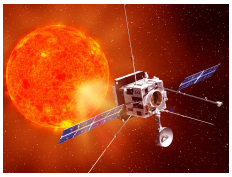

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RPW consortium – SCM instrument

Updated onboard calibration test report

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Team contributions		
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Edition	Revision	Date	Commentaries
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LIST OF TBC AND TBD

LIST OF TBC (AC in french)

Chapter	Description	Dependency

LIST OF TBD (AD in french)

Chapter	Description	Dependency

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1. PURPOSE

The document is a report of the test performed to validate an update of LFR software related to the onboard calibration system working with SCM sensor.
2 points have been updated on the calibration signal sent by LFR to SCM:

- The amplitude of the signal has been multiplied by 2 to solve the problem identified with EM model showing a too low signal at the output of SCM (see the NC report [RD2]).
- The number of frequencies has been increased to 5 pairs instead of 1 initially (10kHz & 626Hz) to have a better coverage of the measurement frequency band (science need).

The test was done with the EM model of the respective units.

2. DOCUMENTATION

2.1. Applicables documents

	Reference	Ed Rev	Date	Title of the Document
DA1				
DA2				
DA3				

2.2. Reference documents

	Reference	Ed Rev	Date	Title of the Document
DR1	SO-TR-RPW-SC-0272-LPC2E	1.0	02/2018	SCM-FS calibration test report
DR2	SOLO-RPW-FT-240	0	11/2016	LFR/SCM internal calibration system too low
DR3				

2.3. Glossary

CNES	Centre National d'Etudes Spatiales
CNRS	Centre National de la Recherche Scientifique
EID	Experiment Interface Document (EID-A:part A, EID-B: part B)
EM	Engineering Model
EMC	Electro Magnetic Compatibility
ESA	European Space Agency
FM	Flight Model
FTV	Fast Temperature Variations
HFR	High Frequency Receiver
LESIA	Laboratoires d'Etudes Spatiales et d'Instrumentation en Astrophysique
LFR	Low Frequency Receiver
LPC2E	Laboratoire de Physique et Chimie de l'Environnement et de l'Espace
PGA	Pin Grid Array
QM	Qualification Model
RPW	Radio Plasma Wave analysis
SCM	Search Coil Magnetometer
TBD	To Be Defined
TBW	To Be Written
TDS	Time Domain Sampler

3. PRINCIPLE OF THE ONBOARD CALIBRATION

3.1. SCM onboard calibration description

The onboard calibration enables to verify the calibration of SCM instrument in flight. It is based on a reference signal sent by MEB-LFR to the secondary coil of each antenna through SCM preamplifier as described.
This secondary coil behaves like a solenoid and generate the reference magnetic field to calibrate SCM onboard.

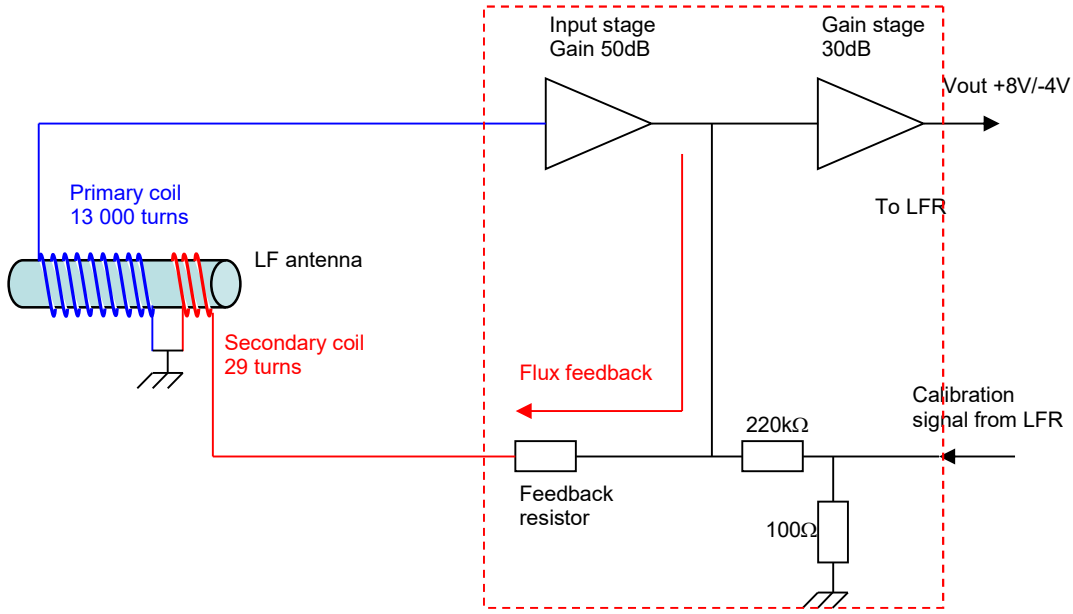


Figure 3.1 – SCM preamplifier and antenna electrical diagram

The reference signal sent by LFR is a mix of 2 sinus waves a 2 frequencies.

