measurements (Blue Phase)

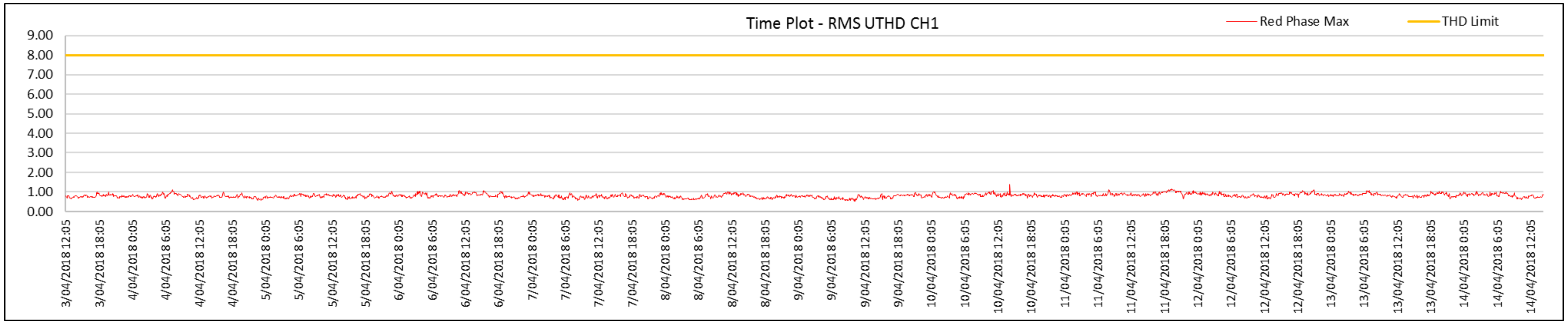

Figure 151 | STS1 - end of feeder – voltage THD measurements (Red Phase)

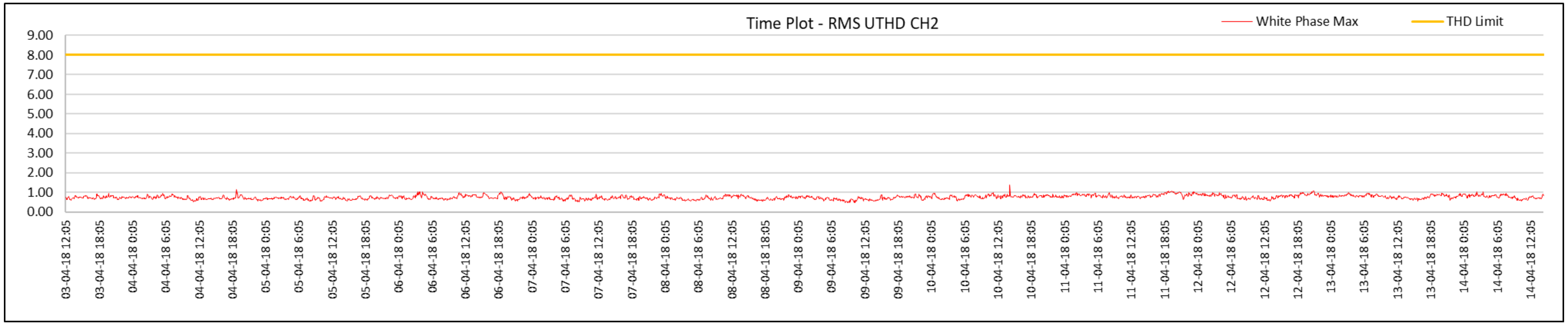

Figure 152 | STS1 - end of feeder – voltage THD measurements (White Phase)

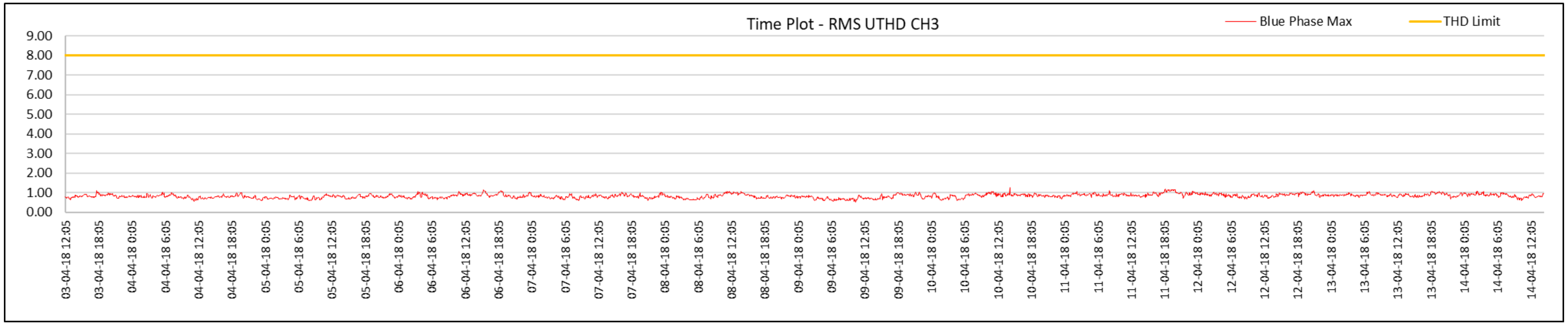

Figure 153 | STS1 - end of feeder – voltage THD measurements (Blue Phase)

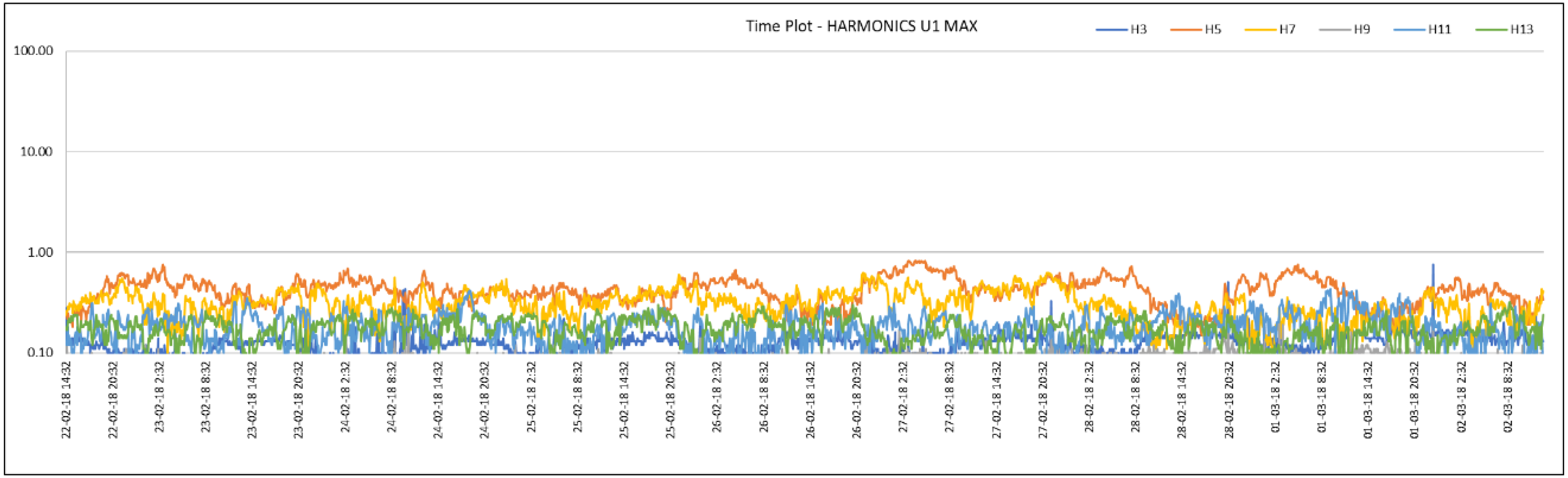

Figure 154 | STS1 – start of feeder – 3rd to 13th (odd) harmonics (Red Phase)

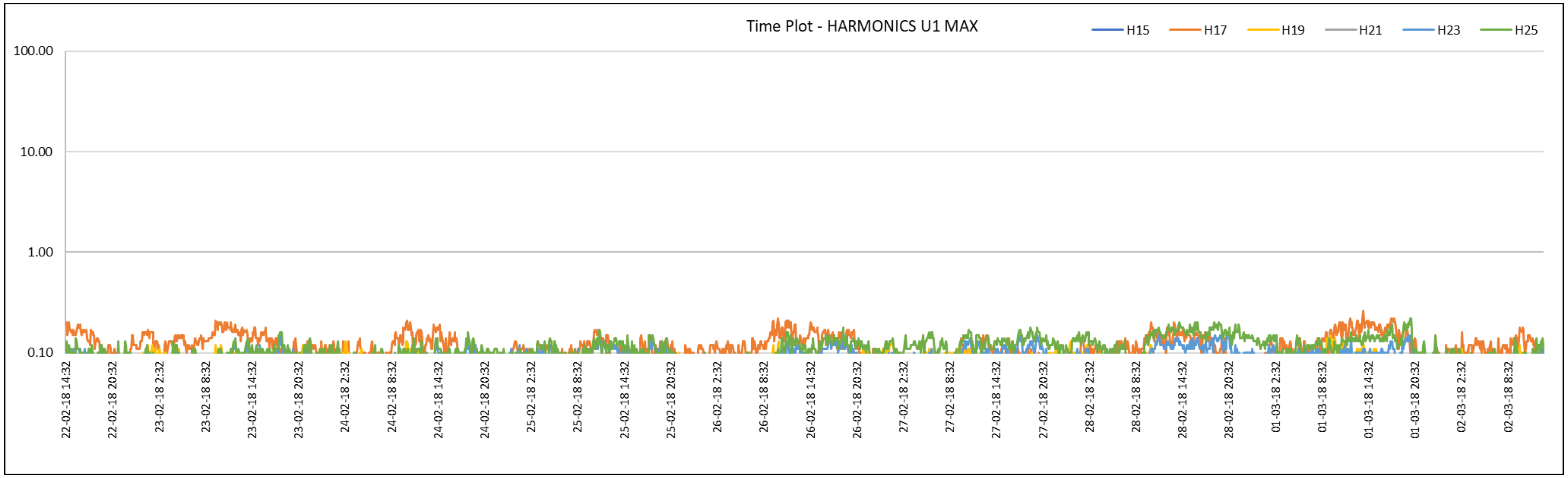

Figure 155 | STS1 – start of feeder – 15th to 25th (odd) harmonics (Red Phase)

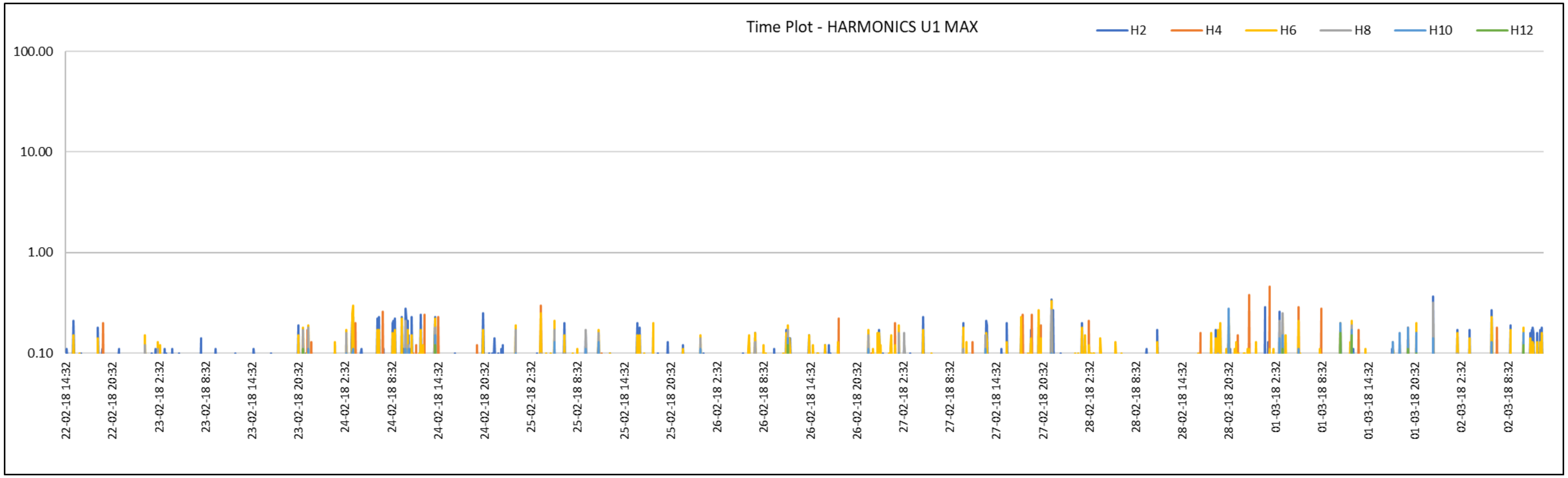

Figure 156 | STS1 – start of feeder – 2th to 12th (even) harmonics (Red Phase)

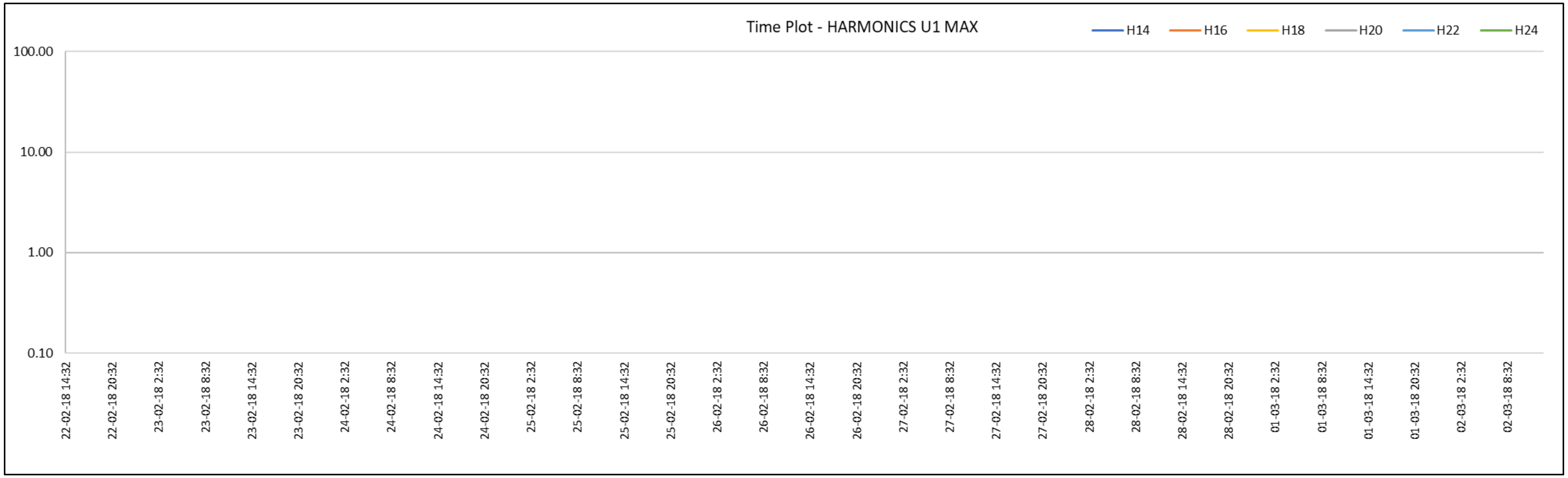

Figure 157 | STS1 – start of feeder – 14th to 24th (even) harmonics (Red Phase)

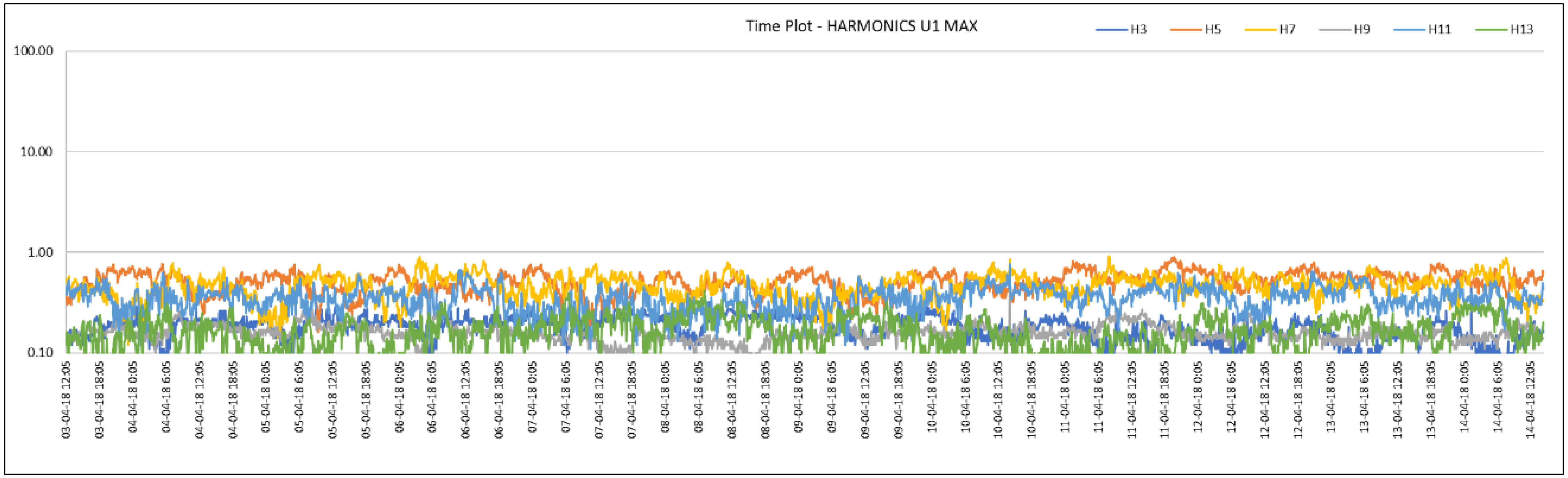

Figure 158 | STS1 – end of feeder – 3rd to 13th (odd) harmonics (Red Phase)

