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NEWMAN TOWNSHIP ELECTRICITY SUPPLY

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EXECUTIVE SUMMARY

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

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

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

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

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

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

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

- Power Quality criteria pertaining to Newman's distribution network (measured across 7 feeders supplying the town, of which 4 are connected to Town Substation and the remaining 3 are fed from South Town Substation); and
- The reportable requirements as outlined in Part 2 and Schedule 1 of the Code, for the 2016/17 Financial Year (FY).

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

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

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

Reportable parameters for Newman Township Electricity Supply over the 2016/17 FY (as outlined in the 'Schedule 1' of the Code) are presented below:

- *>12 hour interruptions*: one interruption of over 12 hours duration was recorded for *small use customers*. It is noted that this interruption occurred on a public holiday and was isolated to three commercial lots. As such no businesses or customers were adversely affected as a result of the outage.
- No *small use customer* was disconnected from the network more frequent than the Code's requirements (i.e., limit of 16 times per FY).
- A total of one complaint was received, which from correspondence with BHPBIOSA was related to shire works and hence not related to the power quality of the BHPBIOSA network.
- Within the 2016/17 FY, a total sum of $16.0M (AUD) was invested by the network operator (BHPBIOSA) towards Newman network operations, maintenance and reinforcement works; to not only address the issues identified by the operator but also to further improve the quality and reliability of supply.
- The key reliability indices are calculated as listed below:
  - *Customer Average Interruption Duration Index* (CAIDI) of 53 minutes – CAIDI is the average outage duration that any given customer experience (i.e., the average restoration time).
  - *System Average Interruption Frequency Index* (SAIFI) of 1.53 interruptions – SAIFI is the number of interruptions that the customers experienced.
  - *Average Service Availability Index* (ASAI) of 99.98% – ASAI is the perceived availability of the network to the customers.
  - *System Average Interruption Duration Index* (SAIDI) of 81 minutes – SAIDI is the average outage duration for each customer served.

The metering data collected from 14 locations throughout the Newman network indicate that the power quality is compliant with the requirement set in the Code. With regards to the Reliability of the Supply, the overall network performance is deemed satisfactory and notable improvements are observed compared to the same indices for previous FY. I**n summary, this report finds the reliability and quality of the supply for Newman Township network in compliance with the Code's requirements with improvement observed compared to the previous financial years.**

TABLE OF CONTENTS

1. INTRODUCTION 14

2. ASSUMPTIONS 15

3. METHODOLOGY 16

4. NEWMAN TOWNSHIP PQ MONITORING 17

4.1. PQ DEVICE SPECIFICATION 17
4.2. PQ DEVICES 17
4.2.1. Locations and In-service Period 17
4.3. PQ DEVICE SETUP 19

5. COMPLIANCE REQUIREMENTS 20

5.1. VOLTAGE FLUCTUATIONS 20
5.1.1. Flicker 20
5.1.2. Voltage Levels 20
5.2. FREQUENCY 20
5.3. VOLTAGE TOTAL HARMONIC DISTORTION 20
5.4. POWER INDUSTRY RELIABILITY INDICATORS 21
5.4.1. Customer Average Interruption Duration Index (CAIDI) 21
5.4.2. System Average Interruption Frequency Index (SAIFI) 21
5.4.3. Average Service Availability Index (ASAI) 21
5.4.4. System Average Interruption Duration Index (SAIDI) 21

6. SITE MEASUREMENTS (PQ LOGGERS DATA) 22

6.1. FEEDER TC1 22
6.1.1. Flicker 22
6.1.2. Voltage 22
6.1.3. Frequency 22
6.1.4. Voltage THD 22
6.1.5. Harmonics 22
6.2. FEEDER TC2 24
6.2.1. Flicker 24
6.2.2. Voltage 24
6.2.3. Frequency 24
6.2.4. Voltage THD 24
6.2.5. Harmonics 24
6.3. FEEDER TC3 26
6.3.1. Flicker 26
6.3.2. Voltage 26
6.3.3. Frequency 26
6.3.4. Voltage THD 26
6.3.5. Harmonics 26
6.4. FEEDER TC4 28
6.4.1. Flicker 28
6.4.2. Voltage 28
6.4.3. Frequency 28
6.4.4. Voltage THD 28

6.4.5. Harmonics *28*
6.5. Feeder STS1 30
6.5.1. Flicker *30*
6.5.2. Voltage *30*
6.5.3. Frequency *30*
6.5.4. Voltage THD *30*
6.5.5. Harmonics *30*
6.6. Feeder STS2 32
6.6.1. Flicker *32*
6.6.2. Voltage *32*
6.6.3. Frequency *32*
6.6.4. Voltage THD *32*
6.6.5. Harmonics *32*
6.7. Feeder STS6 34
6.7.1. Flicker *34*
6.7.2. Voltage *34*
6.7.3. Frequency *34*
6.7.4. Voltage THD *34*
6.7.5. Harmonics *34*

7. RESPONSE TO THE CODE REQUIREMENTS 36

7.1. Quality and Reliability Standards (Part 2) 36
7.1.1. Voltage Fluctuations (Part 2 Division 1 Quality Standards Section 6(2)) *36*
7.1.2. Harmonics (Part 2 Division 1 Quality Standards Section 7) *36*
7.1.2.1. Individual Voltage Harmonics *36*
7.1.2.2. Voltage Total Harmonic Distortions *36*
7.1.3. Voltage Level Compliance (Part 2 Division 2 Quality Standards Section 8 Note (a)) *37*
7.1.4. Frequency Compliance (Part 2 Division 2 Quality Standards Section 8 Note (b)) *37*
7.2. Remedial actions taken for breaches of provisions (Schedule 1 Item 4 (b)) 38
7.3. Supply interrupted (Schedule 1 Item 5) 39
7.3.1. Interruptions Exceeding 12 Hours *39*
7.3.2. Frequent Interruptions *39*
7.4. Number of complaints received (Schedule 1 Item 6 and Item 10) 40
7.5. Complaints received in each discrete area (Schedule 1 Items 7 & 10) 40
7.6. Total amount spent addressing complaints (Schedule 1 Items 8 & 10) 40
7.7. Investments over 2016/2017 FY to improve the Reliability of Supply & Power Quality 40
7.8. Number and Total amount of payments made (Schedule 1 Items 9 & 10) 41
7.9. Reliability of Supply (Schedule 1 Item 11) 41
7.9.1. Average interruption (Schedule 1 Items 11 (a), 12 and 13) *41*
7.9.2. Average number of interruptions (Schedule 1 Items 11 (b), 12 and 13) *42*
7.9.3. Average percentage of time electricity supplied (Schedule 1 Items 11 (c), 12 and 13) *42*
7.9.4. Average total length of all interruptions (Schedule 1 Items 11 (d), 12 and 13) *42*
7.10. Percentile Values (Schedule 1 Items 14 and 15) 43
7.10.1. Percentile – Average Length of Interruption *43*
7.10.2. Percentile - Number of interruptions *44*
7.10.3. Percentile - Total Length of Interruptions *45*

8. CONCLUSION 46

APPENDIX A PQ LOGGING DEVICE (HIOKI 3198) 48

APPENDIX B PQ LOGGING DATA FOR 2016/2017 FY 49

APPENDIX C LOGGER INSTALLATION CHECKLISTS 113

APPENDIX D ELECTRICAL FAULTS LOG FOR 2016/17 FY 114

LIST OF TABLES

Table 1 | PQ Logger Locations 17
Table 2 | Long & short-term flicker limits 20
Table 3 | Harmonic Compatibility Level 20
Table 4 | Total number of breaches of voltage fluctuation compatibility levels 36
Table 5 | Total number of breaches of total harmonic distortion limit 37
Table 6 | Total number of breaches of voltage level limits 37
Table 7 | Total number of breaches of frequency limits 38
Table 8 | Total number of premises of small customers interrupted continuously for more than 12 hours 39
Table 9 | Total number of premises that experienced more than 16 interruptions 39
Table 10 | Total number of formal complaints lodged to BHPBIOSA 40
Table 11 | Total amount spent by BHPBIOSA in network improvements (indicative only) 40
Table 12 | Total number and amount of payments made under Sections 18 and 19 41
Table 13 | The average length of interruption of supply to customer premises expressed in minutes (CAIDI) 41
Table 14 | The average number of interruptions of supply to customer premises (SAIFI) 42
Table 15 | The average percentage of time that electricity has been supplied to customer premises (ASAI) 42
Table 16 | The average total length of all interruptions of supply to customer premises in minutes (SAIDI) 42
Table 17 | Percentile of the average length of interruption of supply to customer premises in 2016/2017 43
Table 18 | Percentile values of the number of interruptions in 2016/2017 44
Table 19 | Percentile values of the total length of interruptions in 2016/2017 45

LIST OF FIGURES

Figure 1 | Single line diagram of the Newman township (coloured circles indicate the location of PQ loggers . 18
Figure 2 | Sampling and interval recording philosophy used in the Hioki PQ loggers (from Hioki Manual) 19
Figure 3 | TC1 feeder – Start – Non-compliant even harmonics 23
Figure 4 | TC1 feeder – End – Non-compliant even harmonics 23
Figure 5 | TC2 feeder – Start – Non-compliant even harmonics 25
Figure 6 | TC2 feeder – End – Non-compliant even harmonics 25
Figure 7 | TC3 feeder – Start – Non-compliant even harmonics 27
Figure 8 | TC3 feeder – End – Non-compliant even harmonics 27
Figure 9 | TC4 feeder – Start – Non-compliant even harmonics 29
Figure 10 | TC4 feeder – End – Non-compliant even harmonics 29
Figure 11 | STS1 feeder – End – Non-compliant even harmonics 31
Figure 12 | STS1 feeder – End – Non-compliant odd harmonics 31
Figure 13 | STS2 feeder – Start – Non-compliant even harmonics 33
Figure 14 | STS2 feeder – End – Non-compliant even harmonics 33
Figure 15 | STS6 feeder – Start – Non-compliant even harmonics 35
Figure 16 | STS6 feeder – Start – Non-compliant odd harmonics 35
Figure 17 | The average length of interruption (minutes) of supply to customers over 2016/2017 FY 43
Figure 18 | Percentile graph showing the number of interruptions (SAIFI) in 2016/2017 44
Figure 19 | Percentile graph showing the total length of interruptions (SAIDI) in 2016/2017 45
Figure 20 | TC1 - start of feeder – flicker measurements (Red Phase) 50
Figure 21 | TC1 - start of feeder – flicker measurements (White Phase) 50
Figure 22 | TC1 - start of feeder – flicker measurements (Blue Phase) 50
Figure 23 | TC1 – end of feeder – flicker measurements (Red Phase) 51
Figure 24 | TC1 - end of feeder – flicker measurements (White Phase) 51
Figure 25 | TC1 - end of feeder – flicker measurements (Blue Phase) 51
Figure 26 | TC1 - start of feeder – voltage measurements (Red Phase) 52
Figure 27 | TC1 - start of feeder – voltage measurements (White Phase) 52
Figure 28 | TC1 - start of feeder – voltage measurements (Blue Phase) 52
Figure 29 | TC1 - end of feeder – voltage measurements (Red Phase) 53
Figure 30 | TC1 - end of feeder – voltage measurements (White Phase) 53
Figure 31 | TC1 - end of feeder – voltage measurements (Blue Phase) 53
Figure 32 | TC1 - start of feeder – frequency measurements 54
Figure 33 | TC1 - end of feeder – frequency measurements 54
Figure 34 | TC1 - start of feeder – voltage THD measurements (Red Phase) 55
Figure 35 | TC1 - start of feeder – voltage THD measurements (White Phase) 55
Figure 36 | TC1 - start of feeder – voltage THD measurements (Blue Phase) 55
Figure 37 | TC1 - end of feeder – voltage THD measurements (Red Phase) 56
Figure 38 | TC1 - end of feeder – voltage THD measurements (White Phase) 56
Figure 39 | TC1 - end of feeder – voltage THD measurements (Blue Phase) 56
Figure 40 | TC1 – start of feeder – 3rd to 13th (odd) harmonics (Red Phase) 57
Figure 41 | TC1 – start of feeder – 15th to 25th (odd) harmonics (Red Phase) 57
Figure 42 | TC1– start of feeder – 2th to 12th (even) harmonics (Red Phase) 57
Figure 43 | TC1 – start of feeder – 14th to 24th (even) harmonics (Red Phase) 57
Figure 44 | TC1 – end of feeder – 3rd to 13th (odd) harmonics (Red Phase) 58
Figure 45 | TC1 – end of feeder – 15th to 25th (odd) harmonics (Red Phase) 58
Figure 46 | TC1– end of feeder – 2th to 12th (even) harmonics (Red Phase) 58

Figure 47 | TC1 – end of feeder – 14th to 24th (even) harmonics (Red Phase) 58
Figure 48 | TC2 - start of feeder – flicker measurements (Red Phase) 59
Figure 49 | TC2 - start of feeder – flicker measurements (White Phase) 59
Figure 50 | TC2 - start of feeder – flicker measurements (Blue Phase) 59
Figure 51 | TC2 – end of feeder – flicker measurements (Red Phase) 60
Figure 52 | TC2 - end of feeder – flicker measurements (White Phase) 60
Figure 53 | TC2 - end of feeder – flicker measurements (Blue Phase) 60
Figure 54 | TC2 - start of feeder – voltage measurements (Red Phase) 61
Figure 55 | TC2 - start of feeder – voltage measurements (White Phase) 61
Figure 56 | TC2 - start of feeder – voltage measurements (Blue Phase) 61
Figure 57 | TC2 - end of feeder – voltage measurements (Red Phase) 62
Figure 58 | TC2 - end of feeder – voltage measurements (White Phase) 62
Figure 59 | TC2 - end of feeder – voltage measurements (Blue Phase) 62
Figure 60 | TC2 - start of feeder – frequency measurements 63
Figure 61 | TC2 - end of feeder – frequency measurements 63
Figure 62 | TC2 - start of feeder – voltage THD measurements (Red Phase) 64
Figure 63 | TC2- start of feeder – voltage THD measurements (White Phase) 64
Figure 64 | TC2 - start of feeder – voltage THD measurements (Blue Phase) 64
Figure 65 | TC2 - end of feeder – voltage THD measurements (Red Phase) 65
Figure 66 | TC2 - end of feeder – voltage THD measurements (White Phase) 65
Figure 67 | TC2 - end of feeder – voltage THD measurements (Blue Phase) 65
Figure 68 | TC2 – start of feeder – 3rd to 13th (odd) harmonics (Red Phase) 66
Figure 69 | TC2 – start of feeder – 15th to 25th (odd) harmonics (Red Phase) 66
Figure 70 | TC2– start of feeder – 2th to 12th (even) harmonics (Red Phase) 66
Figure 71 | TC2– start of feeder – 14th to 24th (even) harmonics (Red Phase) 66
Figure 72 | TC2 – end of feeder – 3rd to 13th (odd) harmonics (Red Phase) 67
Figure 73 | TC2 – end of feeder – 15th to 25th (odd) harmonics (Red Phase) 67
Figure 74 | TC2– end of feeder – 2th to 12th (even) harmonics (Red Phase) 67
Figure 75 | TC2 – end of feeder – 14th to 24th (even) harmonics (Red Phase) 67
Figure 76 | TC3 - start of feeder – flicker measurements (Red Phase) 68
Figure 77 | TC3 - start of feeder – flicker measurements (White Phase) 68
Figure 78 | TC3 - start of feeder – flicker measurements (Blue Phase) 68
Figure 79 | TC3 – end of feeder – flicker measurements (Red Phase) 69
Figure 80 | TC3 - end of feeder – flicker measurements (White Phase) 69
Figure 81 | TC3 - end of feeder – flicker measurements (Blue Phase) 69
Figure 82 | TC3 - start of feeder – voltage measurements (Red Phase) 70
Figure 83 | TC3 - start of feeder – voltage measurements (White Phase) 70
Figure 84 | TC3 - start of feeder – voltage measurements (Blue Phase) 70
Figure 85 | TC3 - end of feeder – voltage measurements (Red Phase) 71
Figure 86 | TC3 - end of feeder – voltage measurements (White Phase) 71
Figure 87 | TC3 - end of feeder – voltage measurements (Blue Phase) 71
Figure 88 | TC3 - start of feeder – frequency measurements 72
Figure 89 | TC3 - end of feeder – frequency measurements 72
Figure 90 | TC3 - start of feeder – voltage THD measurements (Red Phase) 73
Figure 91 | TC3- start of feeder – voltage THD measurements (White Phase) 73
Figure 92 | TC3 - start of feeder – voltage THD measurements (Blue Phase) 73
Figure 93 | TC3 - end of feeder – voltage THD measurements (Red Phase) 74
Figure 94 | TC3 - end of feeder – voltage THD measurements (White Phase) 74
Figure 95 | TC3 - end of feeder – voltage THD measurements (Blue Phase) 74

Figure 96 | TC3 – start of feeder – 3rd to 13th (odd) harmonics (Red Phase) 75
Figure 97 | TC3 – start of feeder – 15th to 25th (odd) harmonics (Red Phase) 75
Figure 98 | TC3– start of feeder – 2th to 12th (even) harmonics (Red Phase) 75
Figure 99 | TC3– start of feeder – 14th to 24th (even) harmonics (Red Phase) 75
Figure 100 | TC3 – end of feeder – 3rd to 13th (odd) harmonics (Red Phase) 76
Figure 101 | TC3 – end of feeder – 15th to 25th (odd) harmonics (Red Phase) 76
Figure 102 | TC3– end of feeder – 2th to 12th (even) harmonics (Red Phase) 76
Figure 103 | TC3 – end of feeder – 14th to 24th (even) harmonics (Red Phase) 76
Figure 104 | TC4 - start of feeder – flicker measurements (Red Phase) 77
Figure 105 | TC4 - start of feeder – flicker measurements (White Phase) 77
Figure 106 | TC4 - start of feeder – flicker measurements (Blue Phase) 77
Figure 107 | TC4 – end of feeder – flicker measurements (Red Phase) 78
Figure 108 | TC4 - end of feeder – flicker measurements (White Phase) 78
Figure 109 | TC4 - end of feeder – flicker measurements (Blue Phase) 78
Figure 110 | TC4 - start of feeder – voltage measurements (Red Phase) 79
Figure 111 | TC4 - start of feeder – voltage measurements (White Phase) 79
Figure 112 | TC4 - start of feeder – voltage measurements (Blue Phase) 79
Figure 113 | TC4 - end of feeder – voltage measurements (Red Phase) 80
Figure 114 | TC4 - end of feeder – voltage measurements (White Phase) 80
Figure 115 | TC4 - end of feeder – voltage measurements (Blue Phase) 80
Figure 116 | TC4 - start of feeder – frequency measurements 81
Figure 117 | TC4 - end of feeder – frequency measurements 81
Figure 118 | TC4 - start of feeder – voltage THD measurements (Red Phase) 82
Figure 119 | TC4- start of feeder – voltage THD measurements (White Phase) 82
Figure 120 | TC4 - start of feeder – voltage THD measurements (Blue Phase) 82
Figure 121 | TC4 - end of feeder – voltage THD measurements (Red Phase) 83
Figure 122 | TC4 - end of feeder – voltage THD measurements (White Phase) 83
Figure 123 | TC4 - end of feeder – voltage THD measurements (Blue Phase) 83
Figure 124 | TC4 – start of feeder – 3rd to 13th (odd) harmonics (Red Phase) 84
Figure 125 | TC4 – start of feeder – 15th to 25th (odd) harmonics (Red Phase) 84
Figure 126 | TC4– start of feeder – 2th to 12th (even) harmonics (Red Phase) 84
Figure 127 | TC4– start of feeder – 14th to 24th (even) harmonics (Red Phase) 84
Figure 128 | TC4 – end of feeder – 3rd to 13th (odd) harmonics (Red Phase) 85
Figure 129 | TC4 – end of feeder – 15th to 25th (odd) harmonics (Red Phase) 85
Figure 130 | TC4 – end of feeder – 2th to 12th (even) harmonics (Red Phase) 85
Figure 131 | TC4 – end of feeder – 14th to 24th (even) harmonics (Red Phase) 85
Figure 132 | STS1 - start of feeder – flicker measurements (Red Phase) 86
Figure 133 | STS1 - start of feeder – flicker measurements (White Phase) 86
Figure 134 | STS1 - start of feeder – flicker measurements (Blue Phase) 86
Figure 135 | STS1 – end of feeder – flicker measurements (Red Phase) 87
Figure 136 | STS1 - end of feeder – flicker measurements (White Phase) 87
Figure 137 | STS1 - end of feeder – flicker measurements (Blue Phase) 87
Figure 138 | STS1 - start of feeder – voltage measurements (Red Phase) 88
Figure 139 | STS1 - start of feeder – voltage measurements (White Phase) 88
Figure 140 | STS1 - start of feeder – voltage measurements (Blue Phase) 88
Figure 141 | STS1 - end of feeder – voltage measurements (Red Phase) 89
Figure 142 | STS1 - end of feeder – voltage measurements (White Phase) 89
Figure 143 | STS1 - end of feeder – voltage measurements (Blue Phase) 89
Figure 144 | STS1 - start of feeder – frequency measurements 90

Figure 145 | STS1 - end of feeder – frequency measurements ... 90
Figure 146 | STS1 - start of feeder – voltage THD measurements (Red Phase) ... 91
Figure 147 | STS1 - start of feeder – voltage THD measurements (White Phase) ... 91
Figure 148 | STS1 - start of feeder – voltage THD measurements (Blue Phase) ... 91
Figure 149 | STS1 - end of feeder – voltage THD measurements (Red Phase) ... 92
Figure 150 | STS1 - end of feeder – voltage THD measurements (White Phase) ... 92
Figure 151 | STS1 - end of feeder – voltage THD measurements (Blue Phase) ... 92
Figure 152 | STS1 – start of feeder – 3rd to 13th (odd) harmonics (Red Phase) ... 93
Figure 153 | STS1 – start of feeder – 15th to 25th (odd) harmonics (Red Phase) ... 93
Figure 154 | STS1 – start of feeder – 2th to 12th (even) harmonics (Red Phase) ... 93
Figure 155 | STS1 – start of feeder – 14th to 24th (even) harmonics (Red Phase) ... 93
Figure 156 | STS1 – end of feeder – 3rd to 13th (odd) harmonics (Red Phase) ... 94
Figure 157 | STS1 – end of feeder – 15th to 25th (odd) harmonics (Red Phase) ... 94
Figure 158 | STS1 – end of feeder – 2th to 12th (even) harmonics (Red Phase) ... 94
Figure 159 | STS1 – end of feeder – 14th to 24th (even) harmonics (Red Phase) ... 94
Figure 160 | STS2 - start of feeder – flicker measurements (Red Phase) ... 95
Figure 161 | STS2- start of feeder – flicker measurements (White Phase) ... 95
Figure 162 | STS2 - start of feeder – flicker measurements (Blue Phase) ... 95
Figure 163 | STS2 – end of feeder – flicker measurements (Red Phase) ... 96
Figure 164 | STS2 - end of feeder – flicker measurements (White Phase) ... 96
Figure 165 | STS2 - end of feeder – flicker measurements (Blue Phase) ... 96
Figure 166 | STS2 - start of feeder – voltage measurements (Red Phase) ... 97
Figure 167 | STS2 - start of feeder – voltage measurements (White Phase) ... 97
Figure 168 | STS2 - start of feeder – voltage measurements (Blue Phase) ... 97
Figure 169 | STS2 - end of feeder – voltage measurements (Red Phase) ... 98
Figure 170 | STS2 - end of feeder – voltage measurements (White Phase) ... 98
Figure 171 | STS2 - end of feeder – voltage measurements (Blue Phase) ... 98
Figure 172 | STS2 - start of feeder – frequency measurements ... 99
Figure 173 | STS2 - end of feeder – frequency measurements ... 99
Figure 174 | STS2 - start of feeder – voltage THD measurements (Red Phase) ... 100
Figure 175 | STS2 - start of feeder – voltage THD measurements (White Phase) ... 100
Figure 176 | STS2 - start of feeder – voltage THD measurements (Blue Phase) ... 100
Figure 177 | STS2 - end of feeder – voltage THD measurements (Red Phase) ... 101
Figure 178 | STS2 - end of feeder – voltage THD measurements (White Phase) ... 101
Figure 179 | STS2 - end of feeder – voltage THD measurements (Blue Phase) ... 101
Figure 180 | STS2 – start of feeder – 3rd to 13th (odd) harmonics (Red Phase) ... 102
Figure 181 | STS2 – start of feeder – 15th to 25th (odd) harmonics (Red Phase) ... 102
Figure 182 | STS2 – start of feeder – 2th to 12th (even) harmonics (Red Phase) ... 102
Figure 183 | STS2 – start of feeder – 14th to 24th (even) harmonics (Red Phase) ... 102
Figure 184 | STS2 – end of feeder – 3rd to 13th (odd) harmonics (Red Phase) ... 103
Figure 185 | STS2 – end of feeder – 15th to 25th (odd) harmonics (Red Phase) ... 103
Figure 186 | STS2 – end of feeder – 2th to 12th (even) harmonics (Red Phase) ... 103
Figure 187 | STS2 – end of feeder – 14th to 24th (even) harmonics (Red Phase) ... 103
Figure 188 | STS6 - start of feeder – flicker measurements (Red Phase) ... 104
Figure 189 | STS6 - start of feeder – flicker measurements (White Phase) ... 104
Figure 190 | STS6 - start of feeder – flicker measurements (Blue Phase) ... 104
Figure 191 | STS6 – end of feeder – flicker measurements (Red Phase) ... 105
Figure 192 | STS6 - end of feeder – flicker measurements (White Phase) ... 105
Figure 193 | STS6 - end of feeder – flicker measurements (Blue Phase) ... 105

Figure 194 | STS6 - start of feeder – voltage measurements (Red Phase) 106
Figure 195 | STS6 - start of feeder – voltage measurements (White Phase) 106
Figure 196 | STS6 - start of feeder – voltage measurements (Blue Phase) 106
Figure 197 | STS6 - end of feeder – voltage measurements (Red Phase) 107
Figure 198 | STS6 - end of feeder – voltage measurements (White Phase) 107
Figure 199 | STS6 - end of feeder – voltage measurements (Blue Phase) 107
Figure 200 | STS6 - start of feeder – frequency measurements 108
Figure 201 | STS6 - end of feeder – frequency measurements 108
Figure 202 | STS6 - start of feeder – voltage THD measurements (Red Phase) 109
Figure 203 | STS6 - start of feeder – voltage THD measurements (White Phase) 109
Figure 204 | STS6 - start of feeder – voltage THD measurements (Blue Phase) 109
Figure 205 | STS6 - end of feeder – voltage THD measurements (Red Phase) 110
Figure 206 | STS6 - end of feeder – voltage THD measurements (White Phase) 110
Figure 207 | STS6 - end of feeder – voltage THD measurements (Blue Phase) 110
Figure 208 | STS6 – start of feeder – 3rd to 13th (odd) harmonics (Red Phase) 111
Figure 209 | STS6 – start of feeder – 15th to 25th (odd) harmonics (Red Phase) 111
Figure 210 | STS6 – start of feeder – 2th to 12th (even) harmonics (Red Phase) 111
Figure 211 | STS6 – start of feeder – 14th to 24th (even) harmonics (Red Phase) 111
Figure 212 | STS6 – end of feeder – 3rd to 13th (odd) harmonics (Red Phase) 112
Figure 213 | STS6 – end of feeder – 15th to 25th (odd) harmonics (Red Phase) 112
Figure 214 | STS6 – end of feeder – 2th to 12th (even) harmonics (Red Phase) 112
Figure 215 | STS6 – end of feeder – 14th to 24th (even) harmonics (Red Phase) 112

1. INTRODUCTION

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

At present, the township of Newman includes 2,395 registered premises comprised of a mixture of residential and commercial customers (compared to 2,938 customers for 2015/16 FY).

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

This *Annual Compliance Report* presents all information required by "Schedule 1 – Information to be published", relating to supply of electricity, for the period of 1st July 2016 to 30th of June 2017. Measurement information is based on sampled data and outlined in Section 6, whereas outage information is based on data provided by BHPBIOSA and outlined in Section 7.

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

2. ASSUMPTIONS

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

The logging information gathered over the limited period is indicative of the performance of the network over the complete financial year (2016/2017 FY).

3. METHODOLOGY

The electricity supply compliance review entailed the following processes:

1. The temporary installation of PQ loggers at the beginning and end of the 11kV feeders emanating from the Town and Southtown Substations (a total of 14 loggers, 2 for each feeder were installed). Each PQ logger was installed on the low voltage (LV) side of pad-mounted transformers. The measuring period lasted between 8 and 10 days in the month of June 2017. The PQ measurements were undertaken in accordance with AS 61000.4.30:2007, Annex A (Power Quality Measurements).
2. Interpretation and analysis of the logged PQ data using HIOKI 3196 & 3198 PQ Analysers.
3. The receipt of the following information from BHPBIOSA:
    - Network outage information for planned and forced outages for the Newman Township during the 2016/2017 FY as well as information on customer complaints.
    - Expenditure information as a consequence of network complaints or programs directed to improve reliability or power quality of the network.
4. Identification of any breaches of The Code's provisions and Electricity Act 1945.
5. Statistical analyses and review of network performance.
6. Preparation of a compliance report that fulfils the requirements outlined in The Code.

4. NEWMAN TOWNSHIP PQ MONITORING

4.1. PQ Device Specification

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

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

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

4.2. PQ Devices

4.2.1. Locations and In-service Period

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

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

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

Table 1 | PQ Logger Locations

Zone Subs	Feeder	Start or End of Feeder	Substation Name	Date Installed	Date Removed
Township	TC1	Start	PS3	10/06/2017 13:05	20/06/2017 16:00
		End	PS68	10/06/2017 12:10	20/06/2017 13:05
	TC2	Start	PS10	10/06/2017 13:40	20/06/2017 14:05
		End	PS14	10/06/2017 15:00	20/06/2017 13:45
	TC3	Start	PS108	10/06/2017 17:00	20/06/2017 11:40
		End	PS69	11/06/2017 11:40	20/06/2017 10:50
	TC4	Start	PS125	12/06/2017 14:10	20/06/2017 16:40
		End	PS27	11/06/2017 14:20	20/06/2017 16:25
South Town	STS1	Start	PS94	11/06/2017 15:05	20/06/2017 14:45
		End	PS25	11/06/2017 15:50	20/06/2017 14:30
	STS2	Start	PS60	11/06/2017 16:25	20/06/2017 16:10
		End	PS70	11/06/2017 17:15	20/06/2017 15:45
	STS6	Start	PS127	12/06/2017 8:35	21/06/2017 7:50
		End	PS121	12/06/2017 10:00	21/06/2017 7:10

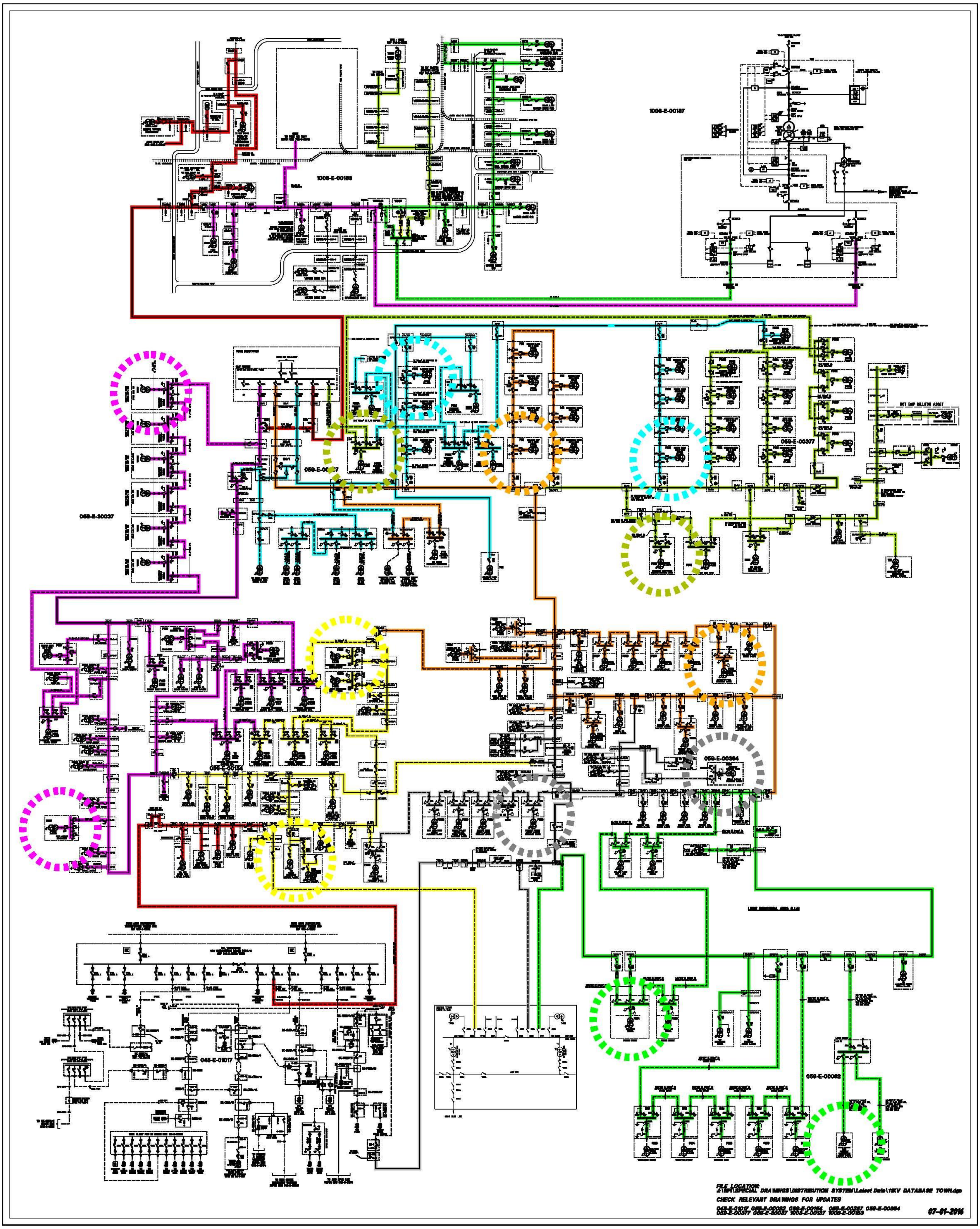

Figure 1 | Single line diagram of the Newman township (coloured circles indicate the location of PQ loggers

4.3.PQ Device Setup

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

As shown in the frequency and voltage time-based PQ plots in Appendix B , three values have been logged and plotted: the maximum RMS, the average RMS and the minimum RMS value over the recording interval. The recording interval setup in the PQ loggers was 5 minutes, with the exception of flicker which uses 10 minute intervals. That is, over the course of the in-service days the PQ loggers sampled various time-based parameters (e.g., Hz, U and I) at 5 Hz; and at the end of every 5-minute sampling interval the 3 abovementioned 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.

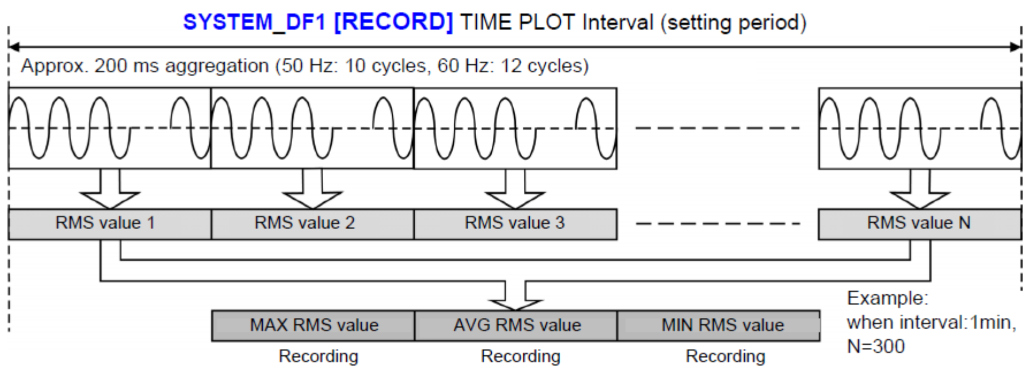

Figure 2 | Sampling and interval recording philosophy used in the Hioki PQ loggers (from Hioki Manual)

4.4. PQ Device Installation Checklist

For each of the 14 PQ loggers which were installed by BHPBIOSA personnel, a PQ Logger Installation Checklist was supplied by APD. Upon completing individual logger's setup, the check sheets were to be completed and signed by the installation supervisor (all received and reviewed by APD).

Refer to Appendix C for copies of the completed checklists.

5. COMPLIANCE REQUIREMENTS

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

5.1. Voltage Fluctuations

5.1.1. Flicker

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

Table 2 | Long & short-term flicker limits

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

5.1.2. Voltage Levels

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

5.2. Frequency

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

5.3. Voltage Total Harmonic Distortion

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

Table 3 | Harmonic Compatibility Level

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

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

5.4. Power Industry Reliability Indicators

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

5.4.1. Customer Average Interruption Duration Index (CAIDI)

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

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

5.4.2. System Average Interruption Frequency Index (SAIFI)

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

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

5.4.3. Average Service Availability Index (ASAI)

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

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

5.4.4. System Average Interruption Duration Index (SAIDI)

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

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

6. Site Measurements (PQ Loggers Data)

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

6.1. Feeder TC1

The PQ logger at the start of the TC1 feeder was installed in the PS3 Callawa Way substation, between 10/06/2017 and 20/06/2017, thus satisfying the 7 days minimum logging requirement.

The PQ logger at the end of the TC1 feeder was installed in the PS68 Capricorn Oval substation between 10/06/2017 and 20/06/2017, thus satisfying the 7 days minimum logging requirement.

As shown in Figure 1 (orange feeder), TC1 originates from the Township substation. The TC1 feeder is a feeder that supplies a number of older distribution substations.

6.1.1. Flicker

The logged flicker data for the start and end of the TC1 feeder are shown in Figure 20 to Figure 22 and Figure 23 to Figure 25 of Appendix B . There were no recorded flicker limit events causing the flicker level to breach The Code's limits (i.e., full compliance with the Code requirements).

6.1.2. Voltage

The logged voltage level data for the start and end of the TC1 feeder are shown in Figure 26 to Figure 28 and Figure 29 to Figure 31 of , respectively. There were no recorded voltage limit events causing the voltage level to breach The Code's limits (i.e., full compliance with the Code requirements).

6.1.3. Frequency

The logged frequency data for the start and end of the TC1 feeder are shown in Figure 32 and Figure 33 of Appendix B . There were no recorded frequency limit events causing the voltage level to breach The Code's limits (i.e., full compliance with the Code requirements).

6.1.4. Voltage THD

The logged voltage THD level data for the start and end of the TC1 feeder are shown in Figure 34 to Figure 36 and Figure 37 to Figure 39 in Appendix B There were no noted voltage limit events causing the voltage THD level to breach The Code's limits (i.e., full compliance with the Code requirements).

6.1.5. Harmonics

The logged harmonic data for the start and end of the TC1 feeder is shown in Figure 40 to Figure 43 and Figure 44 to Figure 47 in Appendix B , respectively.

A summary of non-compliant harmonics and the scale of non-compliances are shown in Figure 3 to Figure 4. It is evident that in a number of occasssions, the 6th harmonics of the voltage is found in exceedence of the limit set by AS/NZS 61000:2001 (i.e., larger than 0.5%). This is attributed to unbalanced 3-phase loads, possibly with DC component, supplied from Town Substation [R Dugan *et al*, *Electrical Power Systems Quality* book, 3rd Edition, 2012]. The compliance issue is observed for <1% of the measurement period, hence of no major concern at the present but should it exacerbate in coming years, then mitigation measure (e.g., passive or active filters) are required to avoid undesirable consequences such as excessive neutral current, overheated installations, malfunction of protection devices and mis-operation or failure of electronic equipment.

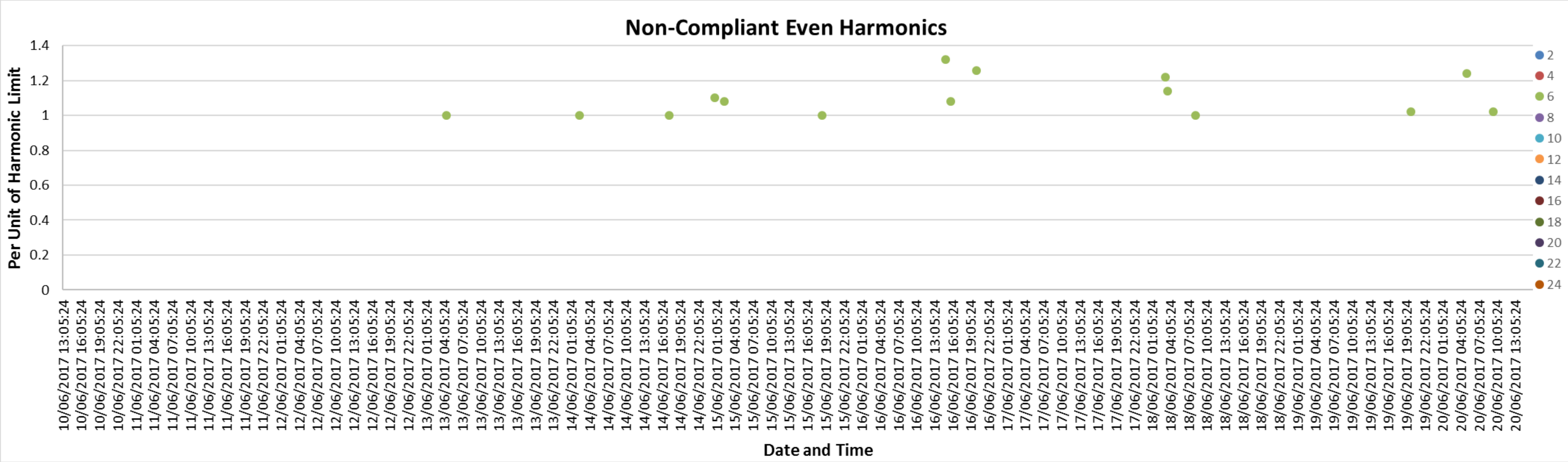

Figure 3 | TC1 feeder – Start – Non-compliant even harmonics

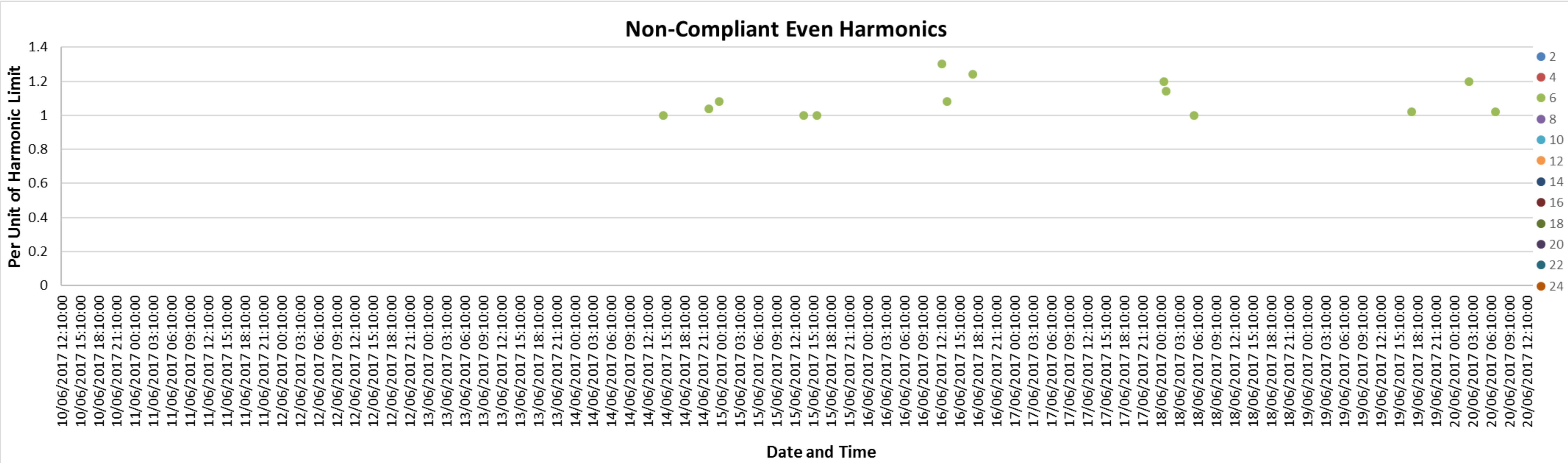

Figure 4 | TC1 feeder – End – Non-compliant even harmonics

6.2. Feeder TC2

The PQ logger at the start of the TC2 feeder was installed in the PS10 McLennan Drive substation,between 10/06/2017 and 20/06/2017, thus satisfying the 7 days minimum logging duration requirement.

The PQ logger at the end of the TC2 feeder was installed in the PS14 Bondini Drive substation, between 10/06/2017 and 20/06/2017, thus satisfying the 7 days minimum logging duration requirement.

As shown in Figure 1 (cyan-coloured feeder), TC2 originates from the Township substation.

6.2.1. Flicker

The logged flicker data for the start and end of the TC2 feeder are shown in Figure 48 to Figure 50 and Figure 51 to Figure 53 of Appendix B , respectively. There were no recorded flicker limit events causing the flicker level to breach The Code's limits (i.e., full compliance with the Code requirements).

6.2.2. Voltage

The logged voltage level data for the start and end of the TC2 feeder are shown in Figure 54 to Figure 56 and Figure 57 to Figure 59 of Appendix B , respectively. There were no recorded voltage limit events causing the voltage level to breach The Code's limits (i.e., full compliance with the Code requirements).

6.2.3. Frequency

The logged frequency data for the start and end of the TC2 feeder are shown in Figure 60 and Figure 61 of Appendix B , respectively. There were no recorded frequency limit events causing the voltage level to breach The Code's limits (i.e., full compliance with the Code requirements).

6.2.4. Voltage THD

The logged voltage THD level data for the start and end of the TC2 feeder are shown in Figure 62to Figure 64 and Figure 65 to Figure 67 in Appendix B , respectively. There were no noted voltage limit events causing the voltage THD level to breach The Code's limits (i.e., full compliance with the Code requirements).

6.2.5. Harmonics

The logged harmonic data for the start and end of the TC2 feeder is shown in Figure 68 to Figure 71 and Figure 72 to Figure 75 in Appendix B , respectively.

A summary of non-compliant harmonics and the scale of non-compliances are shown in Figure 5 to Figure 6. Again, the voltage's 6^{th} harmonic component is observed to exceed the 0.5% limit in a number of occasions, hence further investigations required in the coming years to ensure full compliance with the Code's requirements – refer to Section 6.1.5 for further details.

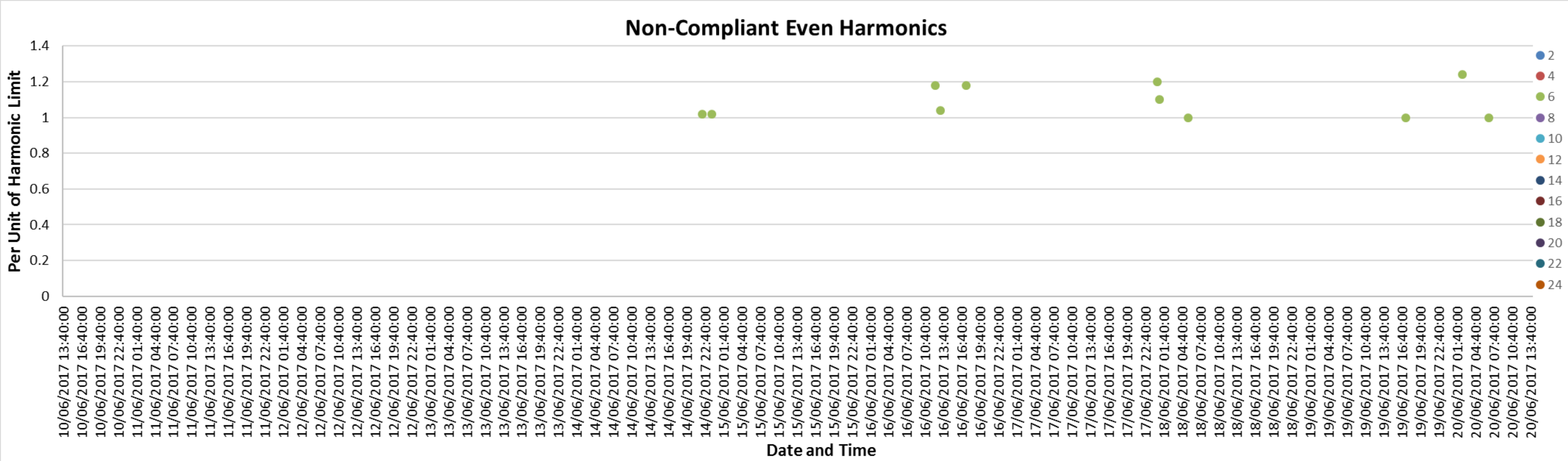

Figure 5 | TC2 feeder – Start – Non-compliant even harmonics

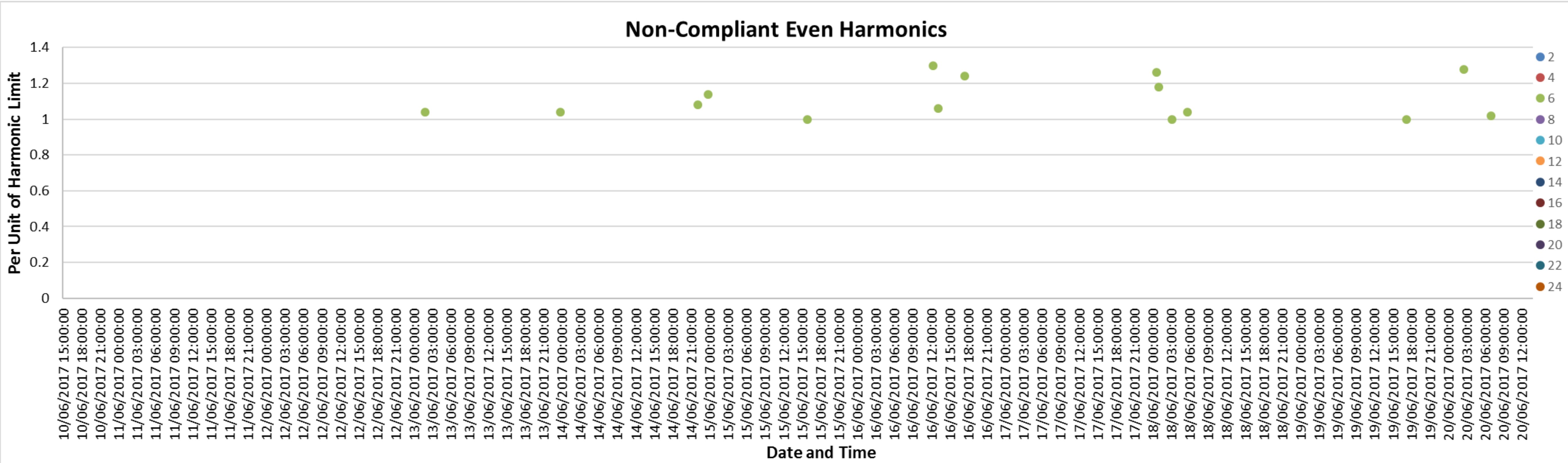

Figure 6 | TC2 feeder – End – Non-compliant even harmonics

6.3. Feeder TC3

The PQ logger at the start of the TC3 feeder was installed in the PS108 Less Tutt Drive substation,between 10/06/2017 and 20/06/2017, thus satisfying the 7 days minimum logging duration requirement.

The PQ logger at the end of the TC3 feeder was installed in the PS69 Giles Avenue substation, between 11/06/2017 and 20/06/2017, thus satisfying the 7 days minimum logging duration requirement.

As shown in Figure 1 (purple feeder), TC3 originates from the Township substation.

6.3.1. Flicker

The logged flicker data for the start and end of the TC3 feeder are shown in Figure 76 to Figure 78 and Figure 79 to Figure 81of Appendix B , respectively. There were no recorded flicker limit events causing the flicker level to breach The Code's limits (i.e., full compliance with the Code requirements).

6.3.2. Voltage

The logged voltage level data for the start and end of the TC3 feeder are shown in Figure 82 to Figure 84 and Figure 85 to Figure 87 of Appendix B , respectively. There were no recorded voltage limit events causing the voltage level to breach The Code's limits (i.e., full compliance with the Code requirements).

6.3.3. Frequency

The logged frequency data for the start and end of the TC3 feeder are shown in Figure 88 and Figure 89 of Appendix B , respectively. There were no recorded frequency limit events causing the voltage level to breach The Code's limits (i.e., full compliance with the Code requirements).

6.3.4. Voltage THD

The logged voltage THD level data for the start and end of the TC3 feeder are shown in Figure 90 to Figure 92 and Figure 93 to Figure 95 in Appendix B , respectively. There were no noted voltage limit events causing the voltage THD level to breach The Code's limits (i.e., full compliance with the Code requirements).

6.3.5. Harmonics

The logged harmonic data for the start and end of the TC3 feeder is shown in Figure 96 to Figure 99 and Figure 100 to Figure 103 in Appendix B , respectively.

A summary of non-compliant harmonics and the scale of non-compliances are shown in Figure 7 to Figure 8. The voltage's 6th harmonic component is observed to exceed the 0.5% limit in a number of occasions, hence further investigations required in the coming years to ensure full compliance with the Code's requirements – refer to Section 6.1.5 for further details.