3.2. Updates implemented

2 points have been updated on the calibration signal sent by LFR to SCM:

- The amplitude of the signal has been multiplied by 2 to solve the problem identified with EM model showing a too low signal at the output of SCM (see the NC report [RD2]).
- The number of frequencies has been increased to 5 pairs instead of 1 initially (10kHz & 626Hz) to have a better coverage of the measurement frequency band (science need).

The updated calibration signal is a sweep composed of 5 pairs of sinus waves sent alternatively one after the other. The frequencies are given in the table below.

Pair N°	High frequency	Low frequency
1	10016 Hz	626 Hz
2	5008 Hz	313 Hz
3	2504 Hz	156.5 Hz
4	1252 Hz	78.25 Hz
5	626 Hz	39.125 Hz

4. UPDATED ONBOARD CALIBRATION TEST

4.1. Test configuration

The test configuration is described on the figure 4.1 below.

- SCM EM is located alone inside the mumetal shielding boxes
- The connection is done using the EQM harnesses RPW25H (boom) and RPW26H (platform) to have a setup as representative as possible.
- SCM power supply is also provided through the harnesses. The loop connector is used in replacement of the TCS board not implemented on LFR EM circuit
- LFR circuit is supplied and driven by its GSE through the SpaceWire interface

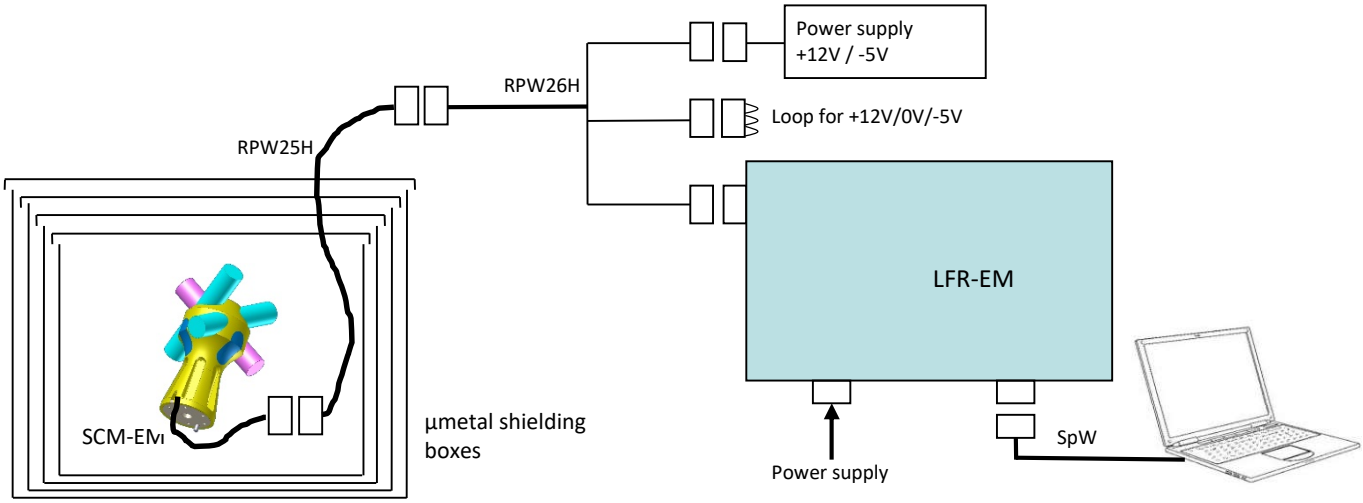


Figure 4.1 – Scheme of the test configuration

To have the signal as high as possible and the best accuracy, a short circuit was put on the resistance of 910 at LFR output specifically for this test. As a consequence the divider on FM (reducing the signal level) is not present here.