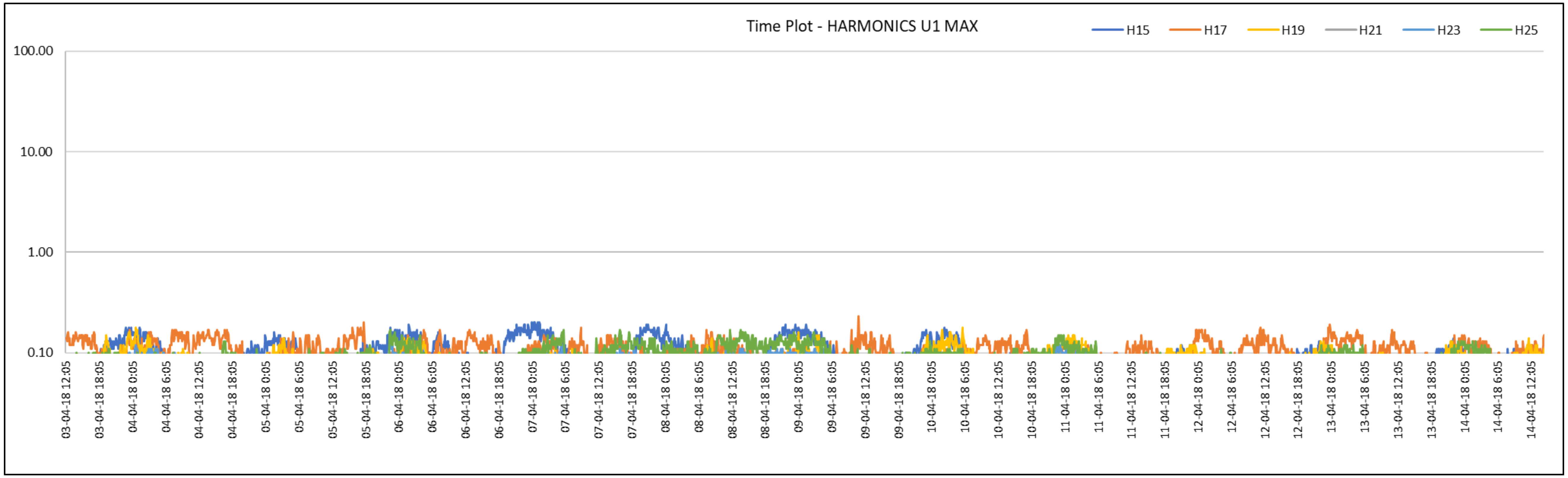

Figure 159 | STS1 – end of feeder – 15th to 25th (odd) harmonics (Red Phase)

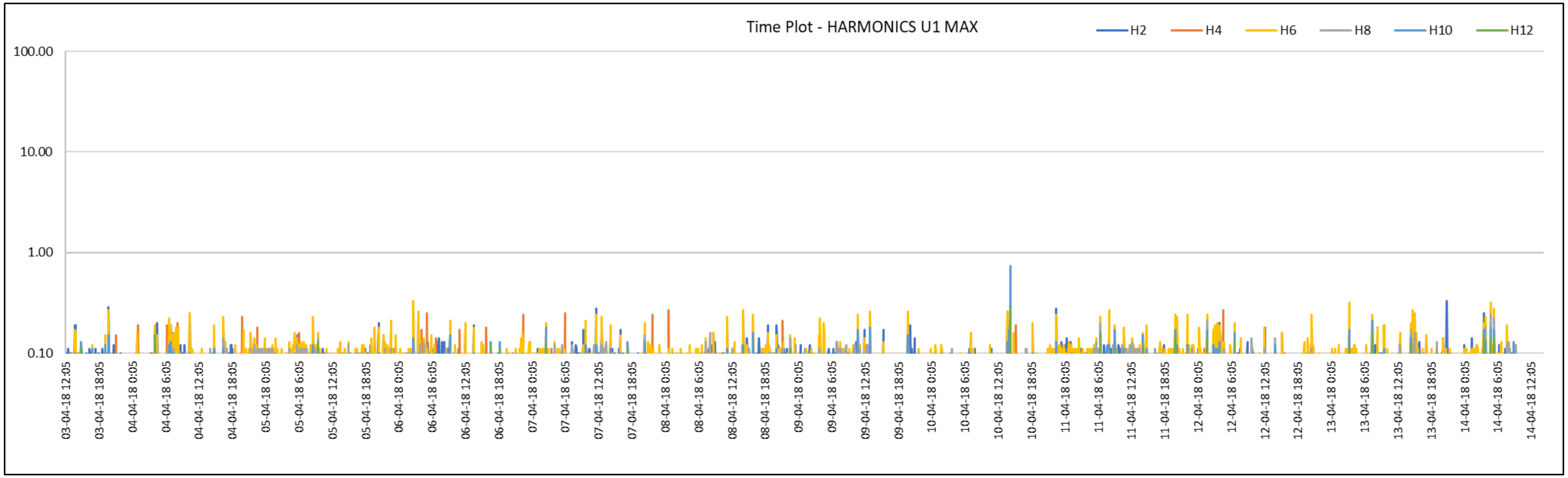

Figure 160 | STS1 – end of feeder – 2th to 12th (even) harmonics (Red Phase)

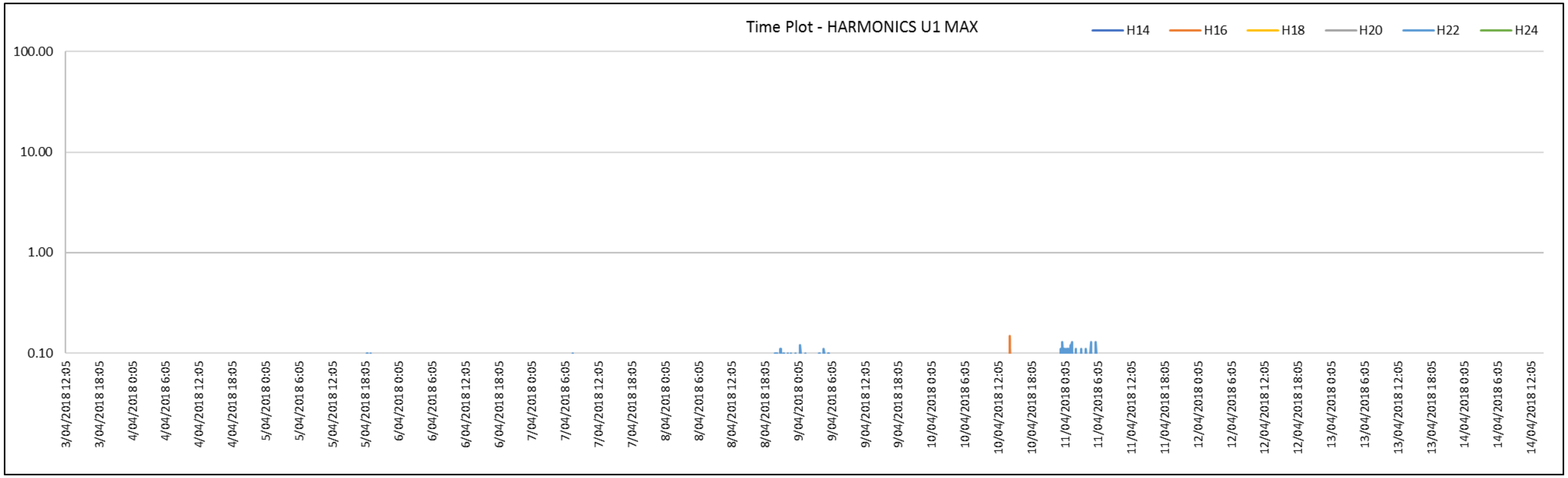

Figure 161 | STS1 – end of feeder – 14th to 24th (even) harmonics (Red Phase)

STS2 Feeder – Flicker, Voltage, Frequency, and Harmonics

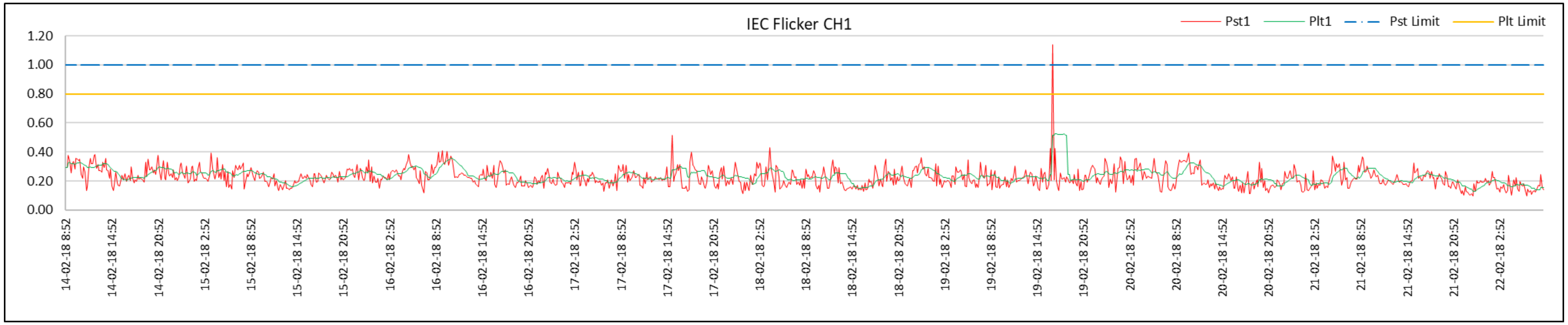

Figure 162 | STS2 - start of feeder – flicker measurements (Red Phase)

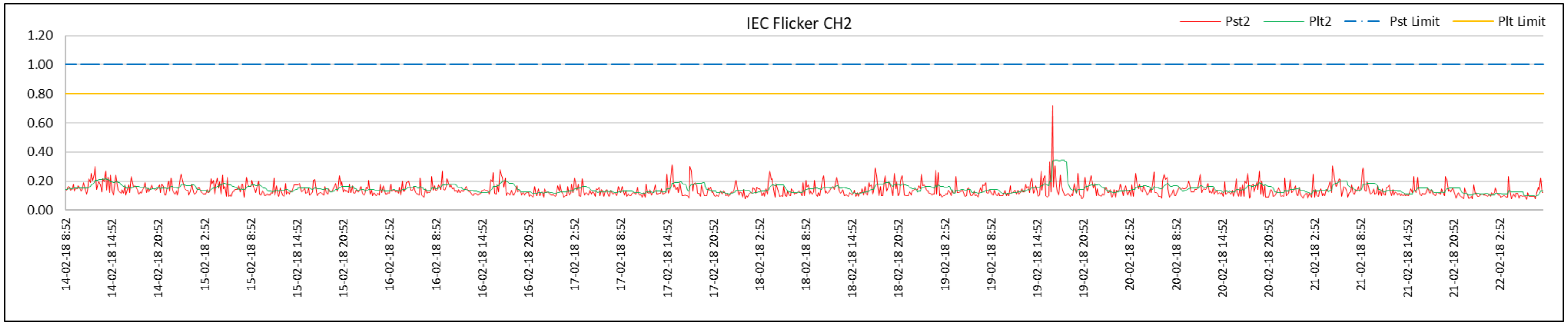

Figure 163 | STS2- start of feeder – flicker measurements (White Phase)

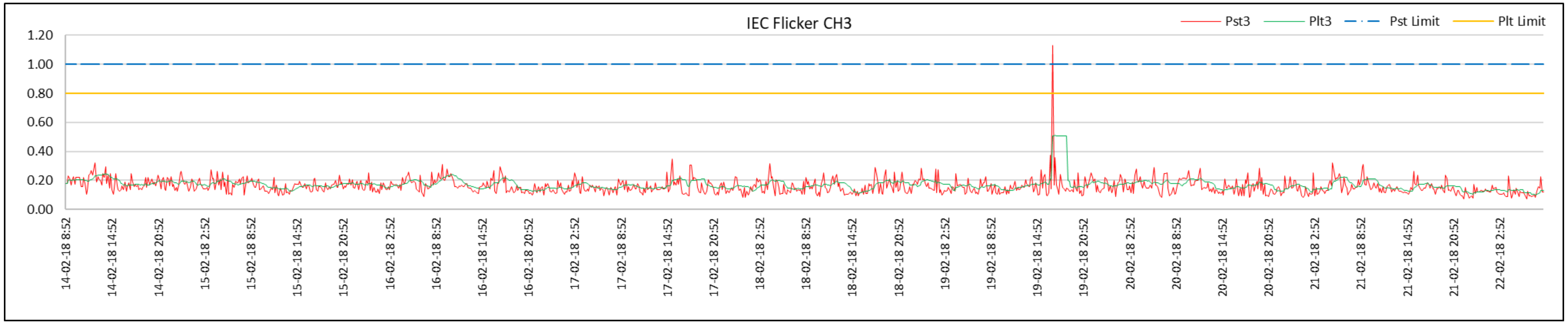

Figure 164 | STS2 - start of feeder – flicker measurements (Blue Phase)

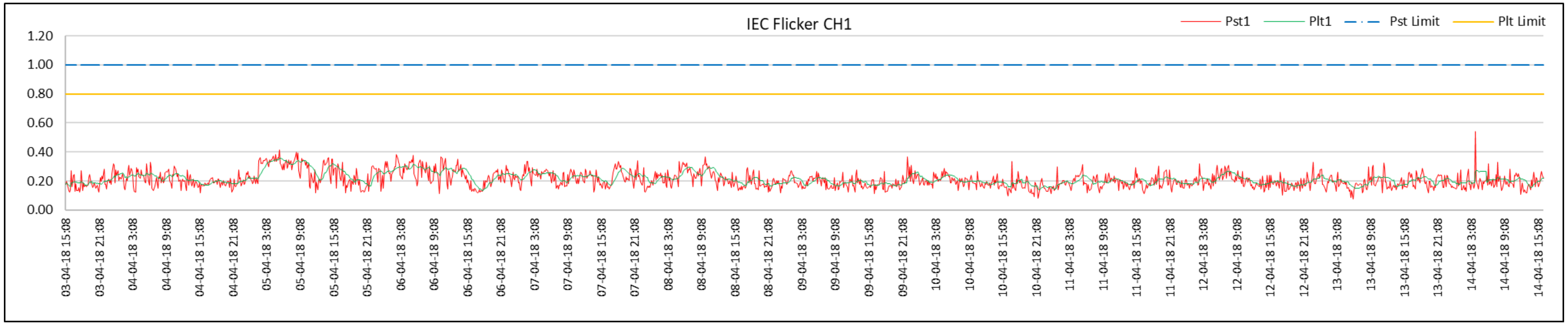

Figure 165 | STS2 – end of feeder – flicker measurements (Red Phase)

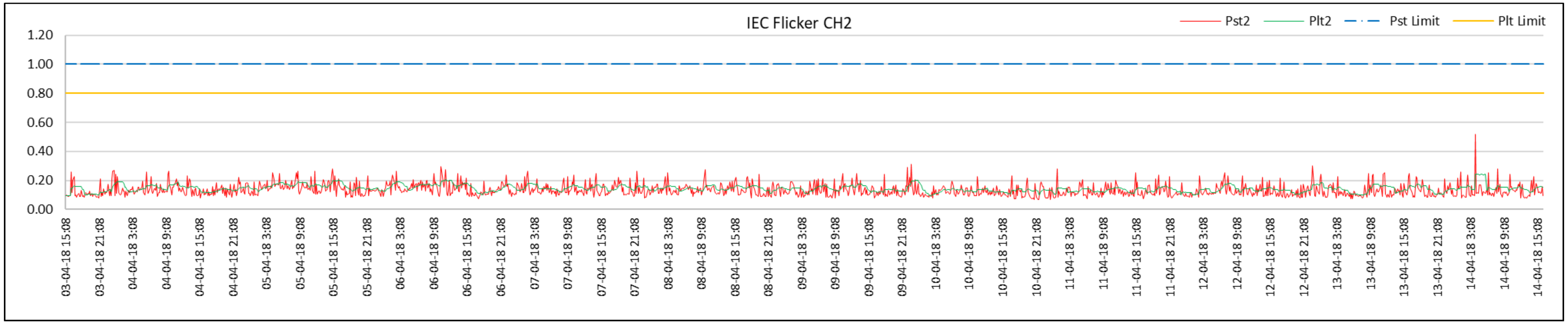

Figure 166 | STS2 - end of feeder – flicker measurements (White Phase)

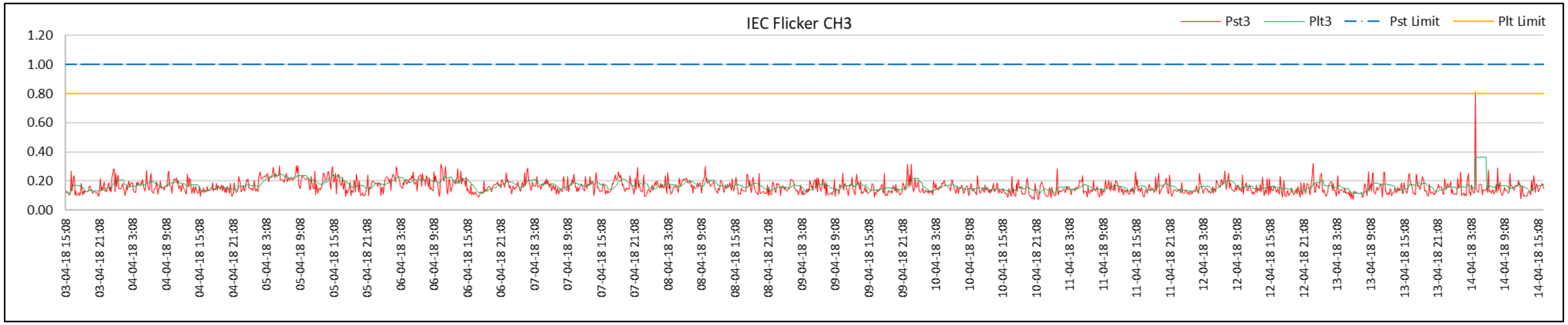

Figure 167 | STS2 - end of feeder – flicker measurements (Blue Phase)

