APD ENGINEERING

BHP NEWMAN TOWNSHIP ELECTRICITY SUPPLY ANNUAL COMPLIANCE REPORT 2019/2020

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EXECUTIVE SUMMARY

BHP own and operate numerous iron ore mines located in the Pilbara region of Western Australia. The township of Newman is located approximately 1,200 km to the north of Perth and the town's electricity network is owned, governed and operated by BHP Supply Authority (BHPSA).

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, with 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, pertaining to Network Quality and Reliability of Supply.

The methodology adopted to examine compliance/non-compliance with the Code utilises the following sources of information:

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

The Code is written in four parts plus a reporting-requirements schedule:

- *Part 1*: Preliminary information associated with terms of reference.
- *Part 2*: Quality and reliability standards (further partitioned into 4 *divisions*).
- *Part 3*: Payment to customers for lack of regulatory adherence.
- *Part 4*: Incidental duties as a Supply Authority.
- *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 eight feeders supplying the town, four of which originating from the Township Zone Substation and the remaining four originating from South Town Zone Substation); and
- The reportable requirements as outlined in Part 2 and Schedule 1 of the Code, for the 2019/20 Financial Year (FY).

With regards to the site measurements, the *average* values of electrical parameters were logged over a period of seven days, at 10-minutes intervals. PQ indices were then calculated and found to be, 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 compliance issues were however identified:

- Voltage Flicker: An increase in the number of short-term and long-term voltage fluctuation limit breaches (15 short-term and 36 long-term breaches) described in AS61000:2001 was recorded compared to the logging periods for previous three years. It should be noted that all the long-term breaches was from a single event on a single transformer and was not noted during any other part of the logging period. The most onerous breaches were observed on the TC2, STS1, STS2 and STS4 feeders. Considering the relatively isolated nature of the flicker issues and the known root-cause, this is deemed to be not of a practical concern at this stage.
- RMS Voltage Magnitude: A relatively similar number of voltage level breaches (five undervoltage breaches) were observed compared to the logging periods for the previous three years. Given the temporary and random nature of the breaches, it is not deemed of a practical concern at this stage, but it is recommended that this parameter be monitored over the coming years.
- Power System Frequency: A single over-frequency and three under frequency breaches of the limits described in the Electricity Act of 1945 Section 25(1)(d) was recorded during the logging period. As these events appear to be isolated and constitute a very small fraction (less than 0.1%) of the total measurement period, it is not deemed of a practical concern at present.
- U-THD: Three U-THD breaches of the limits described in Part 2, Division 1, Section 7 of the Code were recorded during the logging period. It should be noted that all three breaches were from a single event on the same Transformer (PS25). With the exception of these breaches, the average U-THD level recorded on all feeders was consistently below the required limit.

  The recorded individual order harmonics showed a number of temporary and random breaches on all feeders that are not deemed of a practical concern, with the exception of STS4 feeder. A large number of 21st order harmonic level breaches were recorded on the STS4 Feeder Start (PS111). The magnitude of these breaches appears to follow a typical daily demand pattern, with the most onerous events occurring in the early afternoon and little or no events occurring at night. This feeder supplies Pannawarri Shopping Centre and it is anticipated that the harmonics being experienced on PS111 would be from the IGA refrigeration and the shopping centres chillers. BHP team is to further investigates the issue, with proper mitigation measures being undertaken to ensure compliance in coming years.

Reportable parameters for Newman Township Electricity Supply over the 2019/20 FY (as outlined in the 'Schedule 1' of the Code) are presented below:

- *>12-hour interruptions:* In 2019/20, one network interruption which exceeded 12 hours was recorded. Standby generators were employed 3 hours into the outage to supply power to the affected customer(s) until the network issue was rectified and normal supply restored.
- No *small use customer* was disconnected from the network more than the maximum number of times permitted by the Code (i.e., limit of 16 times per year).
- No power quality and reliability related complaints were received from customers during FY 2019/2020.

- The key reliability indices are calculated as listed below:
    - *Customer Average Interruption Duration Index (CAIDI)* of 99 minutes – CAIDI is a measure of the average outage duration or average outage restoration time. [It is defined as "The sum of the durations of sustained[1] customer interruptions divided by the total number of sustained customer interruptions"].
    - *System Average Interruption Frequency Index (SAIFI)* of 0.417 interruptions – SAIFI is the average number of interruptions per customer served. [It is defined as "the total number of sustained customer interruptions divided by the total number of customers served"].
    - *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 41.36 minutes – SAIDI is the average outage duration for each customer served. [It is defined as "the sum of durations of sustained customer interruptions divided by the total number of customers served"].

    An improvement is observed in majority of the reliability indices for this year when compared to the previous years.

In summary, the metering data collected from the 16 locations throughout the Newman Township network indicate that the power quality is, in large, within the limits stipulated by the Code. It should be noted that although the overall reliability of the Newman Township supply appeared to have degraded marginally when compared to the same reliability indices for previous FYs, the overall network performance is still considered to be satisfactory. The relative deterioration in reliability indices can be attributed to the forced outages and events outside of BHPSA's control. As such, this report finds the reliability and quality of the supply for Newman Township network in compliance with the Code's requirements, with further monitoring of areas of the network recommended to ensure quality and reliability is maintained in the upcoming years.

[1] By "sustained" we mean only interruptions lasting 1 minute or longer. (Momentary) Outages lasting less than 1 minute are not included in the index. Planned outages and some other type of outages are also excluded from this index. This note also applies to the SAIFI and SAIDI indices.

TABLE OF CONTENTS

TABLE OF FIGURES

LIST OF TABLES

1. INTRODUCTION

The township of Newman is located approximately 1,200 km to the north of Perth; the town's electricity network is owned, governed and operated by BHP Supply Authority (BHPSA). 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 2,501 registered premises comprised of a mixture of residential and commercial customers.

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 the 30th 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 2019 to 30th of June 2020. Measurement information is based on sampled data and outlined in Section 6, whereas outage information is based on data provided by BHPSA 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 BHP 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 (2019/2020 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 11 kV feeders emanating from the Town and Southtown Substations (a total of 16 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 for each location lasted around 7 days, between April to May 2020. 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 Analyser and SEL735 PQ meters.
3. The receipt of the following information from BHPSA:
   - Network outage information for planned and forced outages for the Newman Township during the 2019/2020 FY as well as information on customer complaints.
   - Expenditure information on programs directed to improve/maintain 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 was 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 from the loggers are then extracted and analysed with the accompanying analysis software (HIOKI 9624 V2.50).

Additionally, SEL-735 PQM meters were used to record data for the TC4(PS125) feeder. The PQM meters are installed on the LV side of the transformers. The PQM meter can measure multiple waveforms using Voltage and Current channels. The measurements from the PQM meters can be extracted in CSV format.

4.2. PQ DEVICE LOCATIONS AND IN-SERVICE PERIODS

A total of 3 PQ loggers were deployed across 15 locations on the Newman TC1, TC2, TC3, TC4, STS1, STS2, STS4 and STS6 feeders. PS125 for TC4 was logged using the existing installed SEL-735 PQM meter. The installation locations and times are as listed in Table 1. Figure 1 presents a colour-coded single line diagram of the eight Newman township feeders. Shaded circles indicate the locations at which the PQ loggers were temporarily located. All loggers were installed on pad-mount transformers (on the LV, or secondary side), due to the difficulty and safety issues of installing the loggers on pole-top transformers.

Table 1 | PQ Logger Locations

ZONE SUB	FEEDER NAME	START/END OF FEEDER	SUBSTATION NAME	DATE INSTALLED	DATE REMOVED
Township	TC1	Start	PS28	07/05/20 16:38	12/05/20 08:46
		End	PS68	28/04/20 11:27	05/05/20 13:52
	TC2	Start	PS10	04/05/20 11:18	11/05/20 11:28
		End	PS14	07/04/20 10:30	14/04/20 12:23
	TC3	Start	PS108	13/04/2020 13:30	20/04/2020 12:15
		End	PS69	13/04/2020 14:00	20/04/2020 12:28
	TC4	Start	PS115	28/04/2020 00:00	05/05/2020 23:59
		End	PS15	14/04/2020 14:18	21/04/2020 08:02
South Town	STS1	Start	PS94	20/04/2020 14:20	27/04/2020 08:18
		End	PS25	20/04/2020 14:44	27/04/2020 08:30

	STS2	Start	PS60	04/05/2020 11:40	11/05/2020 11:40
		End	PS70	21/04/2020 11:19	28/04/2020 10:38
	STS4	Start	PS111	06/04/2020 11:20	13/04/2020 07:45
		End	PS44	06/04/2020 09:35	13/04/2020 07:52
	STS6	Start	PS129	27/04/2020 10:41	04/05/2020 10:15
		End	PS122	27/04/2020 09:48	04/05/2020 09:55

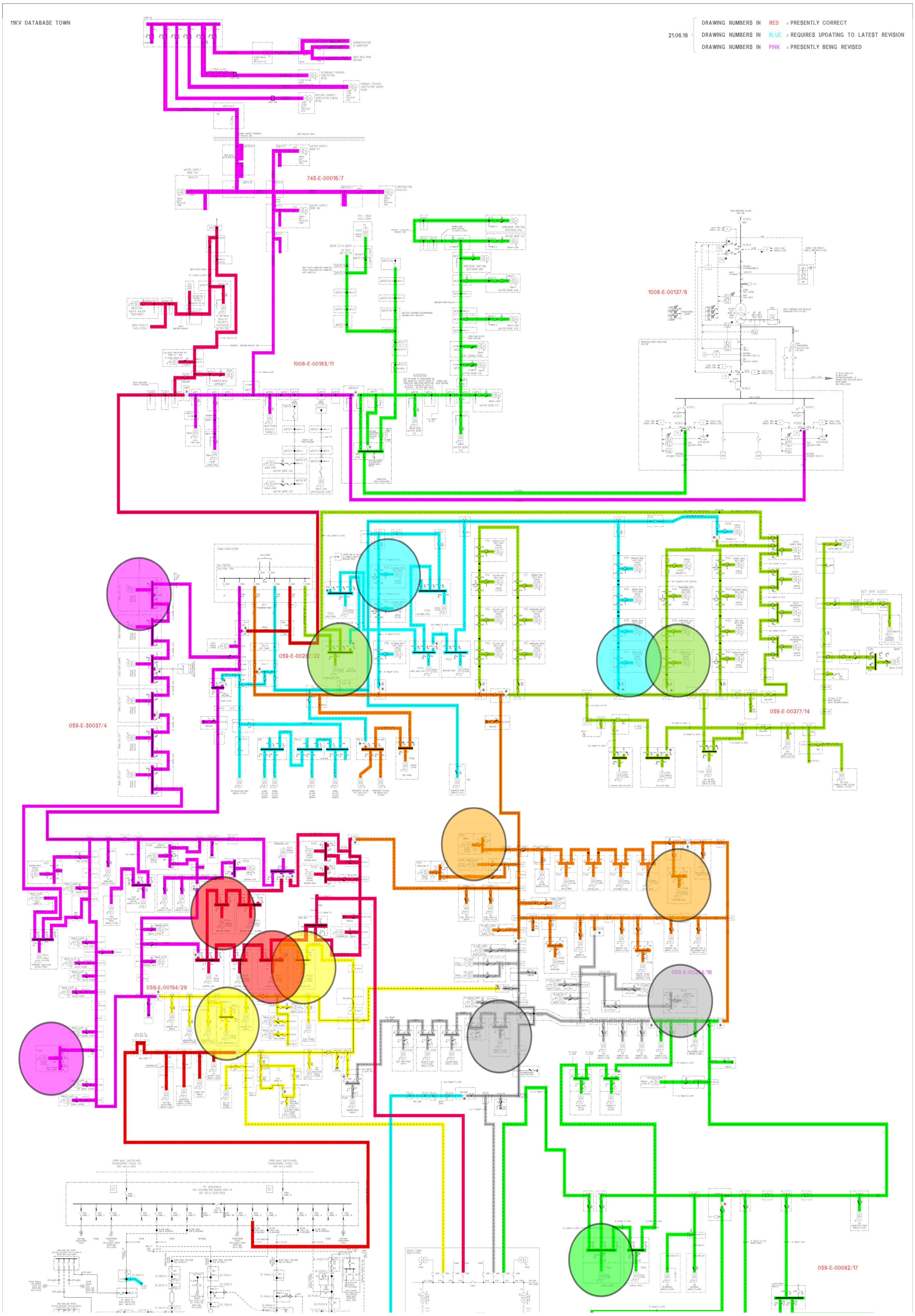


Figure 1 | Single Line Diagram of the Newman township (shaded circles indicate the location of PQ loggers)

4.3. PQ DEVICE SETUP

The setup of the PQ loggers was as per the relevant 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, except for 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 five 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.

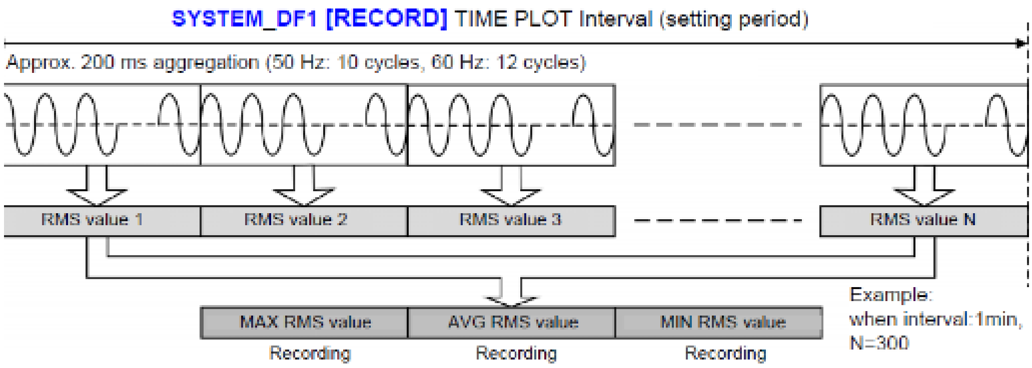


Figure 2 | Sampling and interval recording philosophy used in the Hioki PQ loggers (from Hioki Manual)

5. COMPLIANCE REQUIREMENTS

This section summarises the *Compatibility Levels* to which a 'Distributors' electrical network is to comply, as outlined in 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 AS 61000:2001. The compatibility levels are shown below in Table 2, and are a measure of the voltage quality limits over a 10 minute and two-hour interval for short (P_{ST}) and long term (P_{LT}) flicker, respectively.

Table 2 | Short and long-term flicker limits

COMPATIBILITY LEVEL	VALUE
Short Term (P_{ST})	1.0
Long Term (P_{LT})	0.8

5.1.2. VOLTAGE LEVELS

In accordance with AS 3000:2018 the voltage levels of the electrical network must be maintained between +10%/-6% of the nominal 240 V single-phase supply voltage.

5.2. FREQUENCY

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

5.3. VOLTAGE TOTAL HARMONIC DISTORTION

Part 2, Division 1, Section 7 of the Code specifies that the voltage total harmonic distortion (U-THD) must, as far as is reasonably practical not exceed 8%. Individual odd and even harmonic components are not to exceed the values shown below in Table 3.

Table 3 | Harmonic compatibility levels (in percentage of nominal voltage)

EVEN HARMONICS		ODD HARMONICS (MULTIPLES OF 3)		ODD HARMONICS (NON-MULTIPLES OF 3)	
ORDER (H)	HARMONIC VOLTAGE (%)	ORDER (H)	HARMONIC VOLTAGE (%)	ORDER (H)	HARMONIC VOLTAGE (%)
2	2	3	5	5	6
4	1	9	1.5	7	5
6	0.5	15	0.3	11	3.5
8	0.5	21	0.2	13	3
10	0.5	>21	0.2	17	2
12	0.2			19	1.5
>12	0.2			23	1.5
				25	1.5
				>25	0.2 + 1.3(25/h)

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 number 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 sustained customer interruption (in minutes) divided by the total number of sustained customer interruptions.

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

5.4.2. SYSTEM AVERAGE INTERRUPTION FREQUENCY INDEX (SAIFI)

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

$$SAIFI_{Minutes} = \frac{\sum Number\ of\ Sustained\ Distribution\ Customer\ Interruptions}{\sum Number\ of\ Distribution\ Customers\ Served}$$

5.4.3. AVERAGE SERVICE AVAILABILITY INDEX (ASAI)

Average Service Availability Index is the percentage of time that the service is available to the network 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.

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

6. SITE MEASUREMENTS (PQ LOGGER DATA)

The following sections describe the results and notable PQ events recorded during the 2019/20 logging period for each of the eight feeders included in the audit.

6.1. FEEDER TC1

The PQ logger at the start of the TC1 feeder was installed at the PS28 Library substation between 07/05/2020 and 12/05/2020 while the PQ logger at the end of the TC1 feeder was installed at the PS68 Capricorn Oval substation between 28/04/2020 and 05/05/2020. As shown in Figure 1 (Orange), TC1 originates from the Town substation. The TC1 feeder 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 14 to Figure 15 in Appendix B.1. Table 4 below lists the recorded breach events during the logging period.

Table 4 | Feeder TC1 Flicker Breach Event Details

LOCATION	PHASE(S)	DATE AND TIME	FLICKER EVENT DETAILS/MAGNITUDE
TC1 Start (PS28)	B	09/05/2020 08:09:38	P_{ST} limit (1.0) exceeded: B=1.64

6.1.2. VOLTAGE

The logged voltage level data for the start and end of the TC1 feeder is shown from Figure 16 to Figure 17 in Appendix B.1. There were no noted 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 18 to Figure 19 in Appendix B.1. There were no recorded frequency limit events causing the frequency 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 is shown from Figure 20 to Figure 21 in Appendix B.1. There were no noted voltage THD 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 from Figure 12 to Figure 23 in Appendix B.1. A summary of non-compliant harmonics and the scale of non-compliances is shown in Figure 3 and Figure 4.

The power quality measurements recorded on the TC1 feeder for this report show only temporary and random breaches. As such, these events are not deemed of any practical concern (i.e. not deemed as compliance issues).

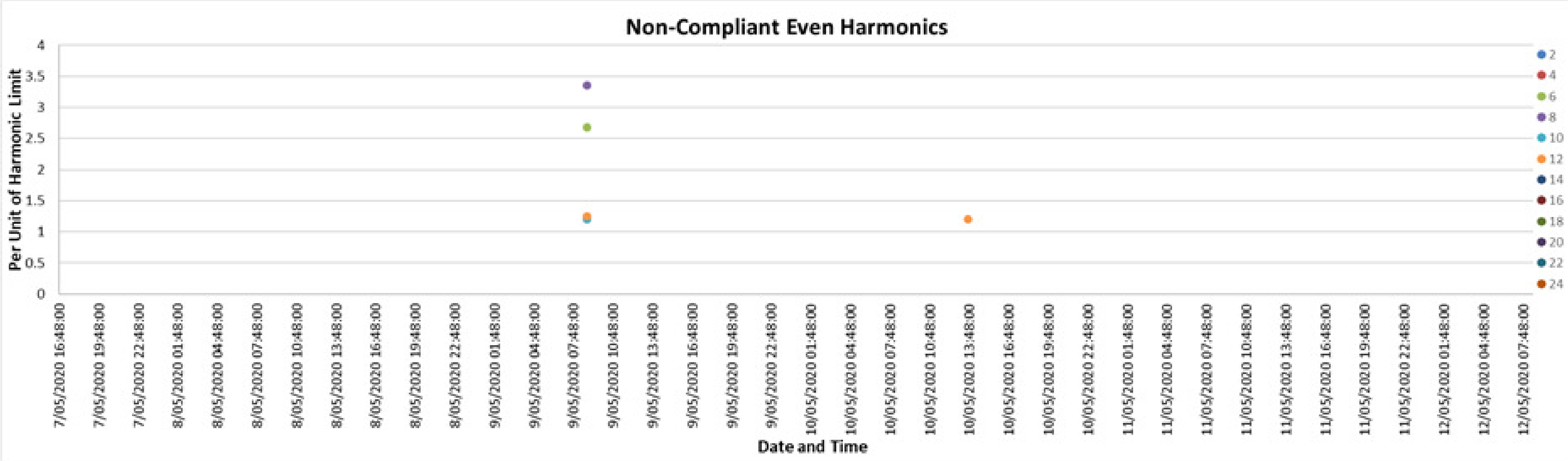


Figure 3 | Feeder TC1 (Start) - Non-Compliant Even Harmonics

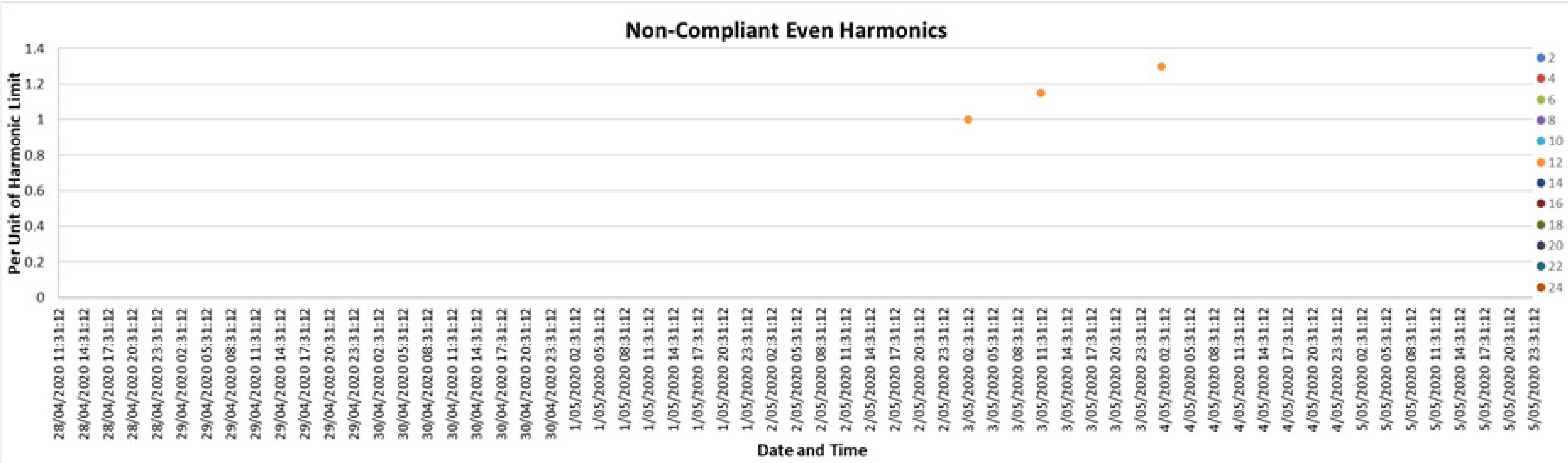


Figure 4 | Feeder TC1 (End) - Non-Compliant Even Harmonics

6.2. FEEDER TC2

The PQ logger at the start of the TC2 feeder was installed at the PS10 McLennan Drive substation between 04/05/2020 and 11/05/2020 while PQ logger at the end of the TC2 feeder was installed at the PS14 Bondini Drive substation between 07/04/2020 and 14/04/2020. As shown in Figure 1 (Cyan), TC2 originates from the Town substation.

6.2.1. FLICKER

The logged flicker data for the start and end of the TC2 feeder is shown from Figure 24 to Figure 25 in Appendix B.2. Table 5 below lists the recorded breach events during the logging period.

Table 5 | Feeder TC2 Flicker Breach Event Details

LOCATION	PHASE(S)	DATE AND TIME	FLICKER EVENT DETAILS/MAGNITUDE
TC2 Start (PS10)	R,W,B	07/05/2020 13:49:15	P_{ST} limit (1.0) exceeded: R=1.08, W=1.60, B=1.34
TC2 Start (PS10)	R	09/05/2020 08:09:15	P_{ST} limit (1.0) exceeded: R=1.59
TC2 End (PS14)	W	09/04/2020 18:49:15	P_{ST} limit (1.0) exceeded: W=1.18

6.2.2. VOLTAGE

The logged voltage level data for the start and end of the TC2 feeder is shown from Figure 26 to Figure 27 in Appendix B.2. Table 6 below lists the recorded breach events during the logging period.

Table 6 | Feeder TC2 Voltage Breach Event Details

LOCATION	PHASE(S)	DATE AND TIME	VOLTAGE EVENT DETAILS/MAGNITUDE
TC2 Start (PS10)	R/W/B	7/05/2020 13:44:15	Undervoltage limit (-6%) exceeded: R=225.25 V, W=216.12 V, B=221.3 V

6.2.3. FREQUENCY

The logged frequency data for the start and end of the TC2 feeder is shown in Figure 28 to Figure 29 in Appendix B.2. There were no recorded frequency limit events causing the frequency 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 30 to Figure 31 in Appendix B.2. There were no noted voltage THD 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 32 to Figure 33 in Appendix B.2. A summary of non-compliant harmonics and the scale of non-compliances is shown in Figure 5 through to Figure 6. Breaches are limited to the location at the start of feeder TC2 and the majority were recorded for a single event. Given the temporary and random nature of the breaches, they are not deemed of any practical concern (i.e. not deemed as compliance issues).

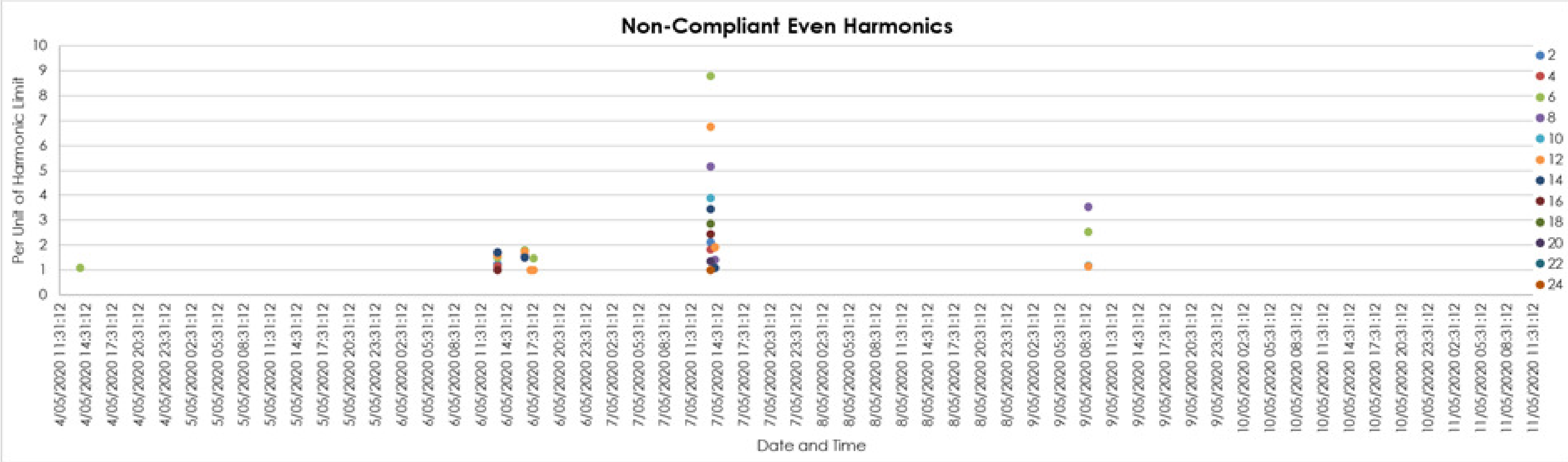


Figure 5 | TC2 Feeder (Start) - Non-Compliant Even Harmonics

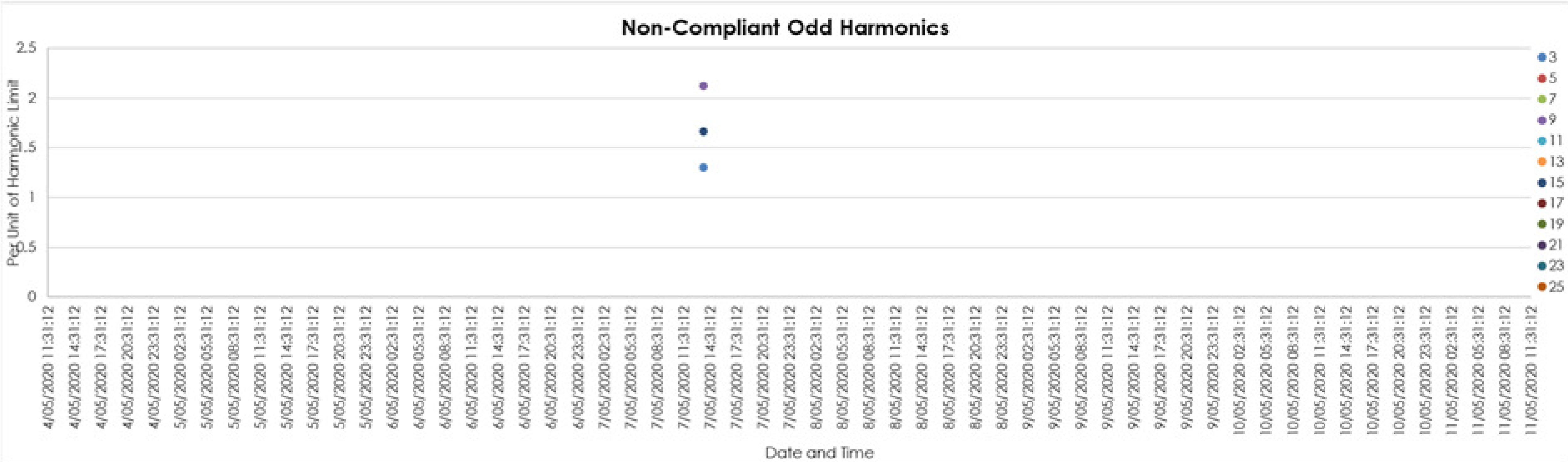


Figure 6 | TC2 Feeder (Start) - Non-Compliant Odd Harmonics

6.3. FEEDER TC3

The PQ logger at the start of the TC3 feeder was installed at the PS108 Les Tutt Drive substation between 13/04/2020 and 20/04/2020 while the PQ logger at the end of the TC3 feeder was installed at the PS69 Giles Avenue substation also between 13/04/2020 and 20/04/220. As shown in Figure 1 (Purple), TC3 originates from the Town substation.

6.3.1. FLICKER

The logged flicker data for the start and end of the TC3 feeder is shown from Figure 34 to Figure 35 in Appendix B.3. 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).

6.3.2. VOLTAGE

The logged voltage level data for the start and end of the TC3 feeder is shown from Figure 36 to Figure 37 in Appendix B.3. 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 38 to Figure 39 in Appendix B.3. There were no recorded frequency limit events causing the frequency 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 40 to Figure 41 in Appendix B.3. There were no noted voltage THD 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 from Figure 42 to Figure 43 in Appendix B.3. No non-compliant harmonics were recorded for the recording period.

6.4. FEEDER TC4

The PQ logger at the start of the TC4 feeder was installed at the PS115 substation between 28/04/2020 and 05/05/2020 while the PQ logger at the end of the TC4 feeder was installed at the PS15 Karrawan Way substation between 14/04/2020 and 21/04/2020. As shown in Figure 1 (Green), TC4 originates from the Town substation.

6.4.1. FLICKER

The logged flicker data for the start and end of the TC4 feeder is shown from Figure 44 to Figure 45 in Appendix B.4. There was no recorded flicker limit events causing flicker level to breach the code's limits.

6.4.2. VOLTAGE

The logged voltage level data for the start and end of the TC4 feeder is shown Figure 46 to Figure 47 in Appendix B.4. 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).

6.4.3. FREQUENCY

The logged frequency data for the start and end of the TC4 feeder is shown Figure 48 to Figure 49 in Appendix B.4. There were no recorded frequency limit events causing the frequency 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 Figure 50 to Figure 51 in Appendix B.4. There were no noted voltage THD 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 52 to Figure 53 in Appendix B.4. No non-compliant harmonics were recorded for the recording period.

6.5. FEEDER STS1

The PQ logger at the start of the STS1 feeder was installed at the PS94 Pardoo Street substation between 20/04/2020 and 27/04/2020 while the PQ logger at the end of the STS1 feeder was installed at the PS25 Laver Street substation also between 20/04/2020 and 27/04/2020. As shown in Figure 1 (Lime Green), 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 54 to Figure 55 in Appendix B.5. Table 7 below lists the recorded breach events during the logging period.

Table 7 | Feeder STS1 Flicker Breach Event Details

LOCATION	PHASE(S)	DATE AND TIME	FLICKER EVENT DETAILS/MAGNITUDE
STS1 End (PS25)	R/W/B	20/04/2020 15:01:02	P_{ST} limit (1.0) exceeded: R=6.19 W=2.29, B=8.18
STS1 End (PS25)	R/W/B	20/04/2020 15:01:02 To 16:51:02	P_{LT} limit (0.1) exceeded: maximum recorded R=6.19 W=2.29, B=8.18

6.5.2. VOLTAGE

The logged voltage level data for the start and end of the STS1 feeder is shown from Figure 56 to Figure 57 in Appendix B.5. There were no noted 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 58 to Figure 59 in Appendix B.5. Table 9 below lists the recorded breach events during Logging Period:

Table 8 | Feeder STS1 Frequency Breach Event Details

LOCATION	PHASE(S)	DATE AND TIME	Frequency EVENT DETAILS/MAGNITUDE
STS1 Start (PS94)	R/W/B	24/04/2020 23:25:00	Frequency dipped below lower limit(48.75) = 48.68
STS1 End (PS25)	R/W/B	20/04/2020 14:56:02 24/04/2020 21:26:02	Frequency exceeded upper limit (51.25) =52.73 Frequency dipped below lower limit(48.75) = 48.68

6.5.4. VOLTAGE THD

The logged voltage THD level data for the start and end of the STS1 feeder is shown Figure 60 to Figure 61 in Appendix B.5. Table 10 below lists the recorded breach events during the Logging Period:

Table 9 | Feeder STS1 THD Breach Event Details

LOCATION	PHASE(S)	DATE AND TIME	Voltage THD EVENT DETAILS/MAGNITUDE
STS1 End (PS25)	R/W/B	20/04/2020 14:56:02	THD limit (8%) exceeded: R=51.62, W=19.72, B=20.03

6.5.5. HARMONICS

The logged harmonic data for the start and end of the STS1 feeder is shown Figure 62 to Figure 63 in Appendix B.5. A summary of non-compliant harmonics and the scale of non-compliances is shown in Figure 7 through 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).

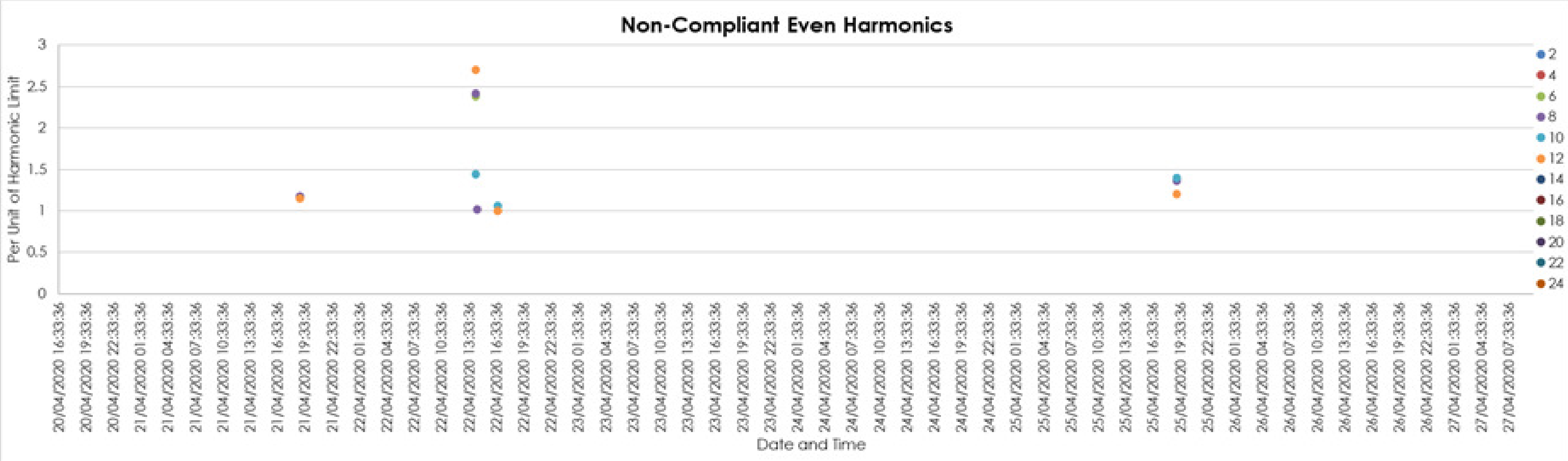


Figure 7 | STS1 Feeder (Start) - Non-Compliant Even Harmonics

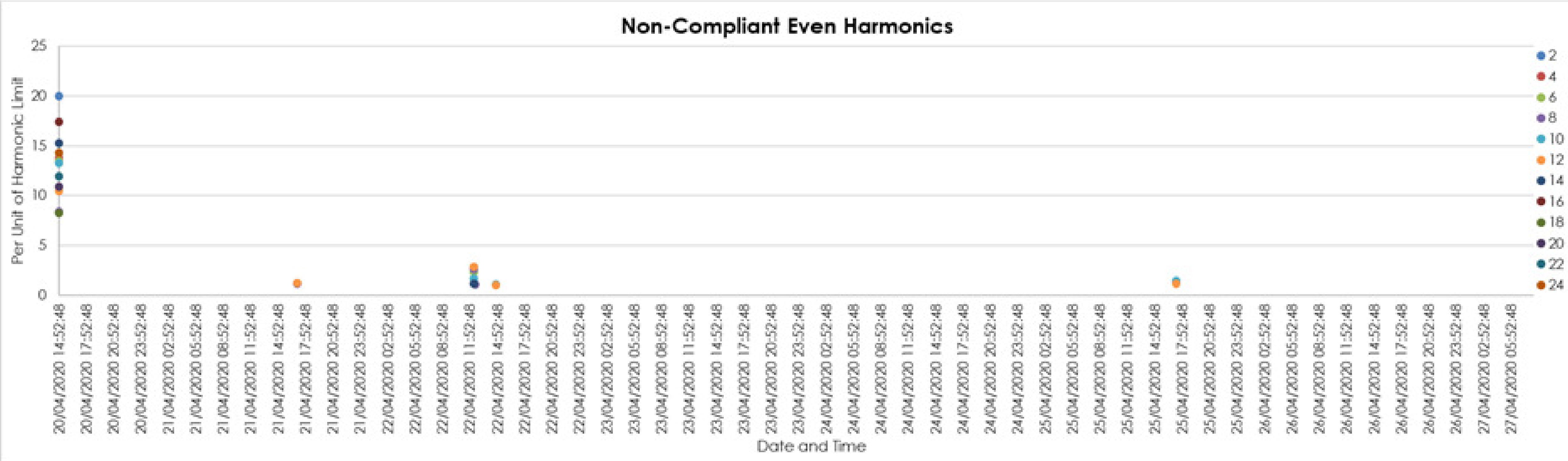


Figure 8 | STS1 Feeder (End) - Non-Compliant Even Harmonics

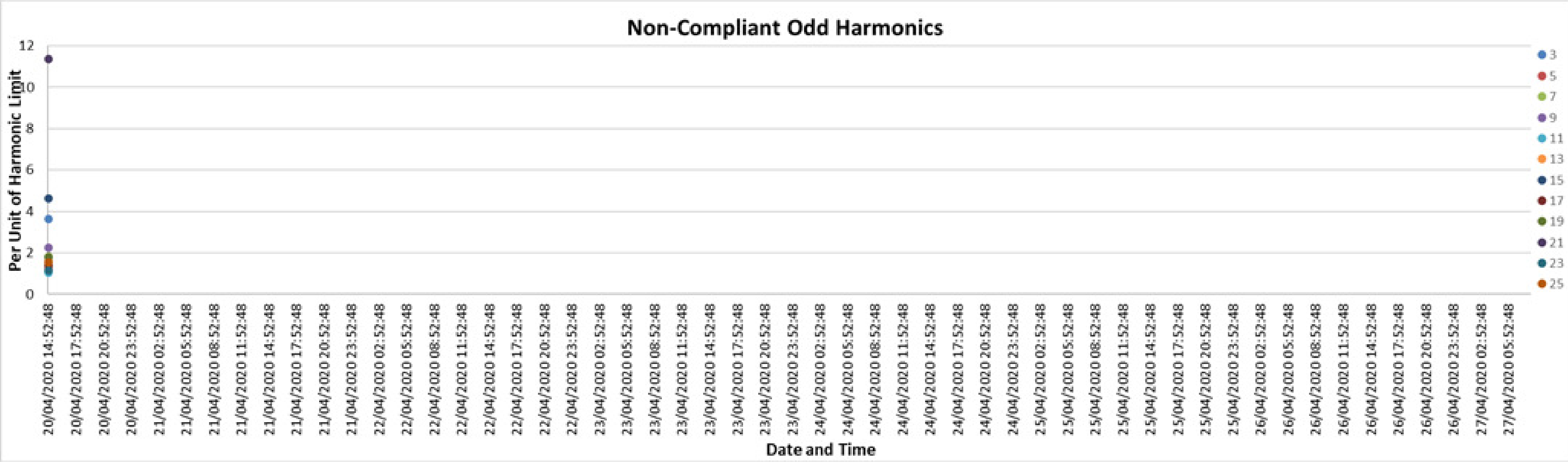


Figure 9 | STS1 Feeder (End) - Non-Compliant Odd Harmonics

6.6. FEEDER STS2

The PQ logger at the start of the STS2 feeder was installed at the PS60 Forrest Avenue substation between 04/05/2020 and 11/05/2020 while the PQ logger at the end of the STS2 feeder was installed at the PS70 Jabbarup Crescent Park substation between 21/04/2020 and 28/04/2020. As shown in Figure **1** (Grey), 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 64 to Figure 65 in Appendix B.6. Table 10 below lists the recorded breach events during the logging period.

Table 10 | Feeder STS2 Flicker Breach Event Details

LOCATION	PHASE(S)	DATE AND TIME	FLICKER EVENT DETAILS/MAGNITUDE
STS2 Start (PS60)	R/W/B	07/05/2020 15:40:00	P_{ST} limit (1.0) exceeded: R=1.021 W=1.485, B=1.242
STS2 Start (PS60)	R	09/05/2020 10:00:00	P_{ST} limit (1.0) exceeded: maximum recorded R=1.578

6.6.2. VOLTAGE

The logged voltage level data for the start and end of the STS2 feeder is shown from Figure 66 to Figure 67 in Appendix B.6. Table 11 below lists the recorded breach events during the Logging Period:

Table 11 | Feeder STS2 Voltage Breach Event Details

LOCATION	PHASE(S)	DATE AND TIME	Voltage EVENT DETAILS/MAGNITUDE
STS2 Start (PS60)	R/W	07/05/2020 15:40:00	Voltage dipped below lower limit (225.60): W=217.16, B=221.59

6.6.3. FREQUENCY

The logged frequency data for the start and end of the STS2 feeder is shown in Figure 68 to Figure 69 in Appendix B.6. Table 12 below lists the recorded breach events during the Logging Period:

Table 12 | Feeder STS2 Frequency Breach Event Details

LOCATION	PHASE(S)	DATE AND TIME	Frequency EVENT DETAILS/MAGNITUDE
STS2 End (PS70)	R/W/B	24/04/2020 21:27:58	Frequency dipped below lower limit (48.75) = 48.68

6.6.4. VOLTAGE THD

The logged voltage THD level data for the start and end of the STS2 feeder is shown from Figure 70 to Figure 71 in Appendix B.6. There were no noted voltage THD 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 from Figure 72 to Figure 73 in Appendix B.6. A summary of non-compliant harmonics and the scale of non-compliances is shown in Figure 10 through to 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).