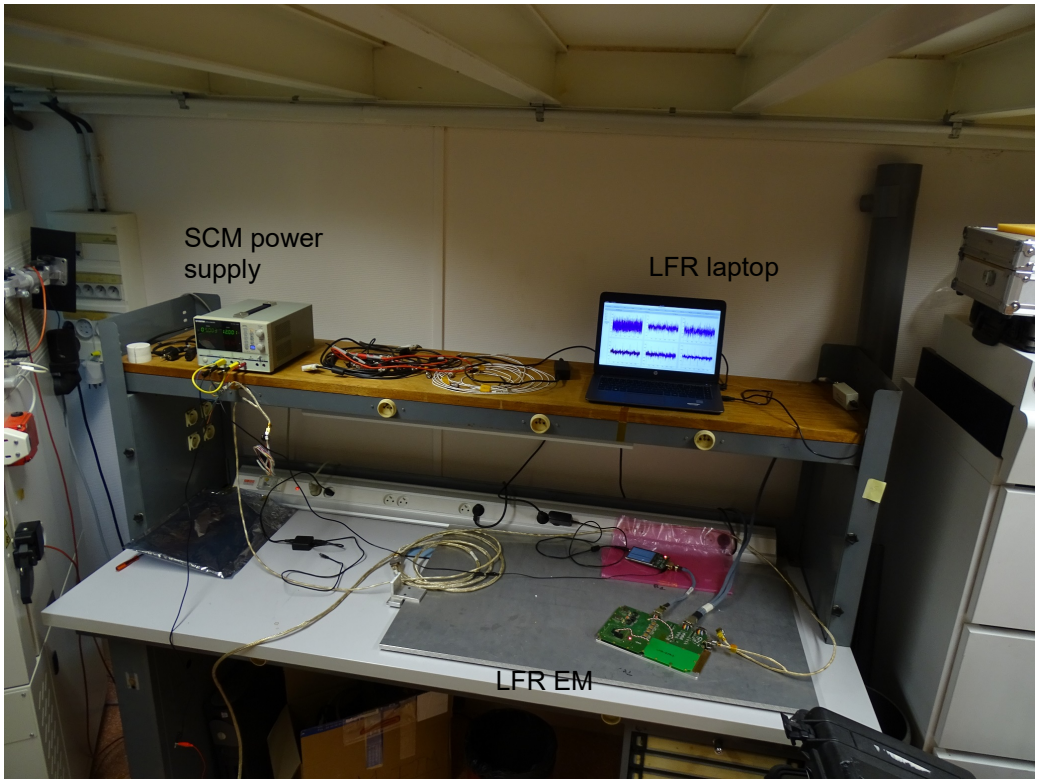


Figure 4.2 – Picture of the test configuration

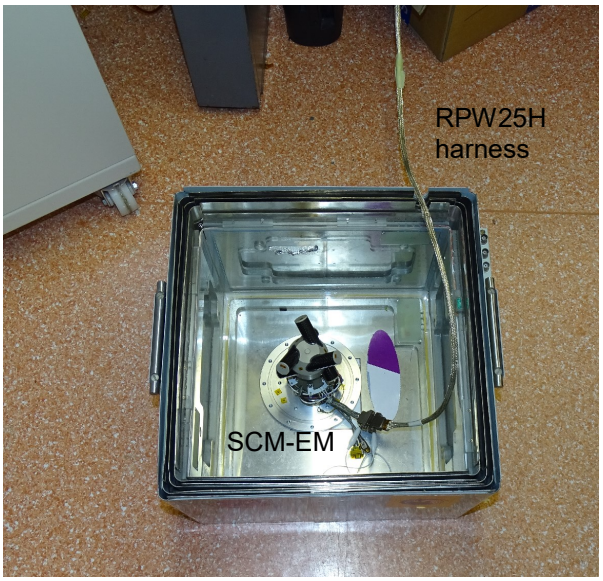


Figure 4.3 – Picture of SCM inside the mumetal shield

4.2. Test results

The test duration was set to have 7 sweeps. The following figures present SCM output signal resulting from the calibration and registered by LFR. LFR provides the data sampled at 3 frequencies:

- f0 24576 Hz
- f1 4096 Hz
- f2 256 Hz

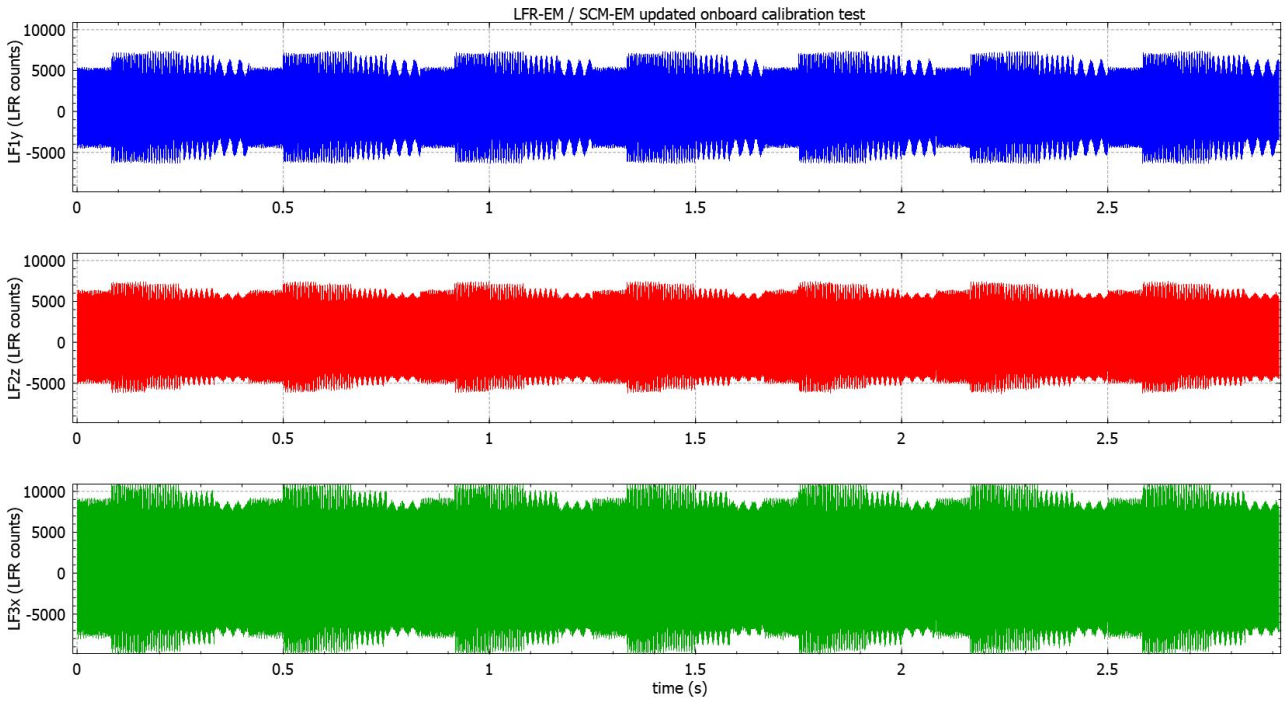


Figure 4.4 – Waveform registered by LFR with 7 calibration sweeps (f0 sampling)

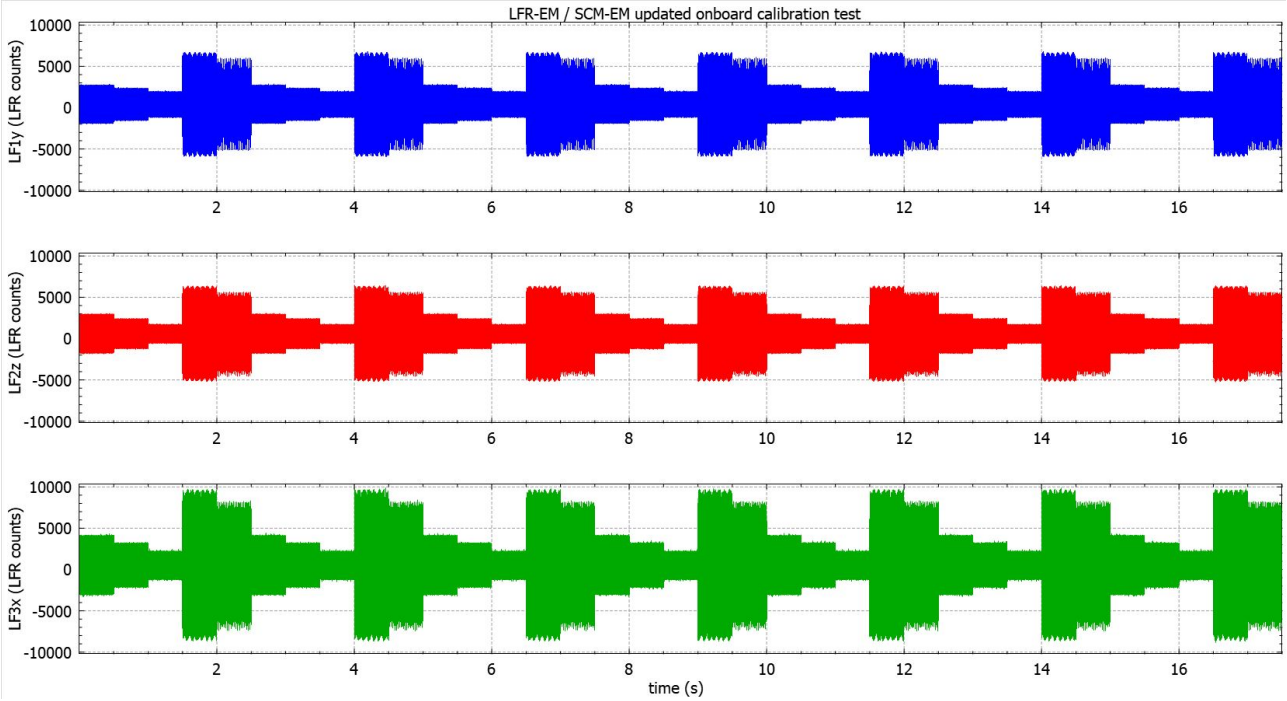


Figure 4.5 – Waveform registered by LFR with 7 calibration sweeps (f1 sampling)