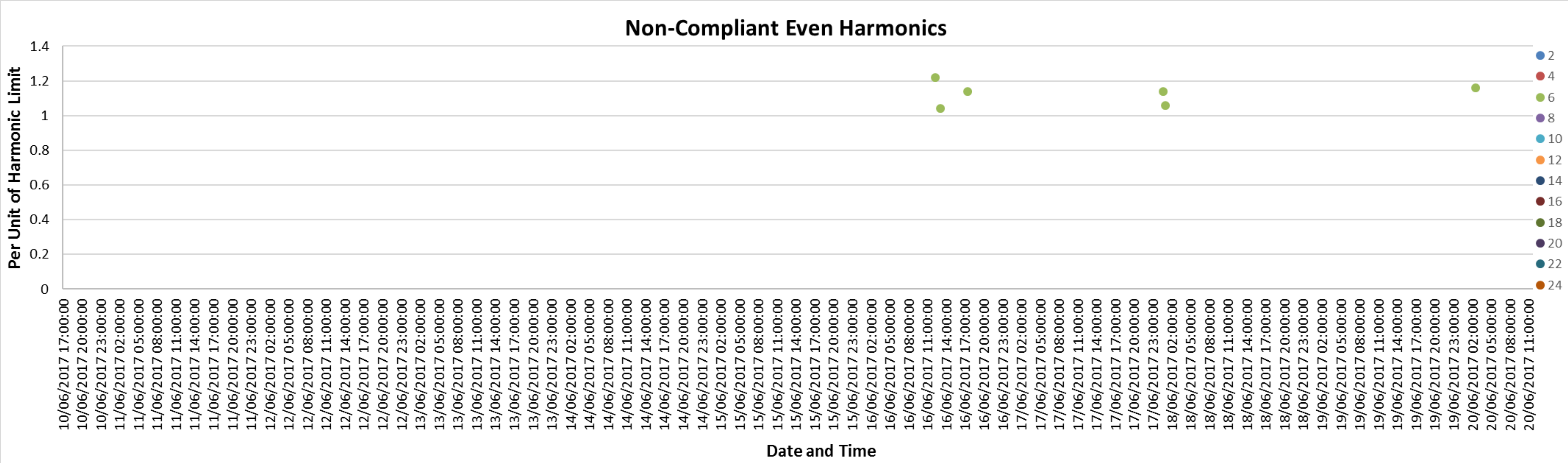

Figure 7 | TC3 feeder – Start – Non-compliant even harmonics

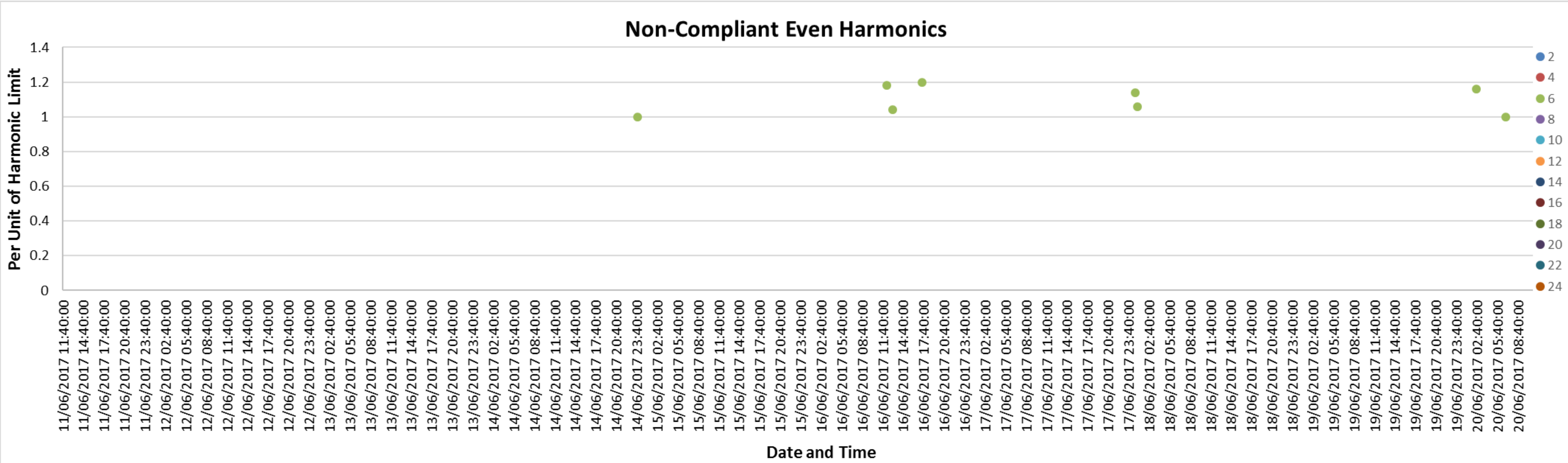

Figure 8 | TC3 feeder – End – Non-compliant even harmonics

6.4. Feeder TC4

The PQ logger at the start of the TC4 feeder was installed in the PS125 Bubbacurry Loop substation, between 12/06/2017 and 20/06/2017, thus satisfying the 7 days minimum logging duration requirement.

The PQ logger at the end of the TC4 feeder was installed in the PS27 Newman Caravan Park substation, between 11/06/2017 and 20/06/2017, thus satisfying the 7 days minimum logging duration requirement.

As shown in Figure 1 (light-green feeder), TC4 originates from the Township substation.

6.4.1. Flicker

The logged flicker data for the start and end of the TC4 feeder are shown in Figure 104 to Figure 106 and Figure 107 to Figure 109 of Appendix B , respectively. There were no recorded flicker limit events causing the flicker level to breach The Code's limits (i.e., full compliance with the Code requirements).

6.4.2. Voltage

The logged voltage level data for the start and end of the TC4 feeder are shown in Figure 110 to Figure 112 and Figure 113 to Figure 115 of Appendix B , respectively. There were no recorded voltage limit events causing the voltage level to breach The Code's limits (i.e., full compliance with the Code requirements).

6.4.3. Frequency

The logged frequency data for the start and end of the TC4 feeder are shown in Figure 116 and Figure 117 of Appendix B . There were no recorded frequency limit events causing the voltage level to breach The Code's limits (i.e., full compliance with the Code requirements).

6.4.4. Voltage THD

The logged voltage THD level data for the start and end of the TC4 feeder are shown in Figure 118 to Figure 120 and Figure 121 to Figure 123 in Appendix B , respectively. There were no noted voltage limit events causing the voltage THD level to breach The Code's limits (i.e., full compliance with the Code requirements).

6.4.5. Harmonics

The logged harmonic data for the start and end of the TC4 feeder is shown in Figure 124 to Figure 127 and Figure 128 to Figure 131 in Appendix B , respectively.

A summary of non-compliant harmonics and the scale of non-compliances are shown in Figure 9 to Figure 10. The voltage's 6th harmonic component is observed to exceed the 0.5% limit in a number of occasions, hence further investigations required in the coming years to ensure full compliance with the Code's requirements – refer to Section 6.1.5 for further details.

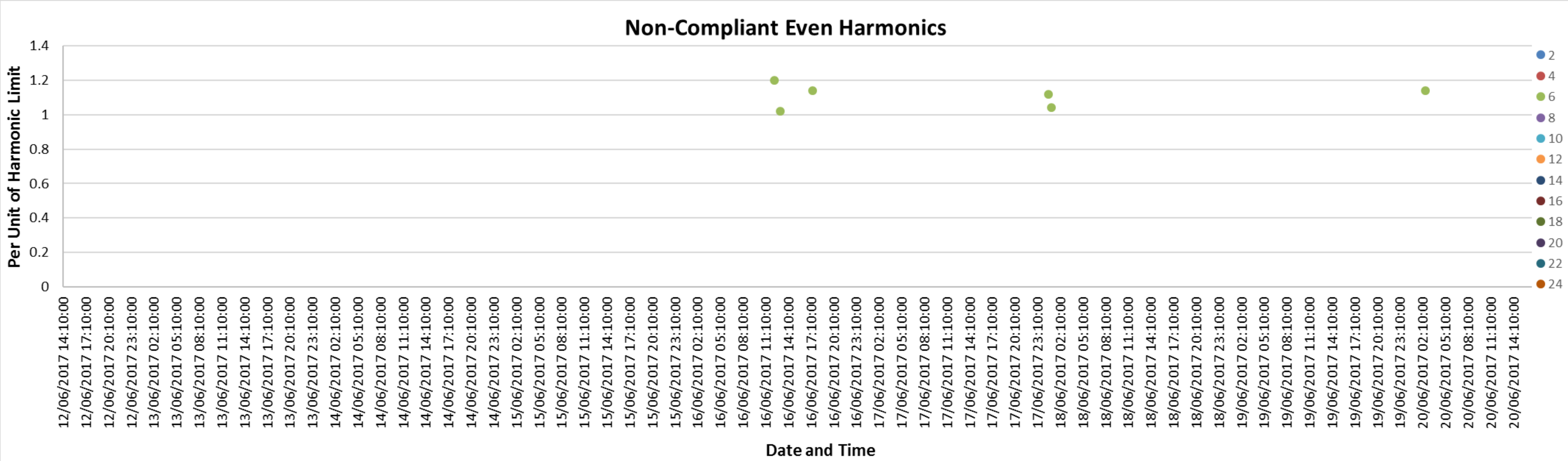

Figure 9 | TC4 feeder – Start – Non-compliant even harmonics

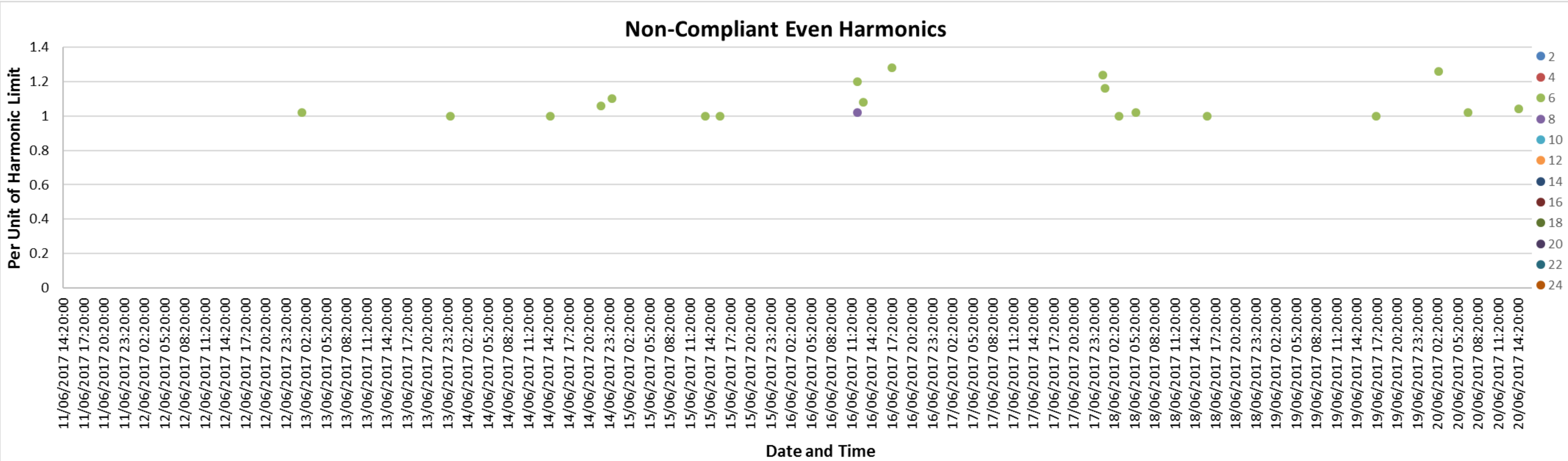

Figure 10 | TC4 feeder – End – Non-compliant even harmonics

6.5. Feeder STS1

The PQ logger at the start of the STS1 feeder was installed in the PS94 Pardoo substation, between 11/06/2017 and 20/06/2017, thus satisfying the 7 days minimum logging duration requirement.

The PQ logger at the end of the STS1 feeder was installed in the PS25 Laver Street substation, between 11/06/2017 and 20/06/2017, thus satisfying the 7 days minimum logging duration requirement.

As shown in Figure 1 (green feeder), STS1 originates from the South Town substation.

6.5.1. Flicker

The logged flicker data for the start and end of the STS1 feeder are shown in Figure 132 to Figure 134 and Figure 135 to Figure 137 of Appendix B , respectively. There were no recorded flicker limit events causing the flicker level to breach The Code's limits (i.e., full compliance with the Code requirements).

6.5.2. Voltage

The logged voltage level data for the start and end of the STS1 feeder are shown in Figure 138 to Figure 140 and Figure 141 to Figure 143 of Appendix B , respectively. There were no recorded voltage limit events causing the voltage level to breach The Code's limits (i.e., full compliance with the Code requirements).

6.5.3. Frequency

The logged frequency data for the start and end of the STS1 feeder are shown in Figure 144 and Figure 145 of Appendix B , respectively. There were no recorded frequency limit events causing the voltage level to breach The Code's limits (i.e., full compliance with the Code requirements).

6.5.4. Voltage THD

The logged voltage THD level data for the start and end of the STS1 feeder are shown in Figure 146 to Figure 148 and Figure 149 to Figure 151in Appendix B , respectively. There were no noted voltage limit events causing the voltage THD level to breach The Code's limits (i.e., full compliance with the Code requirements).

6.5.5. Harmonics

The logged harmonic data for the start and end of the STS1 feeder is shown in Figure 152 to Figure 155 and Figure 156 to Figure 159 in Appendix B , respectively.

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

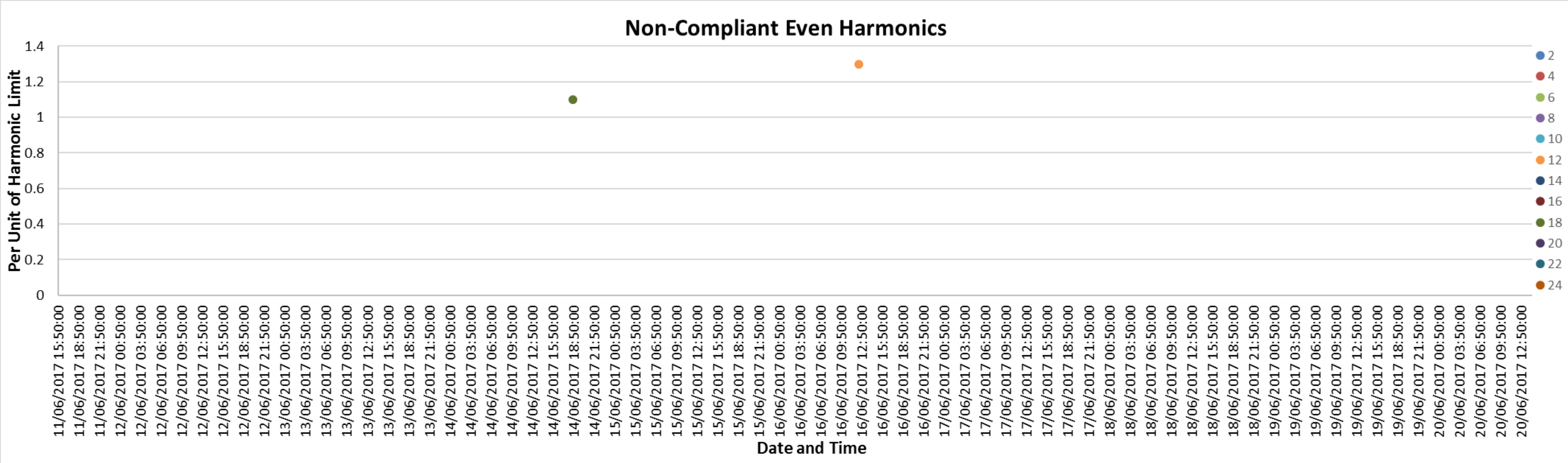

Figure 11 | STS1 feeder – End – Non-compliant even harmonics

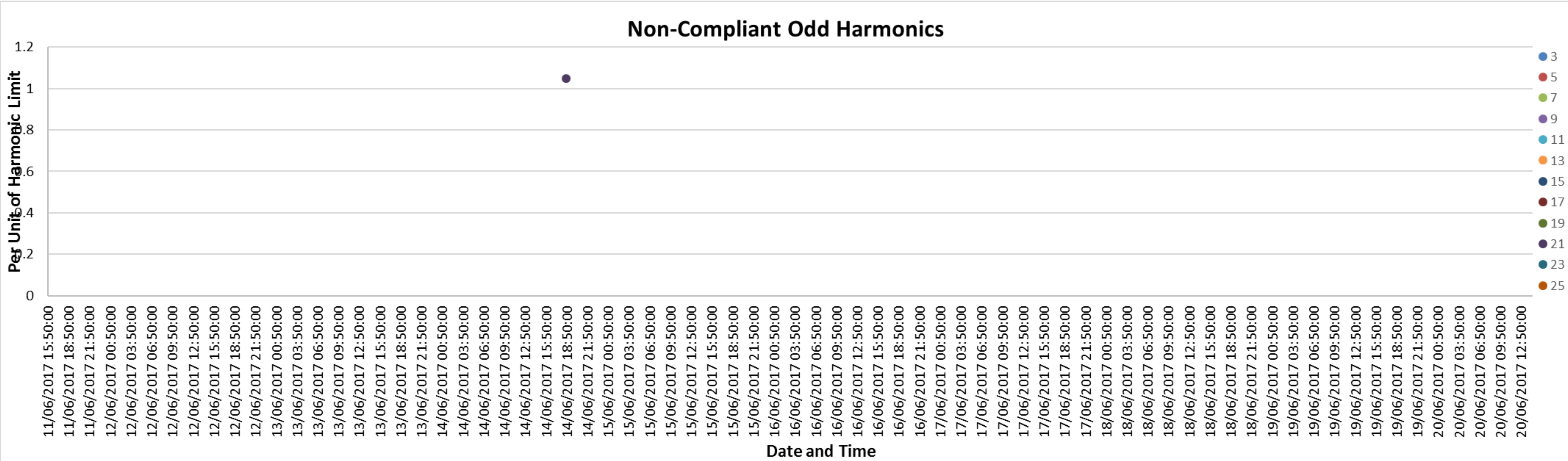

Figure 12 | STS1 feeder – End – Non-compliant odd harmonics

6.6. Feeder STS2

The PQ logger at the start of the STS2 feeder was installed in the PS60 Forrest Avenue substation, between 11/06/2017 and 20/06/2017, thus satisfying the 7 days minimum logging duration requirement.

The PQ logger at the end of the STS2 feeder was installed in the PS70 Jabbarup Crescent Park substation, between 11/06/2017 and 20/06/2017, thus satisfying the 7 days minimum logging duration requirement.

As shown in Figure 1 (grey feeder), STS2 originates from the South Town substation.

6.6.1. Flicker

The logged flicker data for the start and end of the STS2 feeder are shown in Figure 160 to Figure 162 and Figure 163 to Figure 165 of Appendix B , respectively. There were no recorded flicker limit events causing the flicker level to breach The Code's limits (i.e., full compliance with the Code requirements).

6.6.2. Voltage

The logged voltage level data for the start and end of the STS2 feeder are shown in Figure 166 to Figure 168 and Figure 169 to Figure 171 of Appendix B , respectively. There were no recorded voltage limit events causing the voltage level to breach The Code's limits (i.e., full compliance with the Code requirements).

6.6.3. Frequency

The logged frequency data for the start and end of the STS2 feeder are shown in Figure 172 and Figure 173 of Appendix B , respectively. There were no recorded frequency limit events causing the voltage level to breach The Code's limits (i.e., full compliance with the Code requirements).

6.6.4. Voltage THD

The logged voltage THD level data for the start and end of the STS2 feeder are shown in Figure 174 to Figure 176 and Figure 177 to Figure 179 in Appendix B , respectively. There were no noted voltage limit events causing the voltage THD level to breach The Code's limits (i.e., full compliance with the Code requirements).

6.6.5. Harmonics

The logged harmonic data for the start and end of the STS2 feeder is shown in Figure 180 to Figure 183 and Figure 184 to Figure 187 in Appendix B , respectively .

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

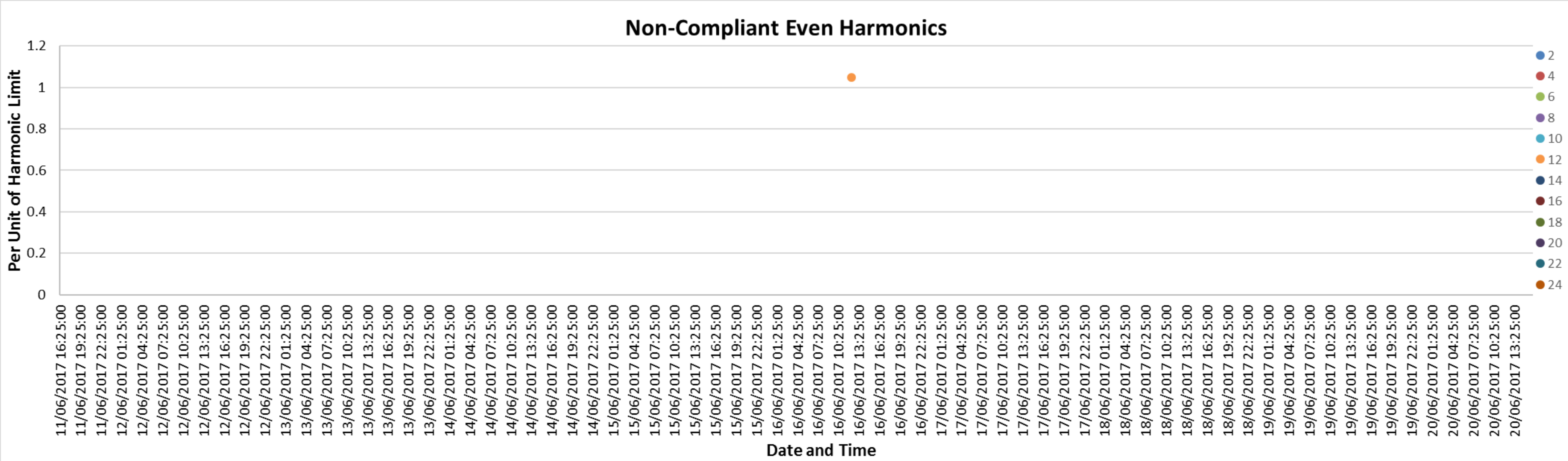

Figure 13 | STS2 feeder – Start – Non-compliant even harmonics

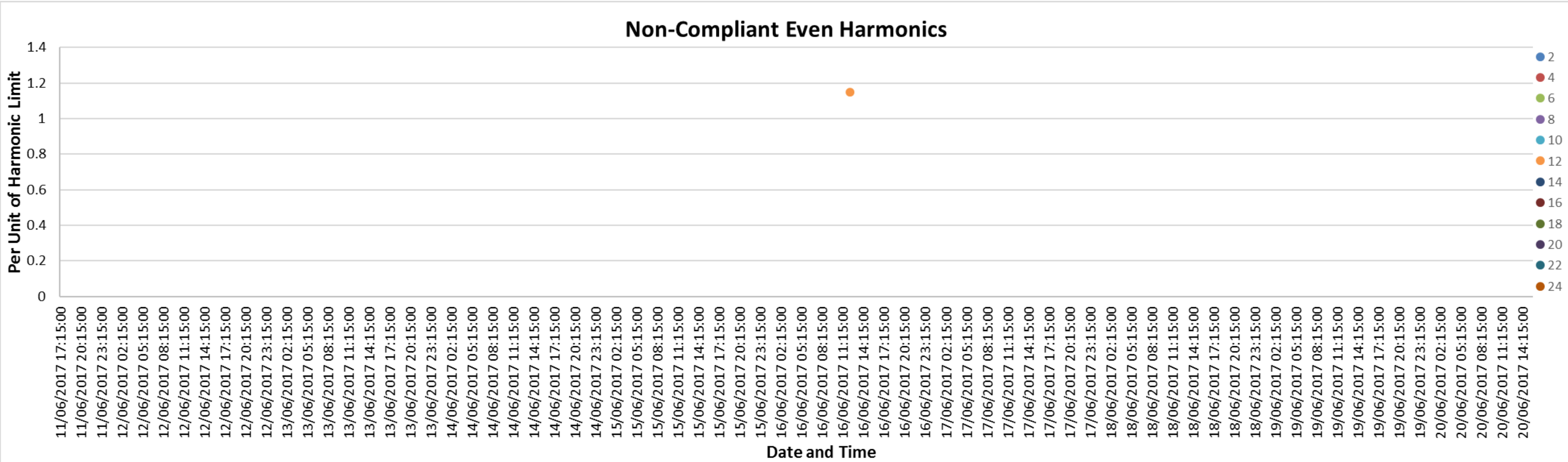

Figure 14 | STS2 feeder – End – Non-compliant even harmonics

6.7. Feeder STS6

The PQ logger at the start of the STS6 feeder was installed in the PS127 Water Treatment substation, between 12/06/2017 and 21/06/2017, thus satisfying the 7 days minimum logging duration requirement.

The PQ logger at the end of the STS6 feeder was installed in the PS121 Newman Drive substation, between 12/06/2017 and 21/06/2017, thus satisfying the 7 days minimum logging duration requirement.

As shown in Figure 1 (yellow feeder), STS6 originates from the South Town substation.

6.7.1. Flicker

The logged flicker data for the start and end of the STS6 feeder are shown in Figure 188 to Figure 190 and Figure 191 to Figure 193 of Appendix B , respectively. There were no recorded flicker limit events causing the flicker level to breach The Code's limits (i.e., full compliance with the Code requirements).

6.7.2. Voltage

The logged voltage level data for the start and end of the STS6 feeder are shown in Figure 194 to Figure 196 and Figure 197 to Figure 199 of Appendix B respectively. There were no recorded voltage limit events causing the voltage level to breach The Code's limits (i.e., full compliance with the Code requirements).

6.7.3. Frequency

The logged frequency data for the start and end of the STS6 feeder are shown in Figure 200 and Figure 201 of Appendix B , respectively. There were no recorded frequency limit events causing the voltage level to breach The Code's limits (i.e., full compliance with the Code requirements).

6.7.4. Voltage THD

The logged voltage THD level data for the start and end of the STS6 feeder are shown in Figure 202 to Figure 204 and Figure 205 to Figure 207 in Appendix B , respectively. There were no noted voltage limit events causing the voltage THD level to breach The Code's limits (i.e., full compliance with the Code requirements).

6.7.5. Harmonics

The logged harmonic data for the start and end of the STS6 feeder is shown in Figure 208 to Figure 211 and Figure 212 to Figure 215 in Appendix B , respectively.

A summary of non-compliant harmonics and the scale of non-compliances are shown in Figure 15 to Figure 16. Note that both 6th and 15th order harmonic components of the supply voltage exceed the prescribed limits in a number of occasions, but this is not deemed of major concern as it occurs in less than 1% of the measurements period. Further investigation of this issue is recommended in coming years should the harmonic components continue to raise.

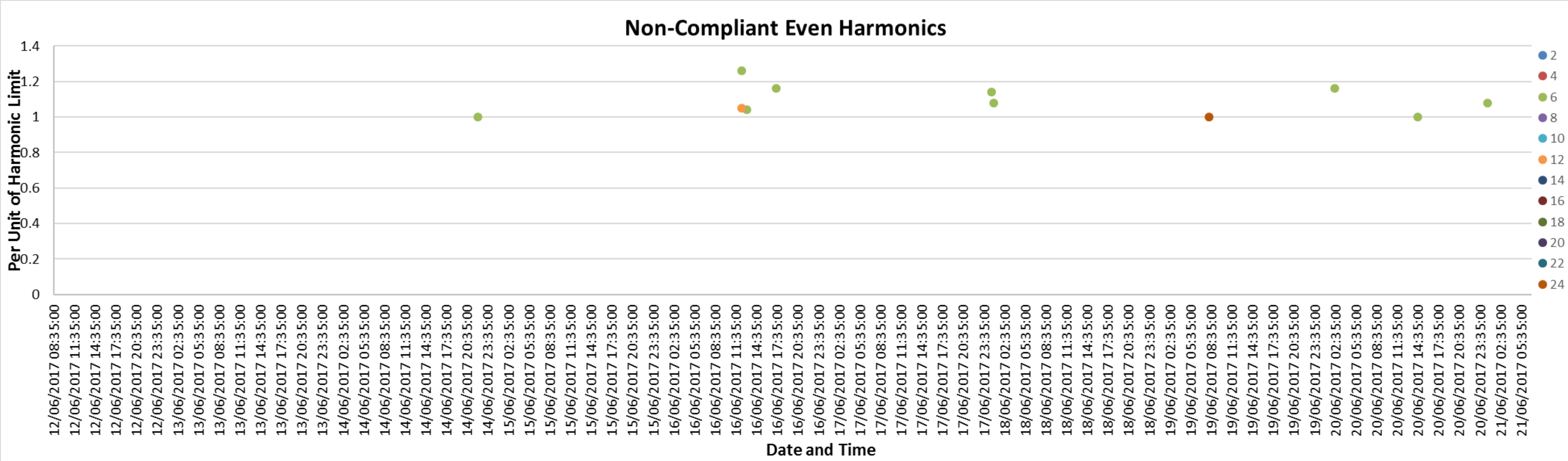

Figure 15 | STS6 feeder – Start – Non-compliant even harmonics

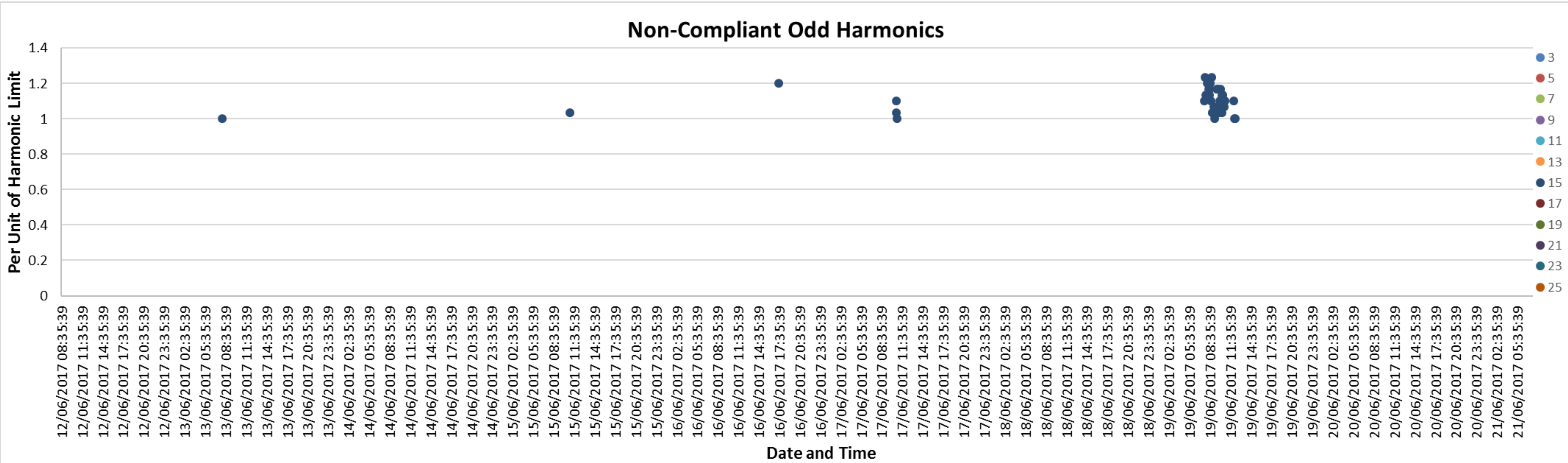

Figure 16 | STS6 feeder – Start – Non-compliant odd harmonics

7. RESPONSE TO THE CODE REQUIREMENTS

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

7.1. Quality and Reliability Standards (Part 2)

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

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

The PQ logging results indicate zero voltage fluctuation breaches on the township network during the logged periods. Table 4 presents the results for the previous three reporting periods together with the 2016/2017 result.

Given the results presented in Table 4, an improvement is observed over the 2016/17 FY compared to the measurements of the years before.

Table 4 | Total number of breaches of voltage fluctuation compatibility levels

Description	Reportable Period			
	2013/2014	2014/2015	2015/2016	2016/2017
Total number of breaches of *Pst*	79	5	1	0
Total number of breaches of *Plt*	72	1	0	0

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

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

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

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

7.1.2.1. Individual Voltage Harmonics

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

7.1.2.2. Voltage Total Harmonic Distortions

The voltage harmonic distortion levels of electricity supplied must not exceed the Voltage Total Harmonic Distortion (U-THD) of 8% stated in Part 2, Division 1, Section 7 of the Code. Table 5 presents the results for the previous three reporting periods together with the 2016/2017 result. In the 2016/2017, zero events occurred where the *maximum* U-THD was greater than the 8% limit. The *average* of the U-THD was consistently well within the 8% limit.

Given the results presented in Table 5, a consistent and well-regulated supply is observed over the 2016/17 FY with respect to the measurements of the years before.

Table 5 | Total number of breaches of total harmonic distortion limit

Description	Reportable Period			
	2013/2014	2014/2015	2015/2016	2016/2017
Total number of breaches of Voltage Total Harmonic Distortion (U-THD)	0	1	0	0

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

This information is not required as part of the reporting requirements of the Code but included here to provide a more complete indication of the power quality of supply.

In accordance with AS 3000:2007, the voltage levels of the electrical network must be maintained at +10% and -6% of the supply voltage of 240V single-phase.

As the voltage measurements were taken at the secondary (LV) side of the pad-mounted transformers located at the beginning and the end of each feeder supplying the township, the voltage level at the customer's connection point would be lower than the logged results. The voltage drop due to customers' loads must be limited to 5%, in accordance to AS 3000. The lowest averaged minimum voltage levels recorded during the PQ logging period was 241V (start of TC3 feeders). Therefore, it is expected that the voltage level at the customer's connection would be within the required range.

Table 6 presents the results for the previous three reporting periods together with the 2016/2017 result. In 2016/2017, there were no instances where the voltage level breached the voltage limits.

Given the results presented in Table 6, a consistent and well-regulated supply is observed over the 2016/17 FY with respect to the measurements of the years before.

Table 6 | Total number of breaches of voltage level limits

Description	Reportable Period			
	2013/2014	2014/2015	2015/2016	2016/2017
Total number of breaches of voltage limits	0	2	0	0

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

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

Table 7 presents the results for the previous three reporting periods together with the 2016/2017 result. For the 2016/2017 PQ logging period, there were no instances where the frequency breached the required limits.

Given the results presented in Table 7, a consistent and well-regulated supply is observed over the 2016/17 FY with respect to the measurements of the years before.

Table 7 | Total number of breaches of frequency limits

Description	Reportable Period			
	2013/2014	2014/2015	2015/2016	2016/2017
Total number of breaches of frequency limits	0	1	0	0

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

Newman BHPBIOSA is found very pro-active in establishing and executing asset replacement and improvement programs in order to sustain and improve power quality and reliability.

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

Asset upgrades including:

- Replacement of pole top distribution transformers with pad mount substations in the Township of Newman due to ageing or defects.
- Replacing sections of O/H line with HV underground cabling within the Township of Newman.
- Ongoing replacement of Oil Circuit Breakers due to ageing or defects.
- The commissioning of existing Capacitor Banks for Junction Substation.

Additionally, the continuation and improvement of a program to reduce bird strike related trips has been successfully progressed which has significantly reduced the number of outages.

In addition to the asset upgrade programs executed over the 2016/17 FY, BHPBIOSA have managed to improve the internal work process, yielding improved quality and reliability of supply. A brief example of process improvement works already completed or currently in-progress by BHPBIOSA includes the following:

- Upgraded ISP (Inspection System Plan) and ISP Manual documents, approved and implemented during the 2016/17 FY. Further revisions and reformatting are being undertaken to continually improve this document.
- Relay Test Instruction (RTI) documents have been developed and implemented to improve the reliability and quality assurance of relay testing to identify potential mal-grading issues, hence further increasing the reliability of the Neman Township supply.

7.3. Supply interrupted (Schedule 1 Item 5)

The provisions of The Code have the following requirements:

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

7.3.1. Interruptions Exceeding 12 Hours

Table 8 presents the interruptions over 12 Hours for small use customer, with one such interruption recorded for 2016/17 FY. The following is noted regarding the nature of the interruption exceeding 12 hours:

- Interruption occurred on a public holiday and was limited to three commercial lots, as such no customers or businesses were adversely affected by the outage.
- Interruption occurred due to an inrush current trip. No person was present at premises to report outage and no network alarms system indications; except for a physical in-field check.

Table 8 | Total number of premises of small customers interrupted continuously for more than 12 hours

Description	Reportable Periods			
	2013/2014	2014/2015	2015/2016	2016/2017
Total number of premises that experienced interruptions more than 12 hours	5	0	0	1

7.3.2. Frequent Interruptions

The permitted number of times a customer can be disconnected in the Newman Township is 16 interruptions as per Section 12 (1) (b) of the Code. Analysis of BHPBIOSA's outage logs presented in Table 9 indicates that the no customers were disconnected more than 16 times.

Table 9 | Total number of premises that experienced more than 16 interruptions

Description	Reportable Periods			
	2013/2014	2014/2015	2015/2016	2016/2017
Total number of premises that experienced interruptions more than 16 times	0	0	0	0

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

According to Schedule 1, "complaint" means that a provision of Electricity Code 2005 Part 2; or an instrument made under Electricity Code 2005 Section 14(3), has not been, or is not being, complied with. For the reporting period, a total of 1 complaints was made, with the information provided in Table 4 to Table 9 it is assumed that each complaint was associated with external factors, such as billing, hence no complaints received on the reliability or quality of the supply.

Table 10 presents the results for the previous three reporting periods together with the 2016/2017 result.

Table 10 | Total number of formal complaints lodged to BHPBIOSA

Description	Reportable Periods			
	2013/2014	2014/2015	2015/2016	2016/2017
Total number of formal complaints received	0	0	0	0

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

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

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

There has been no technical complaint over the 2016/17 FY that required BHPBIO's action.

7.7. Investments over 2016/2017 FY to improve the Reliability of Supply & Power Quality

Table 11 shows the total AUD amount spent in improving the supply quality and reliability and to cater for network expansion[1]. The changes in the network investment over various FY is partly attributed to the re-structuring works taken place in BHPBIOSA over the course of last few years.

Table 11 | Total amount spent by BHPBIOSA in network improvements (indicative only)

Description	Reportable Periods			
	2013/2014	2014/2015	2015/2016	2016/2017
Total amount spend in dollars (AUD)	$14.90 million	$16.90 million	$13.20 million	$16.00 million

[1] Figures presented are indicative only and may differ due to the re-structing works recently taken place in the network operation and mainatance team.

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

This section outlines the total number of payments and the amount of those payments made by BHPBIOSA under Sections 18 and 19 of the Code. That is payment for failure to give the require notice of planned interruptions and payments for supply interruptions exceeding 12 hours. There were no supply interruptions small customer being disconnected for over 16 times, and one recorded interruption exceeding 12 hours. However, as per Part 3 Section 19 (1) (a) of the code, no application for payment was made within 60 days after the interruption, hence no payments were made. Table 12 presents the results for the previous three reporting periods together with the 2016/2017 result.

Table 12 | Total number and amount of payments made under Sections 18 and 19

Description	Reportable Periods			
	2013/2014	2014/2015	2015/2016	2016/2017
Total number of payments	0	0	0	0
Total amount of payments (AUD)	0	0	0	0

7.9. Reliability of Supply (Schedule 1 Item 11)

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

1. *"For each discrete area —*
   - *(a) the average length of interruption of supply to customer premises expressed in minutes;*
   - *(b) the average number of interruptions of supply to customer premises;*
   - *(c) the average percentage of time that electricity has been supplied to customer premises; and*
   - *(d) the average total length of all interruptions of supply to customer premises expressed in minutes."*

In this report, the township of Newman is considered the *discrete area*.

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

The average length of interruption of supply to customer premises for the Newman township electrical network is measured in minutes over the course of the 2016/2017 FY, shown in Table 13. Note that CAIDI index (53 minutes) has notably improved compared to the previous FY (102 minutes) and tracks well below the average of CAIDI recorded over the last 4 years (92 minutes).

Table 13 | The average length of interruption of supply to customer premises expressed in minutes (CAIDI)

Description	Reportable Period				
	2013/2014	2014/2015	2015/2016	2016/2017	Average
Average length of interruptions – CAIDI (minutes)	132	80	102	**53**	92

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

The average number of interruptions of supply to customer premises for the township of Newman over the course of the 2016/2017 FY is shown in Table 14. Note that SAIFI index (1.53) has improved compared to the previous FY (1.64) and tracks well below the average of SAIFI recorded over the last 4 years (2.45).

Table 14 | The average number of interruptions of supply to customer premises (SAIFI)

Description	Reportable Period				
	2013/2014	2014/2015	2015/2016	2016/2017	Average
Average supply interruptions – SAIFI (No. of Interruptions)	2.40	4.23	1.64	**1.53**	2.45

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

The average percentage of time that electricity has been supplied to customer premises over the course of the 2016/2017 FY is shown in Table 15. Note that ASAI index has marginally improved compared to the previous FY and tracks well with the average of ASAI recorded over the last 4 years.

Table 15 | The average percentage of time that electricity has been supplied to customer premises (ASAI)

Description	Reportable Period				
	2013/2014	2014/2015	2015/2016	2016/2017	Average
Average number of supply interruptions ASAI (Percentage of time connected)	99.94%	99.94%	99.97%	**99.98%**	99.96%

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

The average total length of all interruptions of supply to customer premises, expressed in minutes, is shown in Table 16. Note that SAIDI index (81 minutes) has notably improved compared to the previous FY (168 minutes) and tracks well below the average SAIDI recorded over the last 4 years (227 minutes).

Table 16 | The average total length of all interruptions of supply to customer premises in minutes (SAIDI)

Description	Reportable Period				
	2013/2014	2014/2015	2015/2016	2016/2017	Average
SAIDI (minutes)	318	339	168	**81**	227

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

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

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

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

(b) the number of interruptions; and

(c) the total length of interruptions."

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

7.10.1. Percentile – Average Length of Interruption

As required by 'Schedule 1' of The Code, Table 17 presents the CAIDI results on a percentile basis.

Table 17 | Percentile of the average length of interruption of supply to customer premises in 2016/2017

Description	Percentile						
	25th	50th	75th	90th	95th	98th	100th
Average Length of Interruption (CAIDI)	56	53	53	53	53	53	53

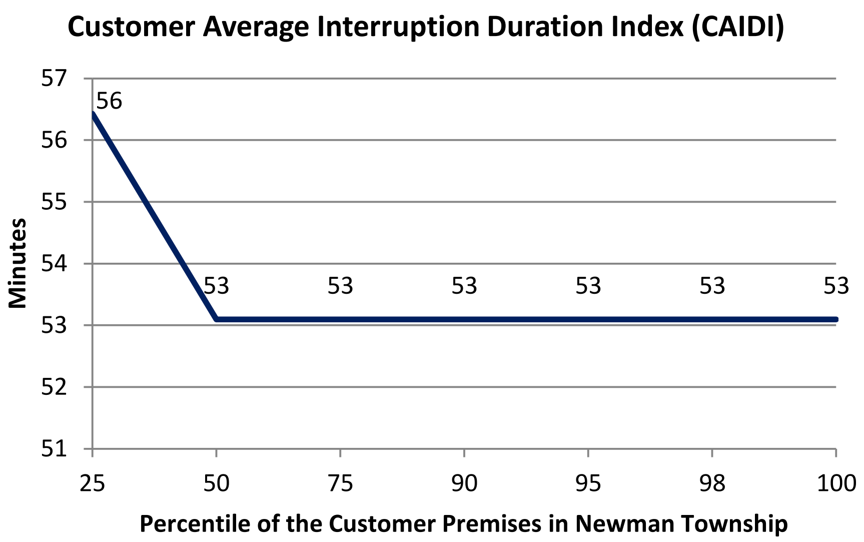

Figure 17 | The average length of interruption (minutes) of supply to customers over 2016/2017 FY

7.10.2. Percentile - Number of interruptions

As required by 'Schedule 1' of The Code, Table 18 presents the SAIFI results on a percentile basis.

Table 18 | Percentile values of the number of interruptions in 2016/2017

Description	Percentile						
	25th	50th	75th	90th	95th	98th	100th
Number of interruptions (SAIFI)	0.34	1.53	1.53	1.53	1.53	1.53	1.53

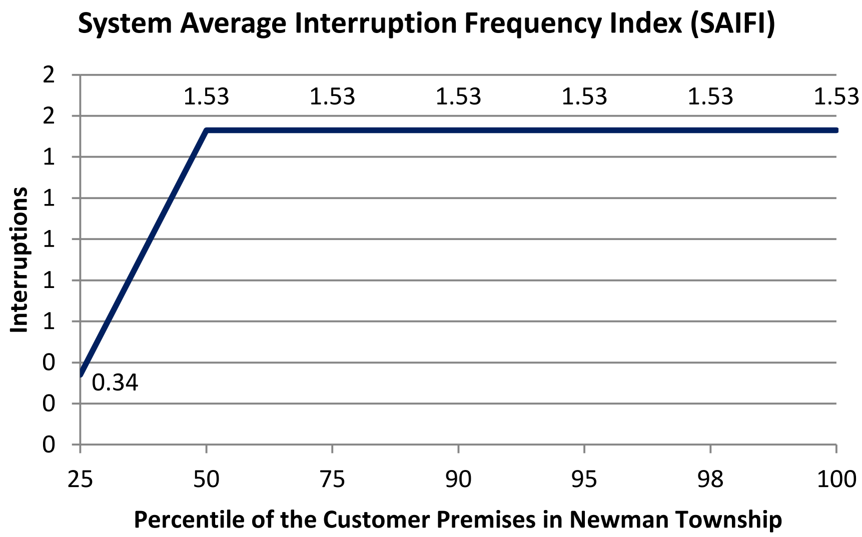

Figure 18 | Percentile graph showing the number of interruptions (SAIFI) in 2016/2017

7.10.3. Percentile - Total Length of Interruptions

As required by 'Schedule 1' of The Code, Table 19 presents the SAIDI results on a percentile basis.

Table 19 | Percentile values of the total length of interruptions in 2016/2017

Description	Percentile						
	25th	50th	75th	90th	95th	98th	100th
Total lengths of interruptions (SAIDI)	19	81	81	81	81	81	81

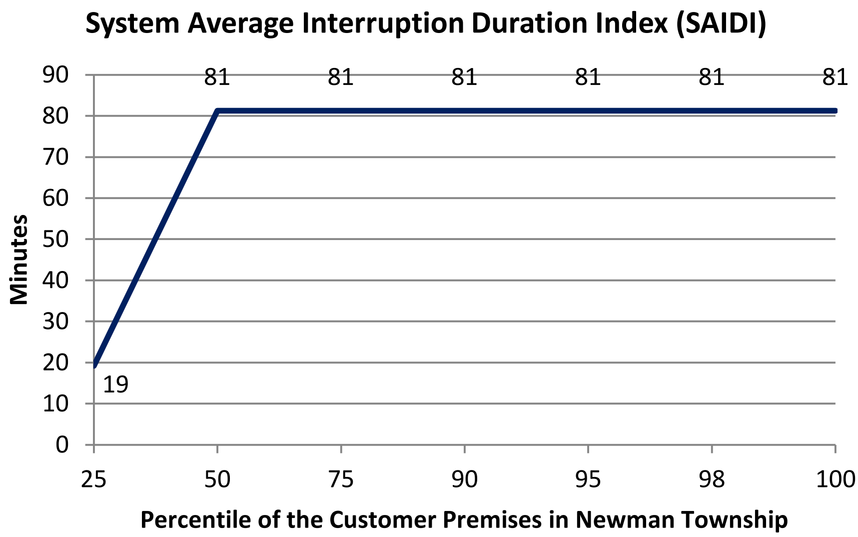

Figure 19 | Percentile graph showing the total length of interruptions (SAIDI) in 2016/2017

8. CONCLUSION

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

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

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

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

Reportable parameters for Newman Township Electricity Supply over the 2016/17 FY (as outlined in the 'Schedule 1' of the Code) are presented below:

- *>12 hour interruptions*: one interruption of over 12 hours duration was recorded for *small use customers*. It is noted that this interruption occurred on a public holiday and was isolated to three commercial lots. As such no businesses or customers were adversely affected as a result of the outage.
- No *small use customer* was disconnected from the network more frequent than the Code's requirements (i.e., limit of 16 times).
- A total of one complaint was received, which from correspondence with BHPBIOSA was related to shire works and hence not related to the power quality of the BHPBIOSA network.
- Within the 2016/17 FY, a total of $16.0M (AUD) was invested by BHPBIOSA towards Newman network operations, maintenance and reinforcement works; to not only address the issues identified by the operator but also to improve the quality and reliability of supply.
- The key reliability indices are calculated as listed below:
  - *Customer Average Interruption Duration Index* (CAIDI) of 53 minutes – CAIDI is the average outage duration that any given customer experience (i.e., the average restoration time).
  - *System Average Interruption Frequency Index* (SAIFI) of 1.53 interruptions – SAIFI is the number of interruptions that the customers experienced.
  - *Average Service Availability Index* (ASAI) of 99.98% – ASAI is the perceived availability of the network to the customers.
  - *System Average Interruption Duration Index* (SAIDI) of 81 minutes – SAIDI is the average outage duration for each customer served.

The metering data collected from 14 locations throughout the Newman network indicate that the power quality, *as so far as is reasonably practical*, is compliant with the Code. With regards to the Reliability of the Supply, the overall network performance is deemed satisfactory and significant improvements from the previous 2015/16 FY reporting period are noted.

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

APPENDIX A PQ Logging Device (HIOKI 3198)

Please refer to the following pages.

APPENDIX B PQ Logging Data for 2016/2017 FY

Please refer to the following pages.