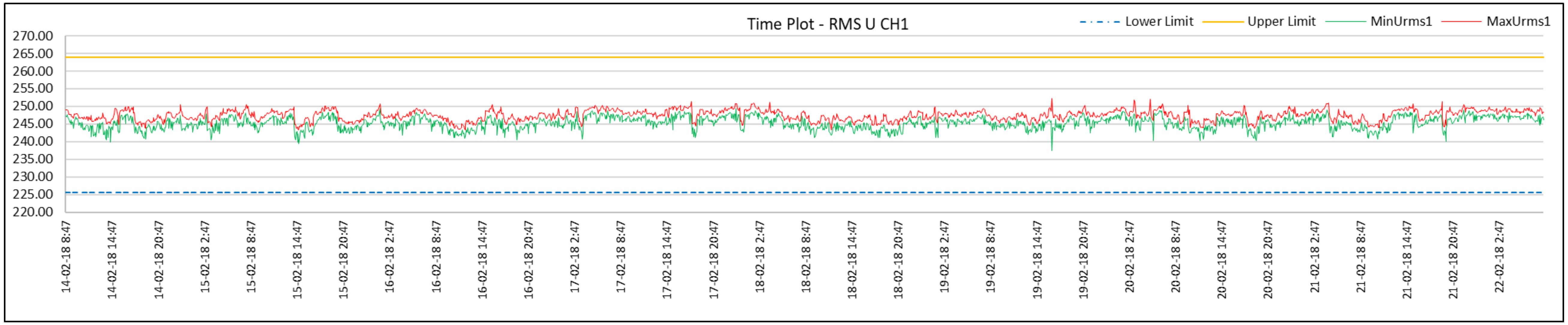

Figure 168 | STS2 - start of feeder – voltage measurements (Red Phase)

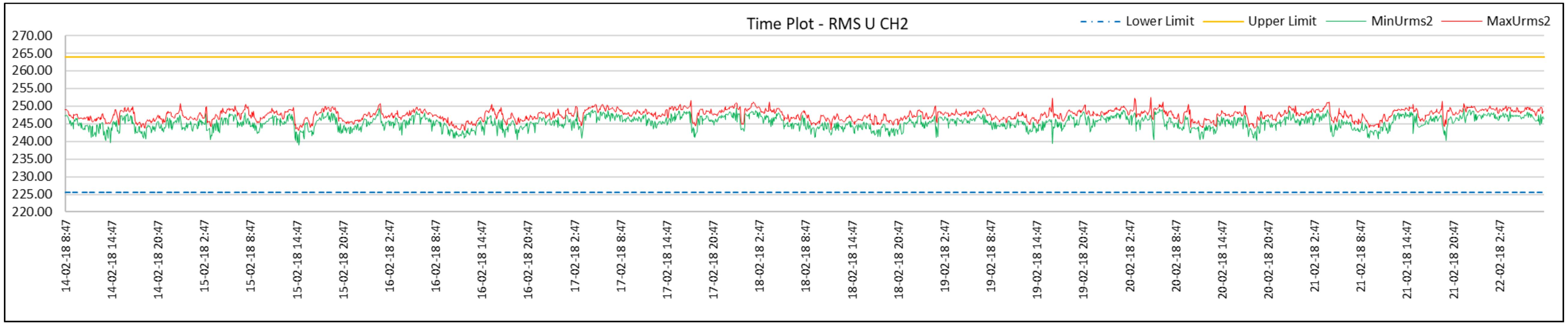

Figure 169 | STS2 - start of feeder – voltage measurements (White Phase)

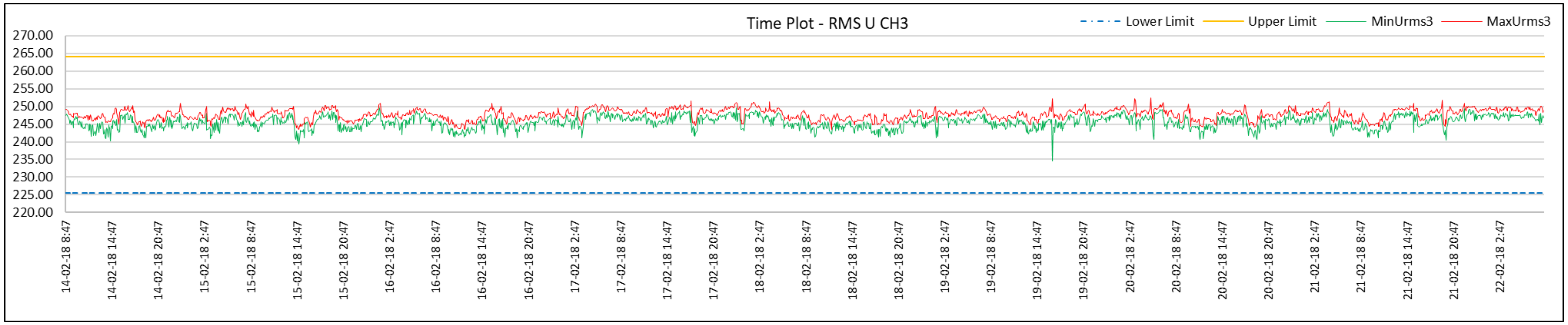

Figure 170 | STS2 - start of feeder – voltage measurements (Blue Phase)

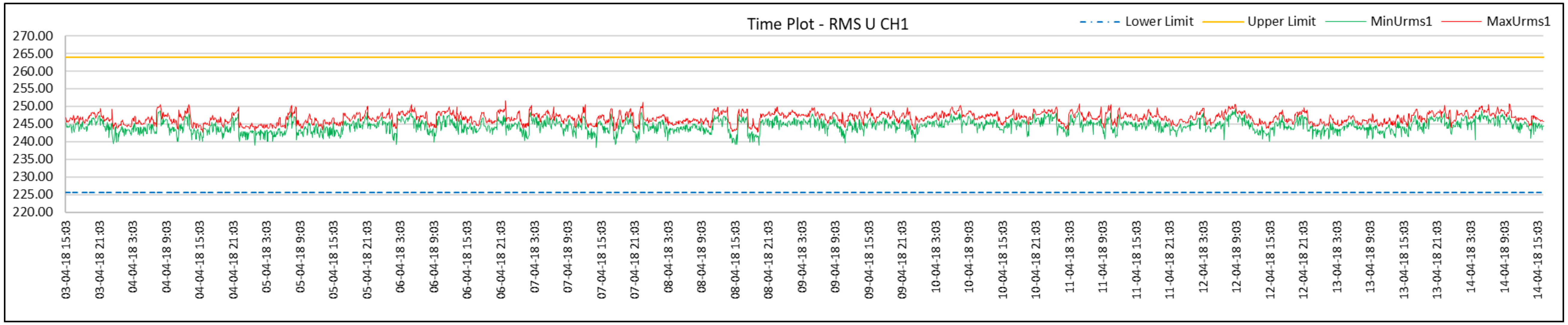

Figure 171 | STS2 - end of feeder – voltage measurements (Red Phase)

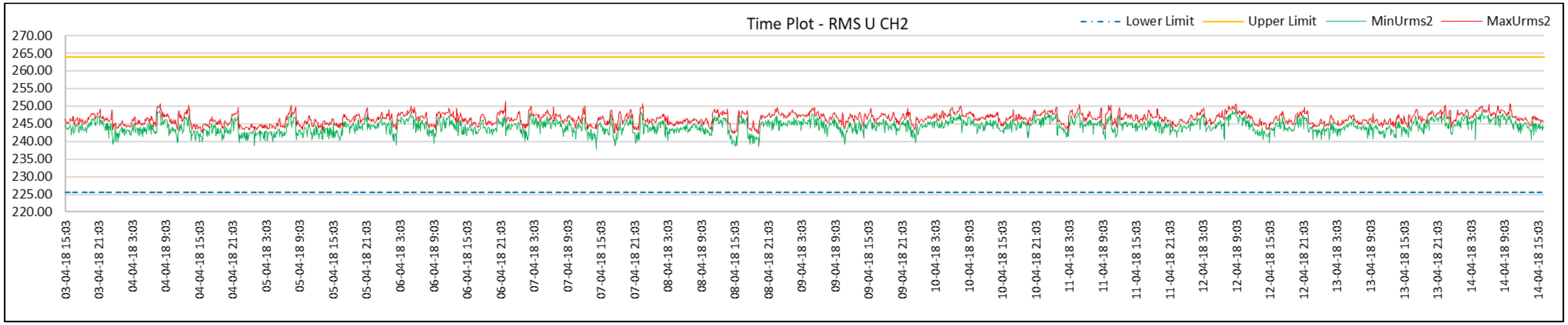

Figure 172 | STS2 - end of feeder – voltage measurements (White Phase)

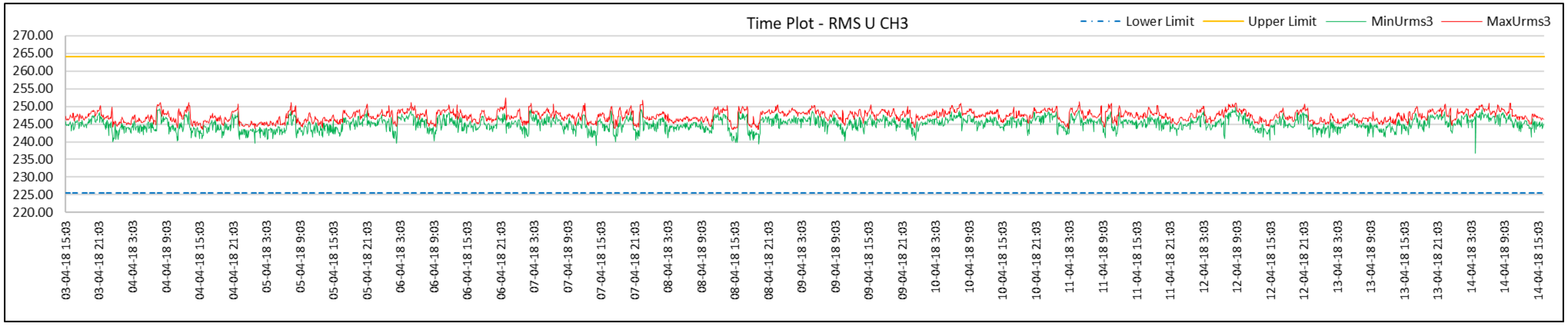

Figure 173 | STS2 - end of feeder – voltage measurements (Blue Phase)

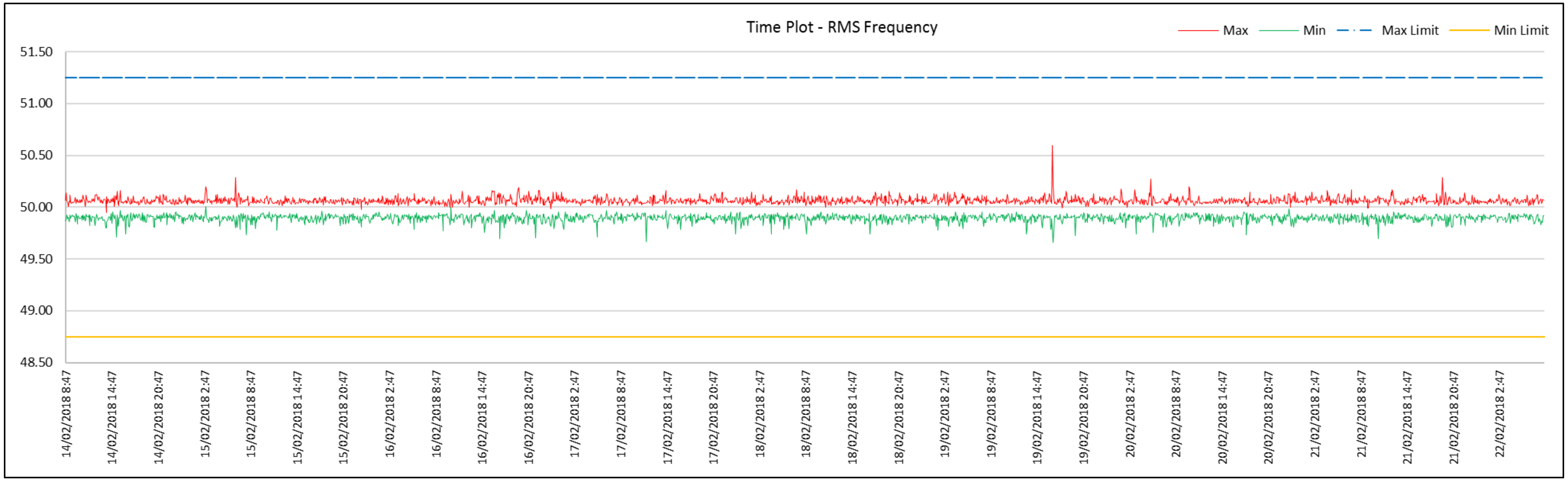

Figure 174 | STS2 - start of feeder – frequency measurements

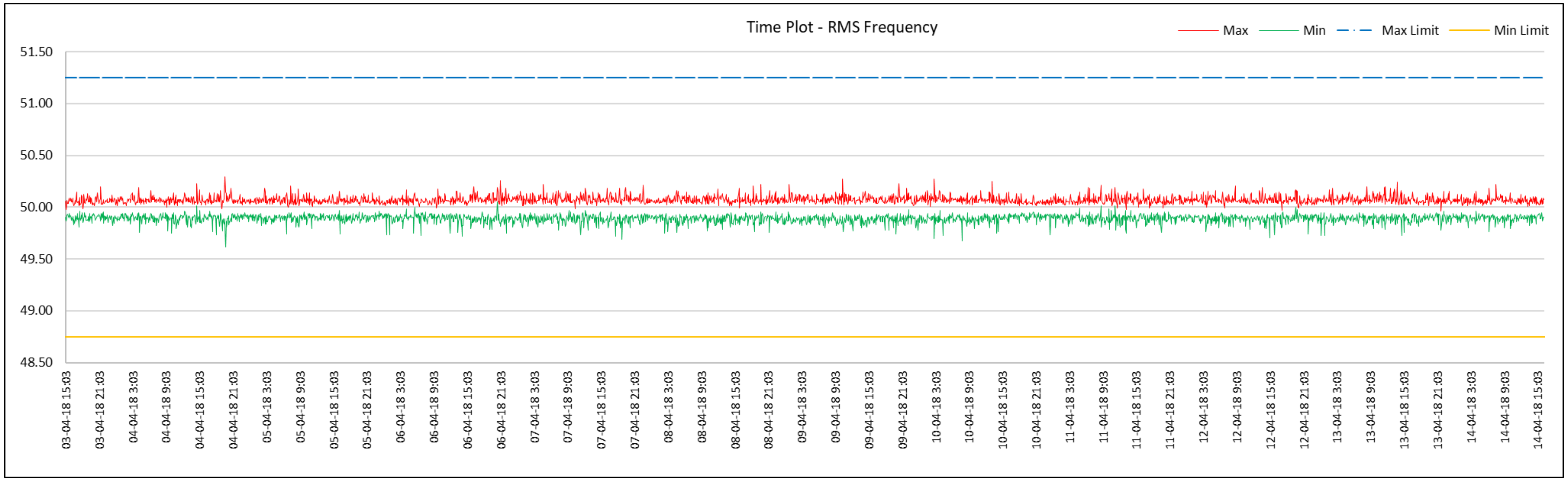

Figure 175 | STS2 - end of feeder – frequency measurements

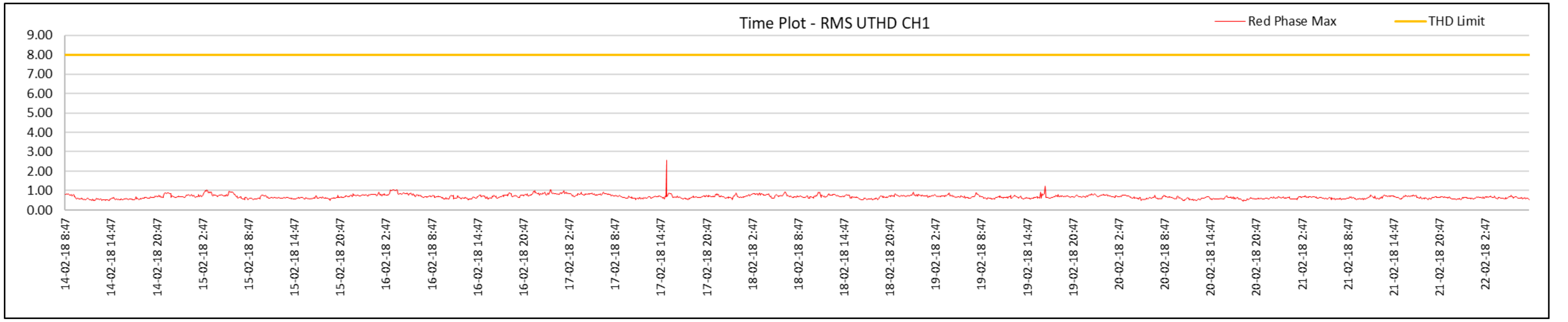

Figure 176 | STS2 - start of feeder – voltage THD measurements (Red Phase)

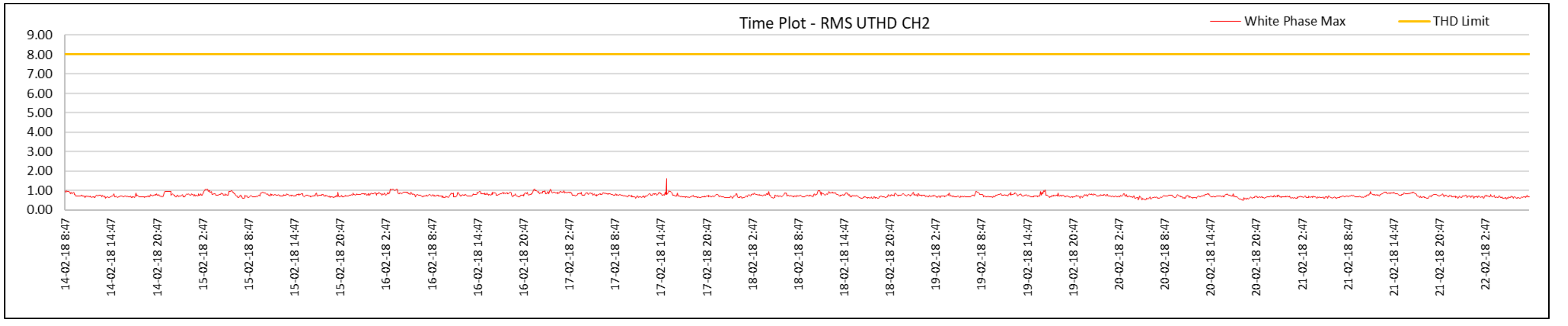

Figure 177 | STS2 - start of feeder – voltage THD measurements (White Phase)