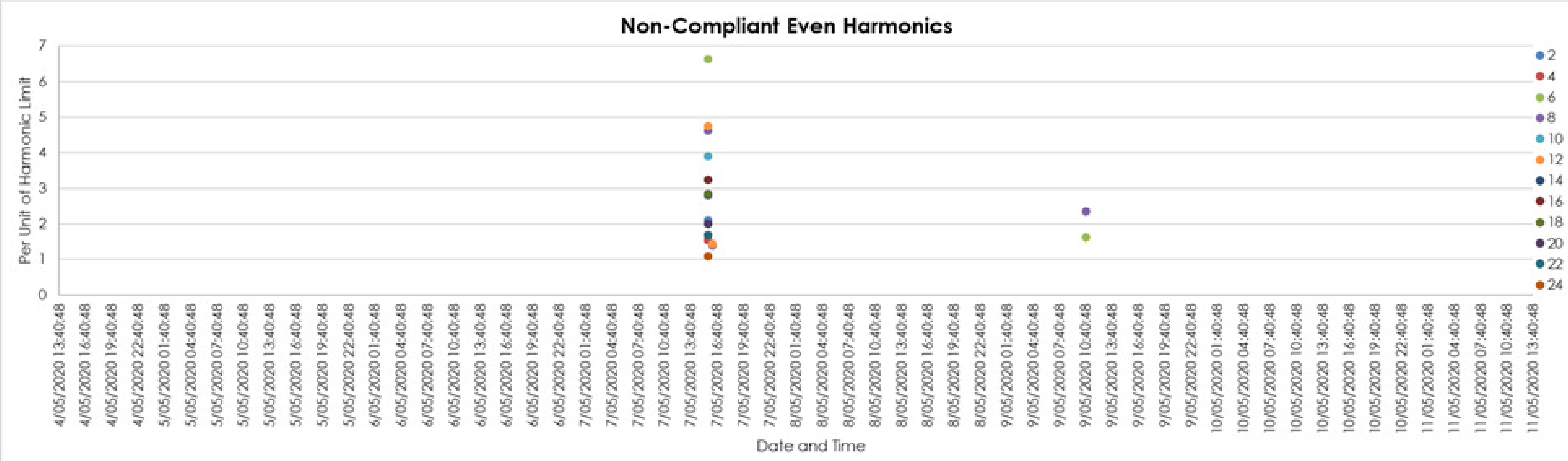


Figure 10 | STS2 Feeder (Start) - Non-Compliant Even Harmonics

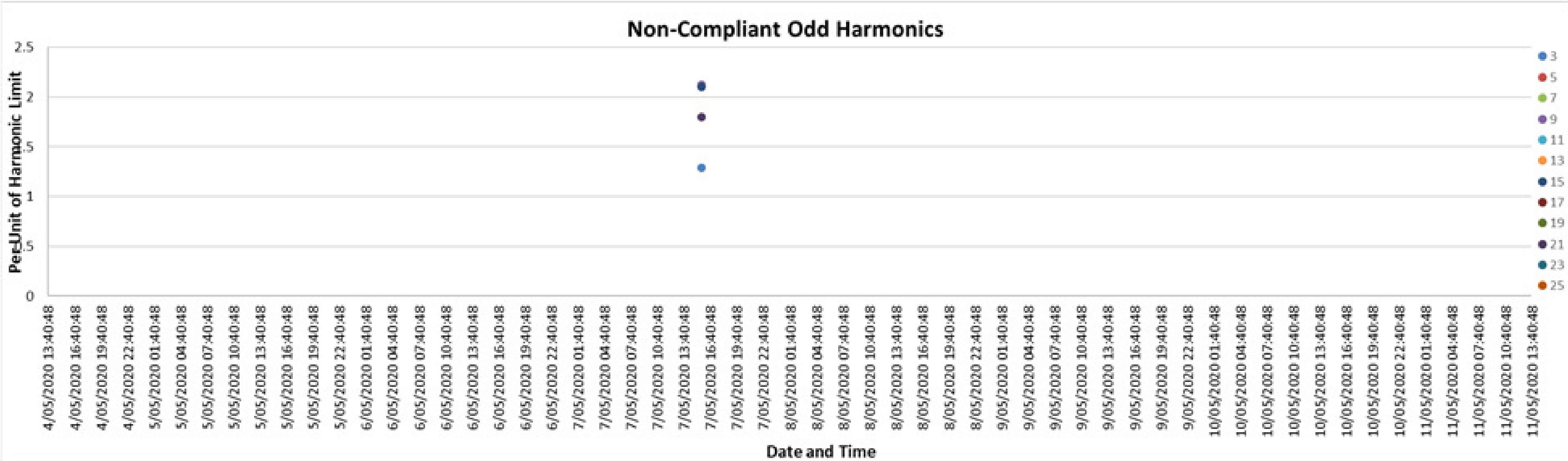


Figure 11 | STS2 Feeder (EndStart) - Non-Compliant Even Odd Harmonics

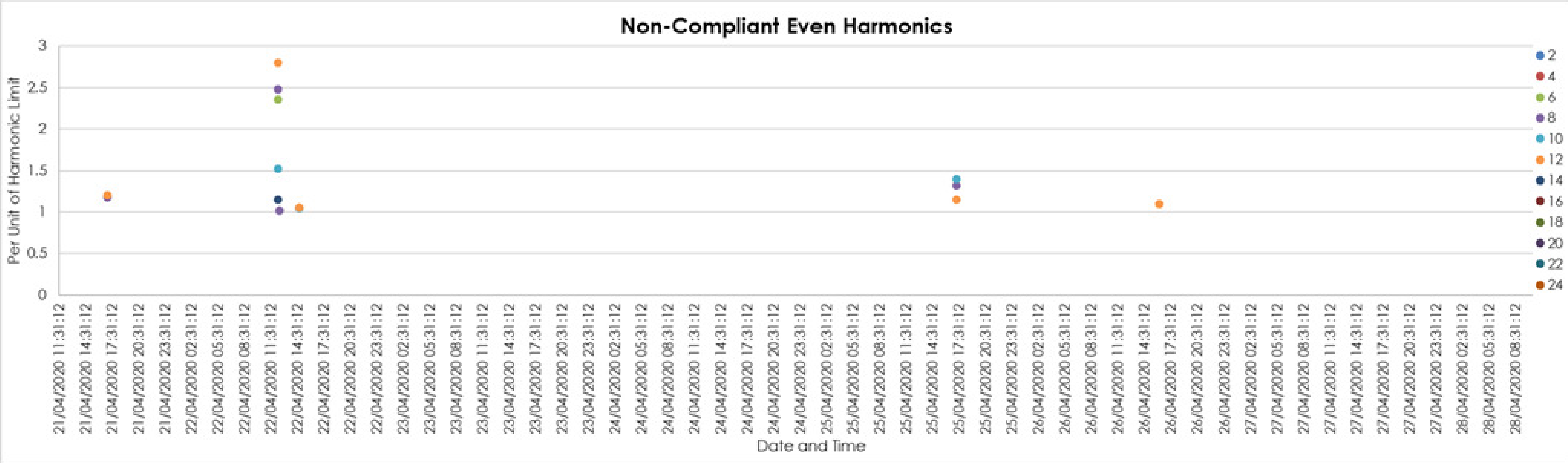


Figure 12 | STS2 Feeder (End) - Non-Compliant Even Harmonics

6.7. FEEDER STS4

The STS4 Feeder has not been audited under previous Annual Compliance Reports, therefore no comments have been made on comparative power quality. The PQ logger at the start of the STS4 feeder was installed at the PS111 Hilditch Avenue substation between 06/04/20 and 13/04/20 while the PQ logger at the end of the STS4 feeder was installed at the PS44 Iron Ore Parade substation between 27/04/20 and 04/05/20. As shown in Figure 1 (Red), STS4 originates from the South Town substation.

6.7.1. FLICKER

The logged flicker data for the start and end of the STS4 feeder is shown from Figure 74 to Figure 75 in Appendix B.7. Table 13 below lists the recorded breach events during the logging period.

Table 13 | Feeder STS4 Flicker Breach Event Details

LOCATION	PHASE(S)	DATE AND TIME	FLICKER EVENT DETAILS/MAGNITUDE
STS4 Start (PS111)	W	09/04/2020 20:50:00	P_{ST} limit (1.0) exceeded: W=1.13
STS4 End (PS44)	W	09/04/2020 18:54:42	P_{ST} limit (1.0) exceeded: W=1.19

6.7.2. VOLTAGE

The logged voltage level data for the start and end of the STS4 feeder is shown from Figure 76 to Figure 77 in Appendix B.7. There were no noted 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 STS4 feeder is shown in Figure 78 to Figure 78 in Appendix B.7. There were no recorded frequency limit events causing the frequency 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 STS4 feeder is shown Figure 80 to Figure 81 in Appendix B.7. There were no noted voltage THD 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 STS4 feeder is shown from Figure 82 to Figure 83 in Appendix B.7. A summary of non-compliant harmonics and the scale of non-compliances is shown in Figure 13. This shows a significant number of non-compliant odd harmonics on the STS4 Start

Feeder (PS111), of which the majority are 21st order harmonic. It is observed that the magnitude of the non-compliances appears to follow a typical daily demand pattern, with the most onerous events occurring in the early afternoon and little or no events occurring at night. More concentrated levels of non-compliance occurred towards the end of the working week and on the particular weekend that fell during the logging period.

This feeder supplies Pannawarri Shopping Centre and it is anticipated that the harmonics being experienced on PS111 would be from the IGA refrigeration and the shopping centres chillers.

It is recommended that BHP investigates the causes of the harmonic breaches to ensure compliance with the Code in coming years.

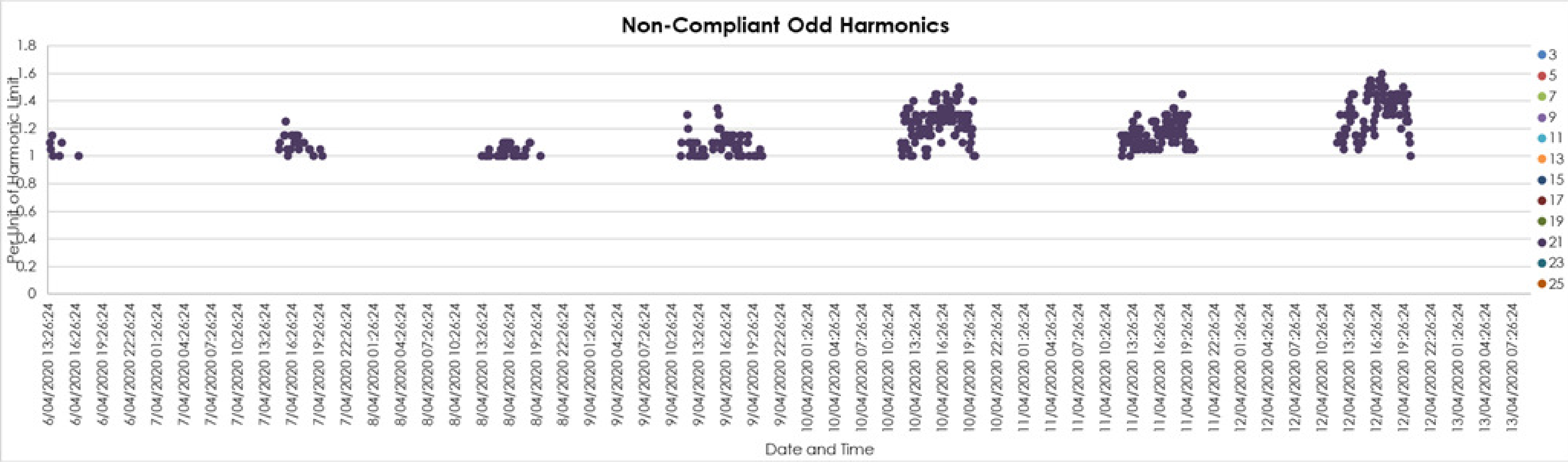


Figure 13 | STS4 Feeder (Start) - Non-Compliant Even Odd Harmonics

6.8. FEEDER STS6

The PQ logger at the start of the STS6 feeder was installed at the PS129 Moondoorow Street substation between 27/04/2020 and 04/05/2020 while the PQ logger at the end of the STS6 feeder was installed at the PS122 Administration substation also between 27/04/2020 and 04/05/2020. As shown in Figure **1** (Yellow), STS6 originates from the South Town substation.

6.8.1. FLICKER

The logged flicker data for the start and end of the STS6 feeder is shown from Figure 84 to Figure 85 in Appendix B.8. There were no noted flicker limit events causing a breach of the Code's limits (i.e. full compliance with the Code requirements).

6.8.2. VOLTAGE

The logged voltage level data for the start and end of the STS6 feeder is shown from Figure 86 to Figure 87 in Appendix B.8. There were no noted voltage limit events causing the voltage level to breach the Code's limits (i.e. full compliance with the Code requirements).

6.8.3. FREQUENCY

The logged frequency data for the start and end of the STS6 feeder is shown in Figure 88 to Figure 89 in Appendix B.8. There were no recorded frequency limit events causing the frequency level to breach the Code's limits (i.e. full compliance with the Code requirements).

6.8.4. VOLTAGE THD

The logged voltage THD level data for the start and end of the STS6 feeder is shown from Figure 90 to Figure 91 in Appendix B.8. There were no noted voltage THD limit events causing the voltage THD level to breach the Code's limits (i.e. full compliance with the Code requirements).

6.8.5. HARMONICS

The logged harmonic data for the start and end of the STS6 feeder is shown from Figure 92 to Figure 93 in Appendix B.8. No non-compliant harmonics were recorded on the feeder.

7. RESPONSE TO THE CODE REQUIREMENTS

This section contains all 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. FLICKER (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. Table 14 presents the results for the previous four reporting periods together with the 2019/2020 result.

Given the results presented, a relative deterioration of the flicker issues is observed over the 2019/2020 FY compared to the logging periods from the previous four years. It should be noted that all 36 P_{LT} breaches are from a single event on PS25(STS1 End), which could be due to anomaly or a one-off incident. If similar or worsened issues are measured in the next year, then further investigations are recommended to identify and mitigate the root-cause.

Table 14 | Total number of flicker level breaches

DESCRIPTION	REPORTABLE PERIOD				
	2015/2016	2016/2017	2017/2018	2018/2019	2019/2020
Total short-term breaches P_{ST}	1	0	8	17	15
Total long-term breaches P_{LT}	0	0	0	4	36*

* All 36 P_{LT} are found to be caused by a single event on PS25 (at STS1 End), hence of no major concern.

7.1.2. VOLTAGE LEVEL (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 AS 3000:2018, the voltage levels of the electrical network must be maintained between +10%/-6% of the nominal 240 V single-phase supply voltage.

Table 15 presents the results for the previous four reporting periods together with the 2019/2020 result. Within the 2019/2020 FY logging period five separate voltage limit breaches were recorded, all of which were undervoltage events (below -6% of 240 V). This shows an improvement when compared to the last year, however, given the negative trend observed in the last 3 years, it is recommended that this parameter be monitored more closely in the upcoming year and, if the problem persists, an investigation should be made into the possible causes for mitigation purposes.

Table 15 | Total number of voltage level breaches

DESCRIPTION	REPORTABLE PERIOD				
	2015/2016	2016/2017	2017/2018	2018/2019	2019/2020
Total voltage limit breaches	0	0	4	8	5

7.1.3. FREQUENCY (PART 2 DIVISION 2 QUALITY STANDARDS SECTION 8 NOTE(B))

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

Table 16 presents the results for the previous four reporting periods together with the 2019/2020 result. Within the 2019/2020 FY logging period a single over-frequency and three under-frequency events were recorded, however due to the isolated and random nature of the events, the electricity supply is expected to fall within the limits given above.

Table 16 | Total number of frequency level breaches

DESCRIPTION	REPORTABLE PERIOD				
	2015/2016	2016/2017	2017/2018	2018/2019	2019/2020
Total frequency limit breaches	0	0	0	1	4

7.1.4. 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 compliance value of 8%.

7.1.4.1. INDIVIDUAL VOLTAGE HARMONICS

Individual, non-compliant harmonics for each respective feeder are presented in Section 6.

7.1.4.2. VOLTAGE TOTAL HARMONIC DISTORTIONS

The voltage harmonic distortion levels of electricity supplied must not exceed the U-THD limit of 8% stated in Part 2, Division 1, Section 7 of the Code. Table 17 presents the results for the previous four reporting periods together with the 2019/2020 result. Within the 2019/20 FY logging period, three events (PS25) were recorded where the maximum U-THD was greater than the 8% limit. It should be noted that all 3 breaches were caused by a single event. With the exception of this event, the average U-THD recorded within the same logging period was consistently well below the 8% limit. It is recommended that this parameter be monitored more closely in the upcoming year.

Table 17 | Total number of total harmonic distortion level breaches

DESCRIPTION	REPORTABLE PERIOD				
	2015/2016	2016/2017	2017/2018	2018/2019	2019/2020
Total U-THD limit breaches	0	0	0	1	3

7.2. REMEDIAL ACTIONS TAKEN FOR BREACHES (SCHEDULE 1 ITEM 4(B))

Newman BHPSA has a pro-active approach toward establishing and executing asset replacement and improvement programs to sustain and improve power quality and reliability across the Newman Township.

To ensure compliance with Australian regulations, BHPSA has undertaken annual PQ logging on the 11 KV supply feeders originating from both the South Town and Township substations during the summer/autumn period. Improvements are implemented based on the PQ logging data results and any complaints received from customers related to power quality issues.

Asset upgrades include:

- Completed works on the major equipment upgrades at the Township Substation involving the replacement of the two ageing 66/11kV power transformers and neutral earth resistors
- Completed the conversion of an overhead section of low voltage powerline along Newman Drive (between Mindarra Drive and Nyabalee Road) to underground cable to improve public safety thus mitigating the conductor-to-ground height clearance issue that existed on this section of line.
- Completed conversion of an overhead section of low voltage powerline along Radio Hill Drive to underground cable to improve public safety thus mitigating the conductor-to-ground height clearance issue that existed on this section of line. This followed a “high load versus live conductor” incident early in 2020 calendar year.
- Continue with improvements driven by the results of investigations, e.g., in 2020/21, the replacement of transformer T7 and pad-mount substation PS61 as part of asset lifecycle ‘end of useful life’ replacement work, as well as the replacement of an aged low voltage switchboard at PS113 ‘Fortescue Flats’
- BHP is considering the replacement of existing line interrupters (which cannot be switched on load) with air break switches (which can be switched on load). This will provide a better reliability of supply experience for customers during the day to day operation of the network.
- Installed one SEL735 Advanced Power Quality and revenue meters at PS115 in order to undertake long term power quality measurements and investigate power quality issues on network. Finalising plans to install additional 15 permanent SEL735 PQM meters by December 2020.
- BHP are continuing the process of migrating from their current retailing and billing contractors (Agility) to Horizon Power with the key driving factor behind the migration being the installation of Advanced Metering Infrastructure (AMI). There AMI smart meters are capable of two-way communication which in turn will provide a number of benefits including:
    - Improved accuracy of meter readings – reducing estimated billing errors;
    - Early detection of power quality issues
    - Improved monitoring of power outages to assist maintenance crews in reducing restoration times.

7.3. SUPPLY INTERRUPTED (SCHEDULE 1 ITEM 5)

Schedule 1 of the Code gives the information to be published within the annual compliance report. The provisions of Item 5 require that the following information be published:

> *"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."*

*Section 12(1) of the Code defines 'permitted number of times' as nine times (for Perth CBD or urban areas) or 16 times (for small use customers in other areas).

7.3.1. INTERRUPTIONS EXCEEDING 12 HOURS

In 2019/20, one network interruption which exceeded 12 hours was recorded. Standby generators were employed 3 hours into the outage to supply power to the affected customer(s) until the network issue was rectified and normal supply restored.

Table 18 | Total number of premises of small customers interrupted continuously for more than 12 hours

DESCRIPTION	REPORTABLE PERIOD				
	2015/2016	2016/2017	2017/2018	2018/2019	2019/2020
Total number of premises that experienced a single interruption exceeding 12 hours	0	1	0	0	1

7.3.2. INTERRUPTIONS EXCEEDING THE PERMITTED NUMBER OF TIMES

The permitted number of times that a customer connection can be disconnected from the electricity supply within the preceding year (defined as the period of 12 months ending on 30 June) is given as 16 as per Section 12(1) of the Code.

There were no customers disconnected more than 16 times as observed in the BHP outage logs.

Table 19 | Total number of premises that experienced >16 interruptions within the preceding year

DESCRIPTION	REPORTABLE PERIOD				
	2015/2016	2016/2017	2017/2018	2018/2019	2019/2020
Total number of premises that experienced more than 16 interruptions	0	0	0	0	0

7.4. NUMBER OF COMPLAINTS RECEIVED (SCHEDULE 1 ITEMS 6 AND 10)

Division 2, Section 25(1) of the Code defines "complaint" as a complaint that a provision of Part 2, or of an instrument made under section 14(3), has not been, or is not being, complied with. Table 20 presents the results for the previous four reporting periods together with the 2019/2020 FY result.

No complaints relating to power quality were received in 2019/2020 FY.

Table 20 | Total number of formal complaints lodged to BHPSA

DESCRIPTION	REPORTABLE PERIOD				
	2015/2016	2016/2017	2017/2018	2018/2019	2019/2020
Total number of formal complaints received	0	0	0	0	0

7.5. COMPLAINTS RECEIVED IN EACH DISCRETE AREA (SCHEDULE 1 ITEMS 7 AND 10)

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

7.6. TOTAL AMOUNT SPENT ADDRESSING COMPLAINTS (SCHEDULE 1 ITEMS 8 AND 10)

There have been no ~~technical~~ complaints over the 2019/20 FY that required BHP's action.

7.7. NUMBER AND TOTAL AMOUNT OF PAYMENTS MADE (SCHEDULE 1 ITEMS 9 AND 10)

Sections 18 and 19 of the Code stipulates that failure on the part of the electricity distributor to provide required notice for either a planned interruption or an interruption exceeding 12 hours to a small use customer shall result in a financial payment.

Table 21 presents the summary of payments made to small use customers over the four previous reporting periods, as well as the 2019/2020 FY period.

Table 21 | Summary of payments made under Sections 18 and 19

DESCRIPTION	REPORTABLE PERIOD				
	2015/2016	2016/2017	2017/2018	2018/2019	2019/2020
Total number of payments	0	0	0	0	0
Total amount of payouts in AUD ($)	0	0	0	0	0

7.8. RELIABILITY OF SUPPLY (SCHEDULE 1 ITEM 11)

The provisions of Schedule 1, Item 11 of the Code requires that the following information to be published:

> *"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 the context of this report, the township of Newman is considered the *discrete area*. The BHPSA 2019/2020 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.

7.8.1. AVERAGE INTERRUPTION (SCHEDULE 1 ITEMS 11(A), 12 AND 13)

Table 22 presents the average duration of a supply interruption to small use customer connections affected by a fault within the Newman township electrical network, also known as the CAIDI described in Section 5.4.1, over the four previous reporting periods as well as the 2019/2020 FY period. An improvement in CAIDI was observed this year when compared to the previous years.

Table 22 | Summary of average interruption length to affected customers (CAIDI)

DESCRIPTION	REPORTABLE PERIOD					AVERAGE
	2015/2016	2016/2017	2017/2018	2018/2019	2019/2020	
Average interruption duration – CAIDI (minutes)	102	53	33	141	99.28	105.51

7.8.2. AVERAGE NUMBER OF INTERRUPTIONS (SCHEDULE 1 ITEMS 11(B), 12 AND 13)

Table 23 presents the average number of interruptions to small use customer connections within the Newman township electrical network, also known as the SAIFI described in Section 5.4.2, over the four previous reporting periods as well as the 2019/2020 FY period. A notable improvement in SAIFI was observed this year when compared to the previous years.

Table 23 | Summary of average number of interruptions (SAIFI)

DESCRIPTION	REPORTABLE PERIOD					AVERAGE
	2015/2016	2016/2017	2017/2018	2018/2019	2019/2020	
Average number of interruptions – SAIFI	1.64	1.53	1.07	2.66	0.417	1.46

7.8.3. AVERAGE TIME PERCENTAGE SUPPLIED (SCHEDULE 1 ITEMS 11(C), 12 AND 13)

Table 24 presents the average percentage of time that electricity has been supplied to small use customer connections, also known as the ASAI described in Section 5.4.3, over the four previous reporting periods as well as the 2019/2020 FY period. An improvement in ASAI was observed this year when compared to the previous years.

Table 24 | Summary of average percentage of time supplied (ASAI)

DESCRIPTION	REPORTABLE PERIOD					AVERAGE
	2015/2016	2016/2017	2017/2018	2018/2019	2019/2020	
Average percentage of time supplied – ASAI (%)	99.97	99.98	99.99	99.93	99.99	99.97

7.8.4. AVERAGE DURATION OF ALL INTERRUPTIONS (SCHEDULE 1 ITEMS 11(D), 12 AND 13)

Table 25 presents the average duration of a supply interruption to any single small use customer connection within the Newman township electrical network, also known as the SAIDI described in Section 5.4.4, over the four previous reporting periods as well as the 2019/2020 FY period. A notable improvement in SAIDI was observed this year when compared to the previous years.

Table 25 | Summary of average interruption duration to all customers (SAIDI)

DESCRIPTION	REPORTABLE PERIOD					AVERAGE
	2015/2016	2016/2017	2017/2018	2018/2019	2019/2020	
Average interruption duration – SAIDI (minutes)	168	81	35	376	41.36	140.27

7.9. 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."*

7.9.1. AVERAGE INTERRUPTION (CAIDI) – PERCENTILE

Table 26 presents the percentile distribution spread for the average duration of interruptions to affected small use customers (CAIDI) within the Newman Township for the 2019/2020 FY logging period.

Table 26 | CAIDI Percentile Distribution 2019/2020 FY

DESCRIPTION	PERCENTILE						
	25TH	50TH	75TH	90TH	95TH	98TH	100TH
Average Length of Interruption (CAIDI)	412	99	99	99	99	99	99

7.9.2. NUMBER OF INTERRUPTIONS (SAIFI) – PERCENTILE

Table 27 presents the percentile distribution spread for the average number of interruptions to small use customers (SAIFI) within the Newman Township for the 2019/2020 FY logging period.

Table 27 | SAIFI Percentile Distribution 2019/2020 FY

DESCRIPTION	PERCENTILE						
	25TH	50TH	75TH	90TH	95TH	98TH	100TH
Average Number of Interruptions (SAIFI)	0.07	0.42	0.42	0.42	0.42	0.42	0.42

7.9.3. AVERAGE DURATION OF ALL INTERRUPTIONS (SAIDI) – PERCENTILE

Table 28 presents the percentile distribution spread for the average duration of all interruptions to a small use customer (SAIDI) within the Newman Township for the 2019/2020 FY logging period.

Table 28 | SAIDI Percentile Distribution 2019/2020 FY

DESCRIPTION	PERCENTILE						
	25TH	50TH	75TH	90TH	95TH	98TH	100TH
Average Length of All Interruptions (SAIDI)	29	41	41	41	41	41	41

8. CONCLUSION

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

With regards to the site measurements, the average values of electrical parameters were logged over a period of seven days, at 10-minutes intervals. PQ indices were then calculated and found, in large, 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 compliance issues were identified:

- Voltage Flicker: An increase in the number of short-term and long-term voltage fluctuation limit breaches (15 short-term and 36 long-term breaches) described in AS61000:2001 was recorded compared to the logging periods for previous four years. It should be noted that all the long term breaches was from a single event on a single transformer and was not noted during any other part of the logging period. The most onerous breaches were observed on the TC2, STS1, STS2 and STS4 feeders.
- RMS Voltage Magnitude: A relatively similar number of voltage level breaches (five undervoltage breaches) were observed compared to the logging periods for the previous three years. Given the temporary and random nature of the breaches, it is not deemed of a practical concern at this stage, but it is recommended that this parameter be monitored over the coming years.
- Power System Frequency: A single over-frequency and three under frequency breaches of the limits described in the Electricity Act of 1945 Section 25(1)(d) were recorded during the logging period. As these events appear to be isolated and constitute a very small fraction (less than 0.1%) of the total measurement period, it is not deemed of a practical concern at present.
- U-THD: Three U-THD breaches of the limits described in Part 2, Division 1, Section 7 of the Code were recorded during the logging period. It should be noted that all three breaches were from a single event on the same Transformer (PS25). With the exception of these single event breaches, the average U-THD level recorded on all feeders was consistently below the required limit.
- The recorded individual order harmonics showed a number of temporary and random breaches on all feeders that are not deemed of a practical concern. A large number of 21st order harmonic level breaches were recorded on the STS4 Feeder Start (PS111). The magnitude of these breaches appears to follow a typical daily demand pattern, and it is recommended that the cause of these breaches is investigated and addressed in due course.

Reportable parameters for Newman Township Electricity Supply over the 2019/20 FY (as outlined in the 'Schedule 1' of the Code) are presented below:

- >12-hour interruptions: In 2019/20, one network interruption which exceeded 12 hours was recorded. Standby generators were employed 3 hours into the outage to supply power to the affected customer(s) until the network issue was rectified and normal supply restored.
- No small use customer was disconnected from the network more than the maximum number of times permitted by the Code (i.e., limit of 16 times per year).
- No power quality and reliability related complaints were received from customers during FY 2019/2020.
- The key reliability indices are calculated as listed below:
    - *Customer Average Interruption Duration Index (CAIDI)* of 99 minutes – CAIDI is a measure of the average outage duration or average outage restoration time. [It is defined as "The sum of the durations of sustained[2] customer interruptions divided by the total number of sustained customer interruptions"].
    - *System Average Interruption Frequency Index (SAIFI)* of 0.417 interruptions – SAIFI is the average number of interruptions per customer served. [It is defined as "the total number of sustained customer interruptions divided by the total number of customers served"].
    - *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 41.36 minutes – SAIDI is the average outage duration for each customer served. [It is defined as "the sum of durations of sustained customer interruptions divided by the total number of customers served"].

  An improvement is observed in majority of the reliability indices when compared to the previous years.

In summary, the metering data collected from the 16 locations throughout the Newman Township network indicate that the power quality is, in large, within the limits stipulated by the Code. It should be noted that although the overall reliability of the Newman Township supply appeared to have degraded marginally when compared to the same reliability indices for previous FYs, the overall network performance is still considered to be satisfactory. The relative deterioration in reliability indices can be attributed to the events outside of BHPSA's control. As such, this report finds the reliability and quality of the supply for Newman Township network in compliance with the Code's requirements, with further monitoring of areas of the network recommended to ensure quality and reliability is maintained in the upcoming years.

[2] By "sustained" we mean only interruptions lasting 1 minute or longer. (Momentary) Outages lasting less than 1 minute are not included in the index. Planned outages and some other types of outages are also excluded from this index. This note also applies to the SAIFI and SAIDI indices.

APPENDIX A. PQ LOGGING DEVICE (HIOKI 3198)

Refer to the attached.

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.

One Single Unit Can Solve All Your Power Supply Problems

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

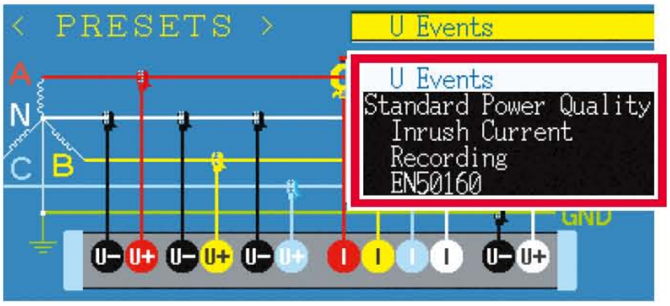
Class A is defined in the international standard IEC61000-4-30, which specifies compatibility with power quality parameters, accuracy, and standards to enable comparison and discussion of the measurement results of different measuring instruments.

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

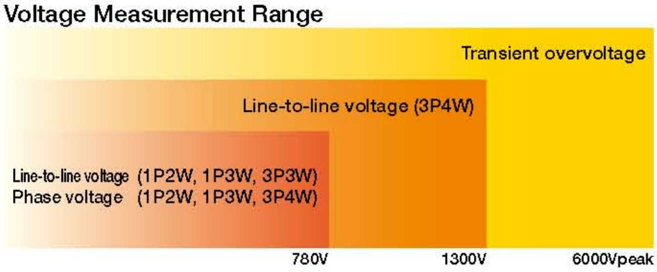


Simply choose the course based on the measurement objective and the necessary configurations will be set automatically.

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.

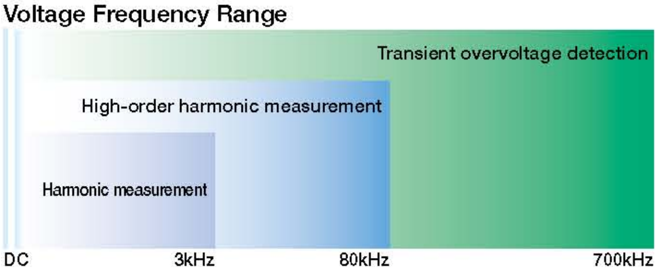
4 Highly Accurate, Broadband, Wide Dynamic Range Makes for Reliable Measurements

Voltage Measurement Range



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

Voltage Frequency Range



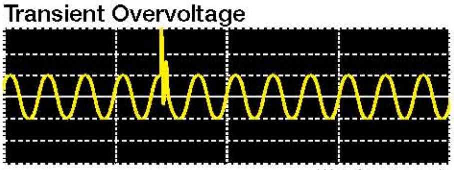
Wide range from DC voltage to 700 kHz

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.

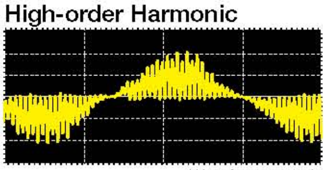
Transient Overvoltage



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.

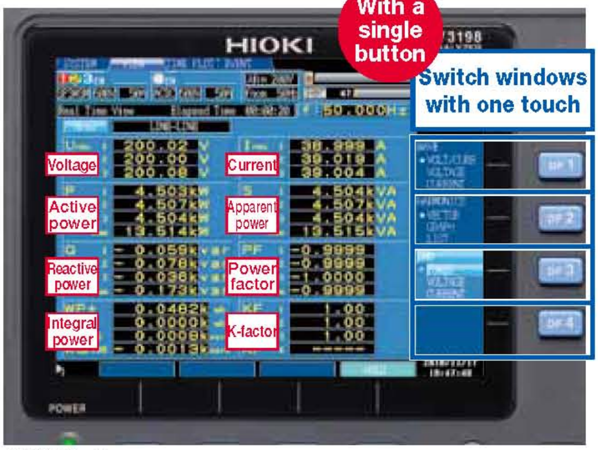
PW3198 Never Misses the Moment a Power Supply Failure Occurs

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**

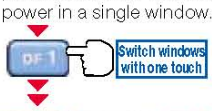
Acquire the Information You Need Quickly by Switching Pages (RMS Value)

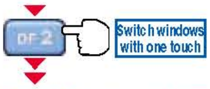
Just connect to the measurement line, and the PW3198 will simultaneously measure all parameters, such as power and harmonic. You can then switch pages to view the needed information immediately.

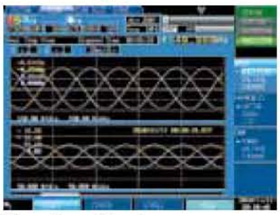


DMM Display

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





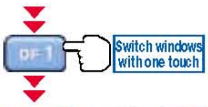


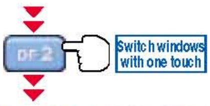
Waveform Display

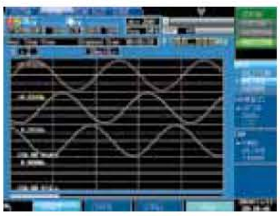
Display the voltage and current waveforms on channels 1 to 4 one above the other in a single window.

Vector Display

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

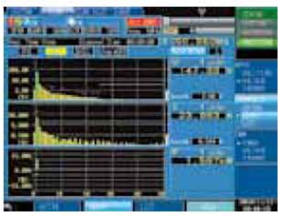






4-channel Waveform Display

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



Harmonic Bar Graph Display

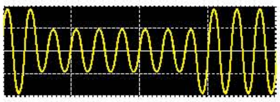
Display the RMS value and phase angle of harmonics from the 0th order to the 50th either in a graph or as numerical values.

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.

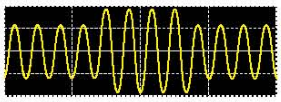
Transient Overvoltage (Impulse)

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.



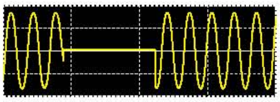
Voltage Dip (Voltage Drop)

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



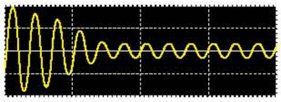
Voltage Swell (Voltage Rise)

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.



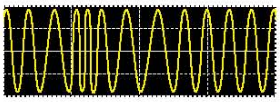
Interruption

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.



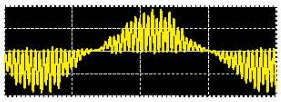
Inrush Current

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



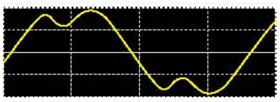
Frequency Fluctuations

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



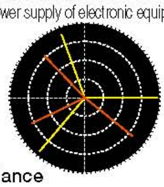
High-order Harmonic

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.

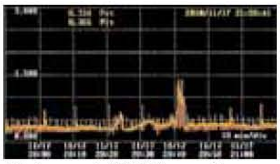
Simultaneous Recording of TIME PLOT Data and Event Waveforms

TIME PLOT Data — TIME PLOT Recording of All Parameters

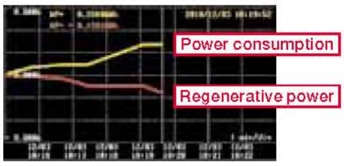
The PW3198 can simultaneously record 8,000 or more parameters, such as voltage, current, power, power factor, frequency, integral power, harmonic, and flicker, at the specified recording interval. The PW3198 never fails to capture the peak because it performs calculations continuously and records the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

Trend Recording
(TIME PLOT Recording)

Harmonic Recording



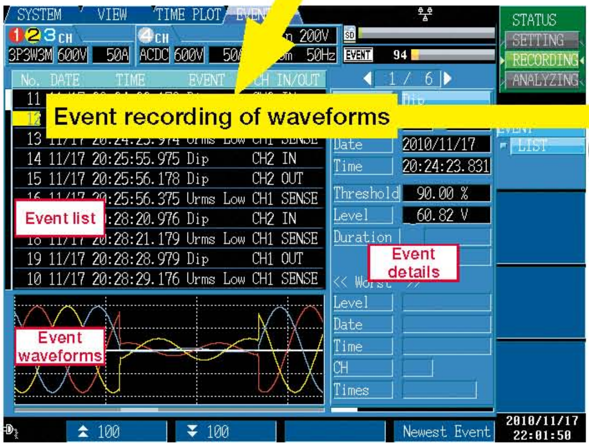
Flicker and ΔV10 Recording

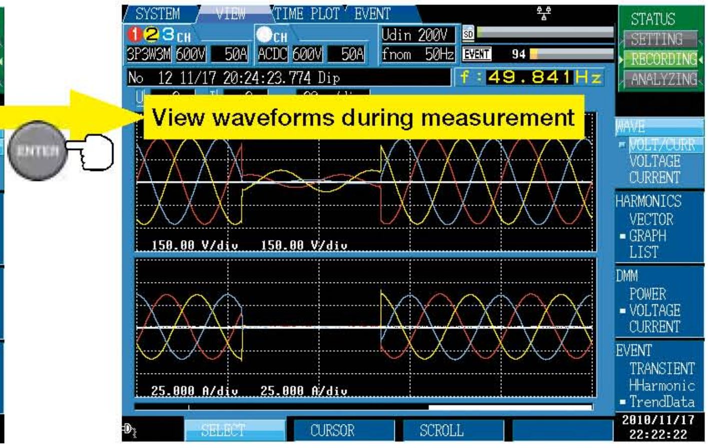


Integral Power Recording

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.



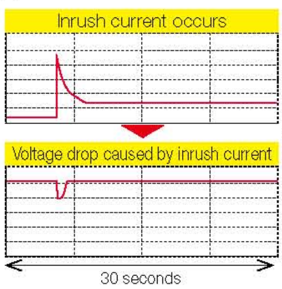


Event List

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

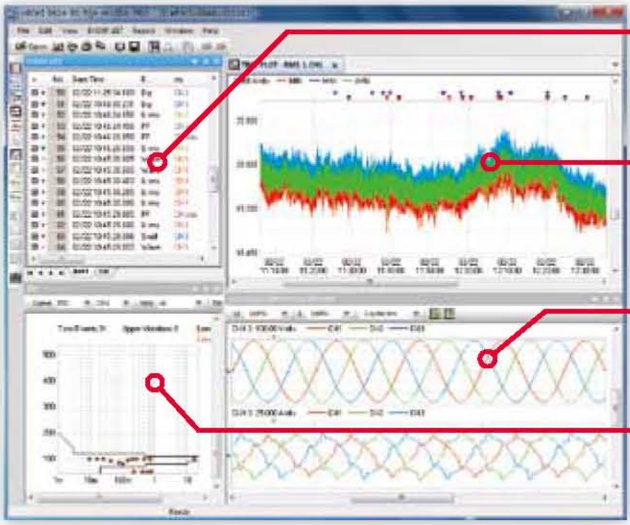
When a voltage drop or inrush current occurs, RMS value changes are recorded over 30 seconds simultaneously. This function can also be used to check the voltage drop caused by inrush current generated by the start of the motor.

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**.



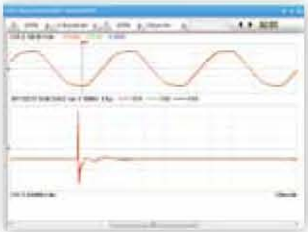
Event List Window
Display a list of power supply failures (events) that occurred.

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.

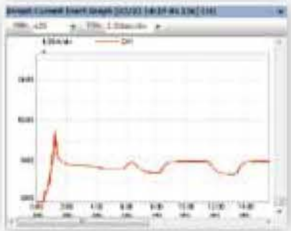
Event Waveform Window
Display the waveform of an event that occurred, plus the vector, harmonic, DMM, and instantaneous harmonic values.

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

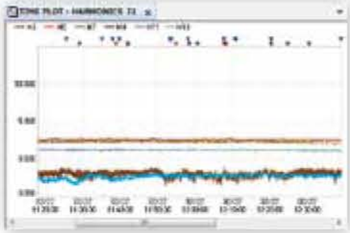
Status Window



Transient Waveform Window



Inrush Current Event Graph Window



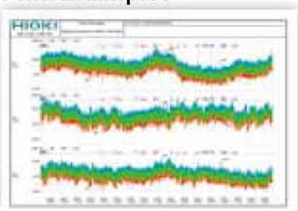
Harmonics TIME PLOT Window

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).

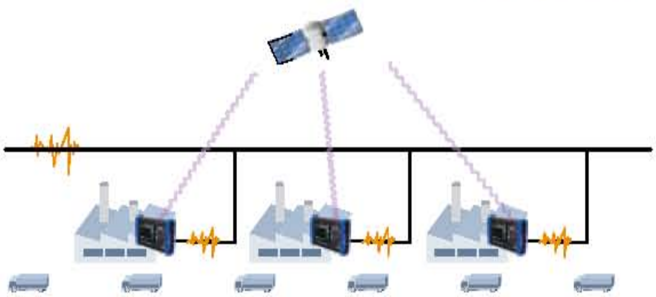
Conduct off-site remote control with a tablet PC using a wireless LAN router

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.

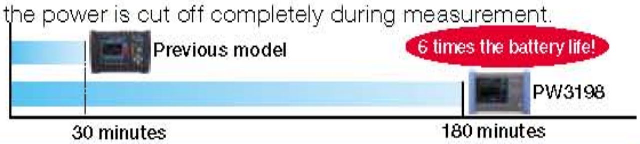
GPS Time Synchronization

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

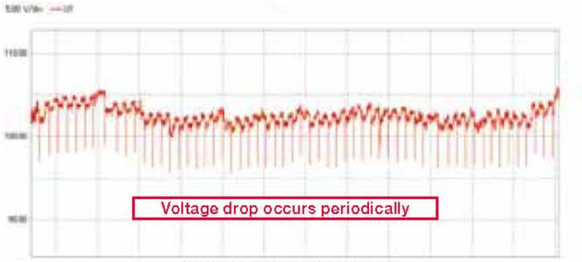
Measure at a power line frequency of 50/60 Hz as well as 400 Hz.

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.



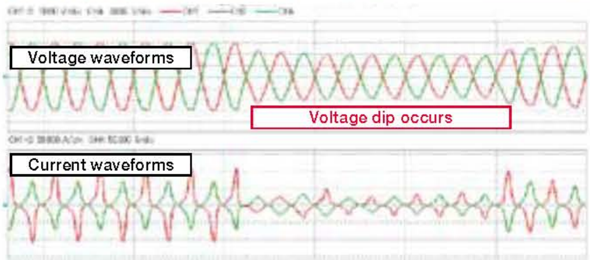
Voltage Fluctuation Graph

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

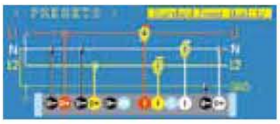
Analysis Report
It was determined that a voltage dip (voltage drop) occurred and impacted the operation of the equipment. **If a voltage dip occurs every day on a regular basis, the probable cause is the start of a large air-conditioning unit, pump, heater, or similar equipment.**

Surveying a Solar Power Generation System

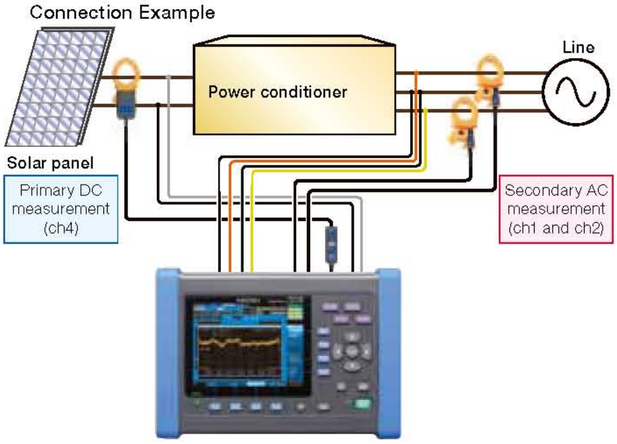
Survey Objective

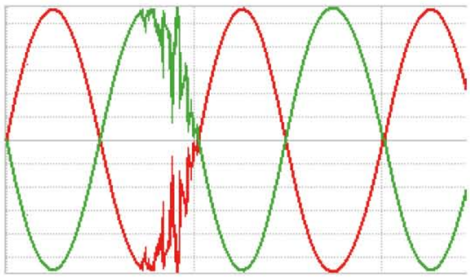
- Maintain a solar power generation system and check its operation (verify the power quality)
- Troubleshoot (impact on the peripheral equipment, operation shutdown, etc.)