TC1 Feeder – Flicker, Voltage, Frequency, and Harmonics

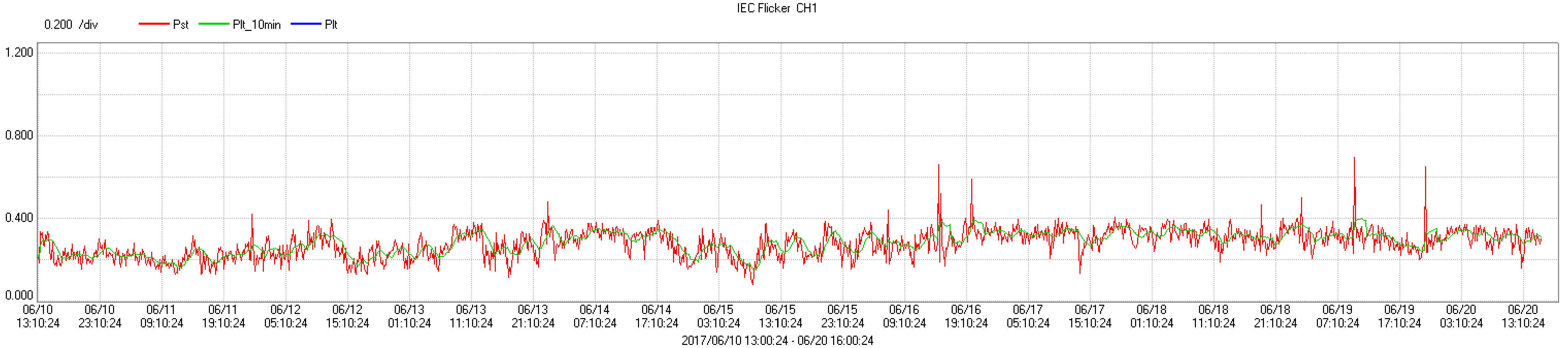

Figure 20 | TC1 - start of feeder – flicker measurements (Red Phase)

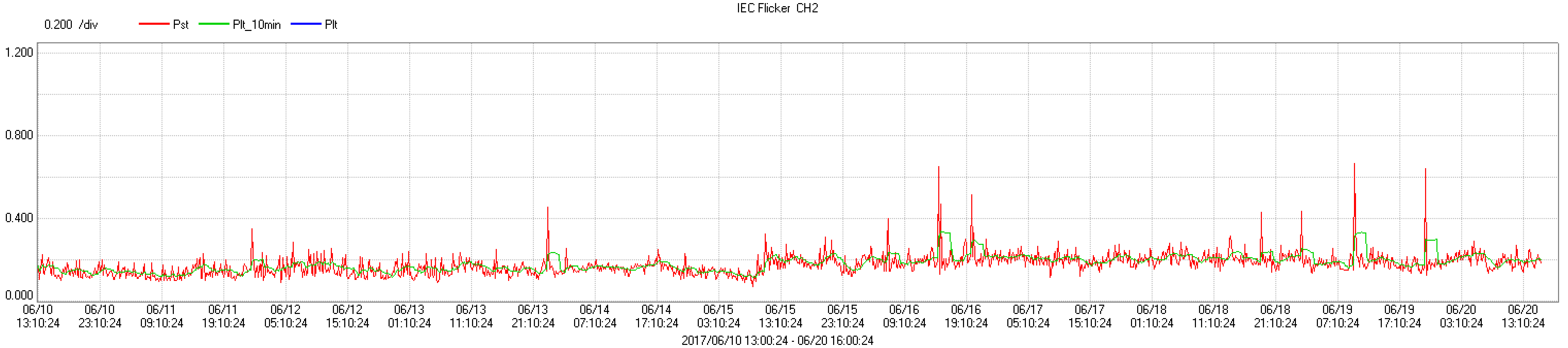

Figure 21 | TC1 - start of feeder – flicker measurements (White Phase)

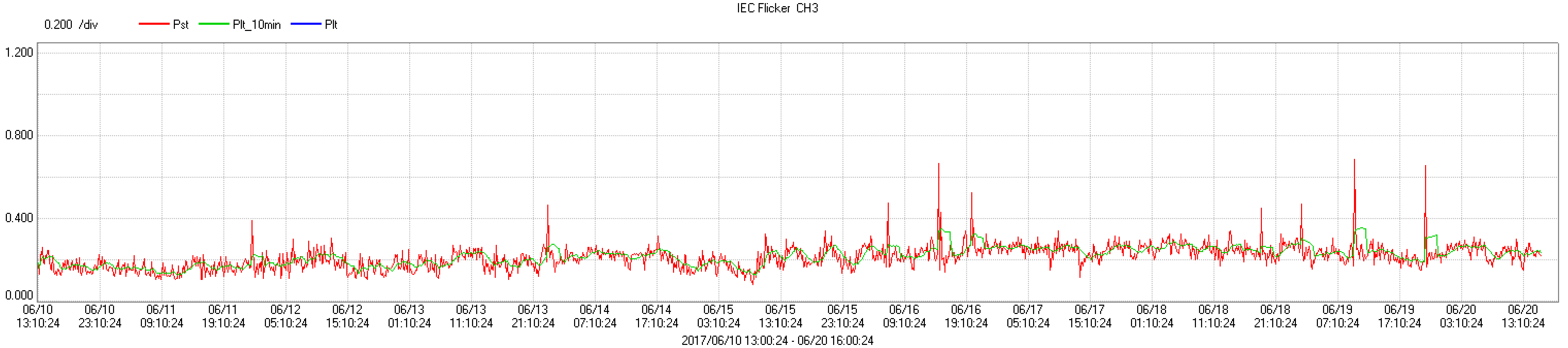

Figure 22 | TC1 - start of feeder – flicker measurements (Blue Phase)

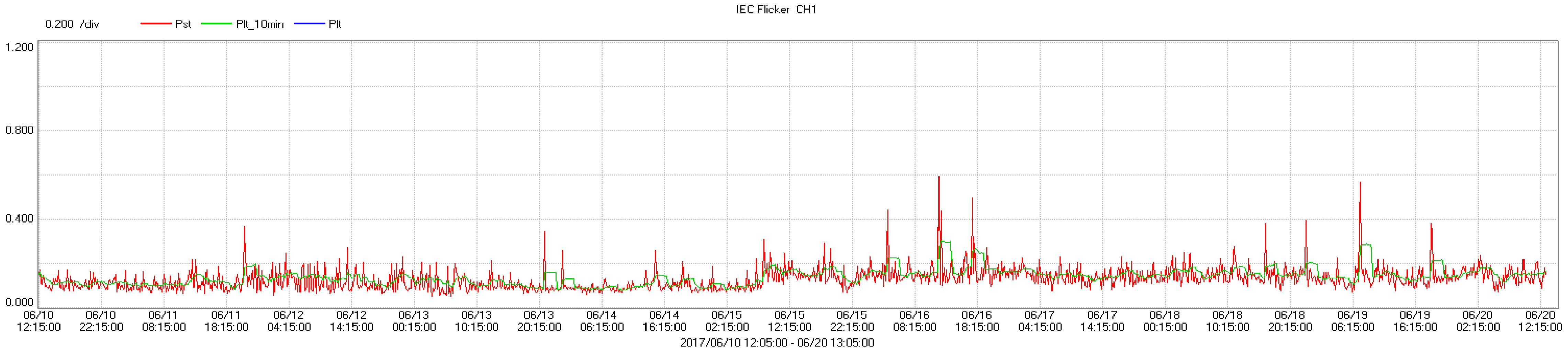

Figure 23 | TC1 – end of feeder – flicker measurements (Red Phase)

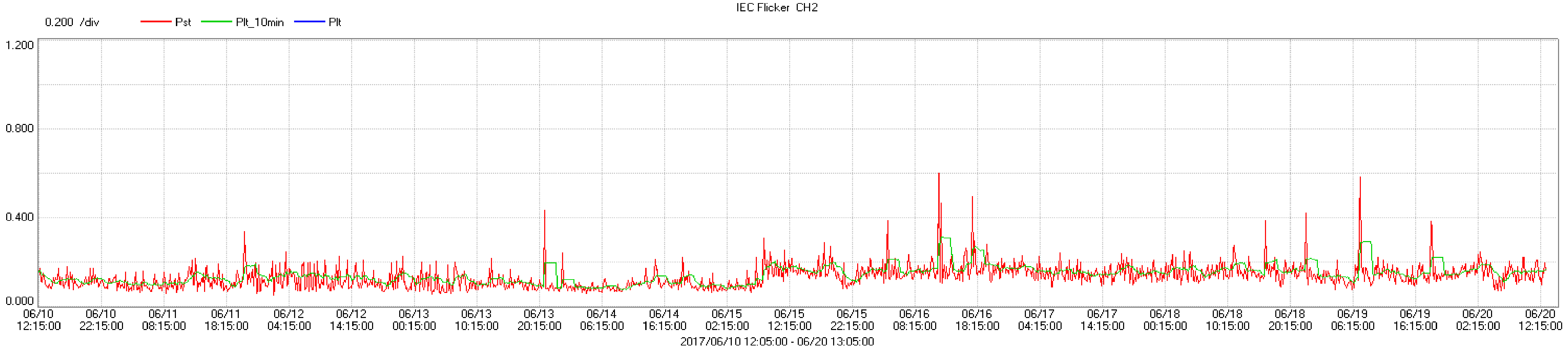

Figure 24 | TC1 - end of feeder – flicker measurements (White Phase)

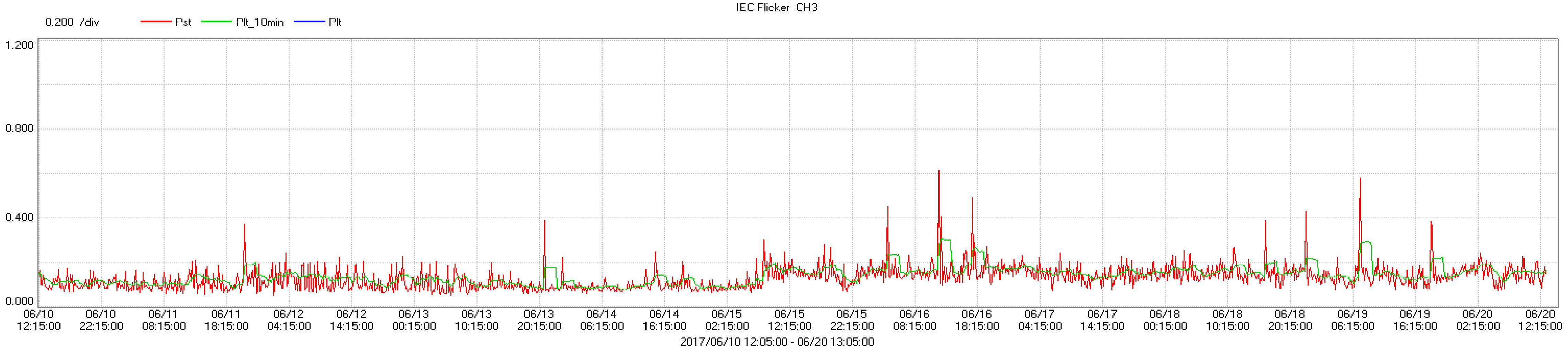

Figure 25 | TC1 - end of feeder – flicker measurements (Blue Phase)

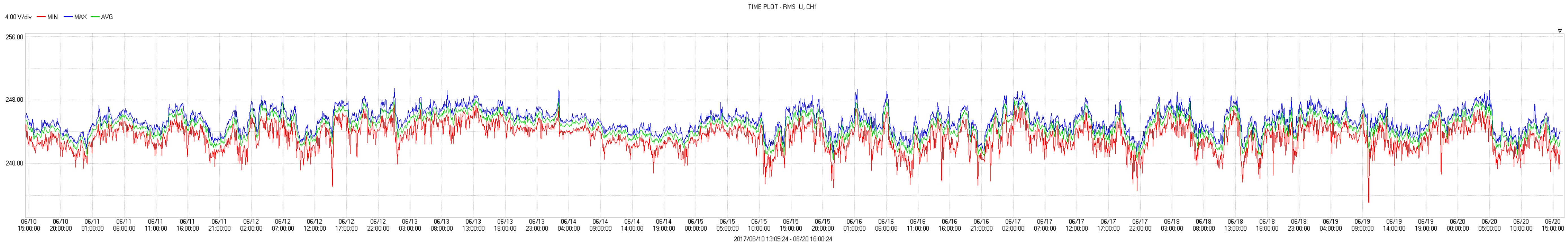

Figure 26 | TC1 - start of feeder – voltage measurements (Red Phase)

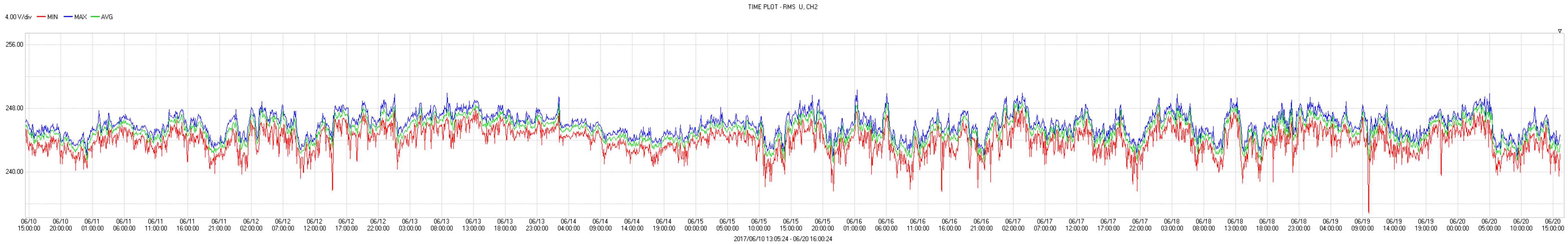

Figure 27 | TC1 - start of feeder – voltage measurements (White Phase)

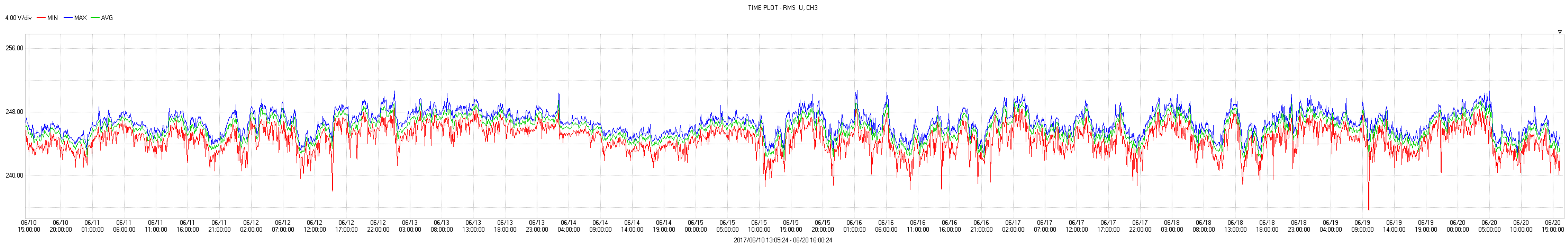

Figure 28 | TC1 - start of feeder – voltage measurements (Blue Phase)

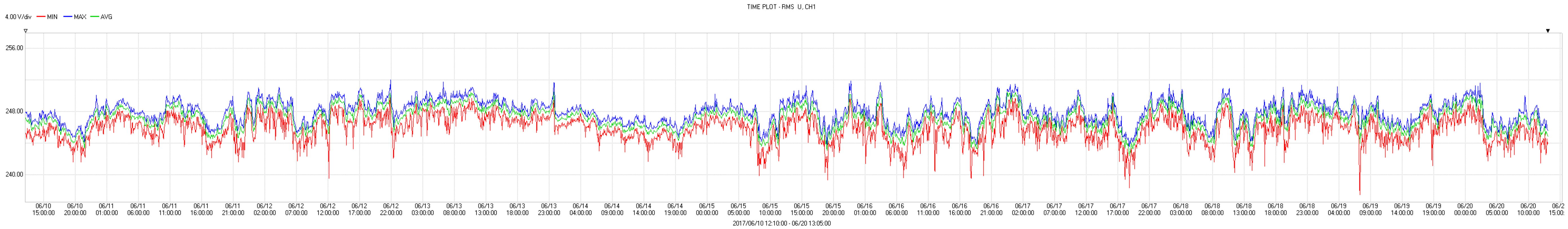

Figure 29 | TC1 - end of feeder – voltage measurements (Red Phase)

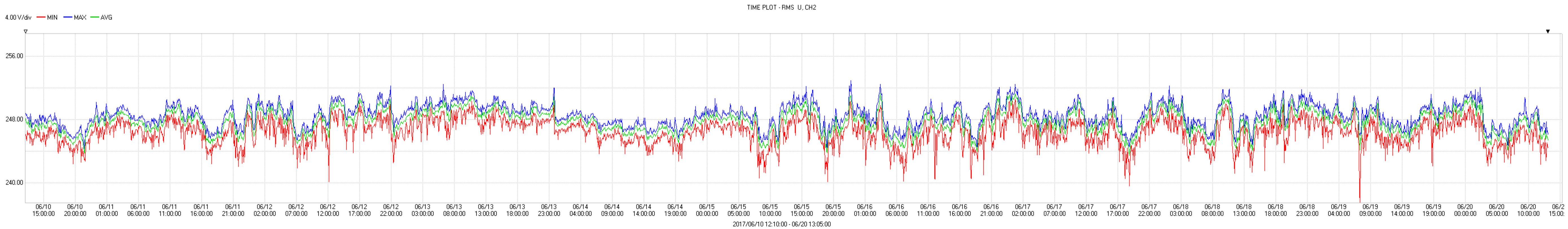

Figure 30 | TC1 - end of feeder – voltage measurements (White Phase)

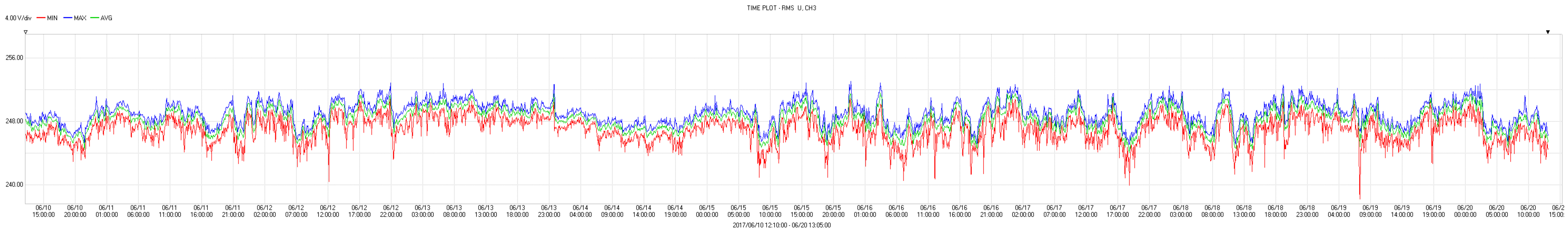

Figure 31 | TC1 - end of feeder – voltage measurements (Blue Phase)

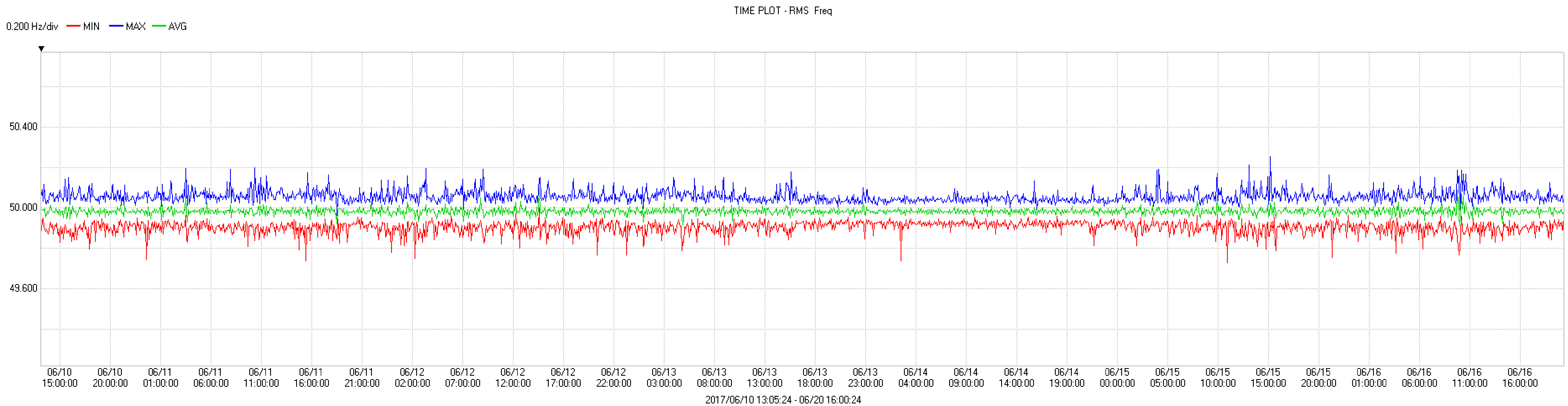

Figure 32 | TC1 - start of feeder – frequency measurements

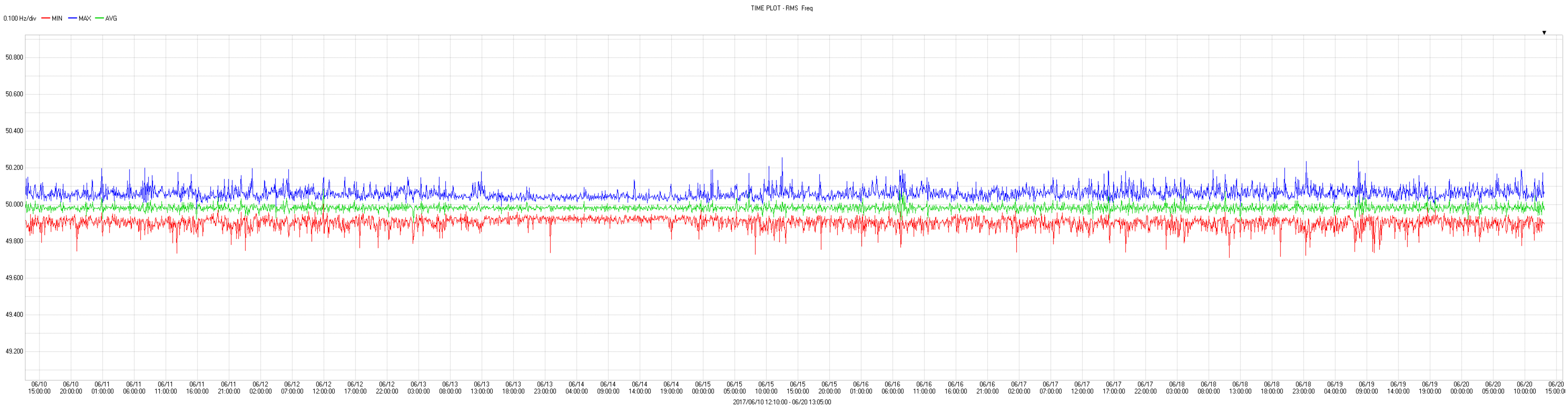

Figure 33 | TC1 - end of feeder – frequency measurements

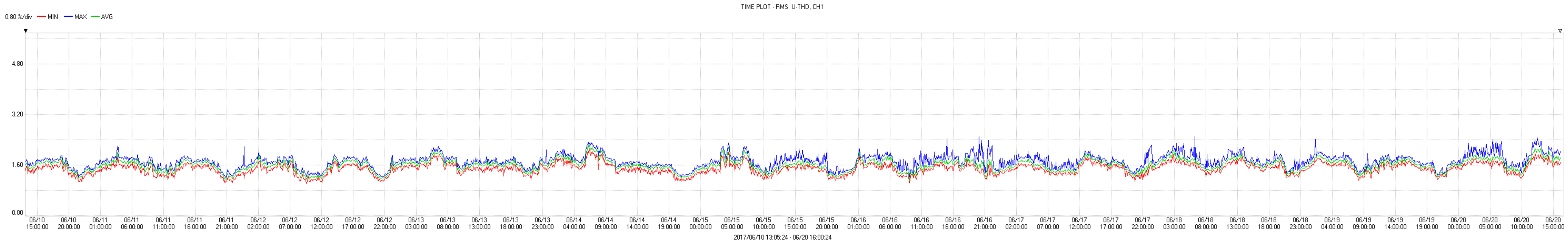

Figure 34 | TC1 - start of feeder – voltage THD measurements (Red Phase)

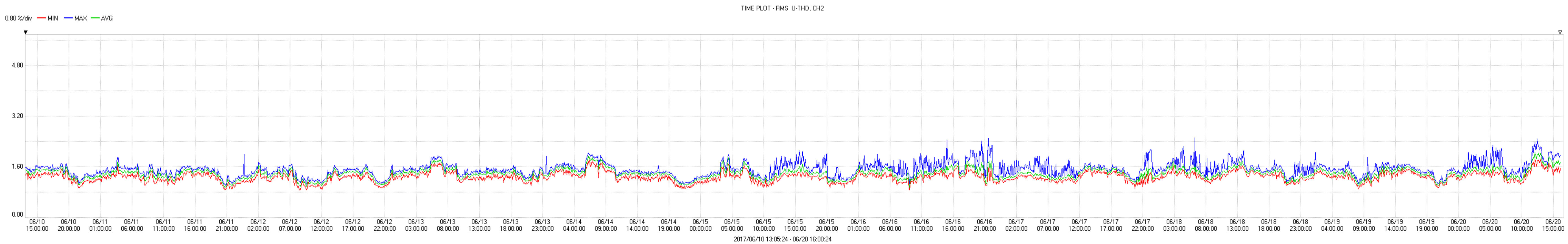

Figure 35 | TC1 - start of feeder – voltage THD measurements (White Phase)

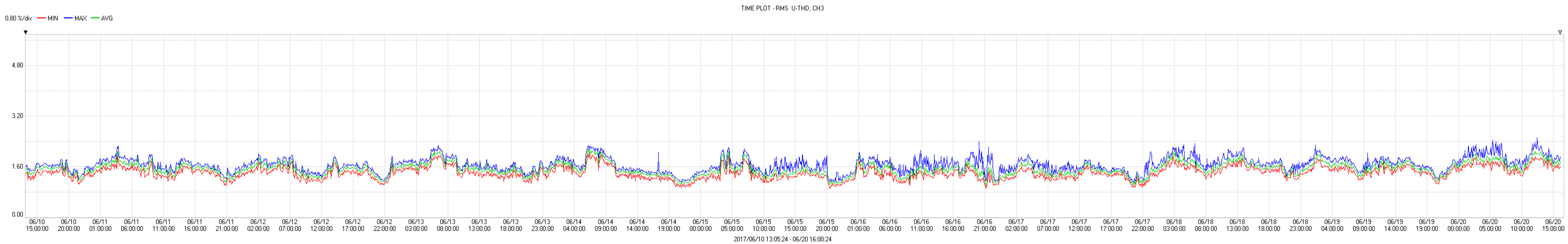

Figure 36 | TC1 - start of feeder – voltage THD measurements (Blue Phase)

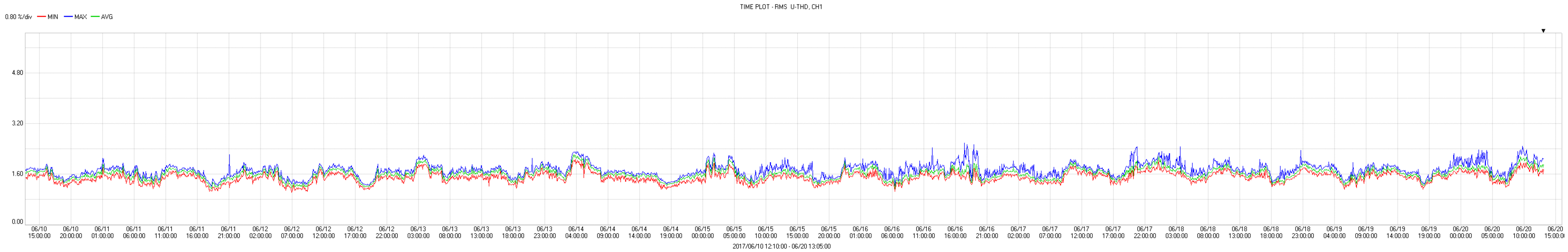

Figure 37 | TC1 - end of feeder – voltage THD measurements (Red Phase)

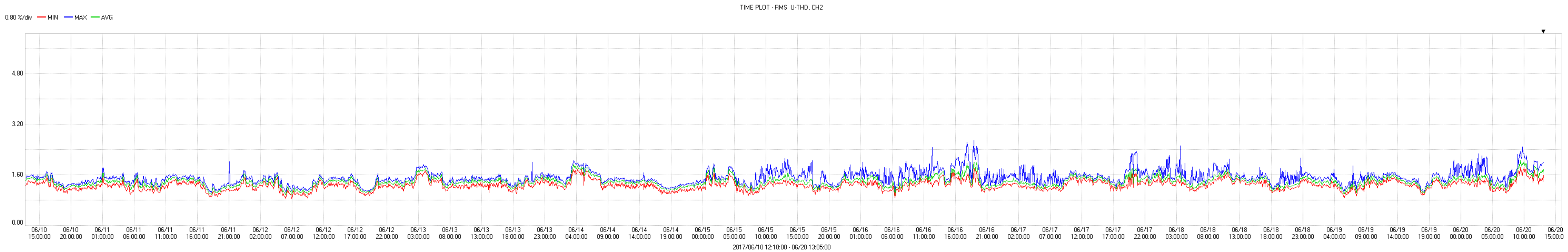

Figure 38 | TC1 - end of feeder – voltage THD measurements (White Phase)

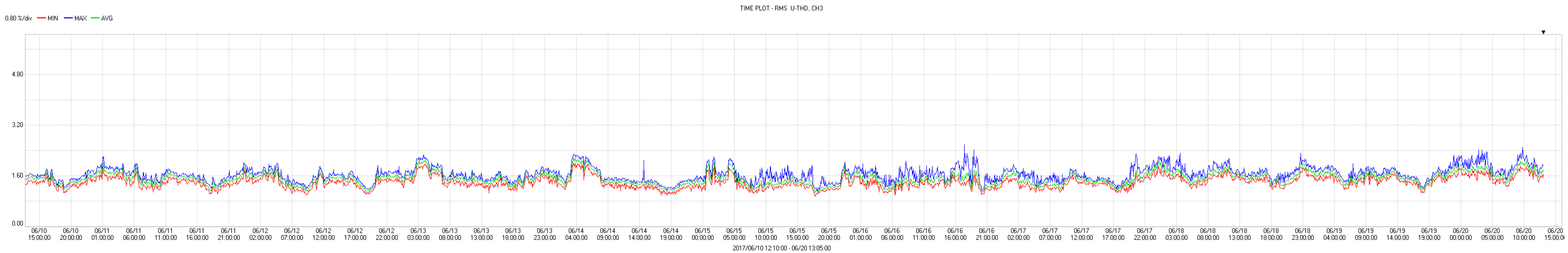

Figure 39 | TC1 - end of feeder – voltage THD measurements (Blue Phase)

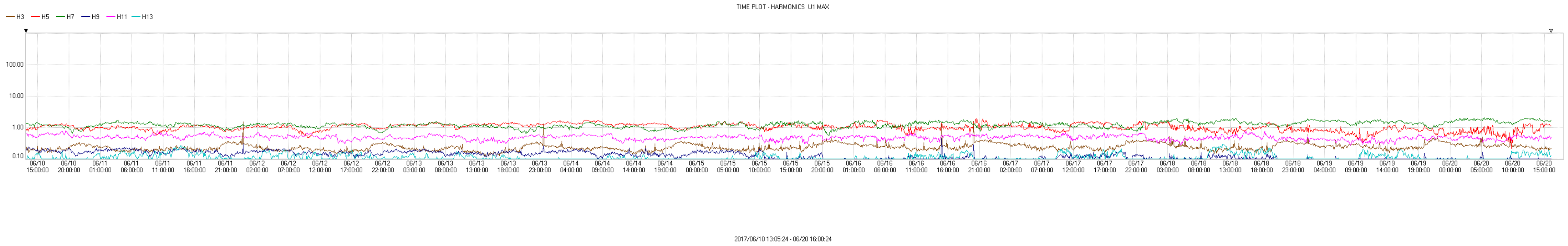

Figure 40 | TC1 – start of feeder – 3rd to 13th (odd) harmonics (Red Phase)

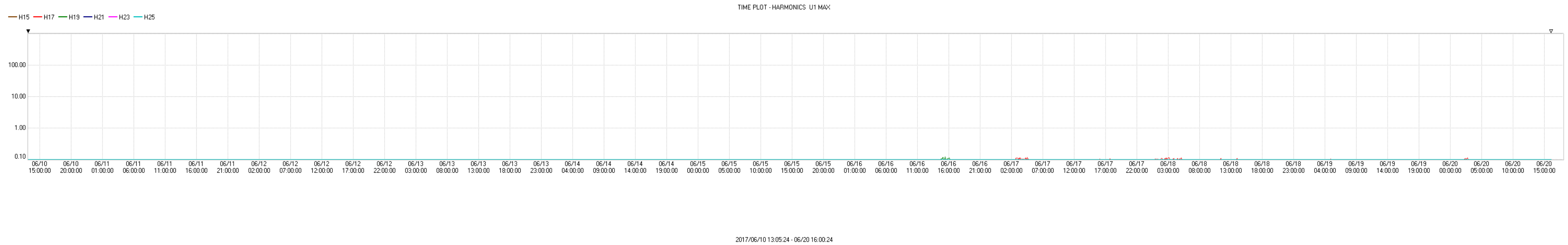

Figure 41 | TC1 – start of feeder – 15th to 25th (odd) harmonics (Red Phase)

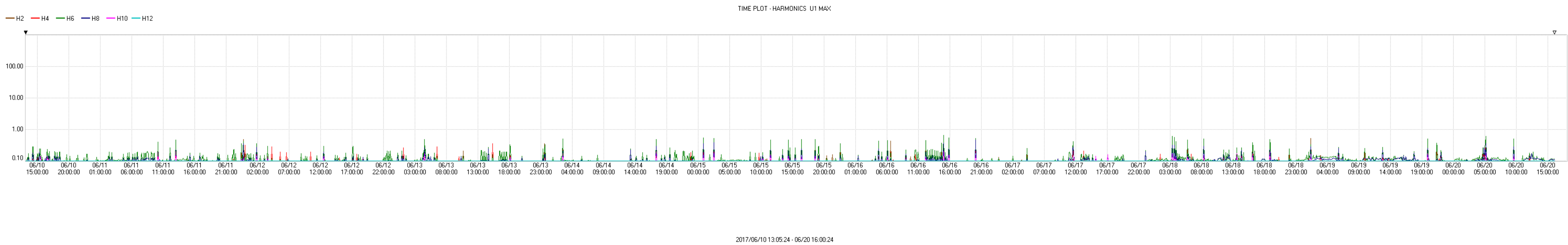

Figure 42 | TC1– start of feeder – 2th to 12th (even) harmonics (Red Phase)

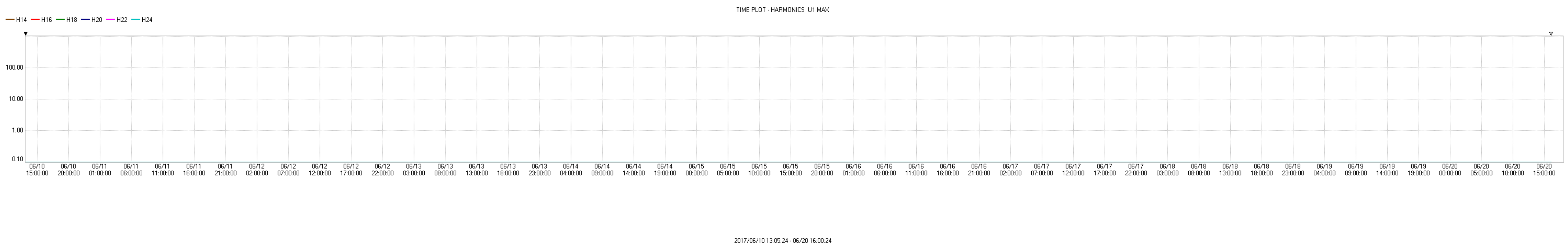

Figure 43 | TC1 – start of feeder – 14th to 24th (even) harmonics (Red Phase)

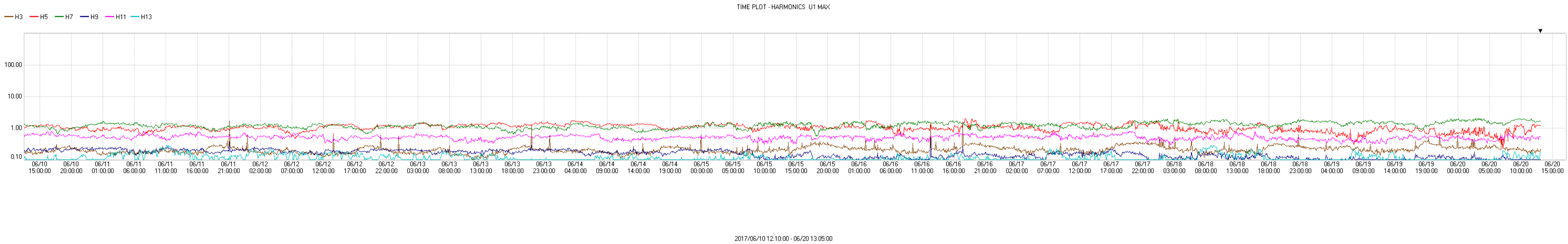

Figure 44 | TC1 – end of feeder – 3rd to 13th (odd) harmonics (Red Phase)

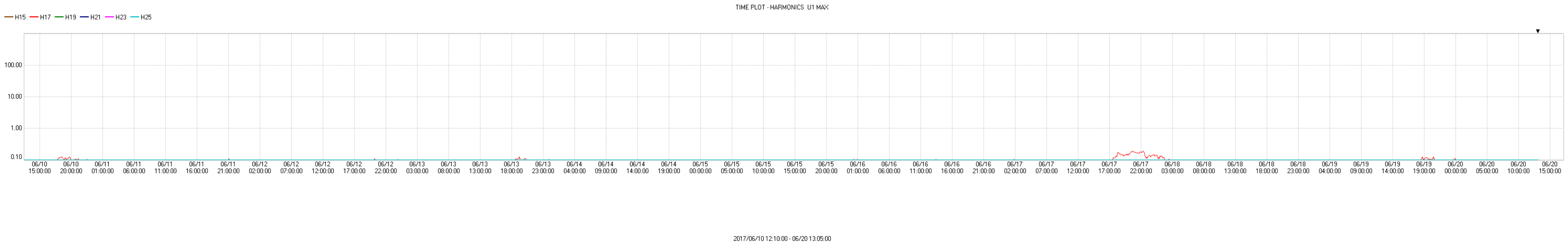

Figure 45 | TC1 – end of feeder – 15th to 25th (odd) harmonics (Red Phase)

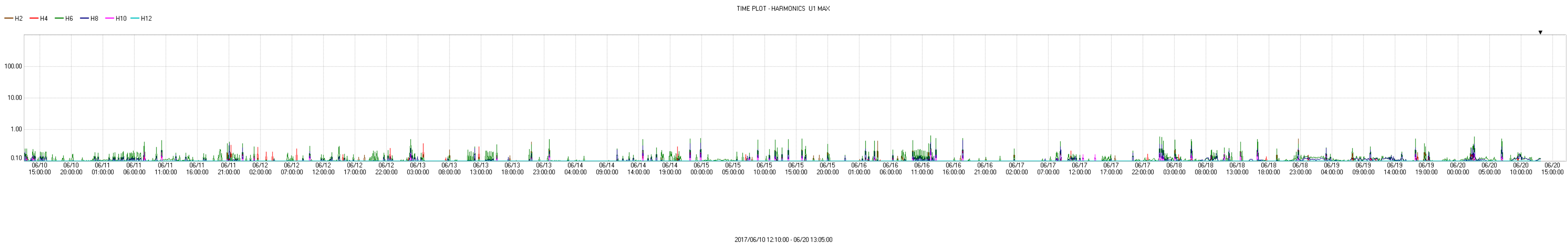

Figure 46 | TC1– end of feeder – 2nd to 12th (even) harmonics (Red Phase)

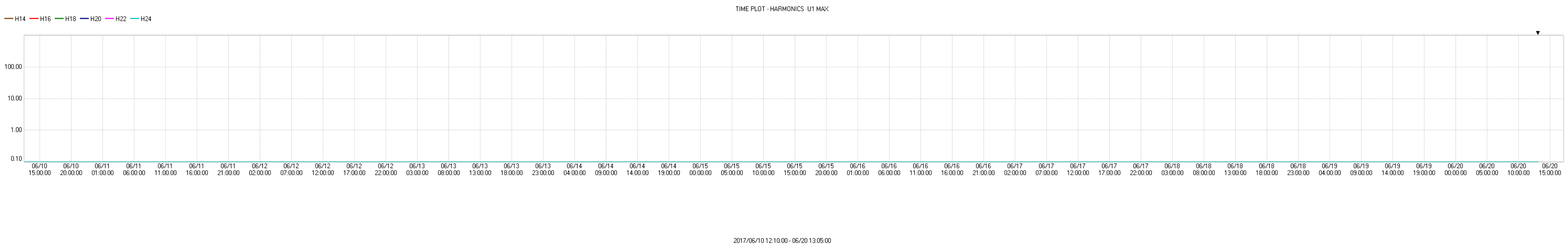

Figure 47 | TC1 – end of feeder – 14th to 24th (even) harmonics (Red Phase)

TC2 Feeder – Flicker, Voltage, Frequency, and Harmonics

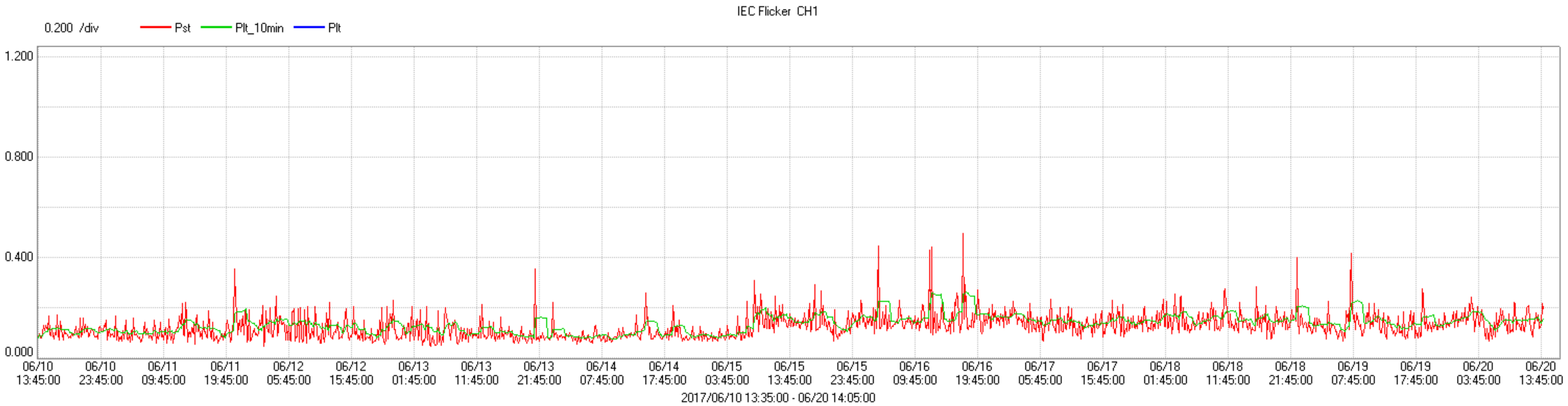

Figure 48 | TC2 - start of feeder – flicker measurements (Red Phase)

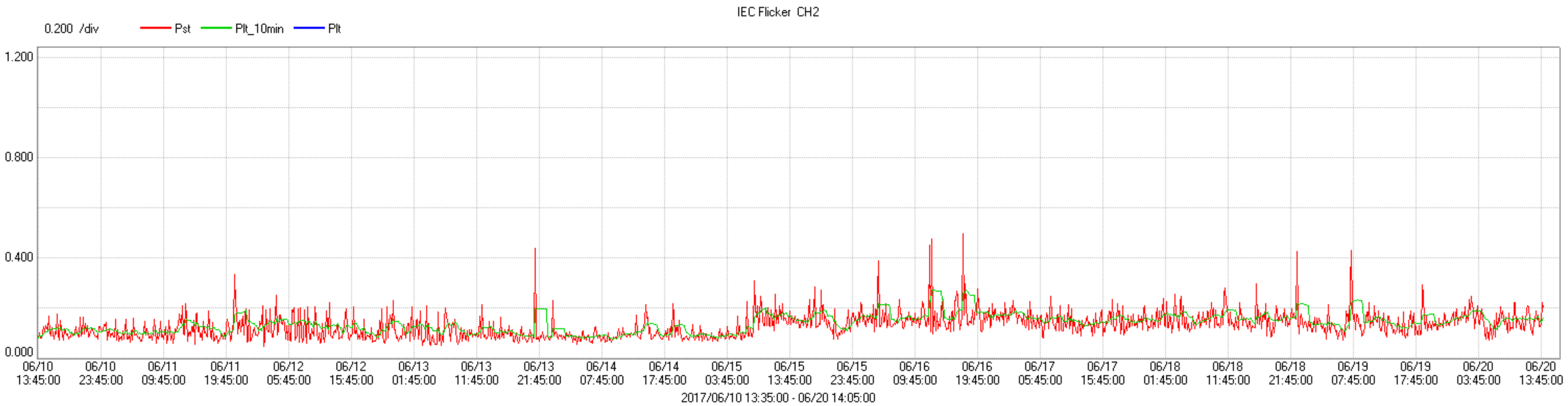

Figure 49 | TC2 - start of feeder – flicker measurements (White Phase)

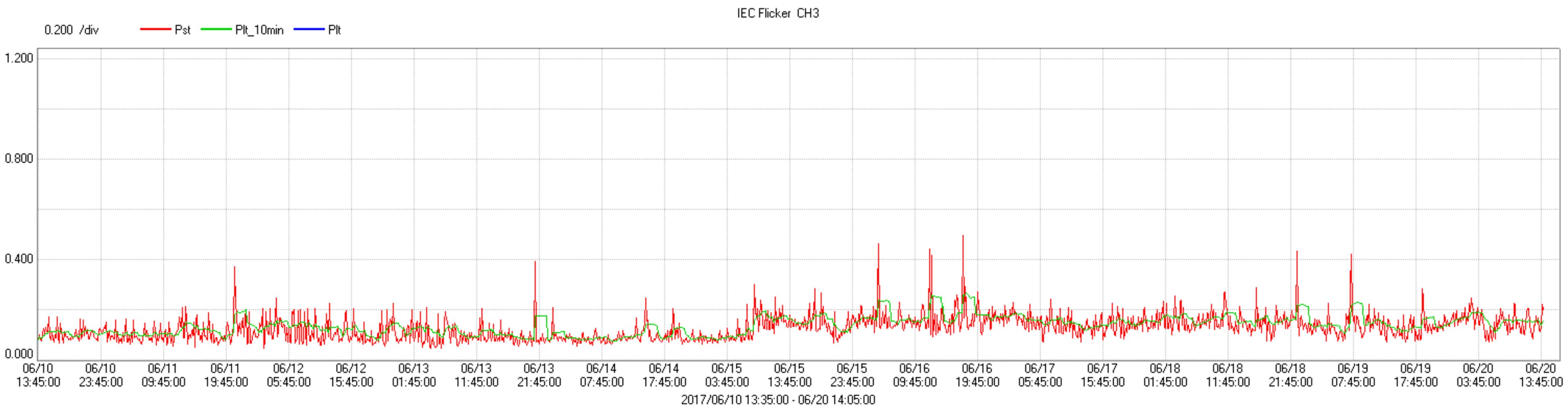

Figure 50 | TC2 - start of feeder – flicker measurements (Blue Phase)

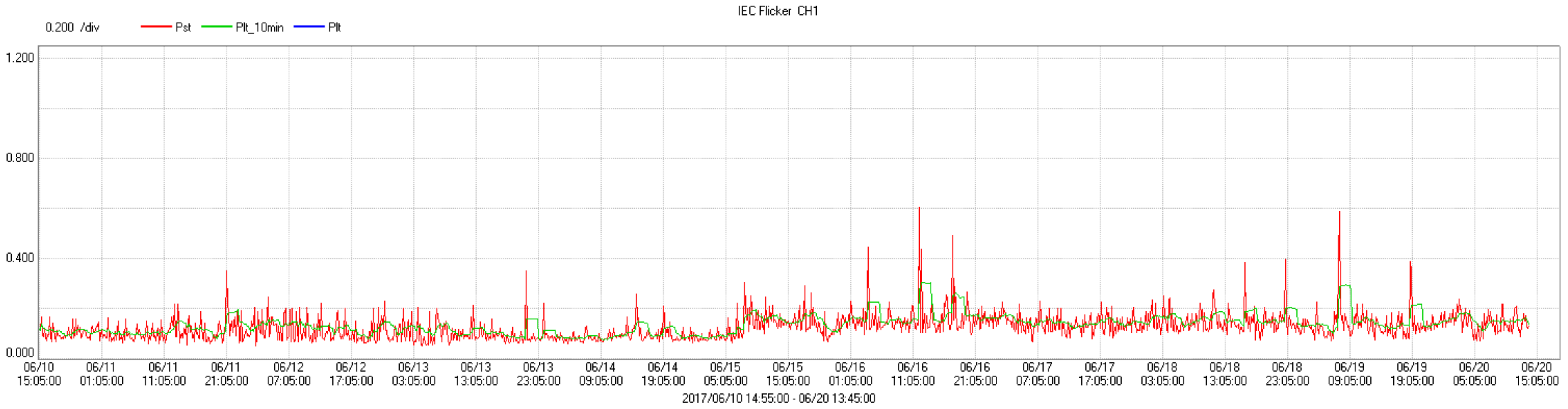

Figure 51 | TC2 – end of feeder – flicker measurements (Red Phase)

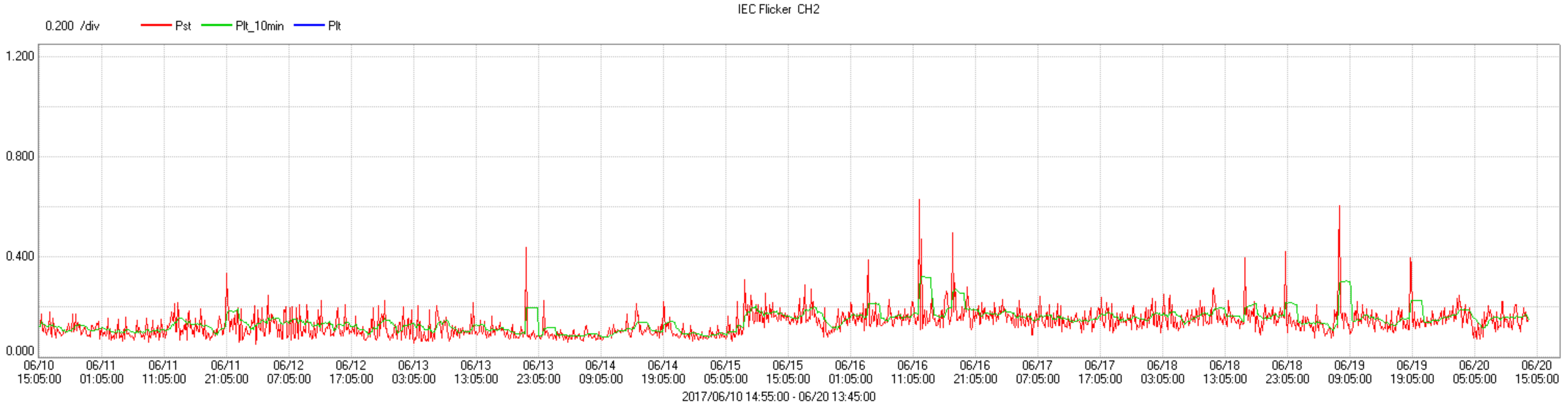

Figure 52 | TC2 - end of feeder – flicker measurements (White Phase)

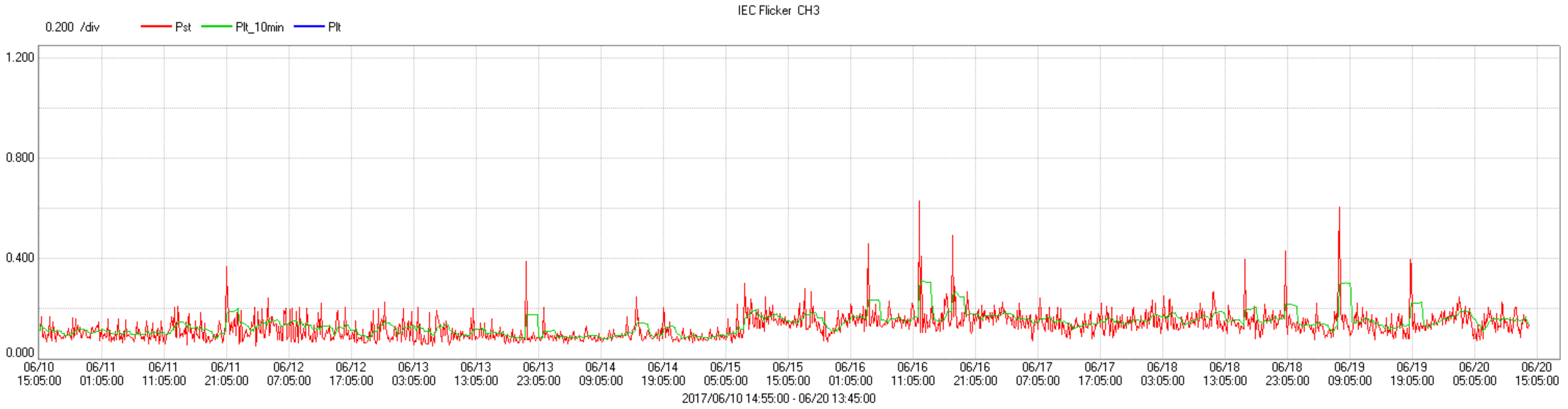

Figure 53 | TC2 - end of feeder – flicker measurements (Blue Phase)

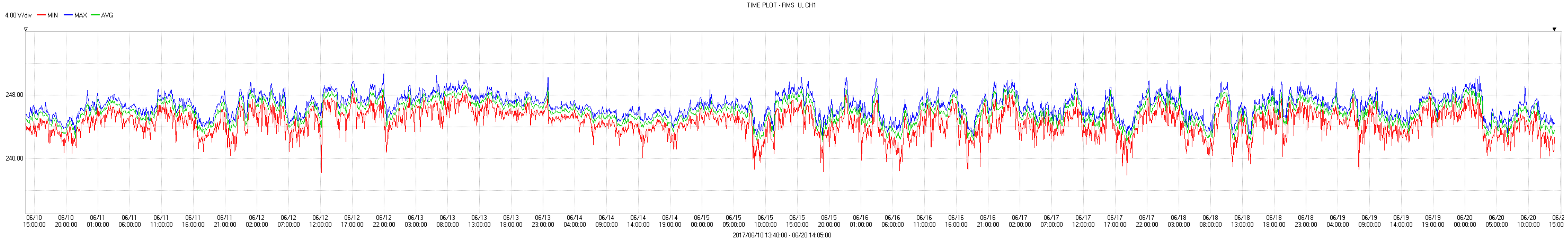

Figure 54 | TC2 - start of feeder – voltage measurements (Red Phase)

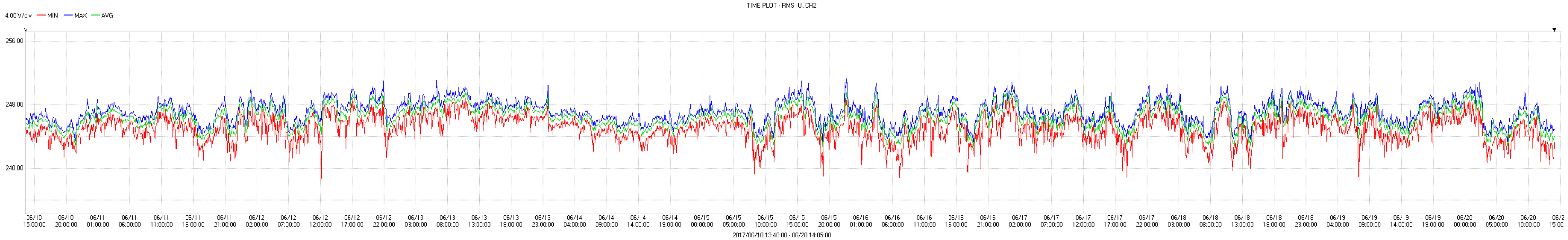

Figure 55 | TC2 - start of feeder – voltage measurements (White Phase)