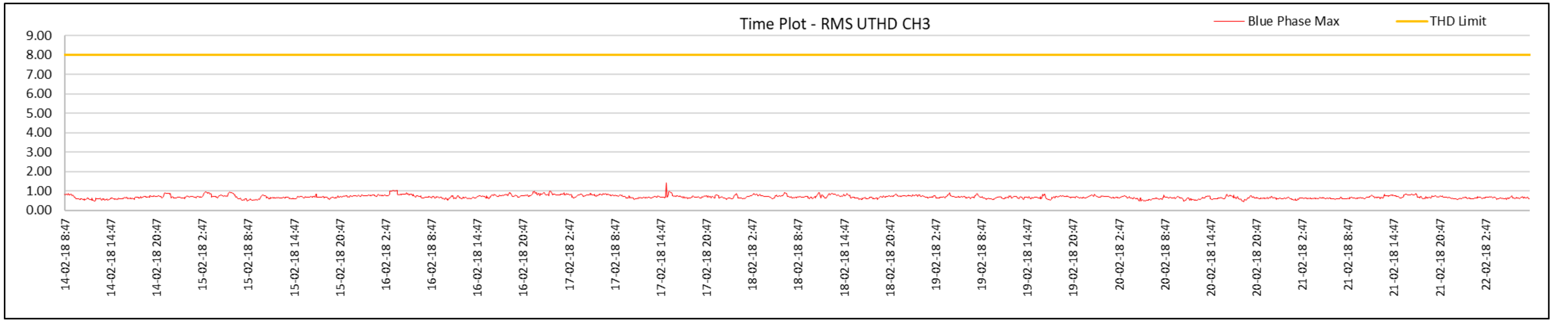

Figure 178 | STS2 - start of feeder – voltage THD measurements (Blue Phase)

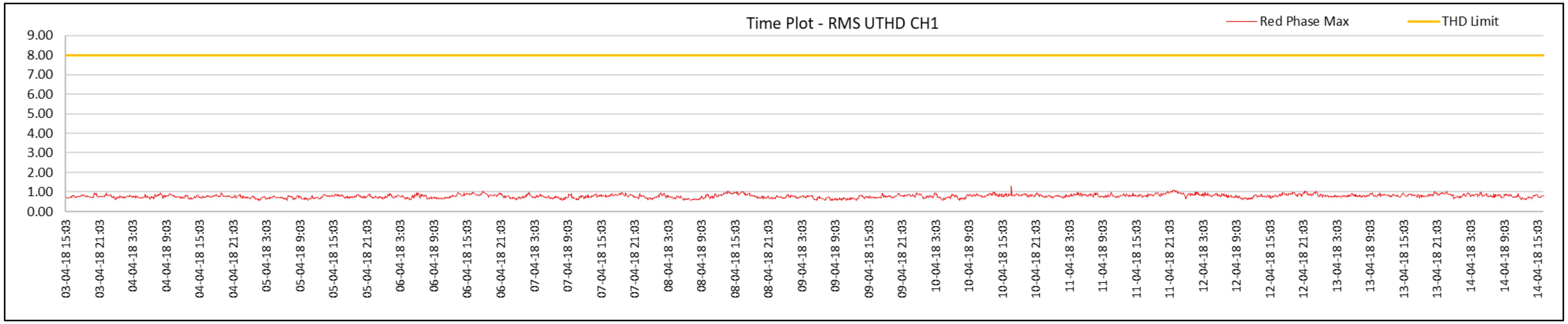

Figure 179 | STS2 - end of feeder – voltage THD measurements (Red Phase)

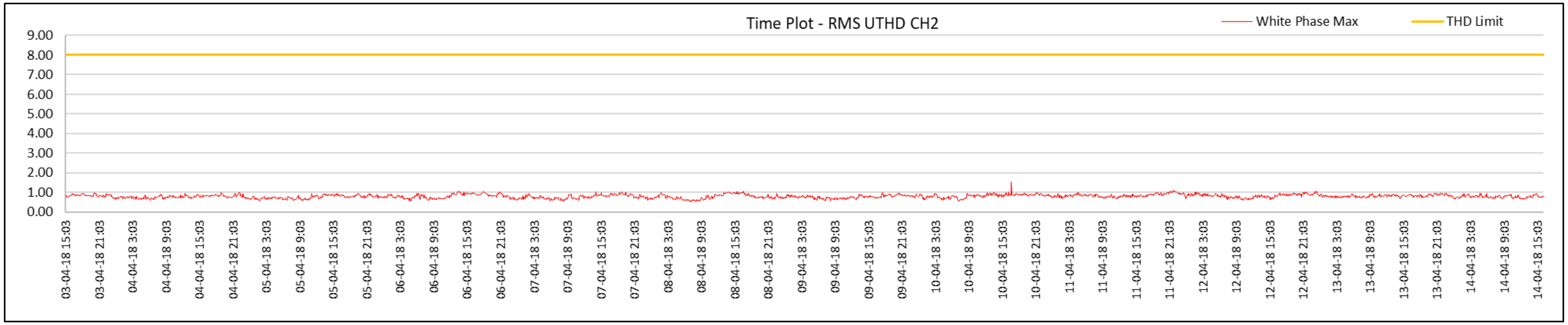

Figure 180 | STS2 - end of feeder – voltage THD measurements (White Phase)

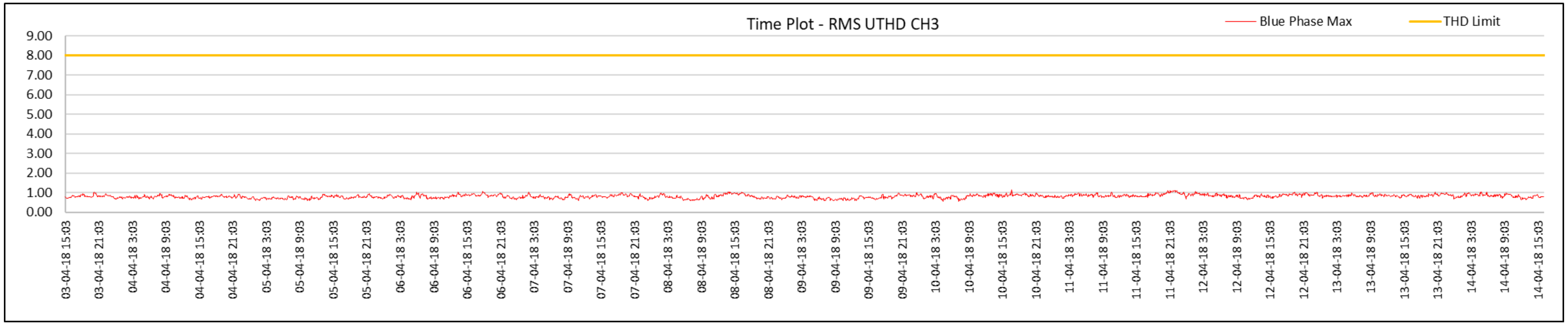

Figure 181 | STS2 - end of feeder – voltage THD measurements (Blue Phase)

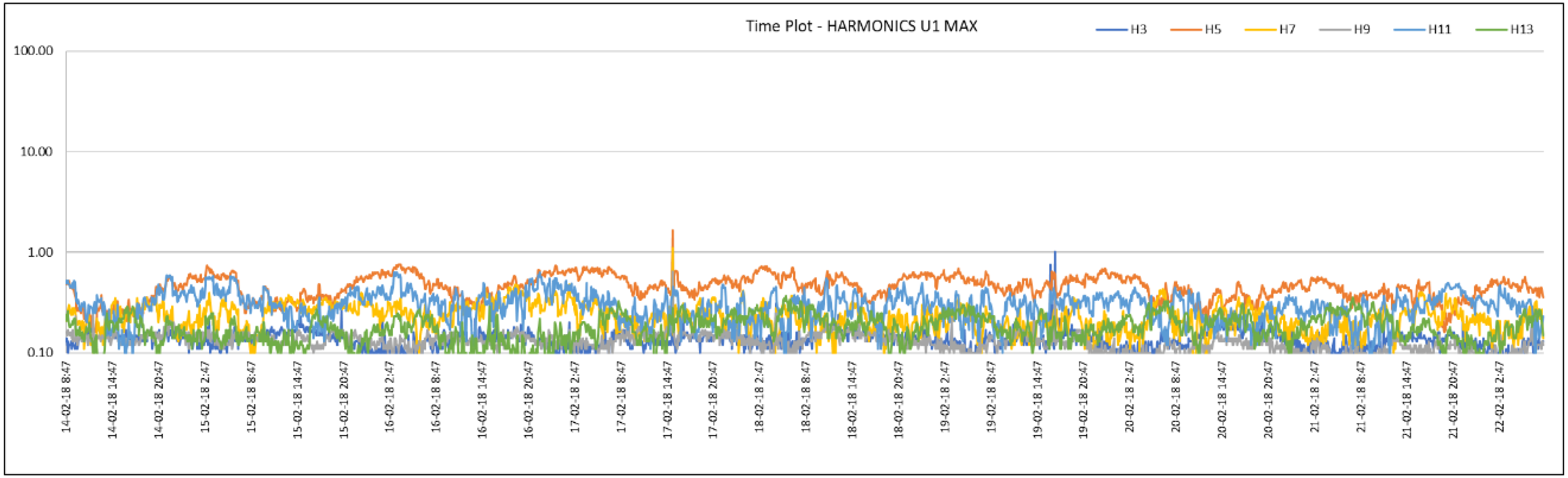

Figure 182 | STS2 – start of feeder – 3rd to 13th (odd) harmonics (Red Phase)

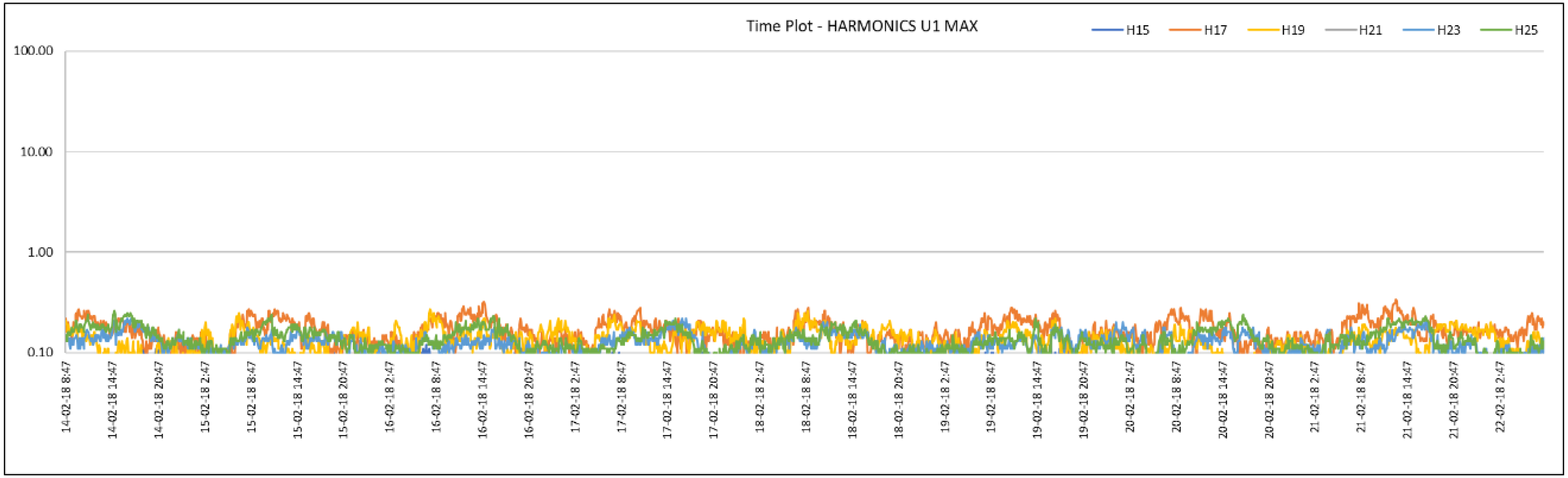

Figure 183 | STS2 – start of feeder – 15th to 25th (odd) harmonics (Red Phase)

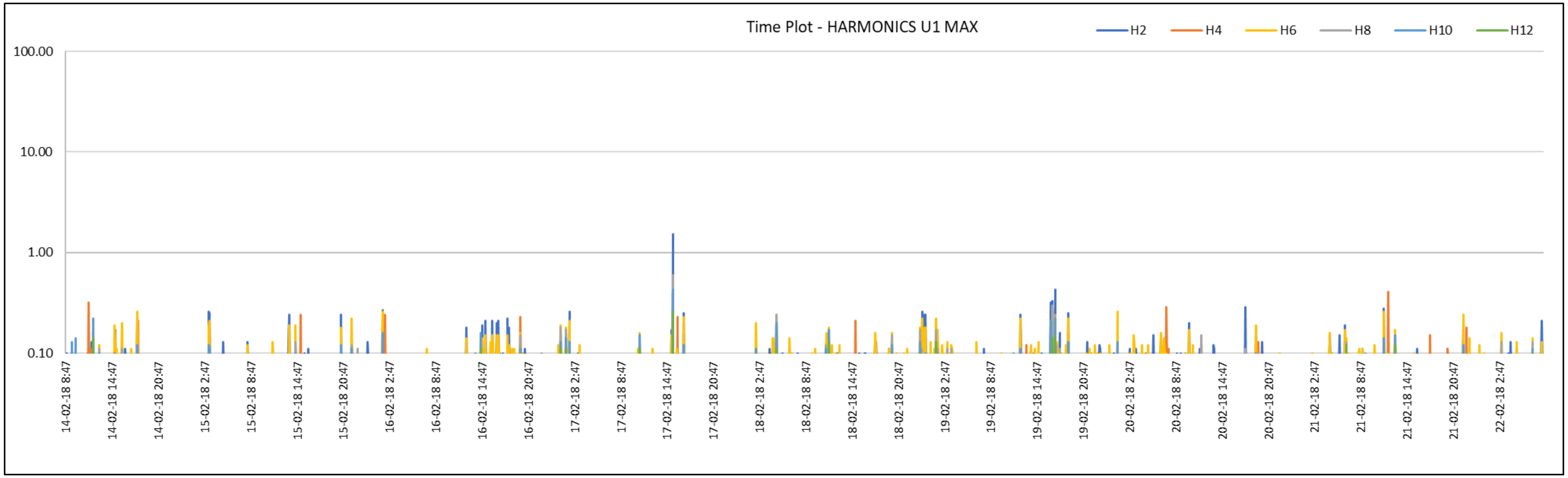

Figure 184 | STS2 – start of feeder – 2th to 12th (even) harmonics (Red Phase)

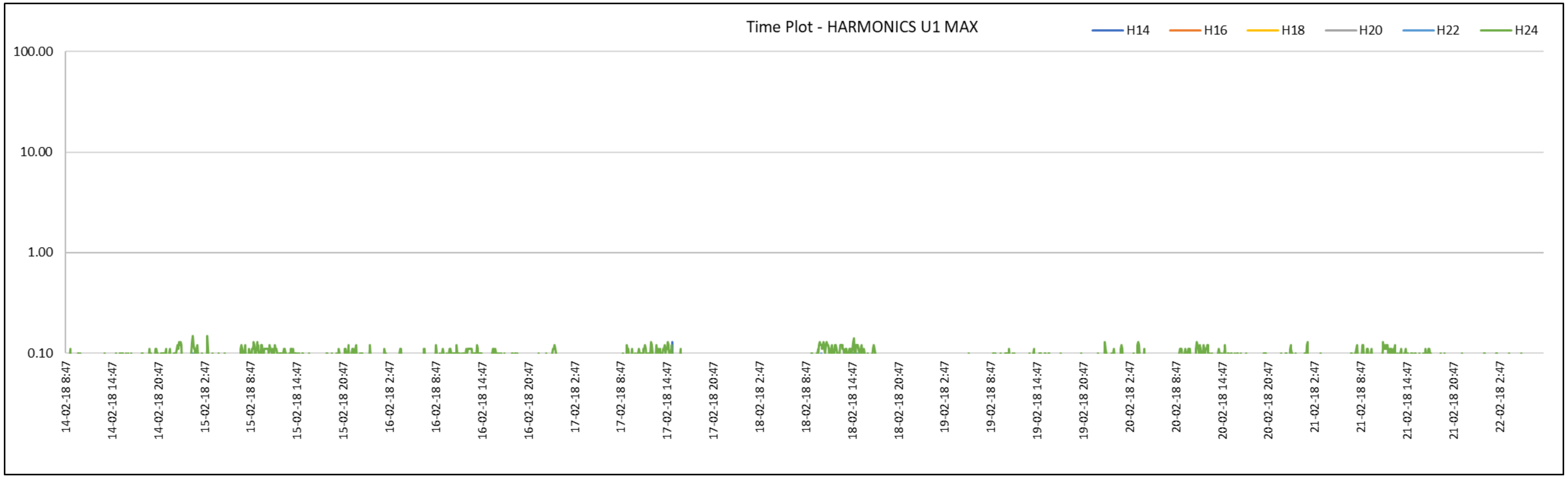

Figure 185 | STS2 – start of feeder – 14th to 24th (even) harmonics (Red Phase)