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.

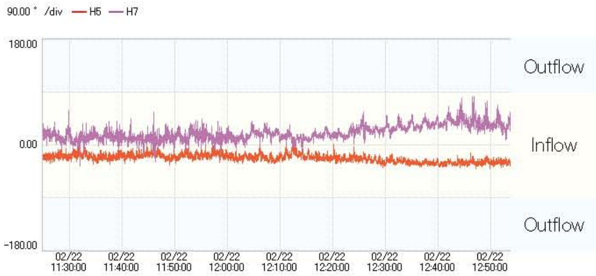


Connection Example





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.

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")x135H(5.31")x21D(0.83")mm, 230g(8.1oz.)		78W(3.07")x152H(5.98")x42D(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, 9V1A output for USA) AC ADAPTER 9445-03 (universal 100 to 240VAC, 9V1A 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")x58H(2.28")x19D(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 ×1, CT6590 ×1	CT9692 ×1, CT6590 ×1	CT9693 ×1, CT6590 ×1

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") × 129H(5.08") × 18D(0.71") mm, 230g (8.1 oz.)	62W(2.44") × 167H(6.57") × 35D(1.38") mm, 410g (14.5 oz.)	62W(2.44") × 196H(7.72") × 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") × 120H(4.72") × 34D(1.34") mm (excluding protruding parts), 165g(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")×145H(5.71")× 42D(1.65)mm, 380g(13.4oz.)	60W(2.36")×112.5H(4.43")× 23.6D(23.6")mm, 160g(5.6oz.)

* : 45 to 66Hz

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")x20(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")x20(0.79")mm busbar,
Cord length : 3m(9.84ft)

CLAMP ON LEAK SENSOR (Leak Current)

Cannot be used to measure power

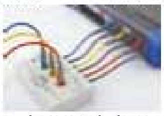
9657-10
10A AC (Up to 5A on Model PW3198),
φ40mm(1.57"),

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.

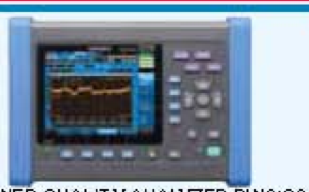
Case

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

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

Clock synchronization

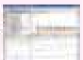
GPS BOX PW9005
To synchronize the PW3198 clock,
Accessory: Connection cable set



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

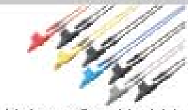
(Set with PQA HiVIEW PRO 9624-50 and bundled accessories)



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/4500 mAh)

●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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APPENDIX B. PQ LOGGING DATA (2019/2020 FY)

Please refer to the following pages.

APPENDIX B.1. FEEDER TC1 FLICKER, VOLTAGE, FREQUENCY AND HARMONICS

Figure 14 | TC1 Start Flicker measurements

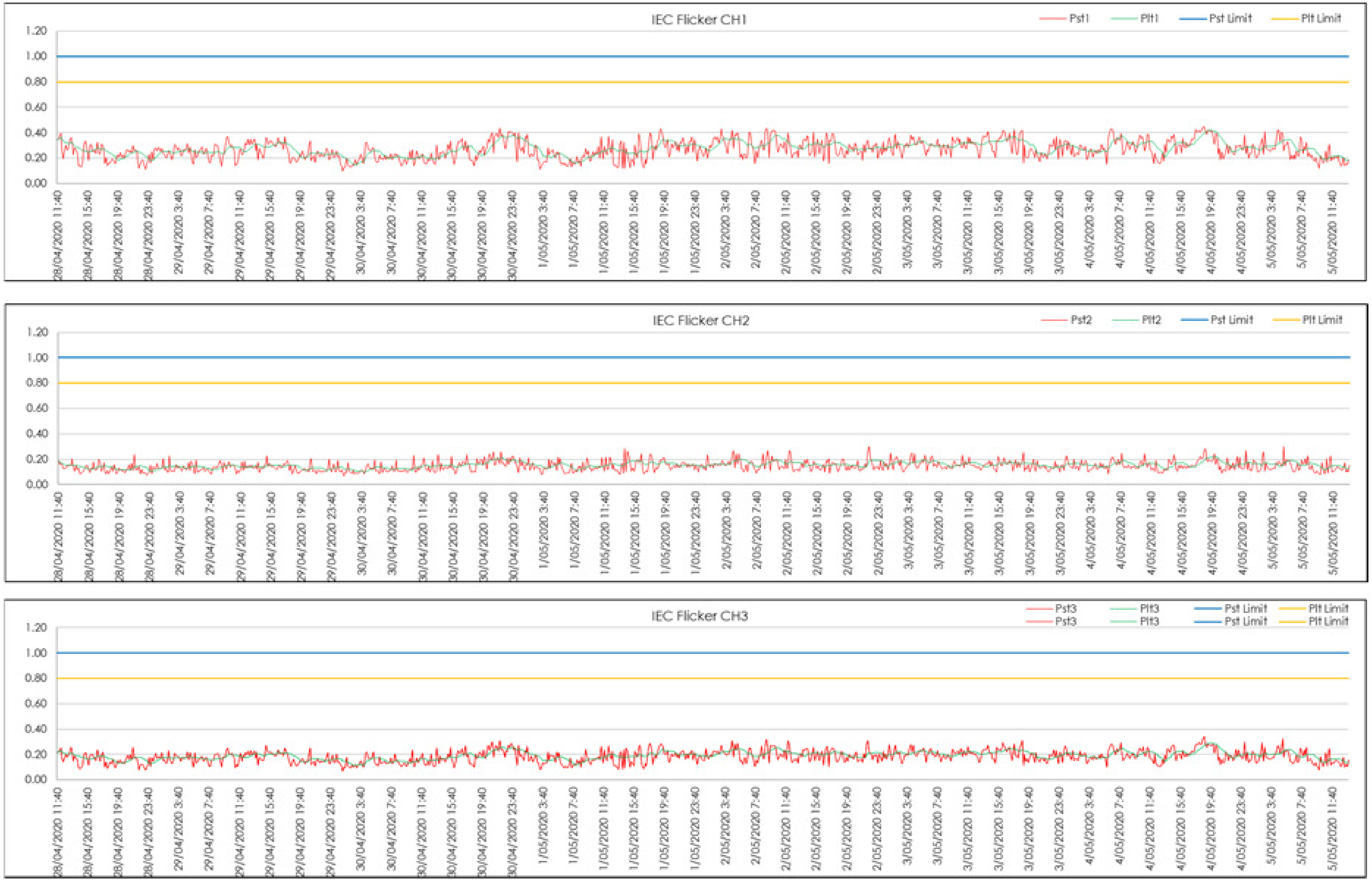


Figure 15 | TC1 End Flicker measurements

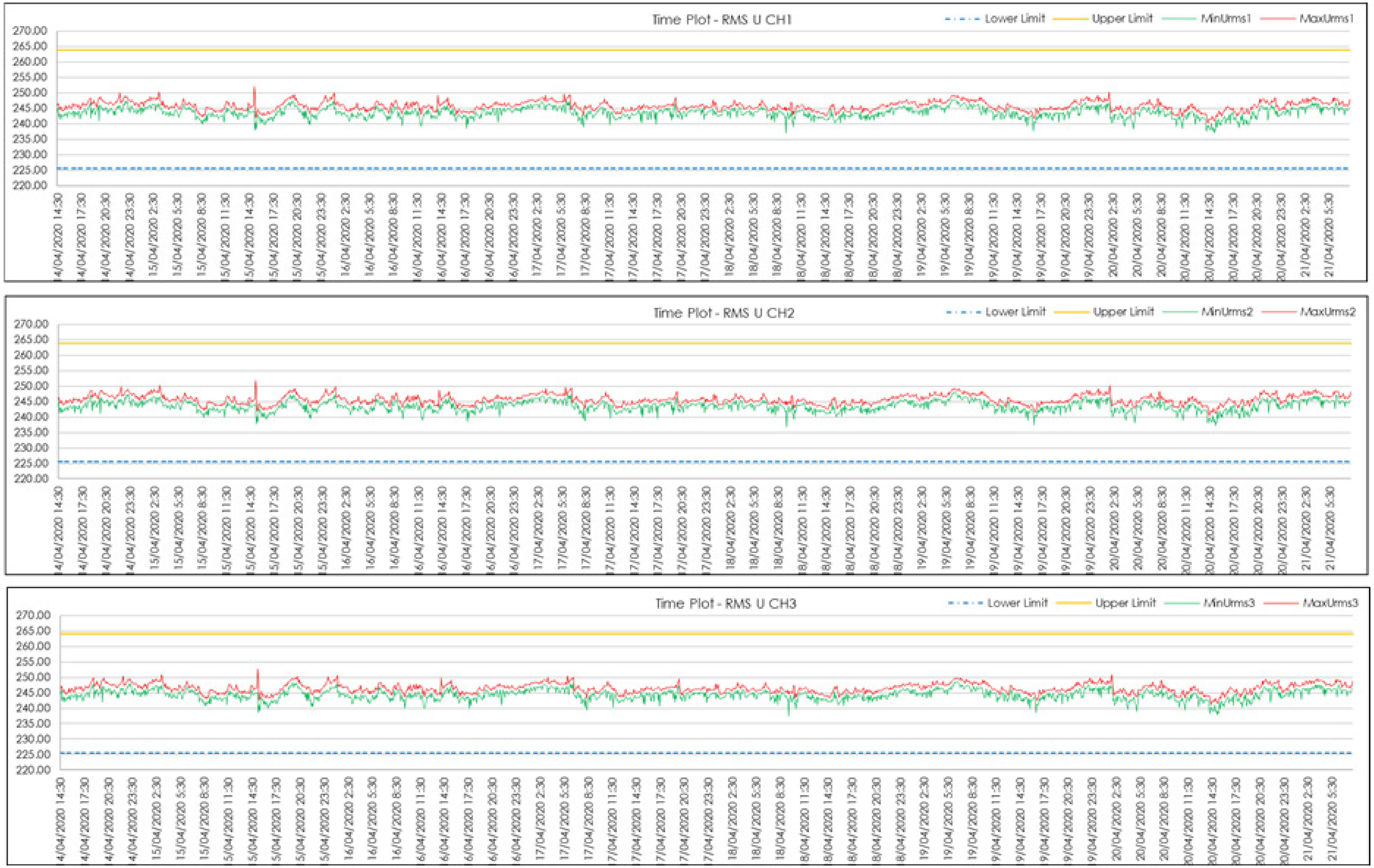
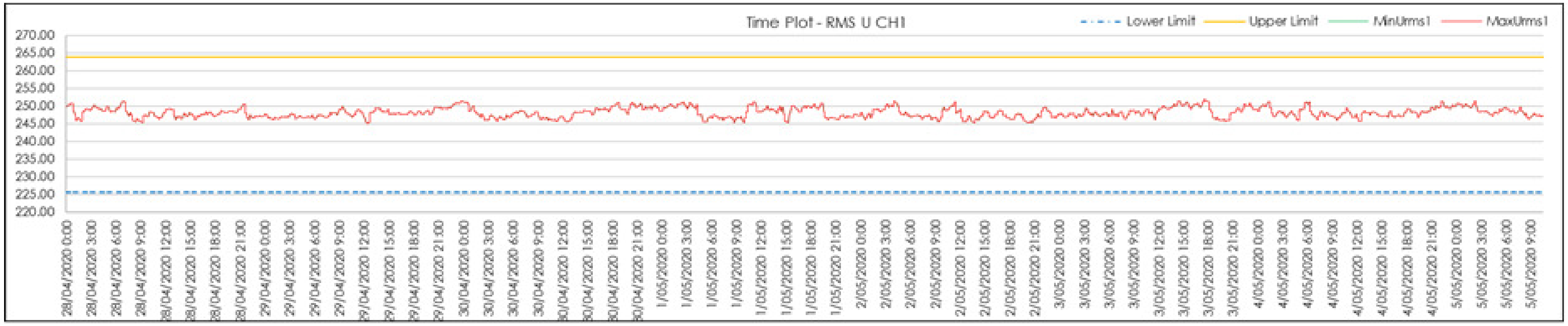
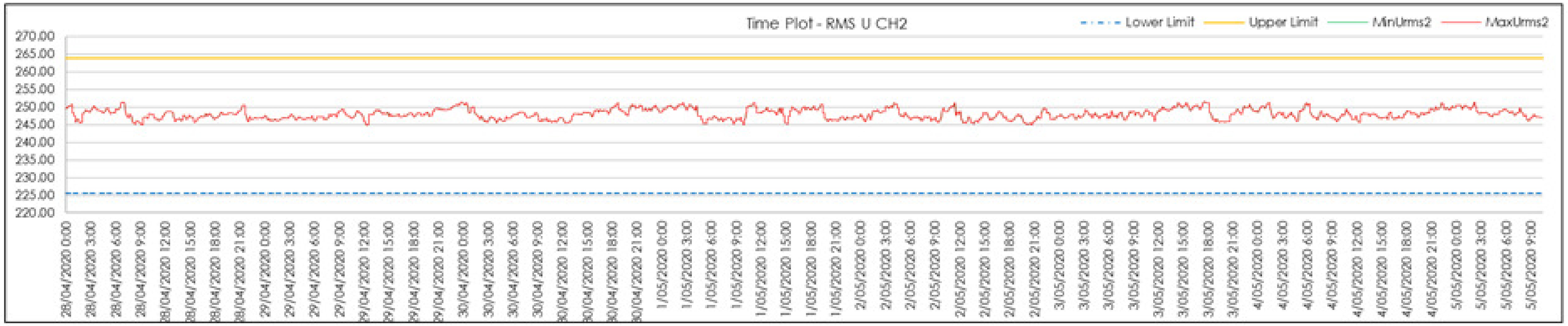


Figure 16 | TC1 Start Voltage measurements





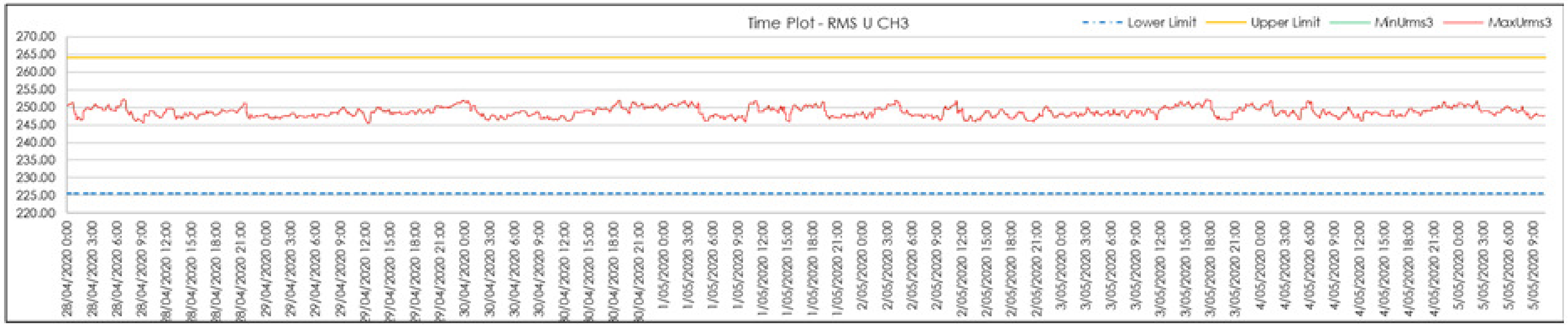


Figure 17 | TC1 End Voltage measurements

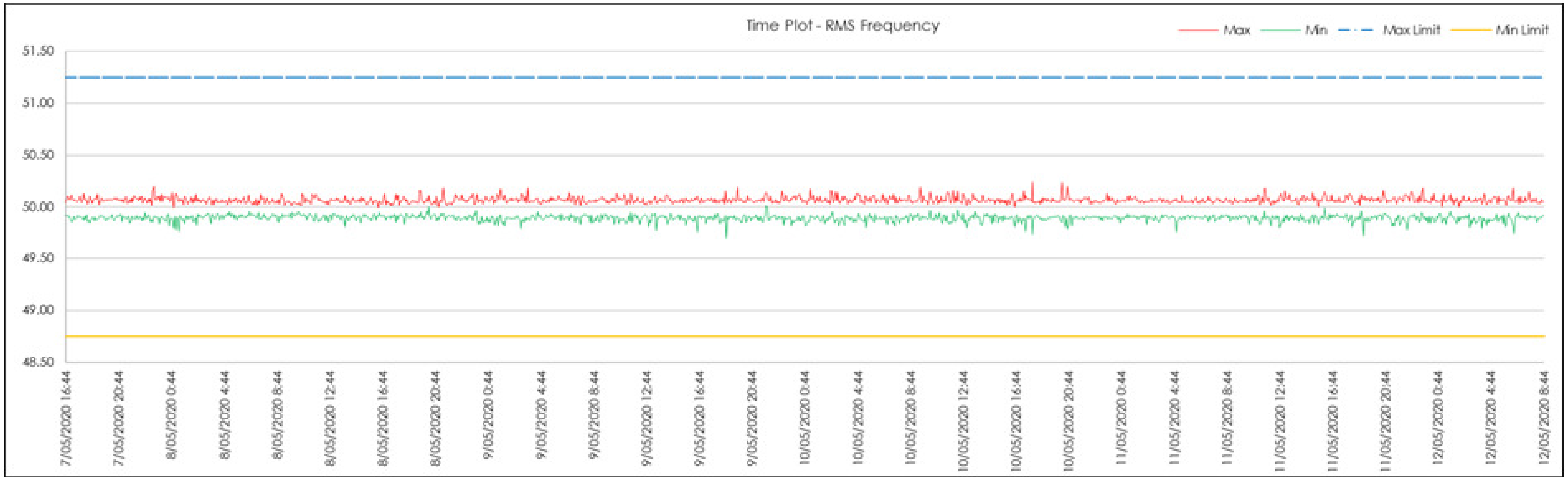


Figure 18 | TC1 Start Frequency measurements

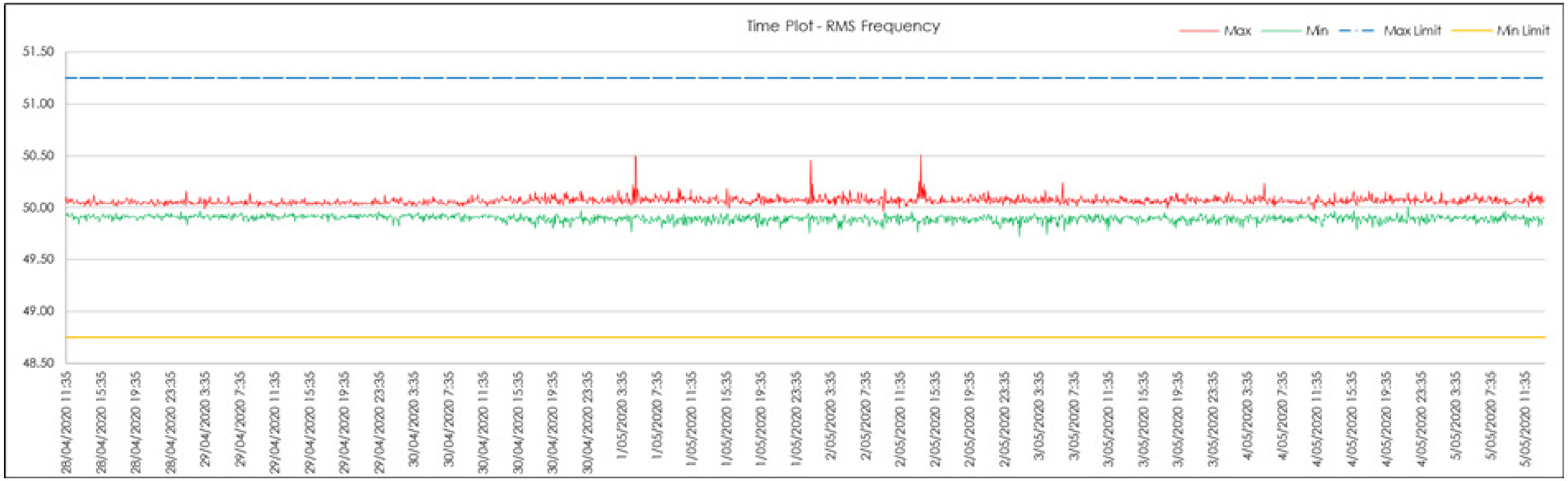


Figure 19 | TC1 End Frequency measurements

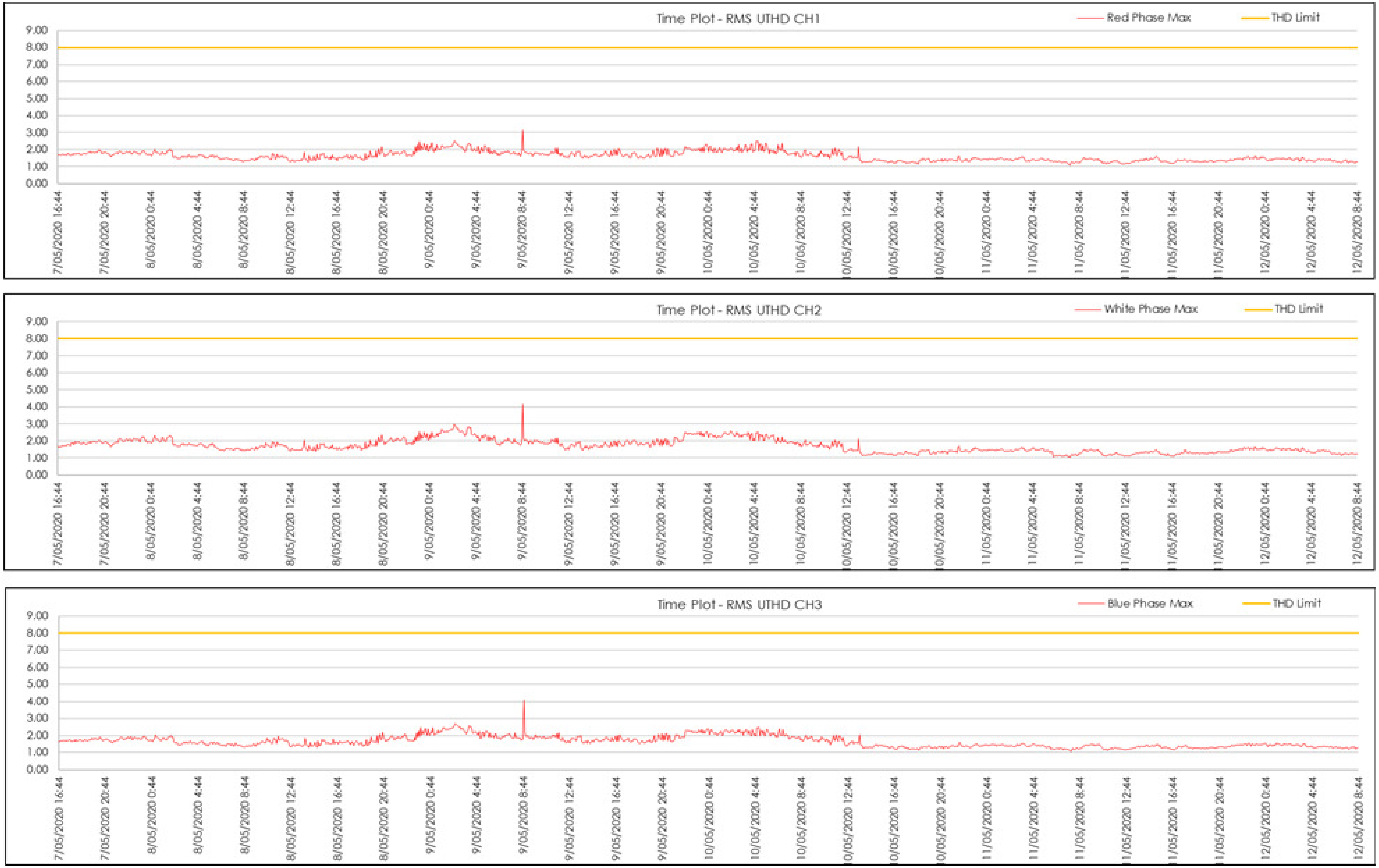


Figure 20 | TC1 Start U-THD measurements

Figure 21 | TC1 End U-THD measurements

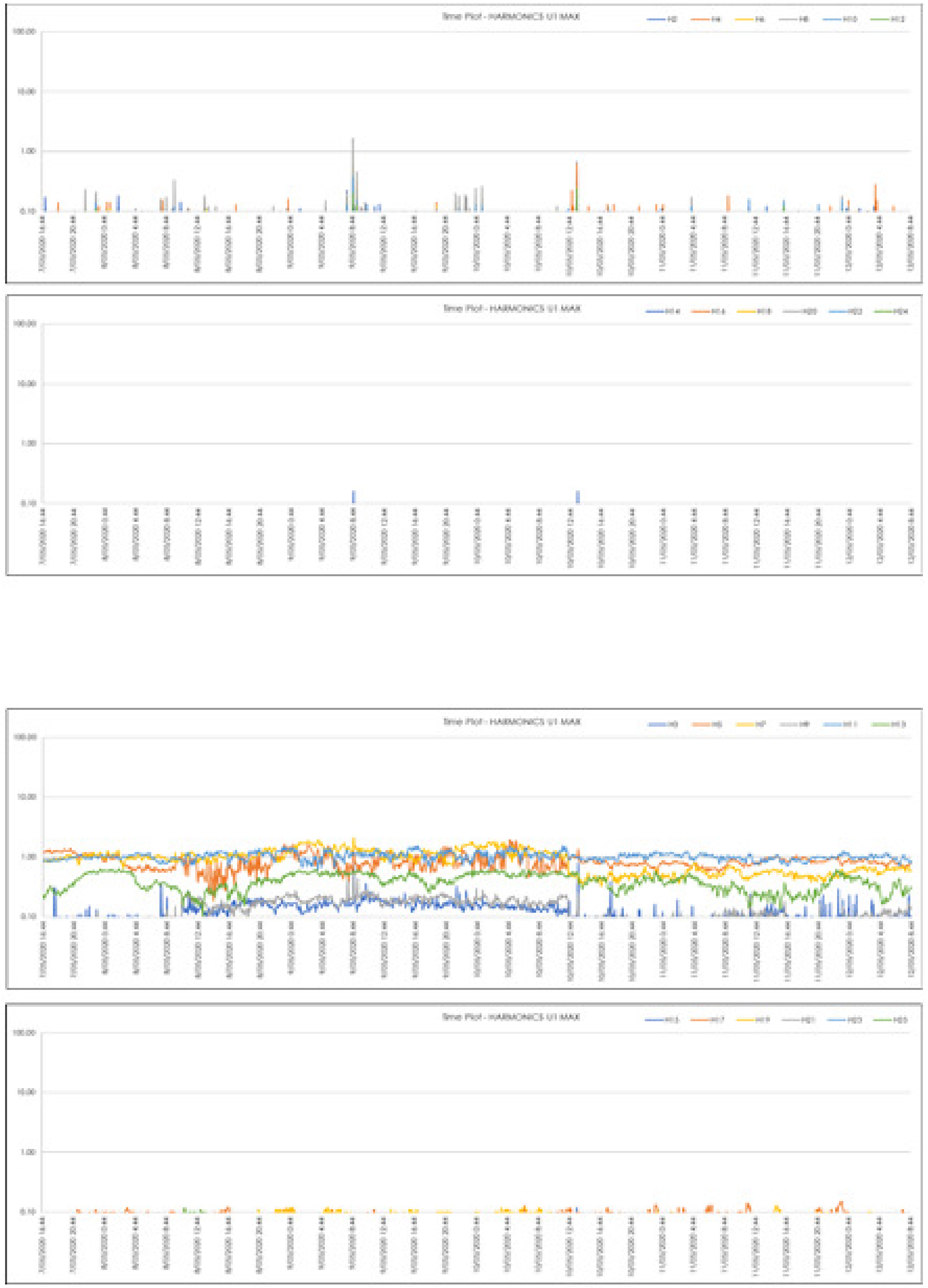


Figure 22 | TC1 Start Harmonics

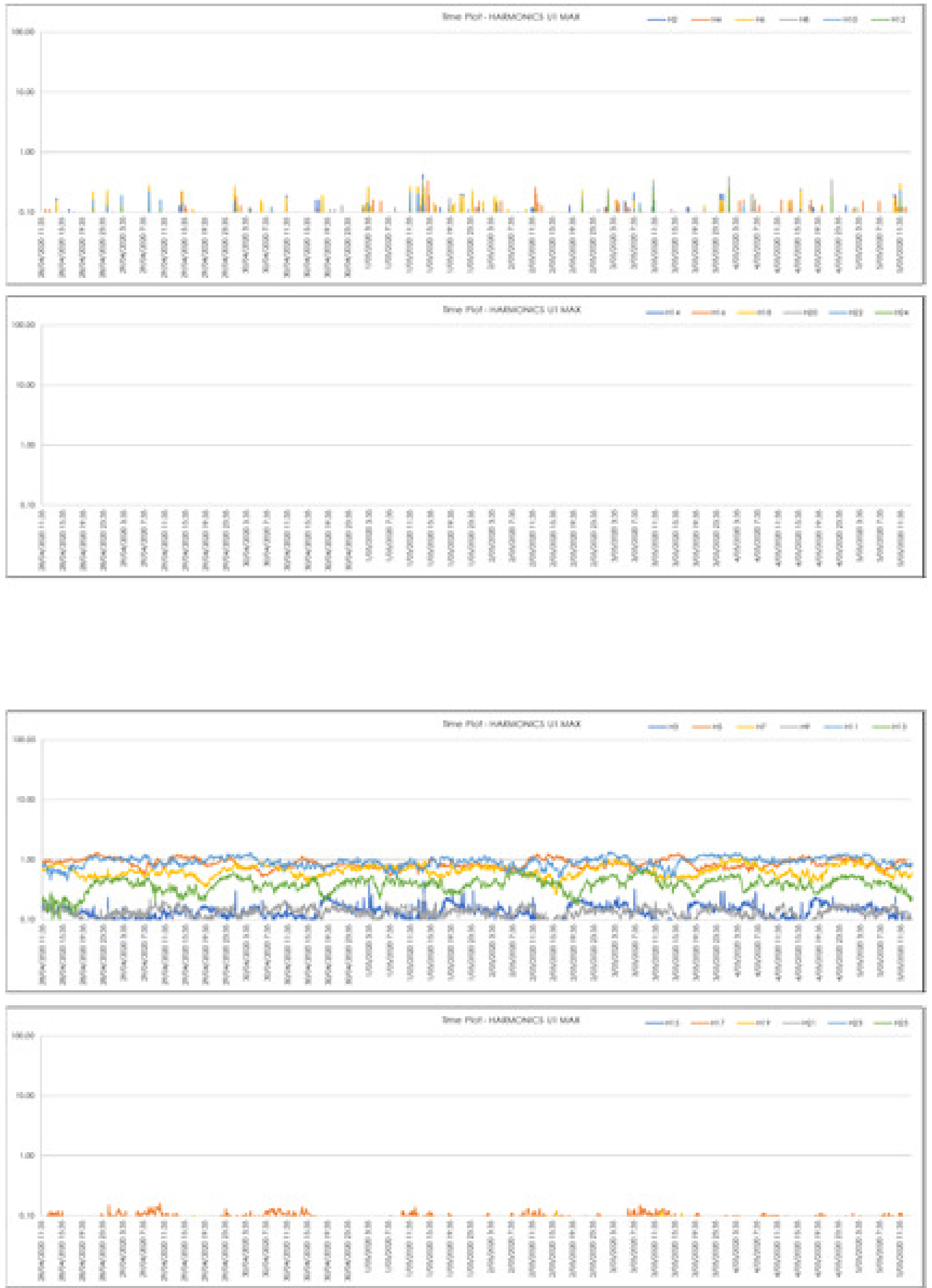


Figure 23 | TC1 End Harmonics

APPENDIX B.2. FEEDER TC2 FLICKER, VOLTAGE, FREQUENCY AND HARMONICS

Figure 24 | TC2 Start Flicker measurements

Figure 25 | TC2 End Flicker measurements

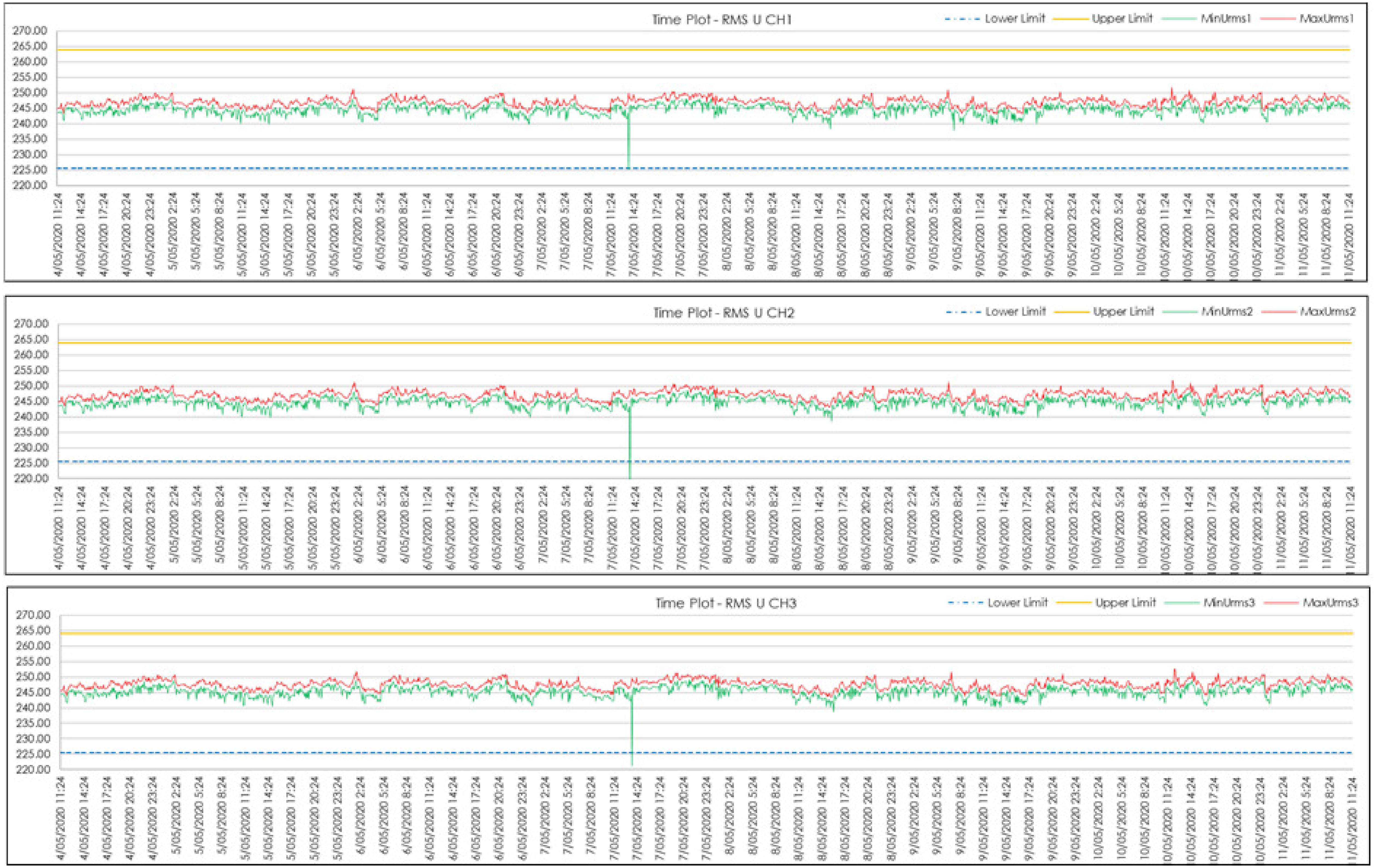


Figure 26 | TC2 Start Voltage measurements

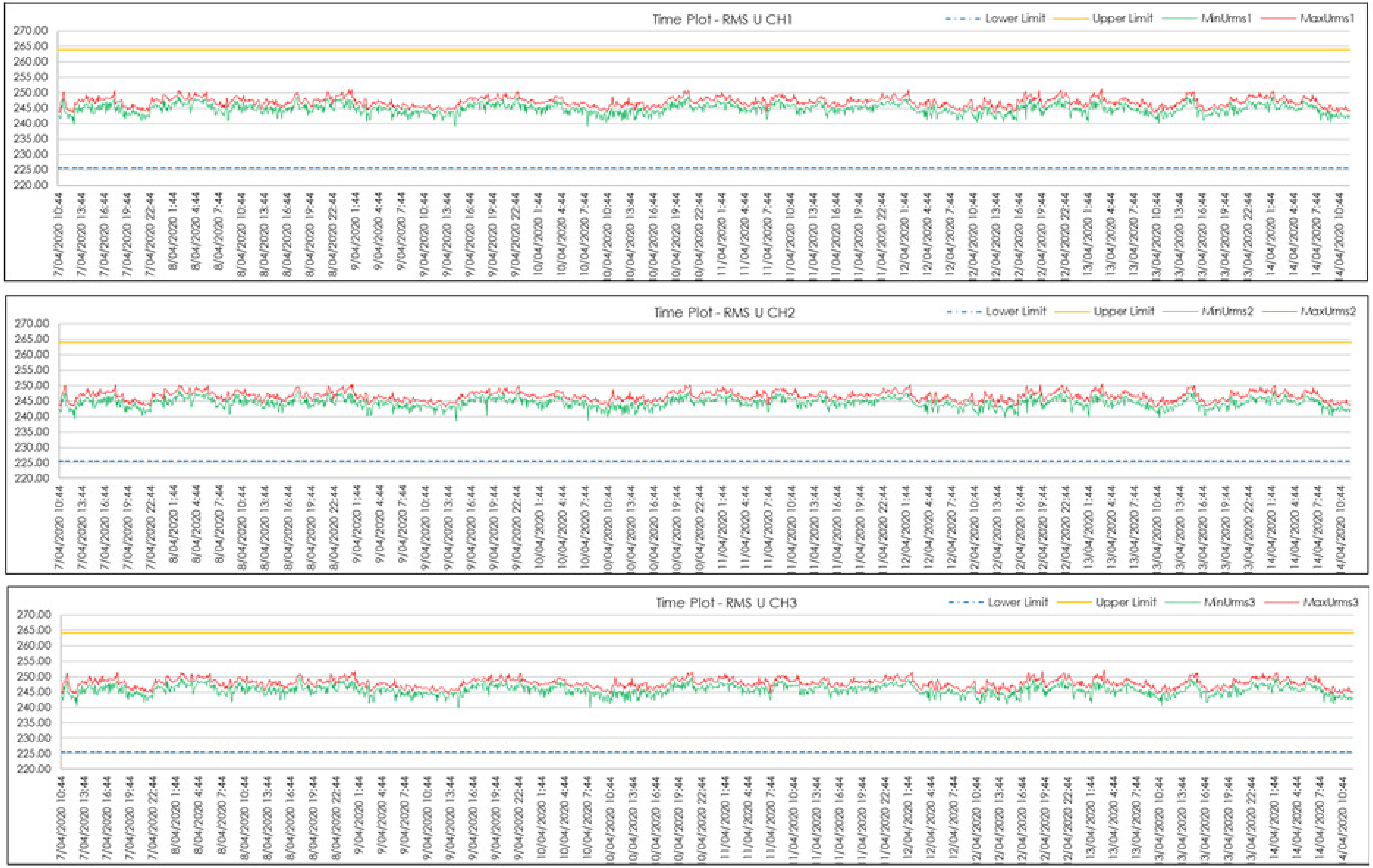


Figure 27 | TC2 End Voltage measurements

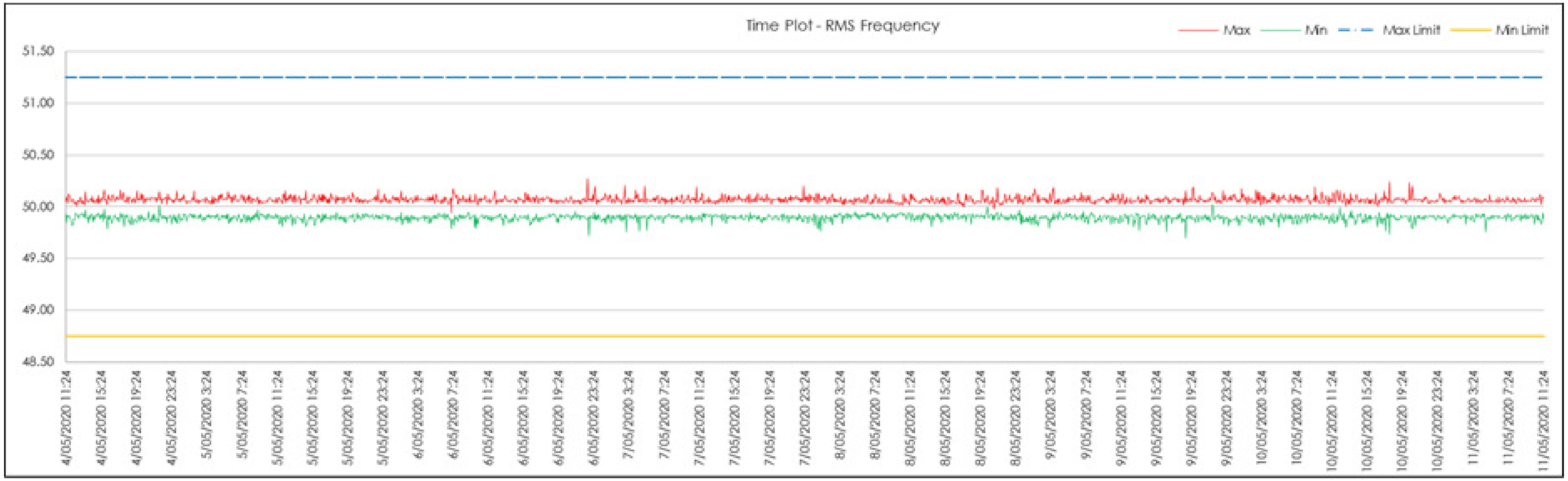


Figure 28 | TC2 Start Frequency measurements

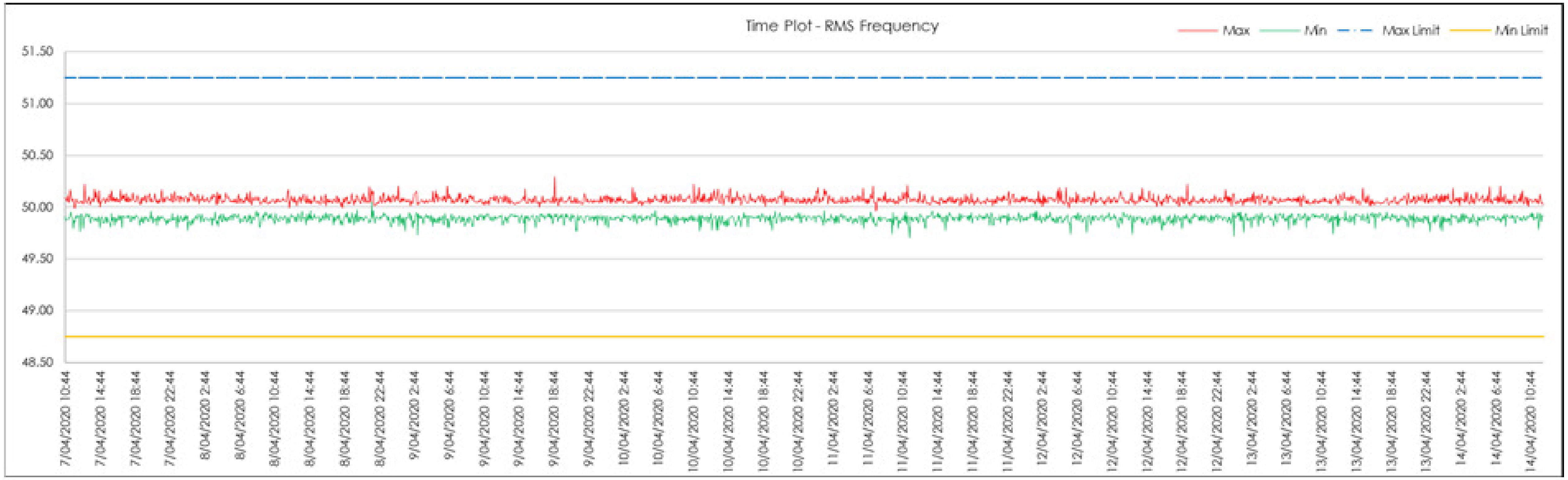


Figure 29 | TC2 End Frequency measurements

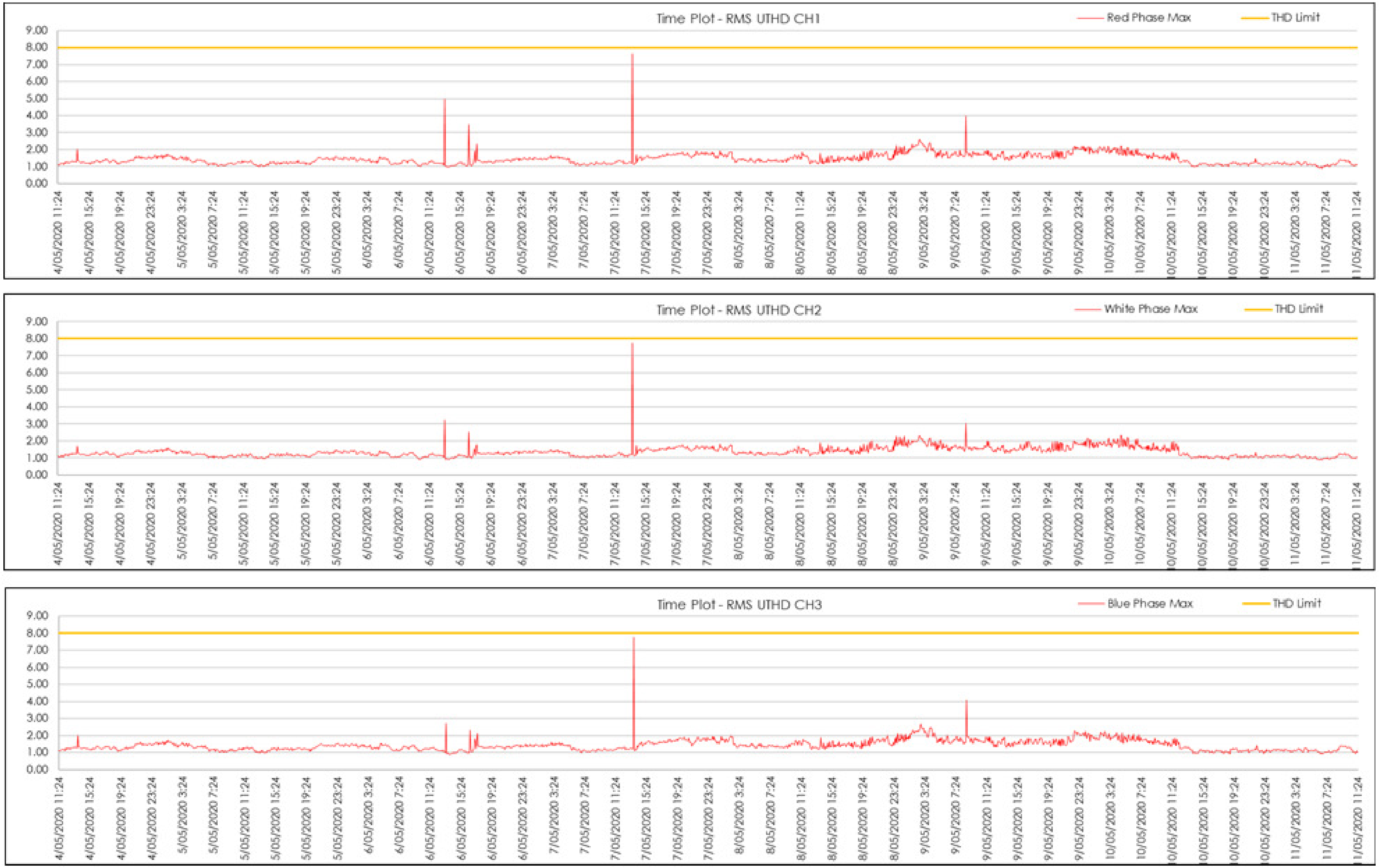
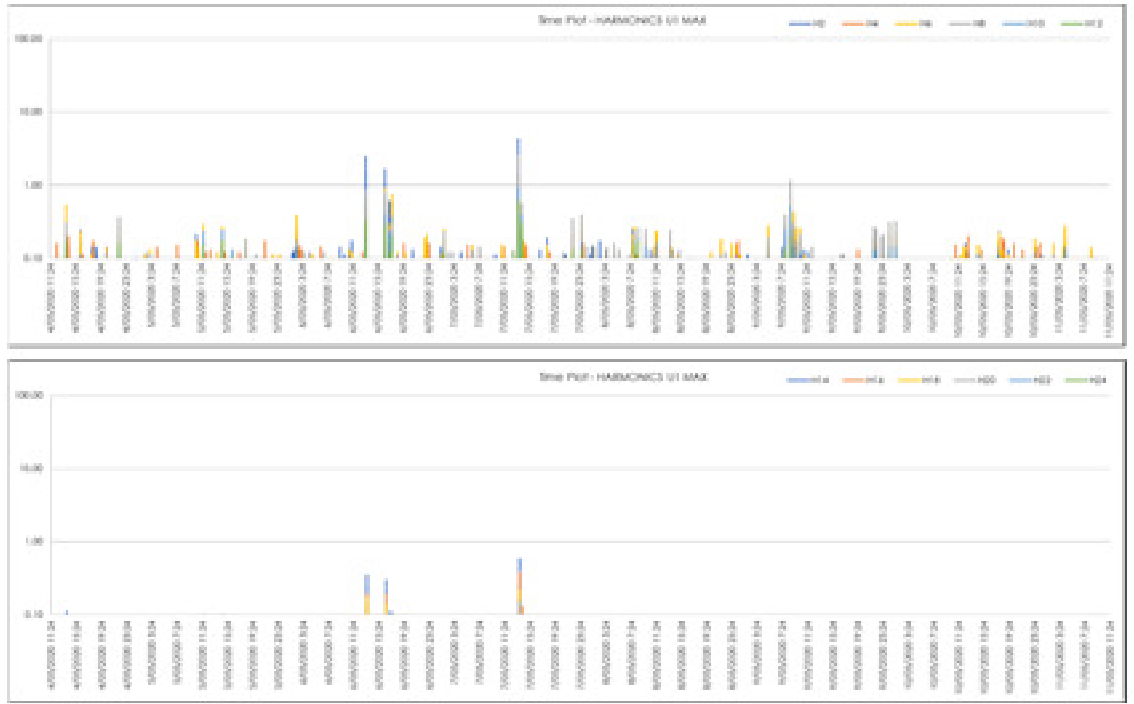