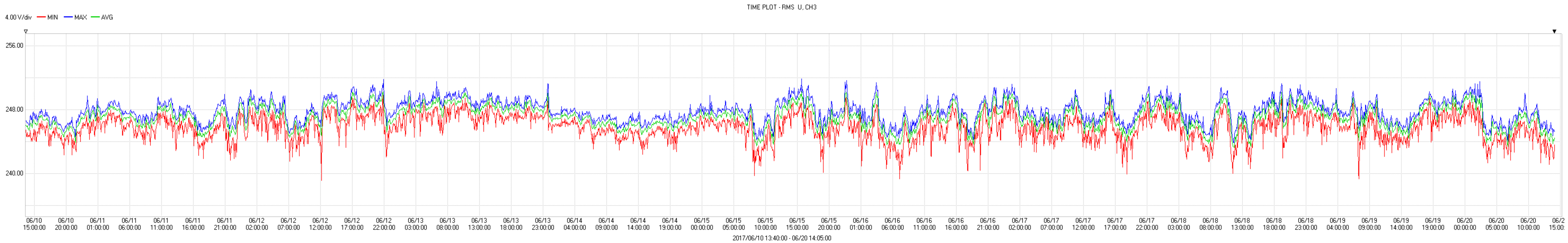

Figure 56 | TC2 - start of feeder – voltage measurements (Blue Phase)

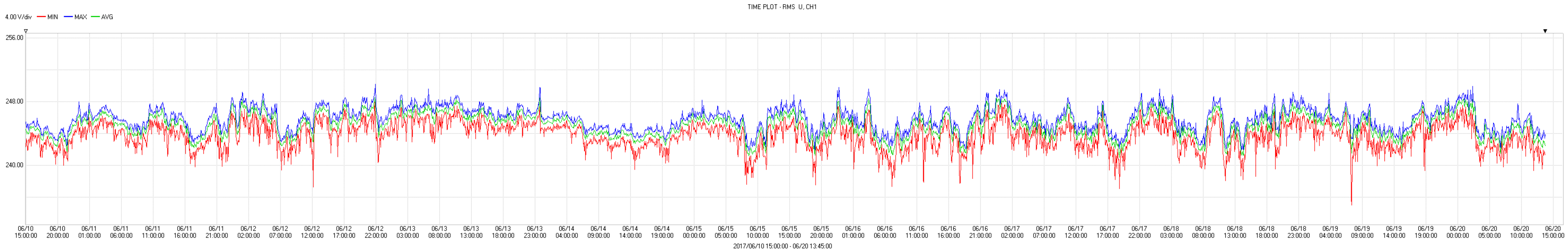

Figure 57 | TC2 - end of feeder – voltage measurements (Red Phase)

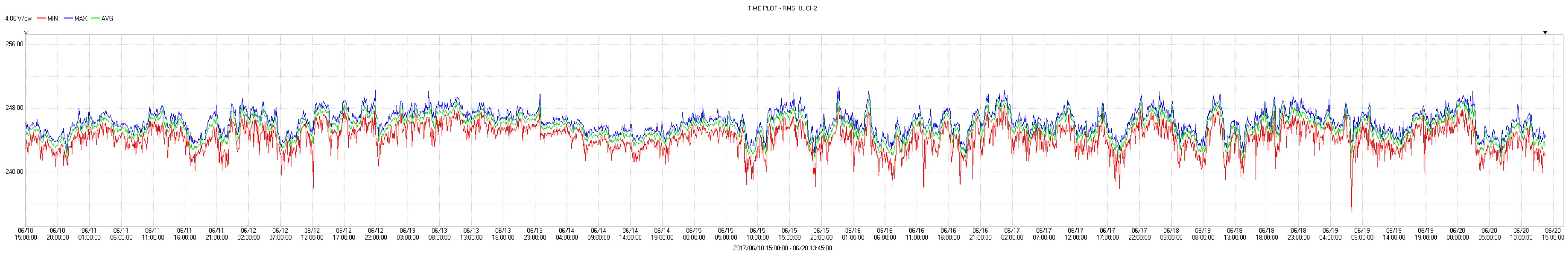

Figure 58 | TC2 - end of feeder – voltage measurements (White Phase)

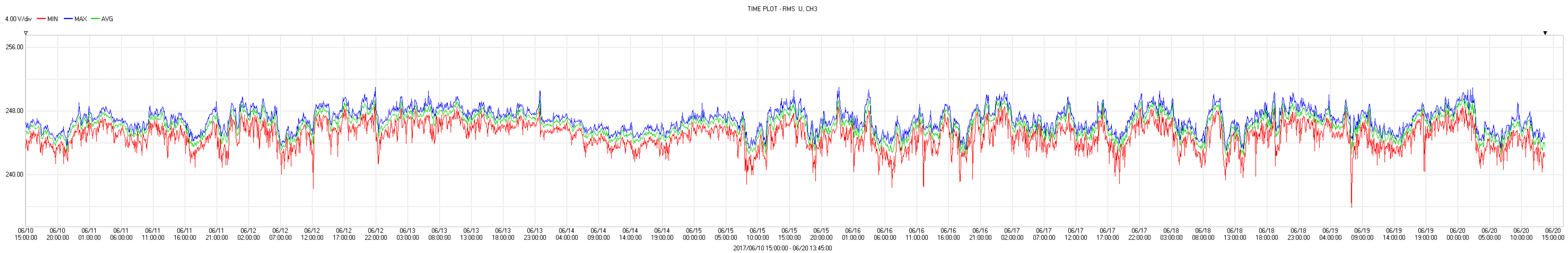

Figure 59 | TC2 - end of feeder – voltage measurements (Blue Phase)

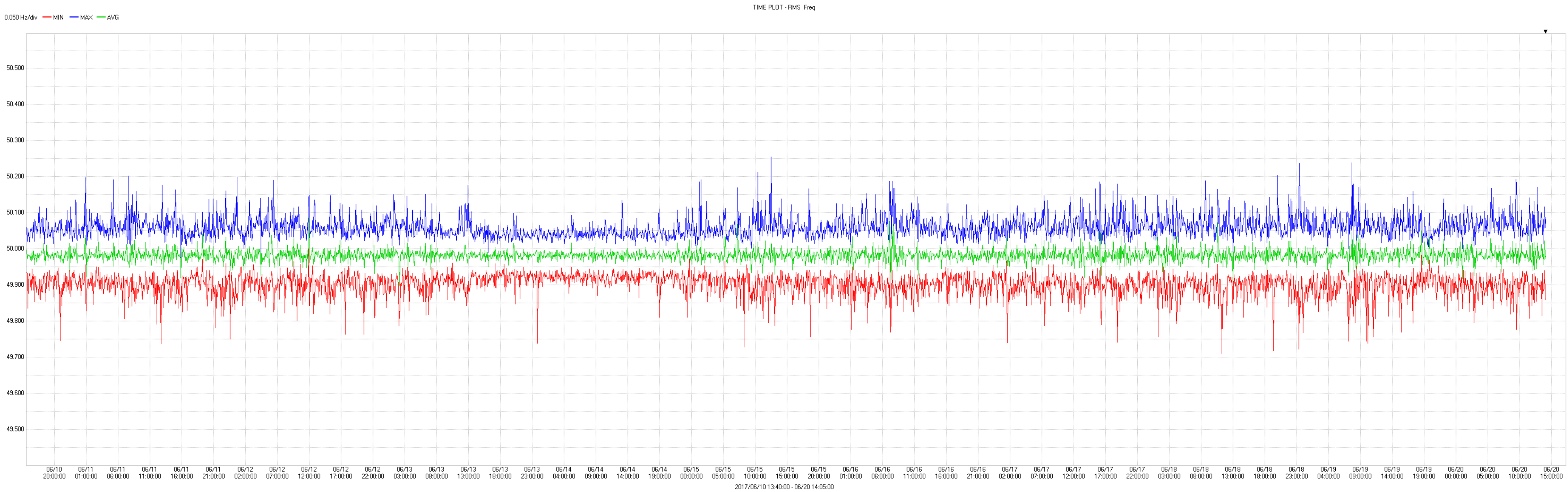

Figure 60 | TC2 - start of feeder – frequency measurements

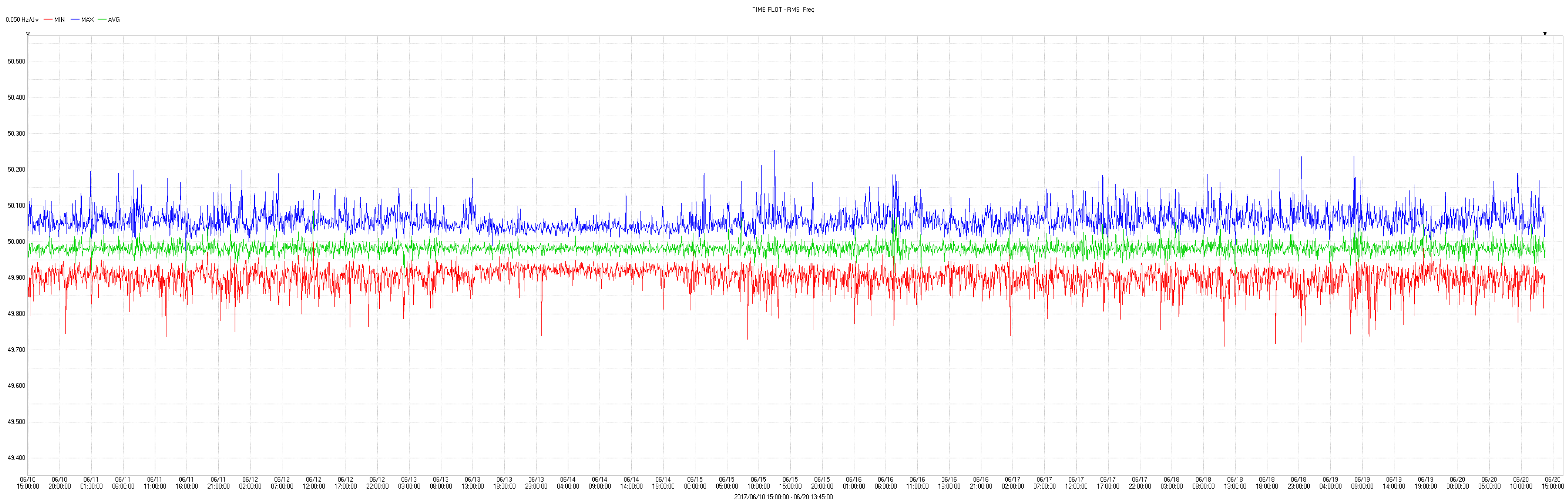

Figure 61 | TC2 - end of feeder – frequency measurements

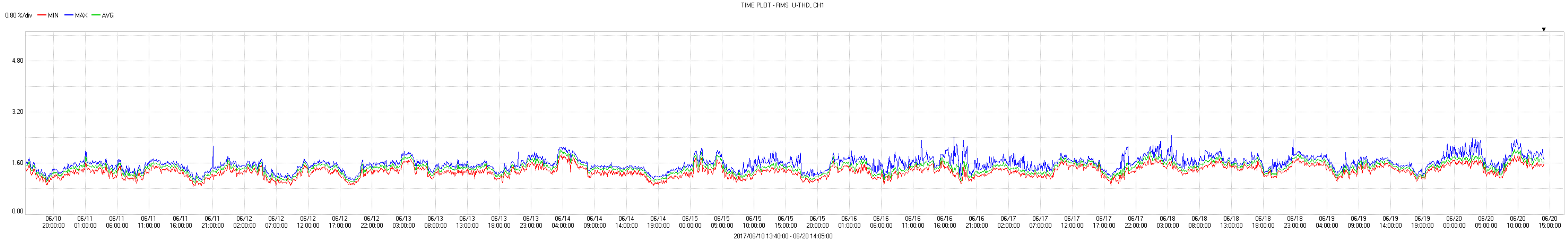

Figure 62 | TC2 - start of feeder – voltage THD measurements (Red Phase)

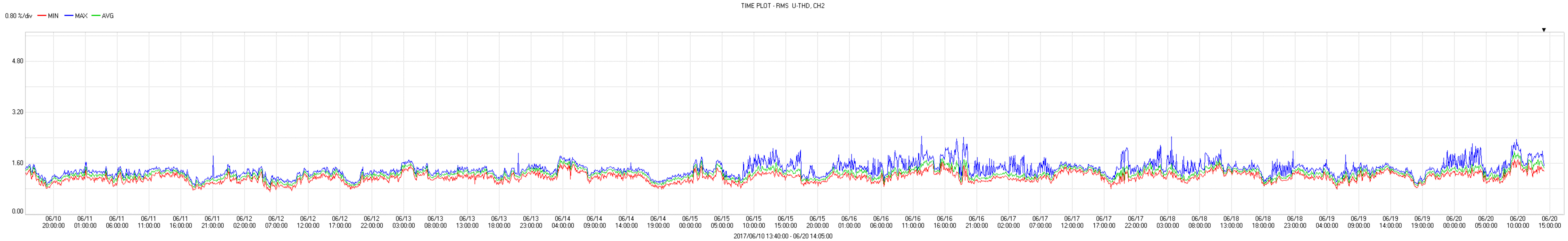

Figure 63 | TC2- start of feeder – voltage THD measurements (White Phase)

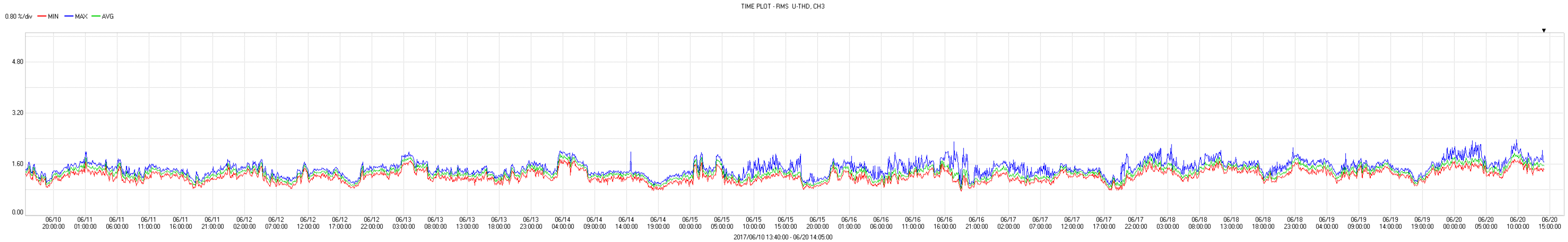

Figure 64 | TC2 - start of feeder – voltage THD measurements (Blue Phase)

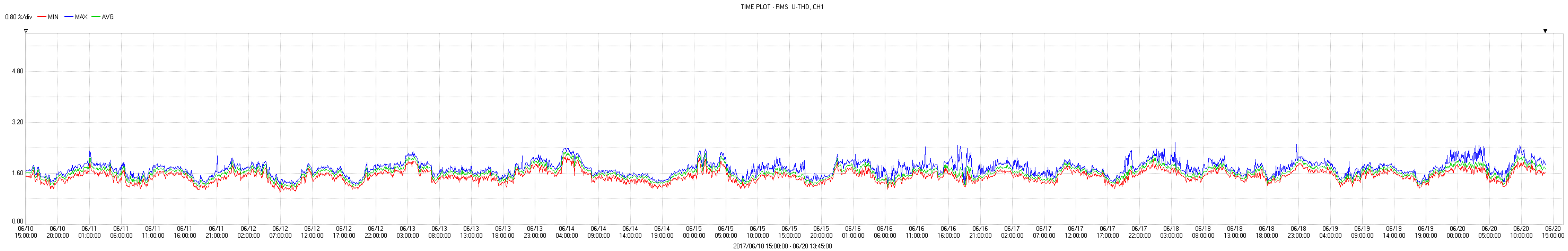

Figure 65 | TC2 - end of feeder – voltage THD measurements (Red Phase)

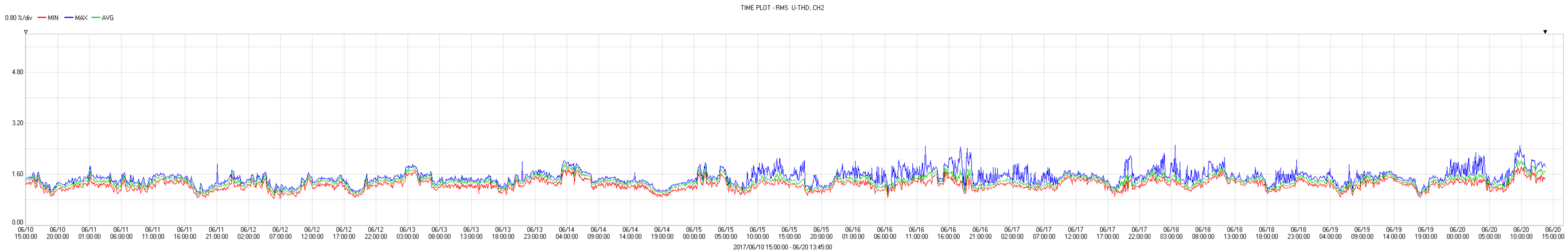

Figure 66 | TC2 - end of feeder – voltage THD measurements (White Phase)

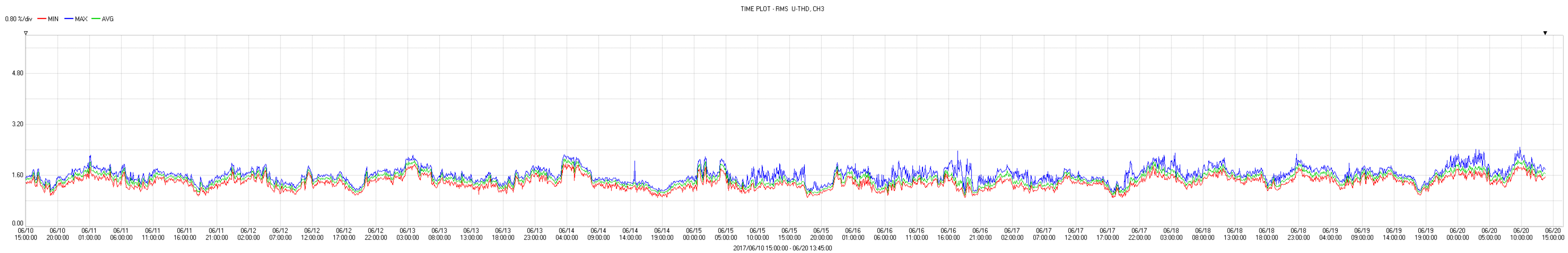

Figure 67 | TC2 - end of feeder – voltage THD measurements (Blue Phase)

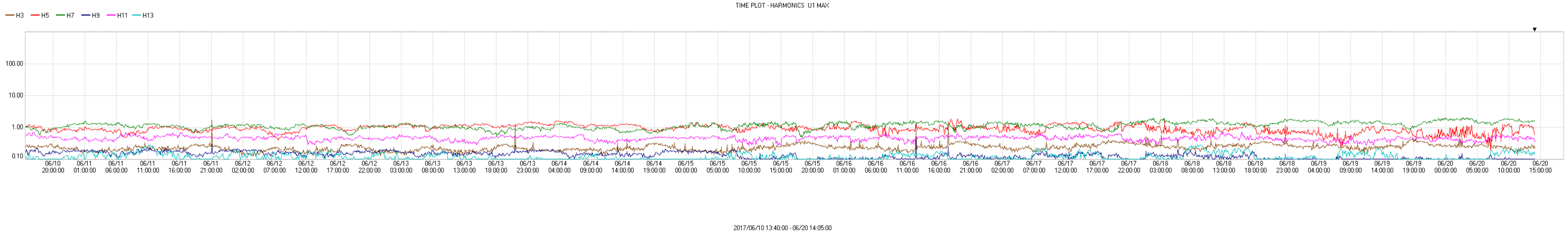

Figure 68 | TC2 – start of feeder – 3rd to 13th (odd) harmonics (Red Phase)

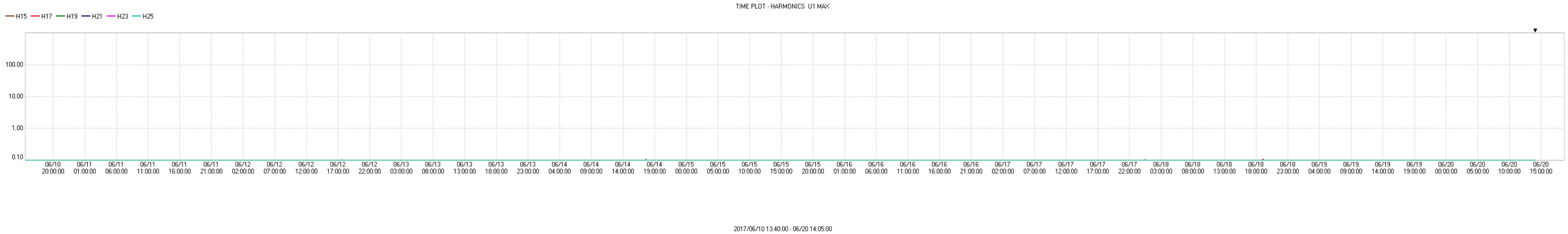

Figure 69 | TC2 – start of feeder – 15th to 25th (odd) harmonics (Red Phase)

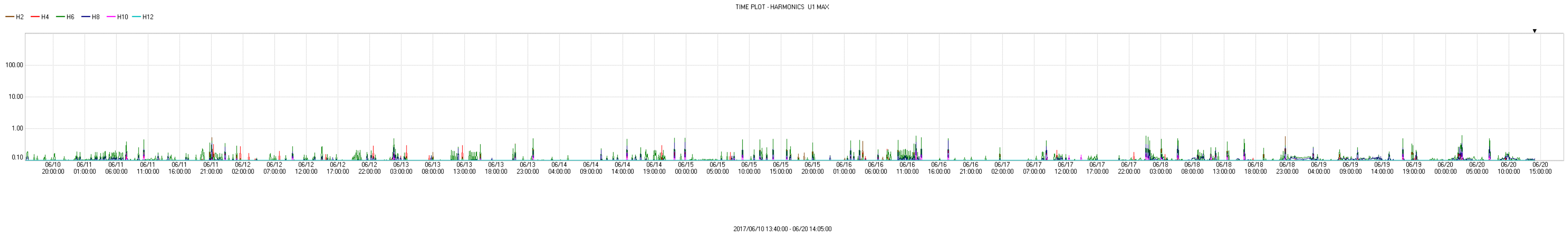

Figure 70 | TC2– start of feeder – 2nd to 12th (even) harmonics (Red Phase)

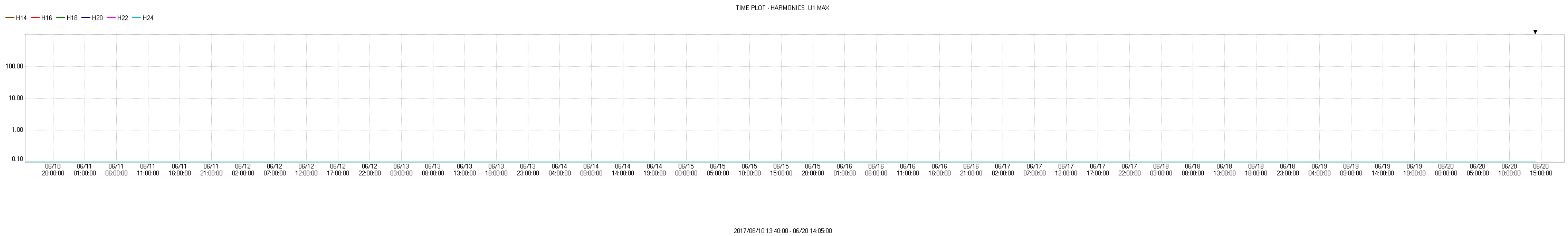

Figure 71 | TC2– start of feeder – 14th to 24th (even) harmonics (Red Phase)

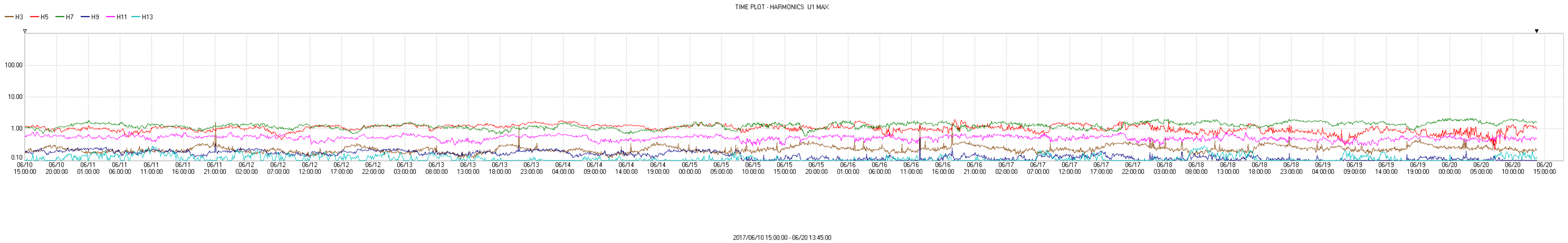

Figure 72 | TC2 – end of feeder – 3rd to 13th (odd) harmonics (Red Phase)

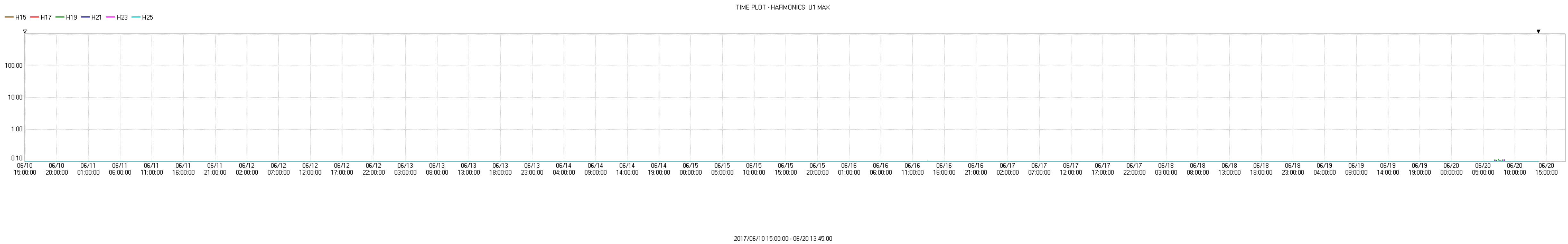

Figure 73 | TC2 – end of feeder – 15th to 25th (odd) harmonics (Red Phase)

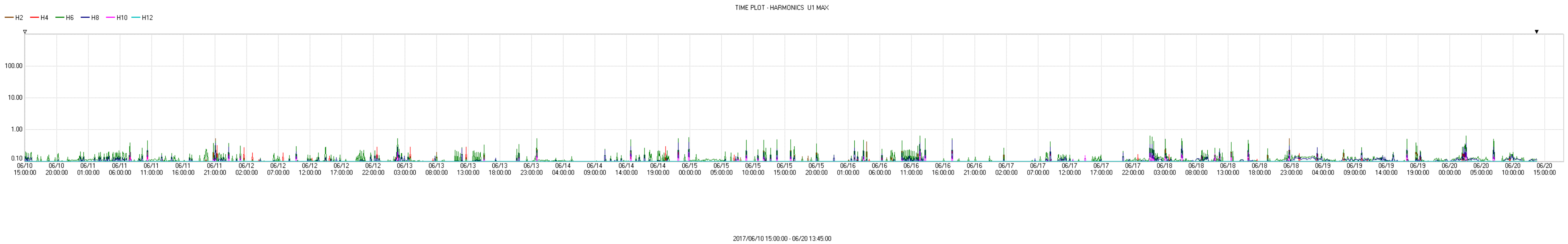

Figure 74 | TC2– end of feeder – 2th to 12th (even) harmonics (Red Phase)

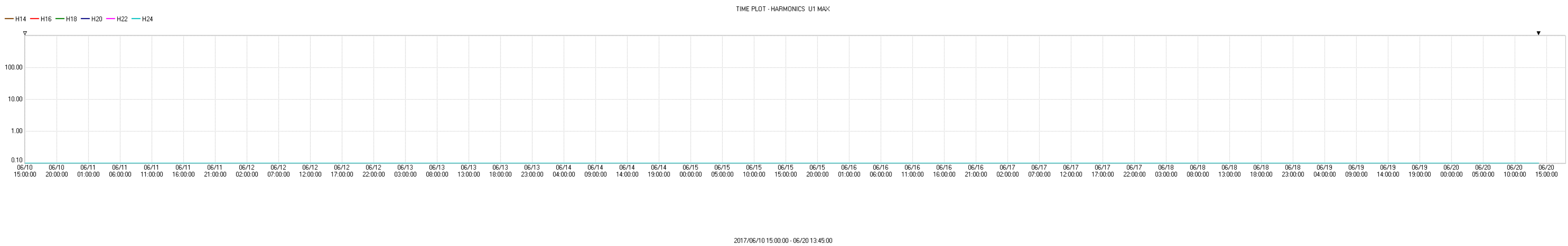

Figure 75 | TC2 – end of feeder – 14th to 24th (even) harmonics (Red Phase)

TC3 Feeder – Flicker, Voltage, Frequency, and Harmonics

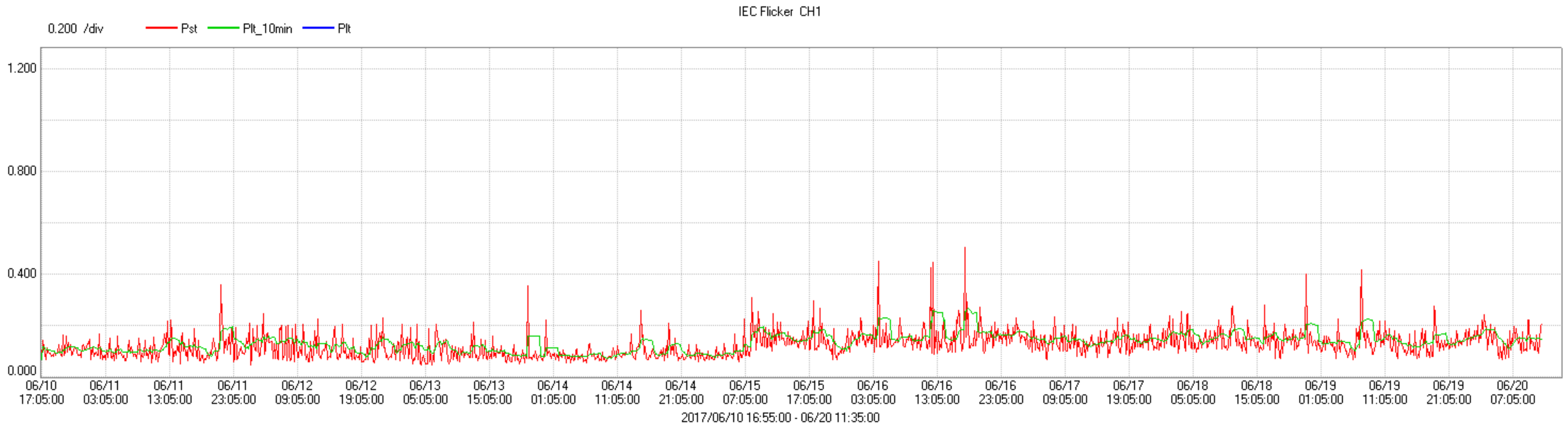

Figure 76 | TC3 - start of feeder – flicker measurements (Red Phase)

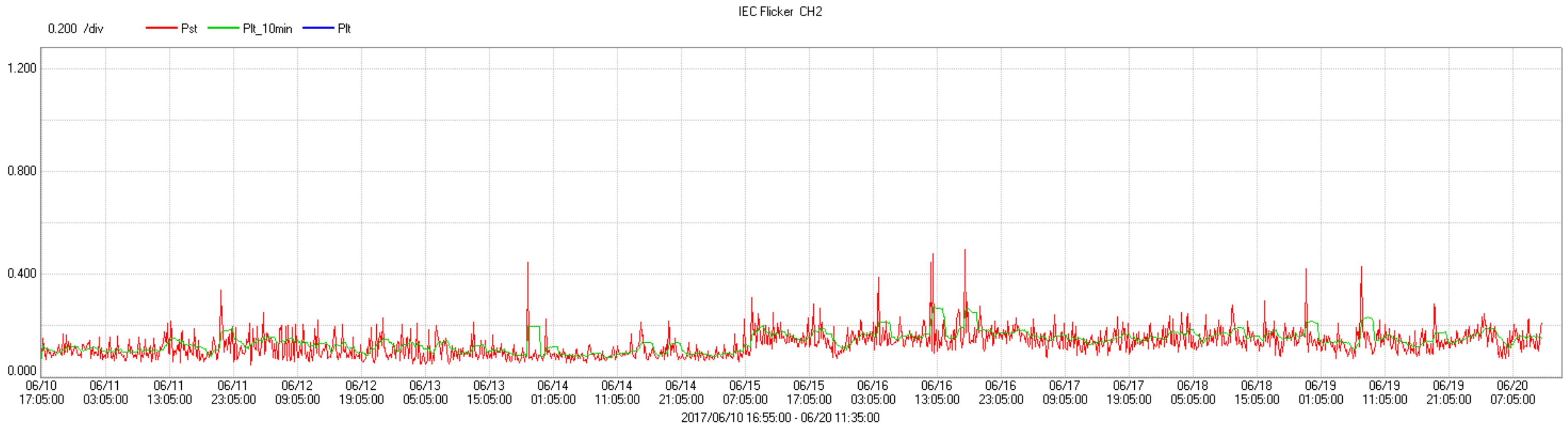

Figure 77 | TC3 - start of feeder – flicker measurements (White Phase)

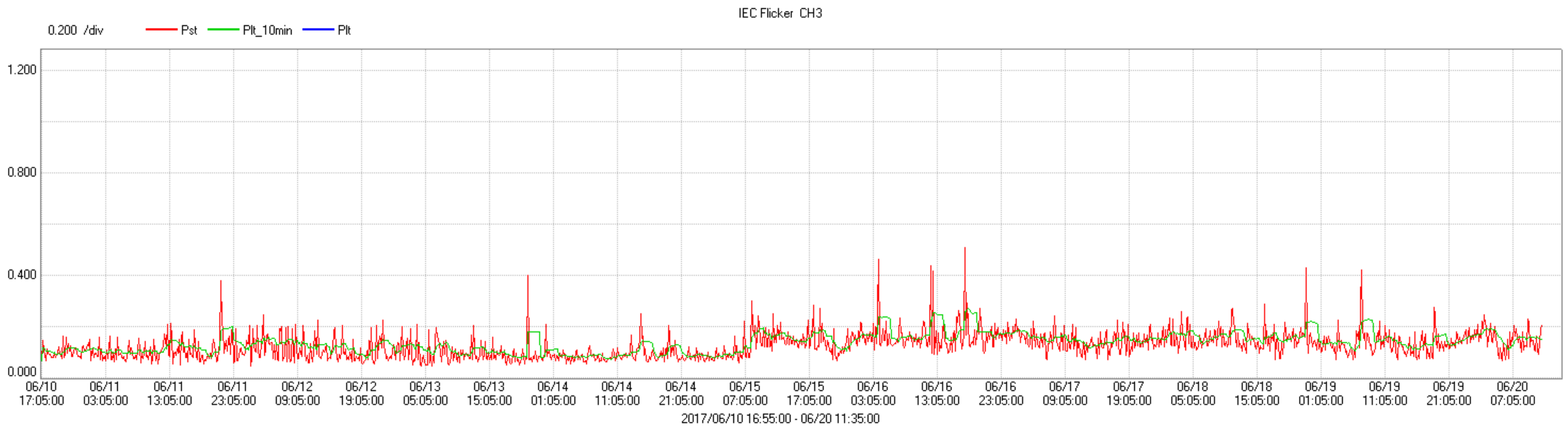

Figure 78 | TC3 - start of feeder – flicker measurements (Blue Phase)

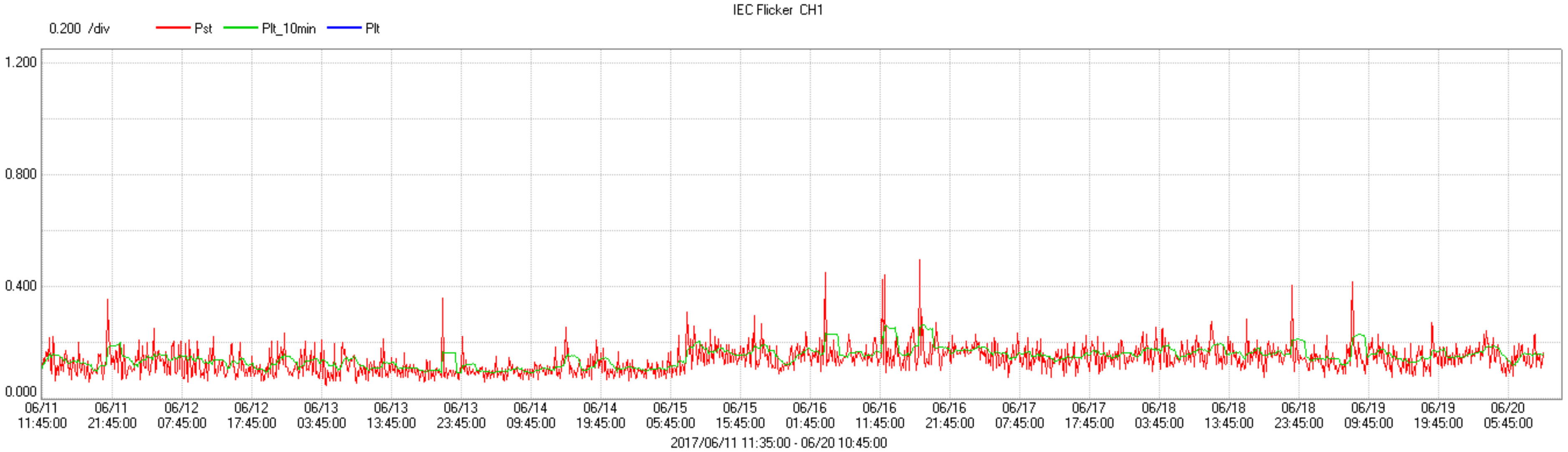

Figure 79 | TC3 – end of feeder – flicker measurements (Red Phase)

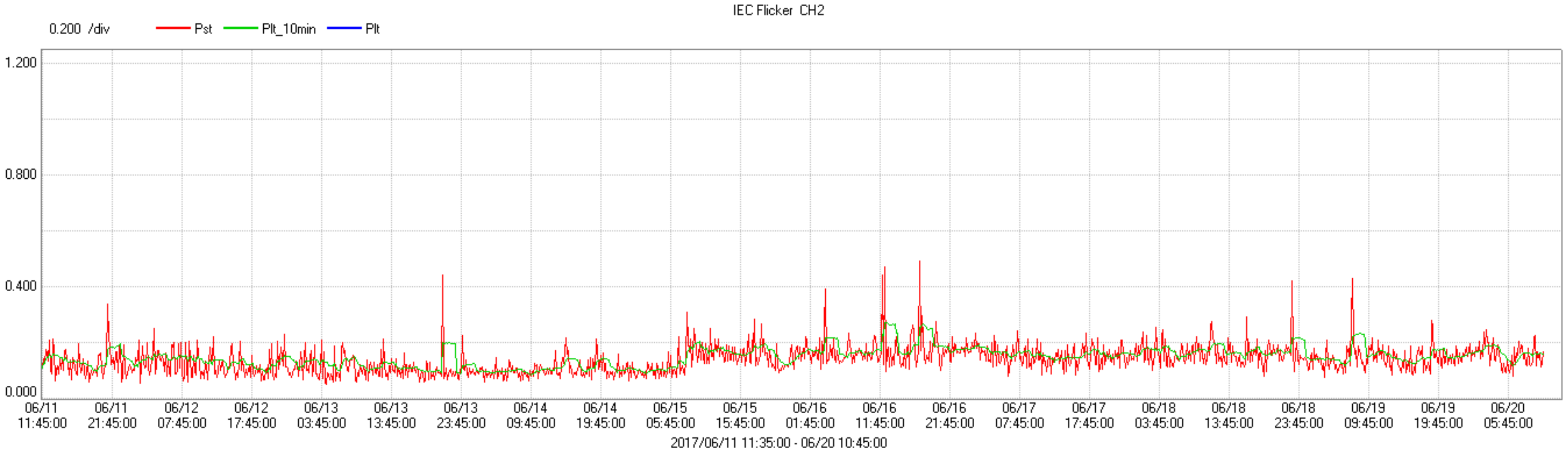

Figure 80 | TC3 - end of feeder – flicker measurements (White Phase)

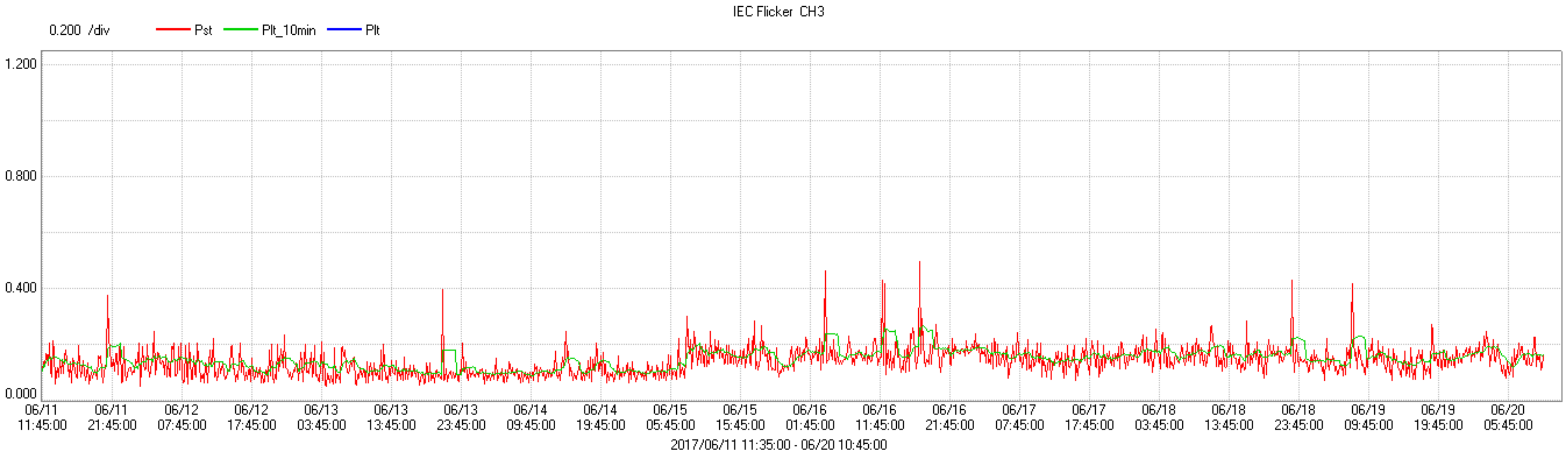

Figure 81 | TC3 - end of feeder – flicker measurements (Blue Phase)

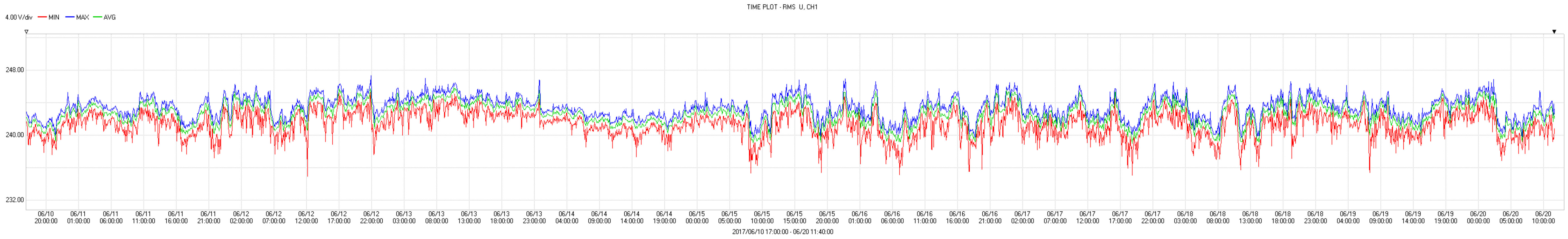

Figure 82 | TC3 - start of feeder – voltage measurements (Red Phase)

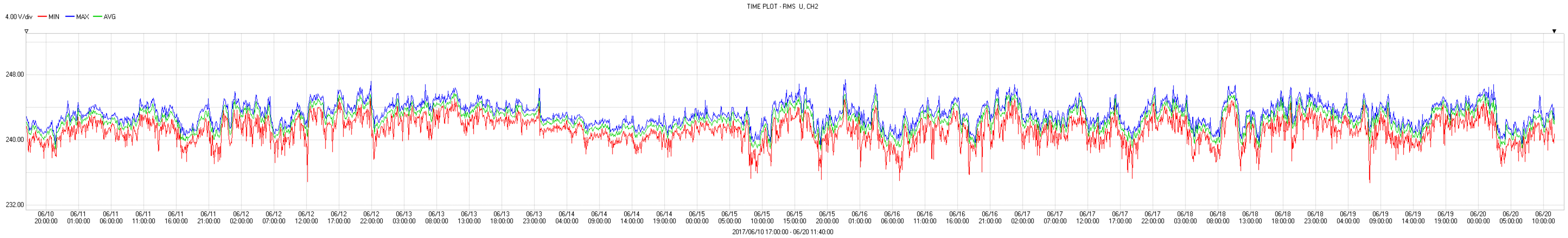

Figure 83 | TC3 - start of feeder – voltage measurements (White Phase)

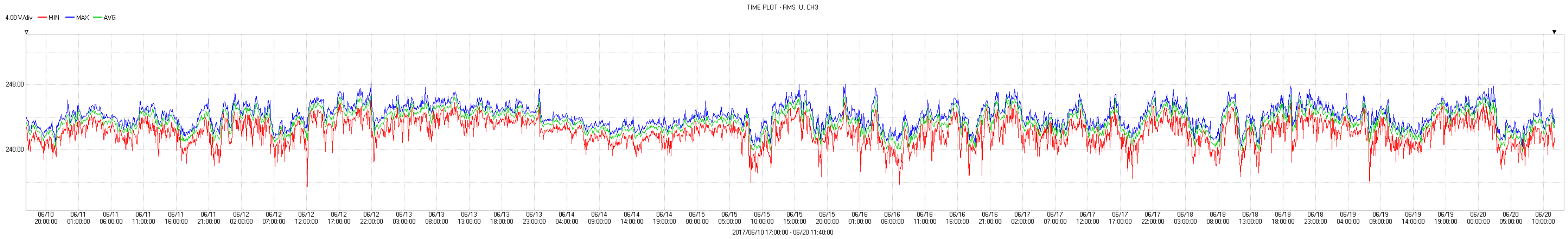

Figure 84 | TC3 - start of feeder – voltage measurements (Blue Phase)

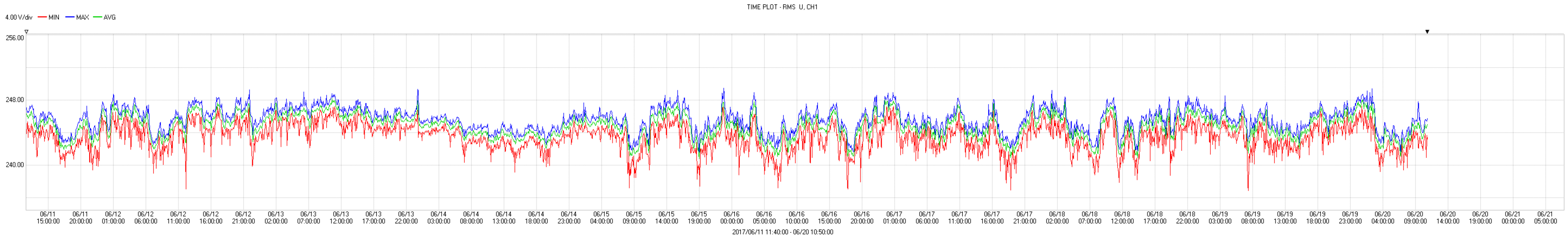

Figure 85 | TC3 - end of feeder – voltage measurements (Red Phase)

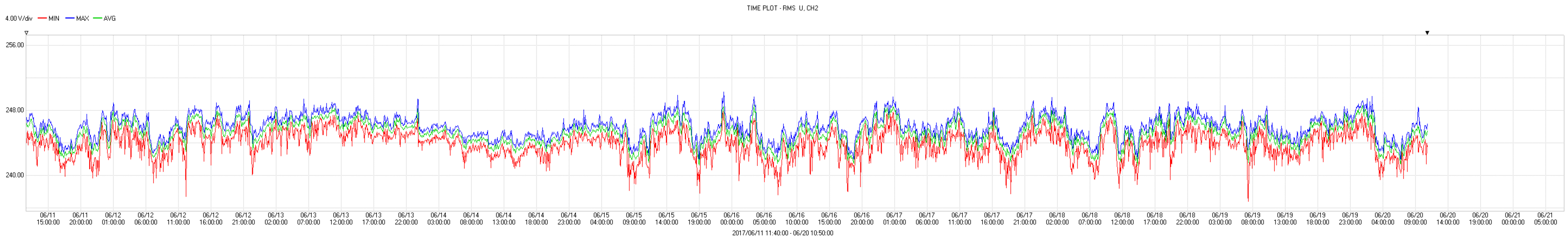

Figure 86 | TC3 - end of feeder – voltage measurements (White Phase)

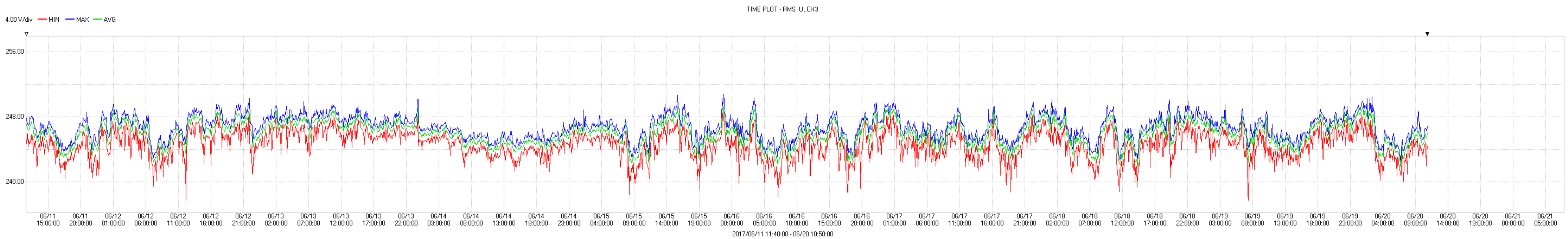

Figure 87 | TC3 - end of feeder – voltage measurements (Blue Phase)