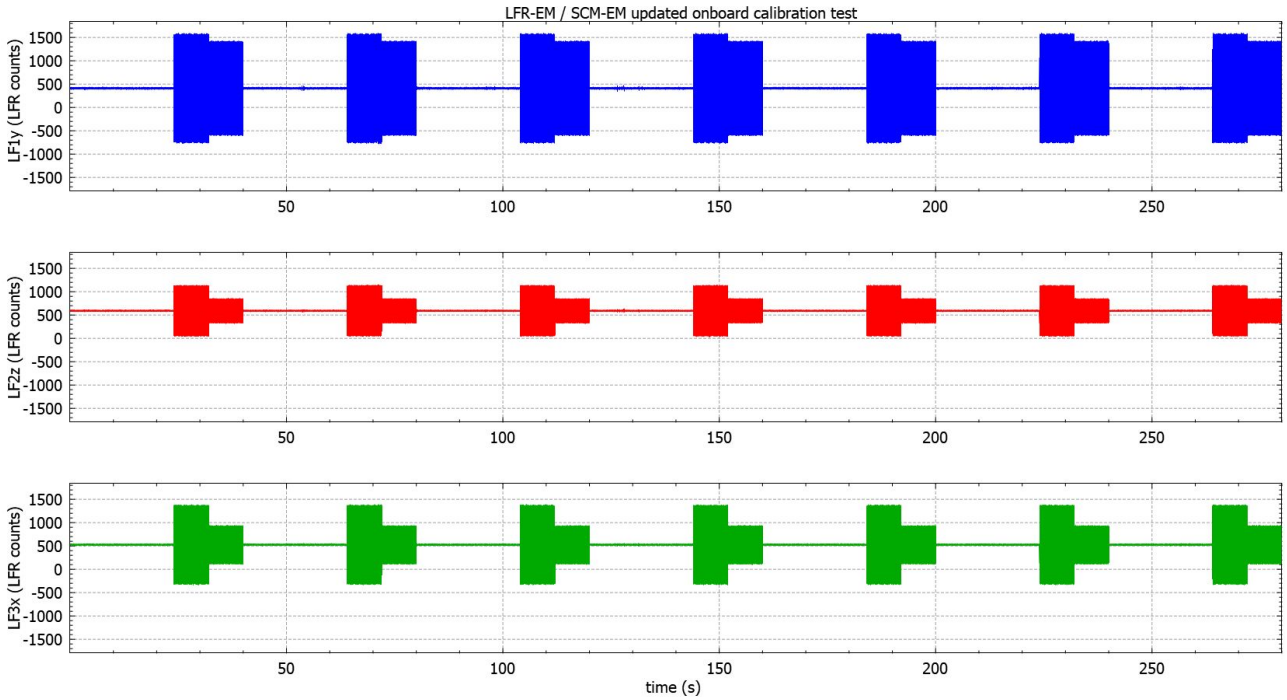


Figure 4.6 – Waveform registered by LFR with 7 calibration sweeps (f2 sampling)

The effects of the sampling frequency are visible and show the consistency of the data. With f2 data, only the 2 lowest frequencies (78Hz and 39Hz) are visible. There is only a background noise when the first 3 pairs are injected.

The following figures present a zoom on 1 sweep and then a focus on each pair.

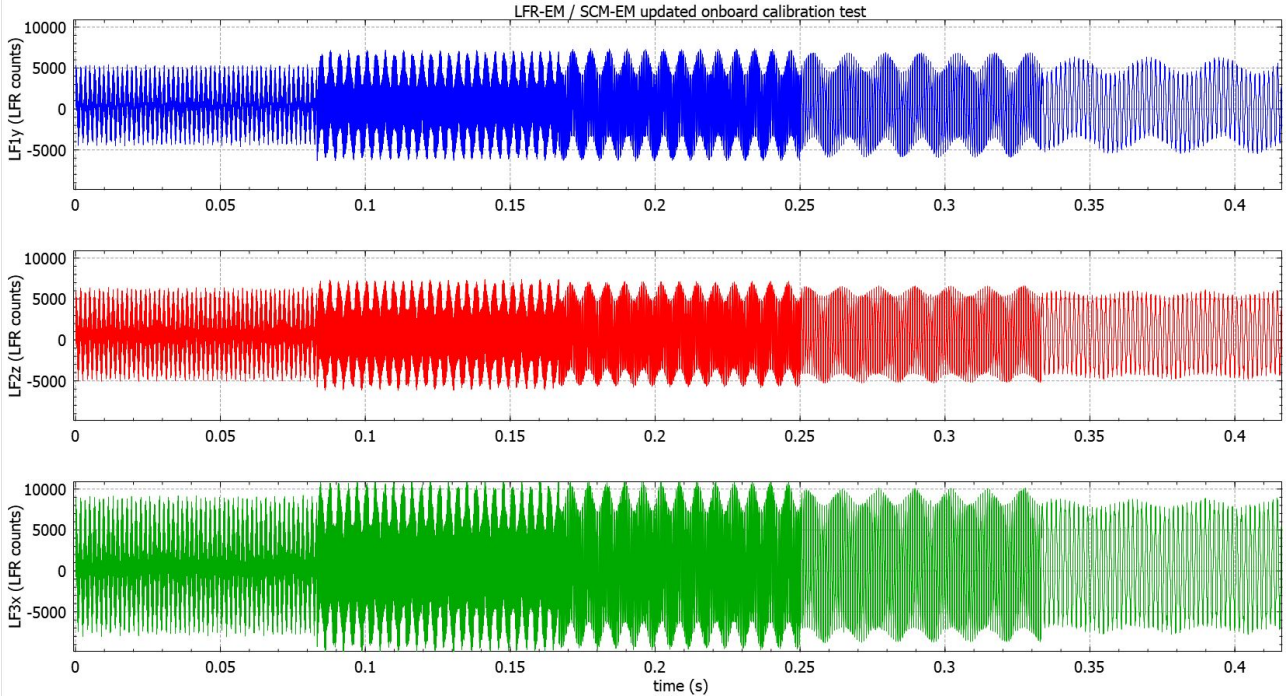


Figure 4.7 – Waveform registered by LFR with 1 calibration sweep (f0 sampling)