Figure 30 | TC2 Start U-THD measurements

Figure 31 | TC2 End U-THD measurements



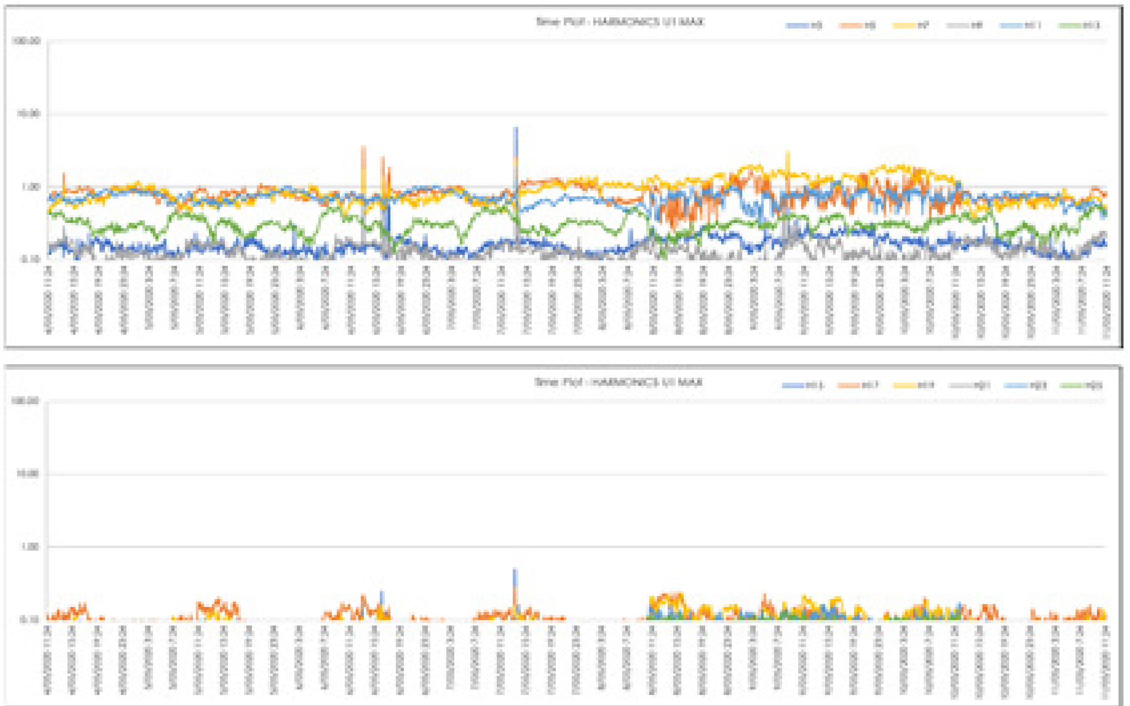
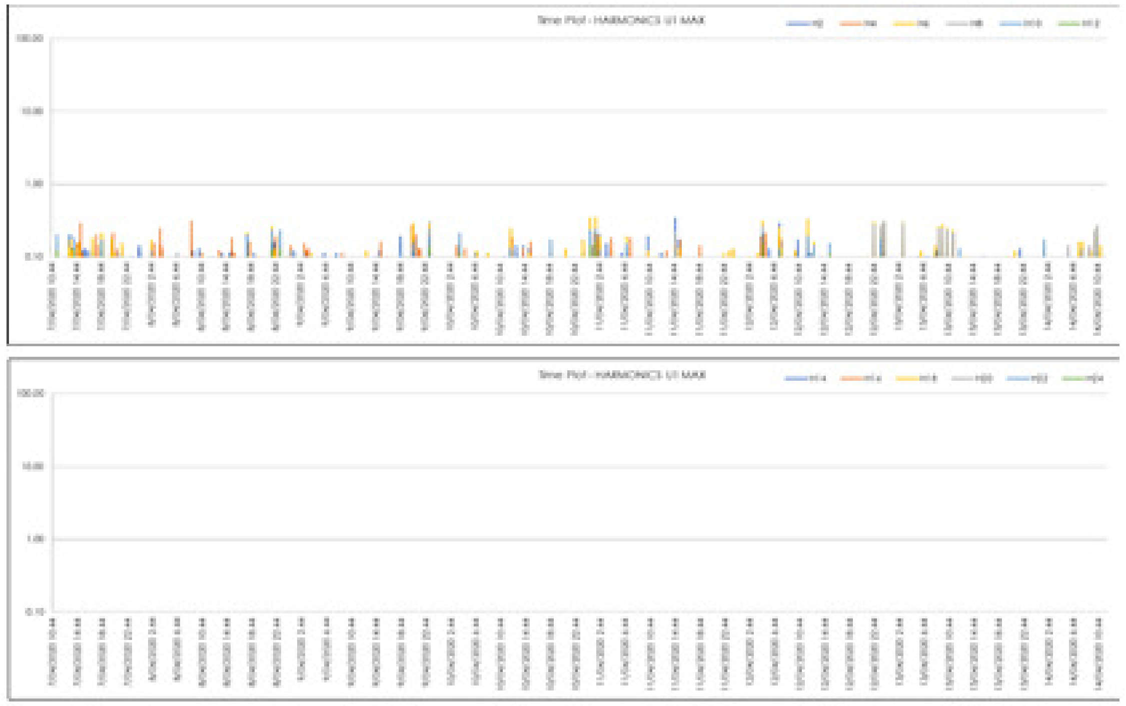


Figure 32 | TC2 Start Harmonics



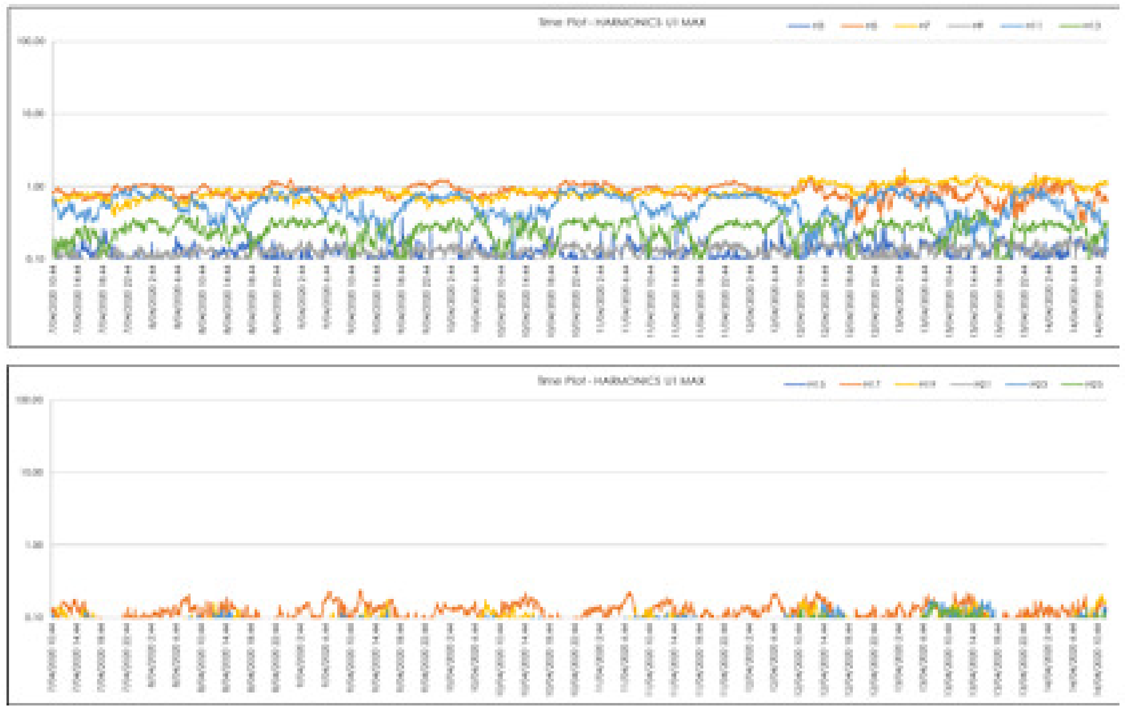


Figure 33 | TC2 End Harmonics

APPENDIX B.3. FEEDER TC3 FLICKER, VOLTAGE, FREQUENCY AND HARMONICS

Figure 34 | TC3 Start Flicker measurements

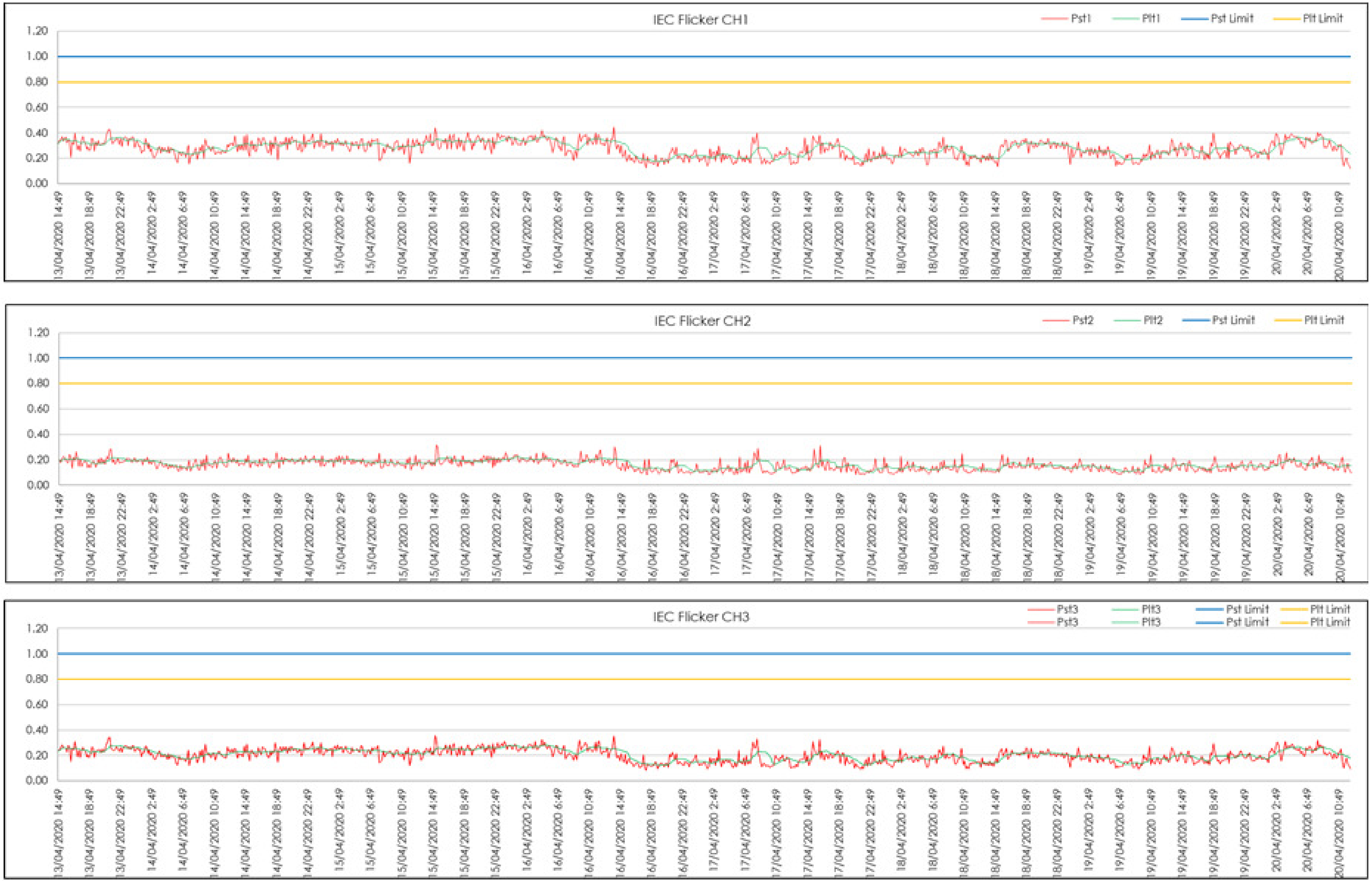


Figure 35 | TC3 End Flicker measurements

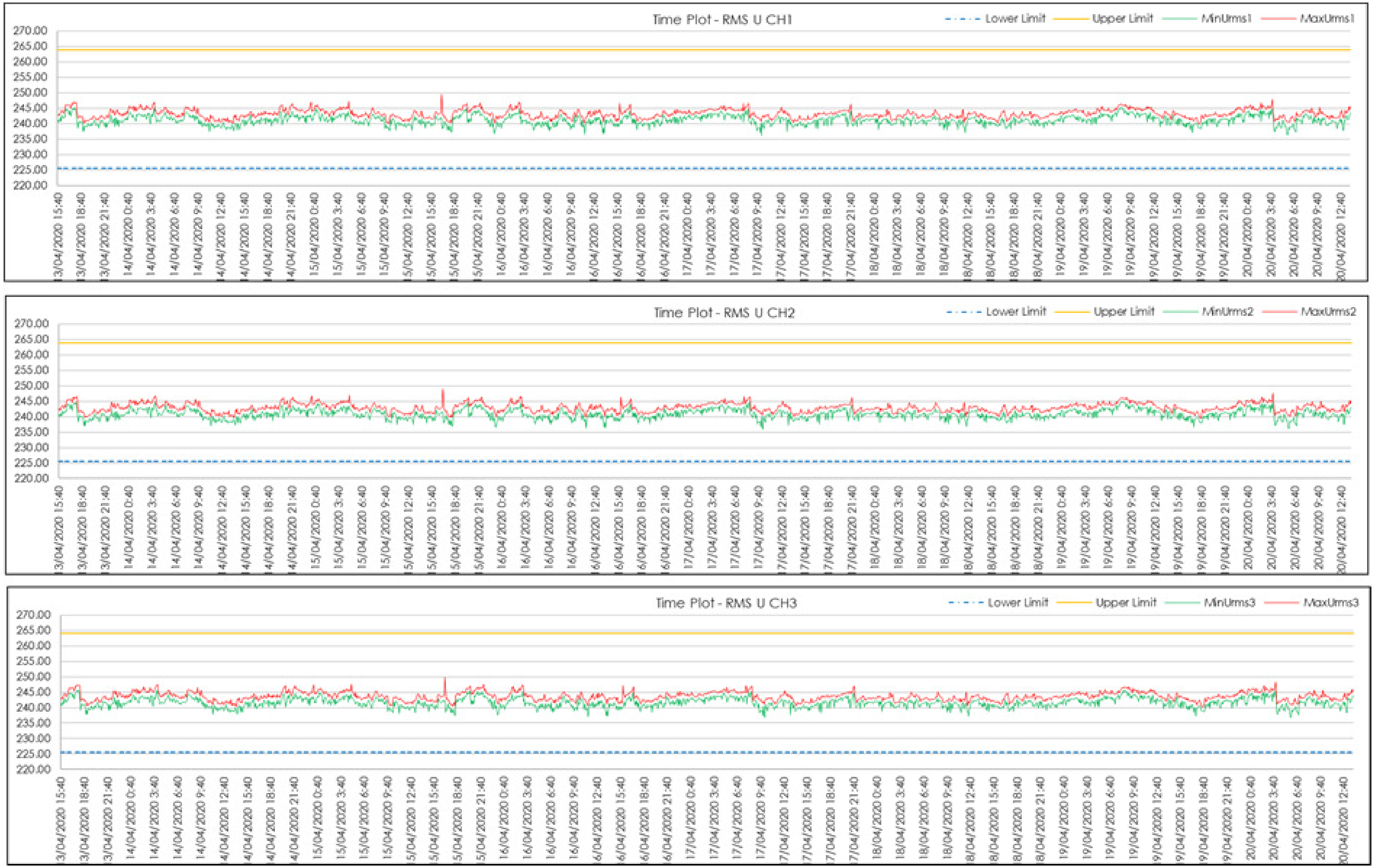


Figure 36 | TC3 Start Voltage measurements

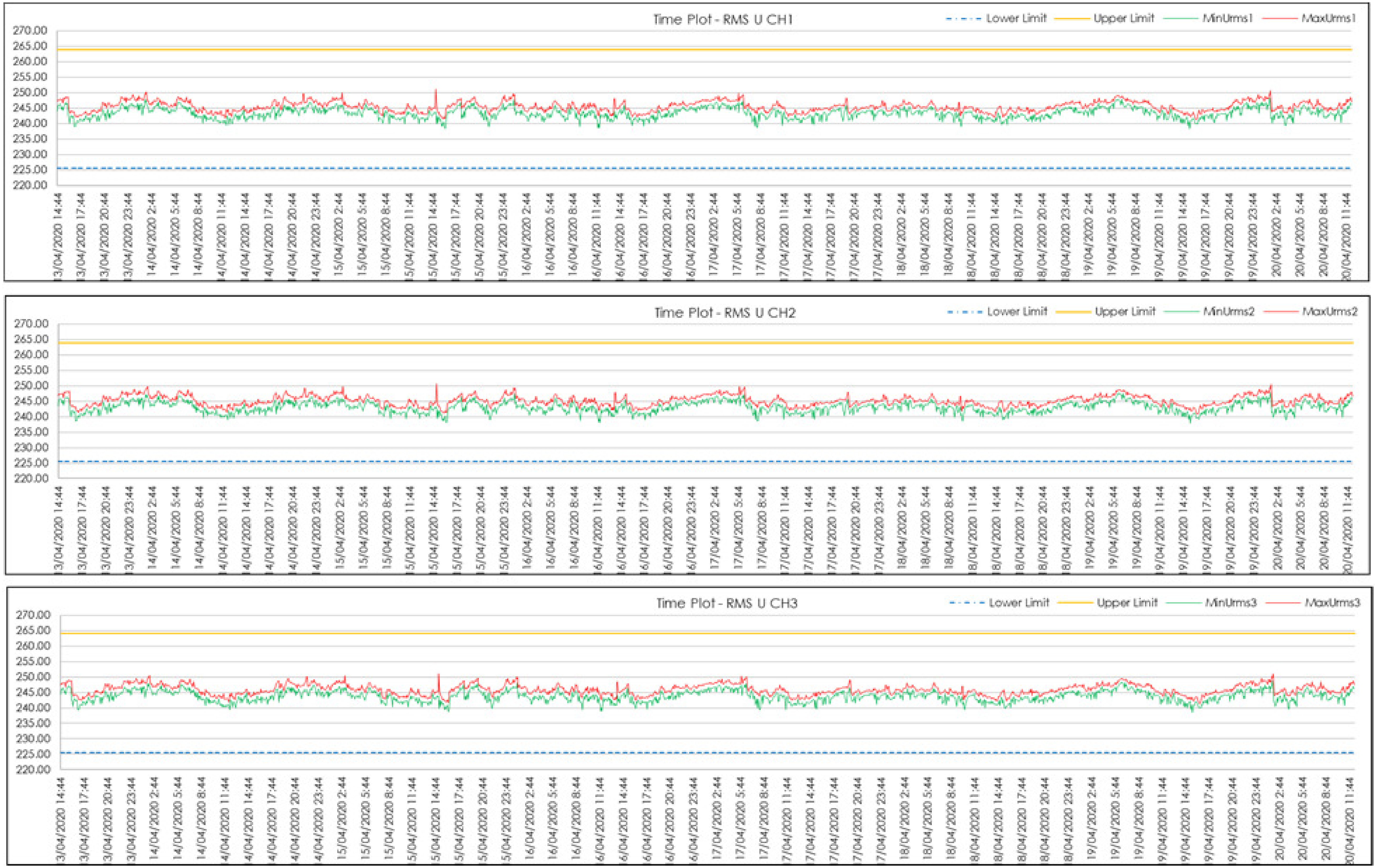


Figure 37 | TC3 End Voltage measurements

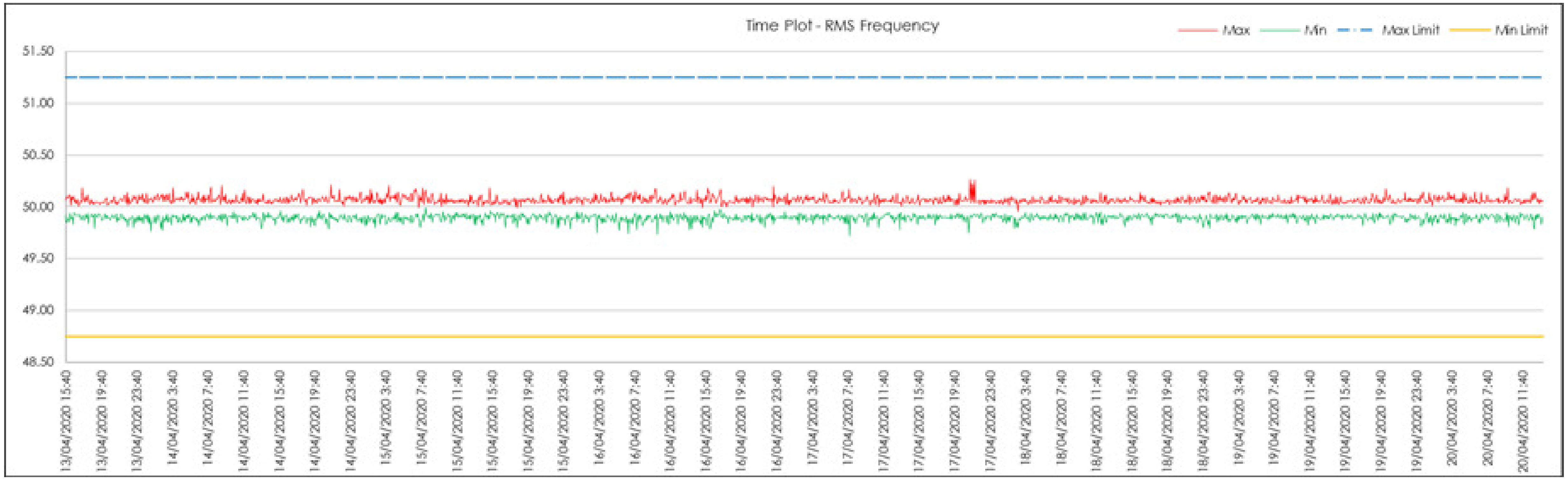


Figure 38 | TC3 Start Frequency measurements

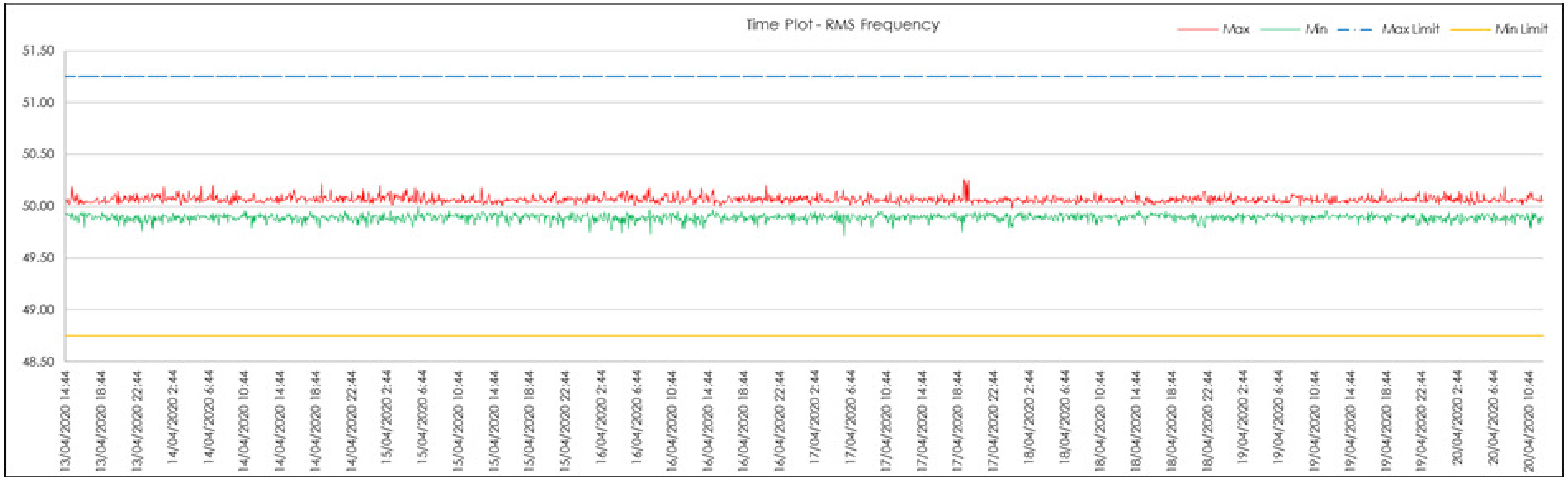
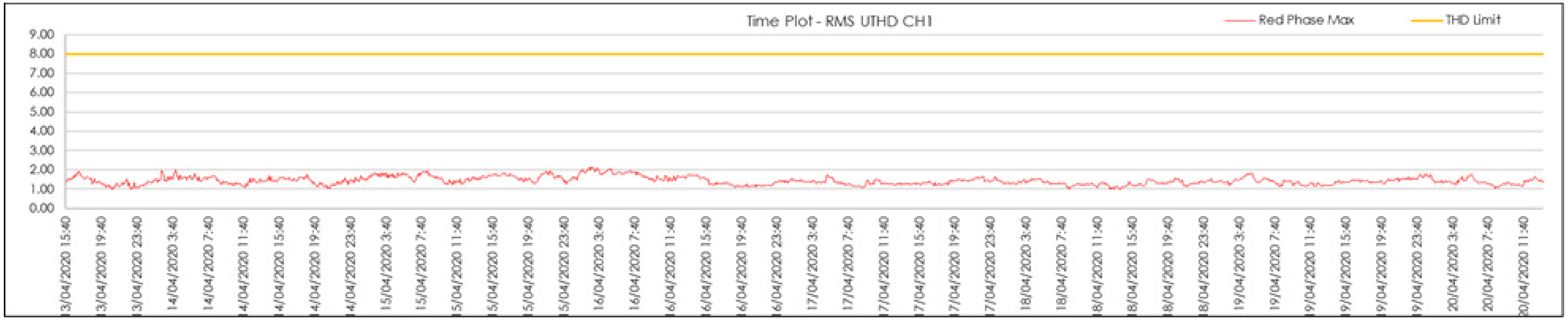
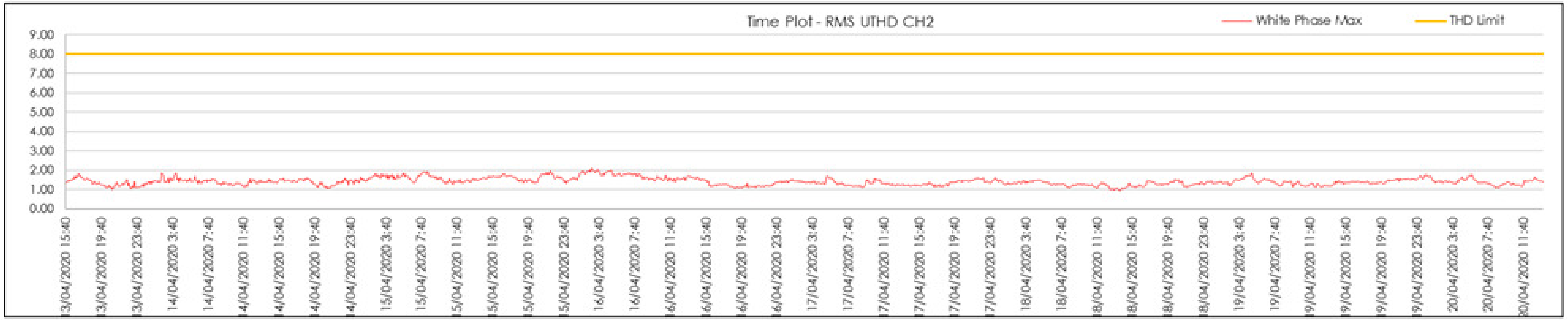


Figure 39 | TC3 End Frequency measurements





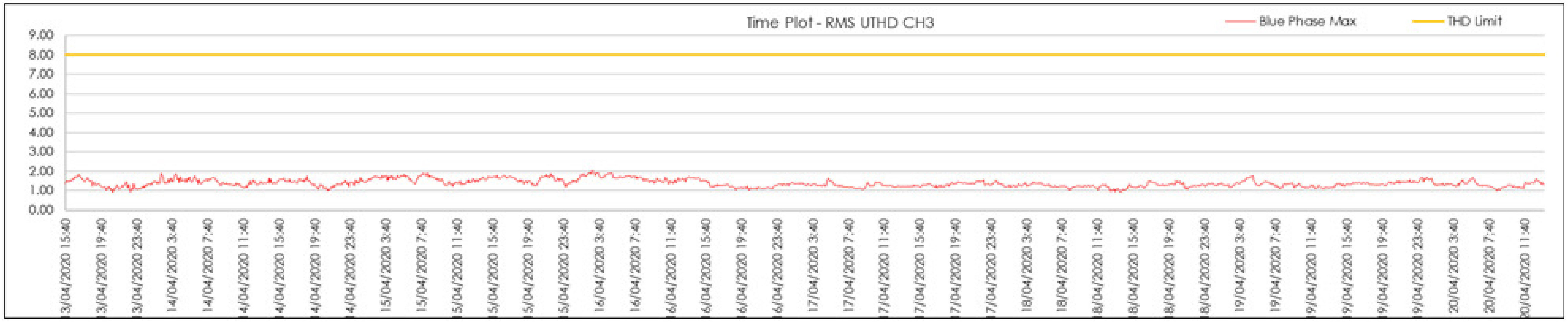


Figure 40 | TC3 Start U-THD measurements

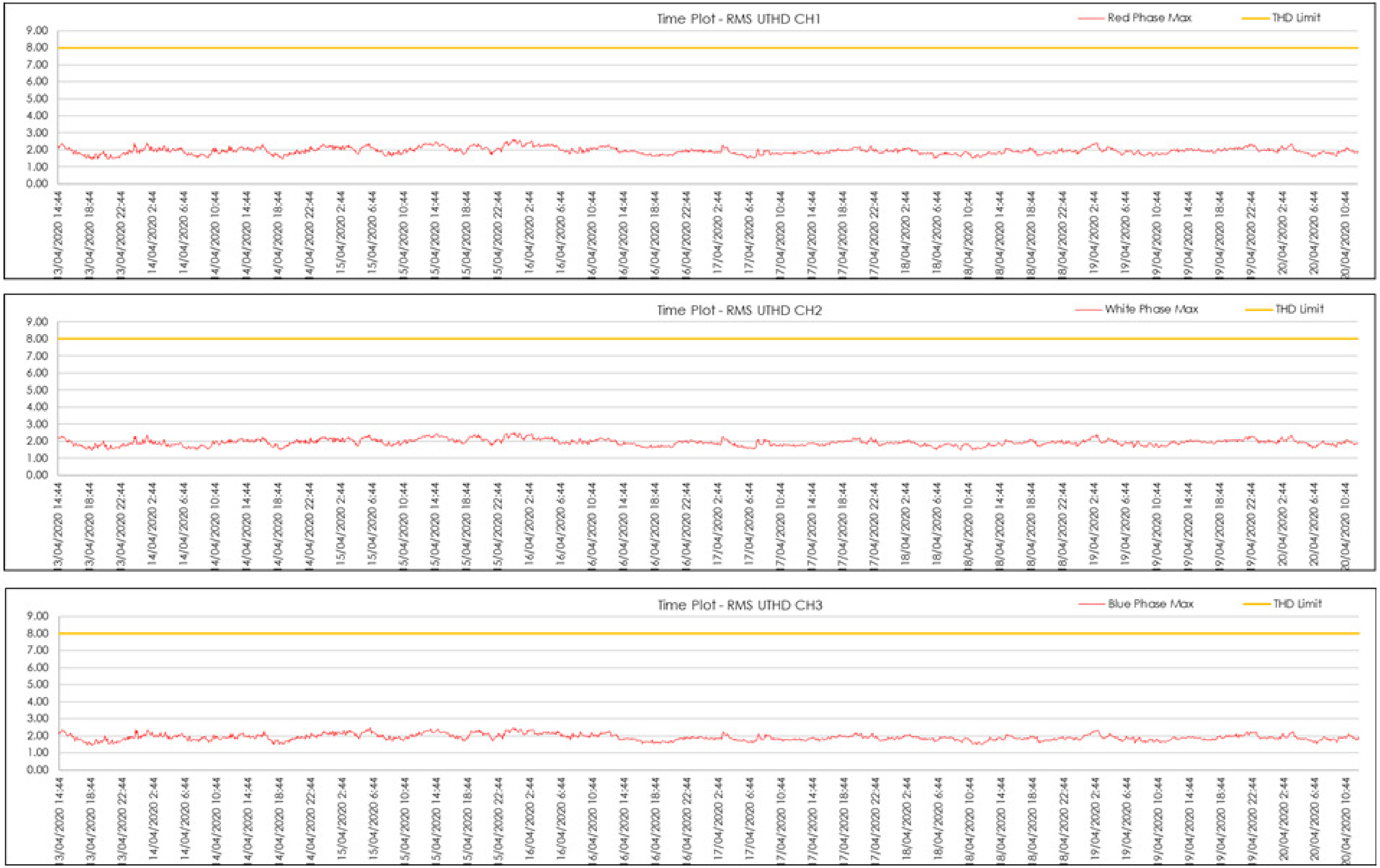


Figure 41 | TC3 End U-THD measurements

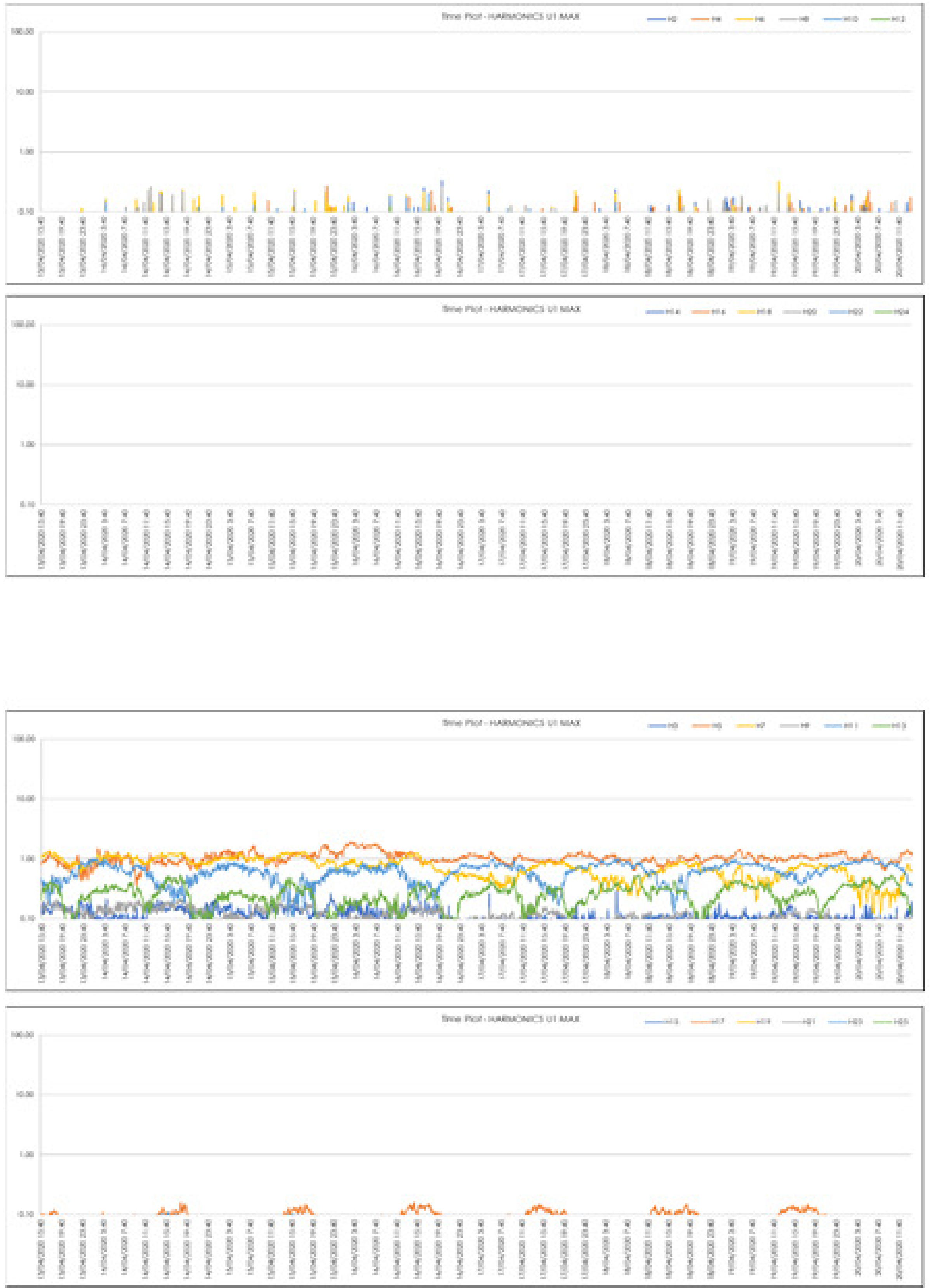
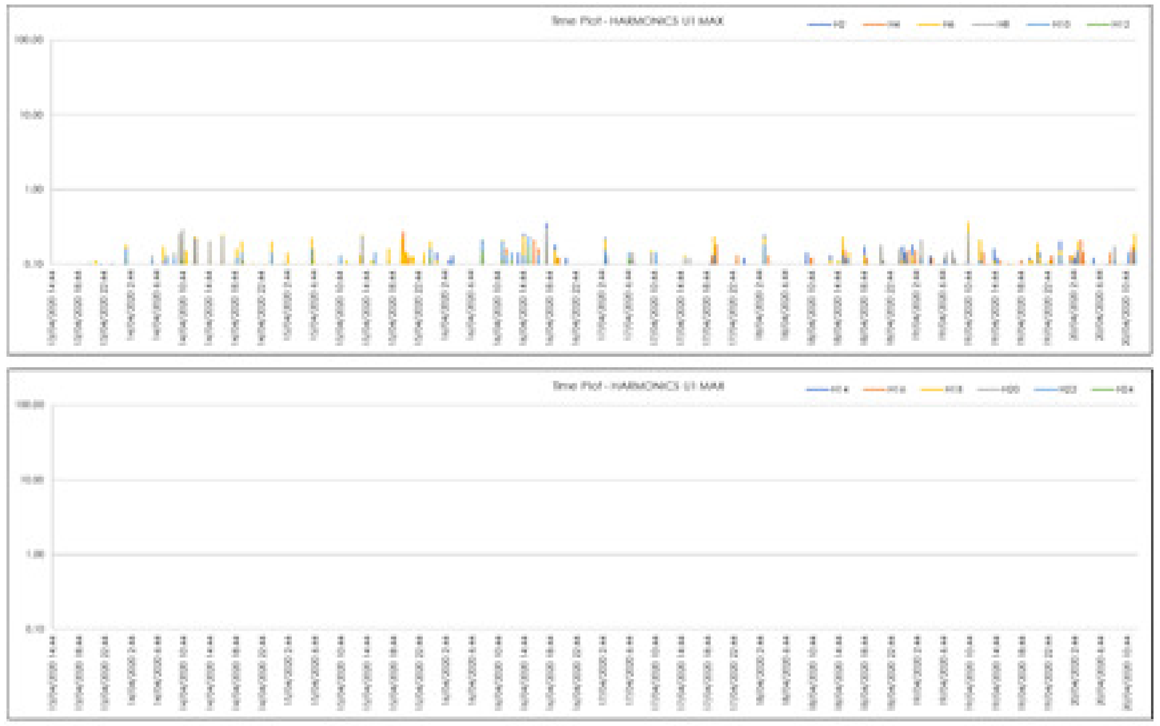