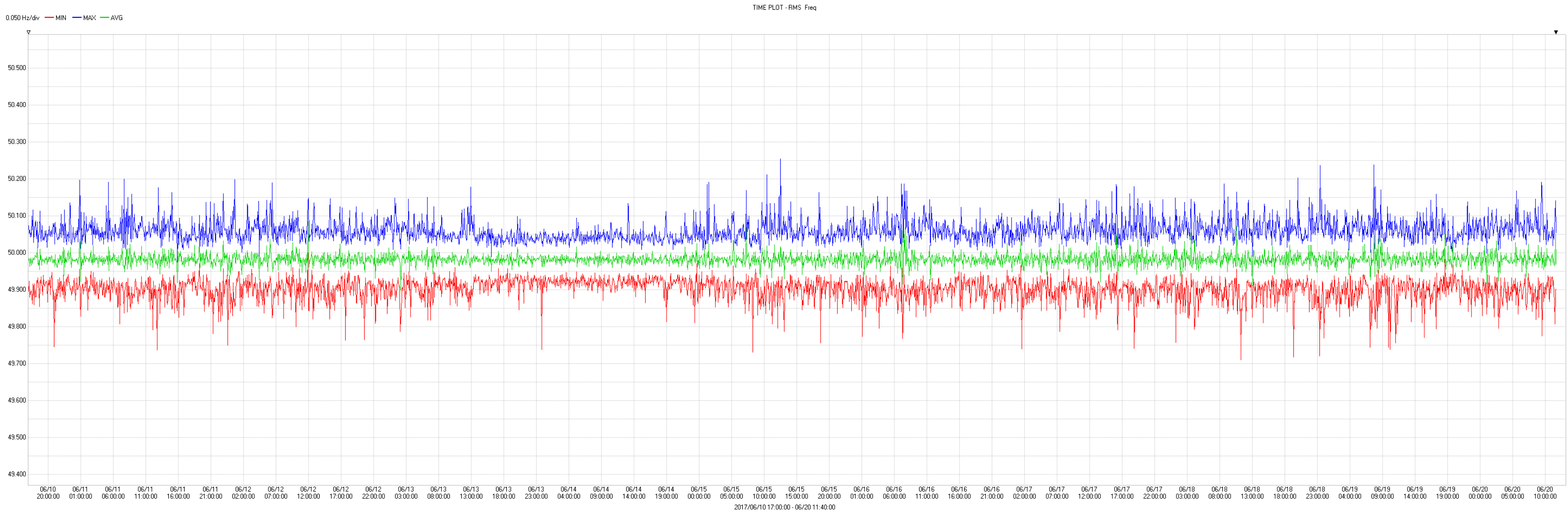

Figure 88 | TC3 - start of feeder – frequency measurements

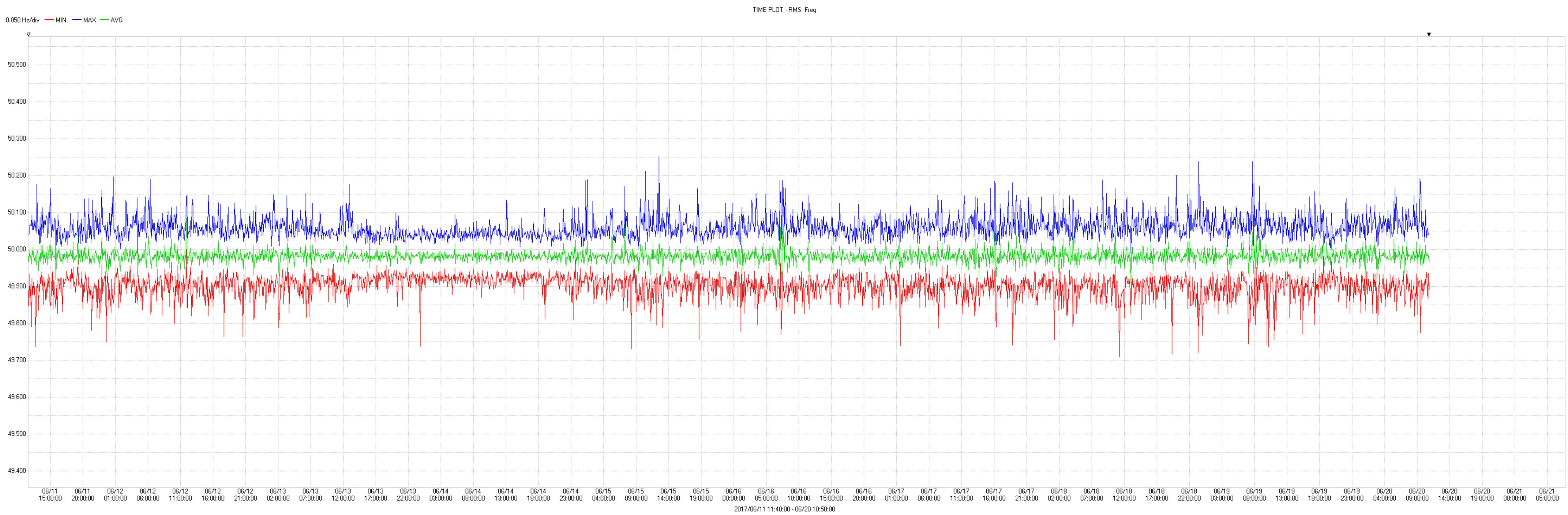

Figure 89 | TC3 - end of feeder – frequency measurements

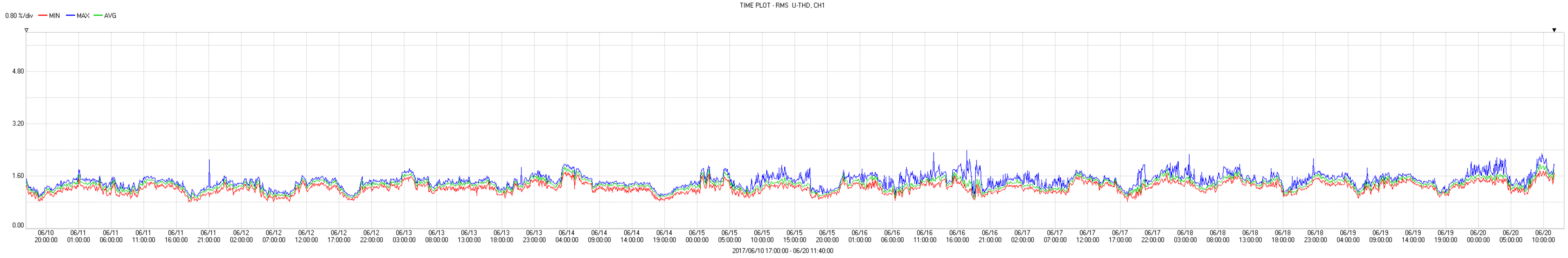

Figure 90 | TC3 - start of feeder – voltage THD measurements (Red Phase)

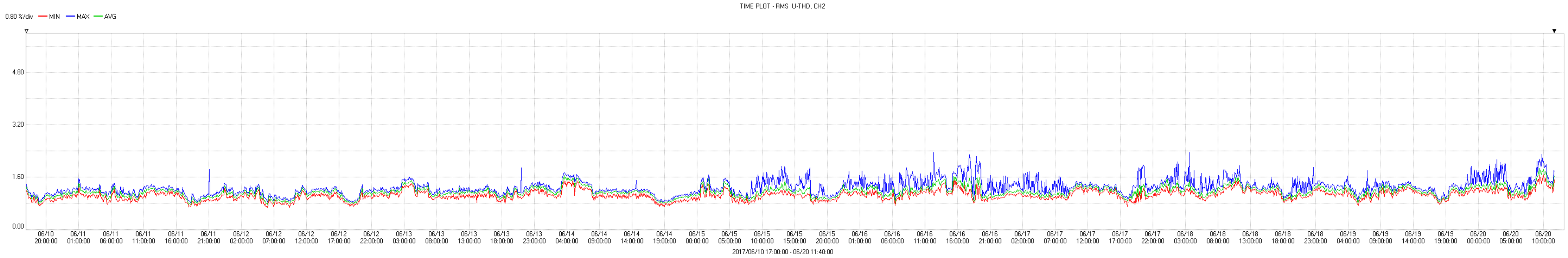

Figure 91 | TC3- start of feeder – voltage THD measurements (White Phase)

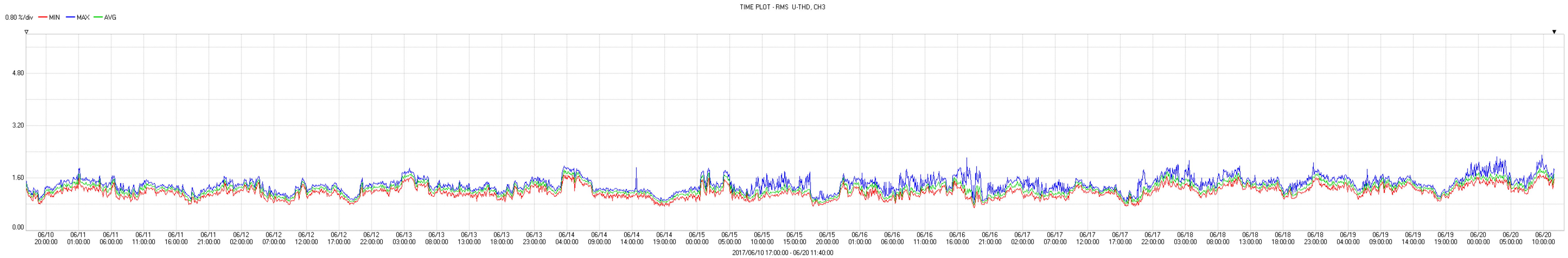

Figure 92 | TC3 - start of feeder – voltage THD measurements (Blue Phase)

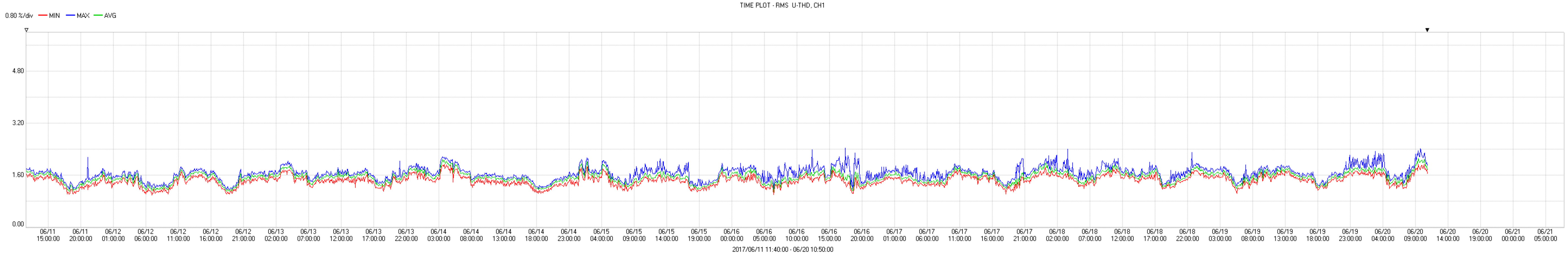

Figure 93 | TC3 - end of feeder – voltage THD measurements (Red Phase)

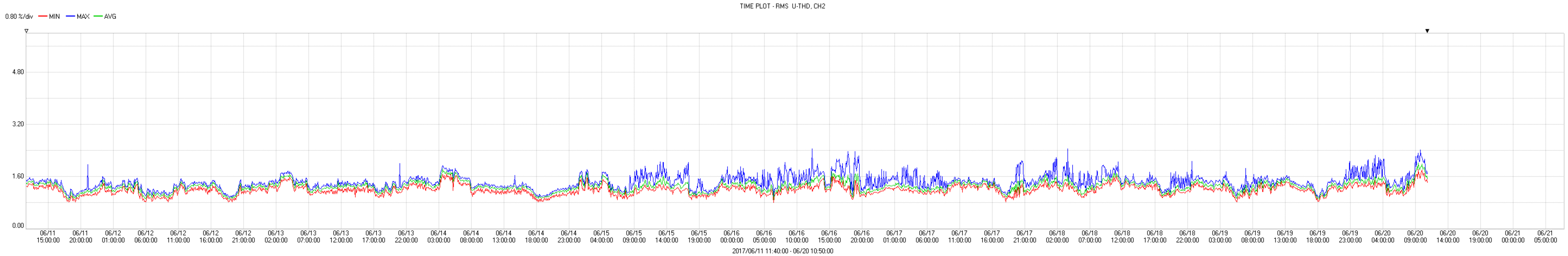

Figure 94 | TC3 - end of feeder – voltage THD measurements (White Phase)

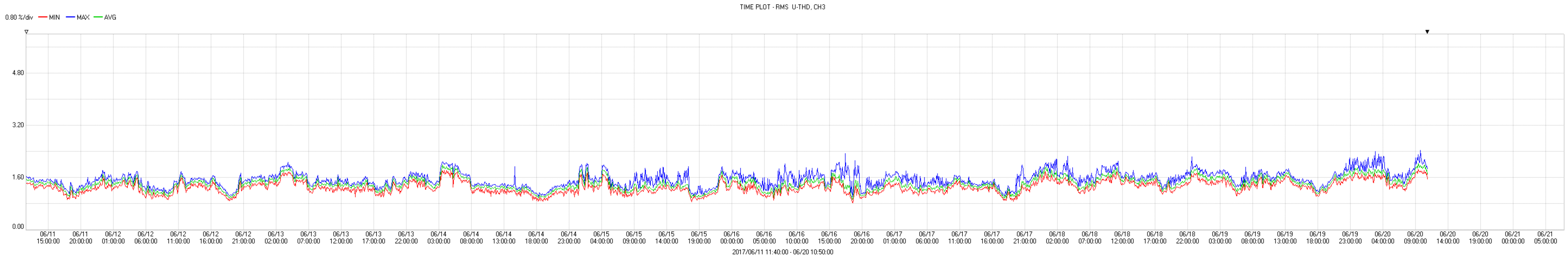

Figure 95 | TC3 - end of feeder – voltage THD measurements (Blue Phase)

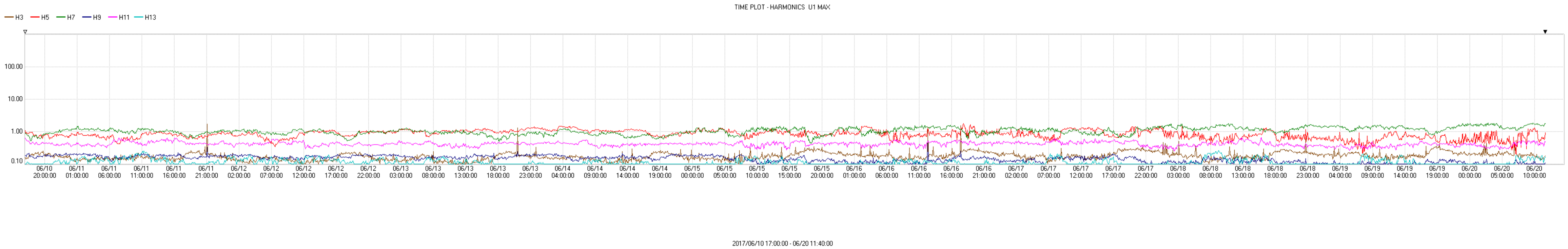

Figure 96 | TC3 – start of feeder – 3rd to 13th (odd) harmonics (Red Phase)

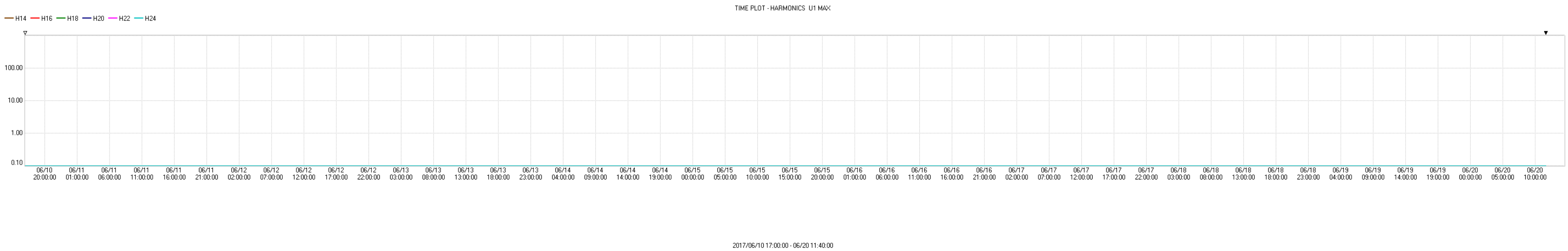

Figure 97 | TC3 – start of feeder – 15th to 25th (odd) harmonics (Red Phase)

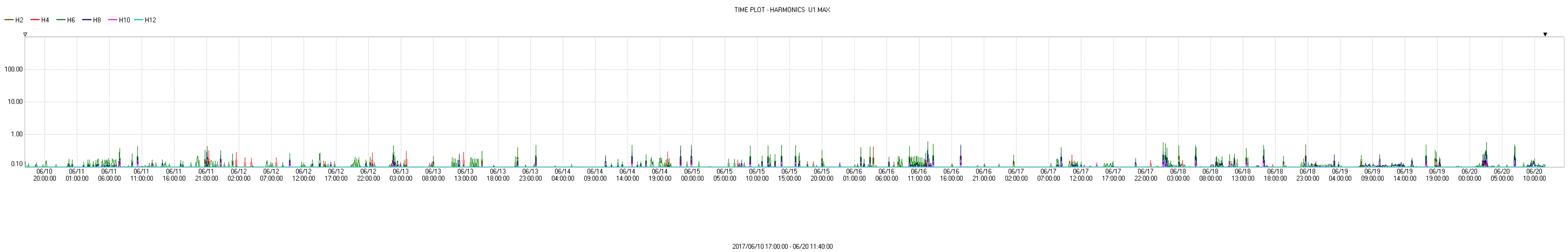

Figure 98 | TC3– start of feeder – 2th to 12th (even) harmonics (Red Phase)

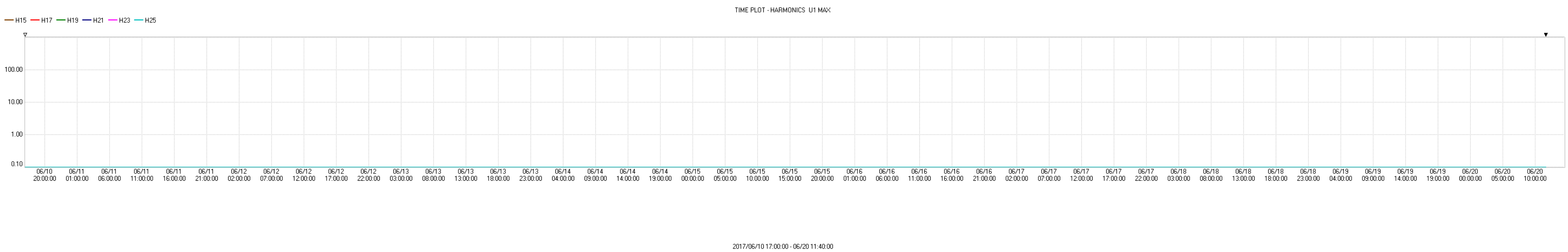

Figure 99 | TC3– start of feeder – 14th to 24th (even) harmonics (Red Phase)

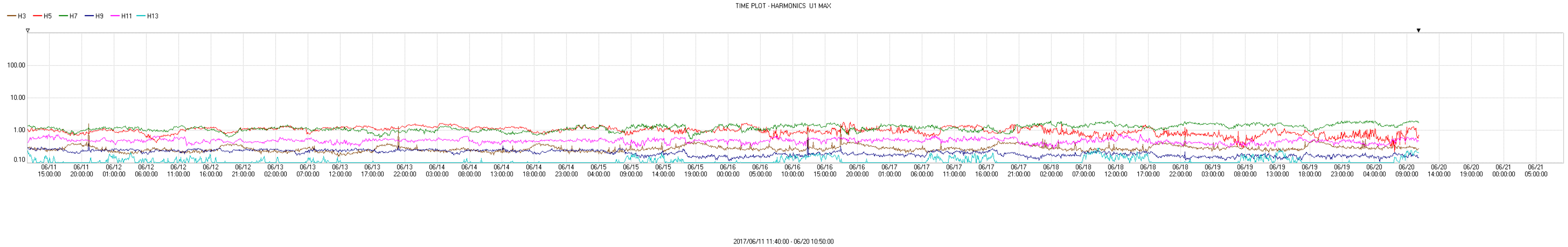

Figure 100 | TC3 – end of feeder – 3rd to 13th (odd) harmonics (Red Phase)

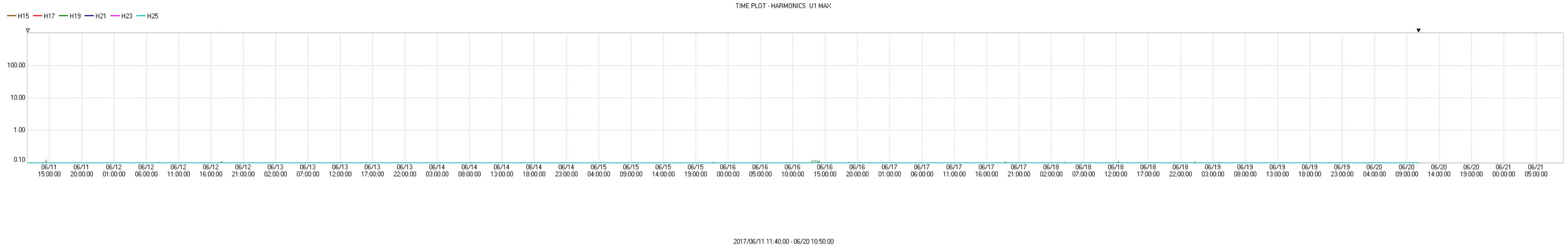

Figure 101 | TC3 – end of feeder – 15th to 25th (odd) harmonics (Red Phase)

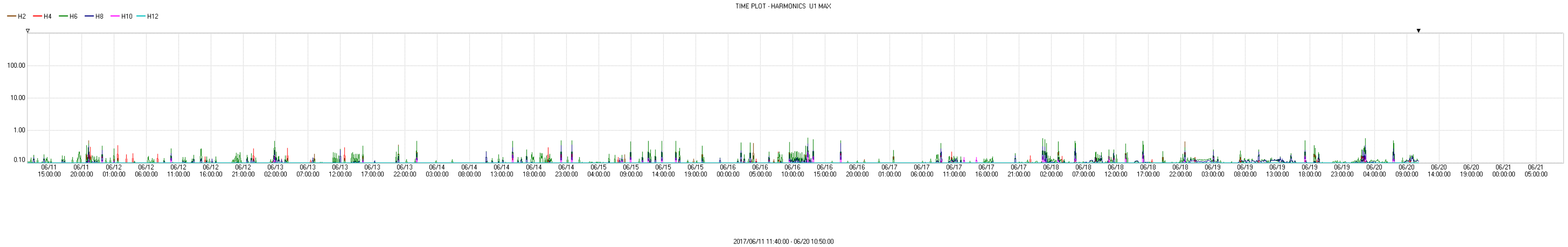

Figure 102 | TC3– end of feeder – 2th to 12th (even) harmonics (Red Phase)

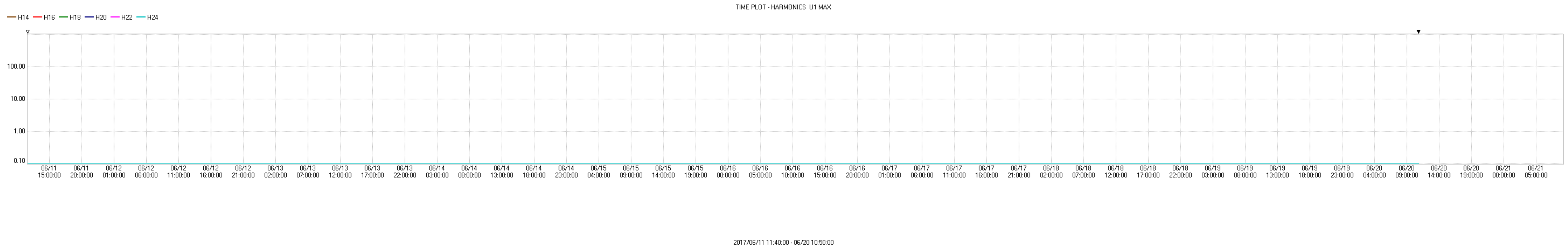

Figure 103 | TC3 – end of feeder – 14th to 24th (even) harmonics (Red Phase)

TC4 Feeder – Flicker, Voltage, Frequency, and Harmonics

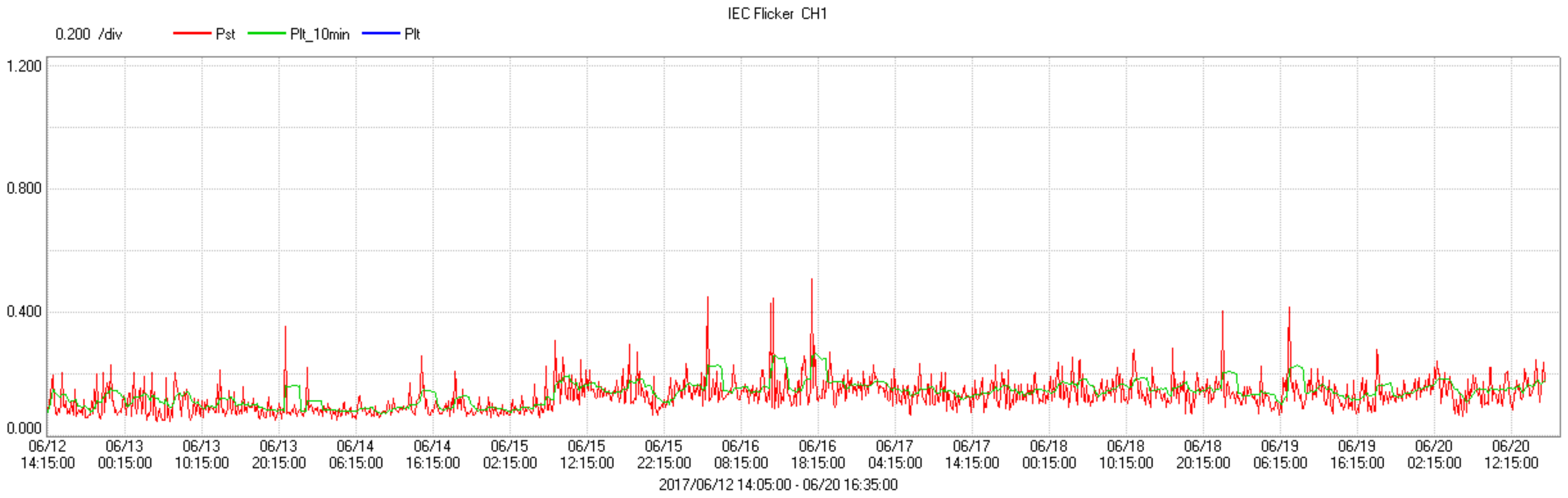

Figure 104 | TC4 - start of feeder – flicker measurements (Red Phase)

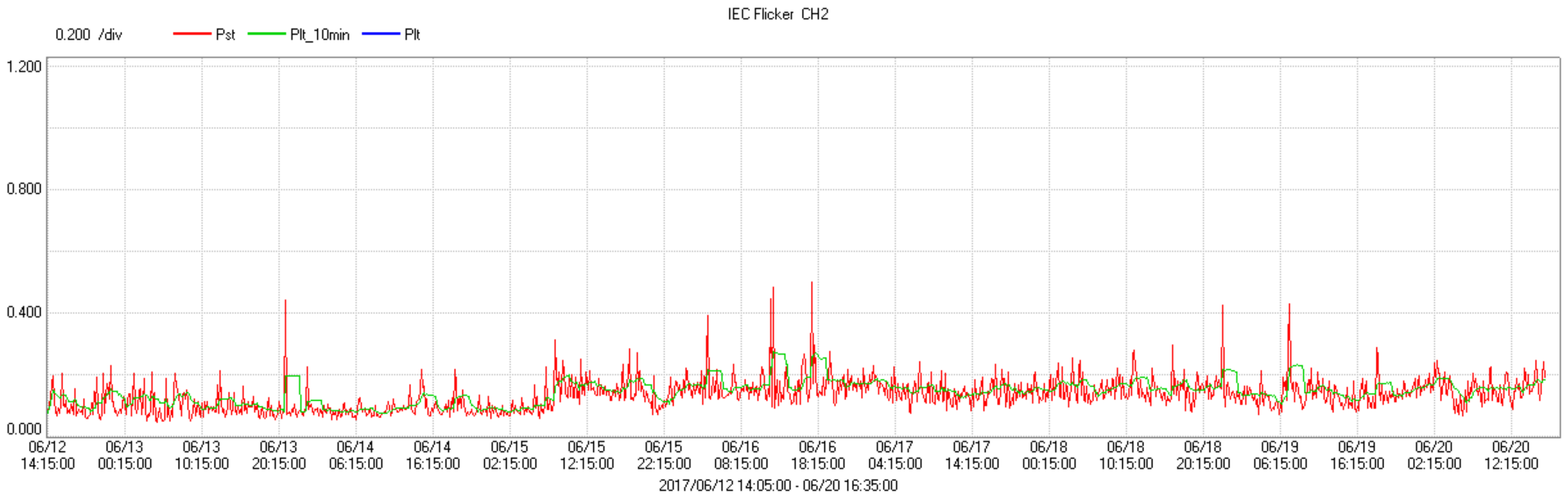

Figure 105 | TC4 - start of feeder – flicker measurements (White Phase)

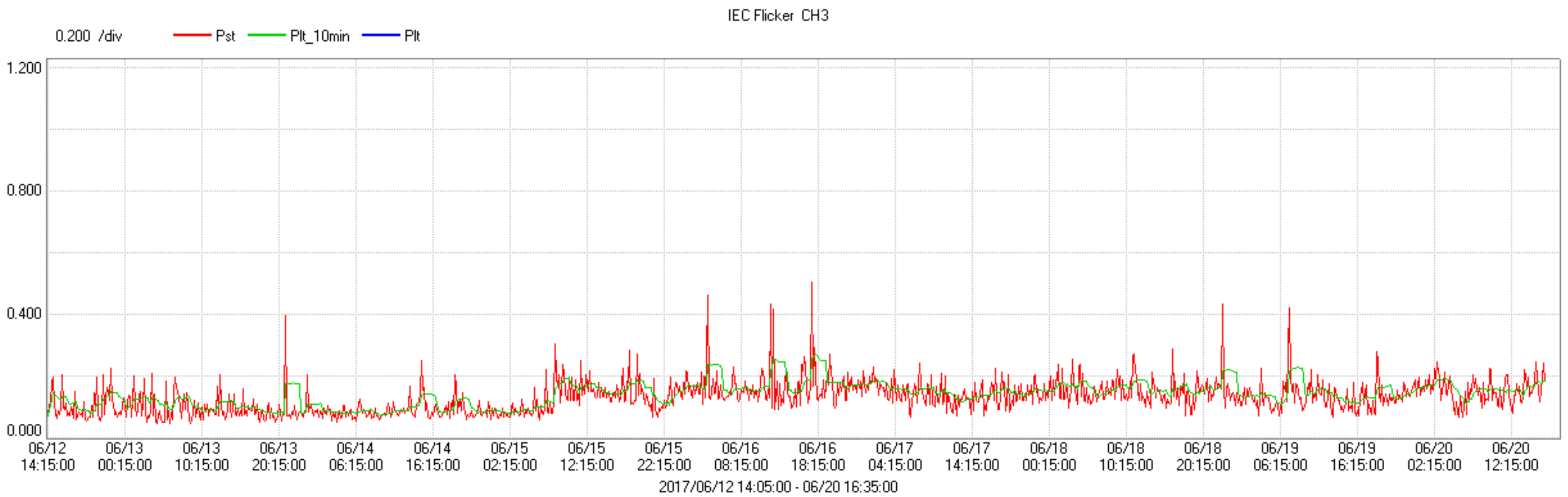

Figure 106 | TC4 - start of feeder – flicker measurements (Blue Phase)

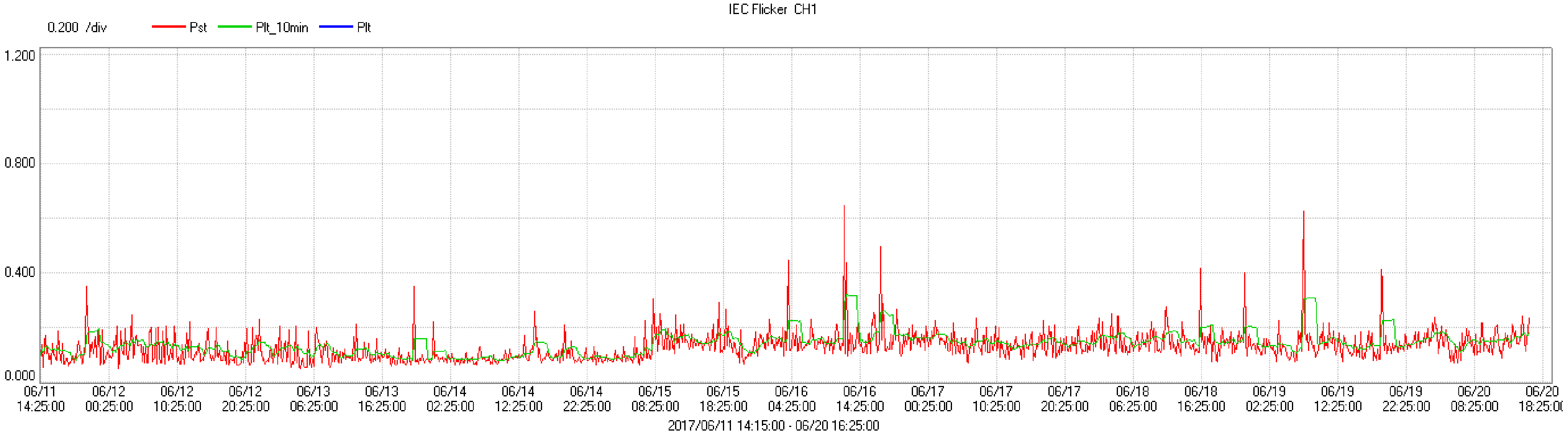

Figure 107 | TC4 – end of feeder – flicker measurements (Red Phase)

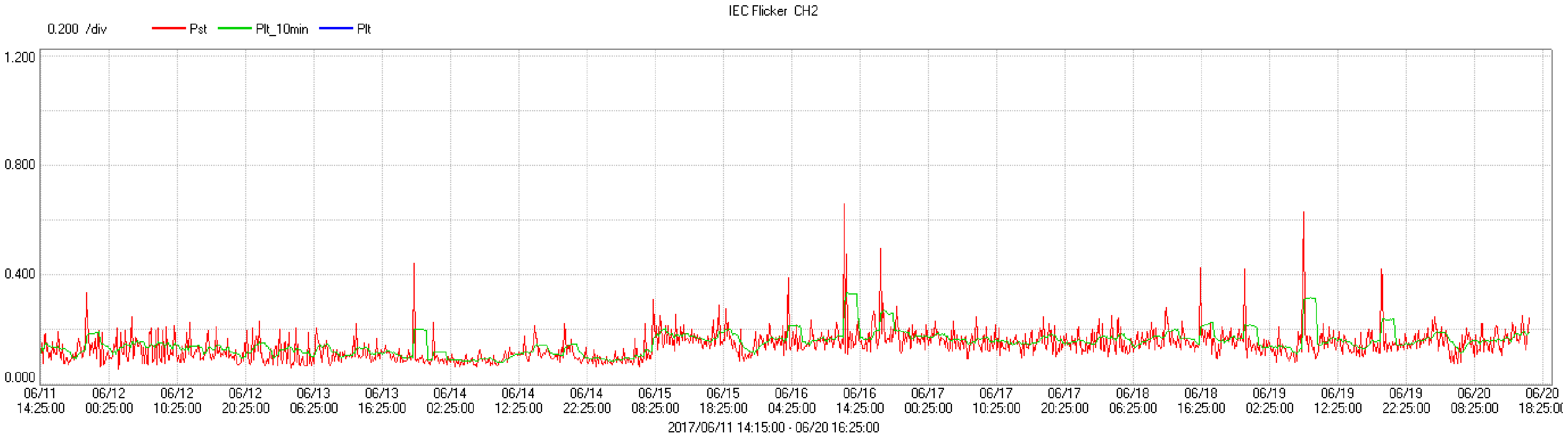

Figure 108 | TC4 - end of feeder – flicker measurements (White Phase)

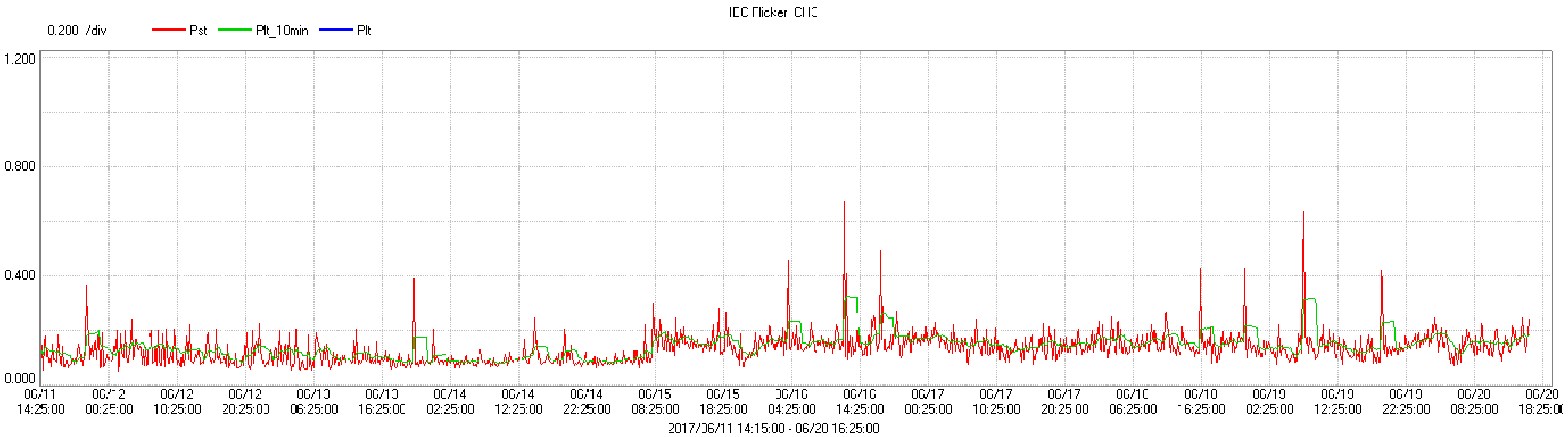

Figure 109 | TC4 - end of feeder – flicker measurements (Blue Phase)

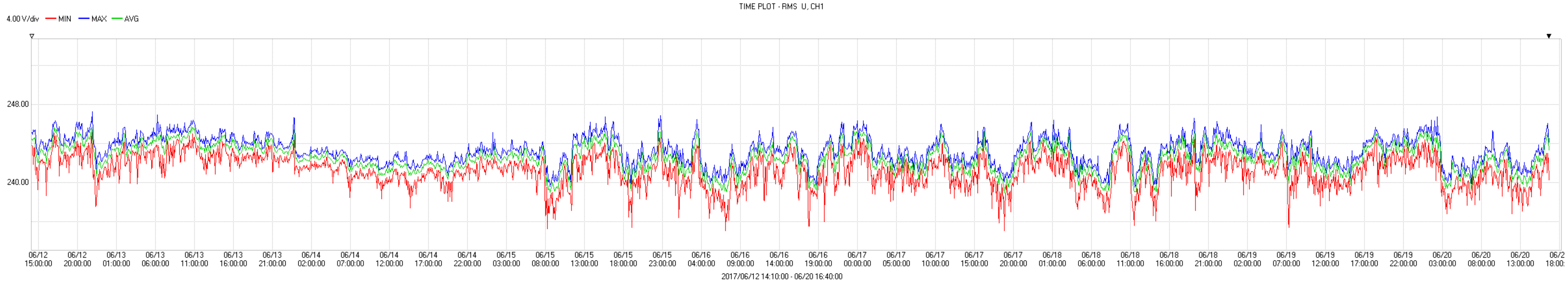

Figure 110 | TC4 - start of feeder – voltage measurements (Red Phase)

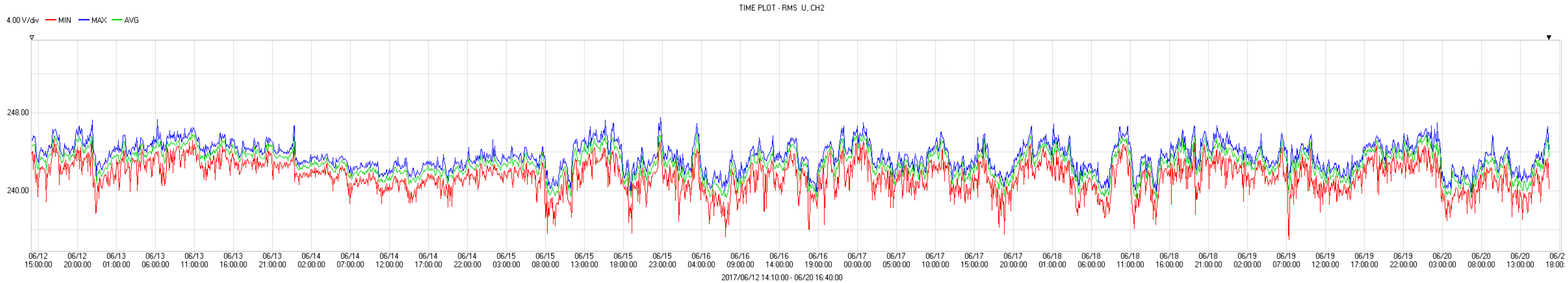

Figure 111 | TC4 - start of feeder – voltage measurements (White Phase)

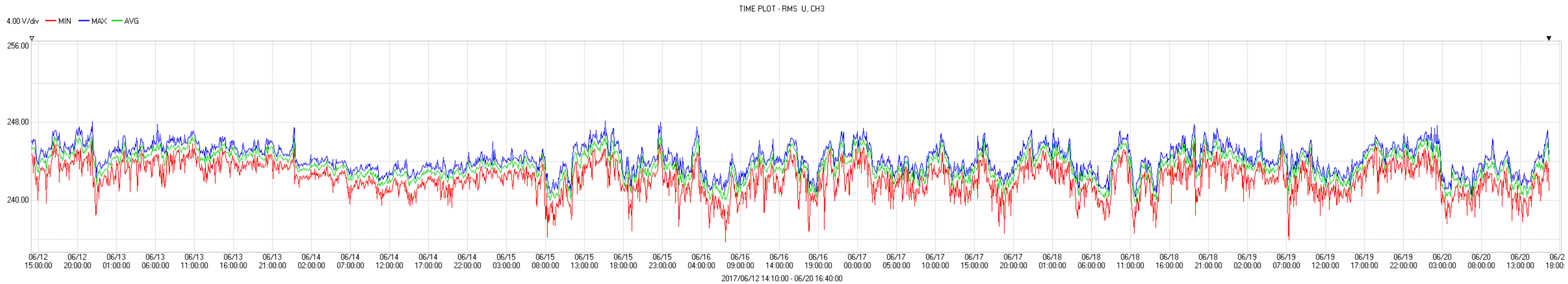

Figure 112 | TC4 - start of feeder – voltage measurements (Blue Phase)

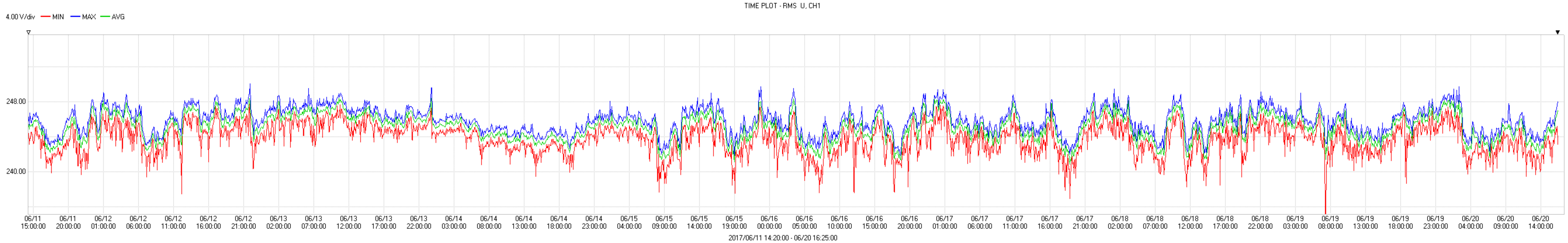

Figure 113 | TC4 - end of feeder – voltage measurements (Red Phase)

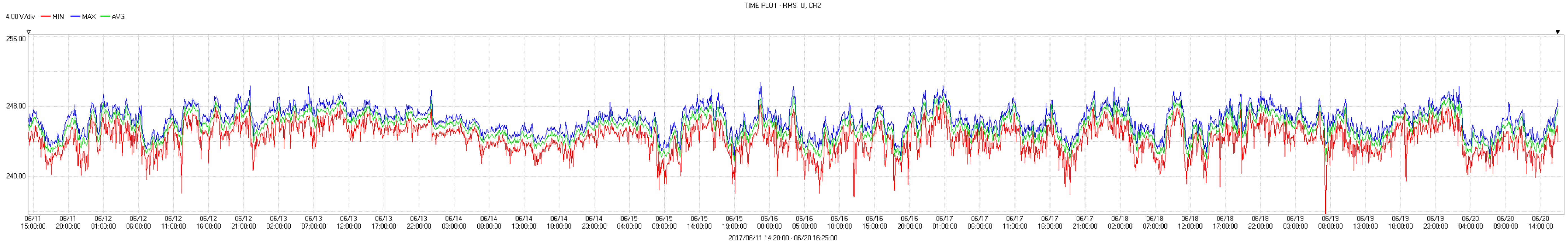

Figure 114 | TC4 - end of feeder – voltage measurements (White Phase)

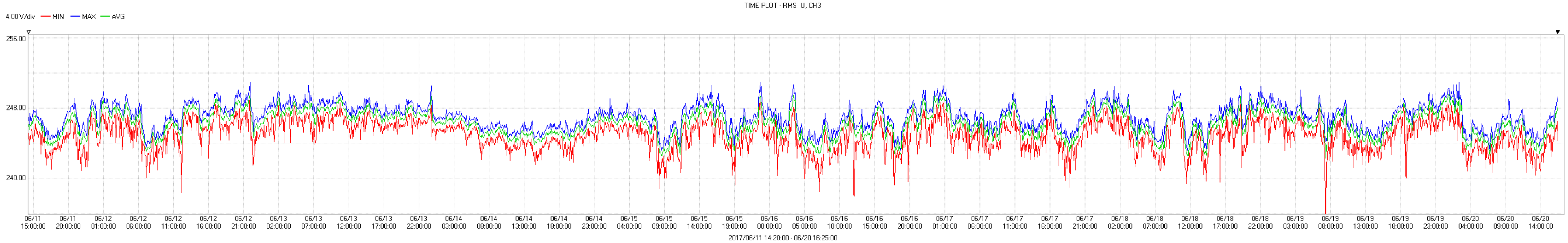

Figure 115 | TC4 - end of feeder – voltage measurements (Blue Phase)

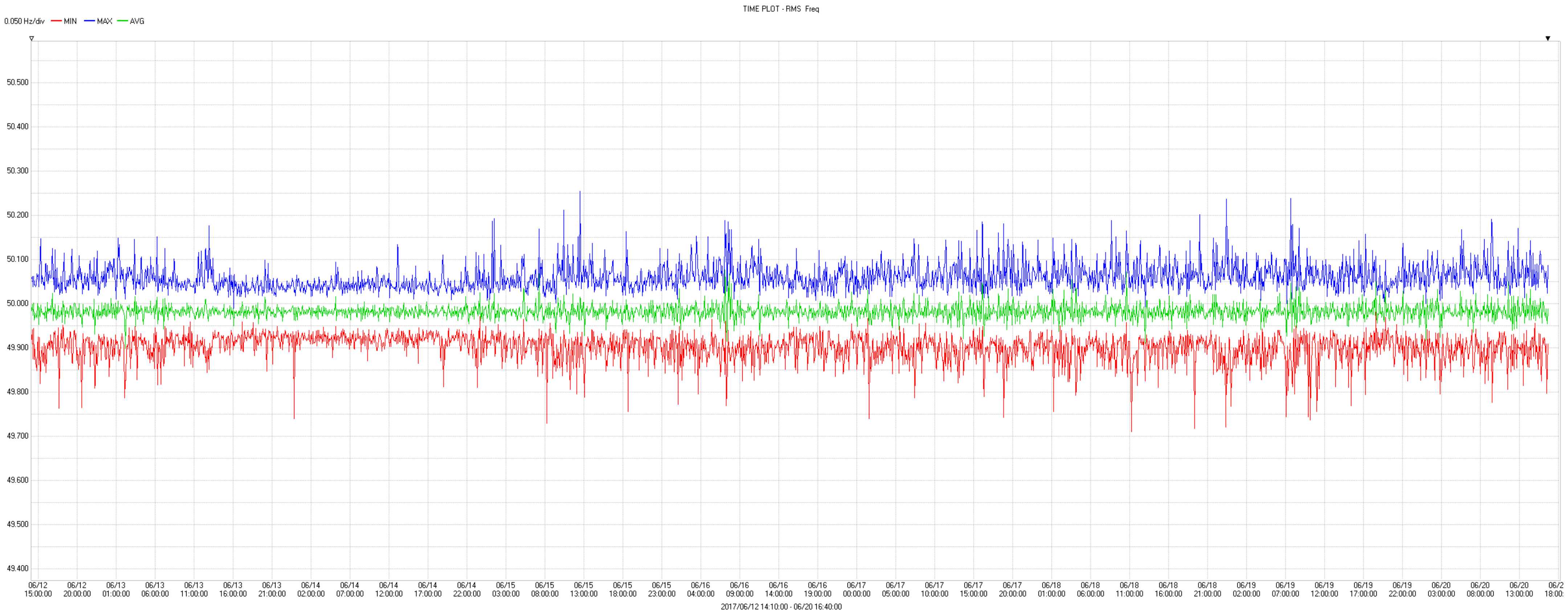

Figure 116 | TC4 - start of feeder – frequency measurements

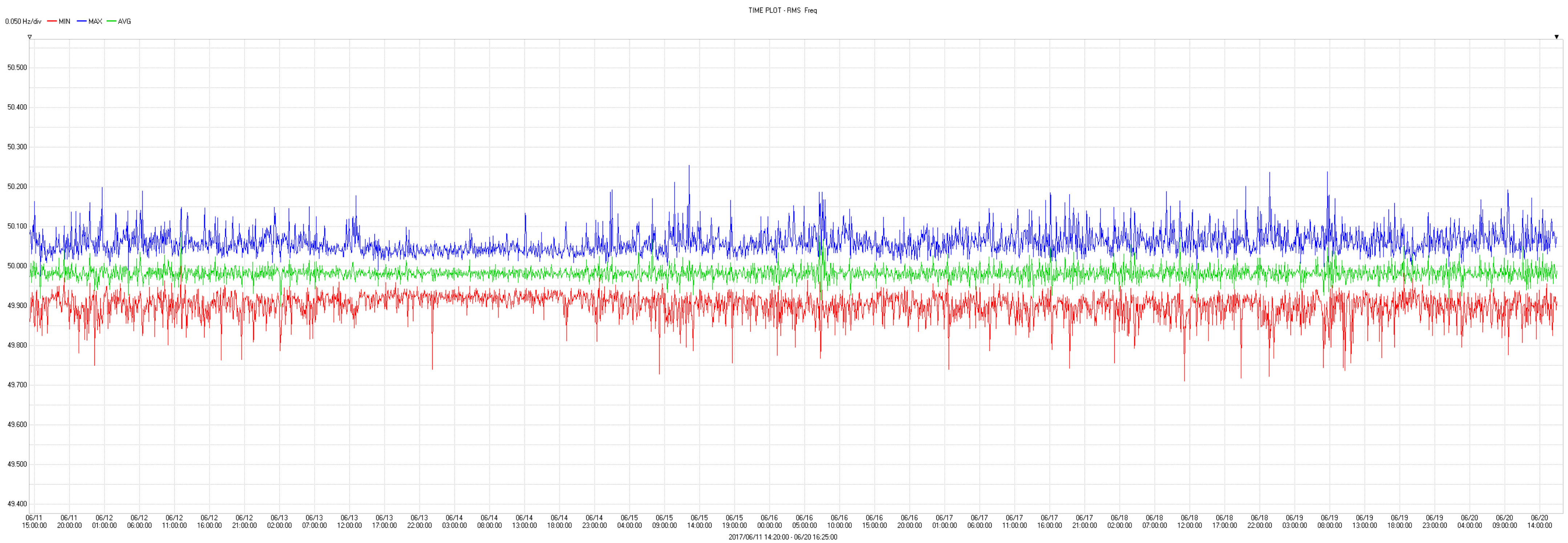

Figure 117 | TC4 - end of feeder – frequency measurements

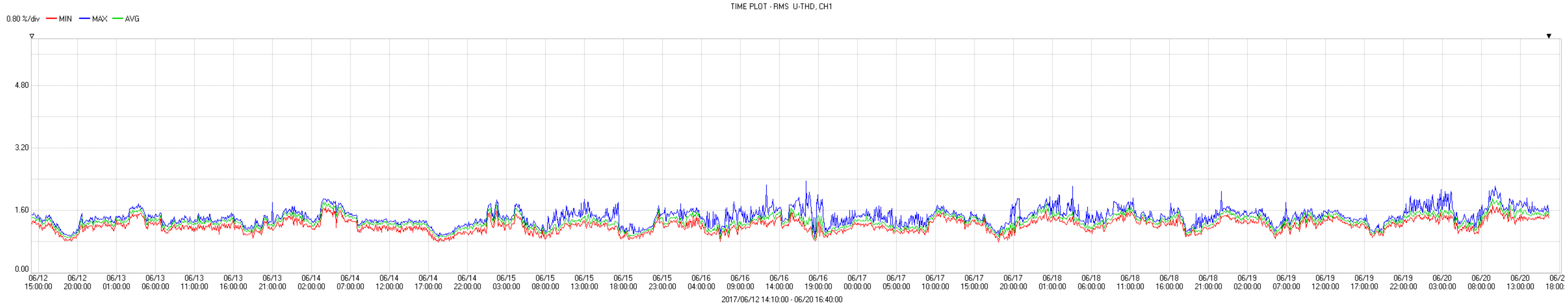

Figure 118 | TC4 - start of feeder – voltage THD measurements (Red Phase)

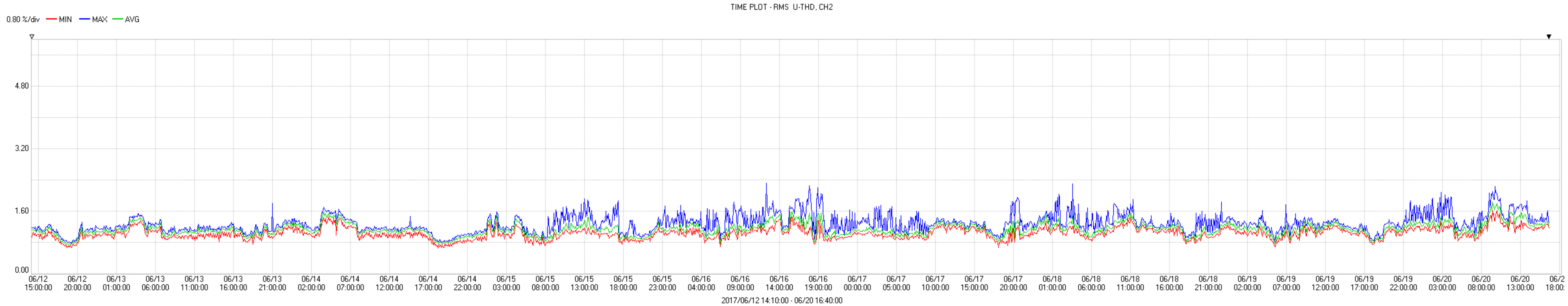

Figure 119 | TC4- start of feeder – voltage THD measurements (White Phase)