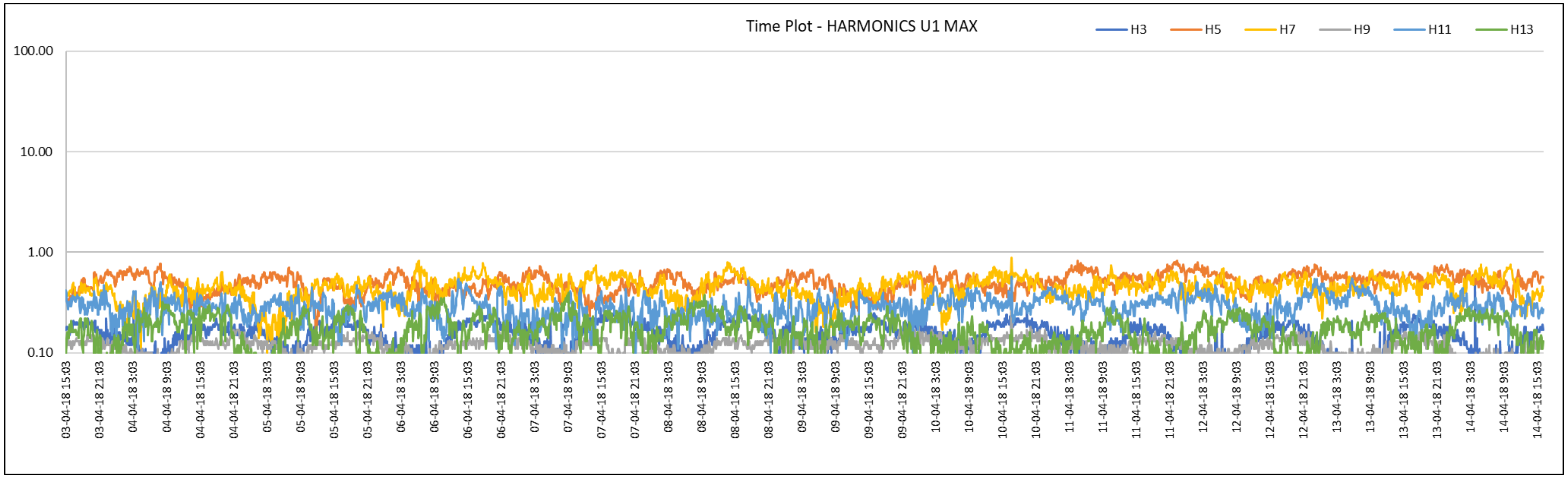

Figure 186 | STS2 – end of feeder – 3rd to 13th (odd) harmonics (Red Phase)

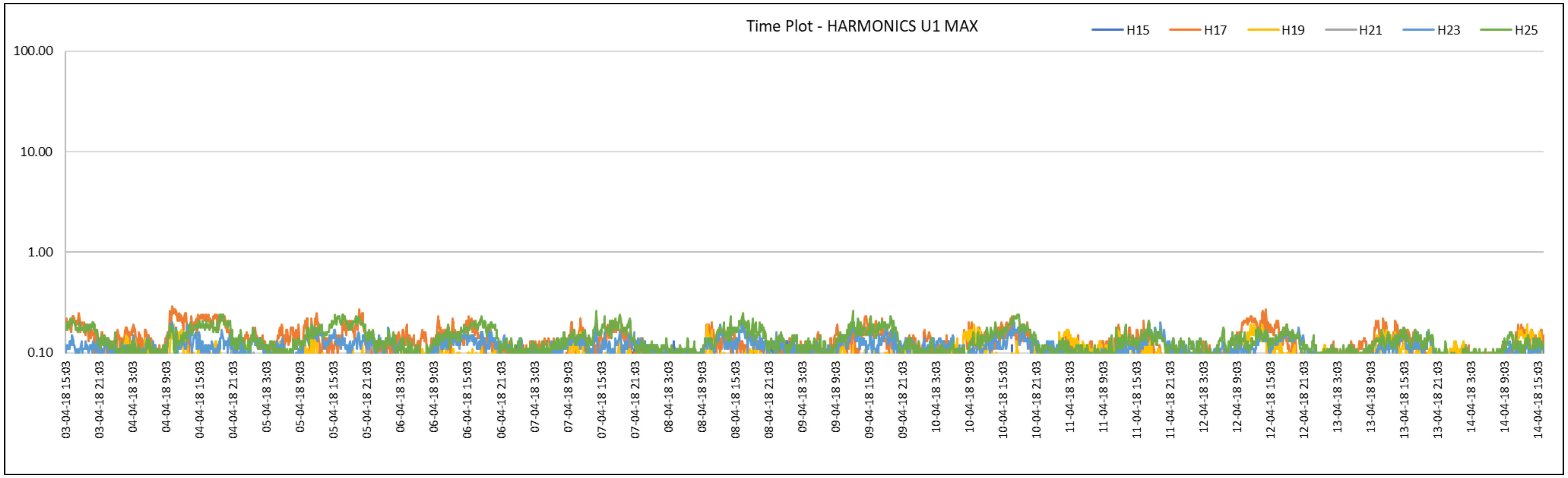

Figure 187 | STS2 – end of feeder – 15th to 25th (odd) harmonics (Red Phase)

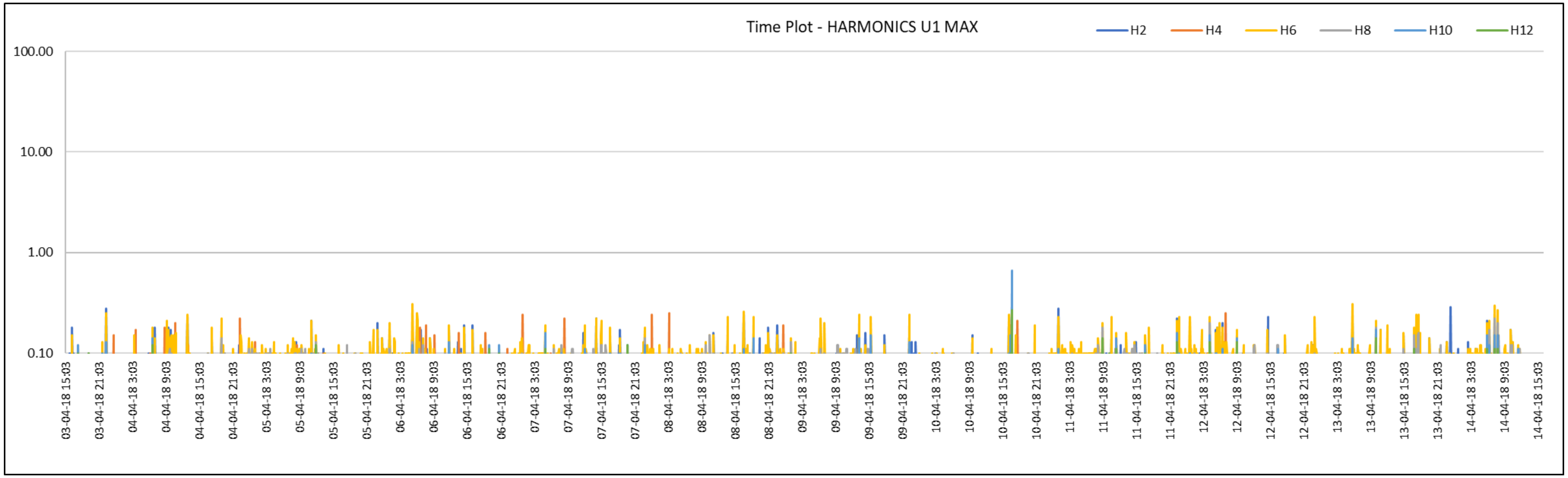

Figure 188 | STS2 – end of feeder – 2th to 12th (even) harmonics (Red Phase)

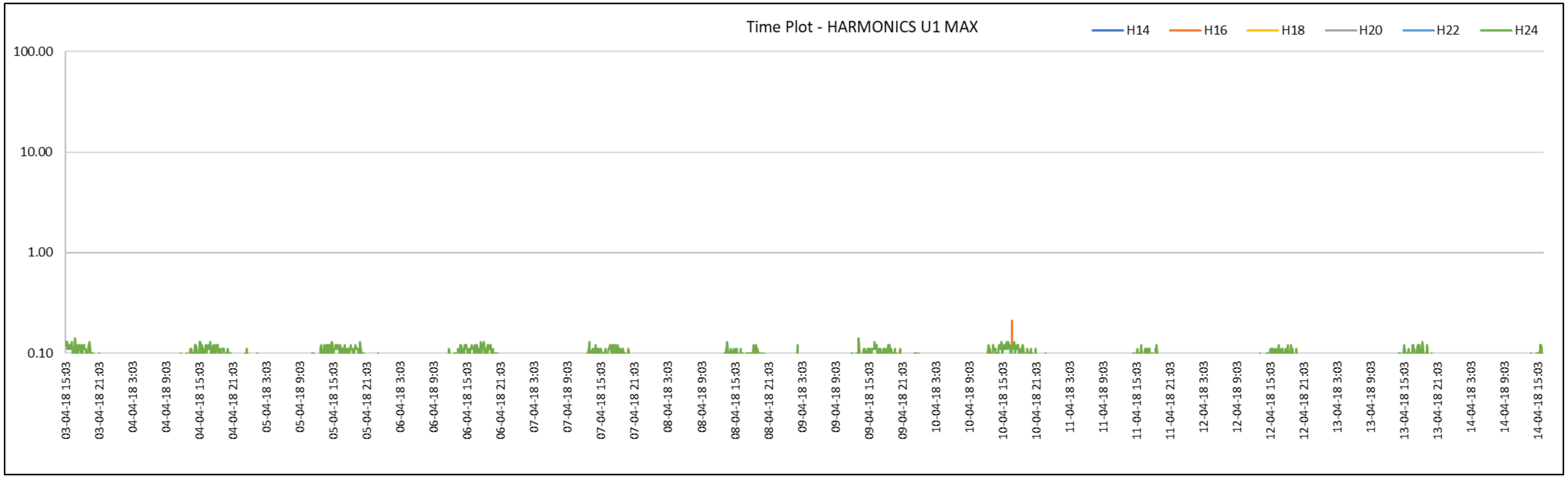

Figure 189 | STS2 – end of feeder – 14th to 24th (even) harmonics (Red Phase)

STS6 Feeder – Flicker, Voltage, Frequency, and Harmonics

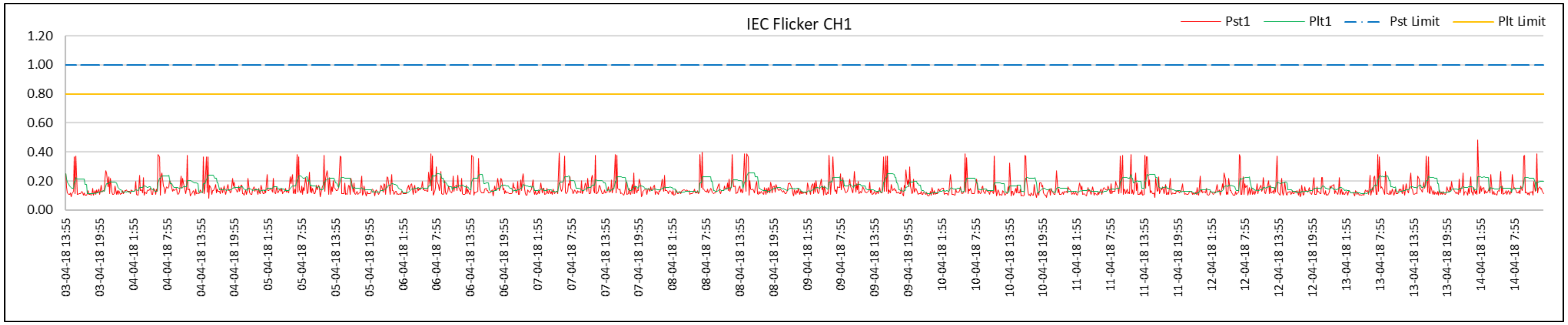

Figure 190 | STS6 - start of feeder – flicker measurements (Red Phase)

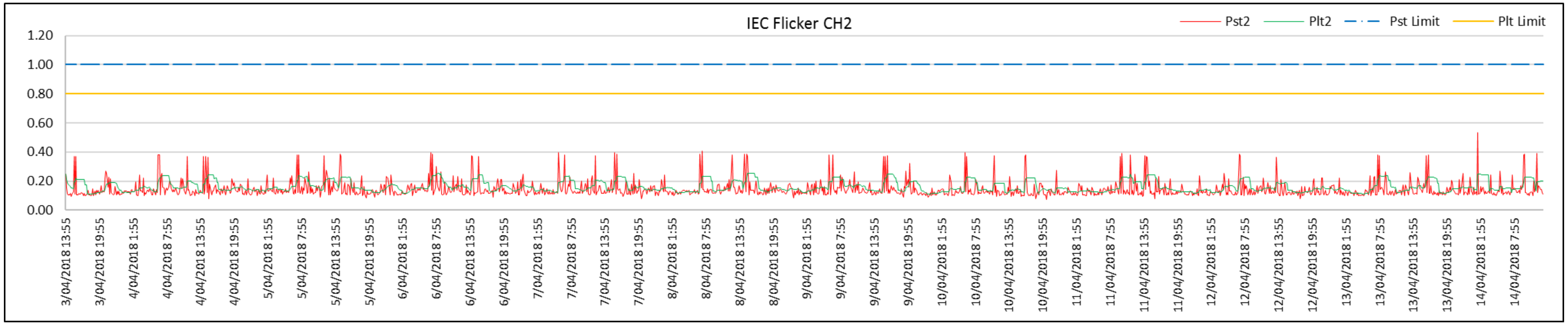

Figure 191 | STS6 - start of feeder – flicker measurements (White Phase)

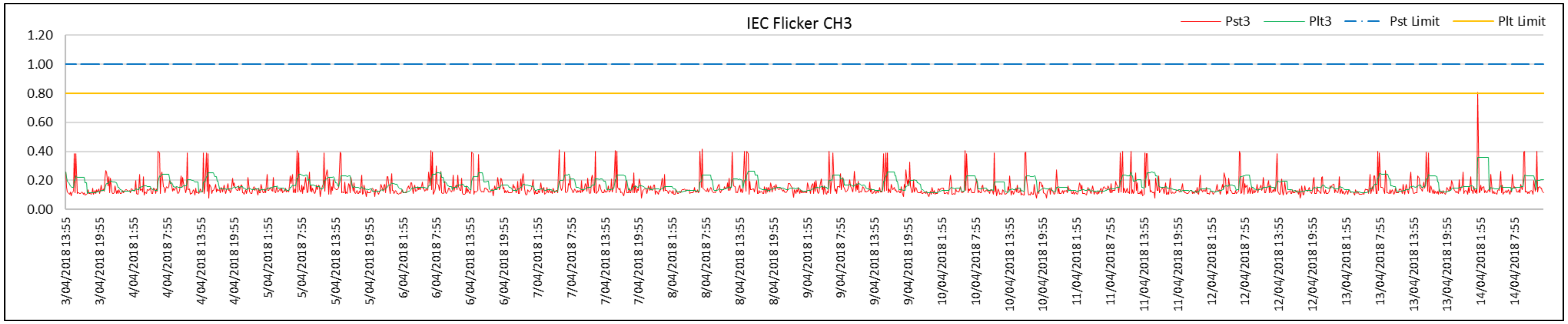

Figure 192 | STS6 - start of feeder – flicker measurements (Blue Phase)

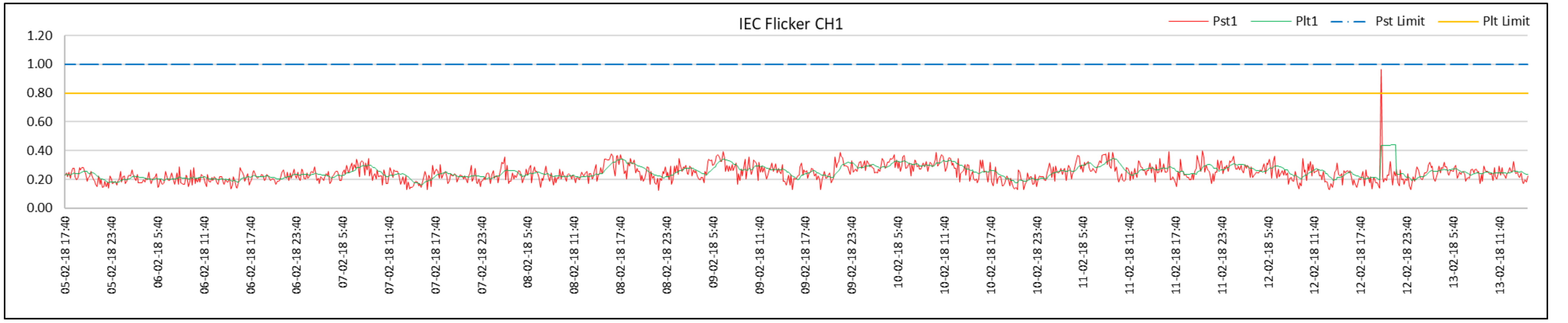

Figure 193 | STS6 – end of feeder – flicker measurements (Red Phase)

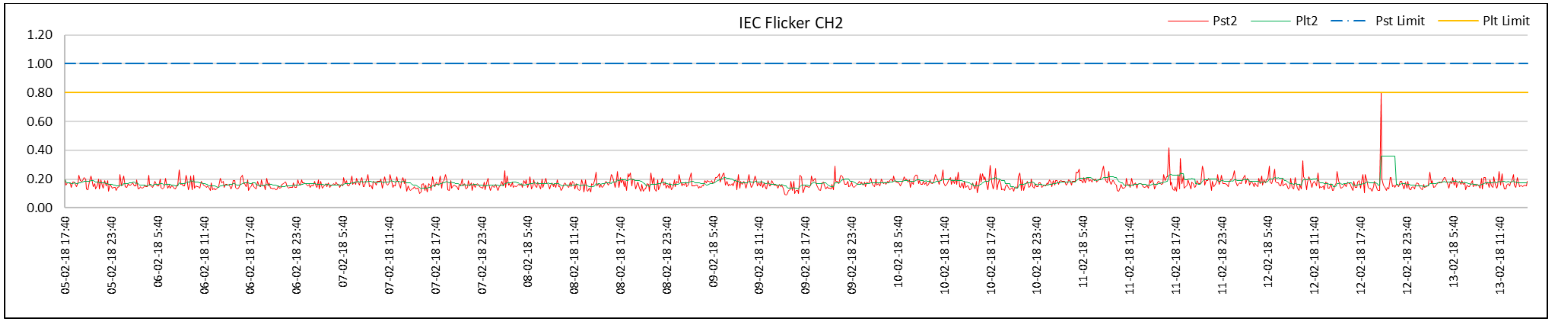

Figure 194 | STS6 - end of feeder – flicker measurements (White Phase)