Figure 42 | TC3 Start Harmonics



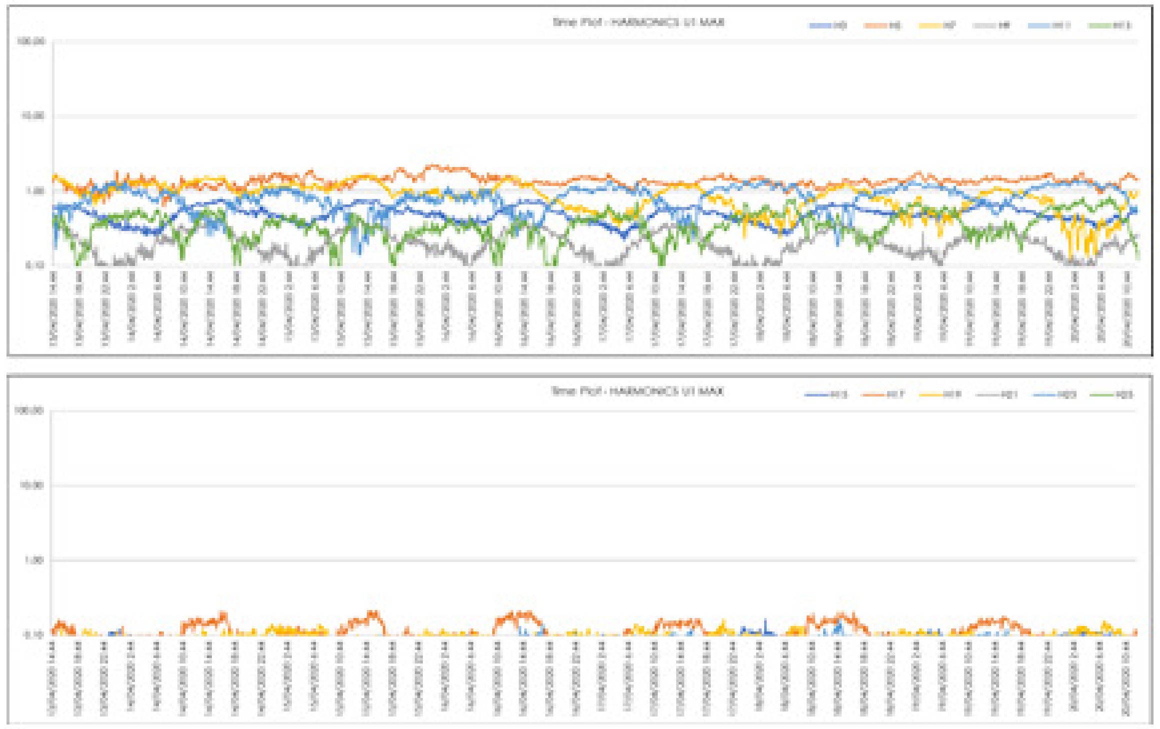
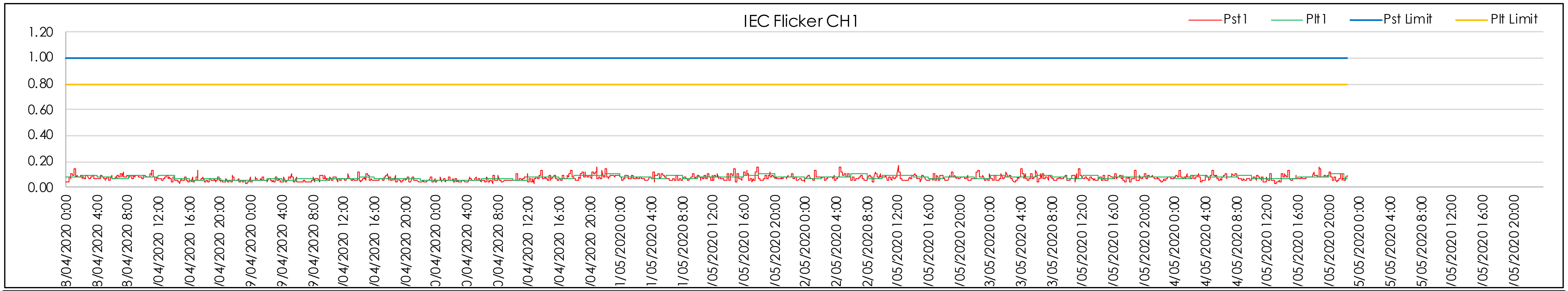
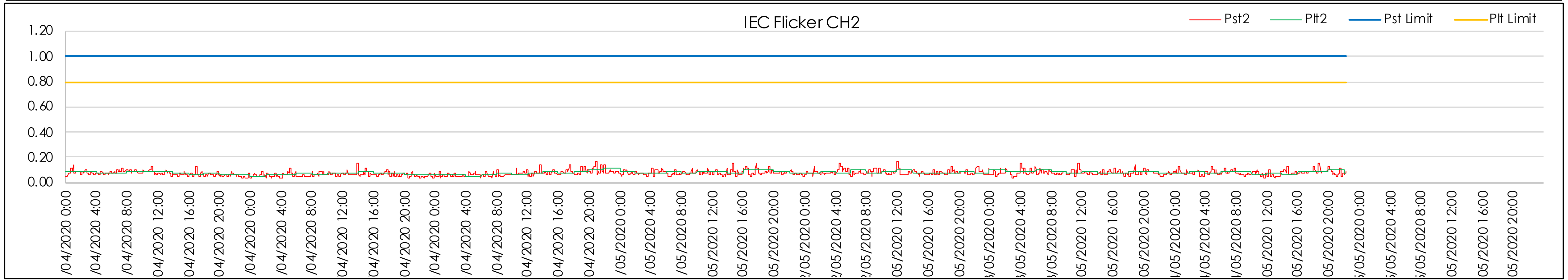


Figure 43 | TC3 End Harmonics

APPENDIX B.4. FEEDER TC4 FLICKER, VOLTAGE, FREQUENCY AND HARMONICS





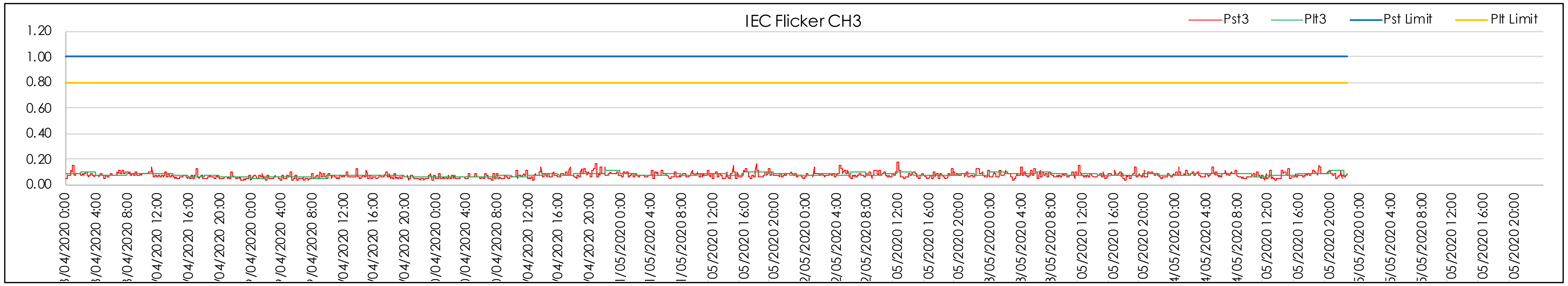


Figure 44 | TC4 Start Flicker measurements

Figure 45 | TC4 End Flicker measurements

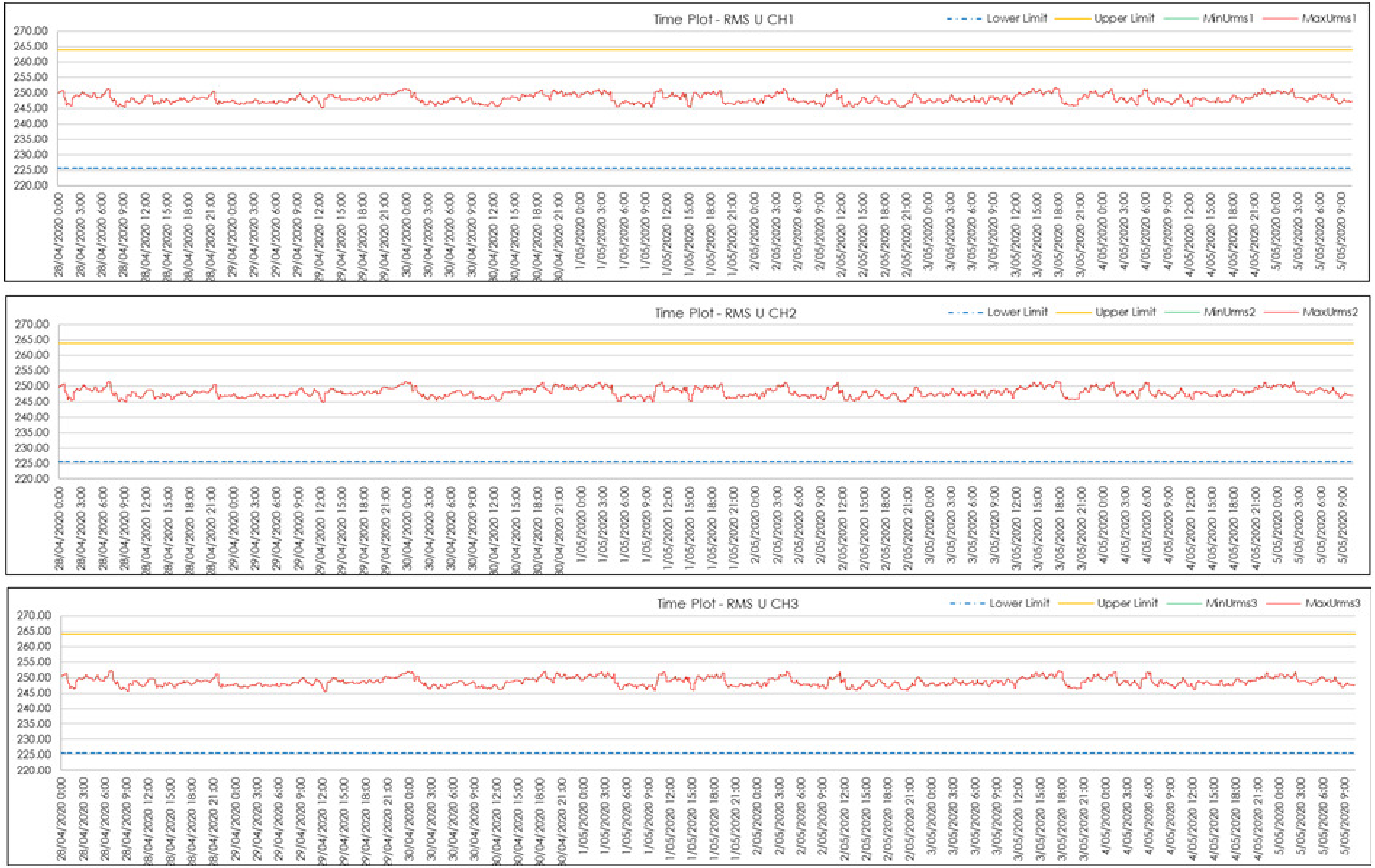
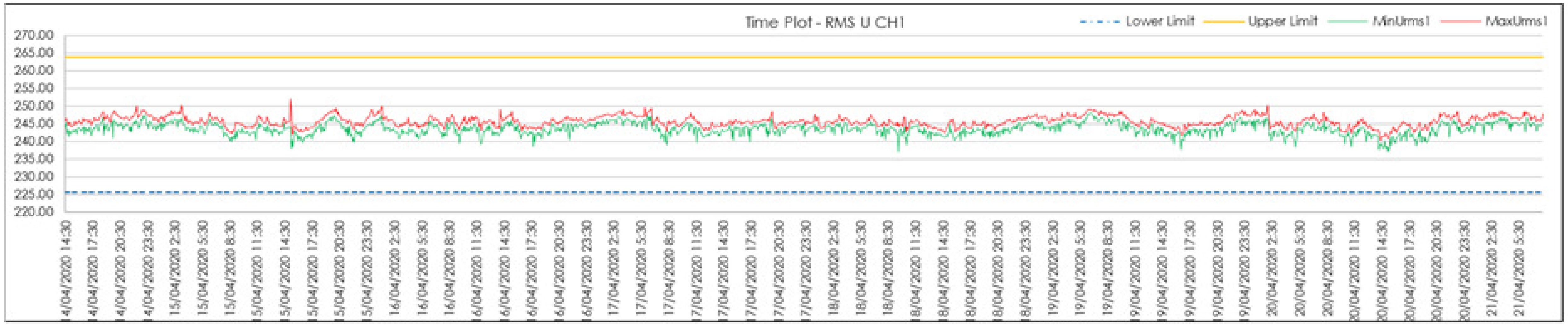
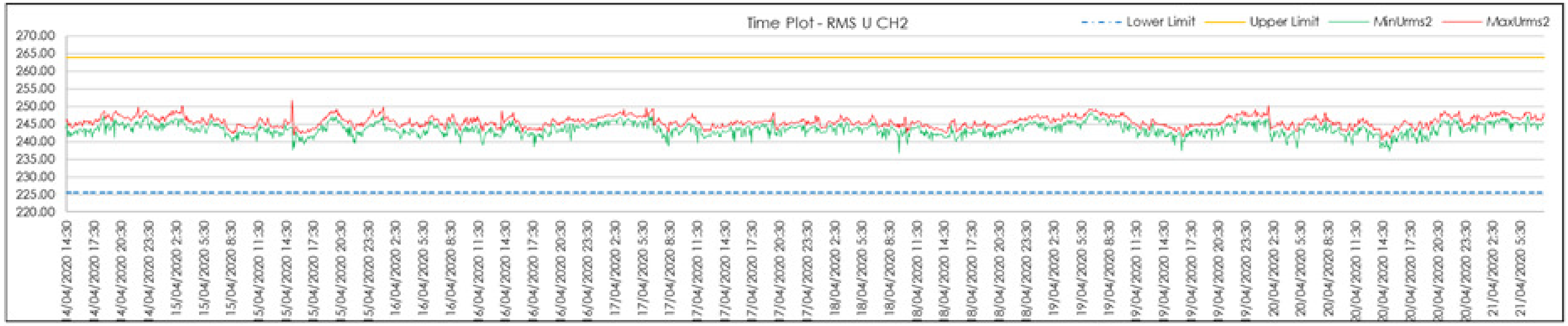


Figure 46 | TC4 Start Voltage measurements





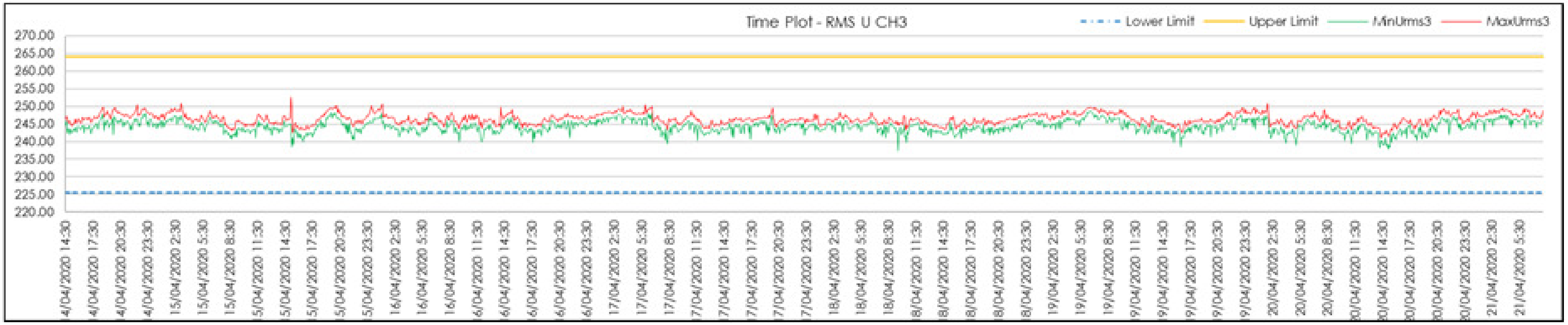


Figure 47 | TC4 End Voltage measurements

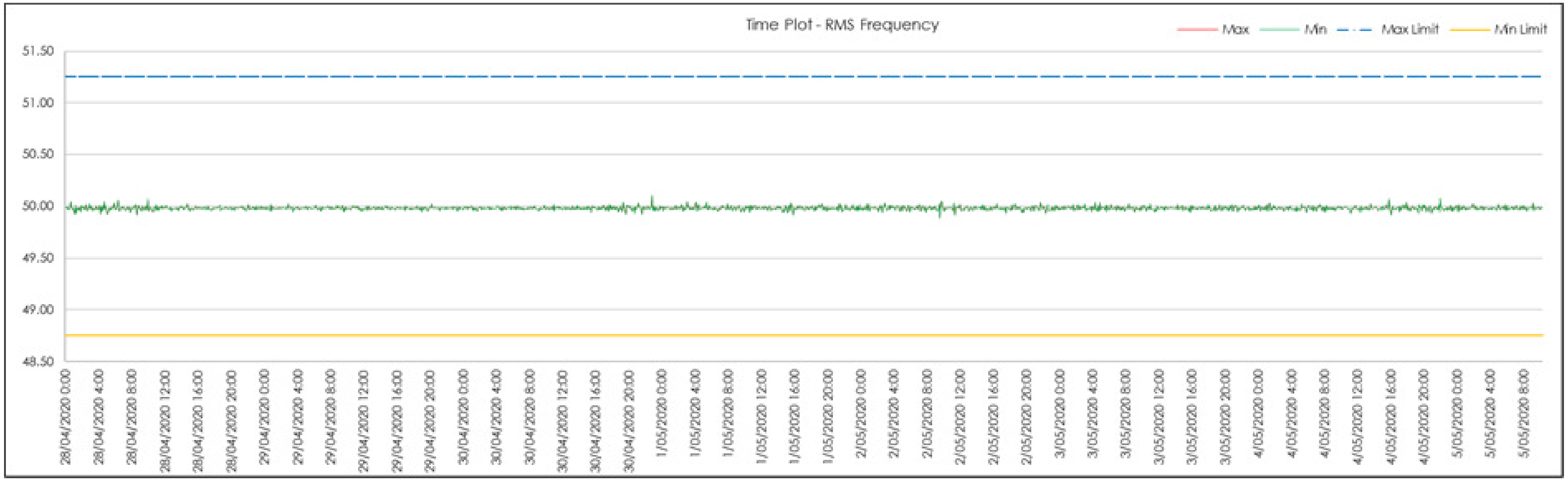


Figure 48 | TC4 Start Frequency measurements

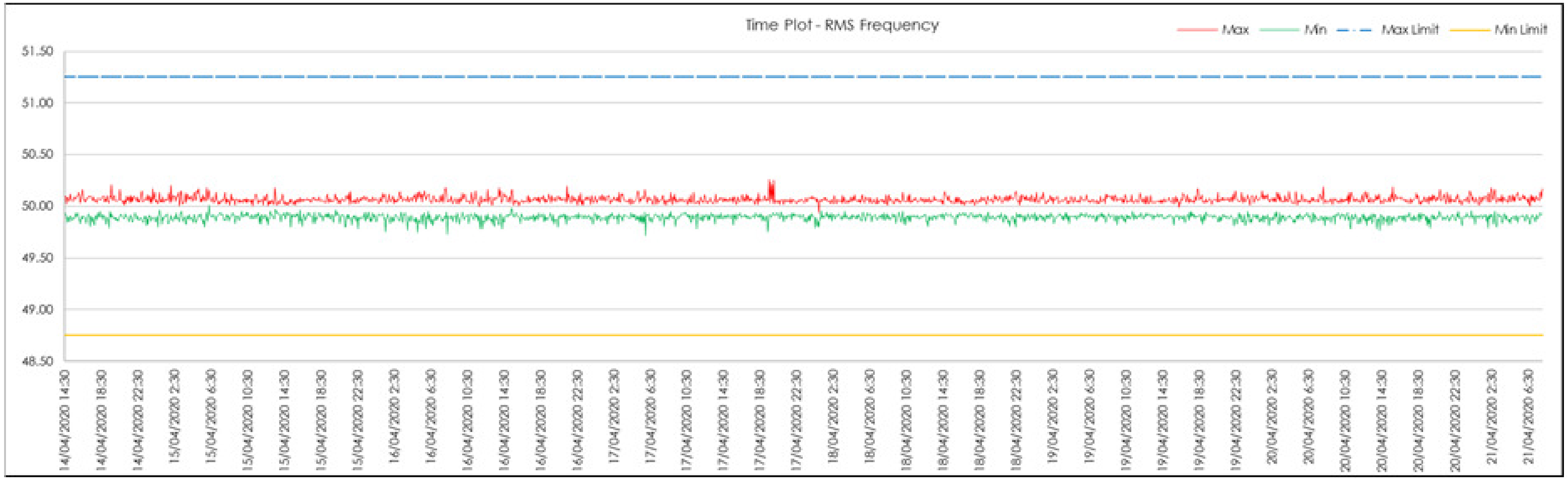


Figure 49 | TC4 End Frequency measurements

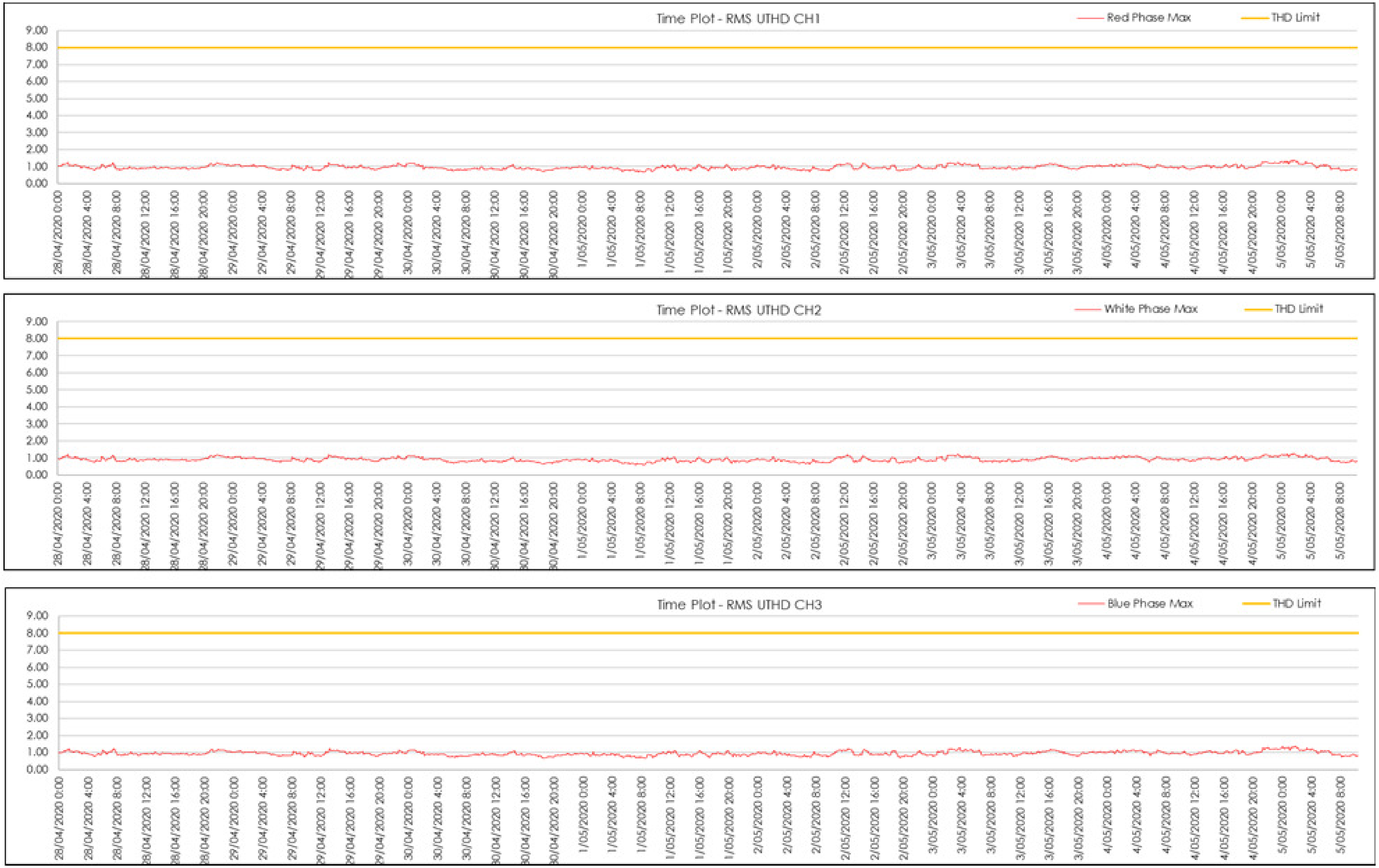
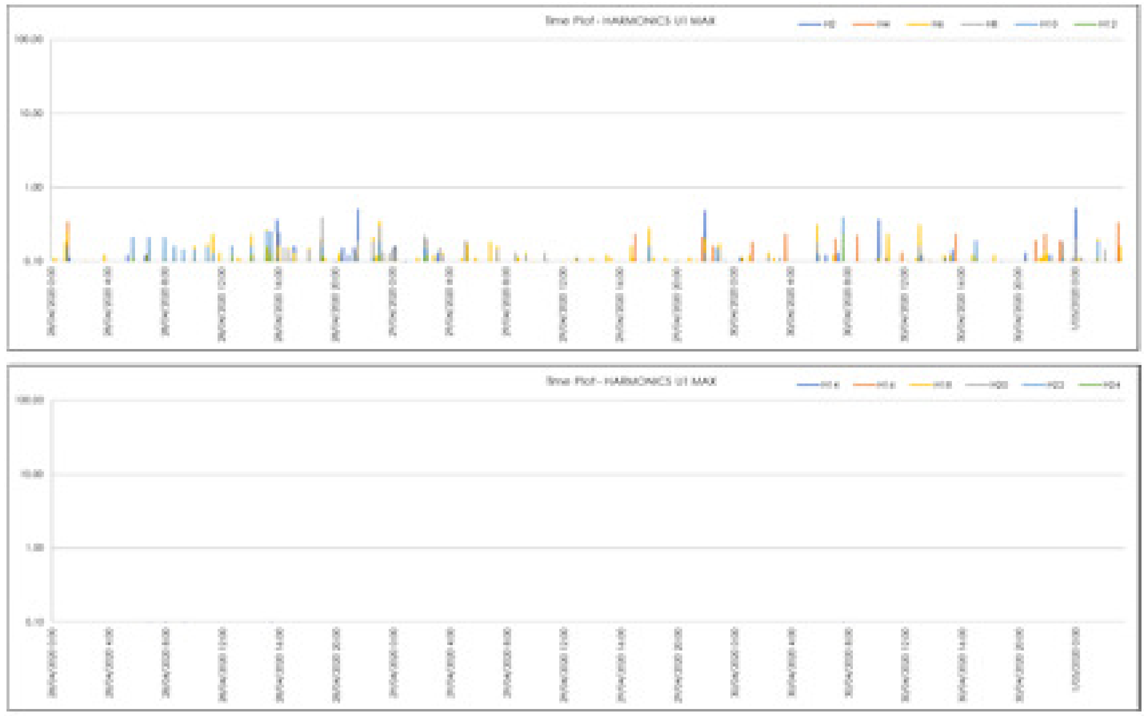


Figure 50 | TC4 Start U-THD measurements

Figure 51 | TC4 End U-THD measurements



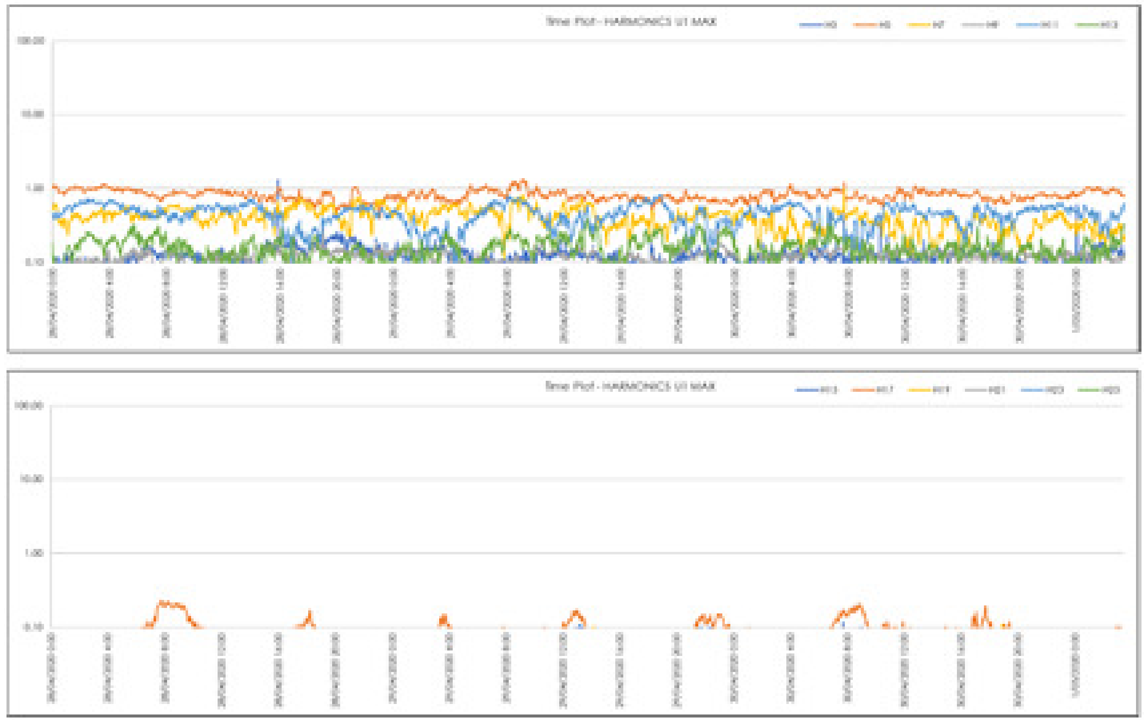


Figure 52 | TC4 Start Harmonics

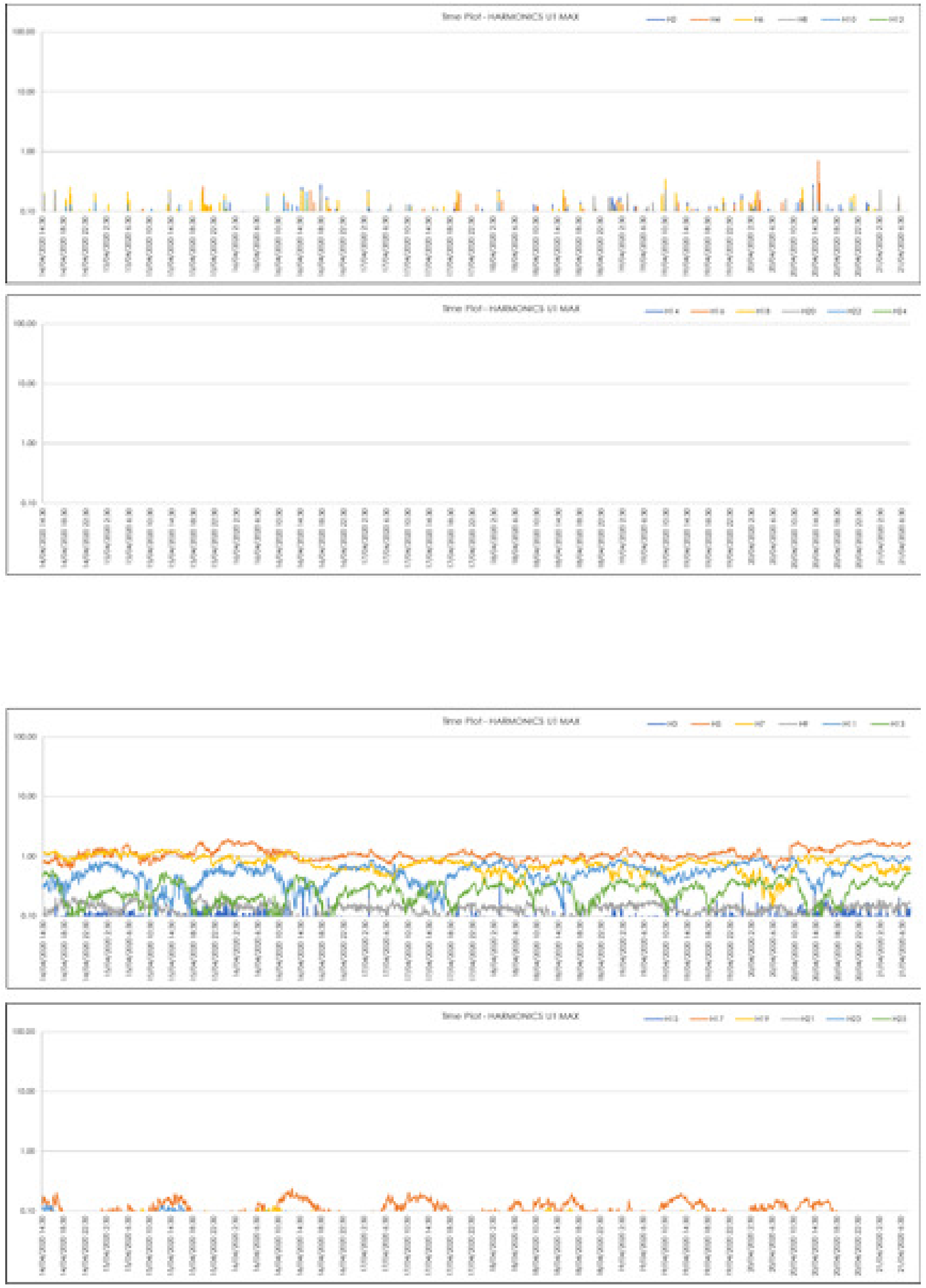
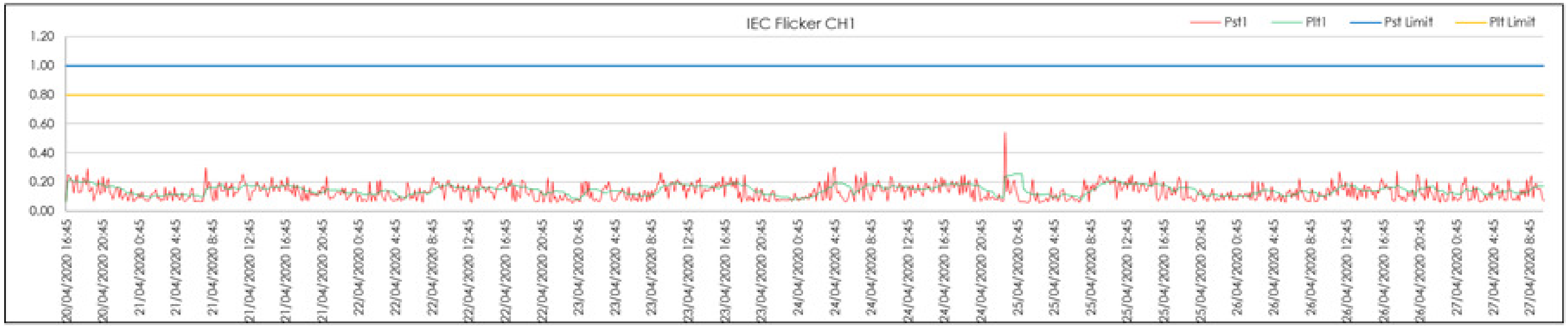
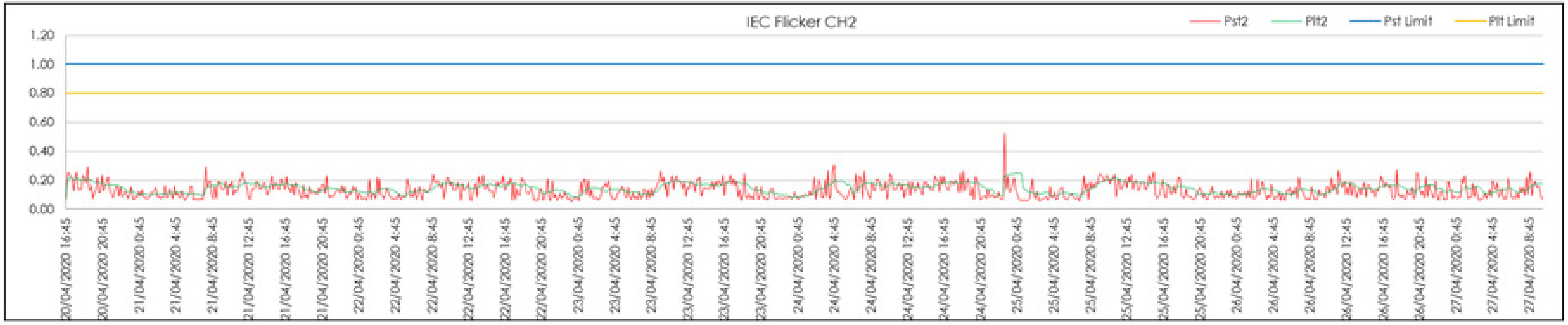