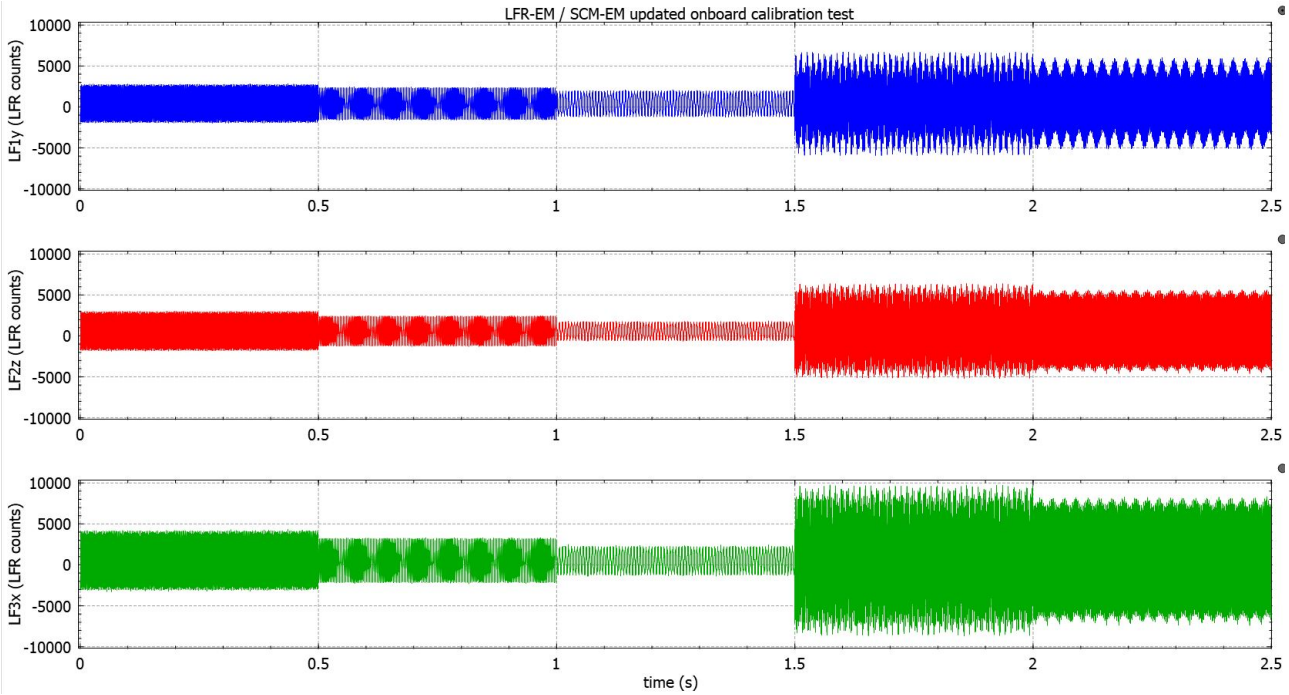


Figure 4.8 – Waveform registered by LFR with 1 calibration sweep (f1 sampling)