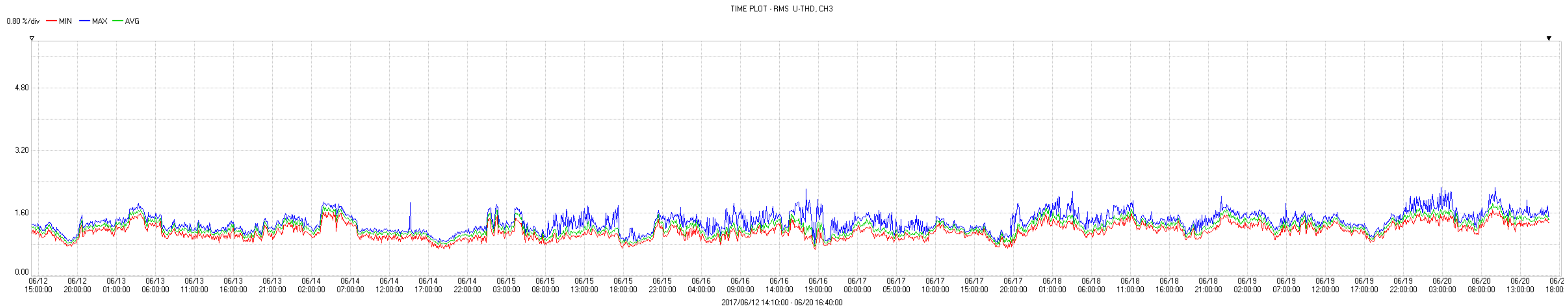

Figure 120 | TC4 - start of feeder – voltage THD measurements (Blue Phase)

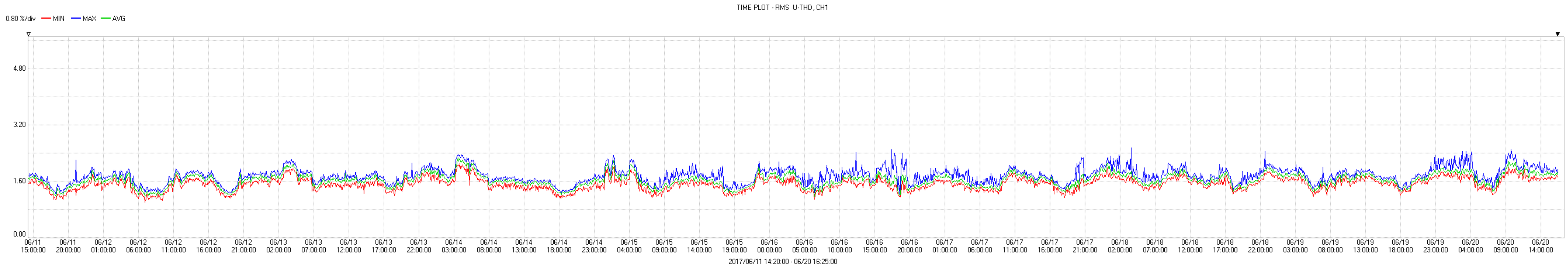

Figure 121 | TC4 - end of feeder – voltage THD measurements (Red Phase)

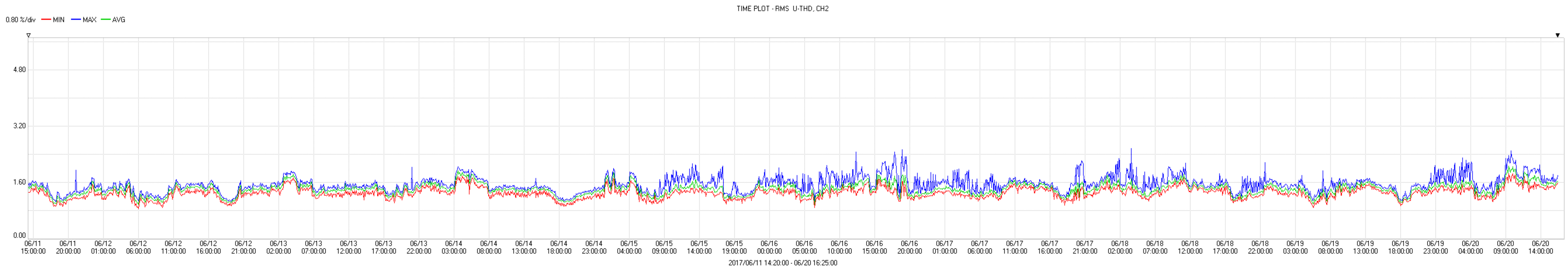

Figure 122 | TC4 - end of feeder – voltage THD measurements (White Phase)

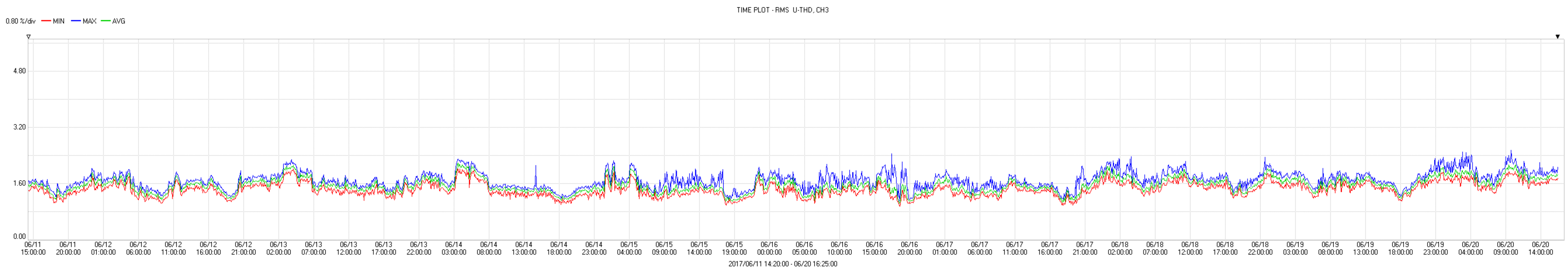

Figure 123 | TC4 - end of feeder – voltage THD measurements (Blue Phase)

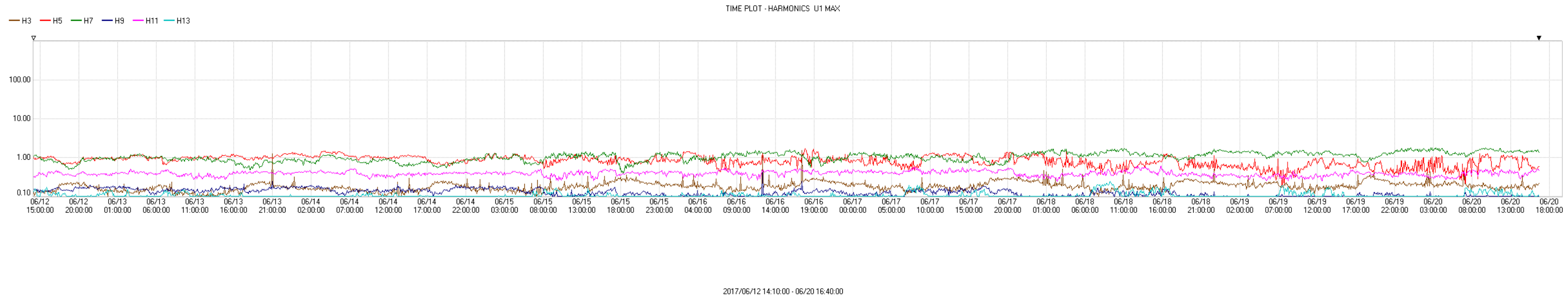

Figure 124 | TC4 – start of feeder – 3rd to 13th (odd) harmonics (Red Phase)

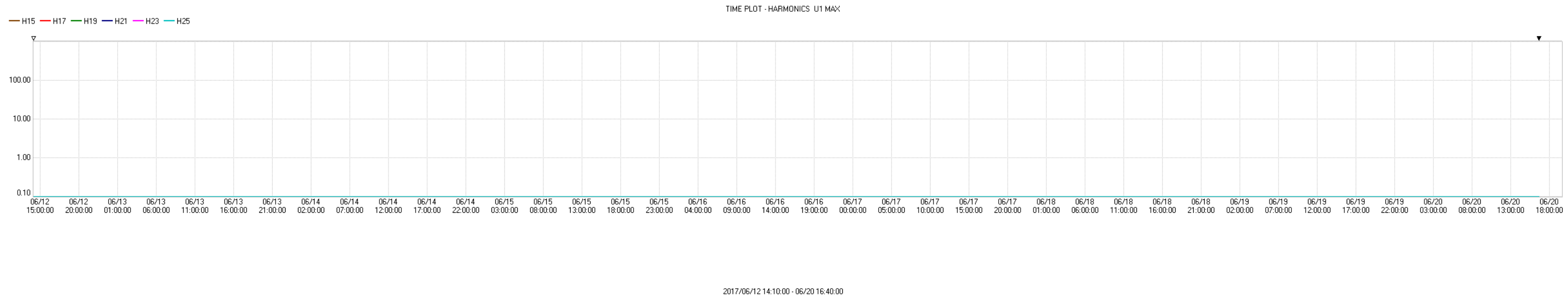

Figure 125 | TC4 – start of feeder – 15th to 25th (odd) harmonics (Red Phase)

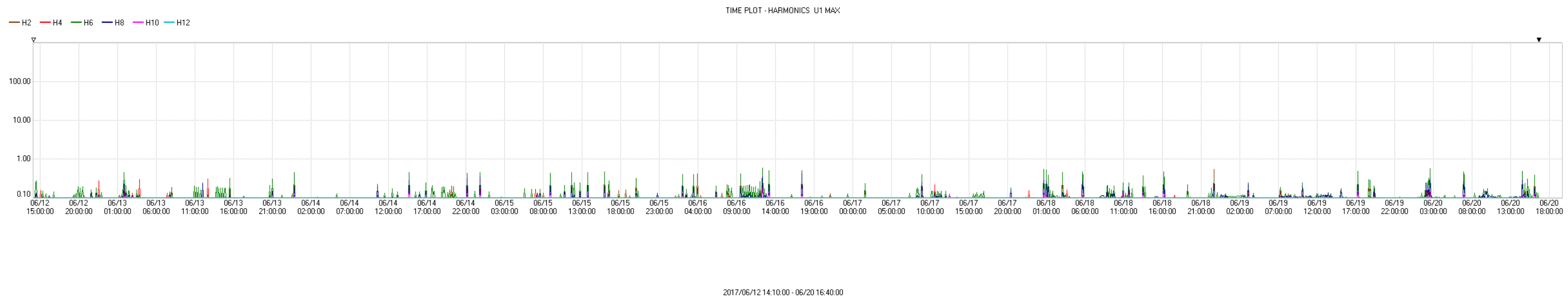

Figure 126 | TC4– start of feeder – 2nd to 12th (even) harmonics (Red Phase)

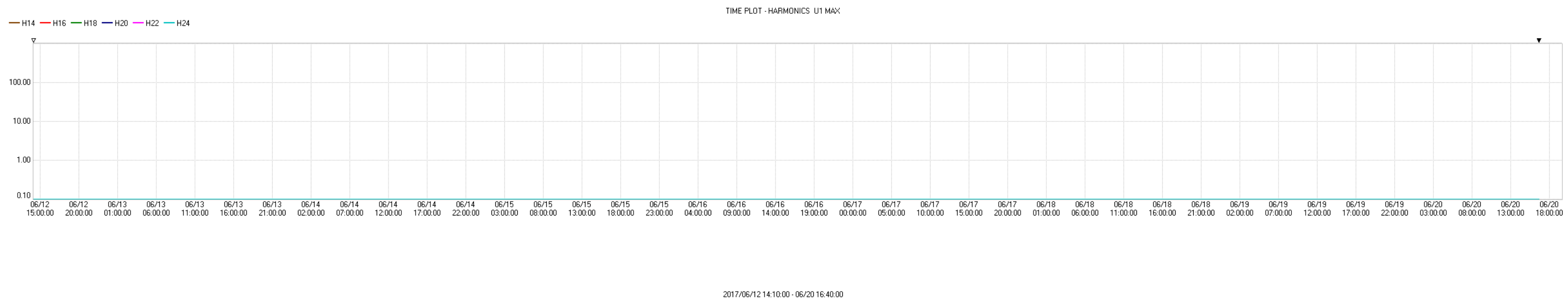

Figure 127 | TC4– start of feeder – 14th to 24th (even) harmonics (Red Phase)

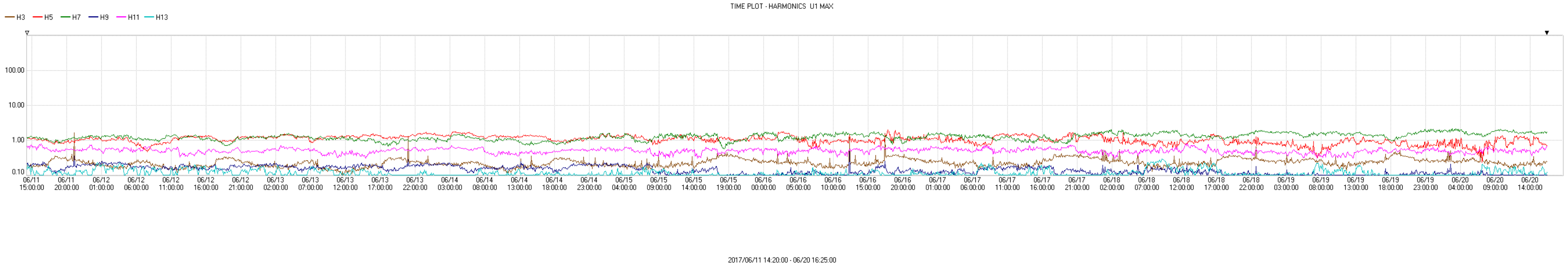

Figure 128 | TC4 – end of feeder – 3rd to 13th (odd) harmonics (Red Phase)

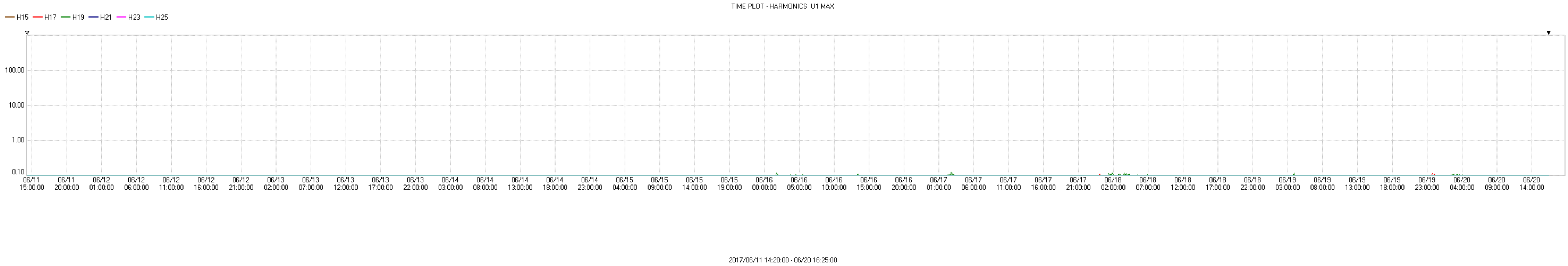

Figure 129 | TC4 – end of feeder – 15th to 25th (odd) harmonics (Red Phase)

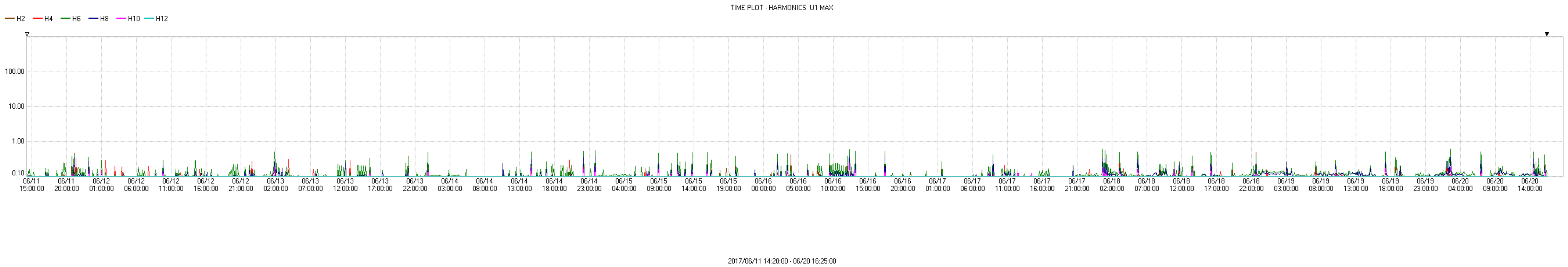

Figure 130 | TC4 – end of feeder – 2nd to 12th (even) harmonics (Red Phase)

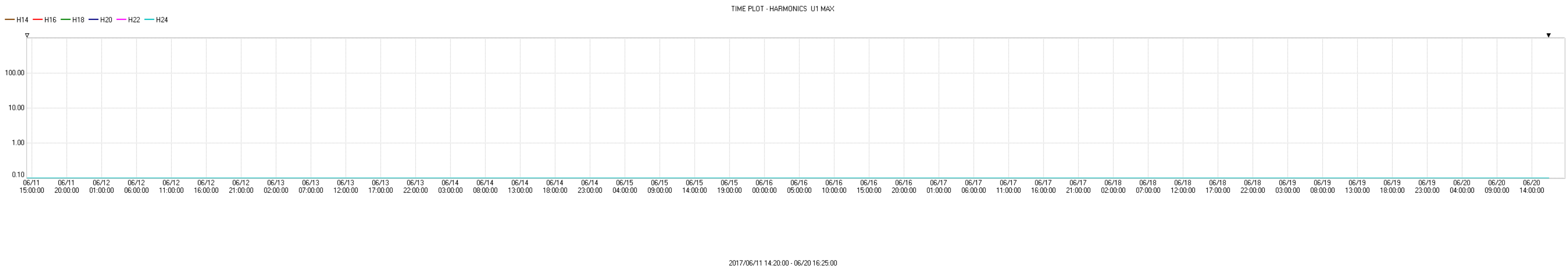

Figure 131 | TC4 – end of feeder – 14th to 24th (even) harmonics (Red Phase)

STS1 Feeder – Flicker, Voltage, Frequency, and Harmonics

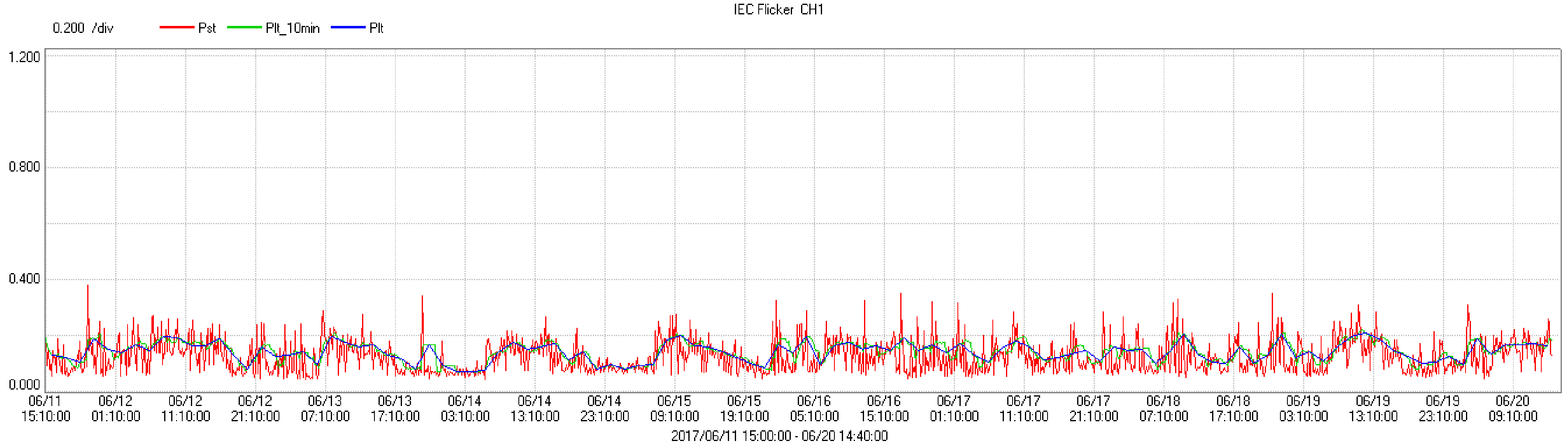

Figure 132 | STS1 - start of feeder – flicker measurements (Red Phase)

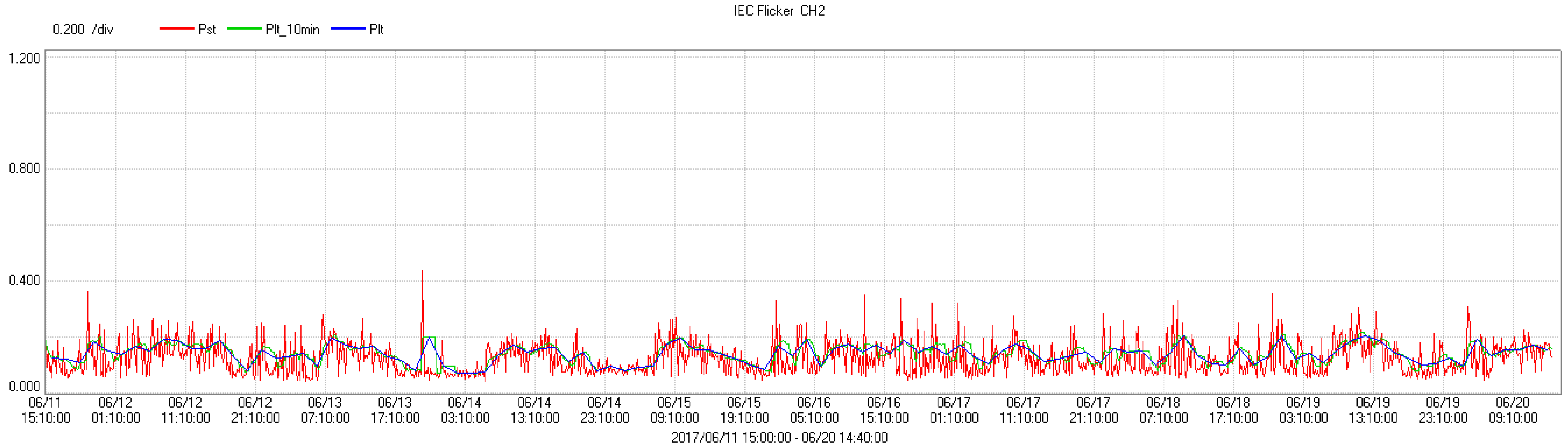

Figure 133 | STS1 - start of feeder – flicker measurements (White Phase)

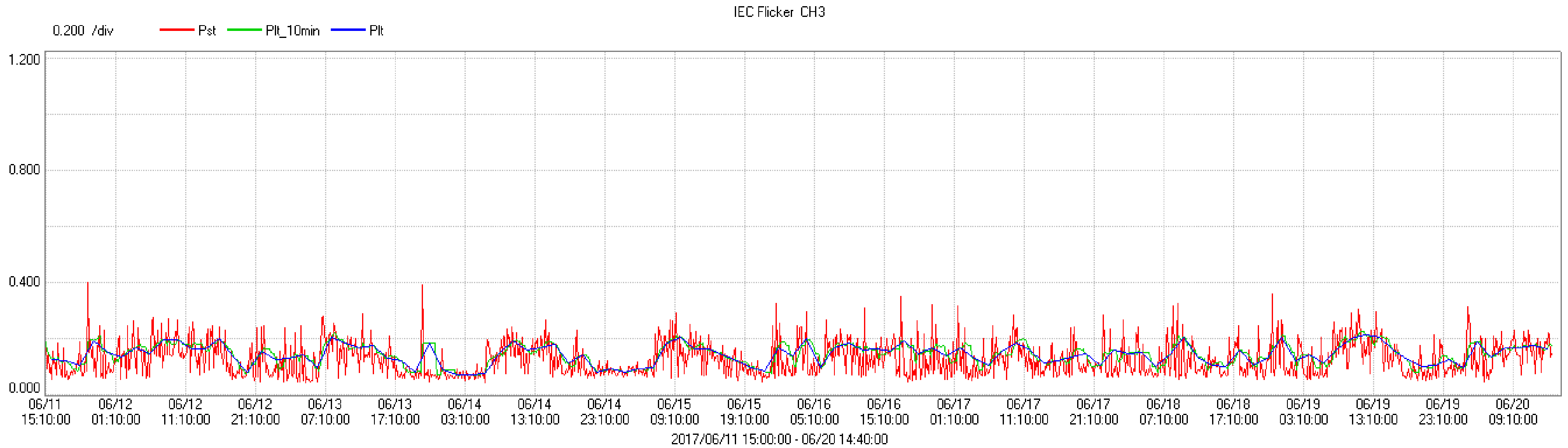

Figure 134 | STS1 - start of feeder – flicker measurements (Blue Phase)

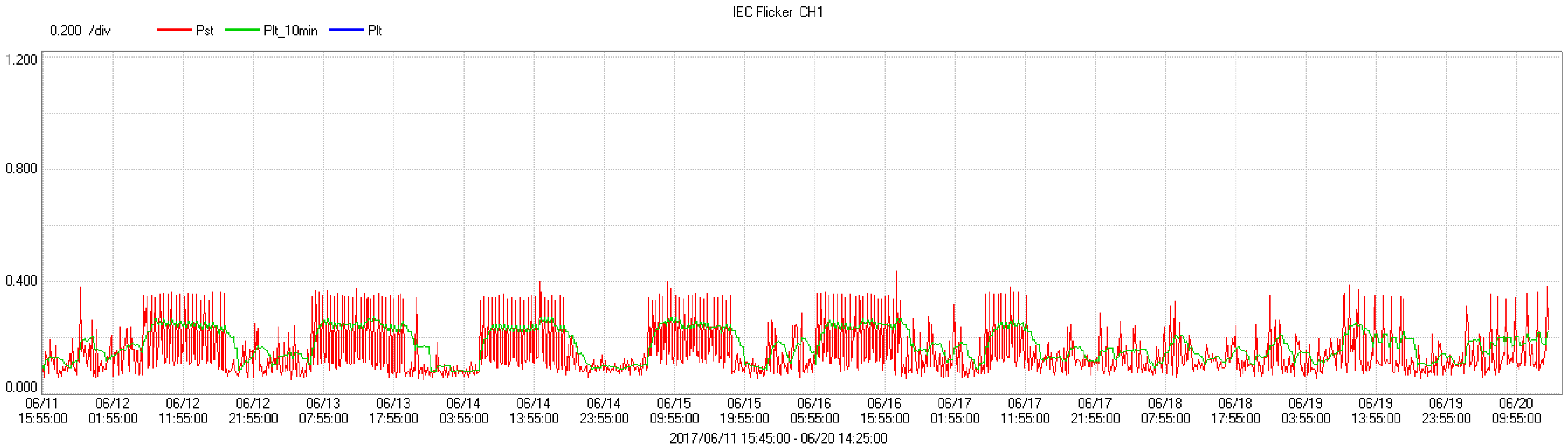

Figure 135 | STS1 – end of feeder – flicker measurements (Red Phase)

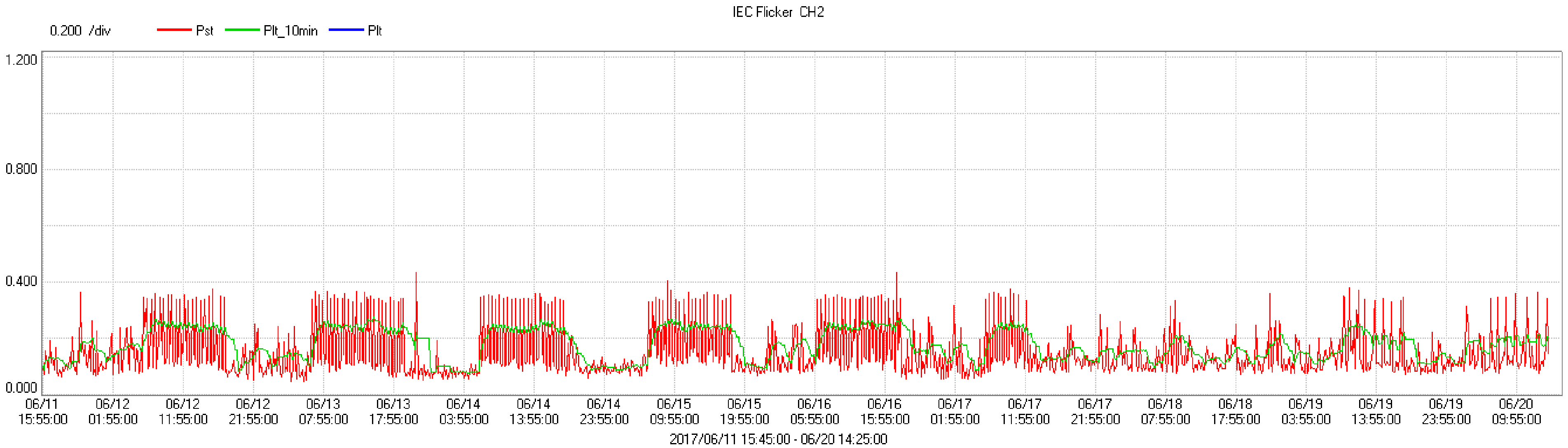

Figure 136 | STS1 - end of feeder – flicker measurements (White Phase)

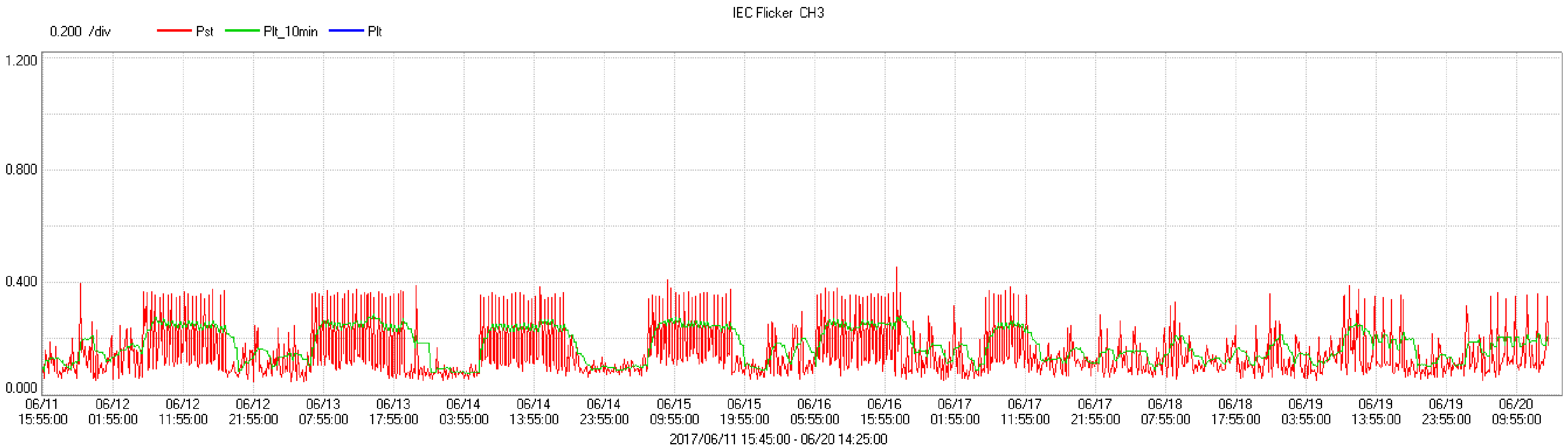

Figure 137 | STS1 - end of feeder – flicker measurements (Blue Phase)

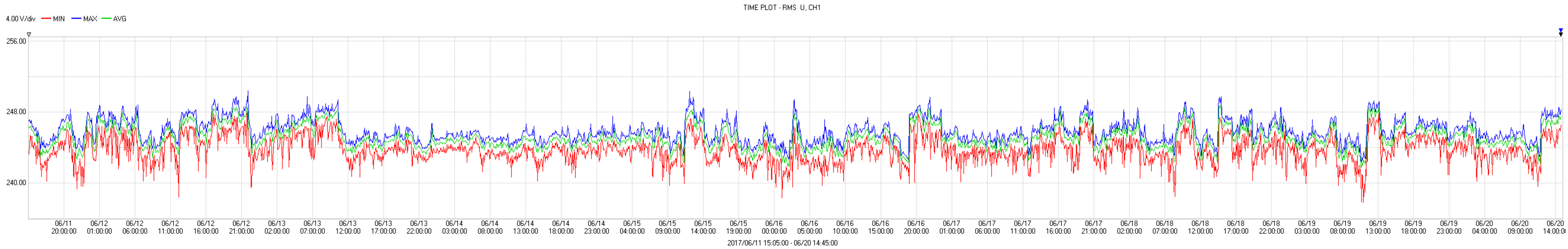

Figure 138 | STS1 - start of feeder – voltage measurements (Red Phase)

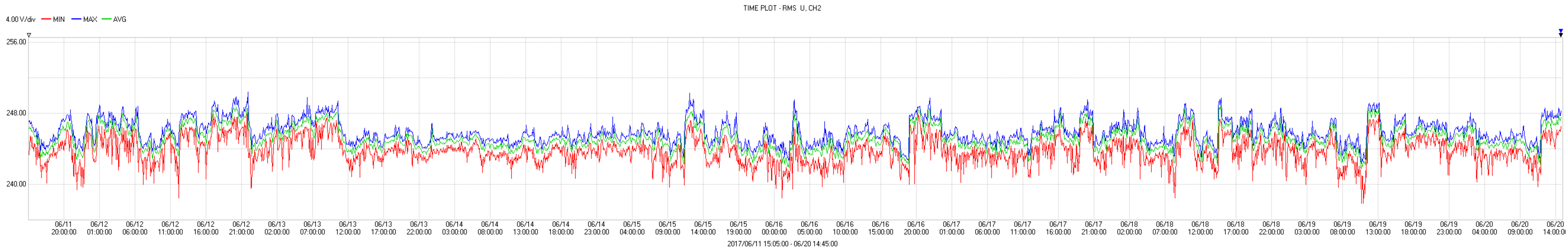

Figure 139 | STS1 - start of feeder – voltage measurements (White Phase)

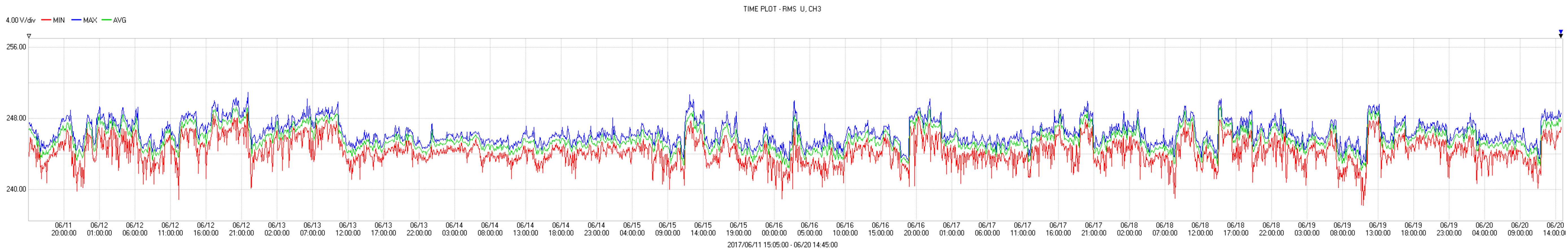

Figure 140 | STS1 - start of feeder – voltage measurements (Blue Phase)

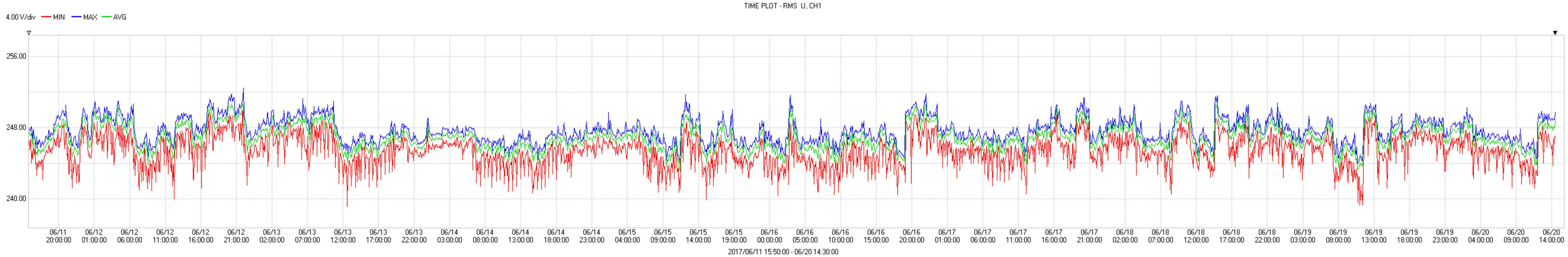

Figure 141 | STS1 - end of feeder – voltage measurements (Red Phase)

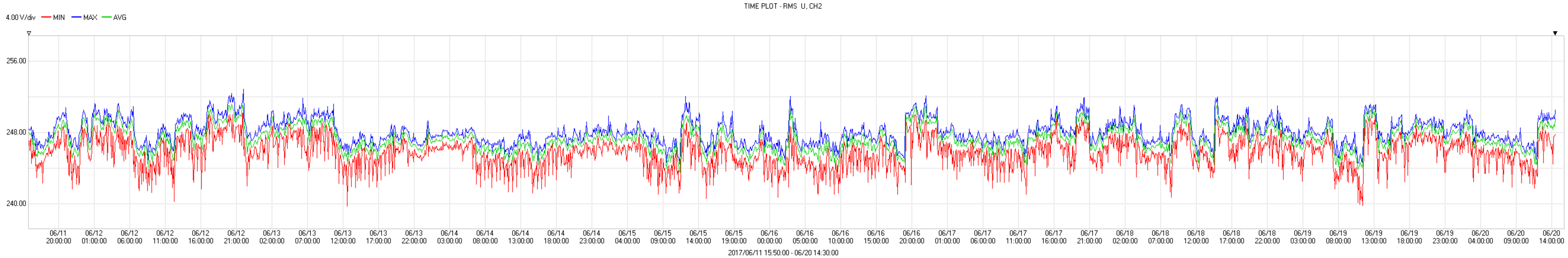

Figure 142 | STS1 - end of feeder – voltage measurements (White Phase)

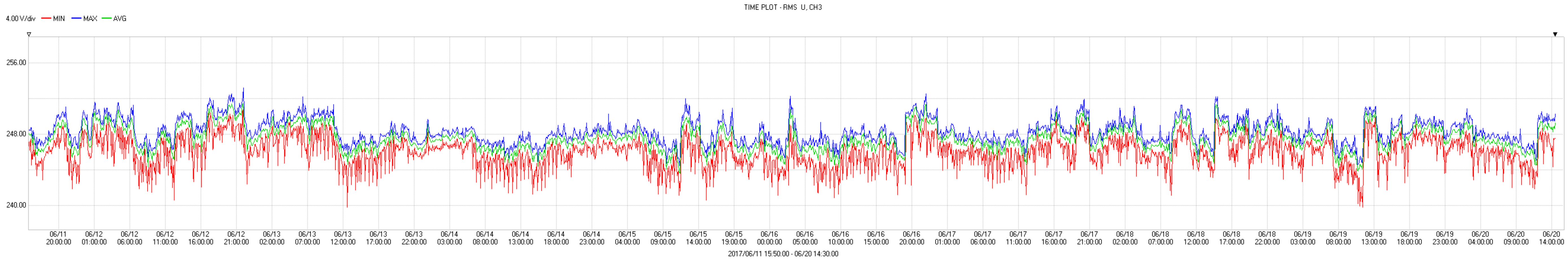

Figure 143 | STS1 - end of feeder – voltage measurements (Blue Phase)

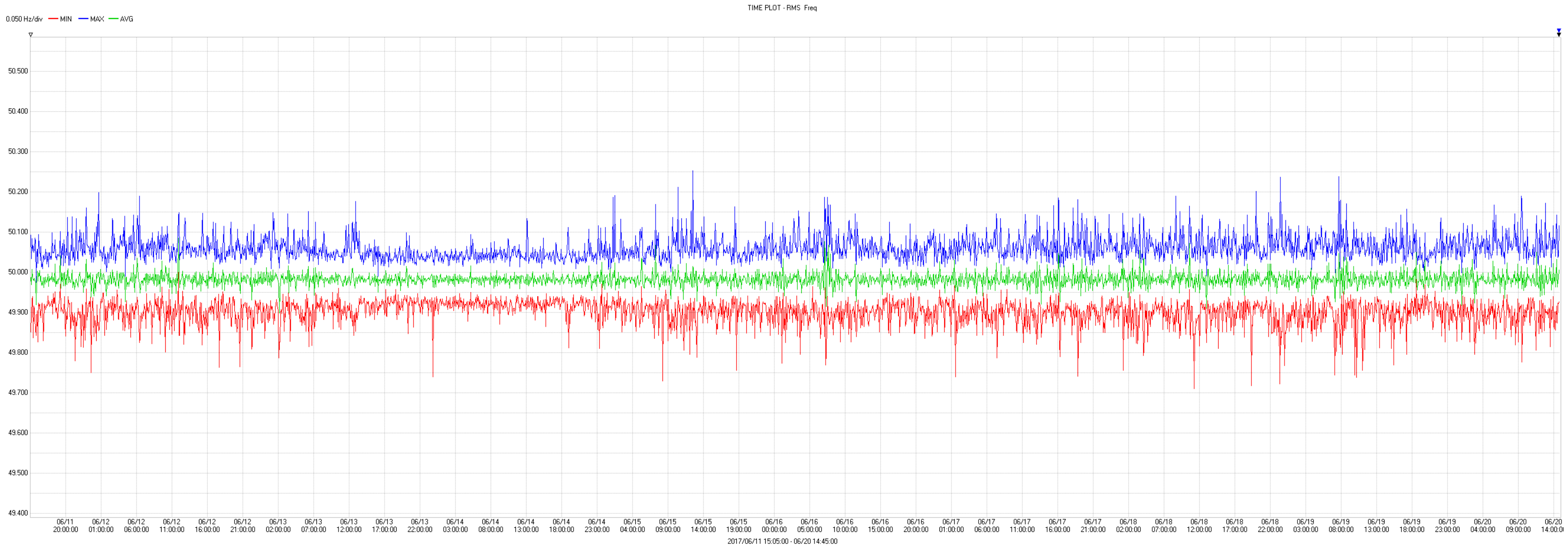

Figure 144 | STS1 - start of feeder – frequency measurements

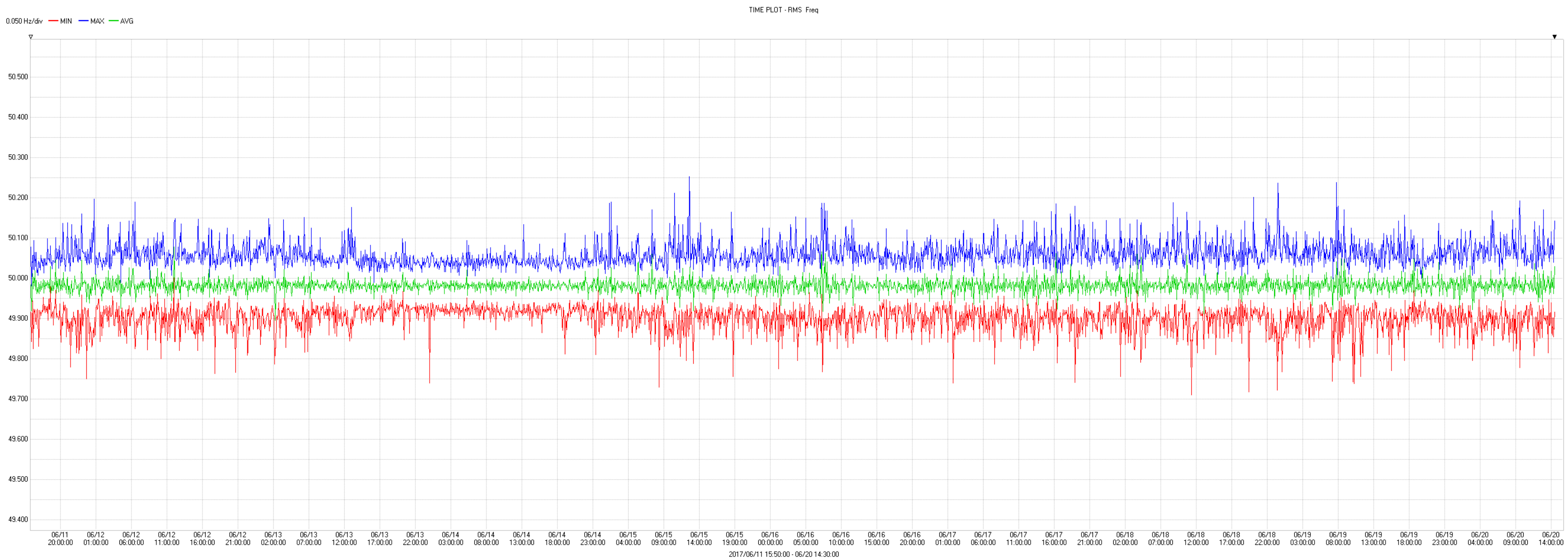

Figure 145 | STS1 - end of feeder – frequency measurements

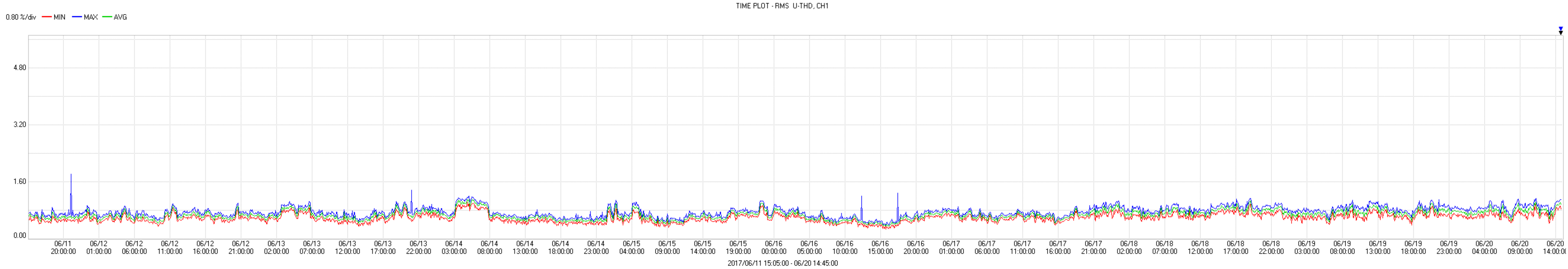

Figure 146 | STS1 - start of feeder – voltage THD measurements (Red Phase)

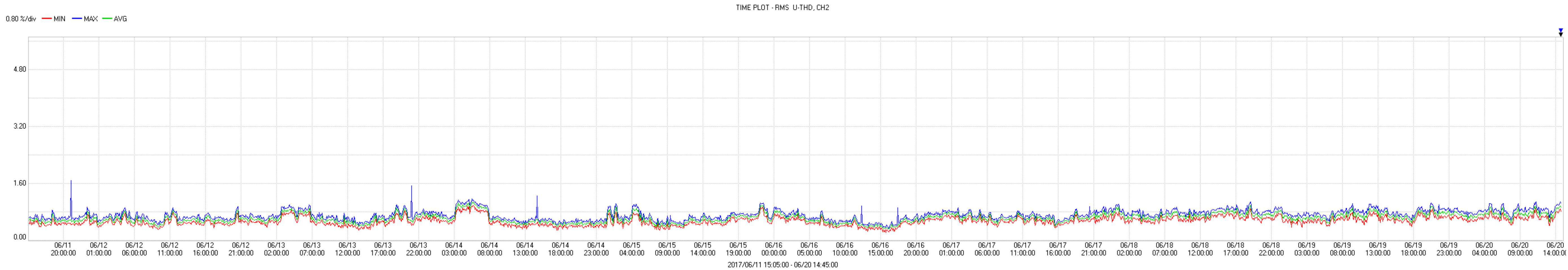

Figure 147 | STS1 - start of feeder – voltage THD measurements (White Phase)

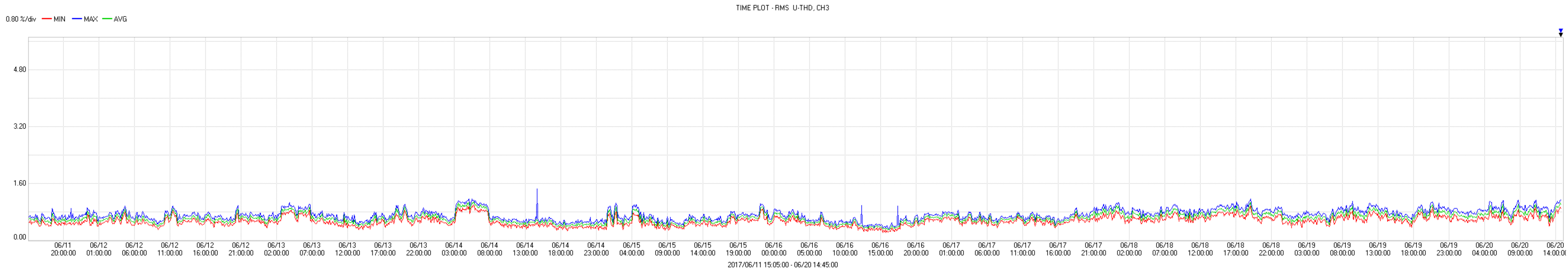

Figure 148 | STS1 - start of feeder – voltage THD measurements (Blue Phase)

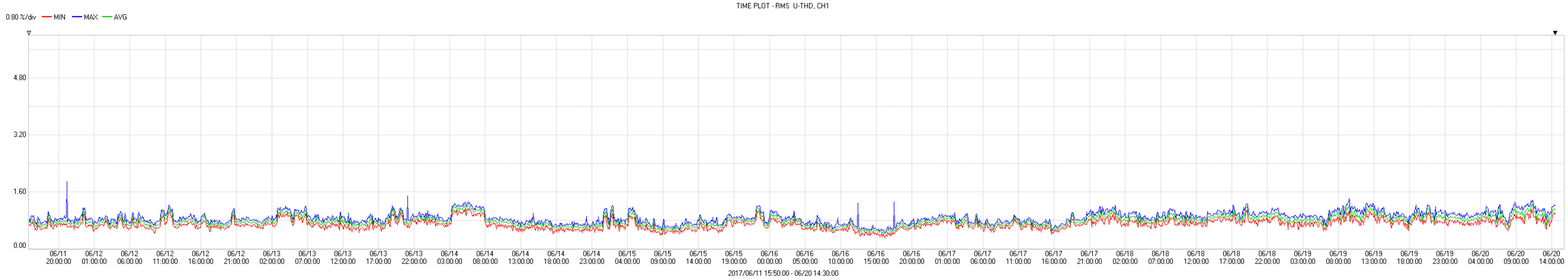

Figure 149 | STS1 - end of feeder – voltage THD measurements (Red Phase)

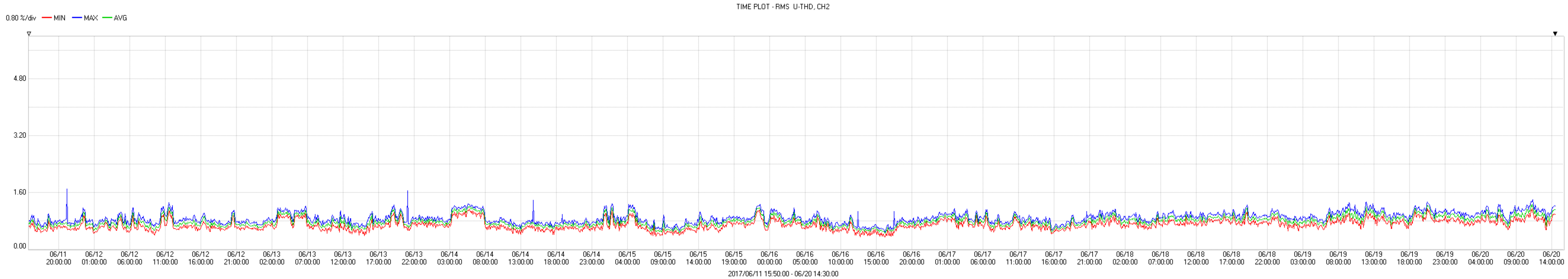

Figure 150 | STS1 - end of feeder – voltage THD measurements (White Phase)

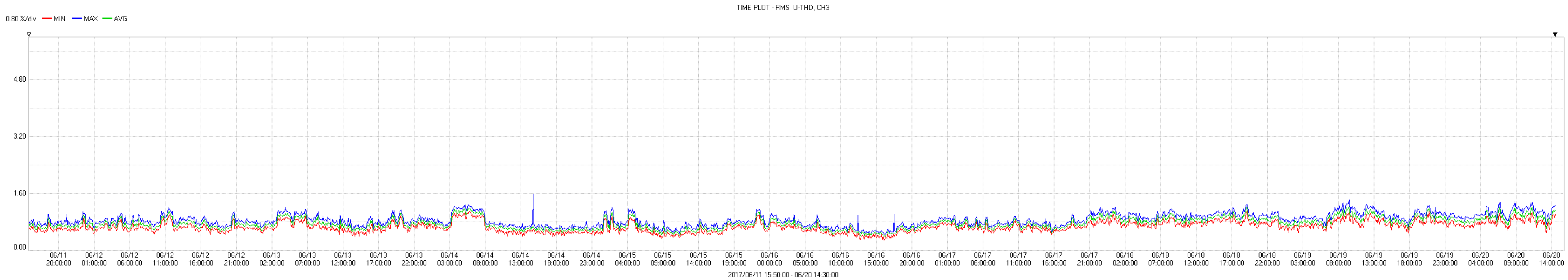

Figure 151 | STS1 - end of feeder – voltage THD measurements (Blue Phase)