Figure 53 | TC4 End Harmonics

APPENDIX B.5. FEEDER STS1 FLICKER, VOLTAGE, FREQUENCY AND HARMONICS





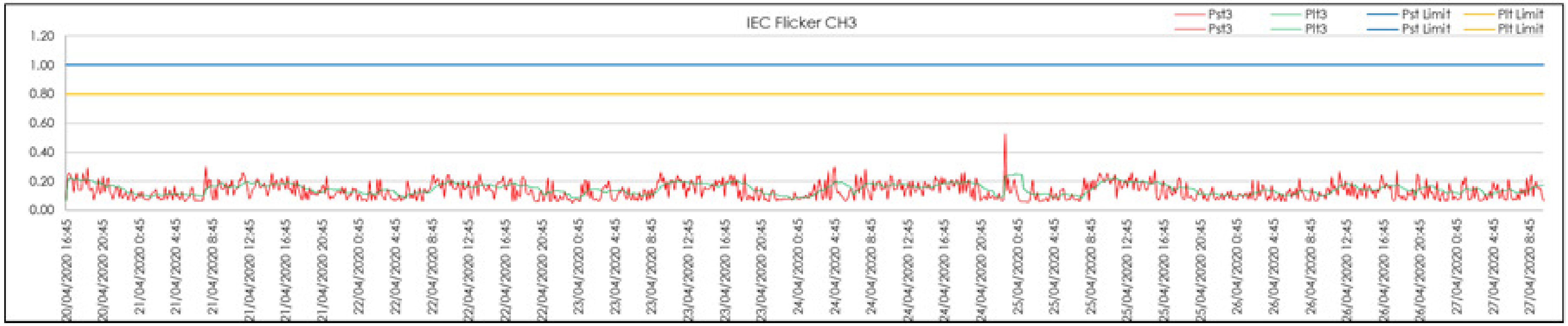


Figure 54 | STS1 Start Flicker measurements

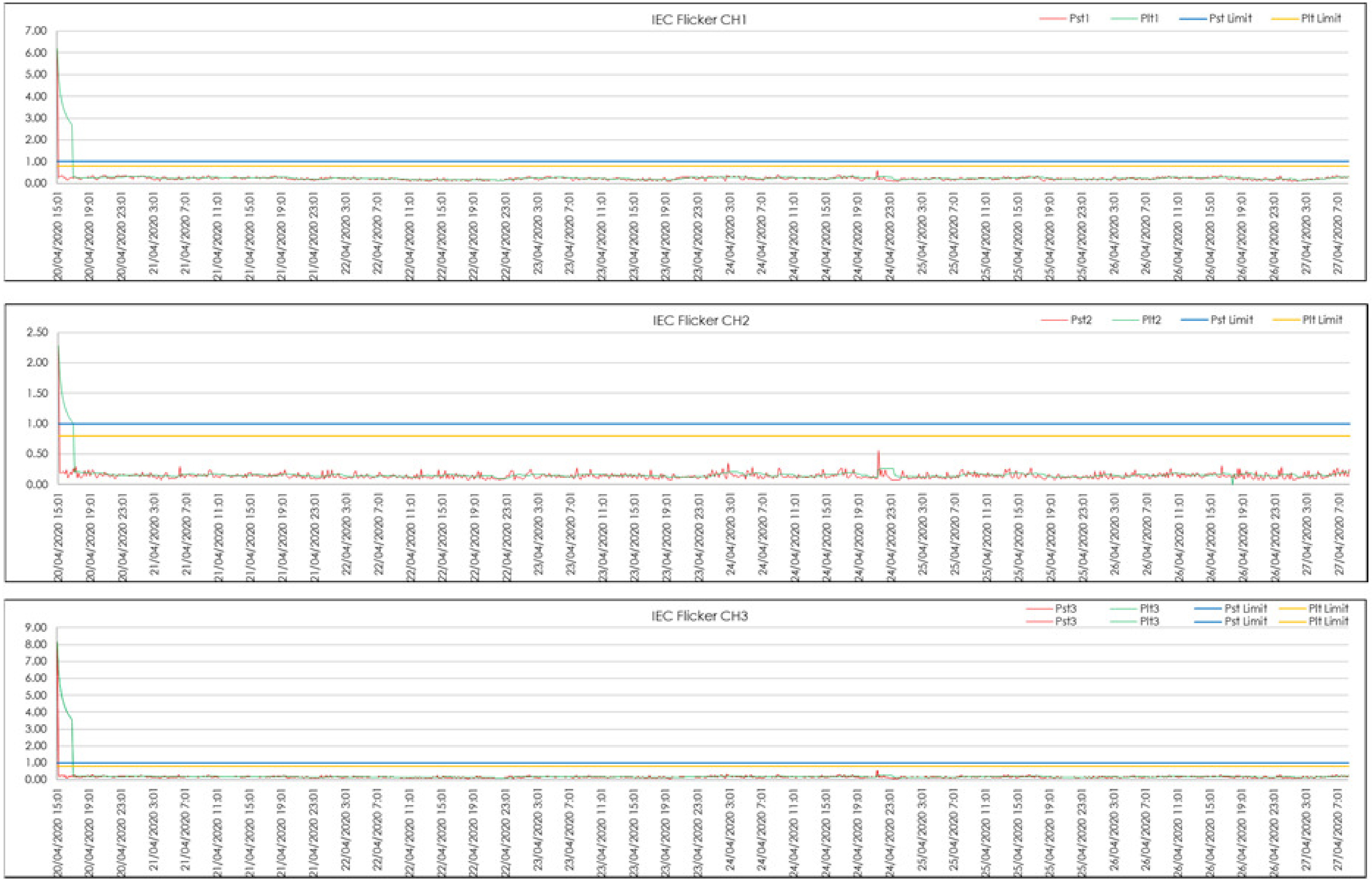


Figure 55 | STS1 End Flicker measurements

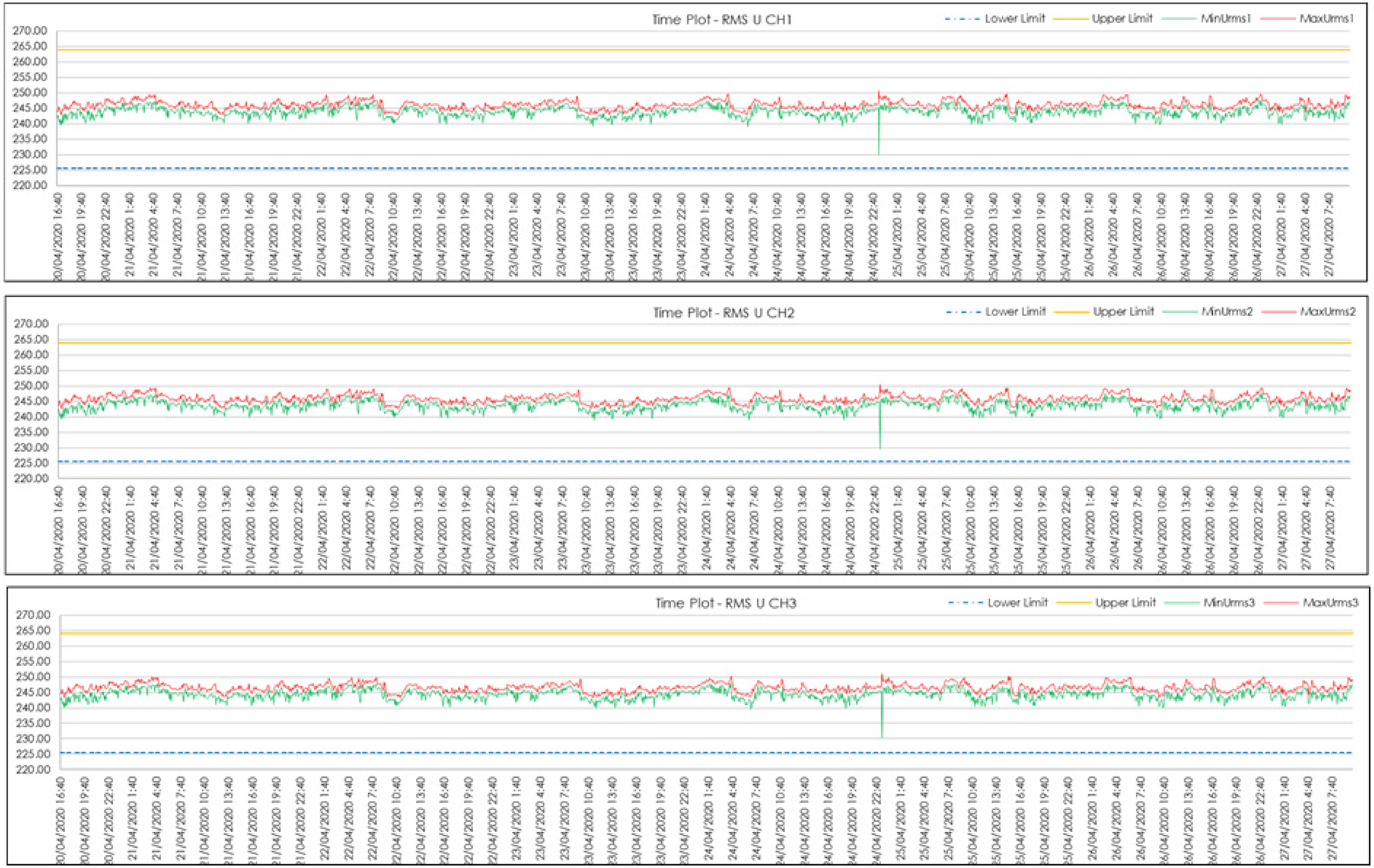


Figure 56 | STS1 Start Voltage measurements

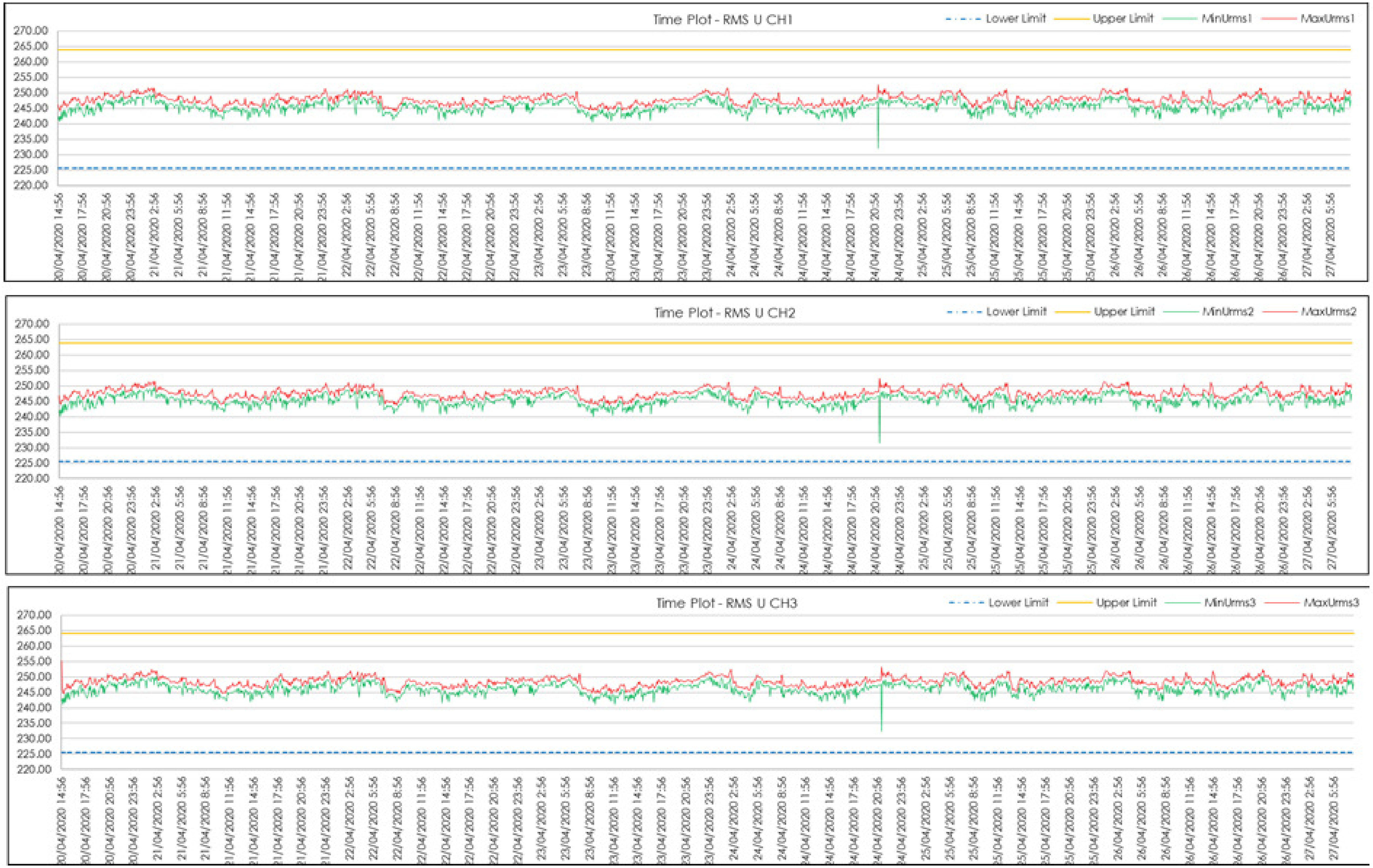


Figure 57 | STS1 End Voltage measurements

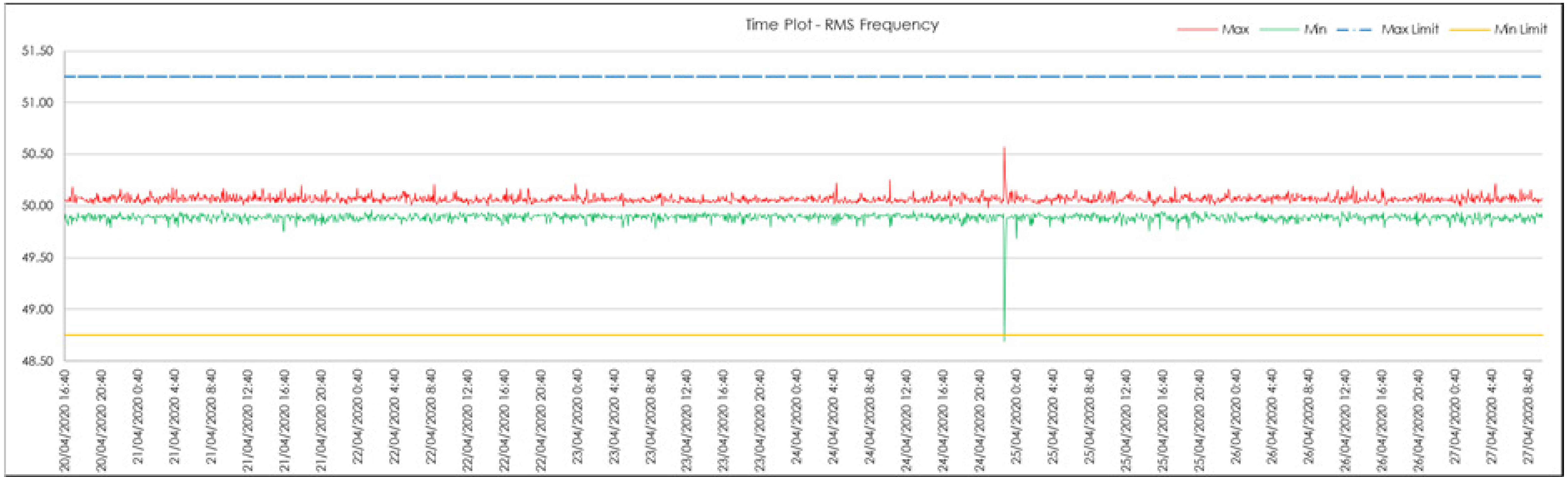


Figure 58 | STS1 Start Frequency measurements

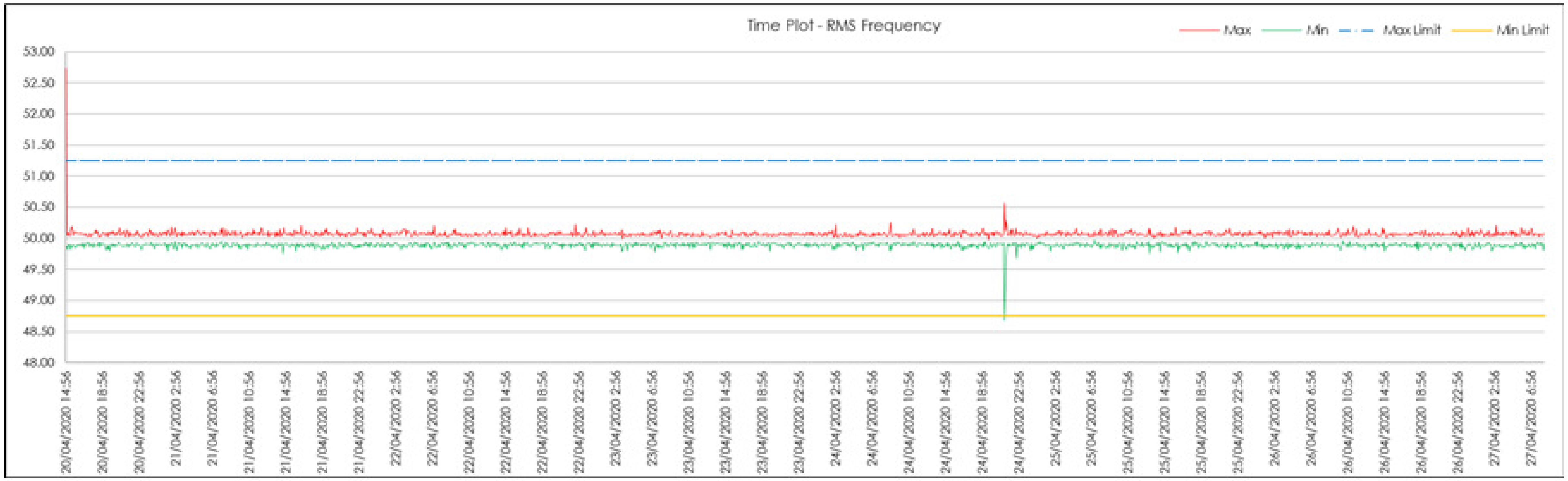
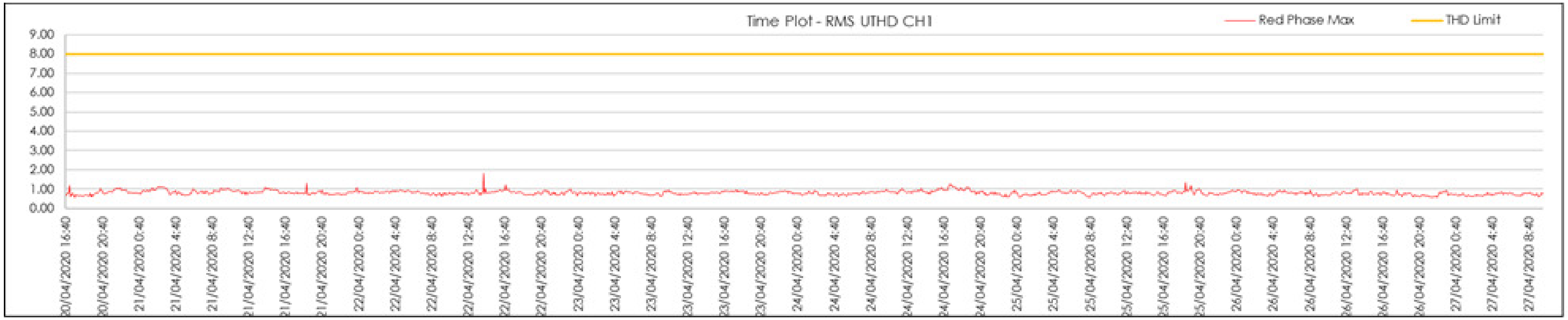
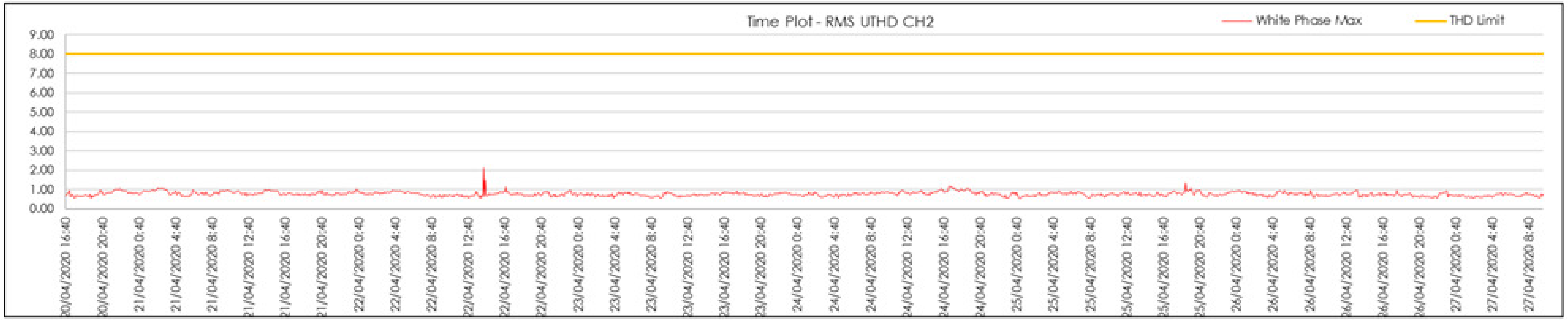


Figure 59 | STS1 End Frequency measurements





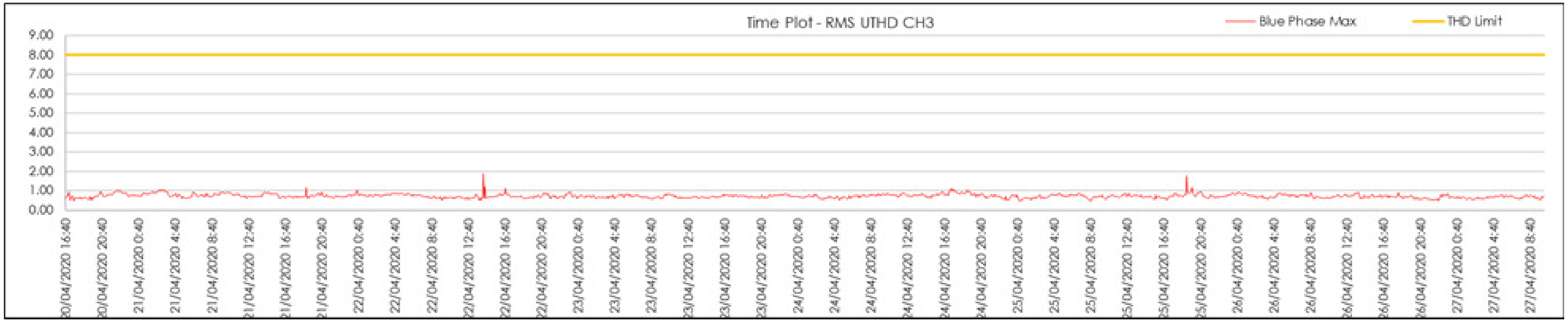


Figure 60 | STS1 Start U-THD measurements

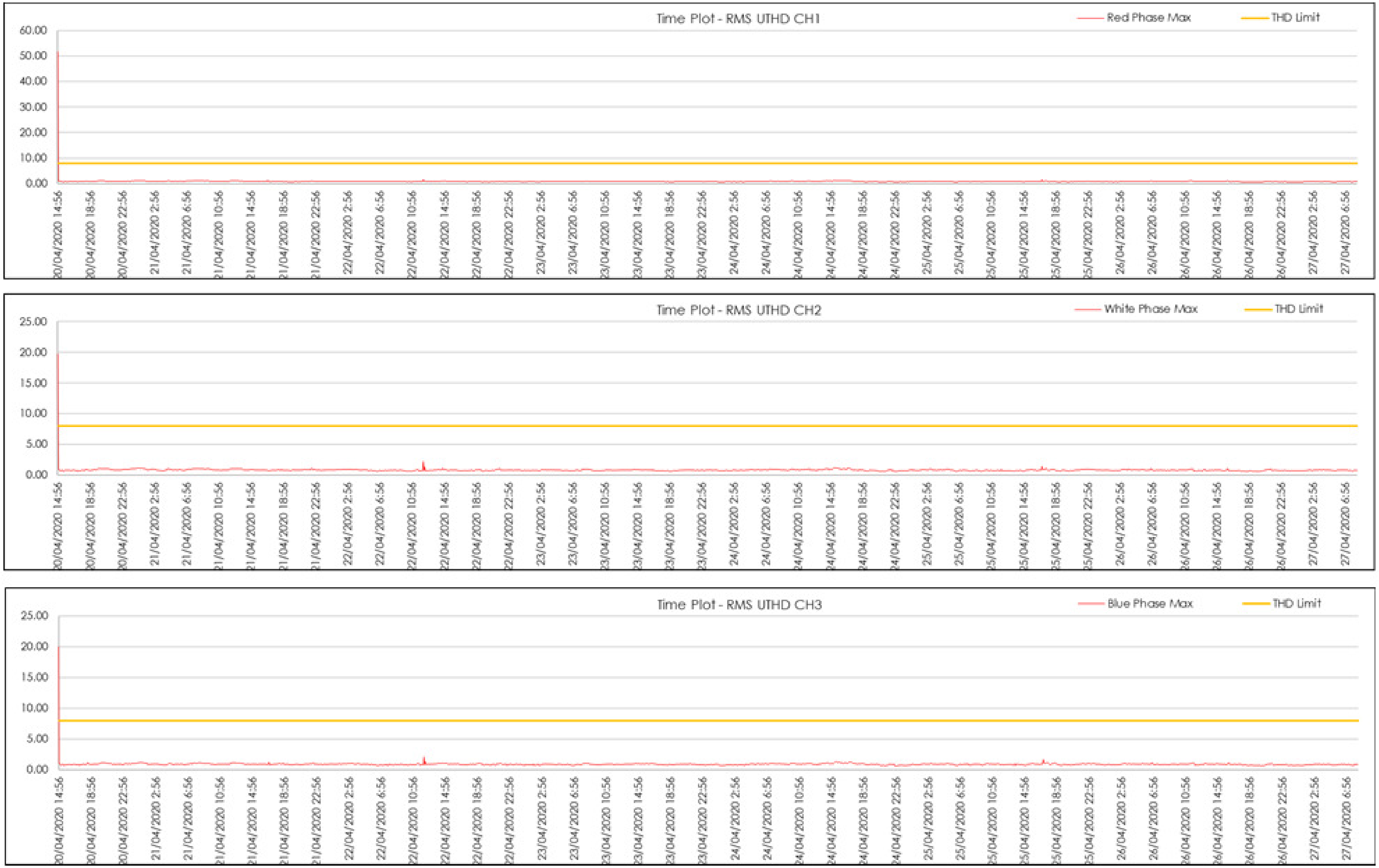


Figure 61 | STS1 End U-THD measurements

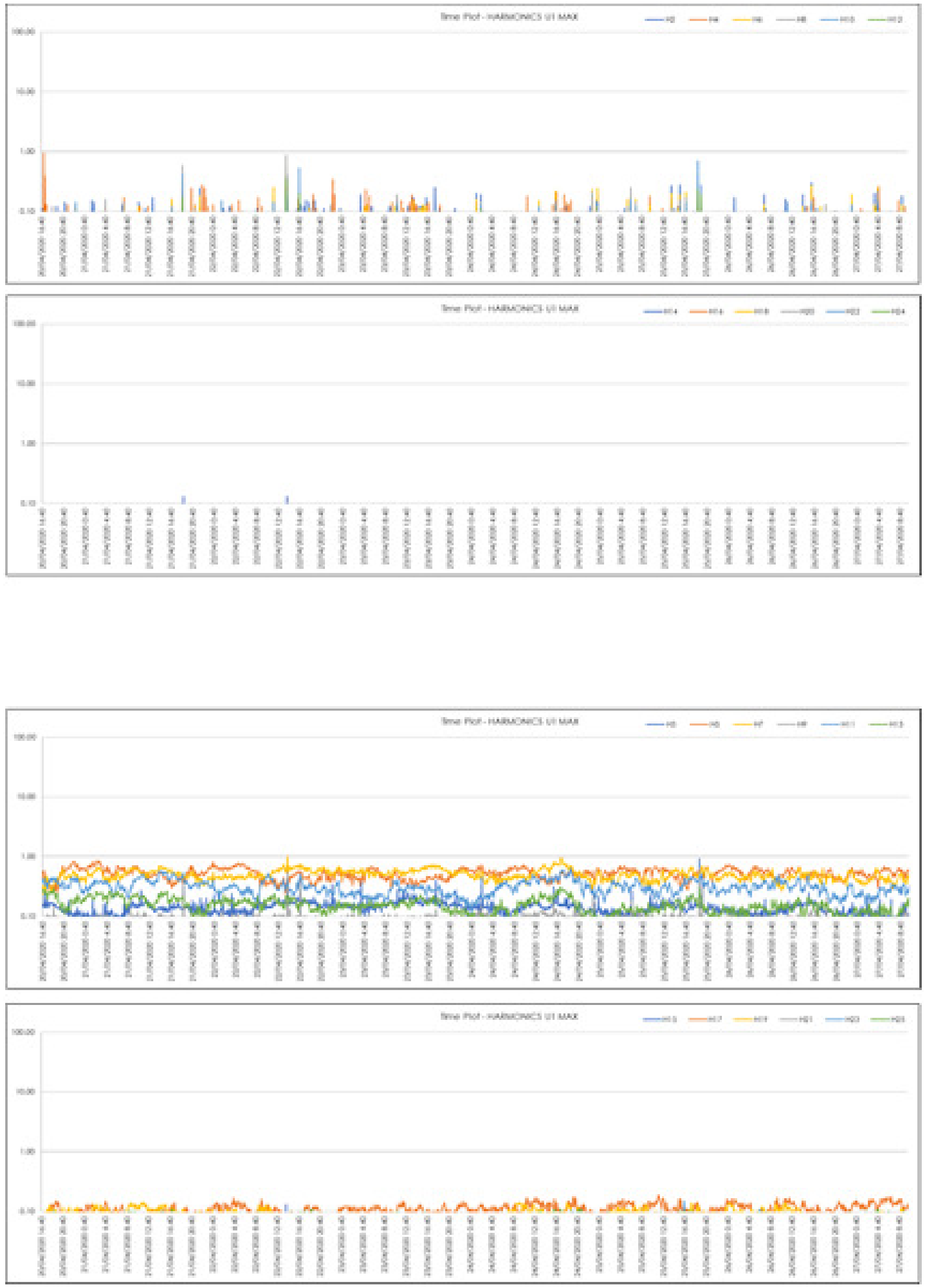


Figure 62 | STS1 Start Harmonics

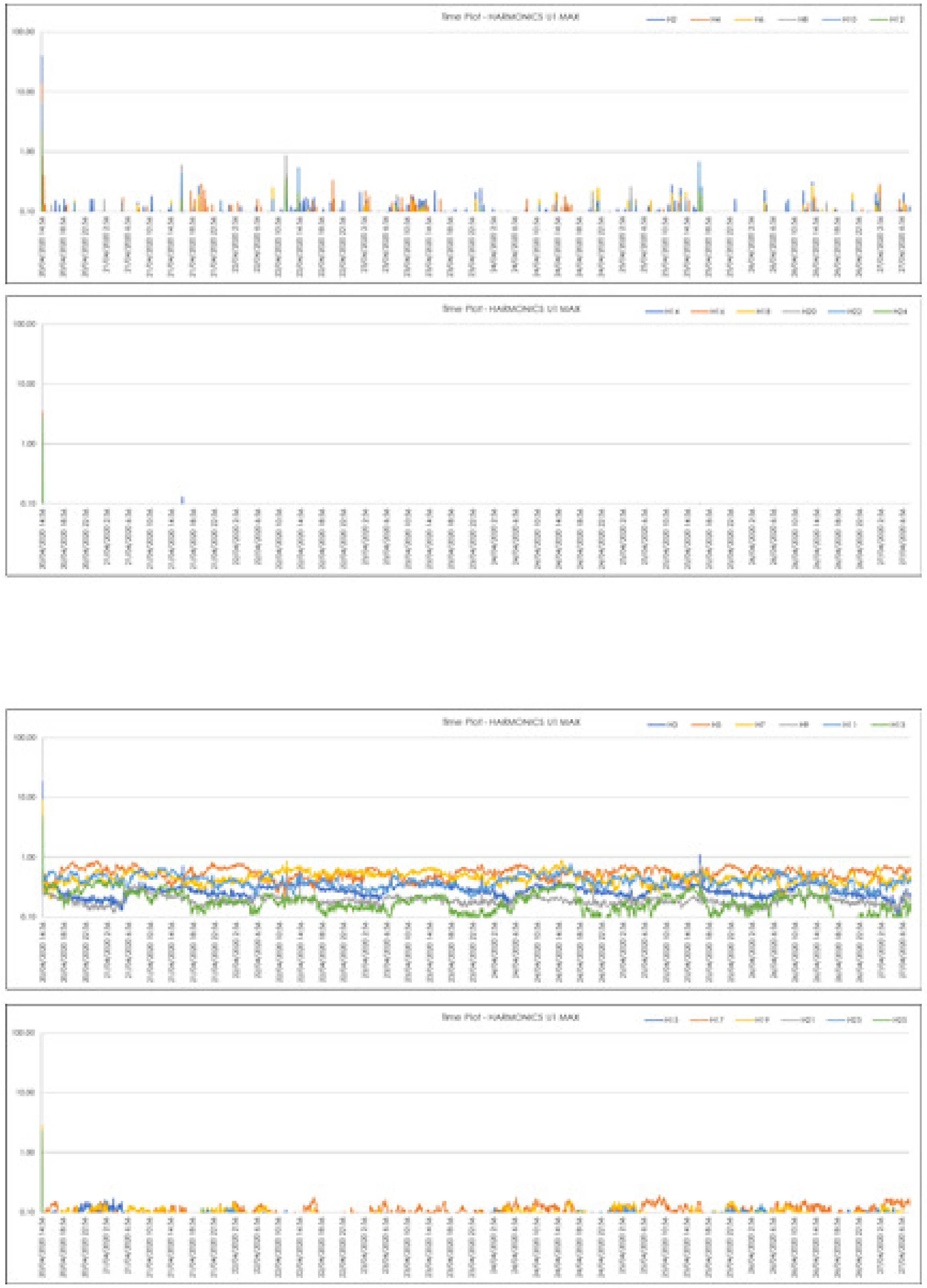
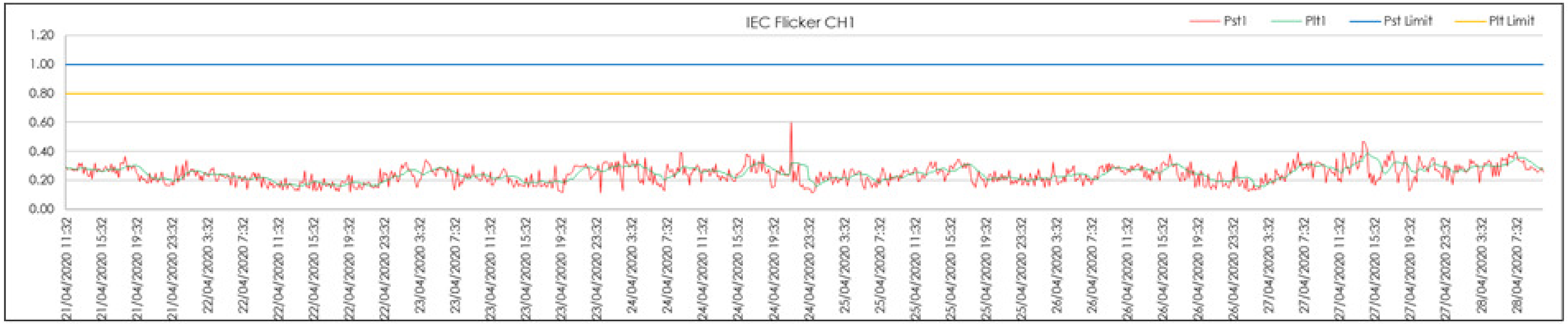
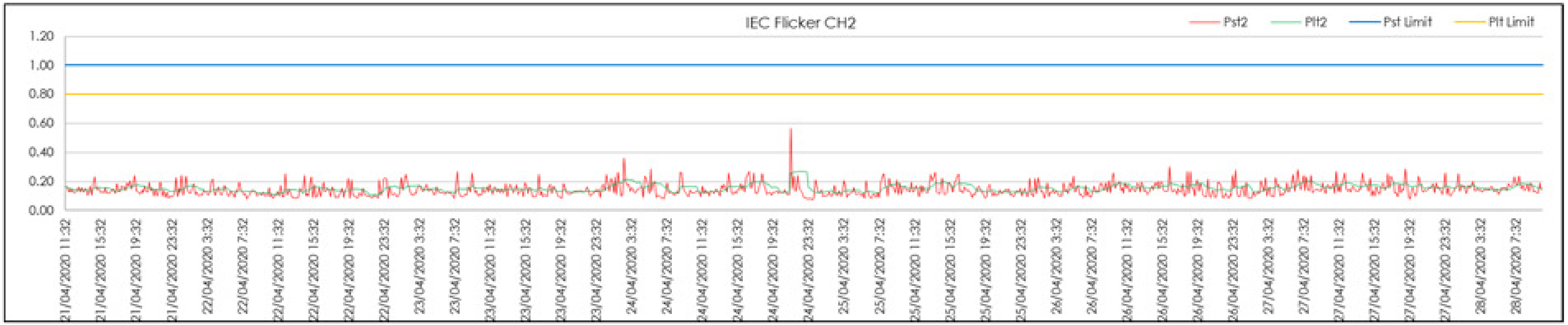