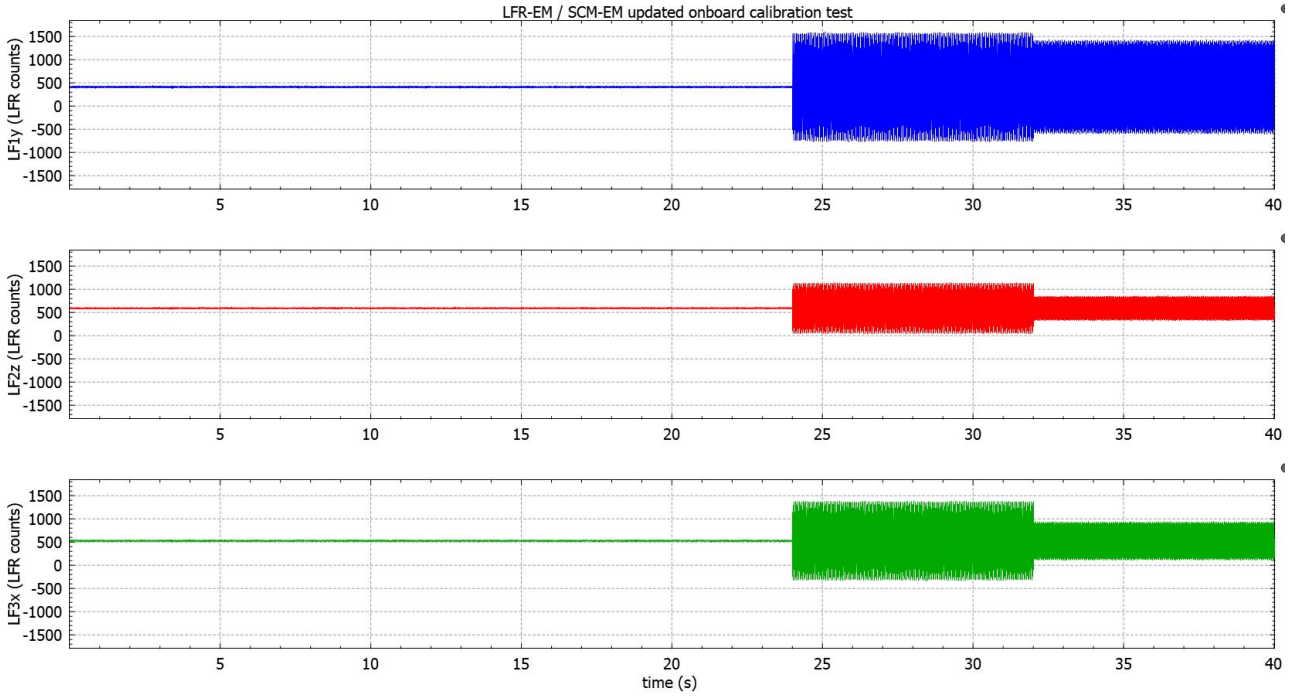
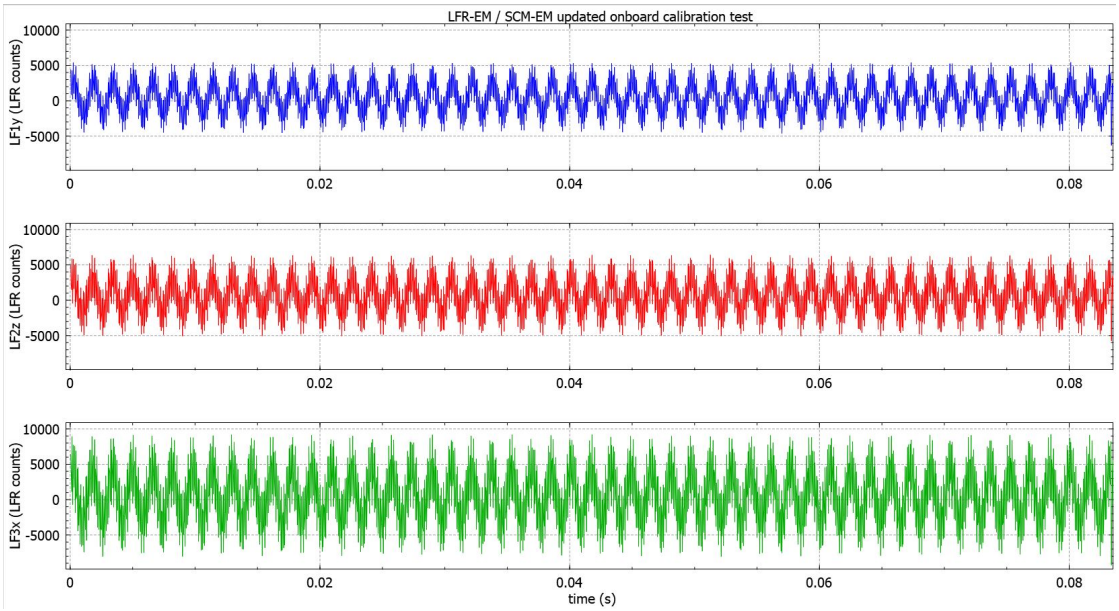


Figure 4.9 – Waveform registered by LFR with 1 calibration sweep (f2 sampling)