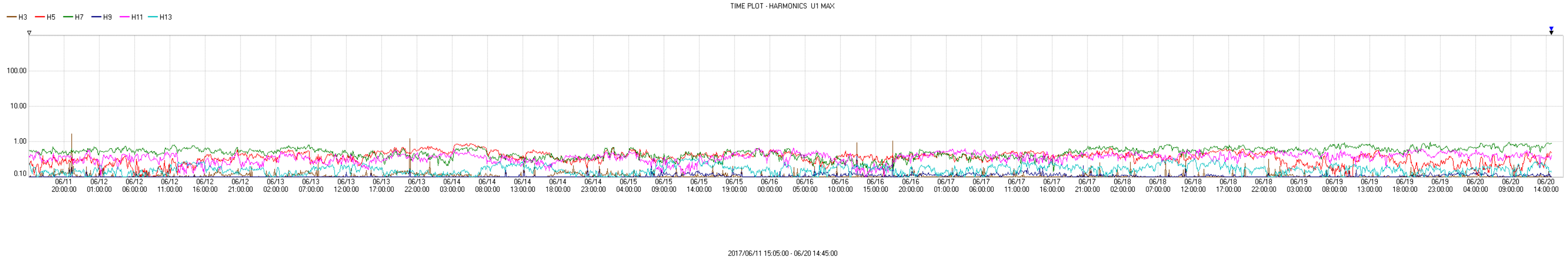

Figure 152 | STS1 – start of feeder – 3rd to 13th (odd) harmonics (Red Phase)

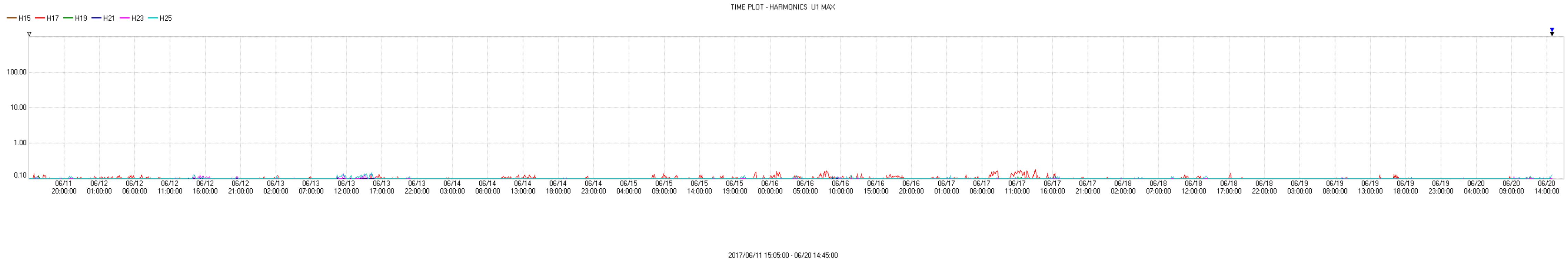

Figure 153 | STS1 – start of feeder – 15th to 25th (odd) harmonics (Red Phase)

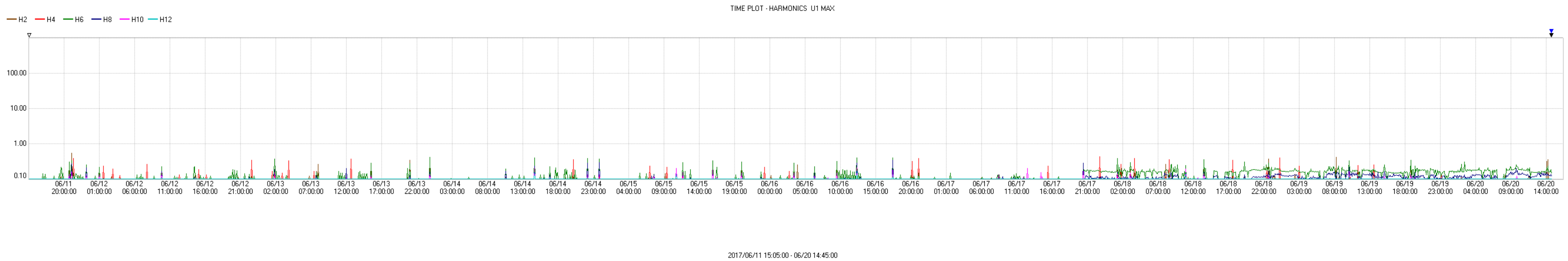

Figure 154 | STS1 – start of feeder – 2th to 12th (even) harmonics (Red Phase)

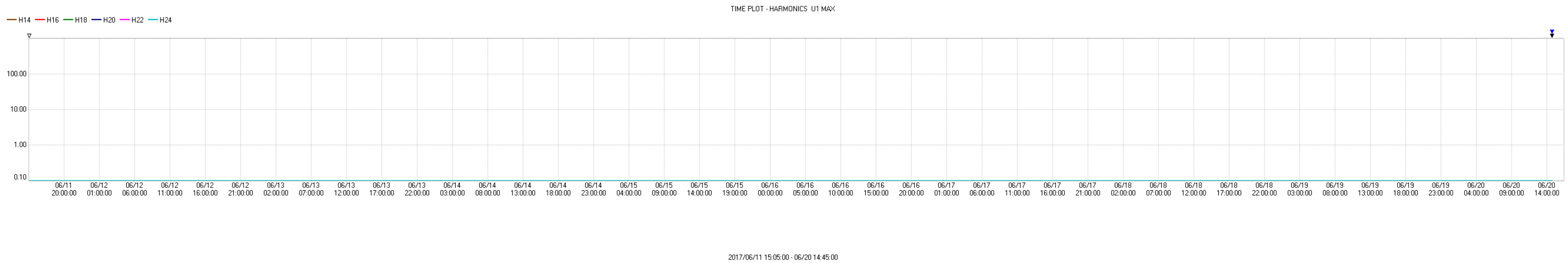

Figure 155 | STS1 – start of feeder – 14th to 24th (even) harmonics (Red Phase)

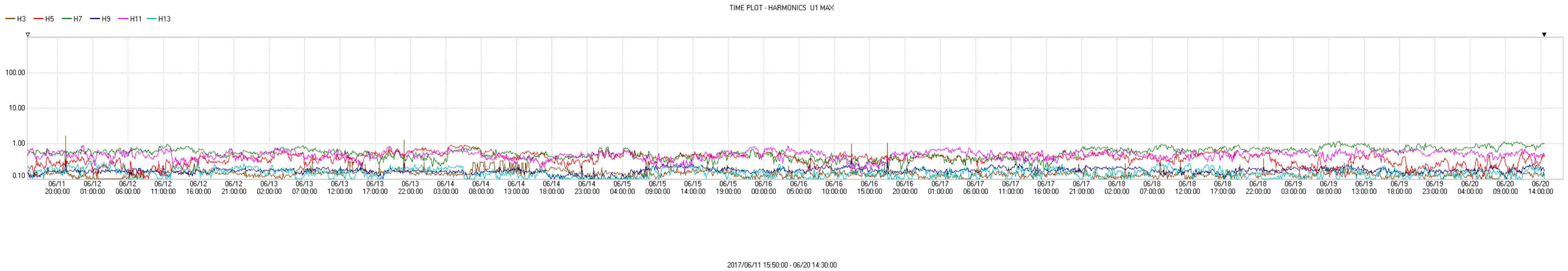

Figure 156 | STS1 – end of feeder – 3rd to 13th (odd) harmonics (Red Phase)

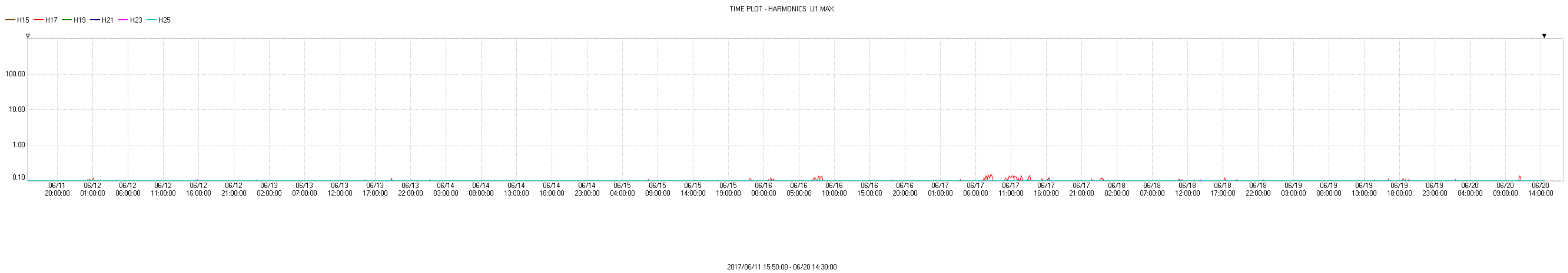

Figure 157 | STS1 – end of feeder – 15th to 25th (odd) harmonics (Red Phase)

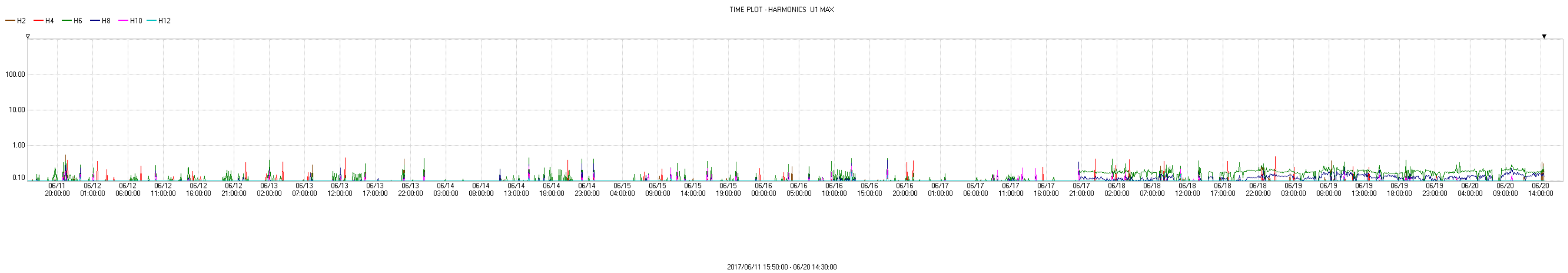

Figure 158 | STS1 – end of feeder – 2nd to 12th (even) harmonics (Red Phase)

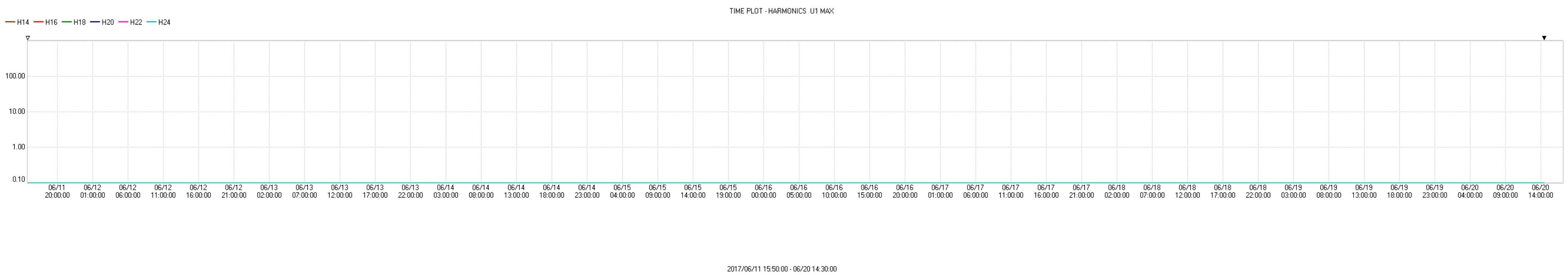

Figure 159 | STS1 – end of feeder – 14th to 24th (even) harmonics (Red Phase)

STS2 Feeder – Flicker, Voltage, Frequency, and Harmonics

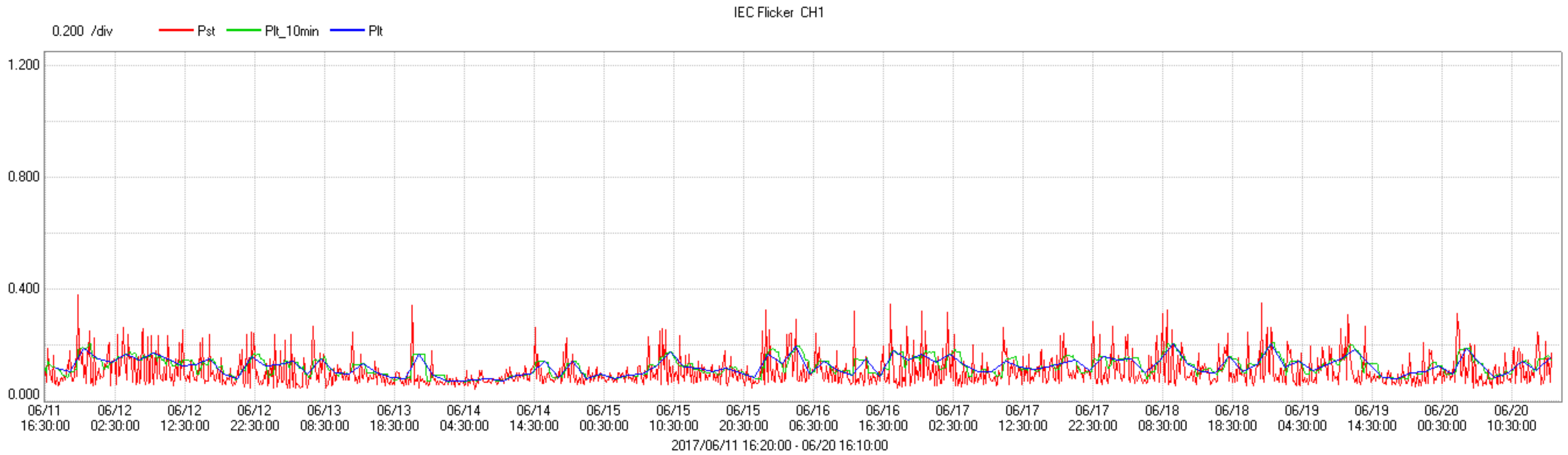

Figure 160 | STS2 - start of feeder – flicker measurements (Red Phase)

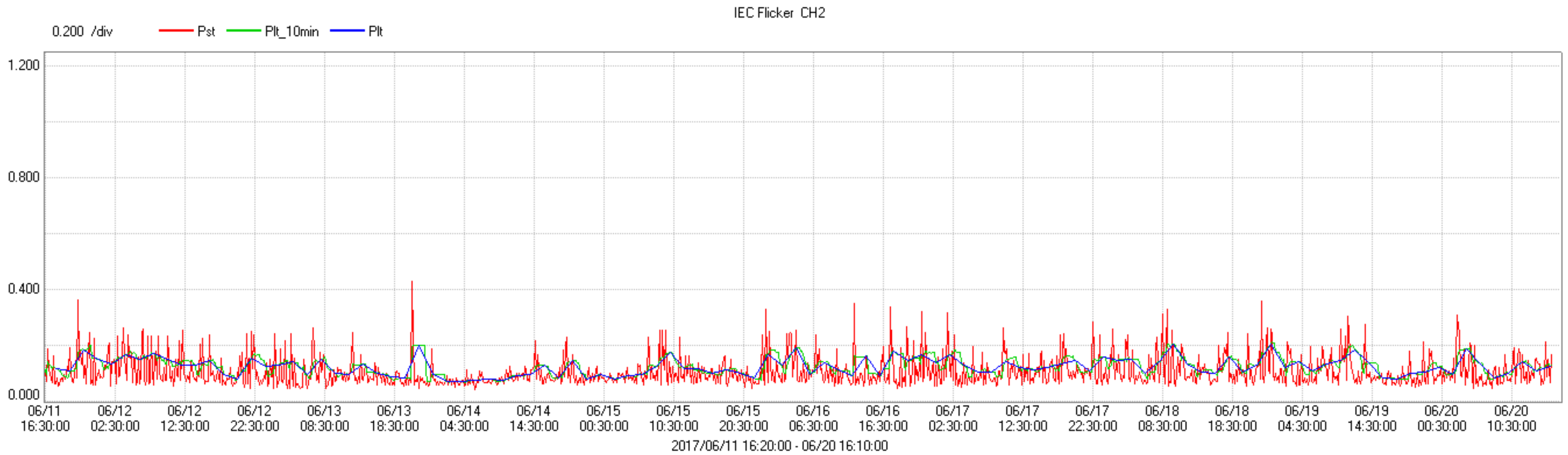

Figure 161 | STS2- start of feeder – flicker measurements (White Phase)

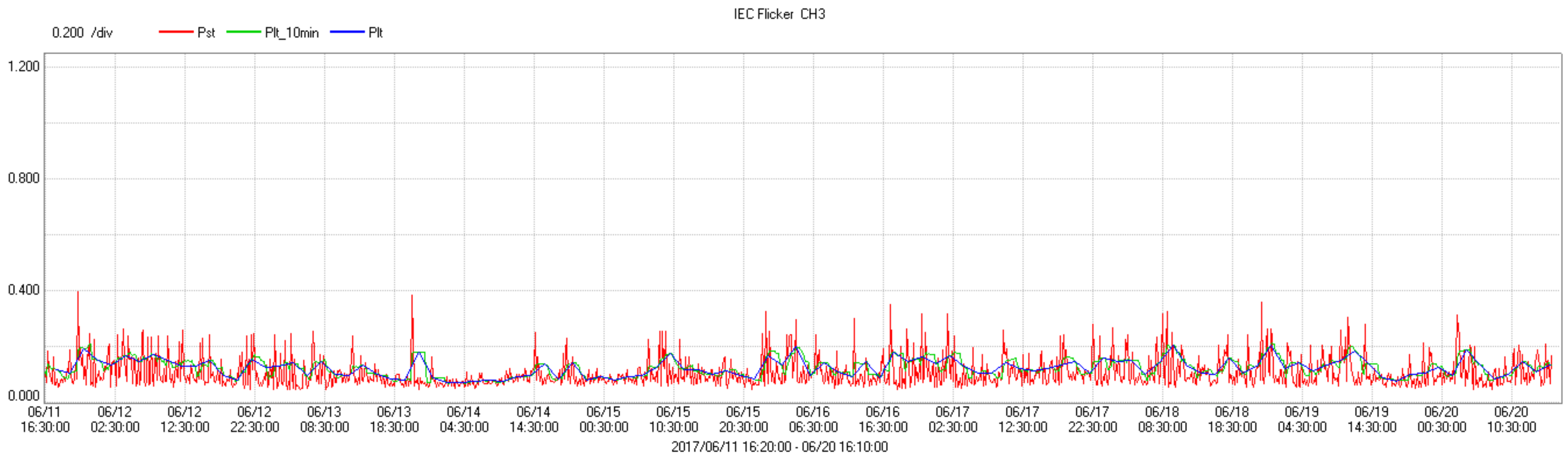

Figure 162 | STS2 - start of feeder – flicker measurements (Blue Phase)

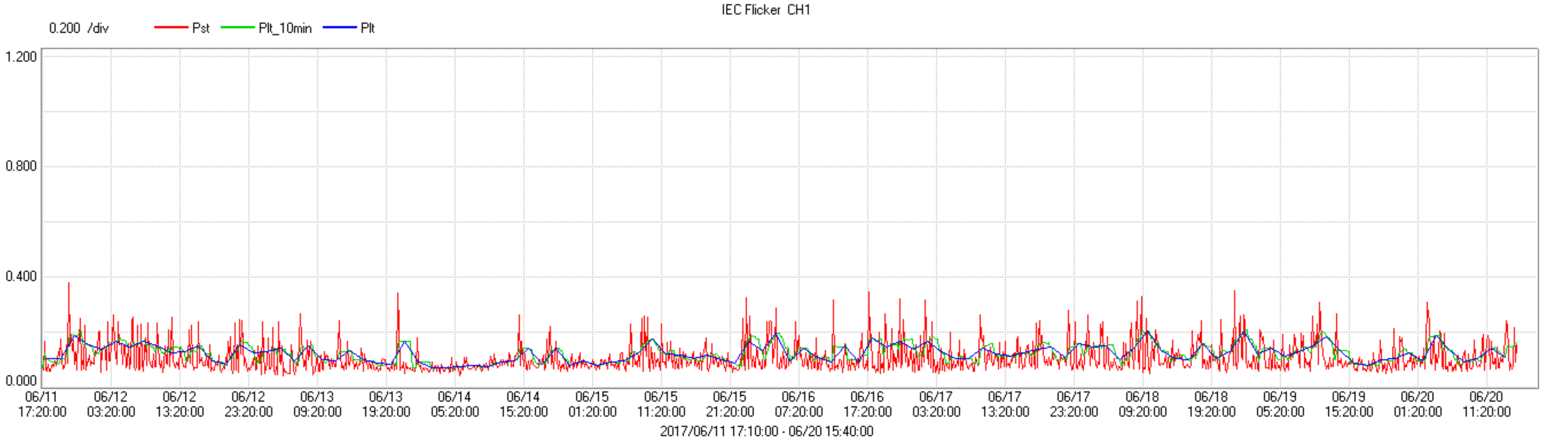

Figure 163 | STS2 – end of feeder – flicker measurements (Red Phase)

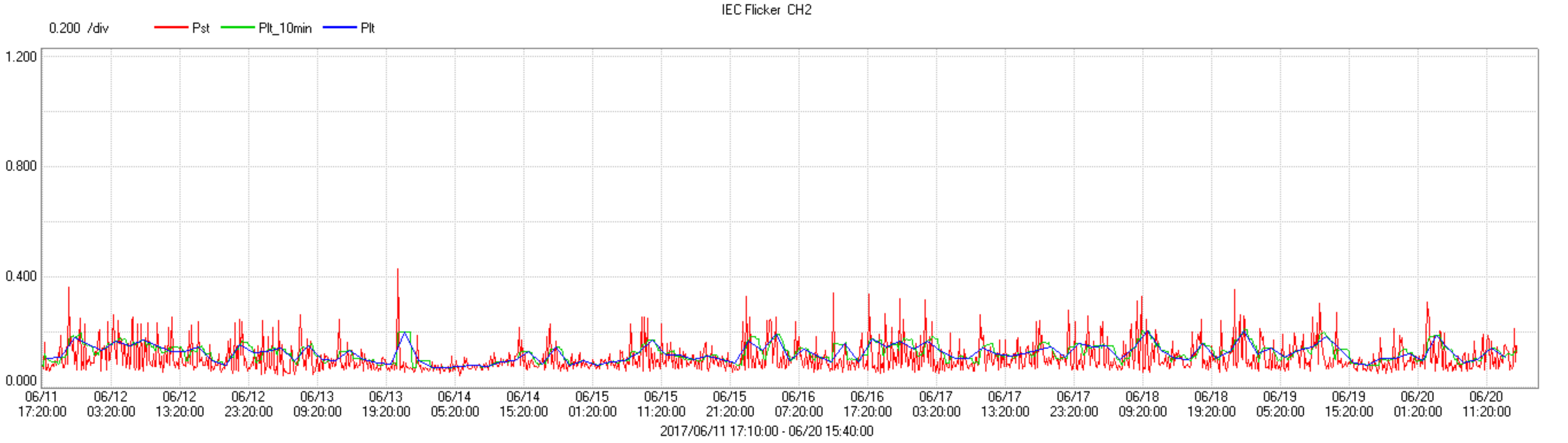

Figure 164 | STS2 - end of feeder – flicker measurements (White Phase)

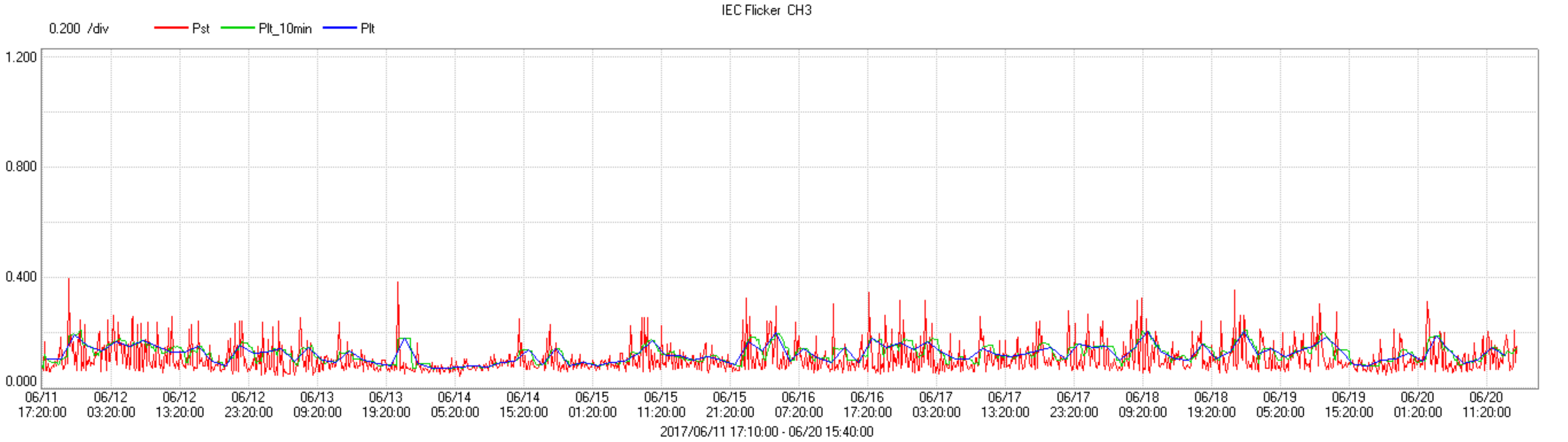

Figure 165 | STS2 - end of feeder – flicker measurements (Blue Phase)

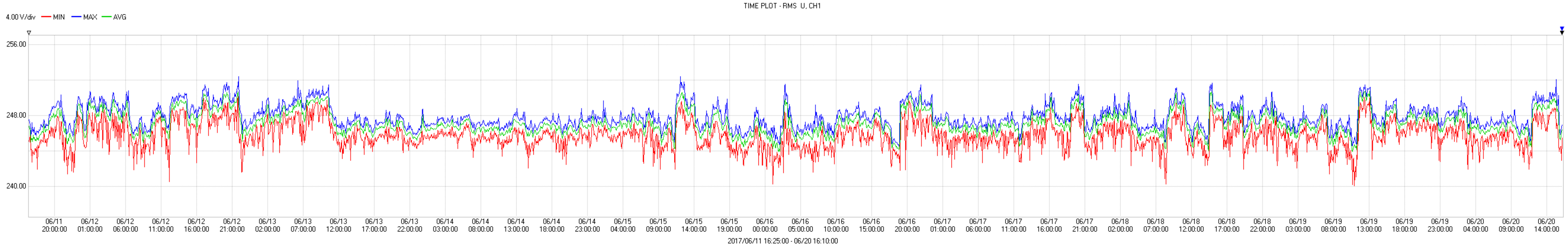

Figure 166 | STS2 - start of feeder – voltage measurements (Red Phase)

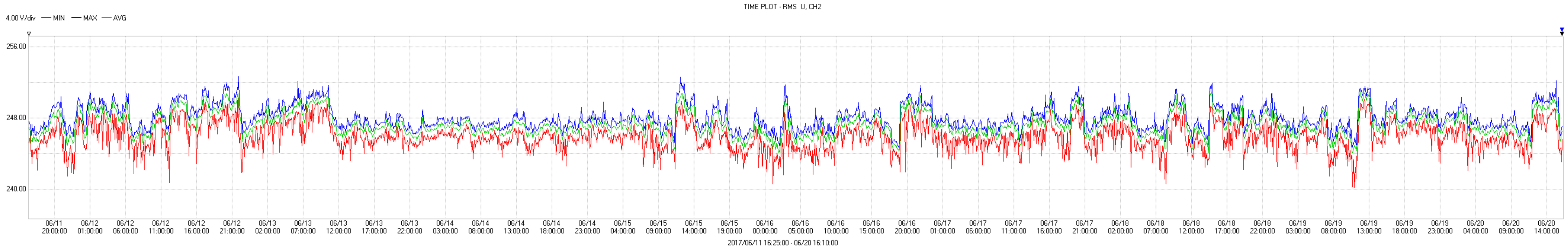

Figure 167 | STS2 - start of feeder – voltage measurements (White Phase)

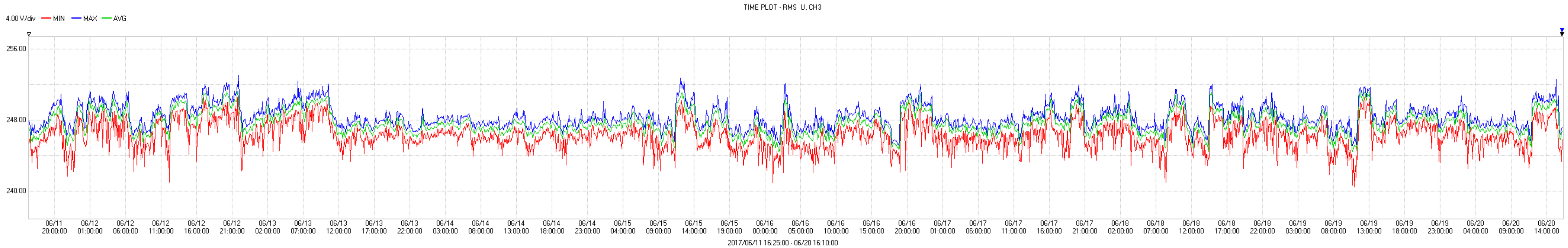

Figure 168 | STS2 - start of feeder – voltage measurements (Blue Phase)

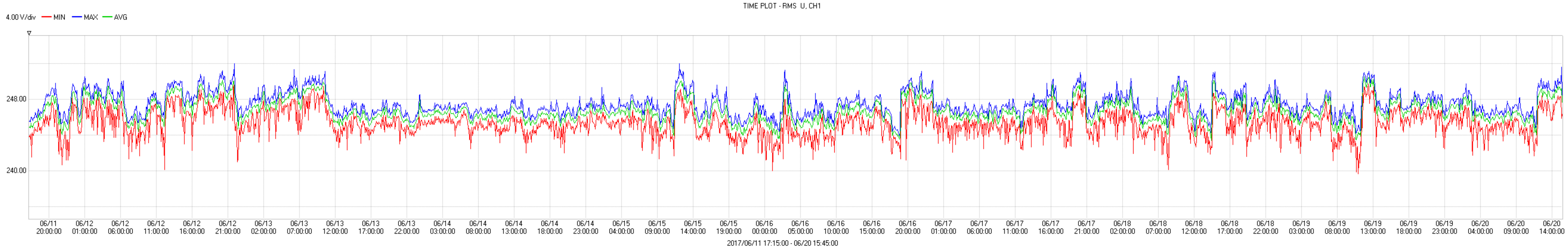

Figure 169 | STS2 - end of feeder – voltage measurements (Red Phase)

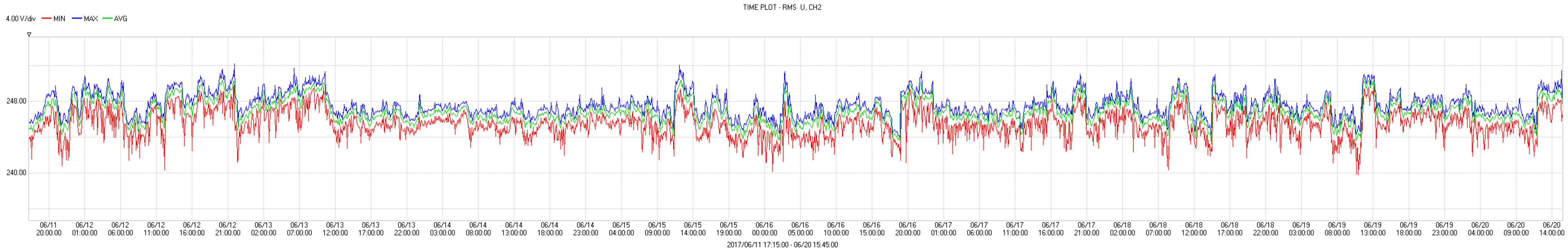

Figure 170 | STS2 - end of feeder – voltage measurements (White Phase)

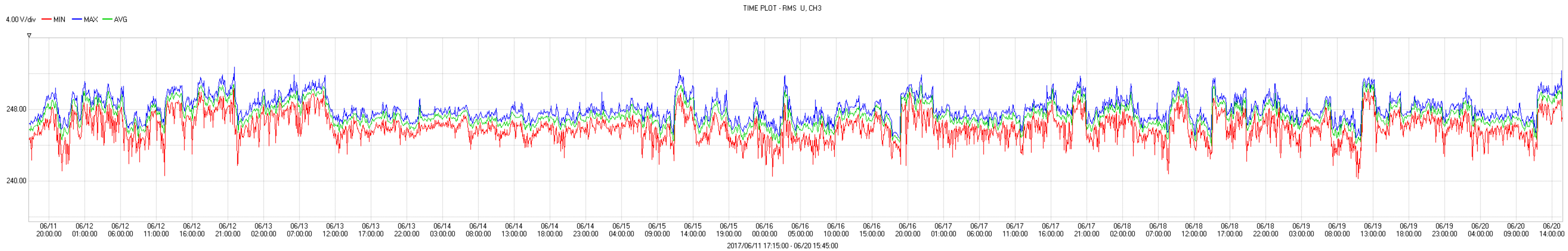

Figure 171 | STS2 - end of feeder – voltage measurements (Blue Phase)

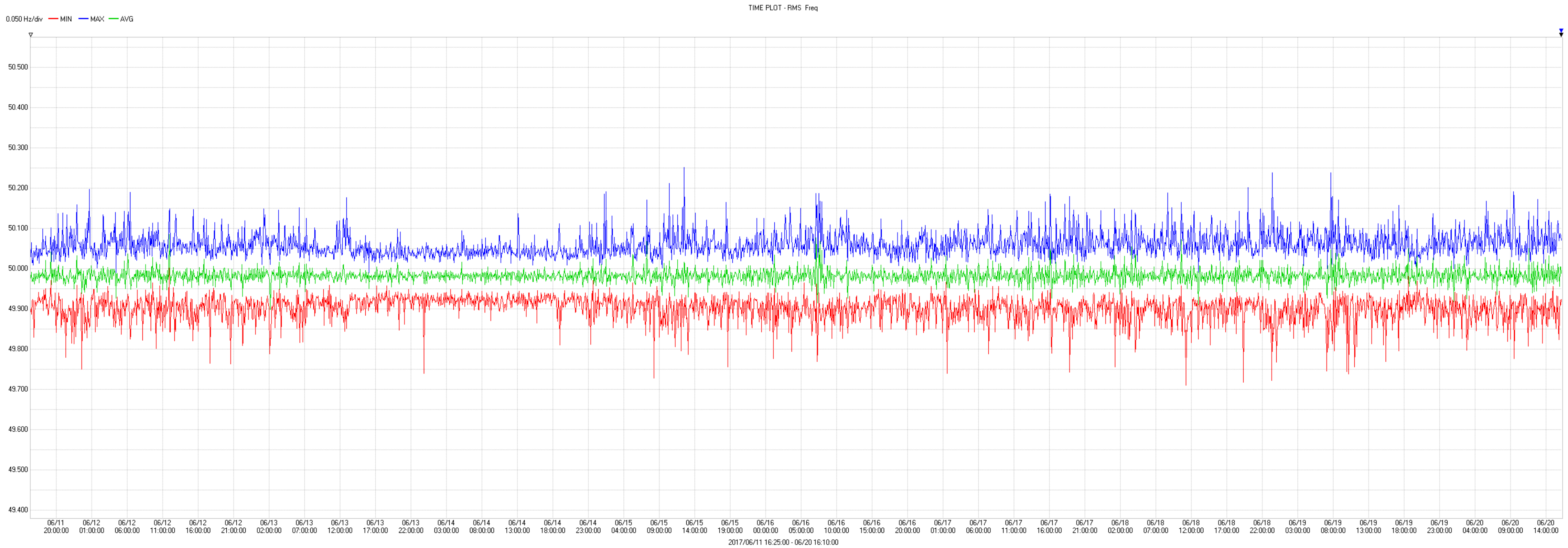

Figure 172 | STS2 - start of feeder – frequency measurements

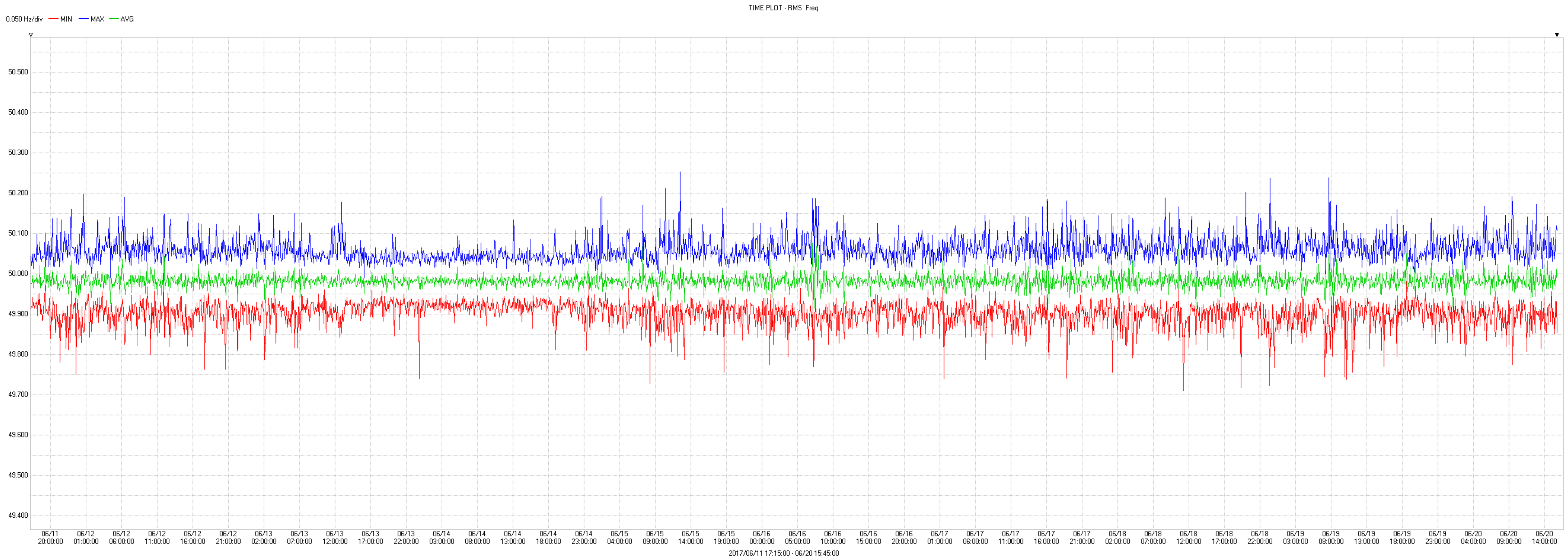

Figure 173 | STS2 - end of feeder – frequency measurements

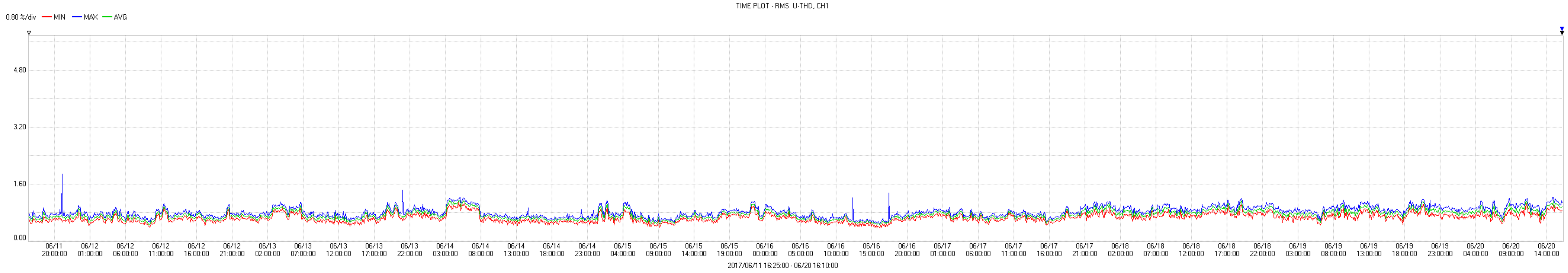

Figure 174 | STS2 - start of feeder – voltage THD measurements (Red Phase)

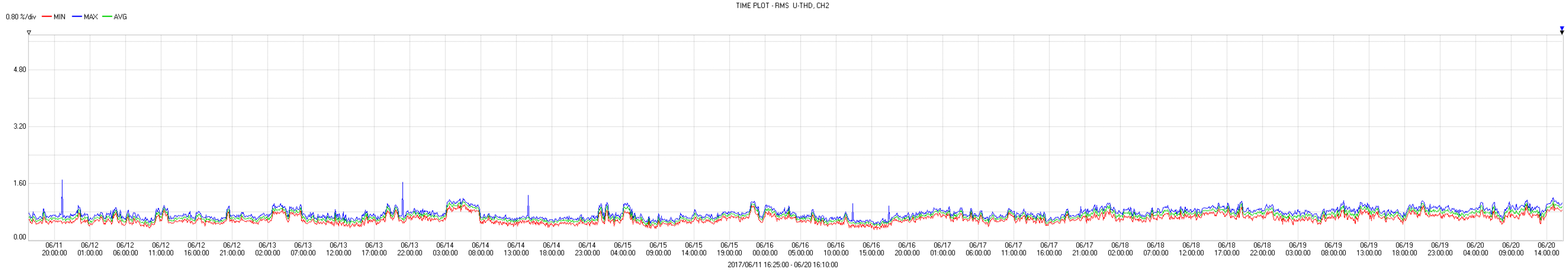

Figure 175 | STS2 - start of feeder – voltage THD measurements (White Phase)

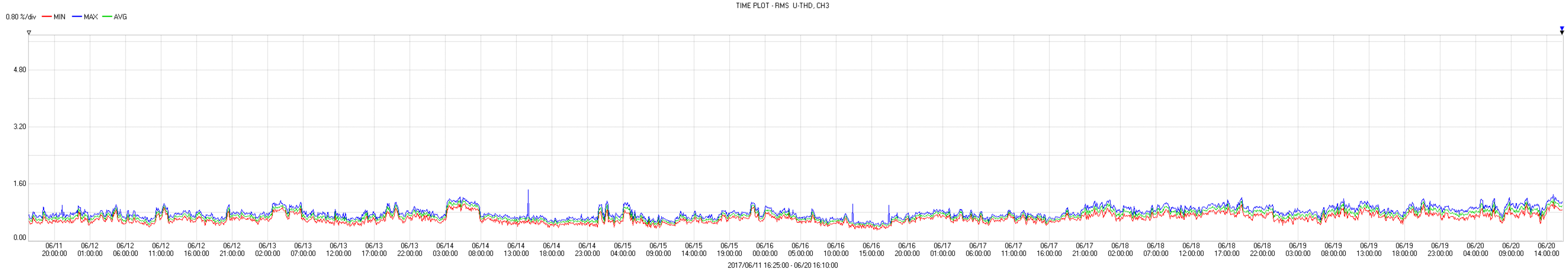

Figure 176 | STS2 - start of feeder – voltage THD measurements (Blue Phase)

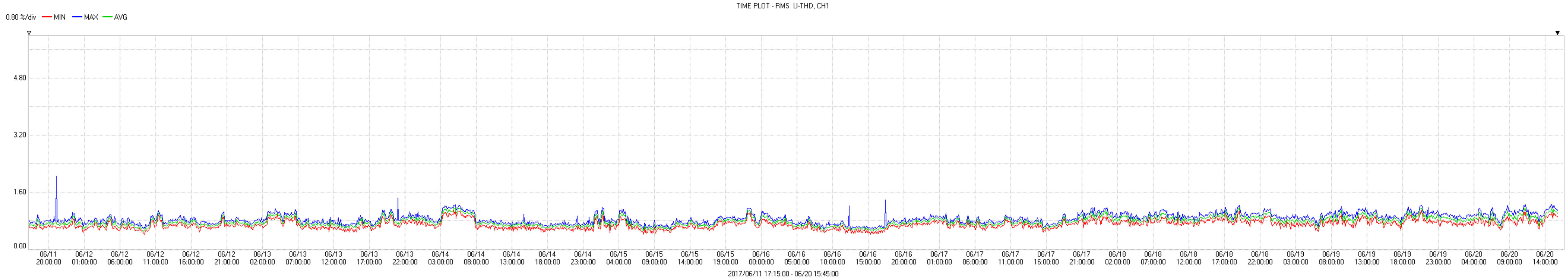

Figure 177 | STS2 - end of feeder – voltage THD measurements (Red Phase)

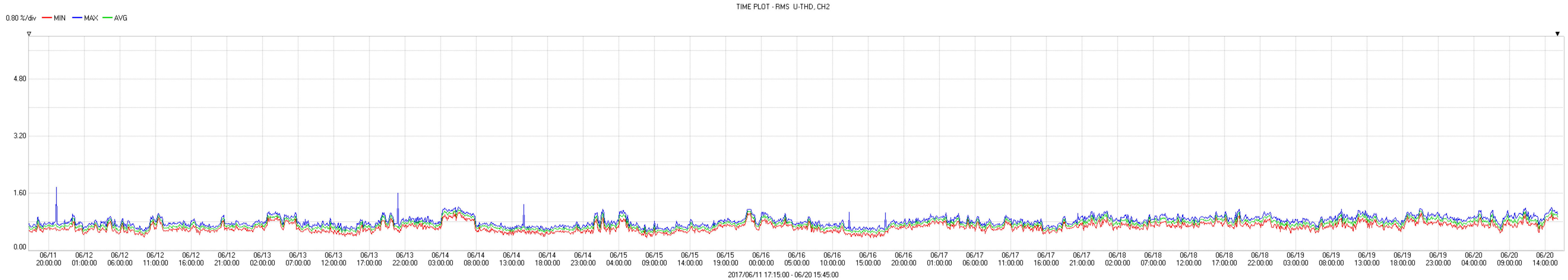

Figure 178 | STS2 - end of feeder – voltage THD measurements (White Phase)

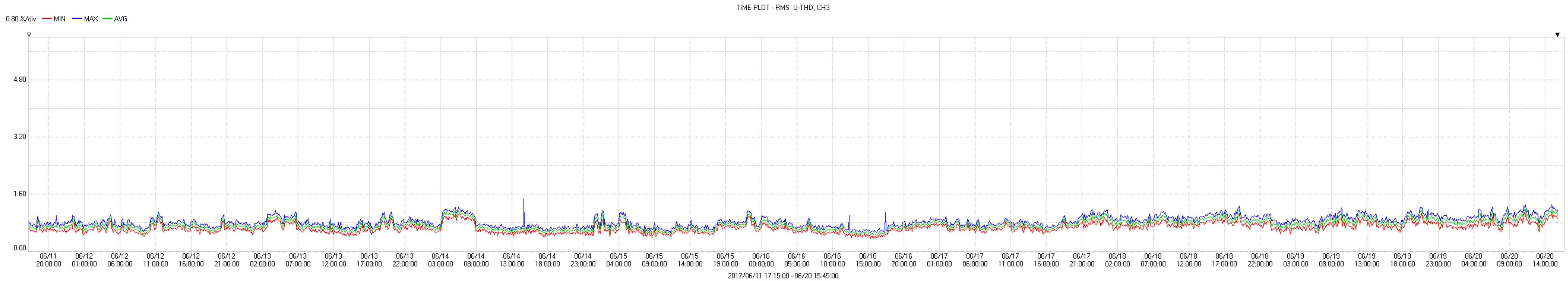

Figure 179 | STS2 - end of feeder – voltage THD measurements (Blue Phase)

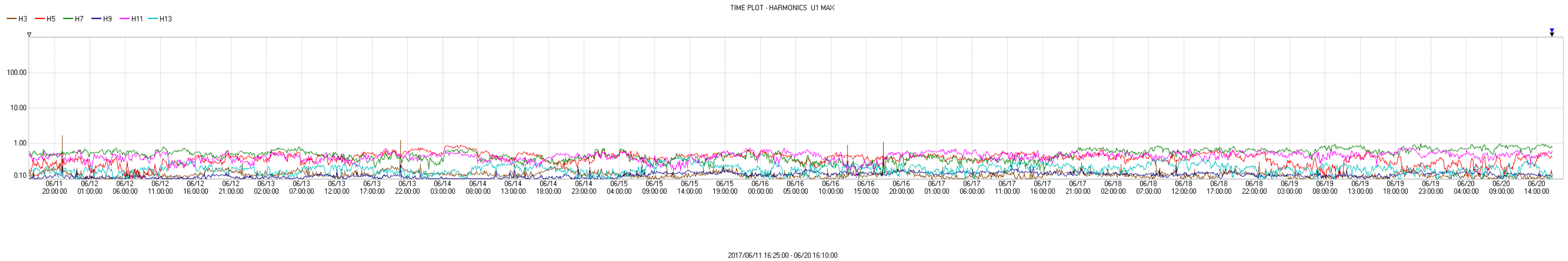

Figure 180 | STS2 – start of feeder – 3rd to 13th (odd) harmonics (Red Phase)

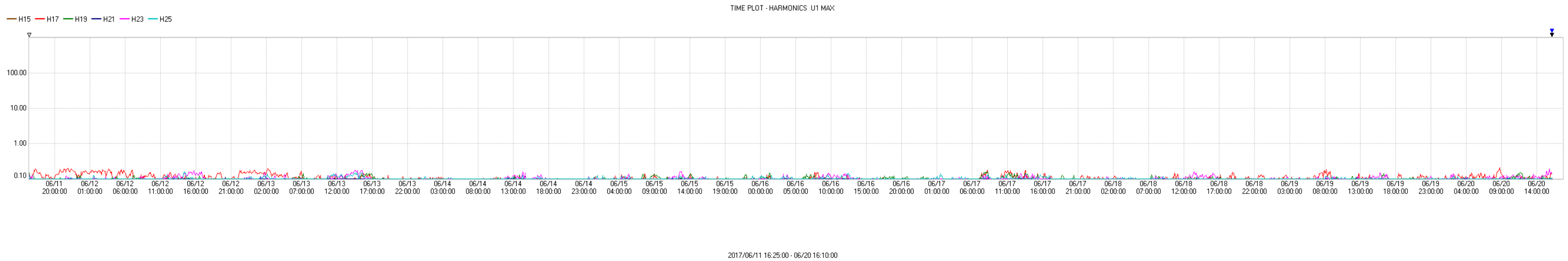

Figure 181 | STS2 – start of feeder – 15th to 25th (odd) harmonics (Red Phase)

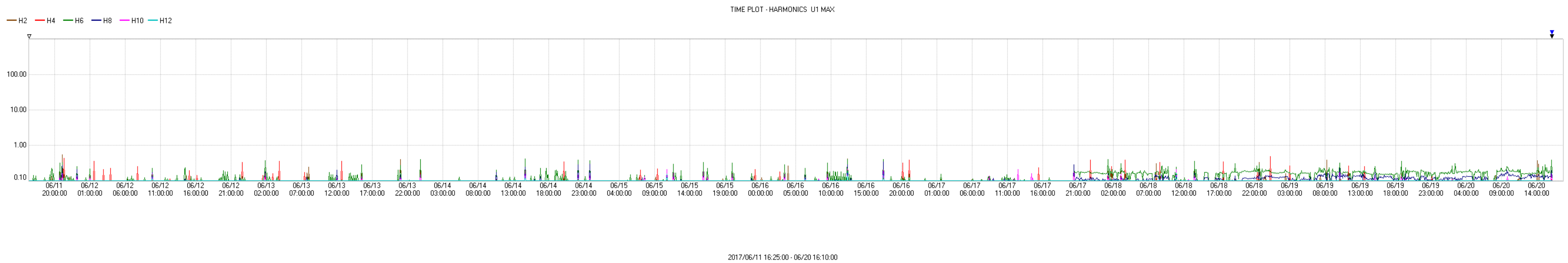

Figure 182 | STS2 – start of feeder – 2th to 12th (even) harmonics (Red Phase)

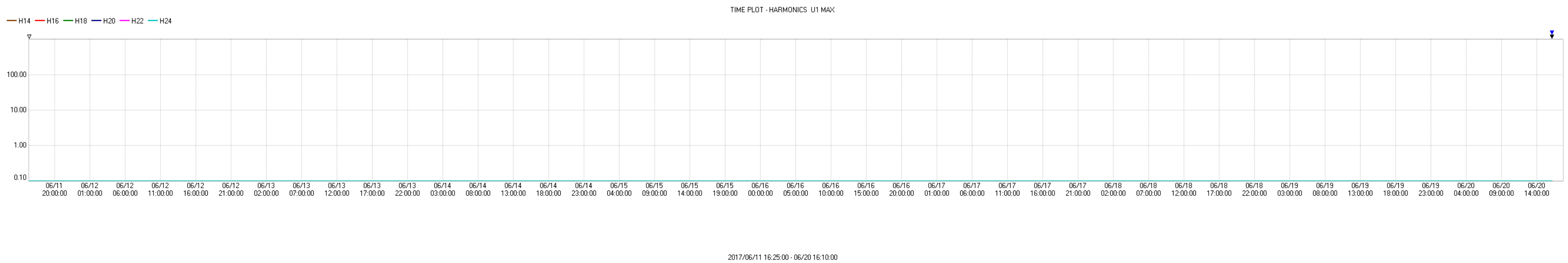

Figure 183 | STS2 – start of feeder – 14th to 24th (even) harmonics (Red Phase)