Figure 63 | STS1 End Harmonics

APPENDIX B.6. FEEDER STS2 FLICKER, VOLTAGE, FREQUENCY AND HARMONICS

Figure 64 | STS2 Start Flicker measurements





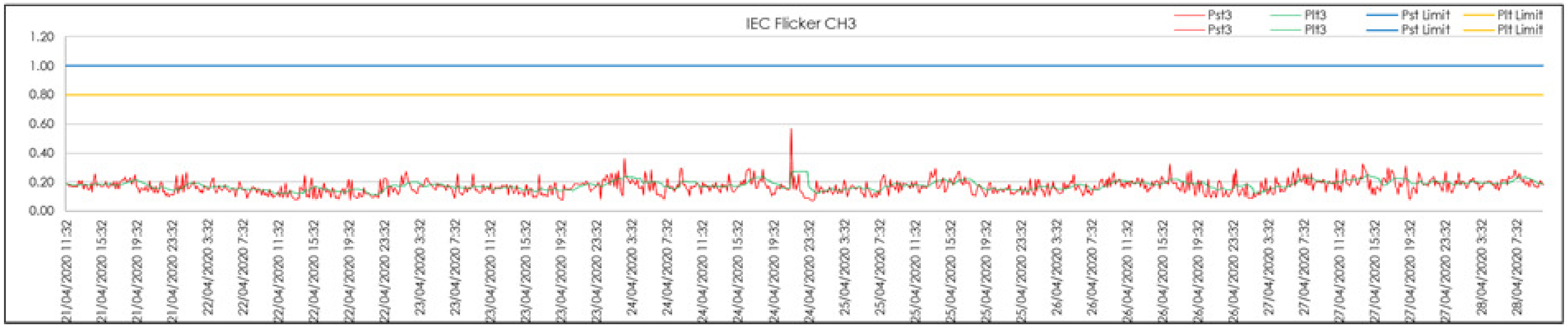


Figure 65 | STS2 End Flicker measurements

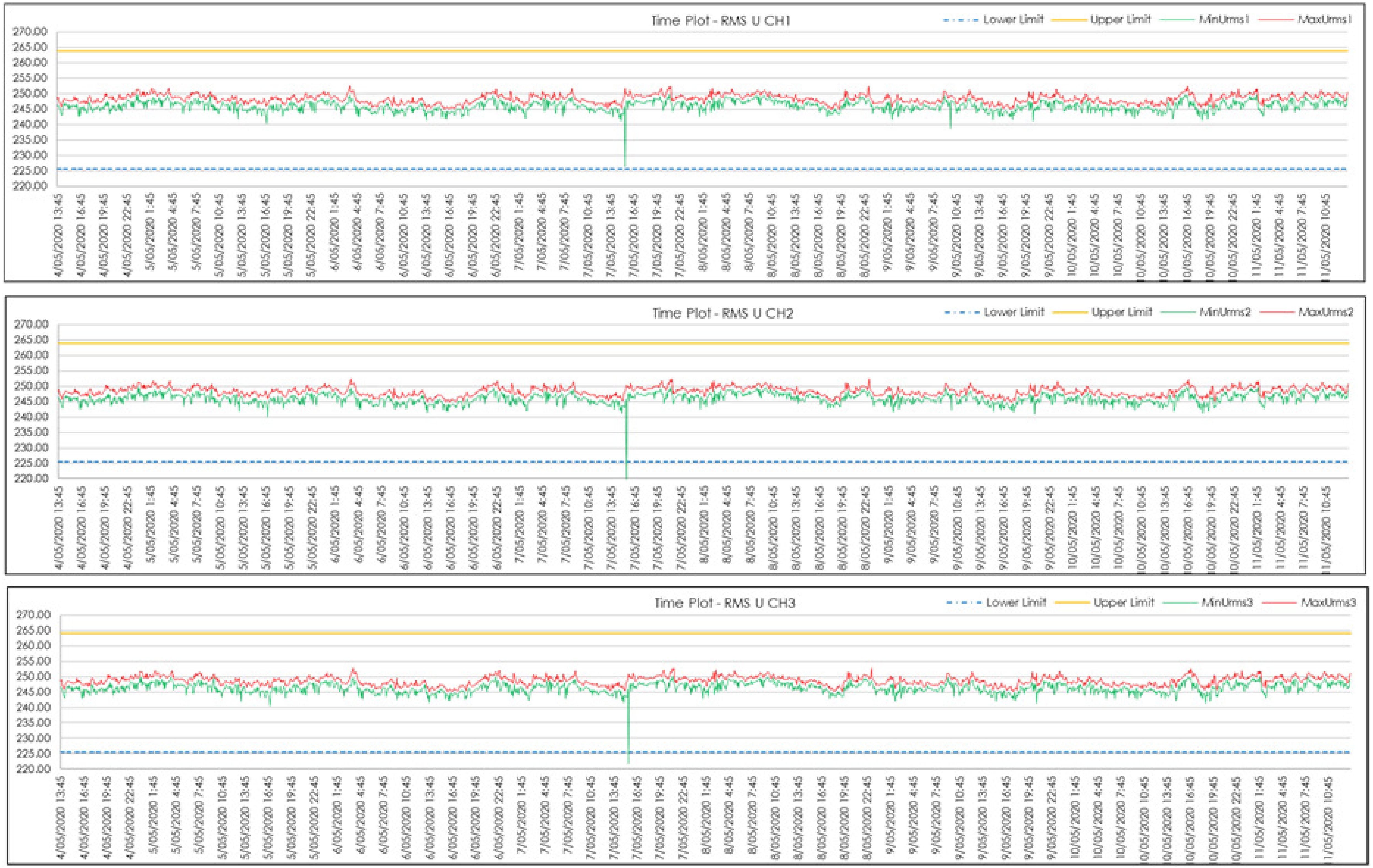


Figure 66 | STS2 Start Voltage measurements

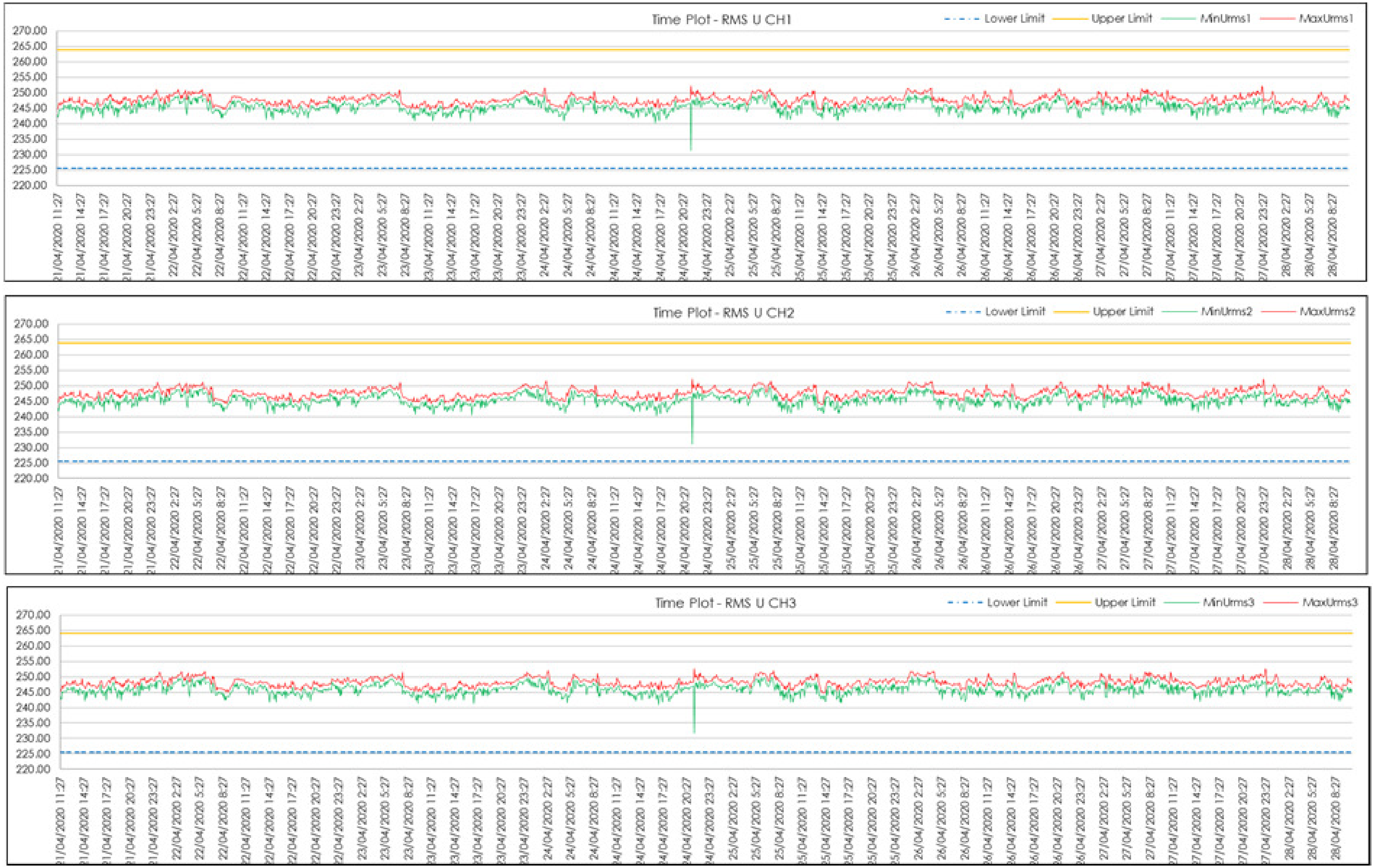


Figure 67 | STS2 End Voltage measurements

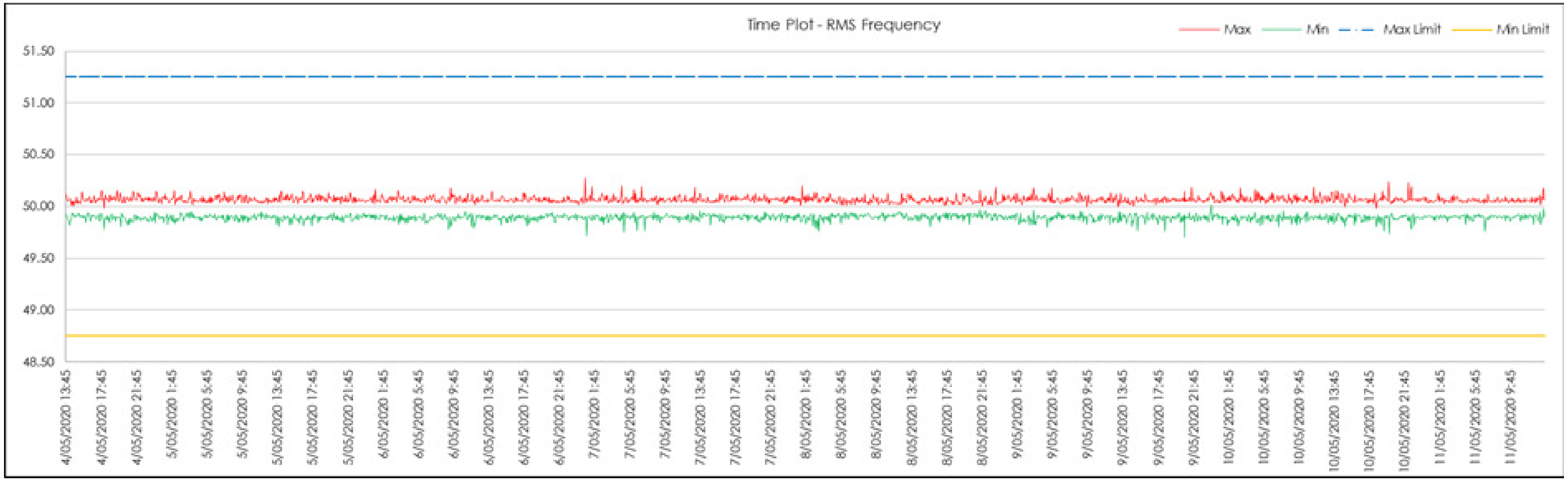


Figure 68 | STS2 Start Frequency measurements

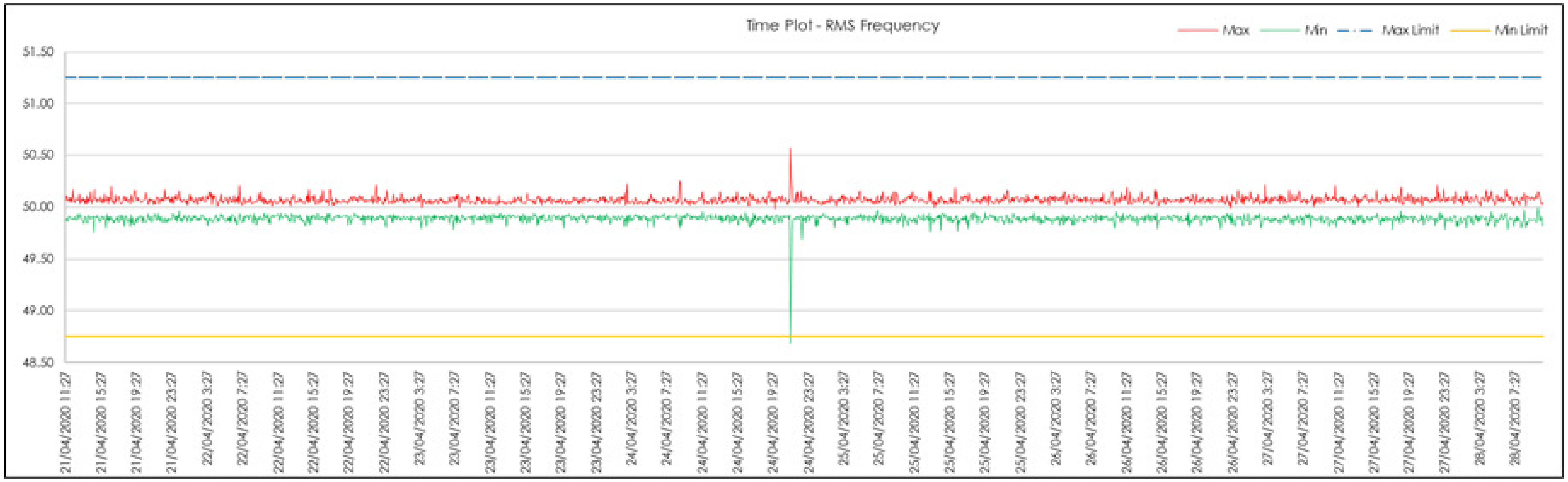


Figure 69 | STS2 End Frequency measurements

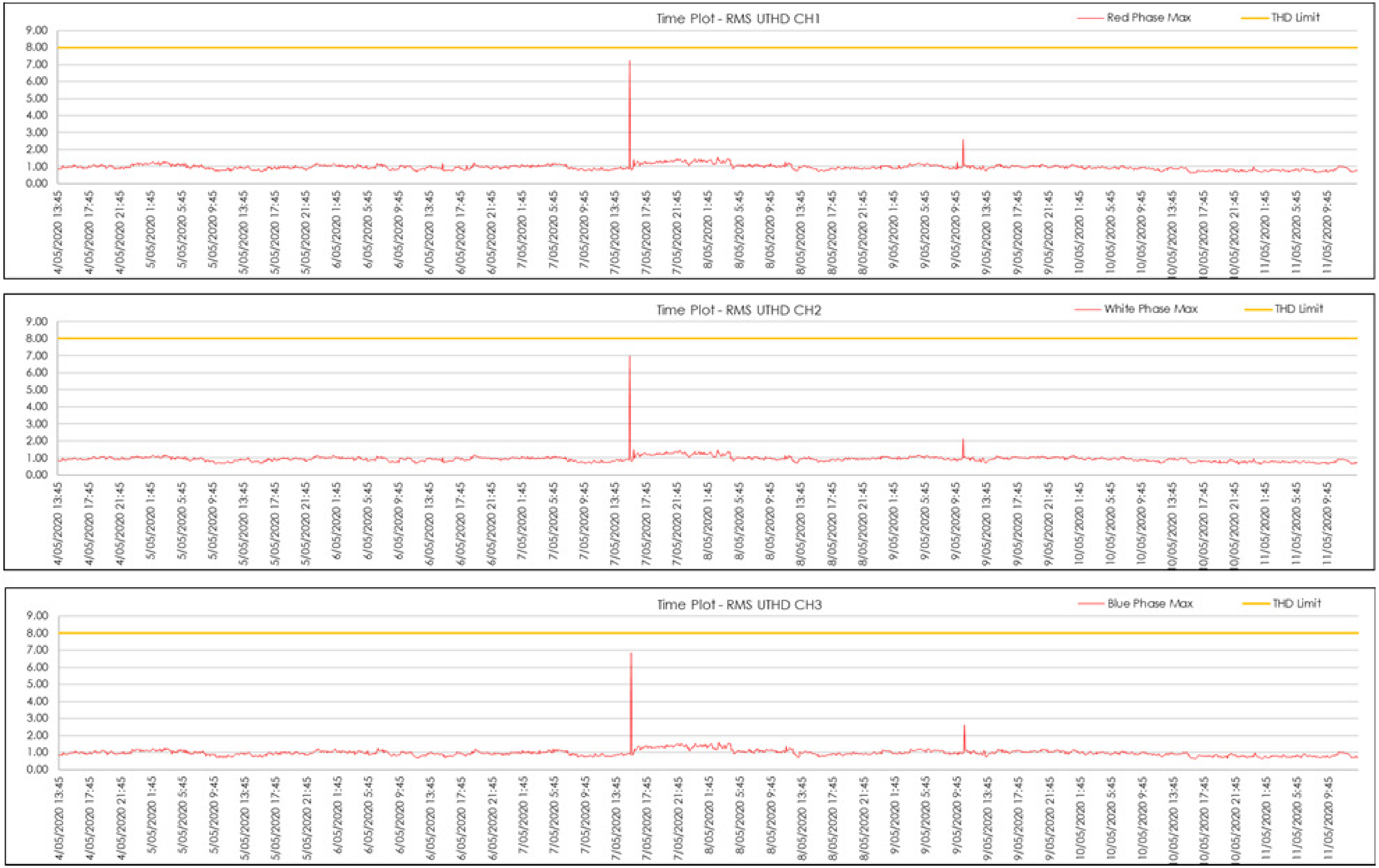
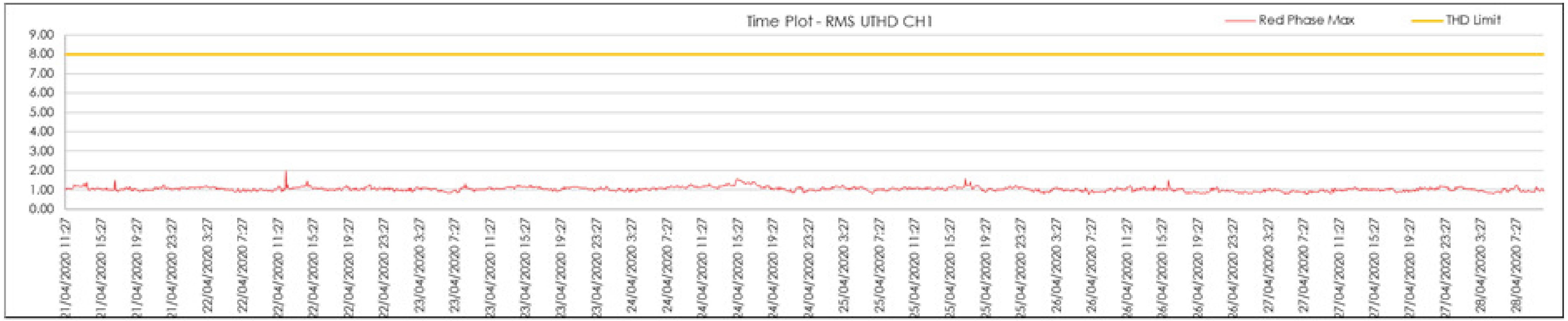
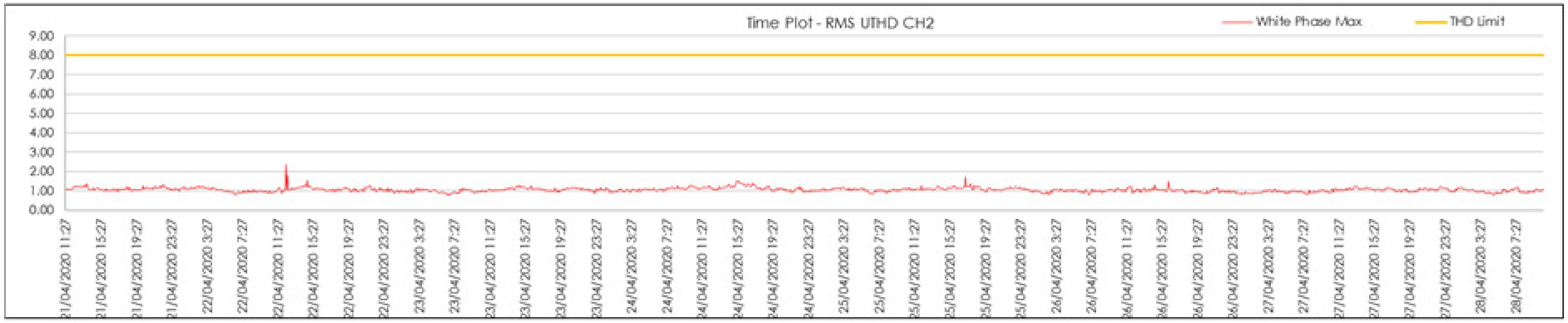


Figure 70 | STS2 Start U-THD measurements





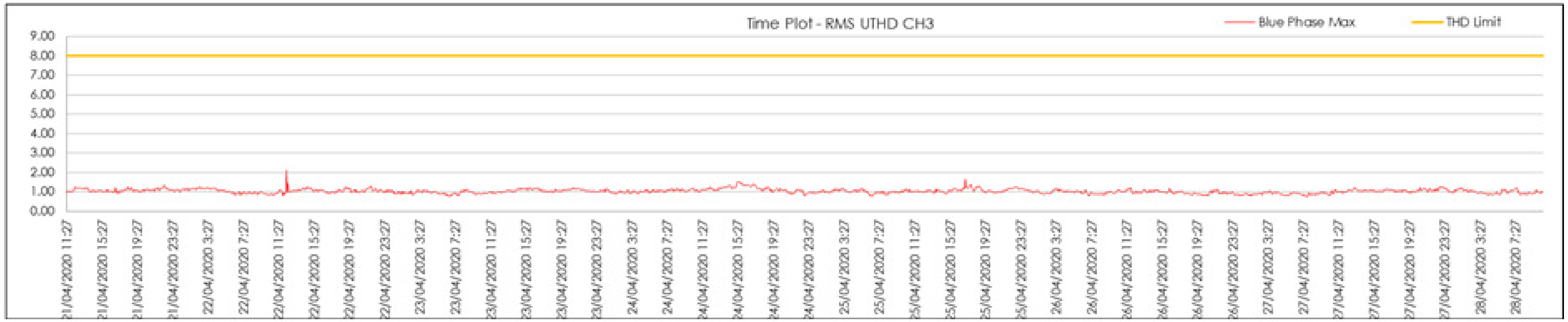
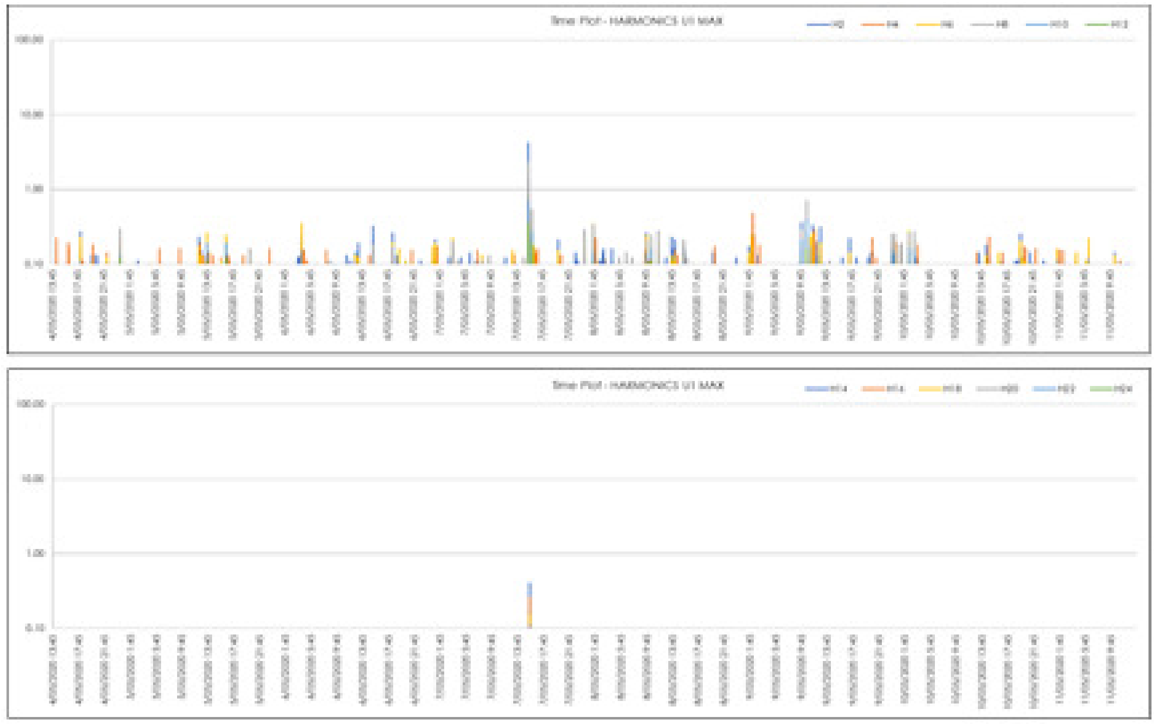


Figure 71 | STS2 End U-THD measurements



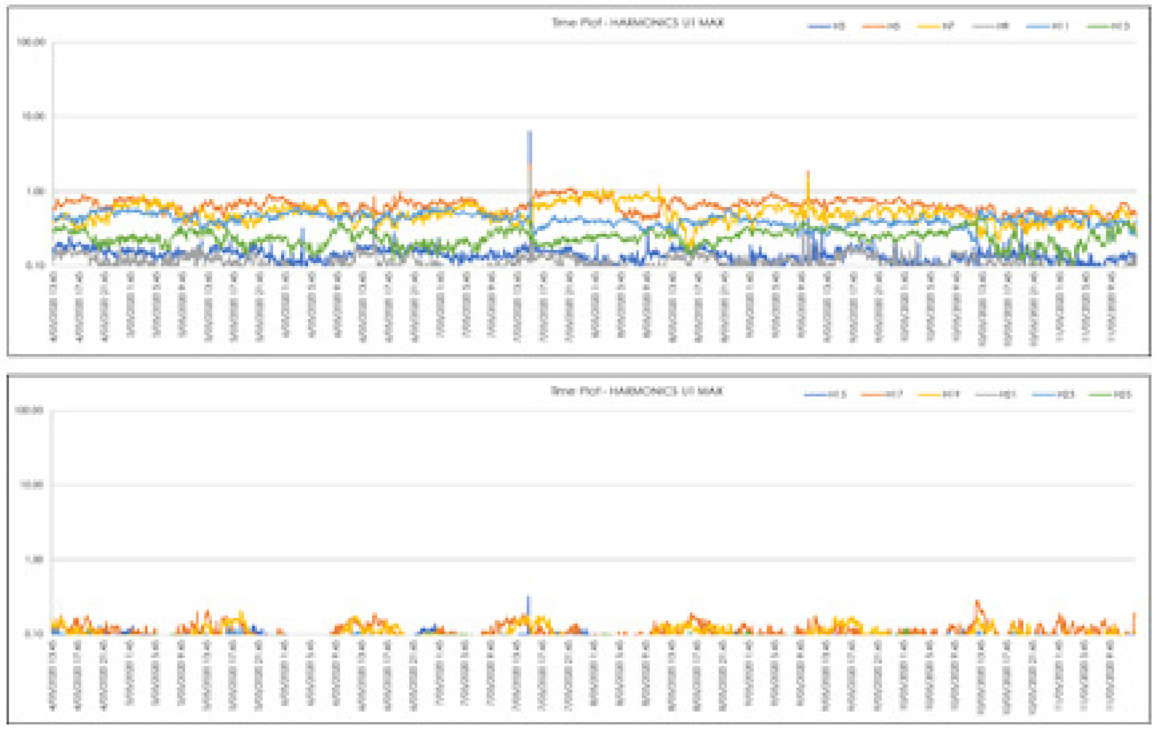


Figure 72 | STS2 Start Harmonics

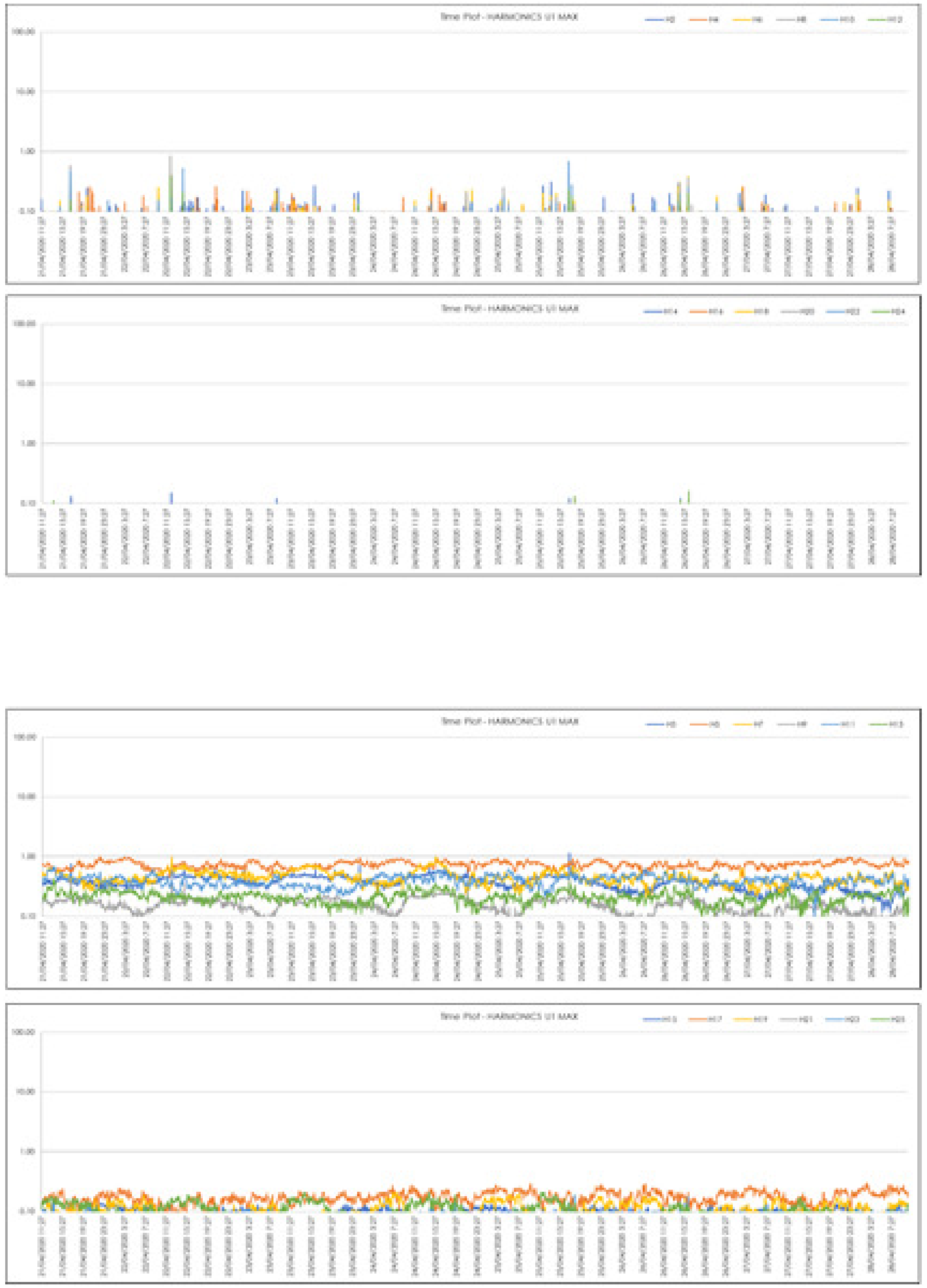
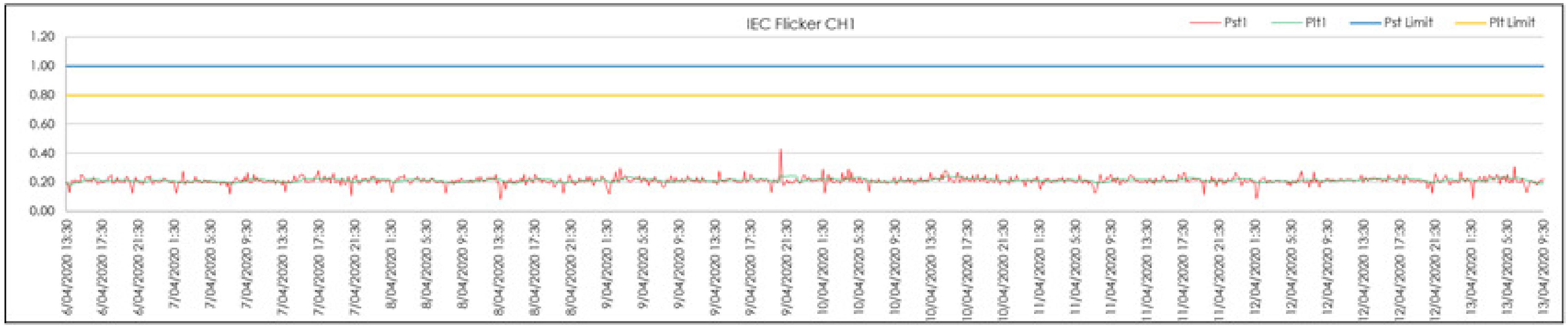
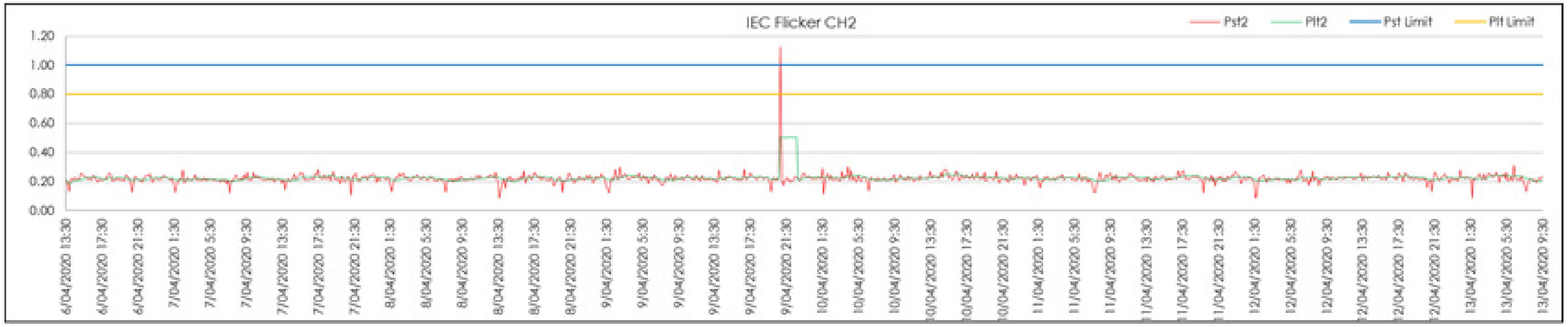


Figure 73 | STS2 End Harmonics

APPENDIX B.7. FEEDER STS4 FLICKER, VOLTAGE, FREQUENCY AND HARMONICS





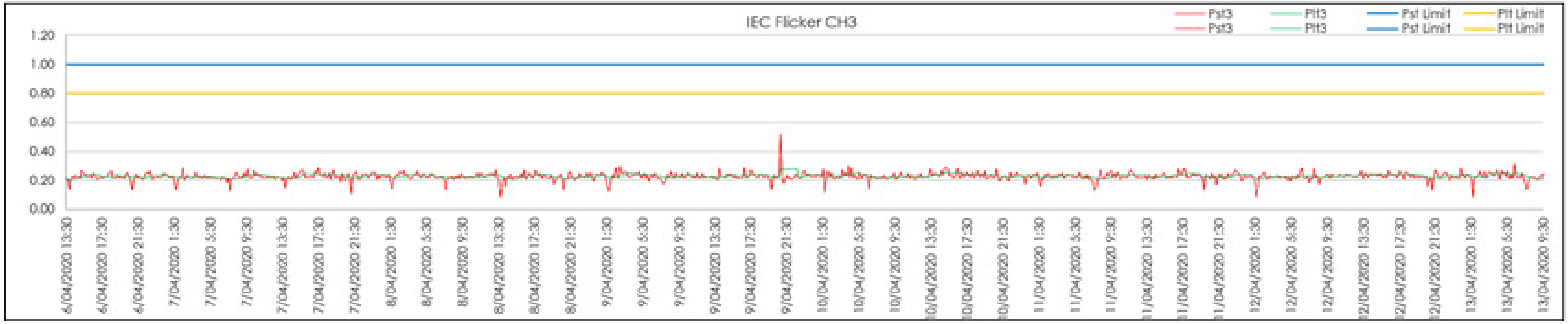


Figure 74 | STS4 Start Flicker measurements

Figure 75 | STS4 End Flicker measurements

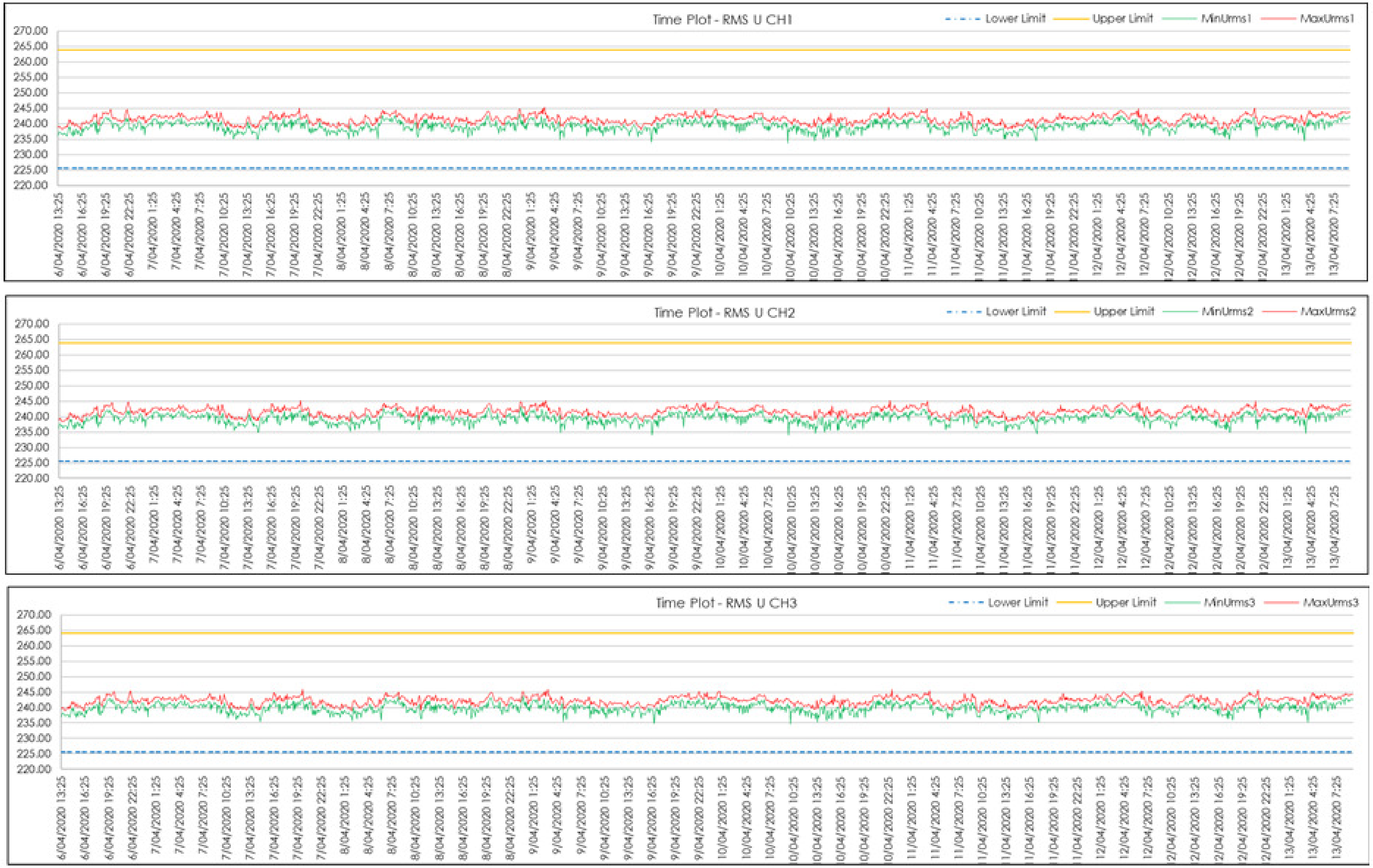


Figure 76 | STS4 Start Voltage measurements

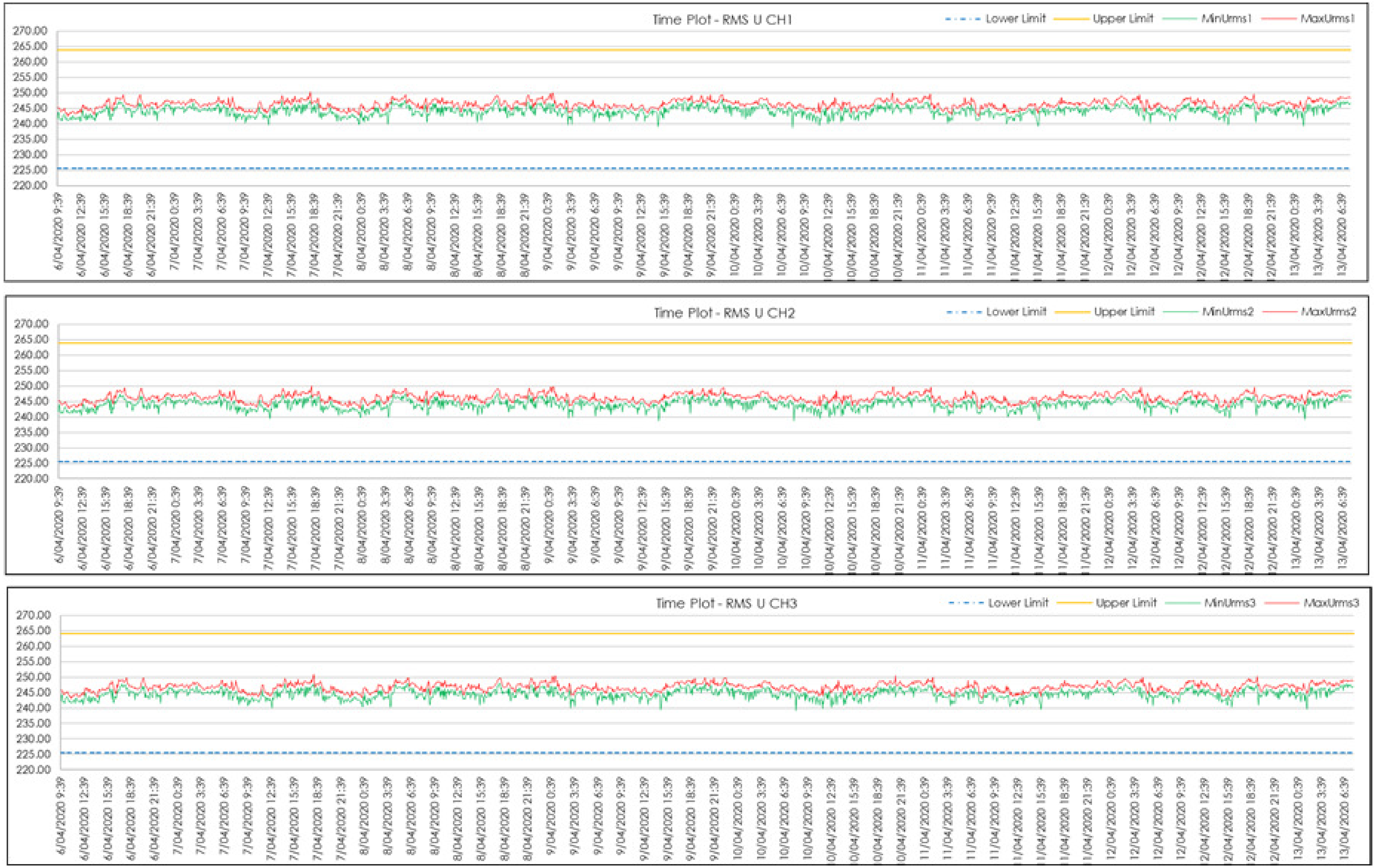


Figure 77 | STS4 End Voltage measurements

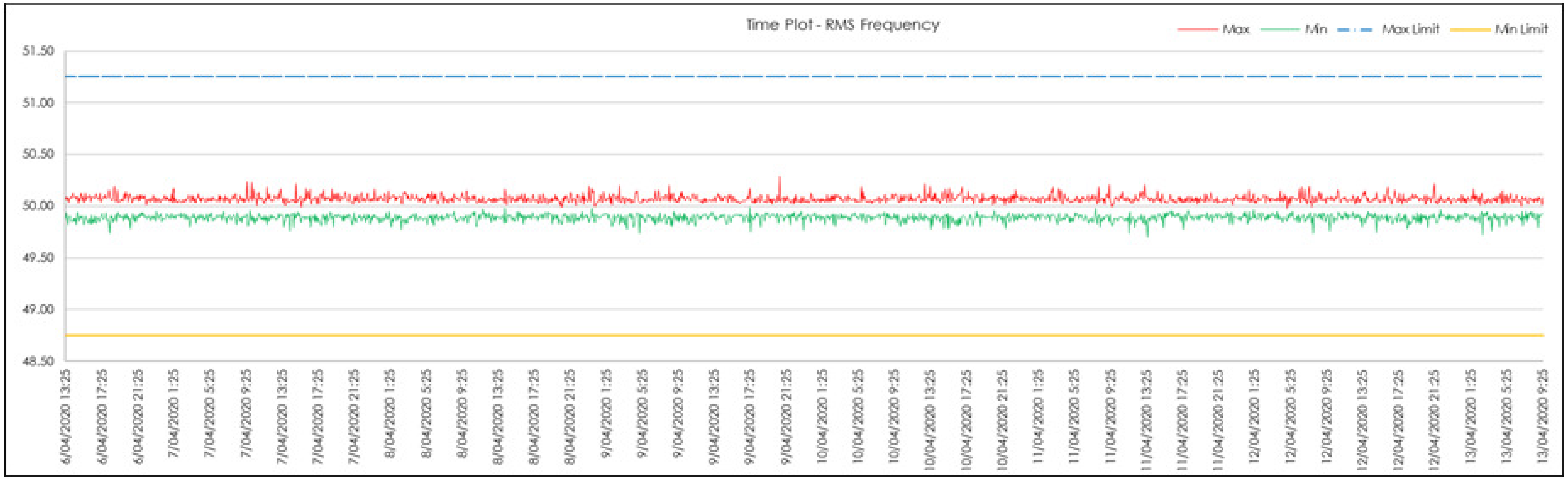


Figure 78 | STS4 Start Frequency measurements

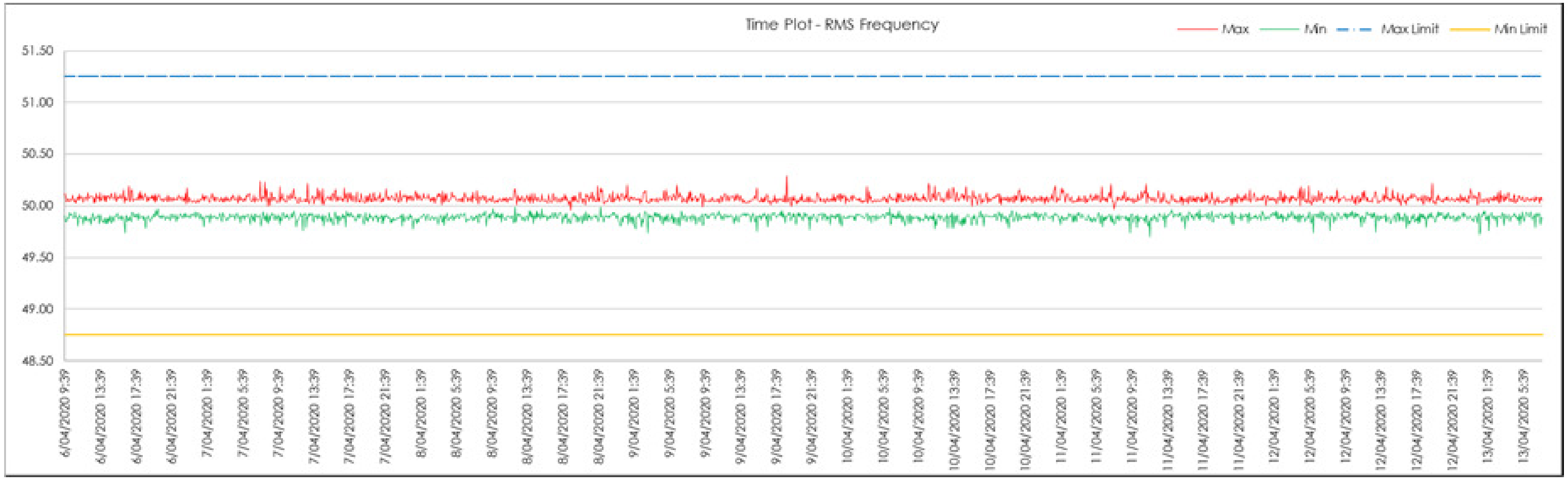


Figure 79 | STS4 End Frequency measurements

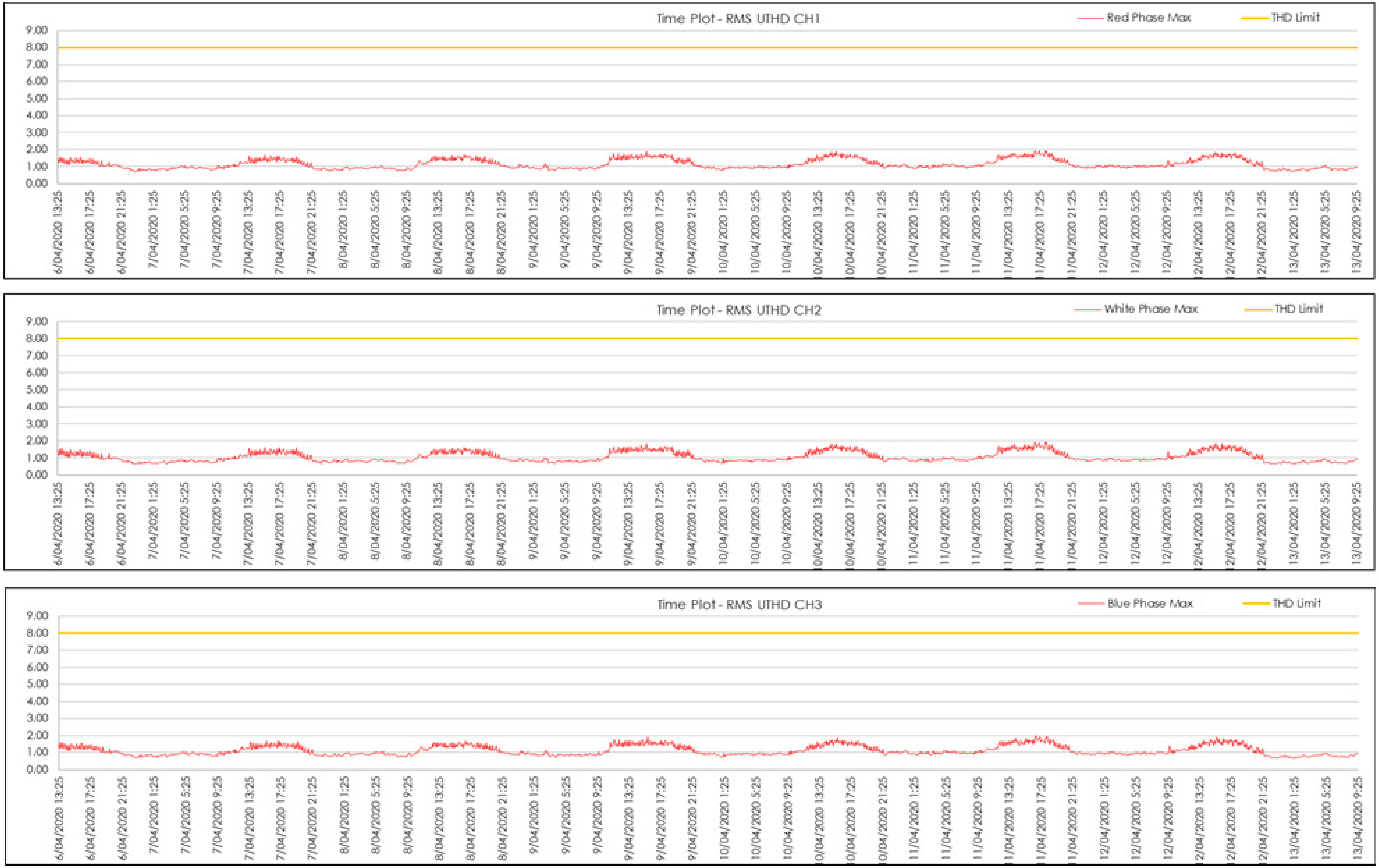
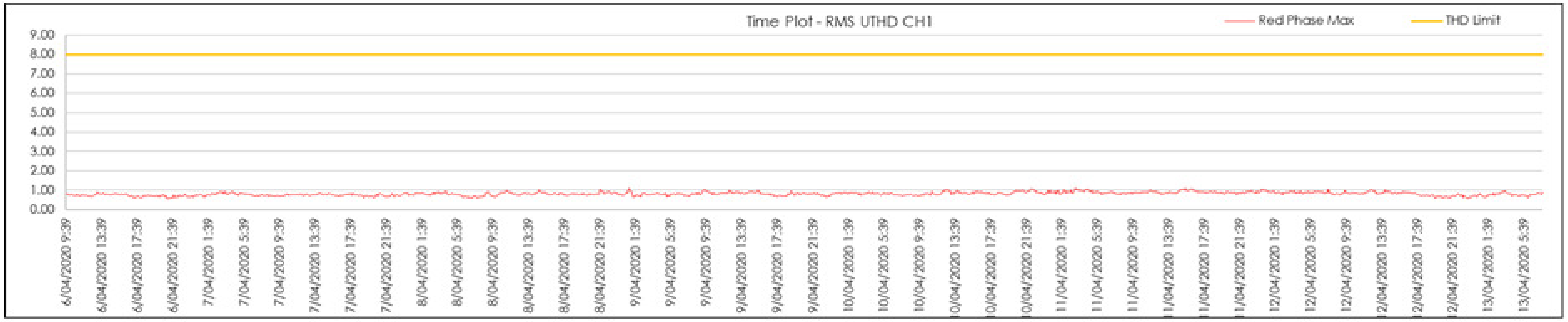
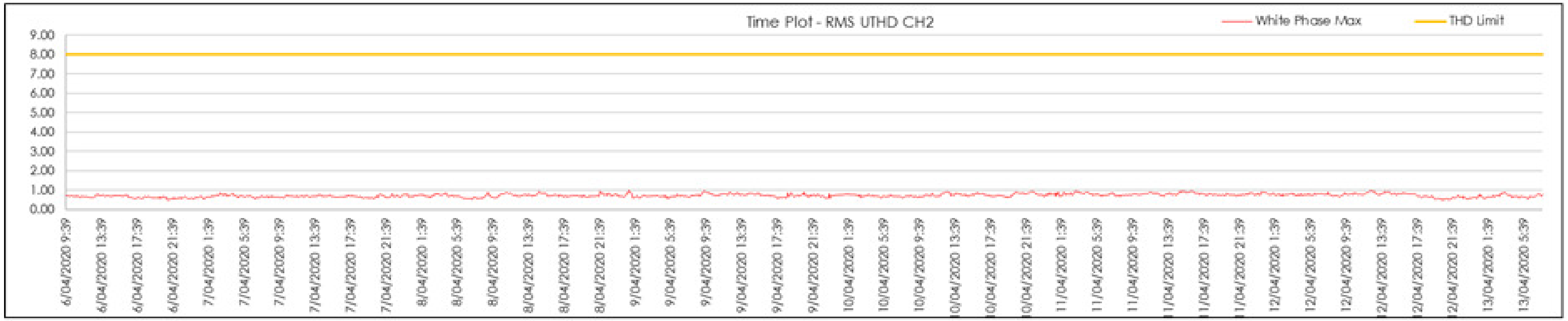