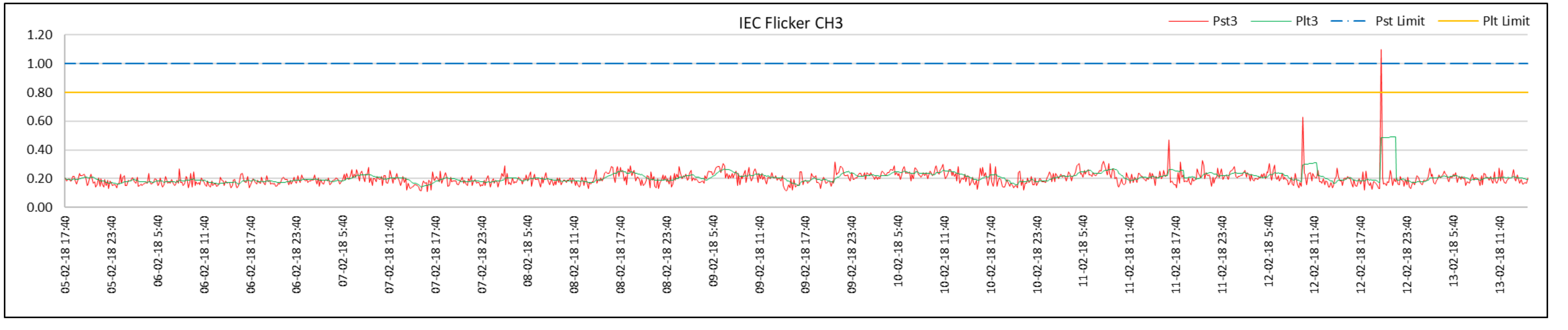

Figure 195 | STS6 - end of feeder – flicker measurements (Blue Phase)

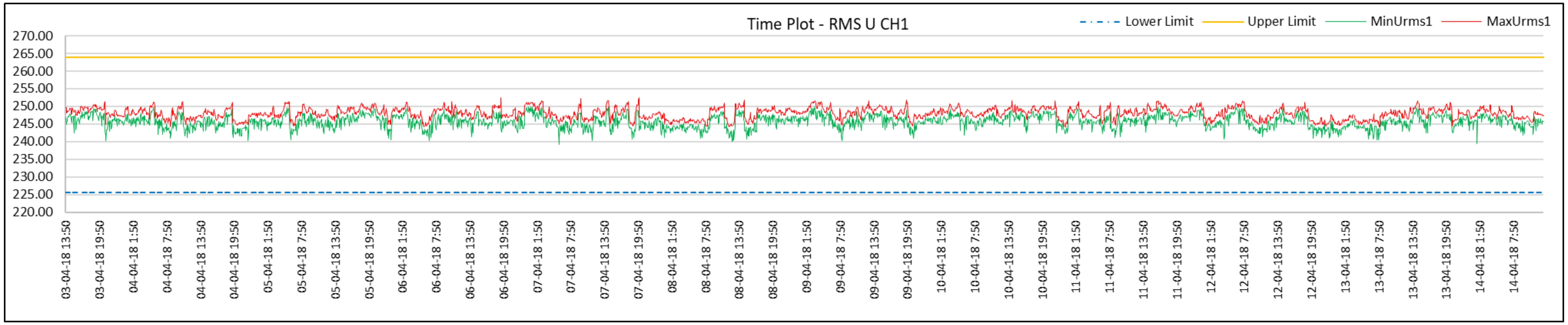

Figure 196 | STS6 - start of feeder – voltage measurements (Red Phase)

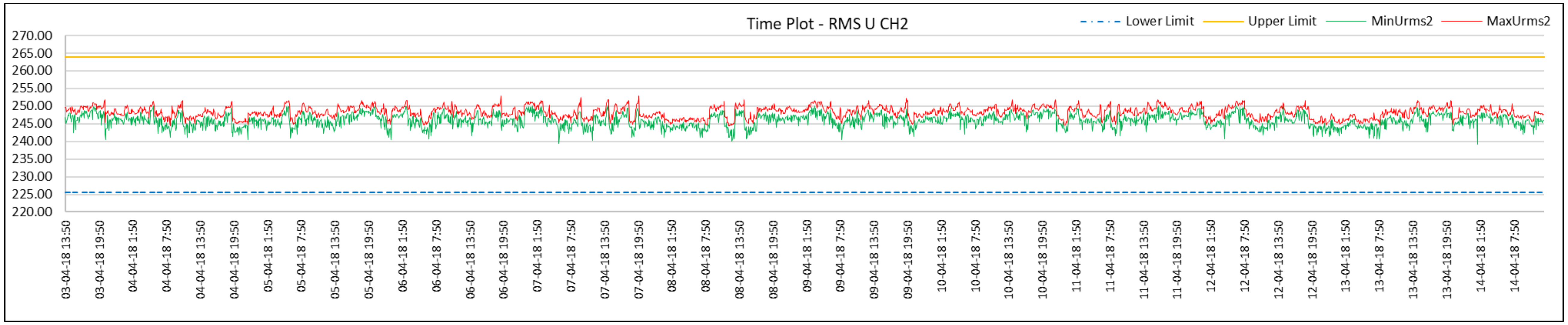

Figure 197 | STS6 - start of feeder – voltage measurements (White Phase)

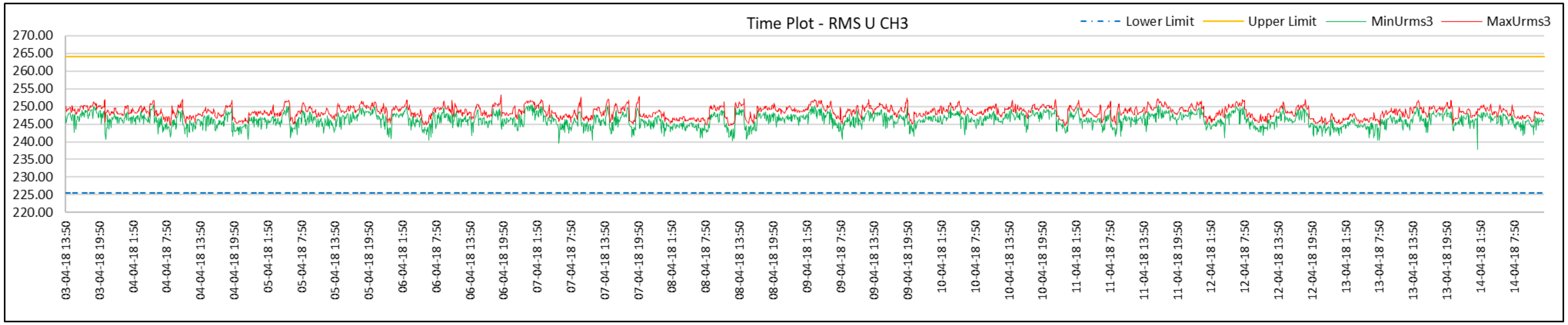

Figure 198 | STS6 - start of feeder – voltage measurements (Blue Phase)

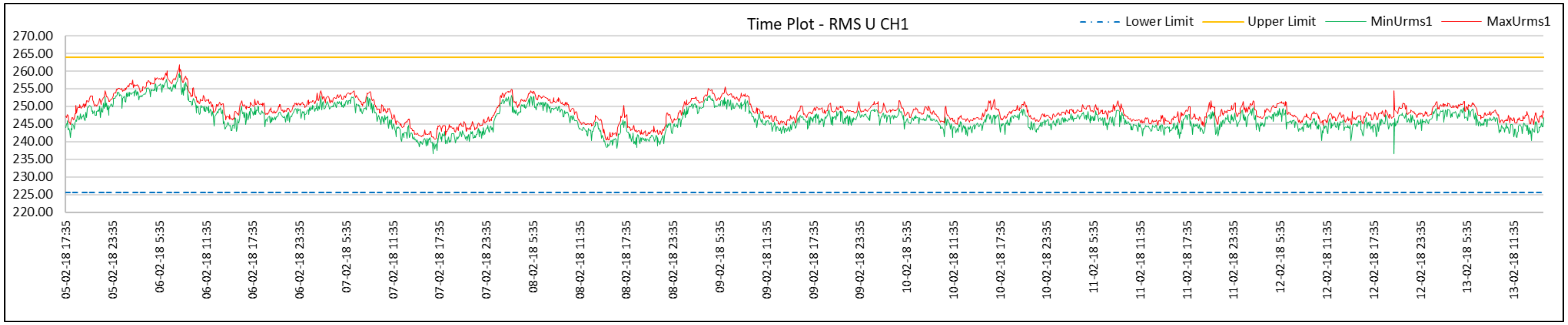

Figure 199 | STS6 - end of feeder – voltage measurements (Red Phase)

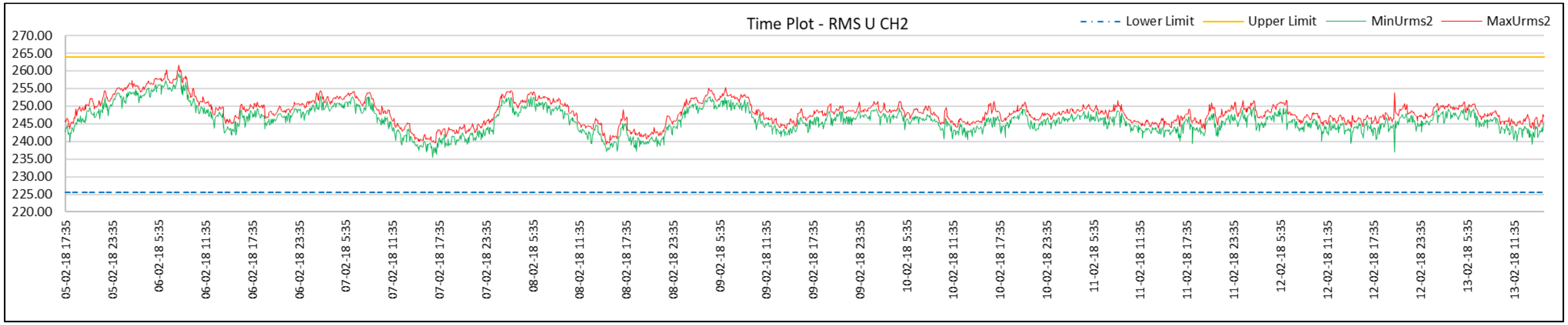

Figure 200 | STS6 - end of feeder – voltage measurements (White Phase)

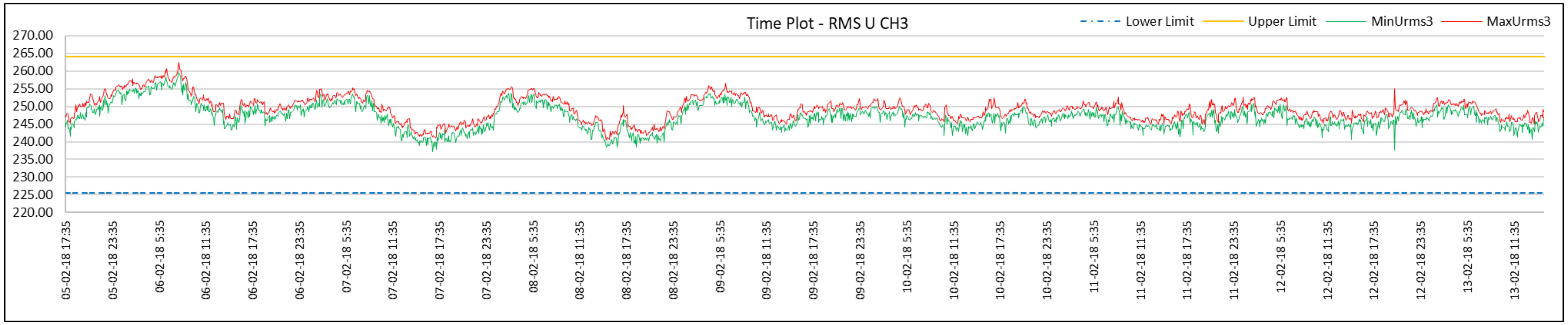

Figure 201 | STS6 - end of feeder – voltage measurements (Blue Phase)

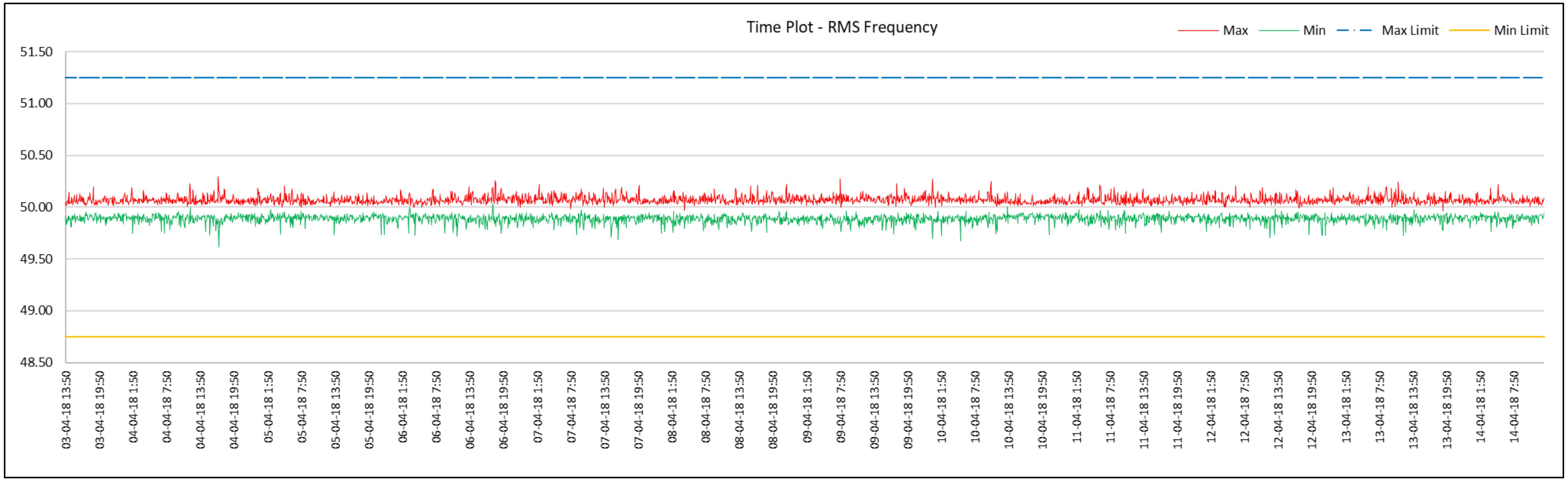

Figure 202 | STS6 - start of feeder – frequency measurements

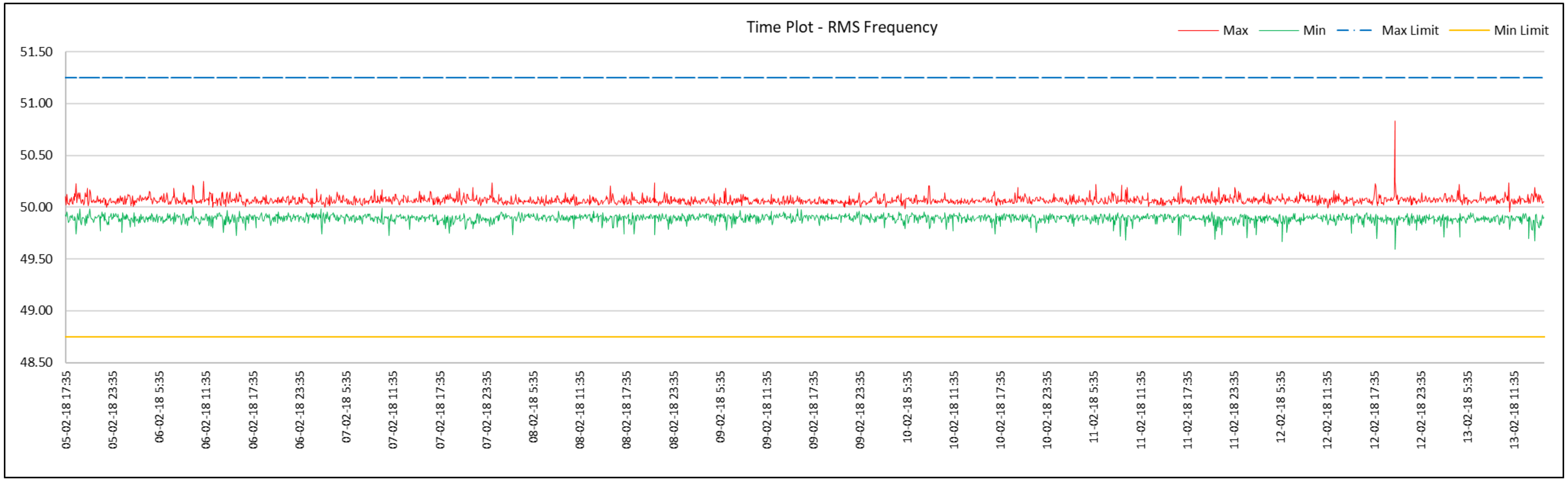

Figure 203 | STS6 - end of feeder – frequency measurements

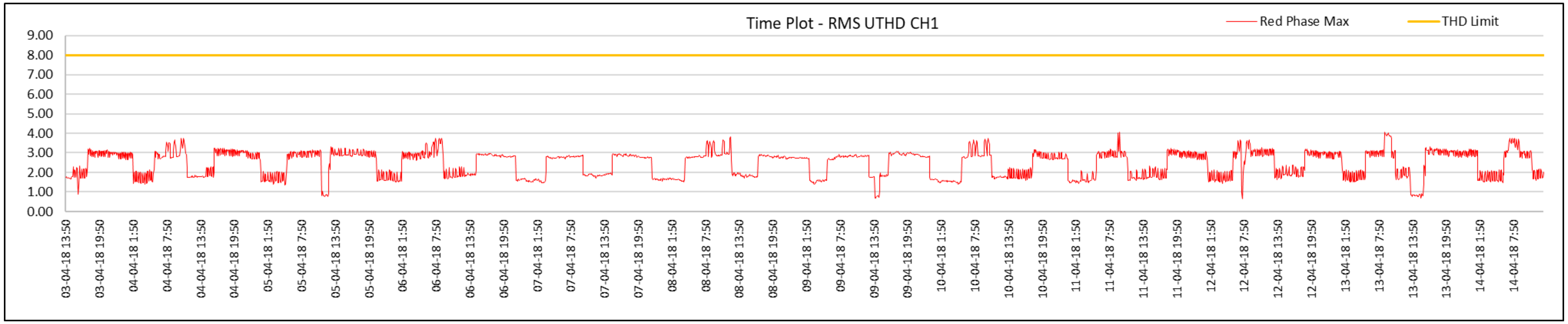

Figure 204 | STS6 - start of feeder – voltage THD measurements (Red Phase)