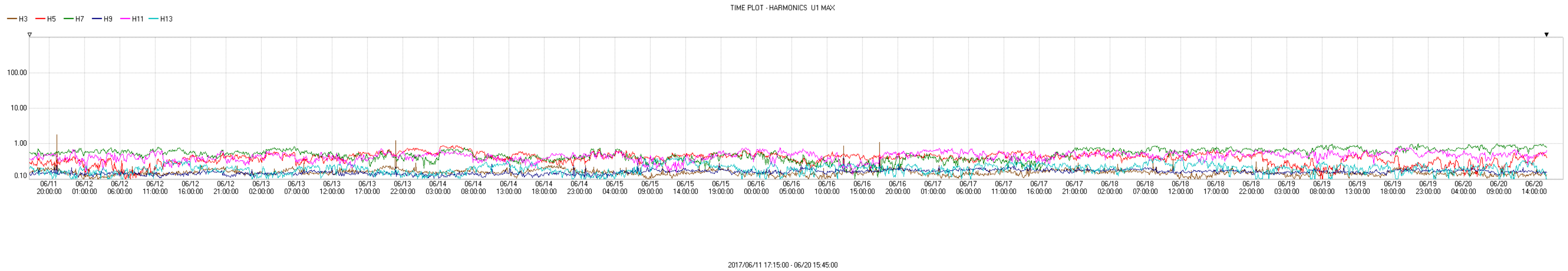

Figure 184 | STS2 – end of feeder – 3rd to 13th (odd) harmonics (Red Phase)

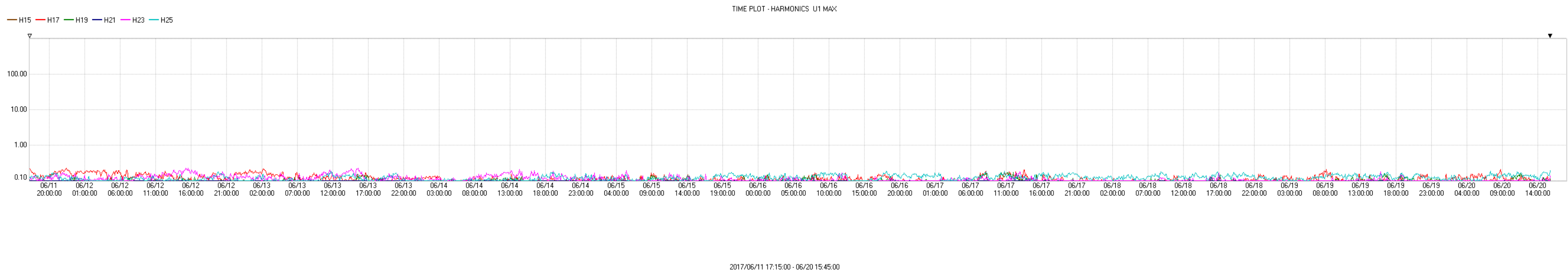

Figure 185 | STS2 – end of feeder – 15th to 25th (odd) harmonics (Red Phase)

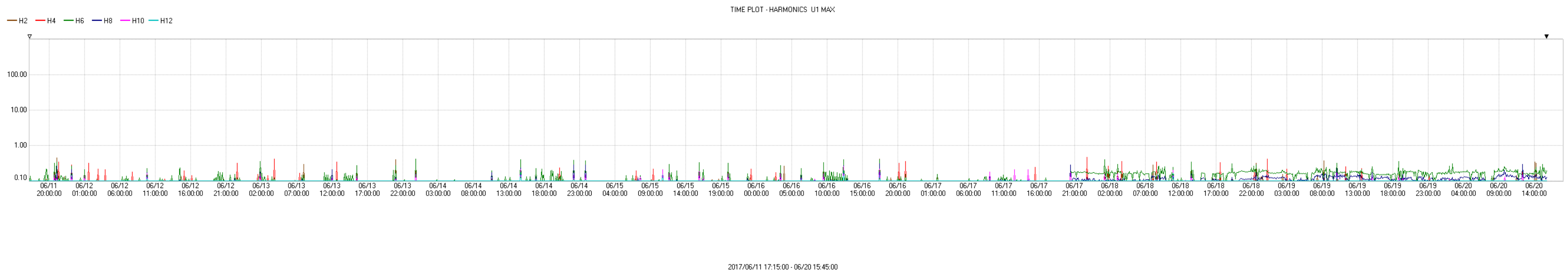

Figure 186 | STS2 – end of feeder – 2th to 12th (even) harmonics (Red Phase)

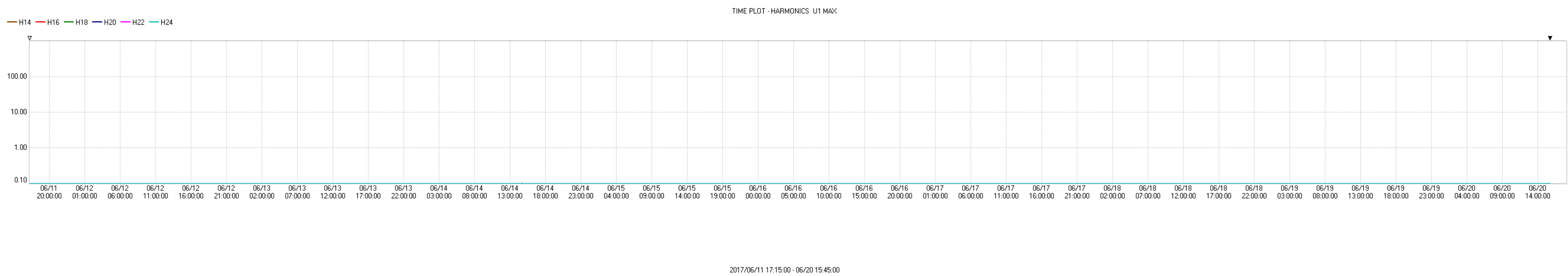

Figure 187 | STS2 – end of feeder – 14th to 24th (even) harmonics (Red Phase)

STS6 Feeder – Flicker, Voltage, Frequency, and Harmonics

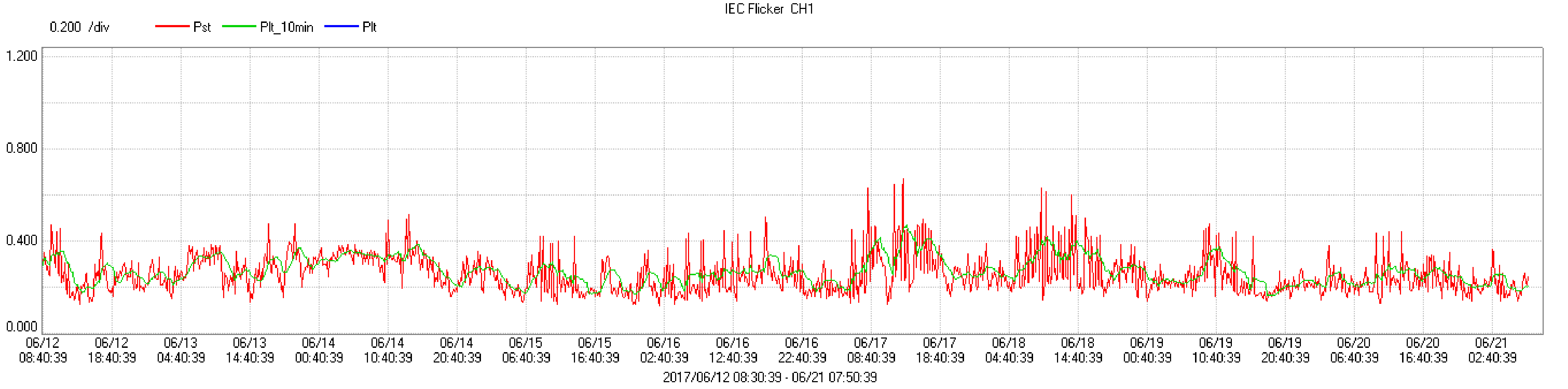

Figure 188 | STS6 - start of feeder – flicker measurements (Red Phase)

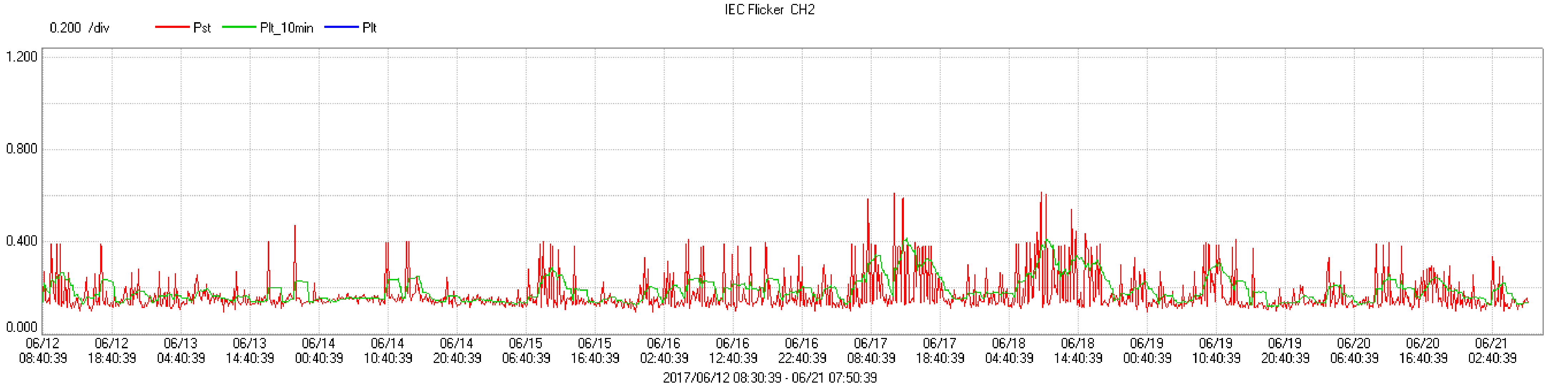

Figure 189 | STS6 - start of feeder – flicker measurements (White Phase)

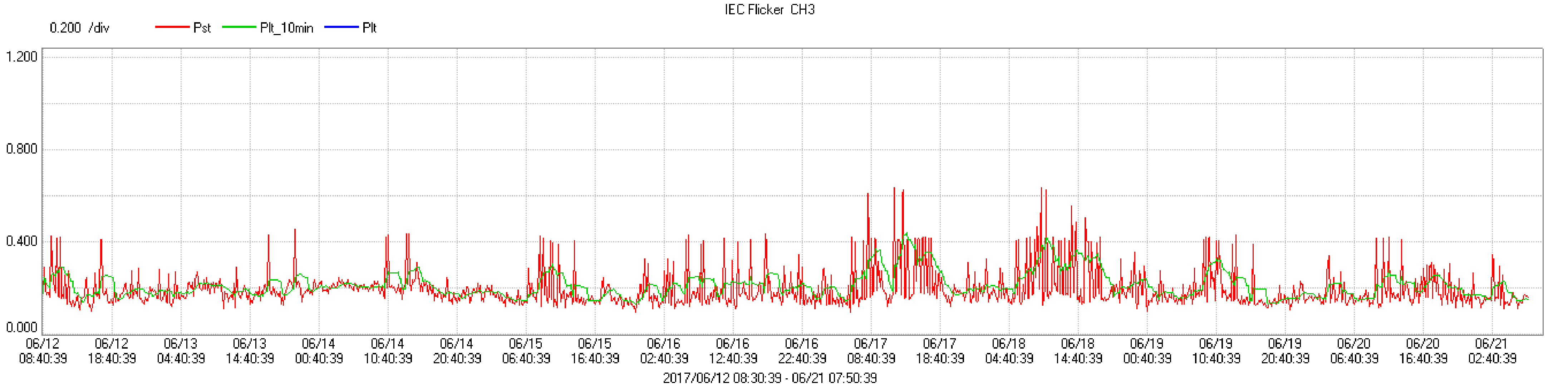

Figure 190 | STS6 - start of feeder – flicker measurements (Blue Phase)

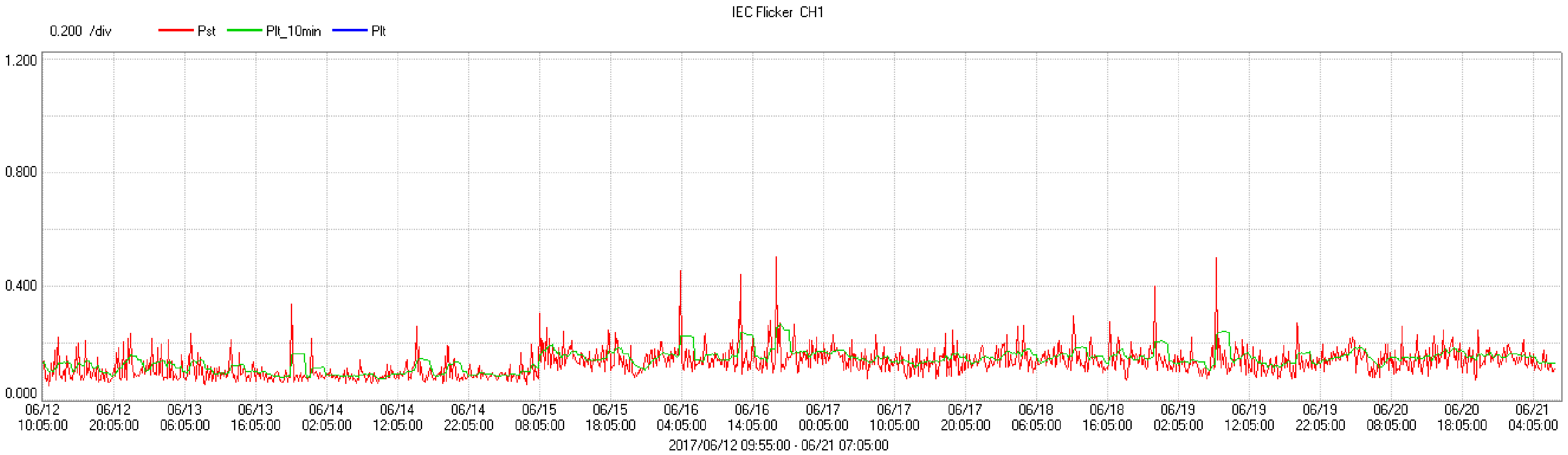

Figure 191 | STS6 – end of feeder – flicker measurements (Red Phase)

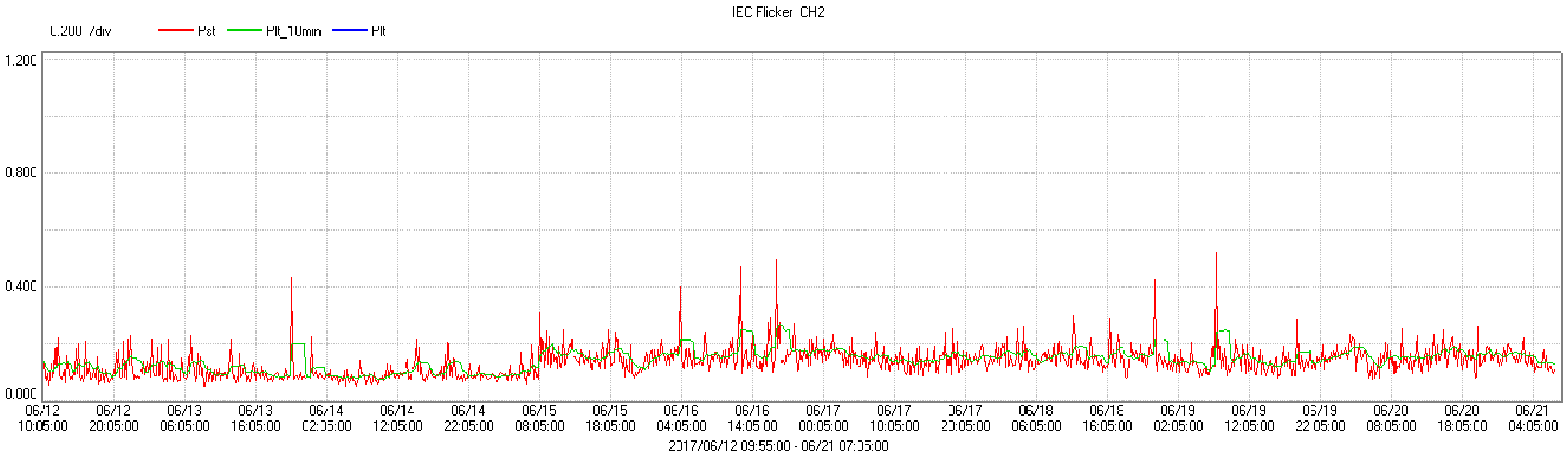

Figure 192 | STS6 - end of feeder – flicker measurements (White Phase)

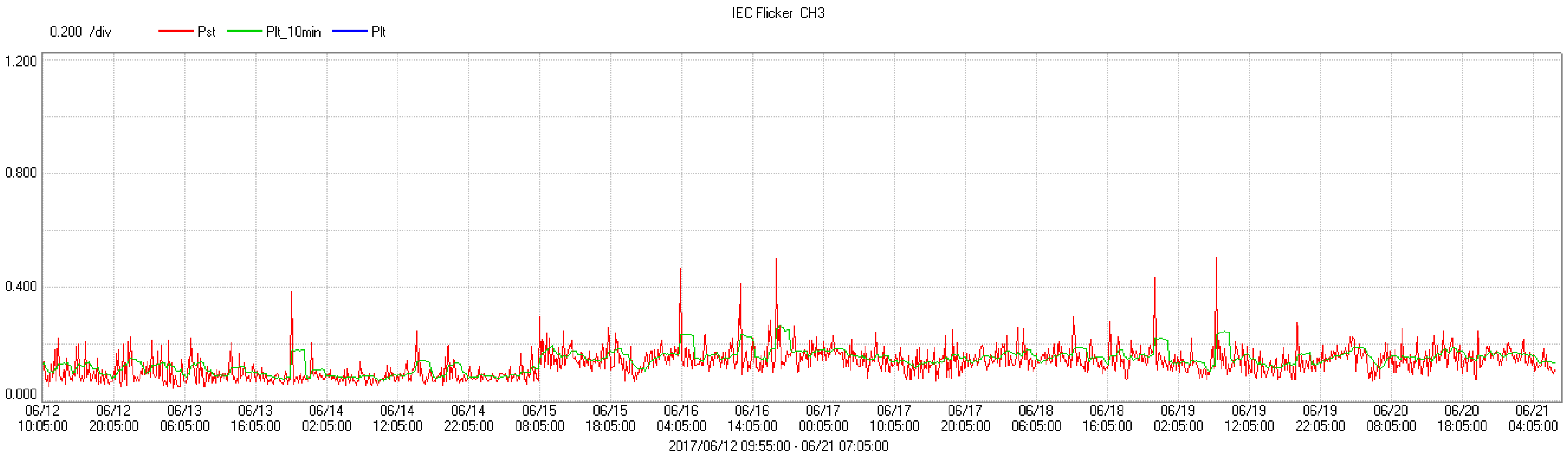

Figure 193 | STS6 - end of feeder – flicker measurements (Blue Phase)

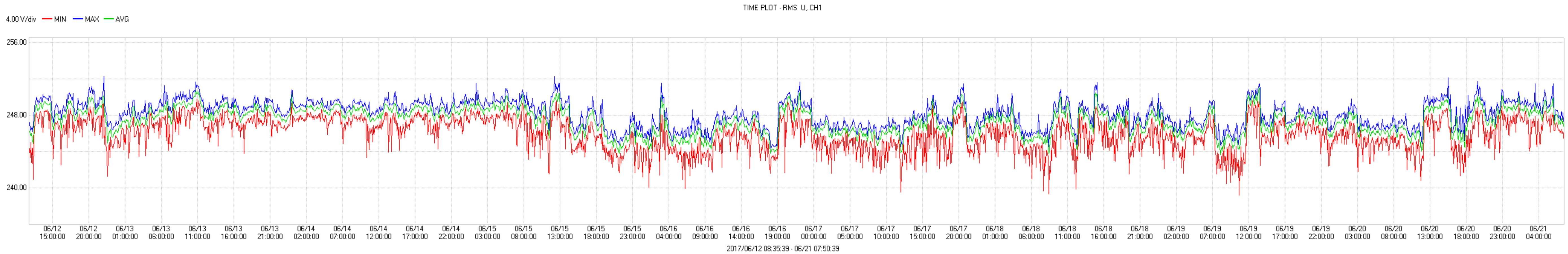

Figure 194 | STS6 - start of feeder – voltage measurements (Red Phase)

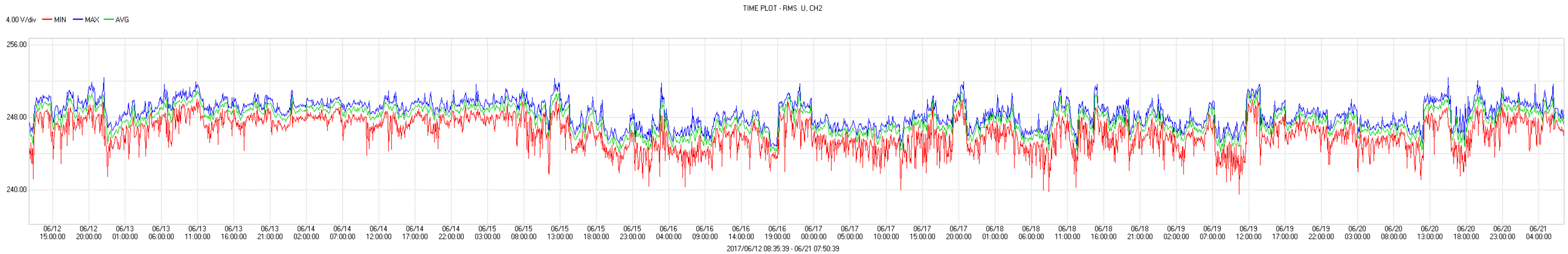

Figure 195 | STS6 - start of feeder – voltage measurements (White Phase)

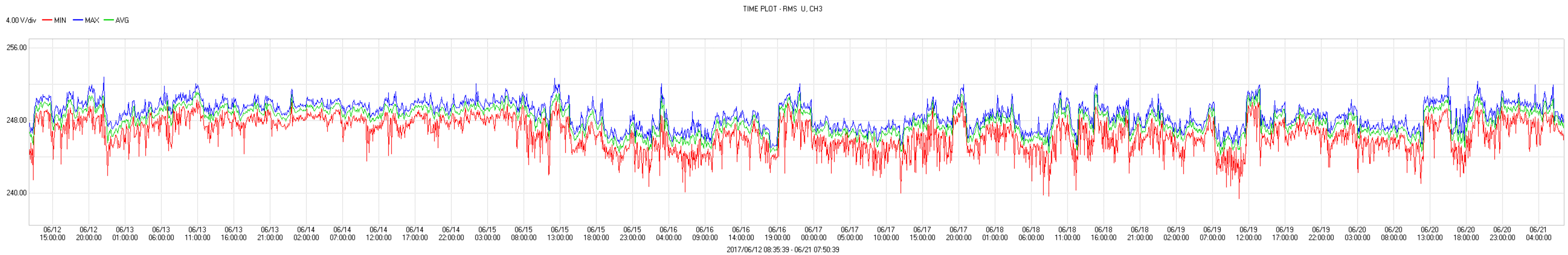

Figure 196 | STS6 - start of feeder – voltage measurements (Blue Phase)

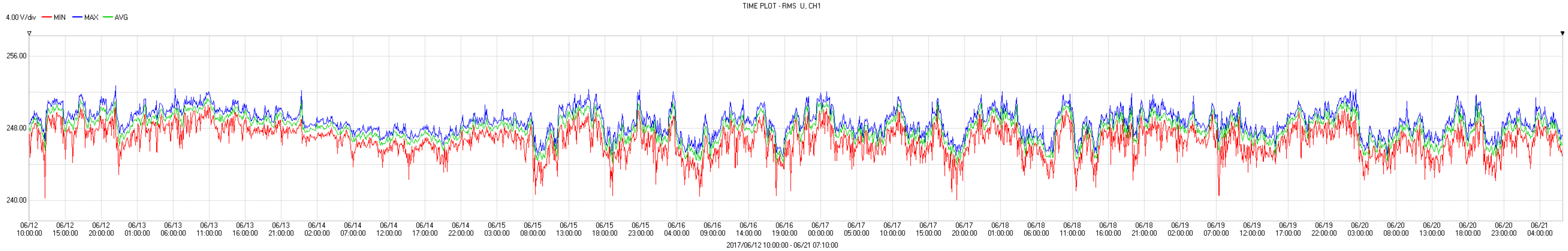

Figure 197 | STS6 - end of feeder – voltage measurements (Red Phase)

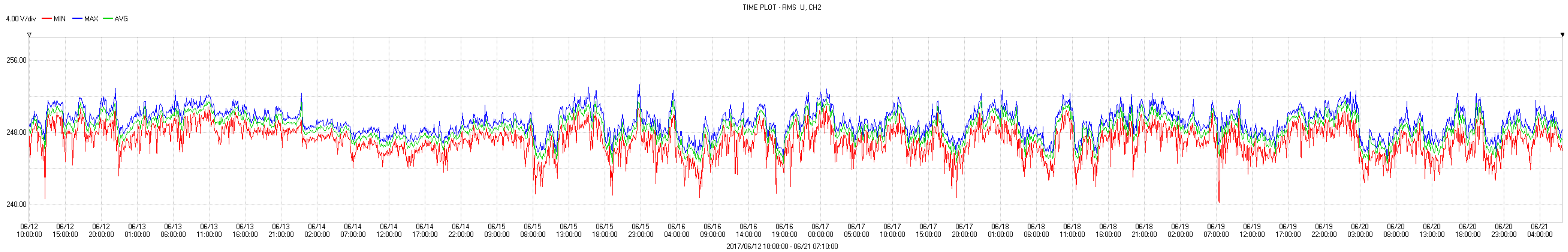

Figure 198 | STS6 - end of feeder – voltage measurements (White Phase)

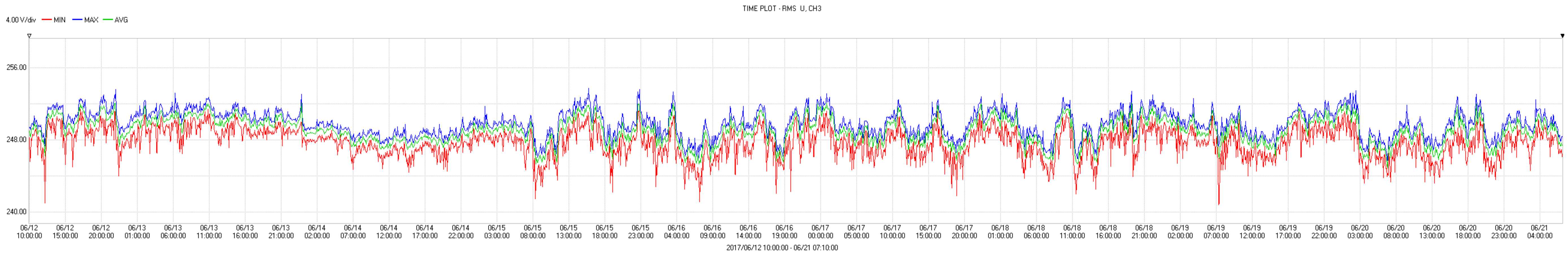

Figure 199 | STS6 - end of feeder – voltage measurements (Blue Phase)

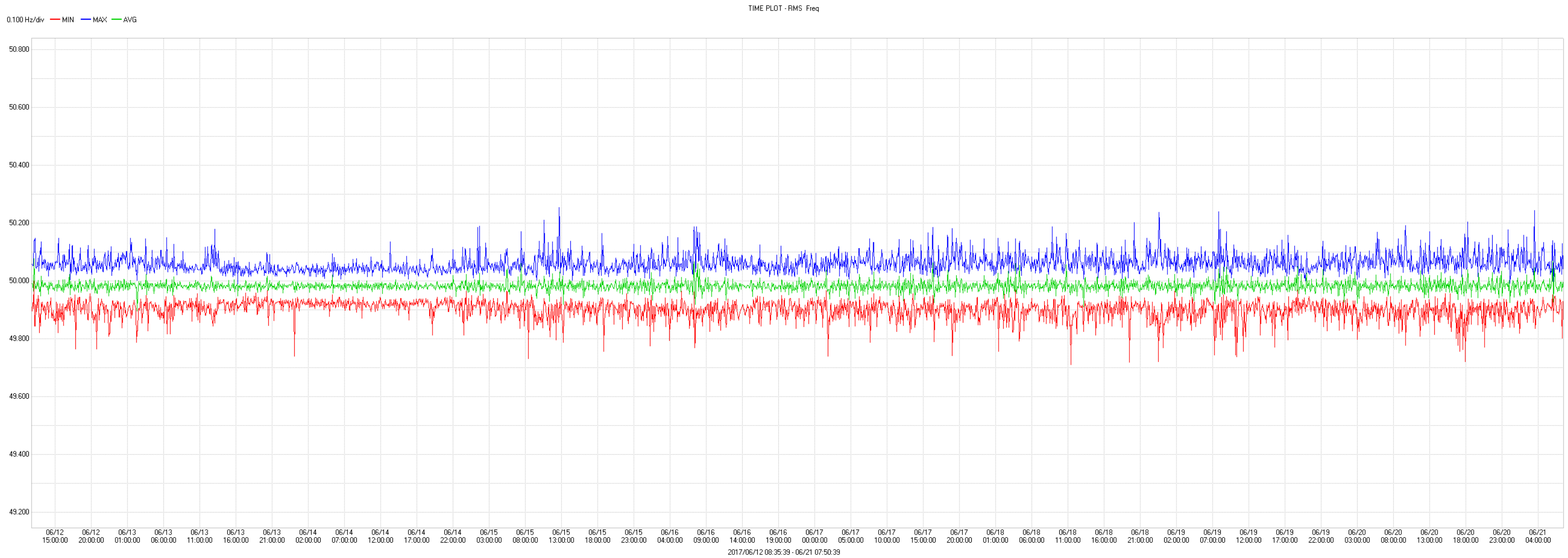

Figure 200 | STS6 - start of feeder – frequency measurements

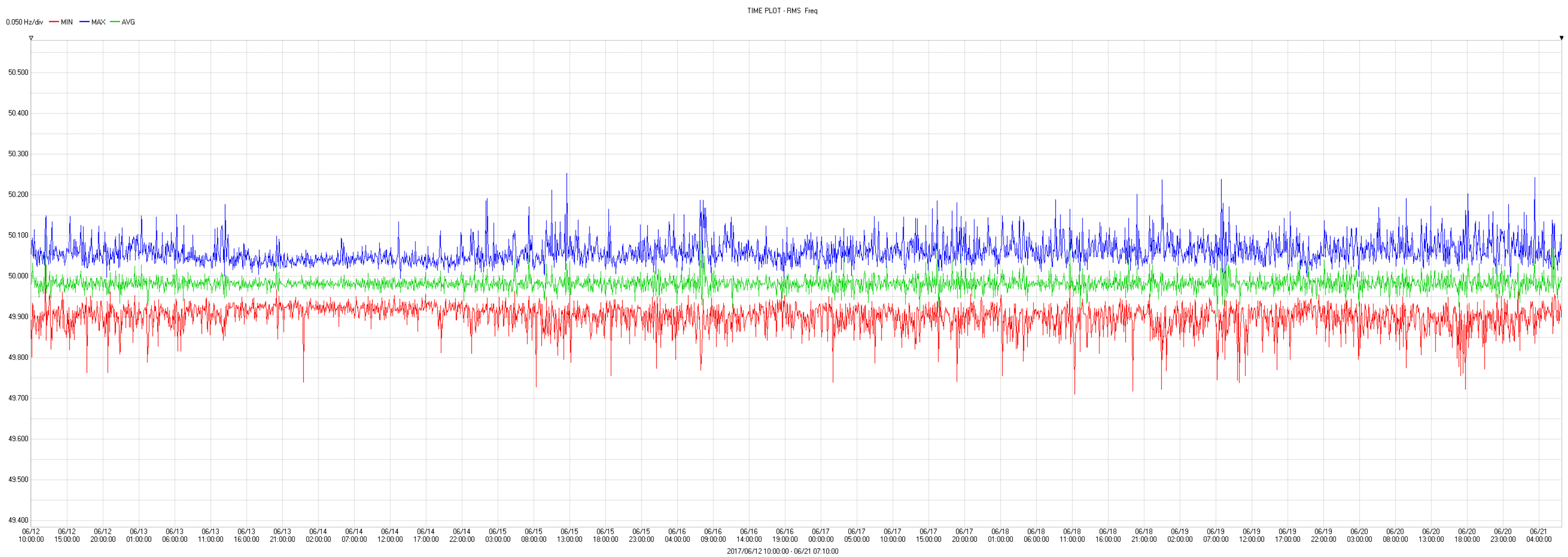

Figure 201 | STS6 - end of feeder – frequency measurements

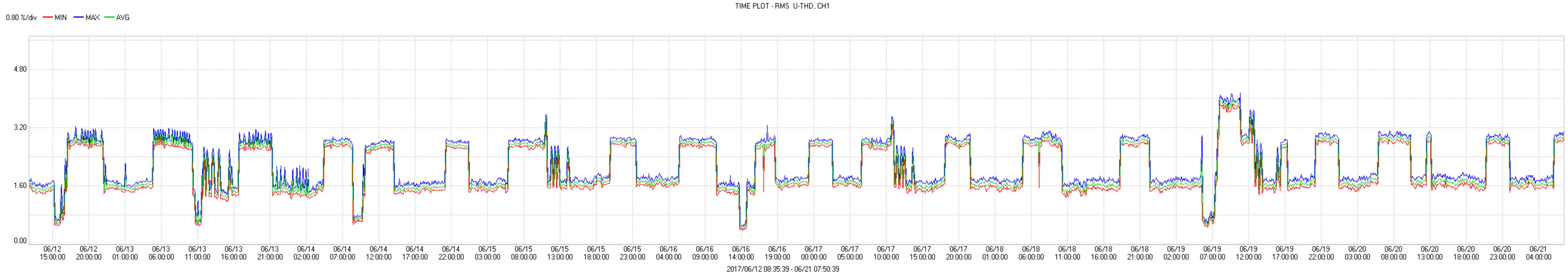

Figure 202 | STS6 - start of feeder – voltage THD measurements (Red Phase)

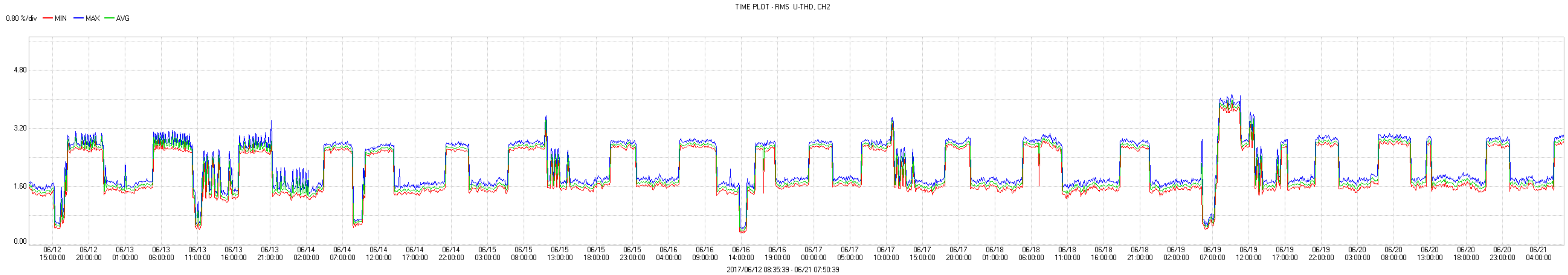

Figure 203 | STS6 - start of feeder – voltage THD measurements (White Phase)

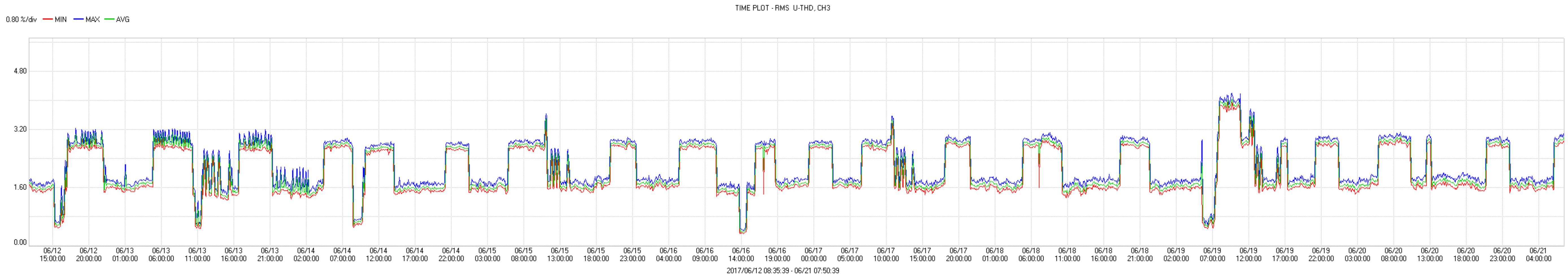

Figure 204 | STS6 - start of feeder – voltage THD measurements (Blue Phase)

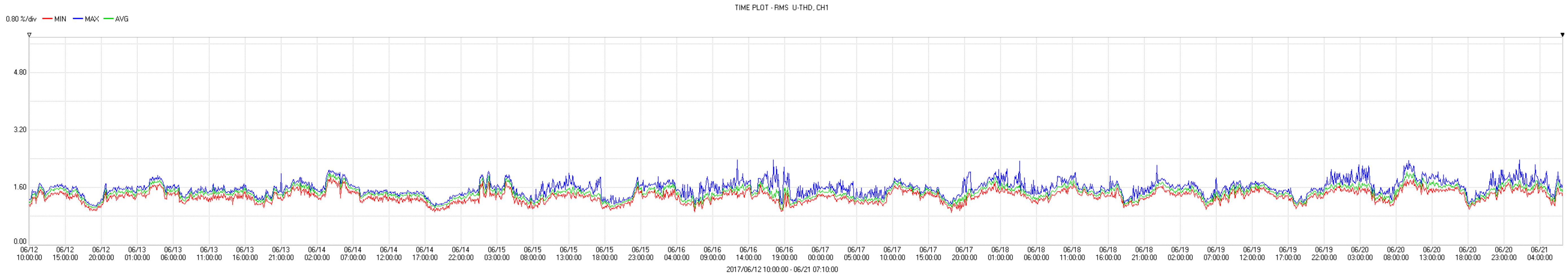

Figure 205 | STS6 - end of feeder – voltage THD measurements (Red Phase)

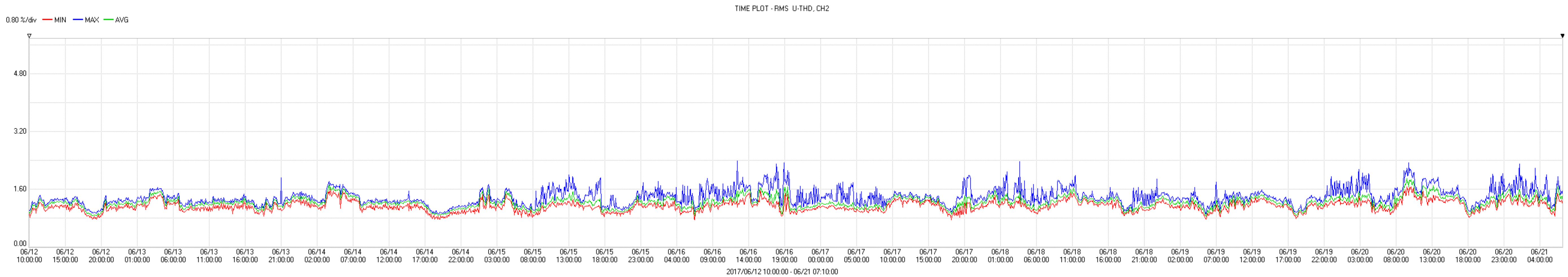

Figure 206 | STS6 - end of feeder – voltage THD measurements (White Phase)

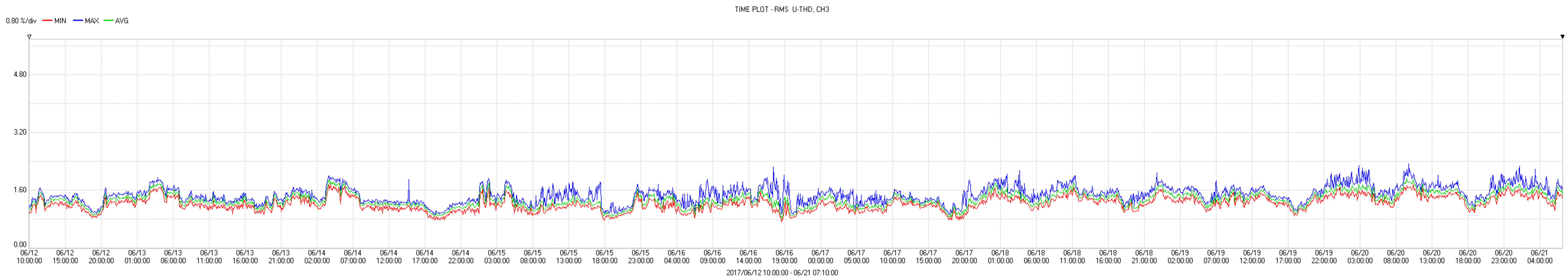

Figure 207 | STS6 - end of feeder – voltage THD measurements (Blue Phase)

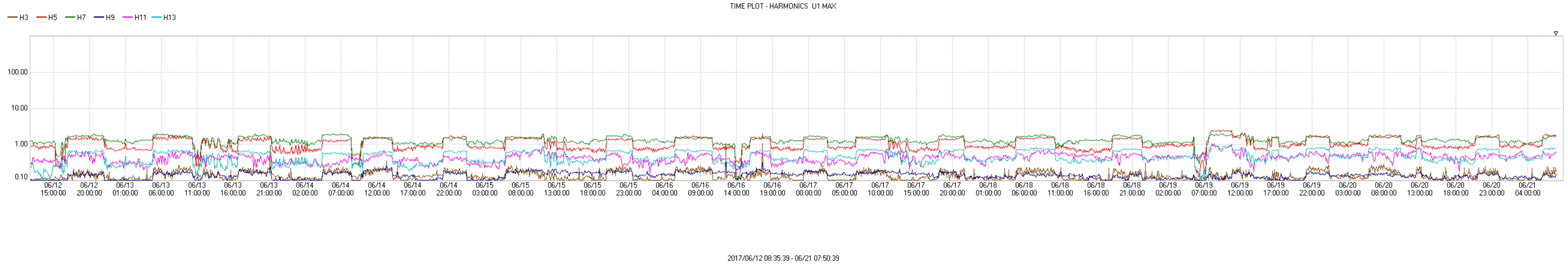

Figure 208 | STS6 – start of feeder – 3rd to 13th (odd) harmonics (Red Phase)

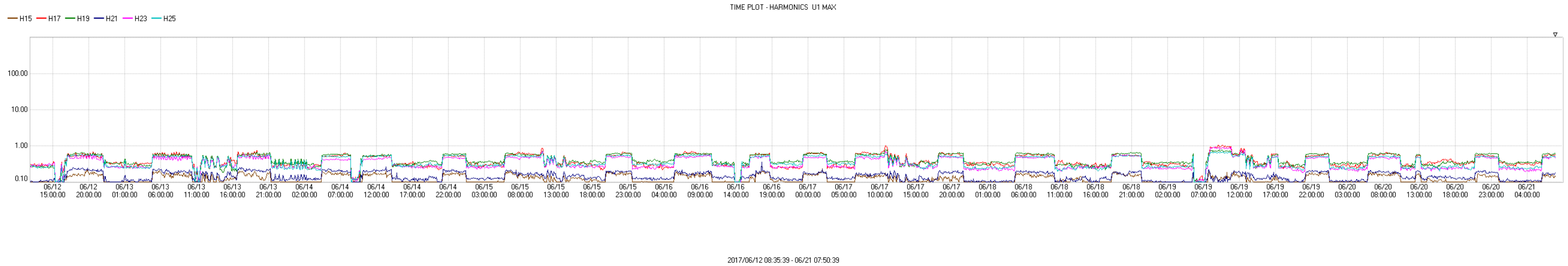

Figure 209 | STS6 – start of feeder – 15th to 25th (odd) harmonics (Red Phase)

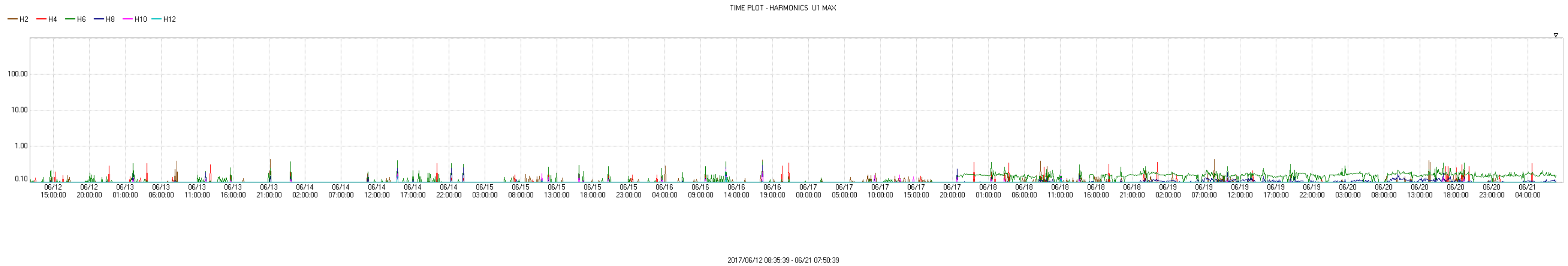

Figure 210 | STS6 – start of feeder – 2th to 12th (even) harmonics (Red Phase)

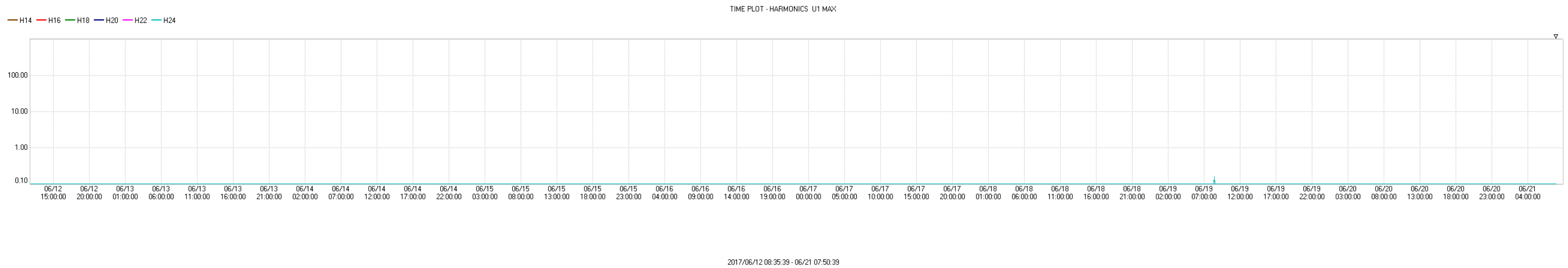

Figure 211 | STS6 – start of feeder – 14th to 24th (even) harmonics (Red Phase)

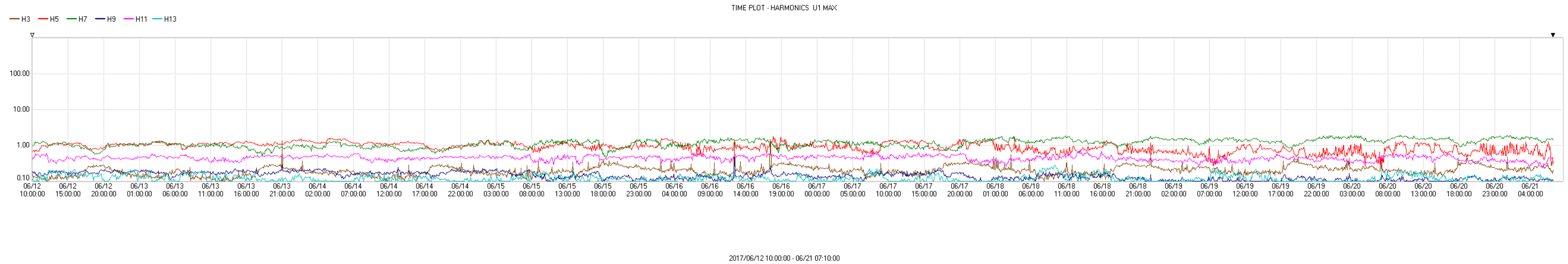

Figure 212 | STS6 – end of feeder – 3rd to 13th (odd) harmonics (Red Phase)

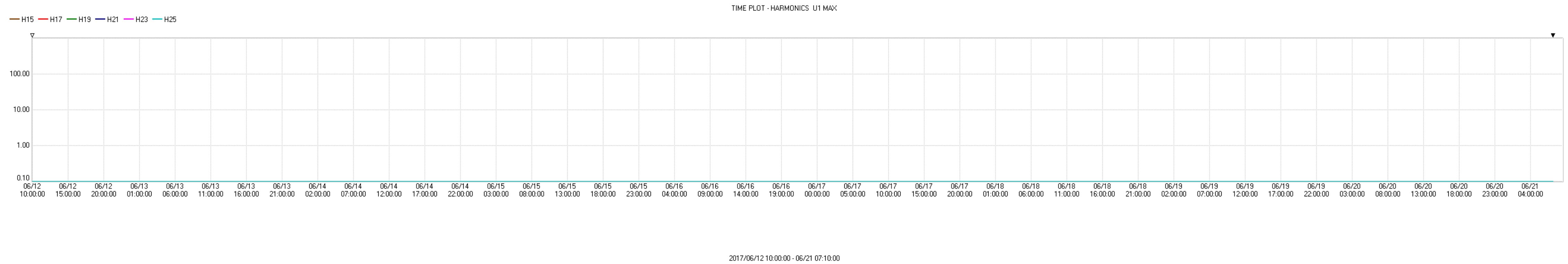

Figure 213 | STS6 – end of feeder – 15th to 25th (odd) harmonics (Red Phase)

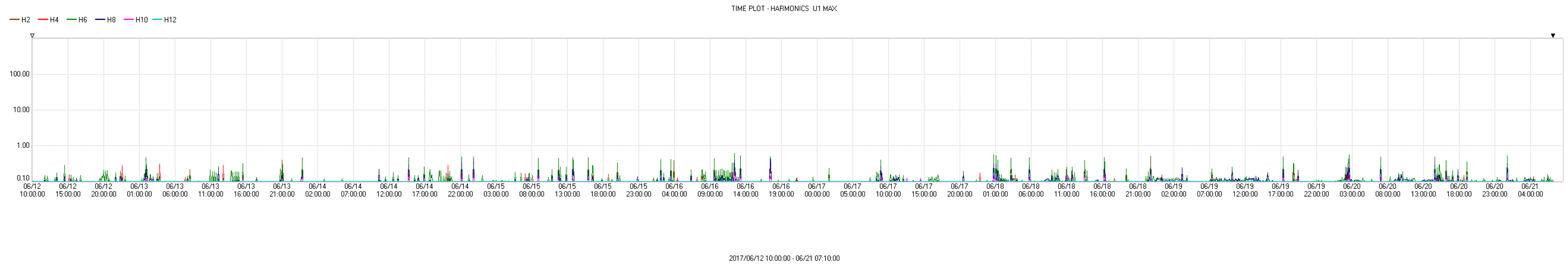

Figure 214 | STS6 – end of feeder – 2nd to 12th (even) harmonics (Red Phase)

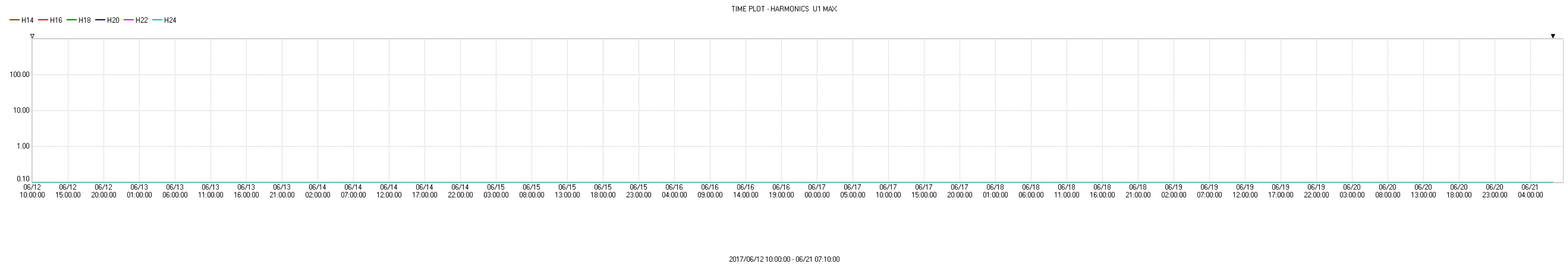

Figure 215 | STS6 – end of feeder – 14th to 24th (even) harmonics (Red Phase)

APPENDIX C Logger Installation Checklists

Please refer to the following pages.

APPENDIX D Electrical Faults Log for 2016/17 FY

Please refer to the following pages.