Figure 80 | STS4 Start U-THD measurements





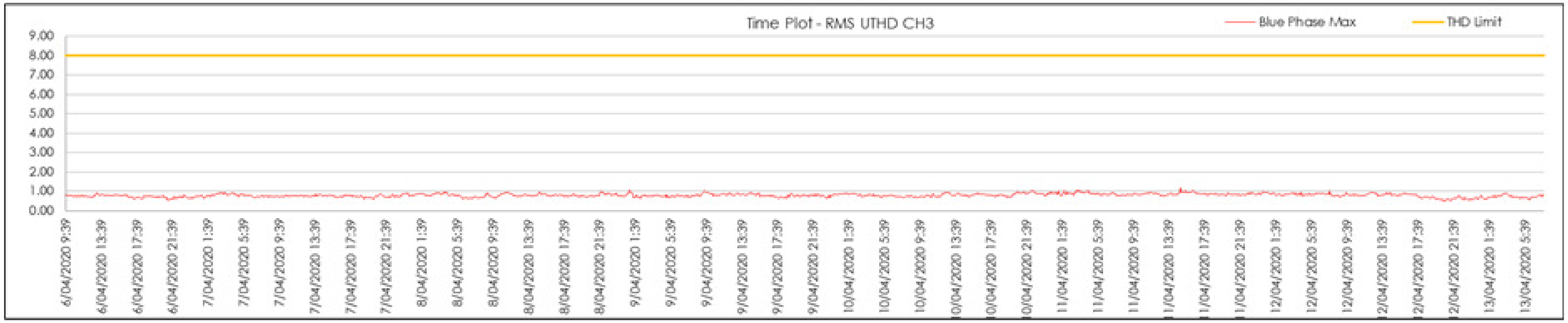


Figure 81 | STS4 End U-THD measurements

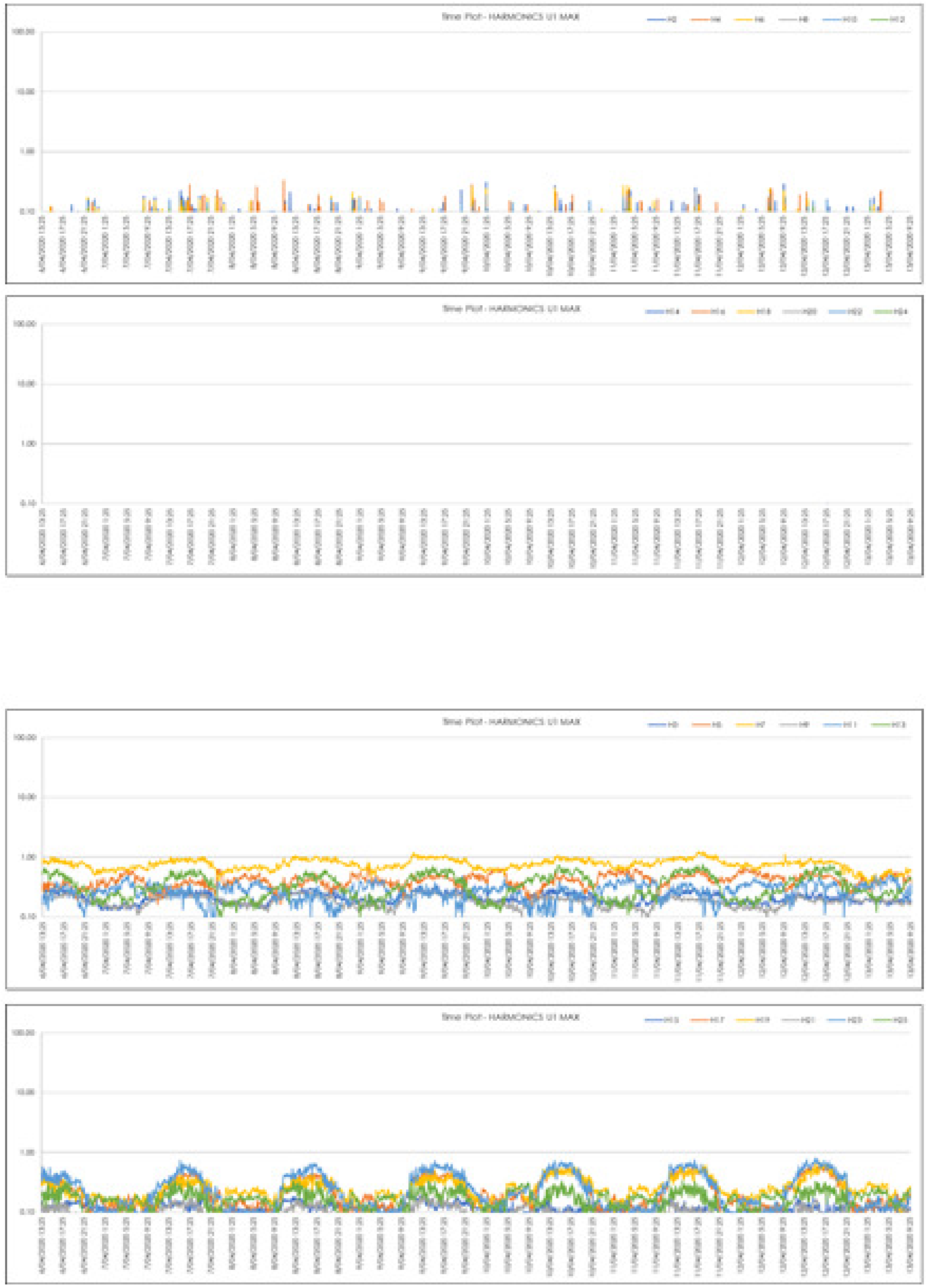


Figure 82 | STS4 Start Harmonics

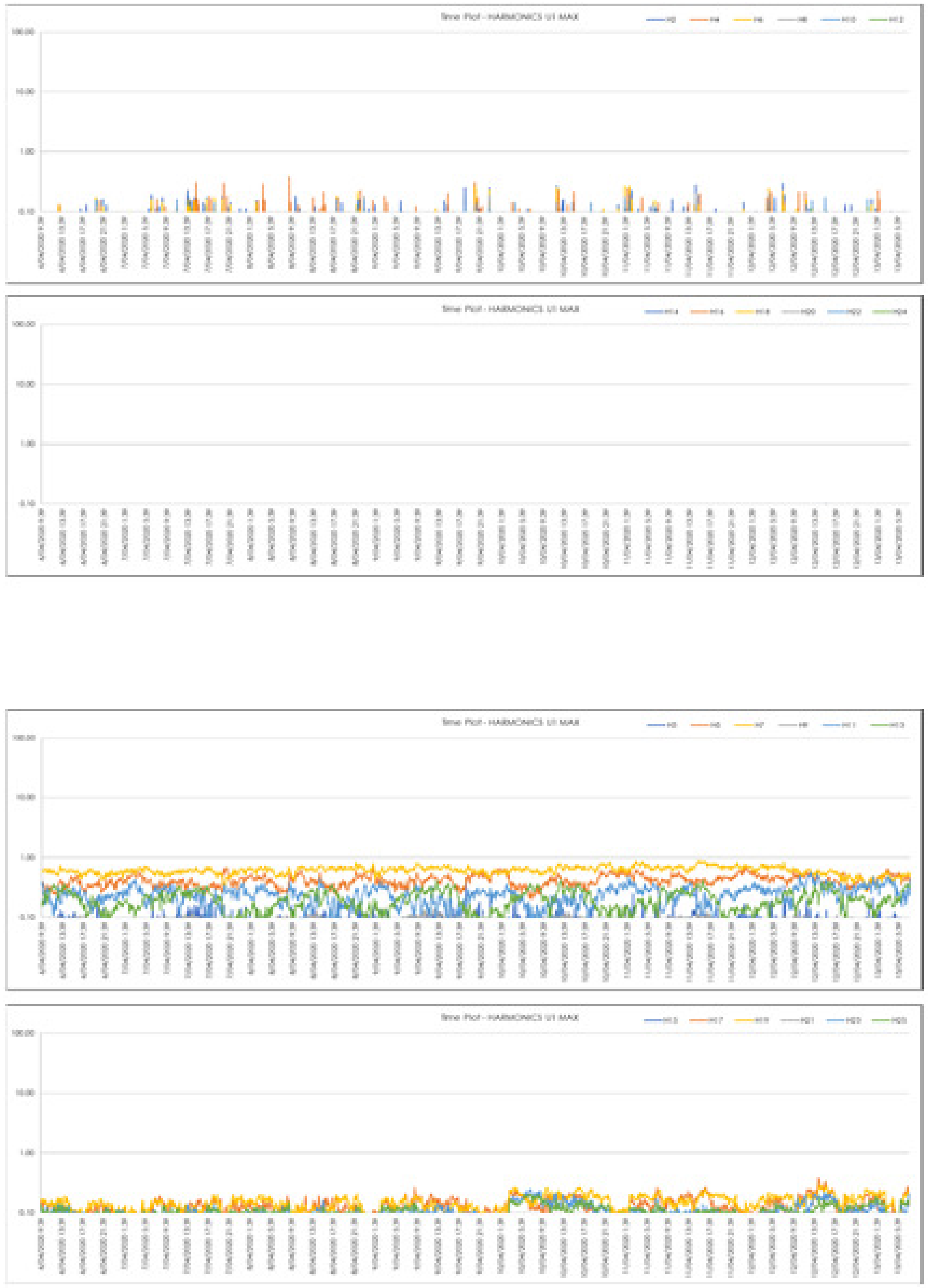


Figure 83 | STS4 End Harmonics

APPENDIX B.8. FEEDER STS6 FLICKER, VOLTAGE, FREQUENCY AND HARMONICS

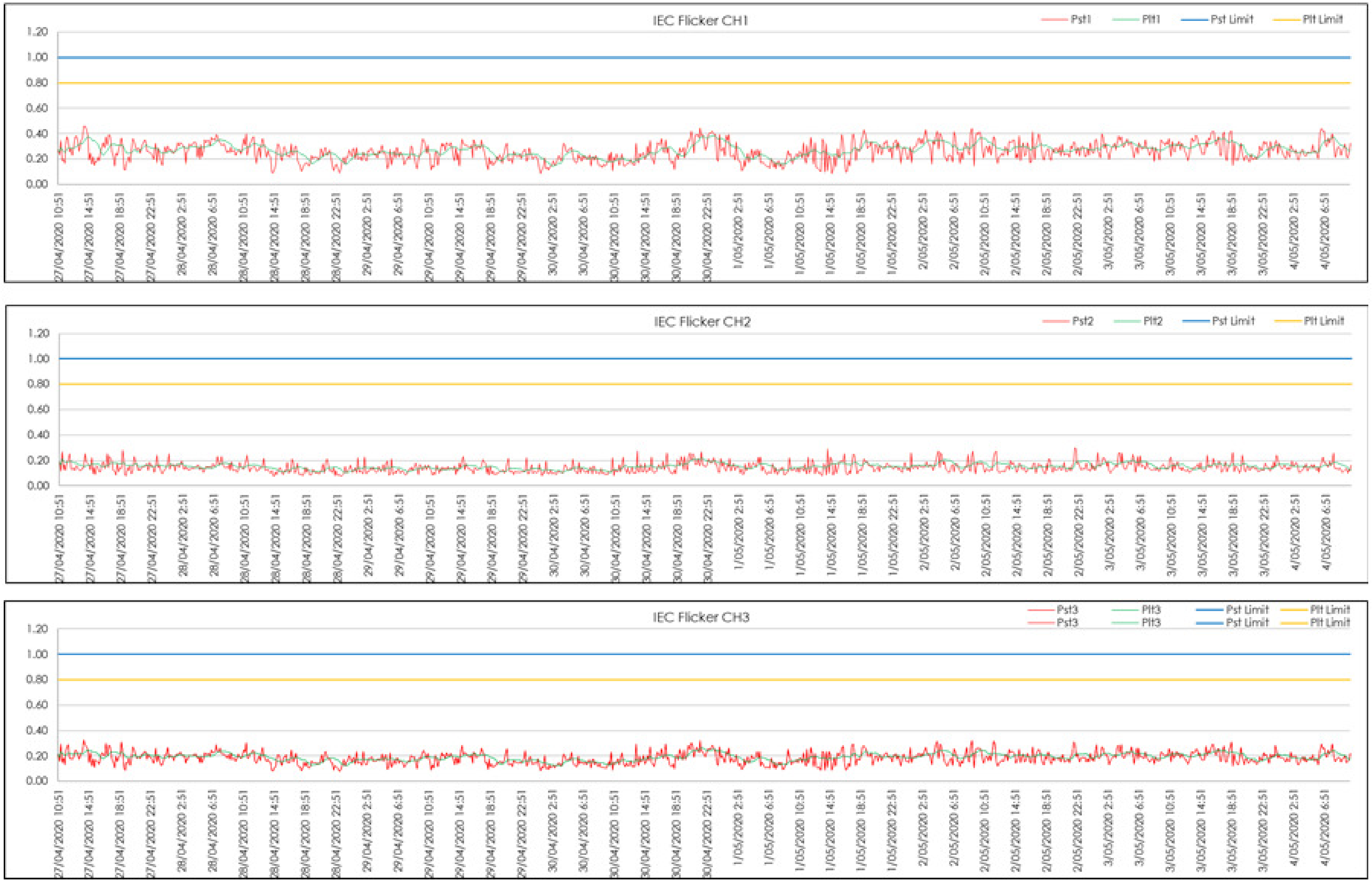
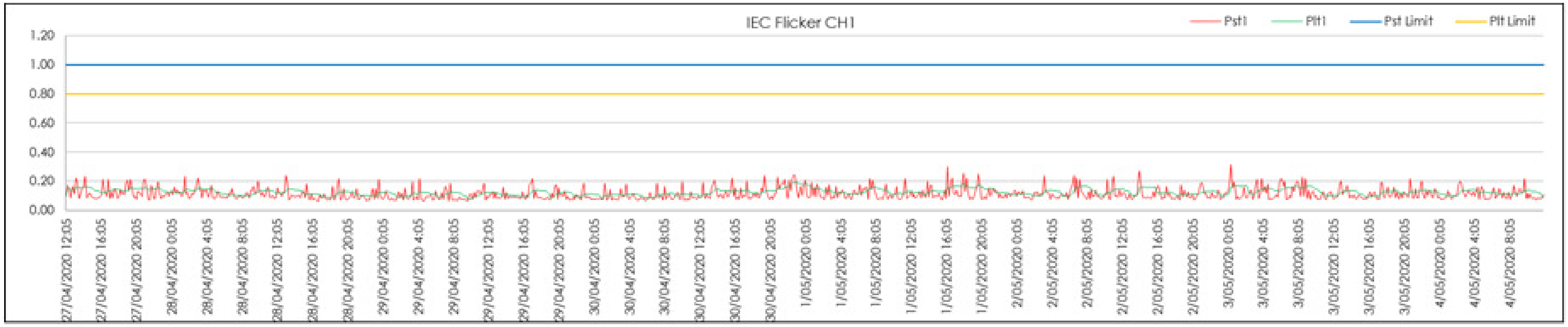
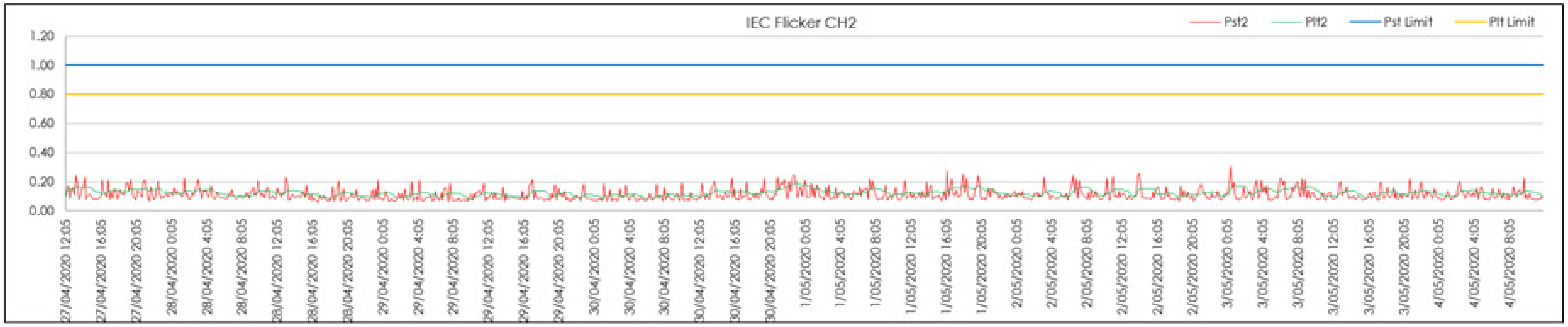


Figure 84 | STS6 Start Flicker measurements





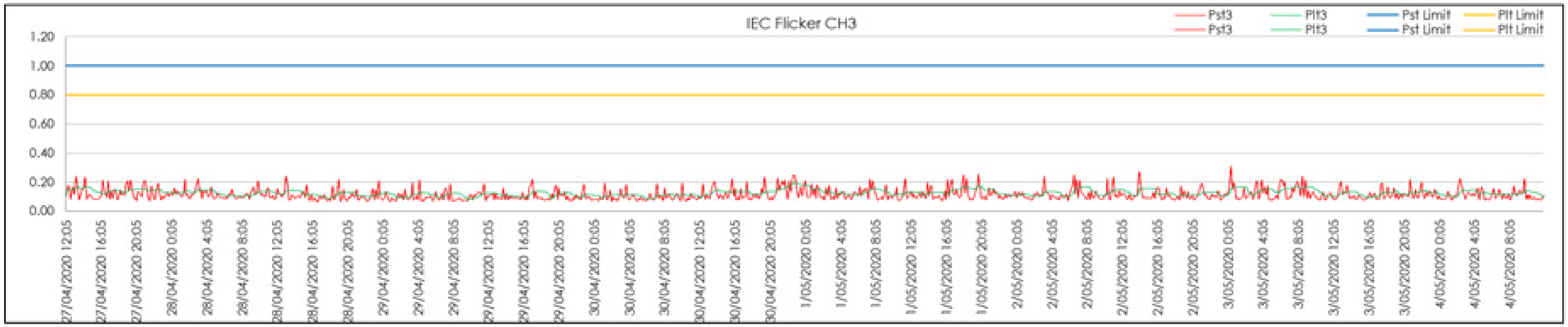


Figure 85 | STS6 End Flicker measurements

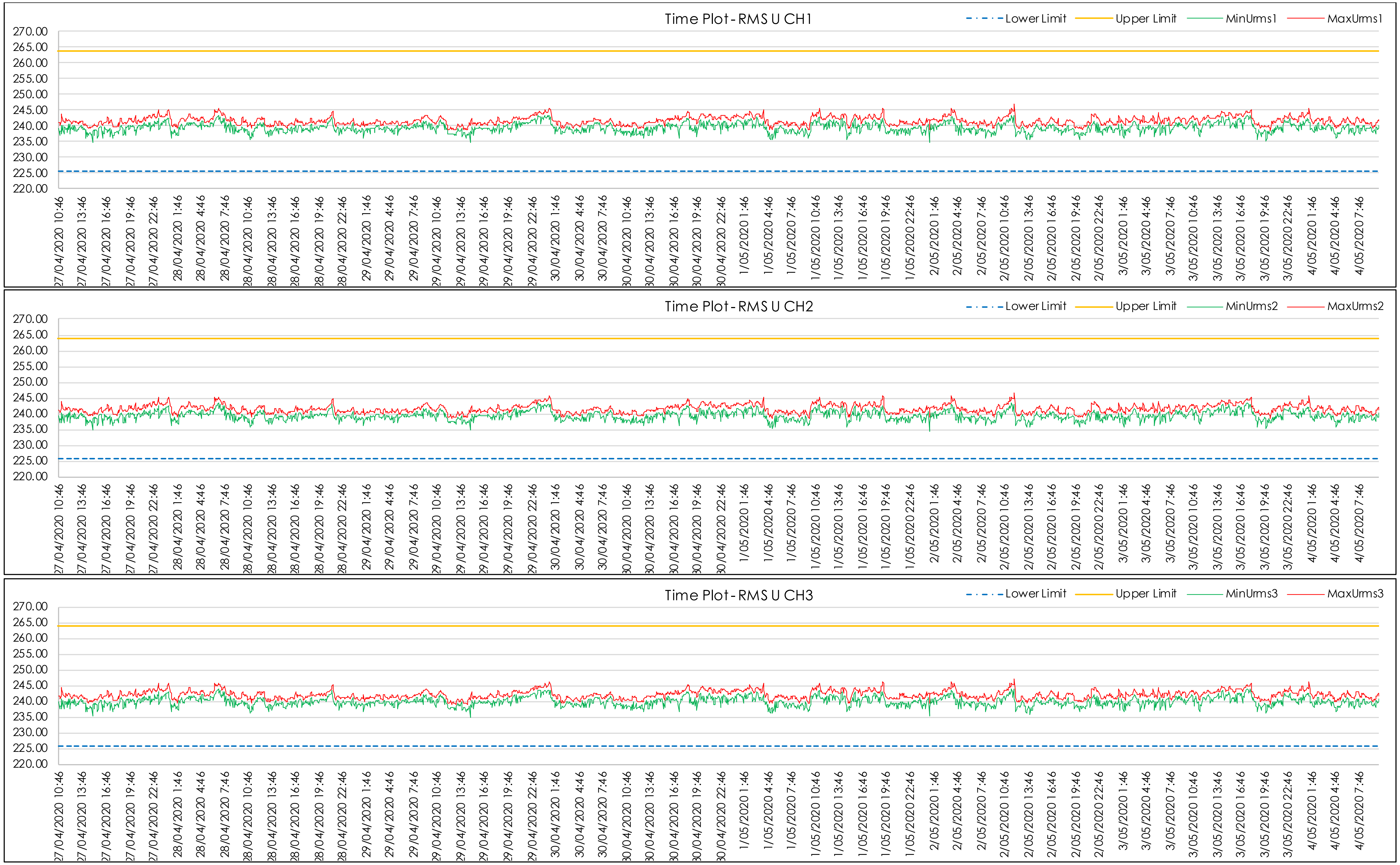
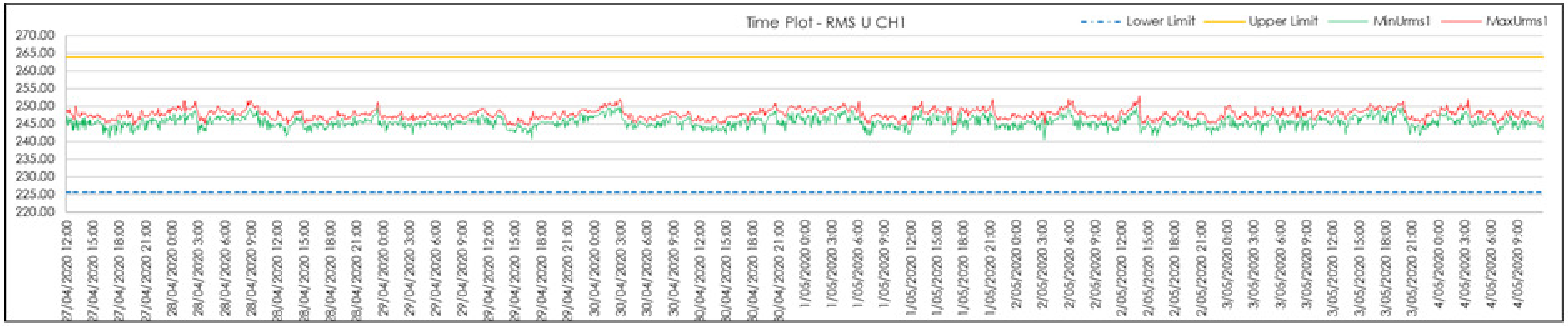
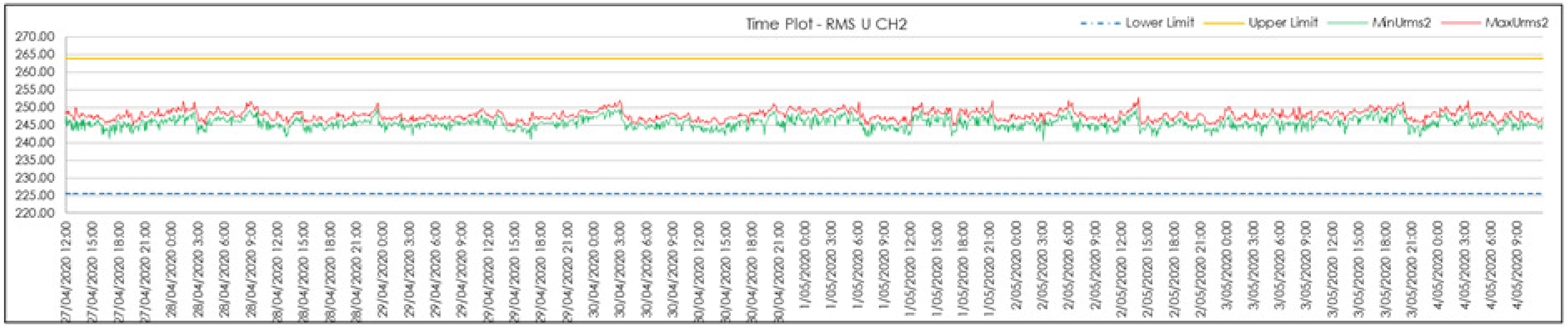


Figure 86 | STS6 Start Voltage measurements





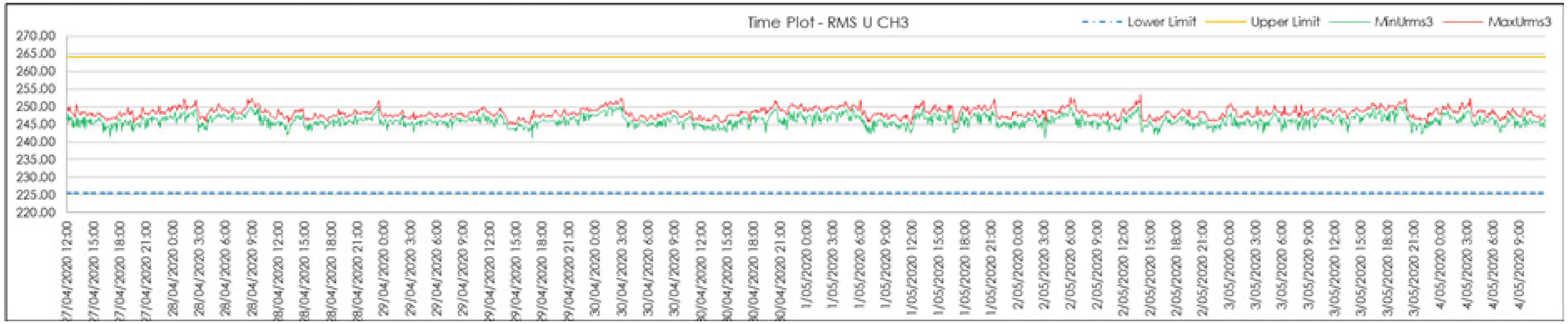


Figure 87 | STS6 End Voltage measurements

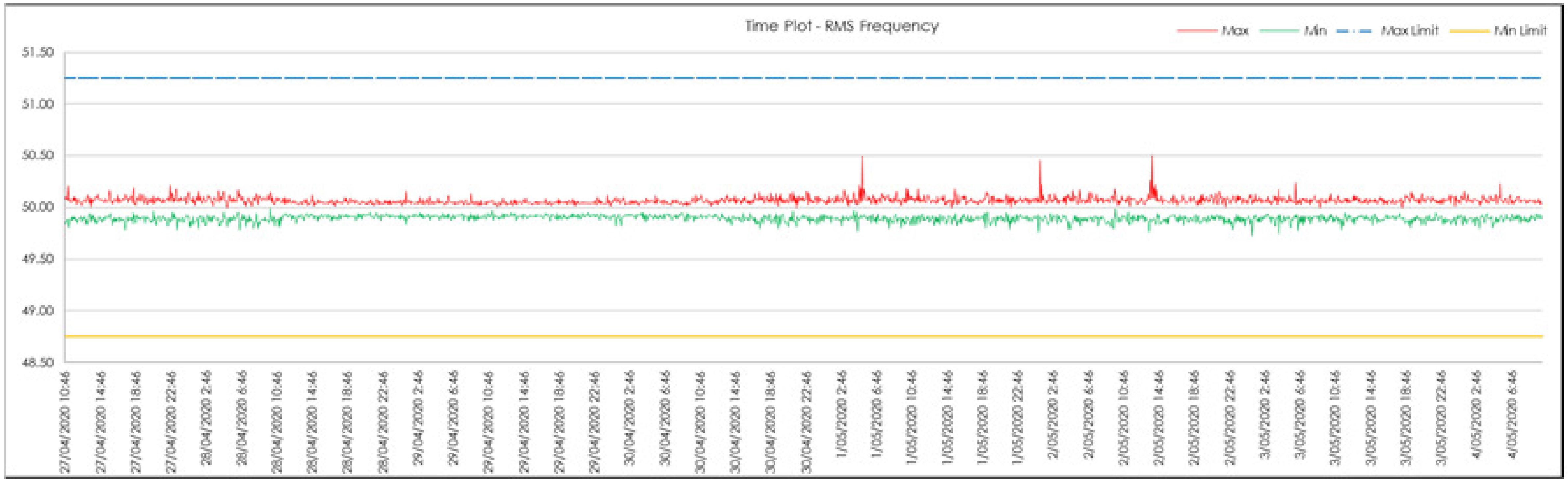


Figure 88 | STS6 Start Frequency measurements

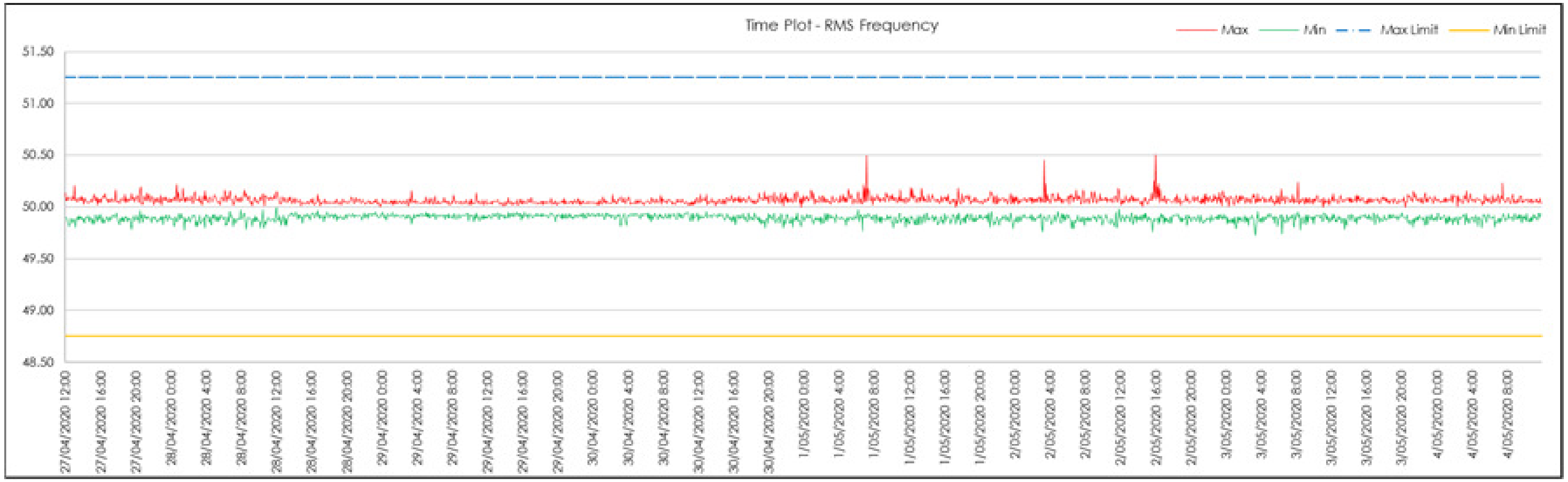


Figure 89 | STS6 End Frequency measurements

Figure 90 | STS6 Start U-THD measurements

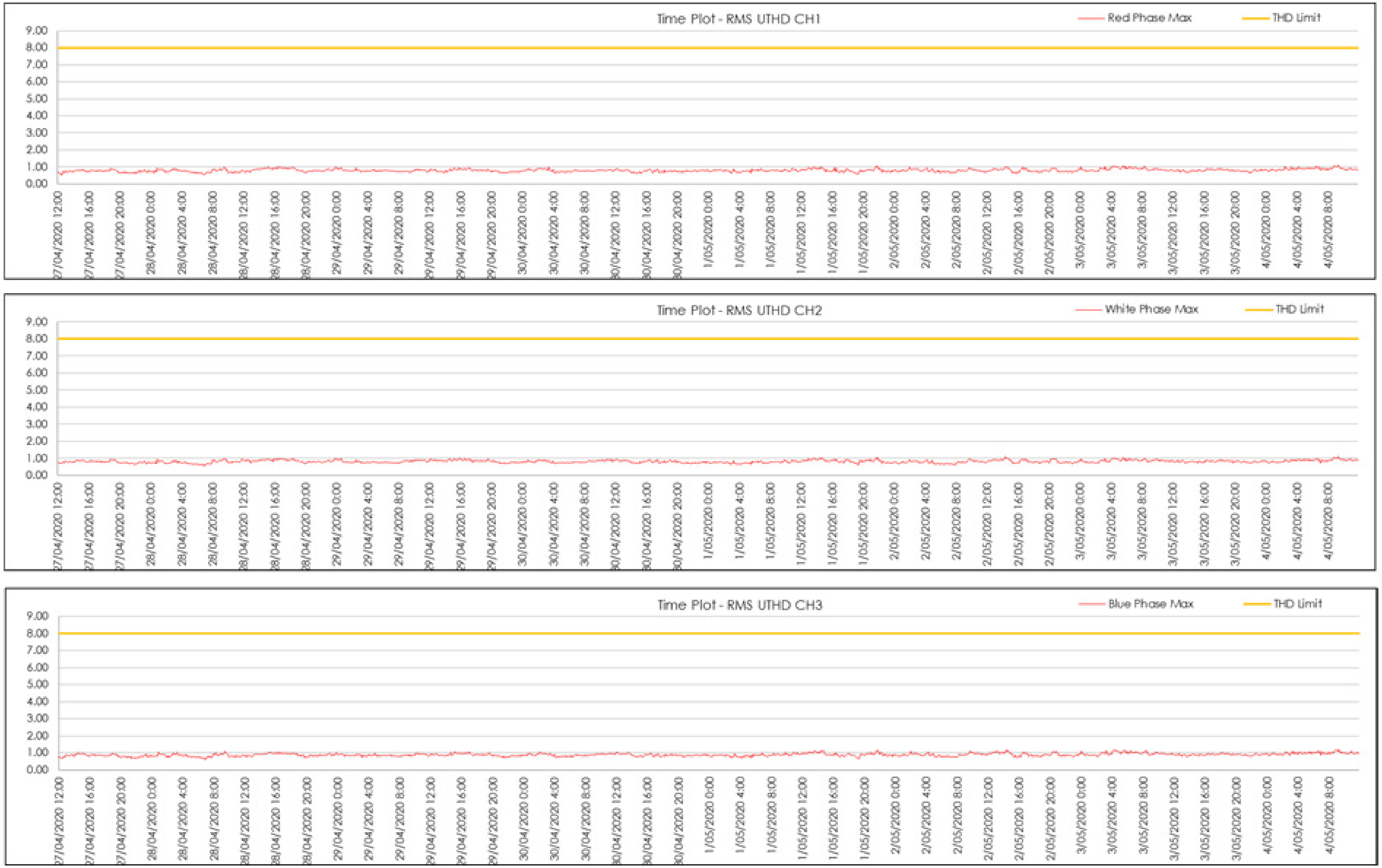
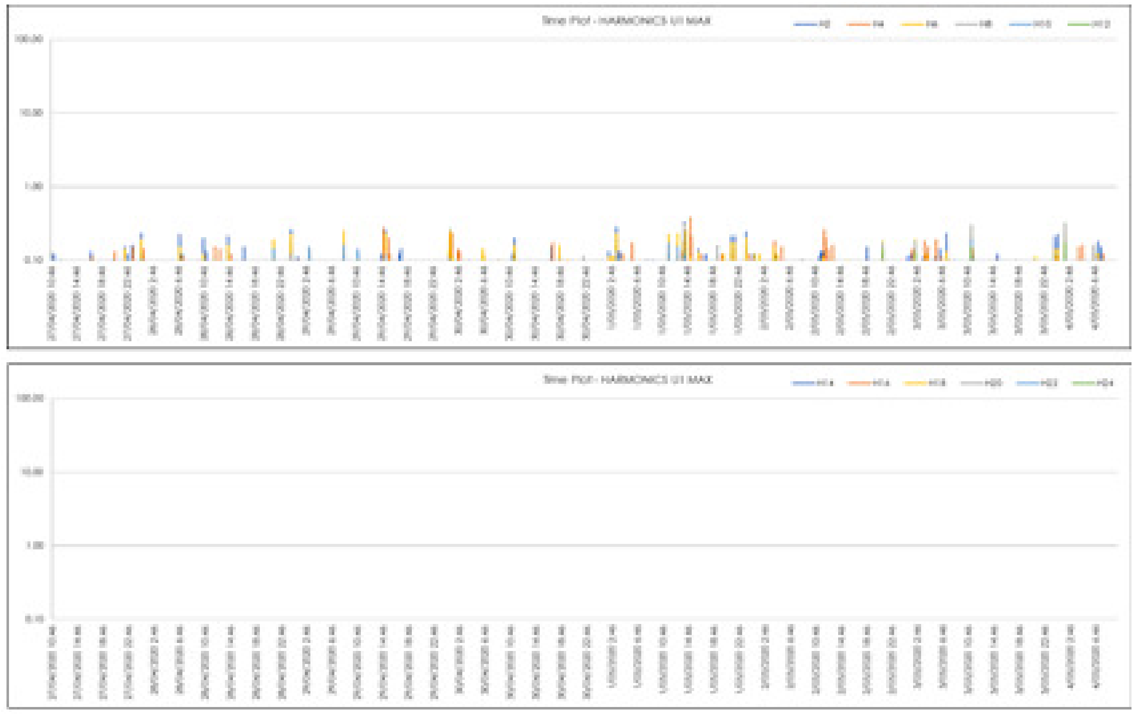


Figure 91 | STS6 End U-THD measurements



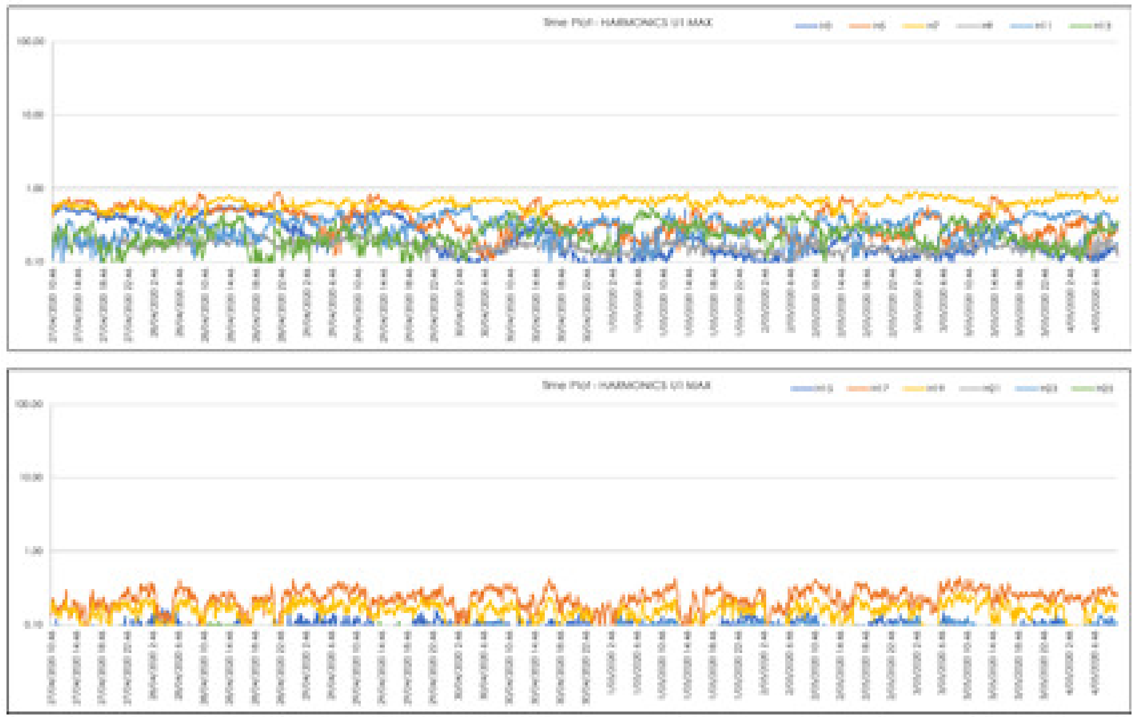


Figure 92 | STS6 Start Harmonics

APD ENGINEERING

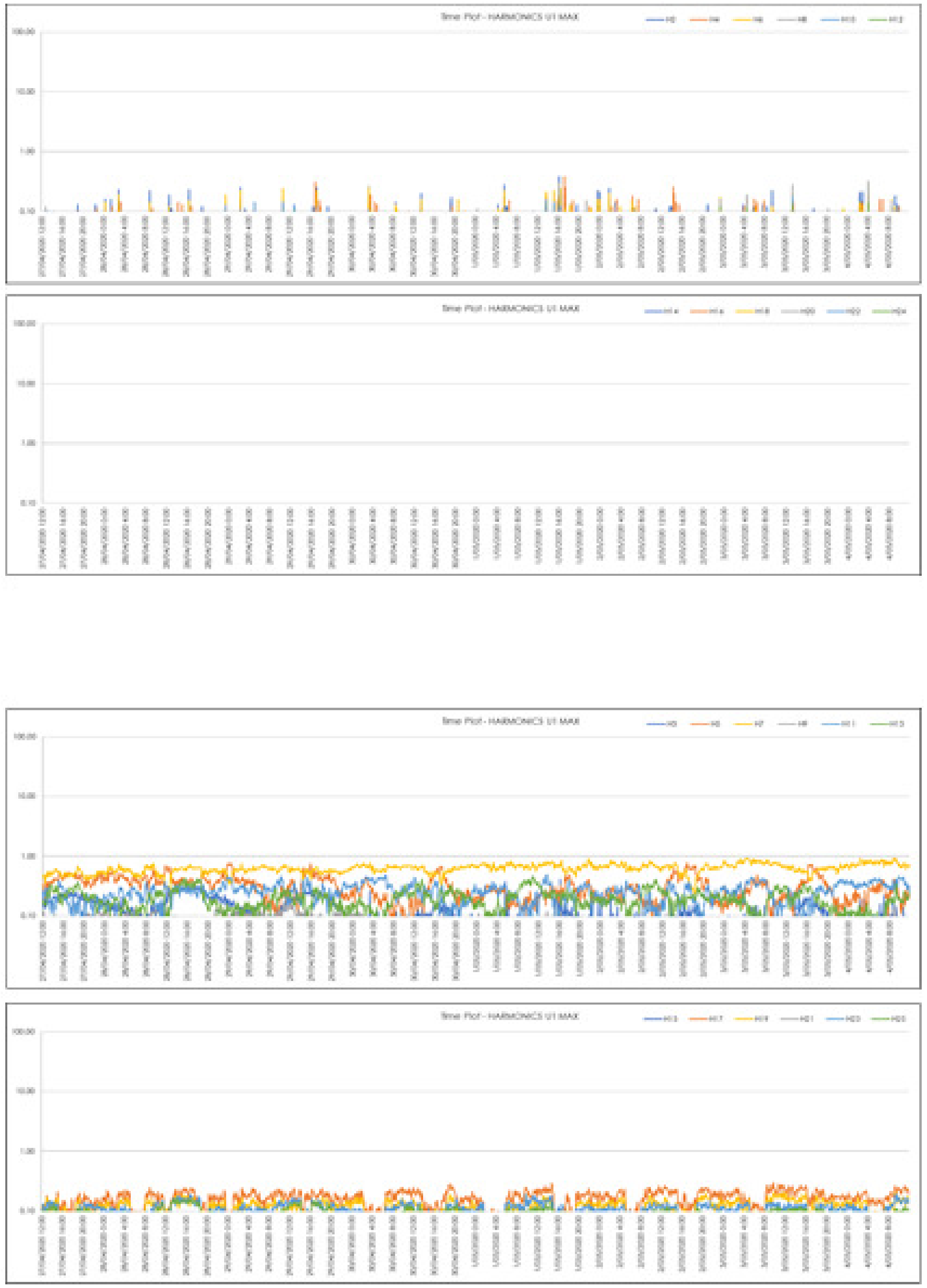


Figure | STS6 End Harmonics

APPENDIX C. ELEC. FAULT LOGS (2019/2020 FY)

Event	Notification Number (1SAP)	Date	Outage Duration (mins)	Affected Generation/Fdr/Distribution Description	System Voltage kV	Circuit-Breaker/Fuse that cleared the fault	Effect on operations	Total Consumers affected
410	427223216	2020-07-04	482.00	PS121, PS120 and T6	11	RMU9000-PS111 cb RMU9000-31/46/4 cb	Loss of supply to Newman Season's Hotel and YMCA	3
406	426782885	2020-05-14	62.00	Town LIA PS25 LV feeder to Pole 02/38/17/5	0.415	LV Link Pole 02/38/17/5	Lost 415V supply to 4 customers Laver Steet LIA	4
404	426727567	2020-05-06	558.00	East Newman PadSubs15,16,17, 103,24,23,22	11	Town DOF 34/46	Lost power to Padsubs 15,16,17,103,24,23,22	122
400	426324560	2020-03-18	70.00	PS124 LV Incomer	0.415	PS124 LV Incomer	Loss of supply to Residential areas at Daniels Drive, Newma Town	
391	422724723	2020-02-10		5-51 Homestead Ramble		160A CB at Pillar DP110.2.5	Loss of supply to 5-51 Homestead Ramble	
384	425638704	2020-01-14	150.00	Town: Newman day care center	0.415	Pole Top LV Fuses	Loss of supply to 1 x Children's Day care centre	1
380	425250670	2019-12-05	**1221**	Town - Old LIA Ready Mix	0.415	Town Ready Mix DOF 31/29	Ready Mix Cement Factory	1
379	425230671	2019-12-03	83.00	Town: 7 Callawa Way	0.415	Town Distribution Pillar	Services to 4 Units	4
375	425177818	2019-11-26	220	Capi Roadhouse K21 Bore	11	WB34/114 DOF	Capi Roadhouse K21 Bore	
367	424206906	2019-07-29	35.00	TC3 Feeder, STS4	11	Town Fdr TC3	RMU01 Tripped on Earth Fault causing loss of supply to majority of TC3's and STS4's Load	865