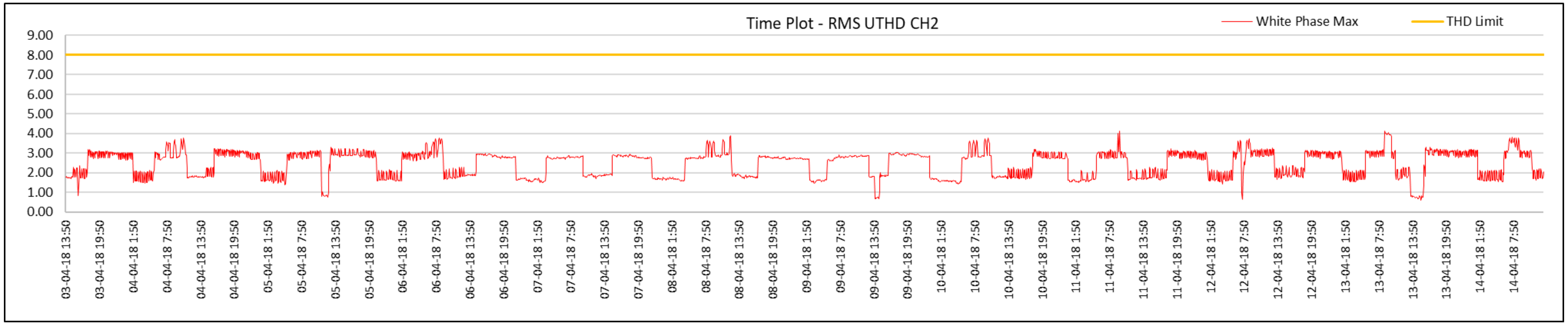

Figure 205 | STS6 - start of feeder – voltage THD measurements (White Phase)

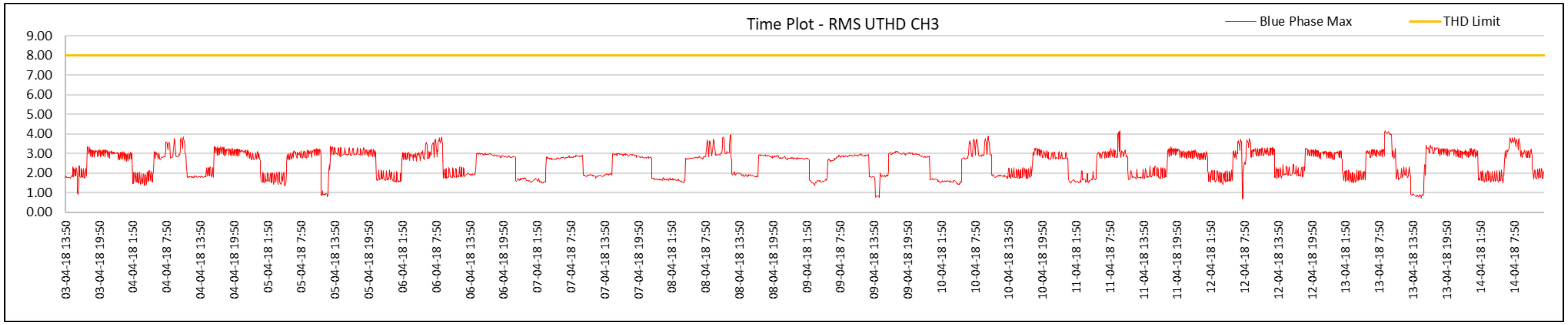

Figure 206 | STS6 - start of feeder – voltage THD measurements (Blue Phase)

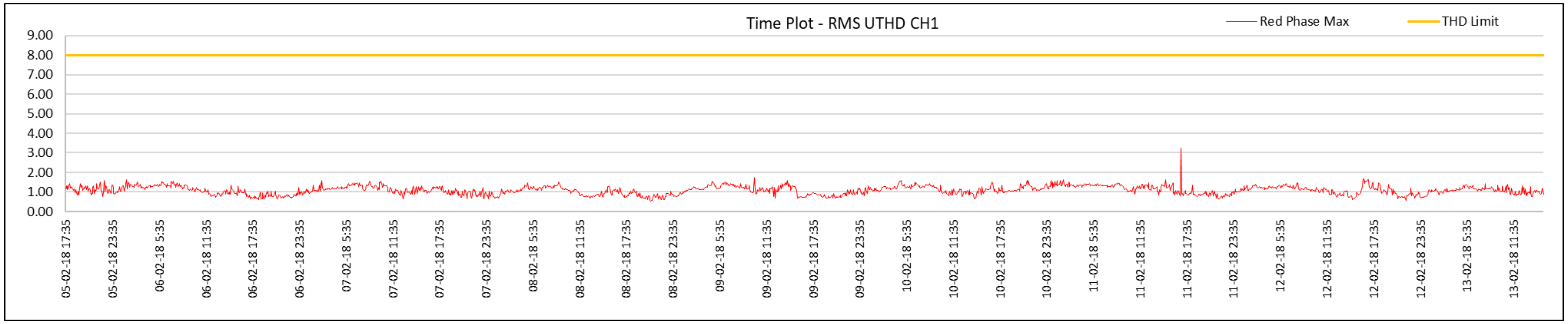

Figure 207 | STS6 - end of feeder – voltage THD measurements (Red Phase)

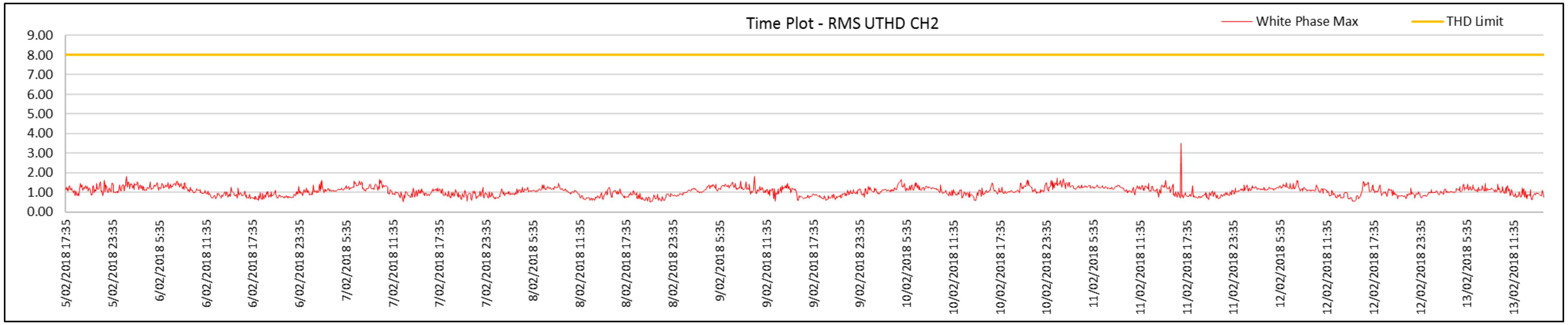

Figure 208 | STS6 - end of feeder – voltage THD measurements (White Phase)

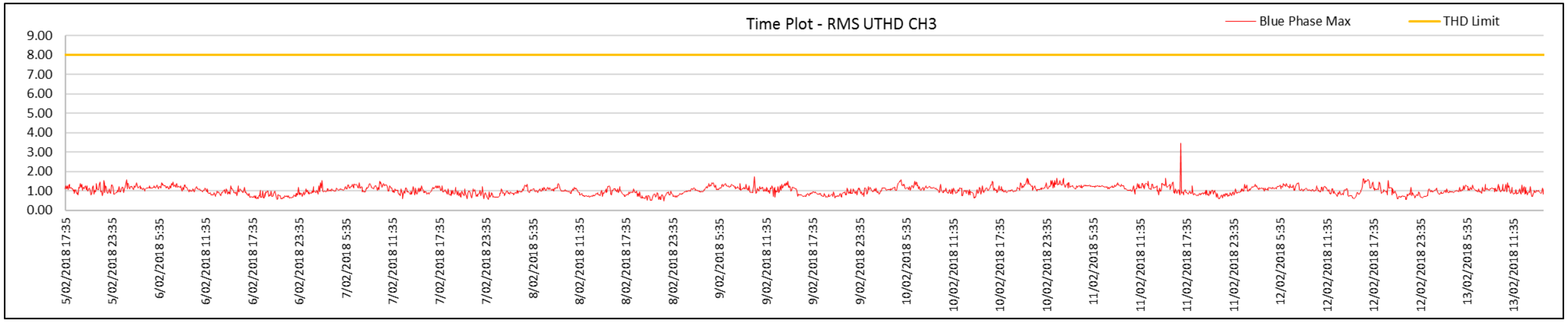

Figure 209 | STS6 - end of feeder – voltage THD measurements (Blue Phase)

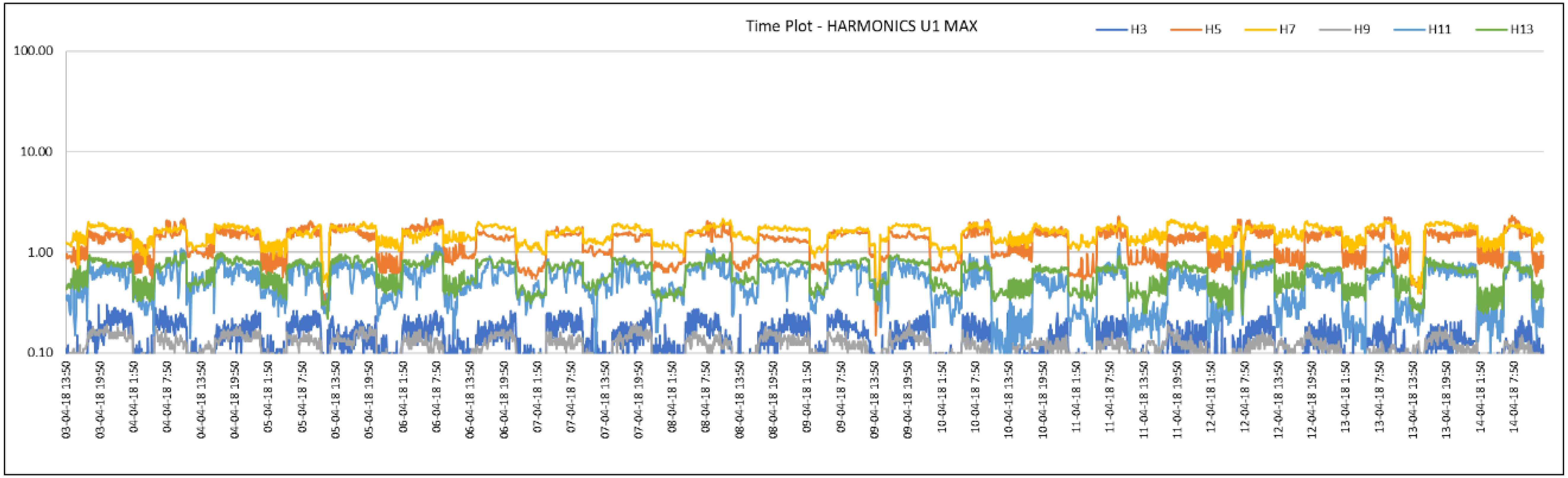

Figure 210 | STS6 – start of feeder – 3rd to 13th (odd) harmonics (Red Phase)

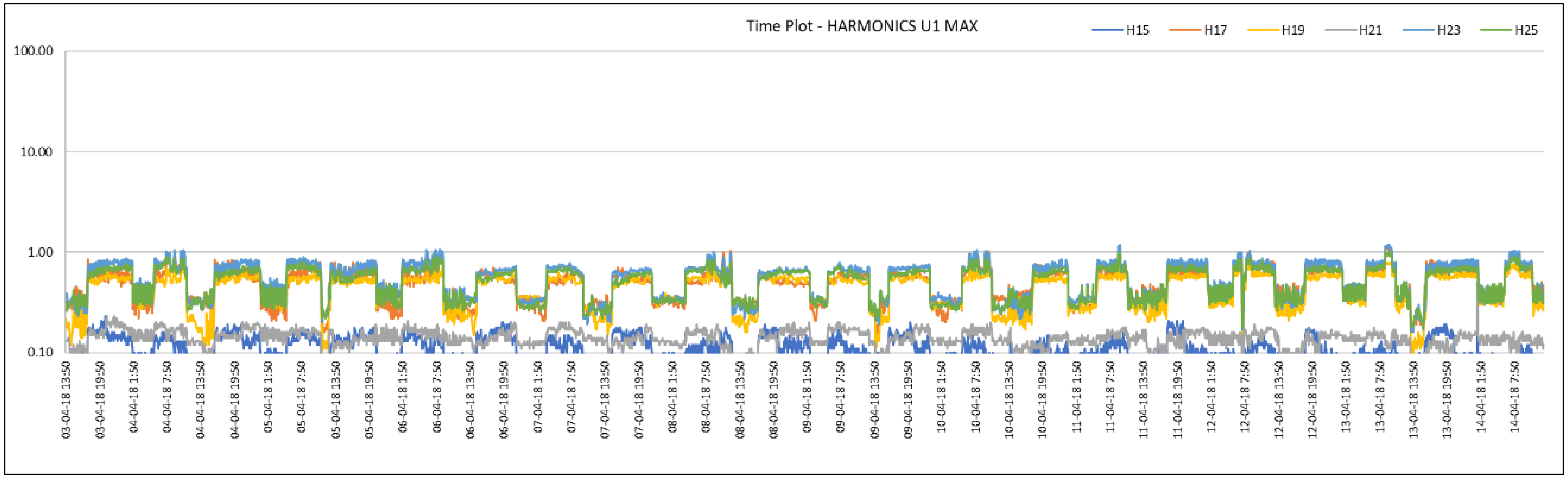

Figure 211 | STS6 – start of feeder – 15th to 25th (odd) harmonics (Red Phase)

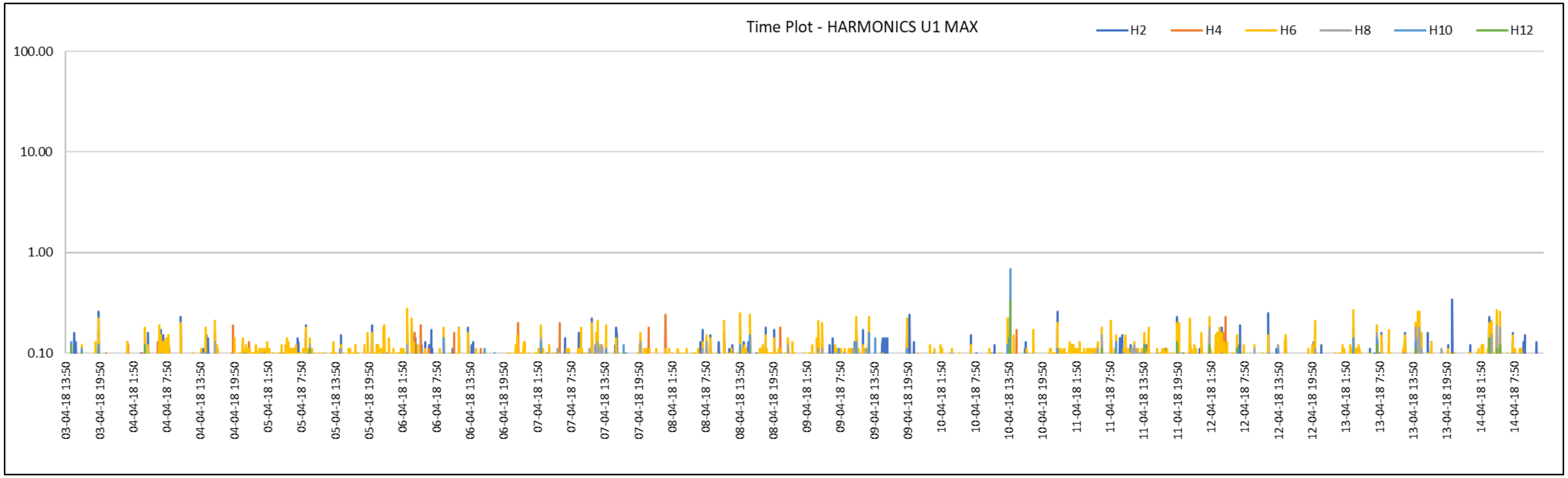

Figure 212 | STS6 – start of feeder – 2th to 12th (even) harmonics (Red Phase)

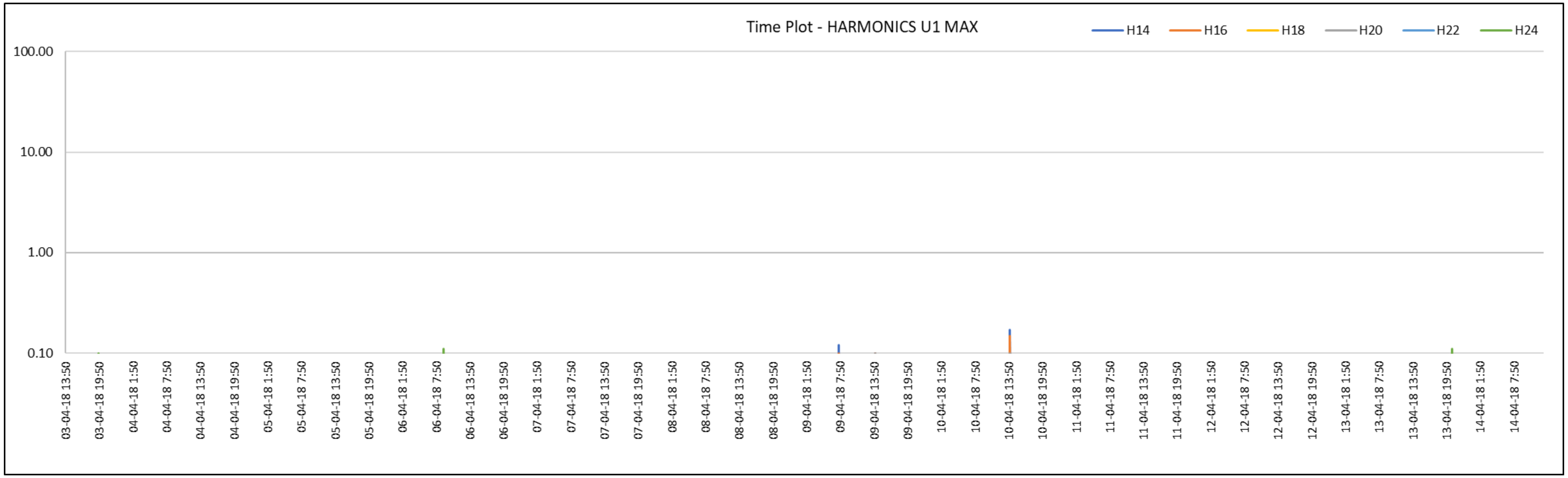

Figure 213 | STS6 – start of feeder – 14th to 24th (even) harmonics (Red Phase)

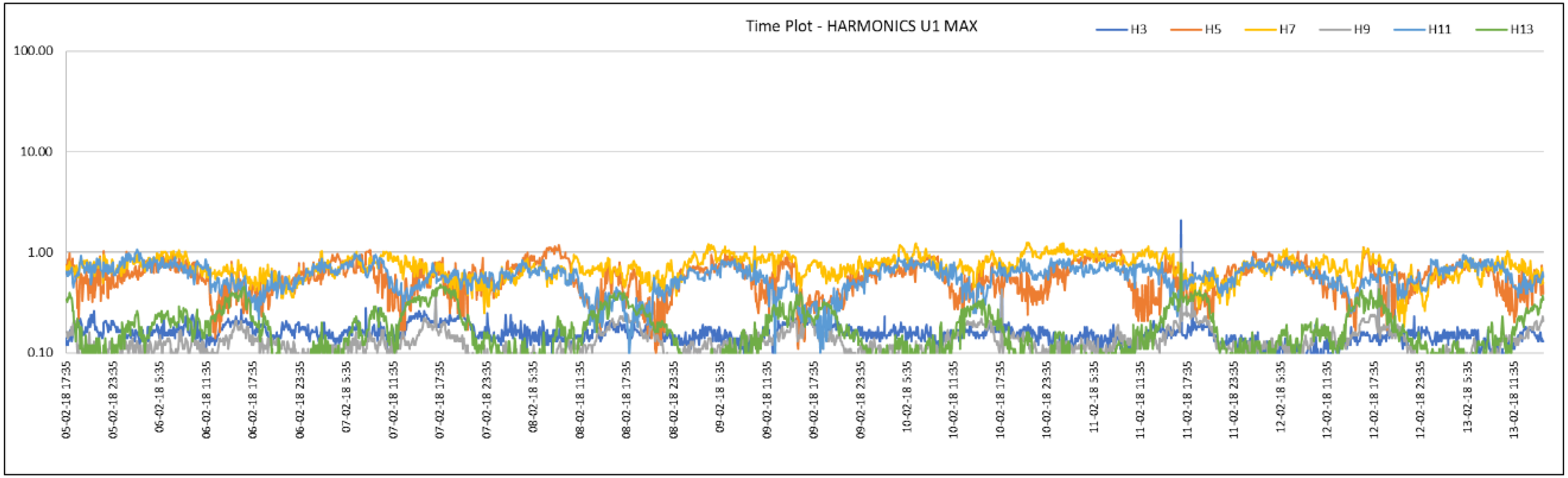

Figure 214 | STS6 – end of feeder – 3rd to 13th (odd) harmonics (Red Phase)

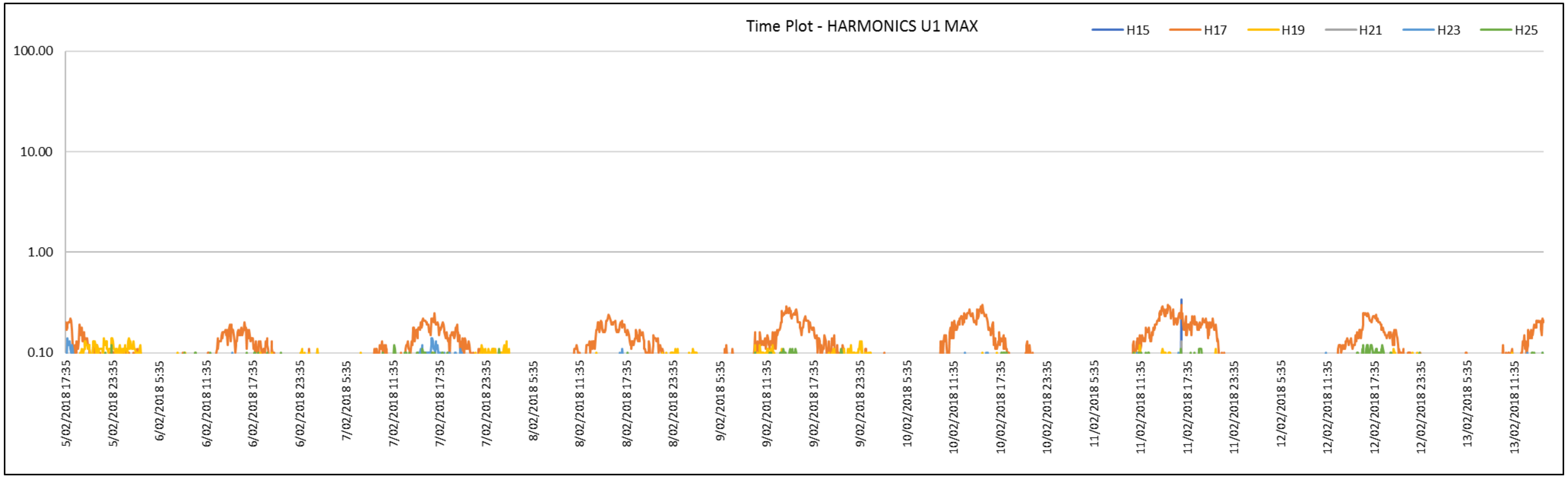

Figure 215 | STS6 – end of feeder – 15th to 25th (odd) harmonics (Red Phase)

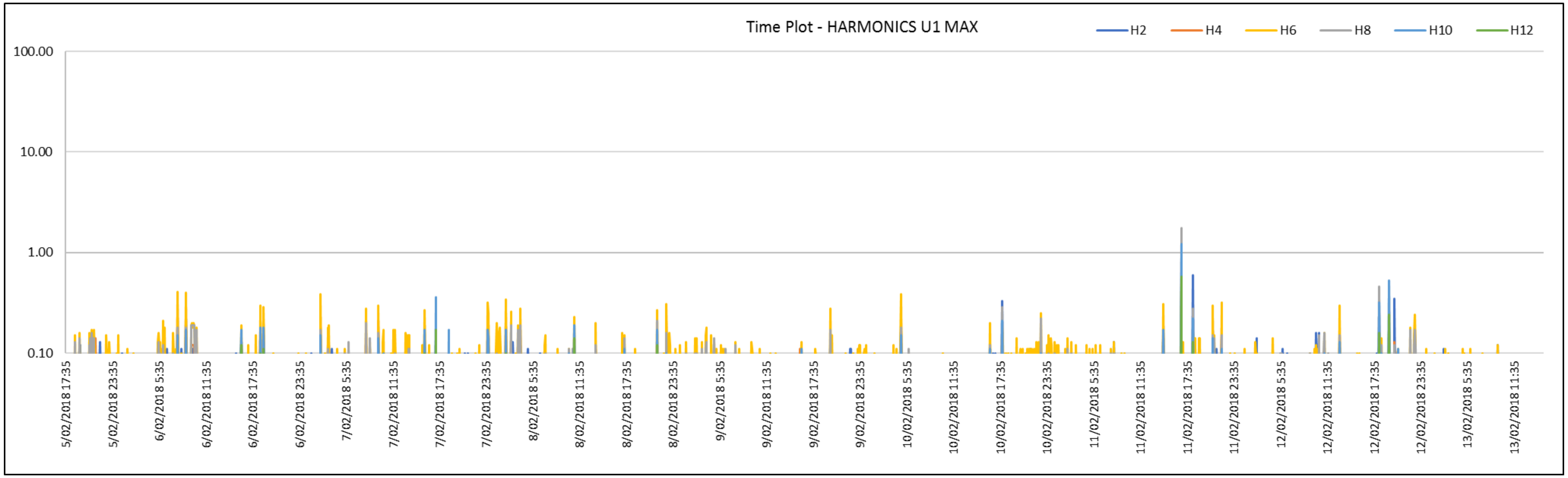

Figure 216 | STS6 – end of feeder – 2th to 12th (even) harmonics (Red Phase)

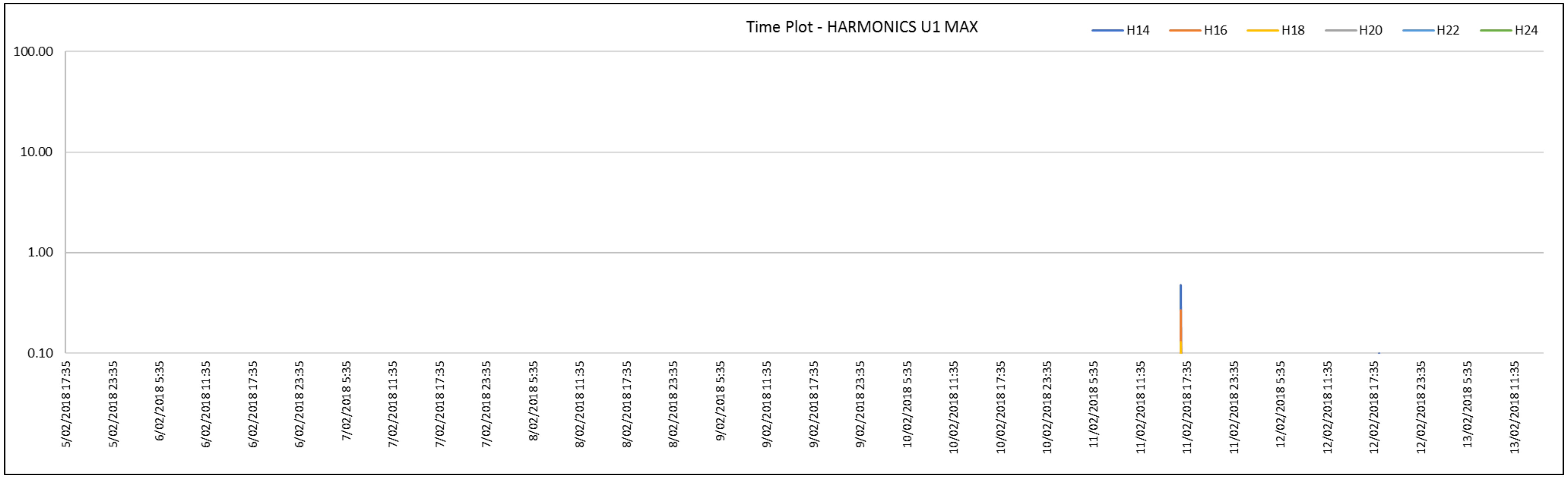

Figure 217 | STS6 – end of feeder – 14th to 24th (even) harmonics (Red Phase)

APPENDIX C Electrical Faults Log for 2017/18 FY

Please refer to the following pages.

CLICK HERE TO INSERT NEW EVENT ('Enable Content' first)

NPI UTILITIES INLAND DISTRIBUTION INCIDENT LOG

SAIDI/SAIFI Calculations

- Use drop down boxes to determine affected customers

Event	Notification Number (1SAP)	Date	Time off (GPS/non GPS)	Time restored (GPS/non GPS)	Outage Duration (mins)	Affected Generation/Fdr/Distribution Description	System Voltage	Protection Relay that cleared the fault	Fault Current (Amps)	Fault Duration (Seconds)	Syst Frequency during fault (Hz)	Effect on operations	Probable/exact Cause	Action/Investigation	1Doc Failure Investigation RPT Link	Substation	Customers Affected	Feeder	Customers Affected	TX/RMU/REC	Customers Affected	Total Consumers affected	Fduration (From column C)
319	420046555	2018-05-30	10:27:00	10:44:00	17.00	Town Sub TC2 & TC4	11	Karnaji Sub KNJ701.0 Town	3000		50	Town Feeders TC2 & TC4	Operator fault. Closed earth switch onto live cable at RMU1	Investigate malgrading of 66kV protection with 11kV. Operator Error to be investigated by leadership team.			0	TC2	471		0	471	17.00
317	419763421	2018-05-02	06:18:00	6:46:00	28.00	STS2 Feeder	11	Micom P127	665A	N/A	N/A	Outage to South Newman Residential Area. Approximately 160 Residential customers affected.	Confirmed Birdstrike at Pole 33.51	Line patrol completed. Power Restored.			0	STS2	255		0	255	28.00
314	419645733	2018-04-19	12:09:00	12:50:00	41.00	TC4 & Recloser 34/37 Feeder	11	TC4 P127 & Recloser at Gun Club Earth Fault	400	N/A	N/A	Loss of power to East Newman and Air port line	Hot Joint at ABS 34/114	Repairs to ABS underway. Line patrol done prior and discovered no other issues.			0	TC4	330		0	330	41.00
309	419313074	2018-03-10	14:24:00	15:04	40.00	South Town STS701 66kV Incomer	11	Fire Panel Unwanted control signal sent to open all breakers during routine FIP maintenance.	NA	NA	50	Loss of supply to half of Newman Town including LIA and Shopping area	Faulty fire panel isolation	- Applied Out of Service and Information Tag onto the FIP2 STS unit to indicate that there is a potential issue with the HV isolation switch and fire panel maintenance cannot to be done in the meantime. a visual inspection of the system and basic display checks can be done. - Initial review indicated that the fire panel HV isolation switch has been implemented however drawing updates were not done. - Team conversations indicate that isolation was done at software level, not at hardware level – to be verified at site inspection. - Obtained sequence of events from fire maintenance Technician who was present during the outage. - Communicated outage to relevant parties. - Updated and rectified SCADA historical server.	http://io1doc/webtop/drl/objectId/0b03c41a832f299e	Southtown	708		0		0	708	40.00
304		2018-02-17	15:15:00	15:22	7.00	STS2 Feeder	11	N/A	N/A	N/A	N/A	Emergency Interruption to clear foliage from vicinity of mains, impending storm/cyclone activity. 11kV ABS 32/47/1 opened to energise work area. Interruption to PS70, T35, T72 & T30 - Total of 98 customers	Foliage	Foliage cleared ok, Supply restored, 7 minute outage			0	STS2	255		0	255	7.00
290	418545218	2017-11-30	13:21:00	13:58	37.00	North Newman distribution T14	11kV	Fuse	N/A	N/A	N/A	Loss of supply to residences on Mindarra Dr	Hot joint on aged fuse	Fuse replaced and line re energised with no issues	http://io1doc/webtop/drl/objectId/0b03c41a831ceb82		0		0	T14	20	20	37.00
281	418354050	2017-11-04	16:51:48	17:34:00	42.20	TC4 & Recloser 34/37 Feeder	11kV	TC4 P127 & Recloser 34/37 Earth Fault	B phase 517A Earth 427A	N/A	N/A	Loss of power to East Newman and Air port line	Line patrol done but did not find probable cause.	Line re-energinzed without any issues.			0	REC 34/37 TC4	148	PS127	1	149	42.20
274	418124813	2017-10-03	19:00:00	20:30:00	90.00	T37 Newman Town	11kV	White Phase DOF	N/A	N/A	N/A	Loss of supply to a section of Newman Town supplied by T37. Approx. 15-20 customers affected.	line patrol could not find any issues with the lines.	Blown DOF reinstated and supply restored with no other issues.			0		0	T37	40	40	90.00
273	418123805	2017-10-03	13:11:00	13:45:00	34.00	STS2 Feeder	11kV	STS2 Micom	693A Earth Fault	N/A	N/A	Loss of supply to South of Newman Town, approximately 170 customers affected.	line patrol could not find any issues with the lines.	Feeder restored without any issues.			0	STS2	255		0	255	34.00
267	417555810	2017-08-22	16:20:00	17:42:00	82.00	Newman Town Wilara street to Mindarra drive	11kV	Pole 35/35 DOFs	N/A	N/A	N/A	Lost of supply to approximately 120 customers in the North Newman Town area.	More inspections required but suspect it may be a bad joint or bruised/underrated fuses.	Load supplied through the fuses were approximately 60-70A. Fuses are meant to be rated at 150A. Recommend liney to visually inspect joints and Pole 35/35 devices then replace all 3 fuses to new 150A ones.	http://io1doc/webtop/drl/objectId/0b03c41a830b65fd		0	DOF 35/35 TC3	30		0	30	82.00
259	432960056	2017-07-03	14:13:59	16:21:00	127.02	Capi Roadhouse feeder	11	DOF at Pole 34/114	N/A	N/A	N/A	Loss of supply to K21 bore and Capi Roadhouse	Birdstrike, line patrol discovered dead bird	Restored DOFs and re-energized line. Protection worked as per design.			0	DOF 34/52 TC4	1		0	1	127.02
258	416855399	2017-07-02	09:19:00	13:50:00	271.00	Newman Airport Feeder	11	DOF at Pole 34/52	N/A	N/A	N/A	Outage to Corner B, Airport and Capi.	Birdstrike at Pole 34.71 T36 Gun Club. Feathers found.	Line patrol done and DOFs replaced. Supply Restored. Further investigation to Recloser 34/64 required.			0		0	PS81	1	1	271.00
257	416850797	2017-07-02	06:30:00	7:00:00	30.00	PS78 LV LIA Supply	11	PS78 LV CB	N/A	N/A	N/A	Loss of LV supply to parts of the LIA at Newman Town	LV Hot joint on an LV overhead switch.	Performed switching and planned outage to isolate LV and HV to caryy out hot joint repairs. Break in outage planned for later part of the day. Protection worked as per design.			0		0	PS78	2	2	30.00
256	416845742	2017-07-01	11:30:00	13:35:00	125.00	Newman Town T11 Residential supply	11	DOFs	N/A	N/A	N/A	Lost 1 phase supply to apprximately residential lots	Tree branch fell onto LV overhead. Blue Phase DOF blew.	Linesperson isolated the line to clear the tree branch. Perfromed check on the LV overhead line. Installed armour rods to LV overhead to reinforce the line. Replaced DOFS and re-energized line. Protection worked as per design.			0		0	T11	28	28	125.00

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