4.2.1. 10kHz – 626Hz snapshot



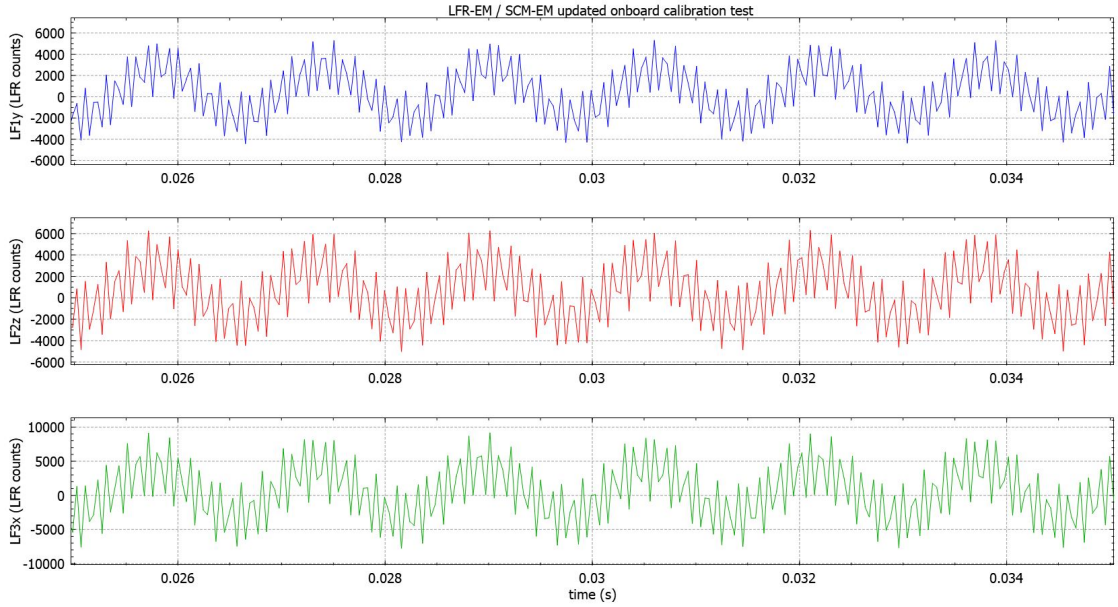


Figure 4.11 – 10kHz-626Hz signal at f0 (full sweep and zoom)

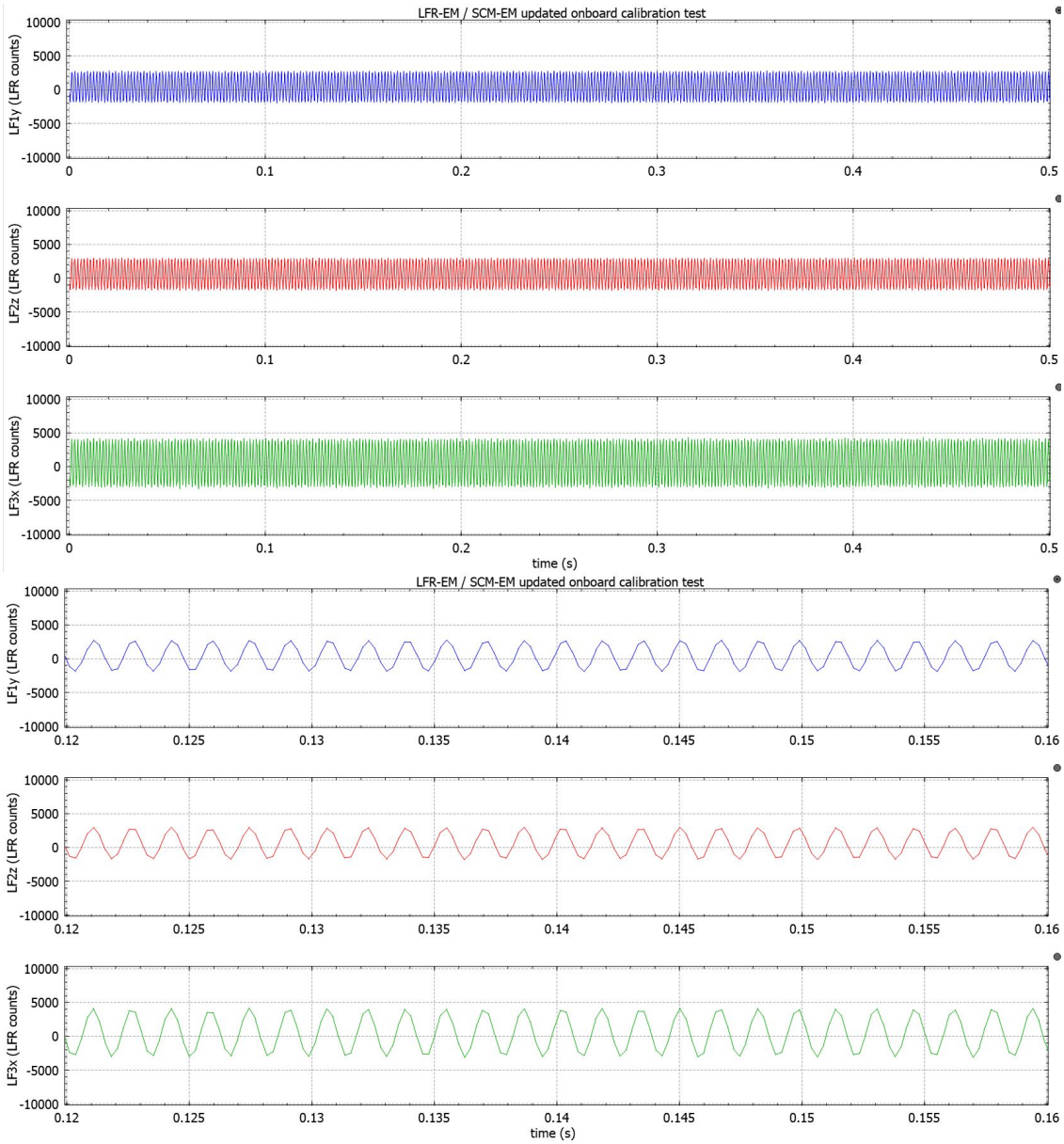


Figure 4.12 – 10kHz-626Hz signal at f1 (full sweep and zoom)

f2 data are not presented since the sampling frequency is 256Hz, none of the 2 frequencies is visible, there is only the background noise.

4.2.2. 5kHz – 313Hz snapshot

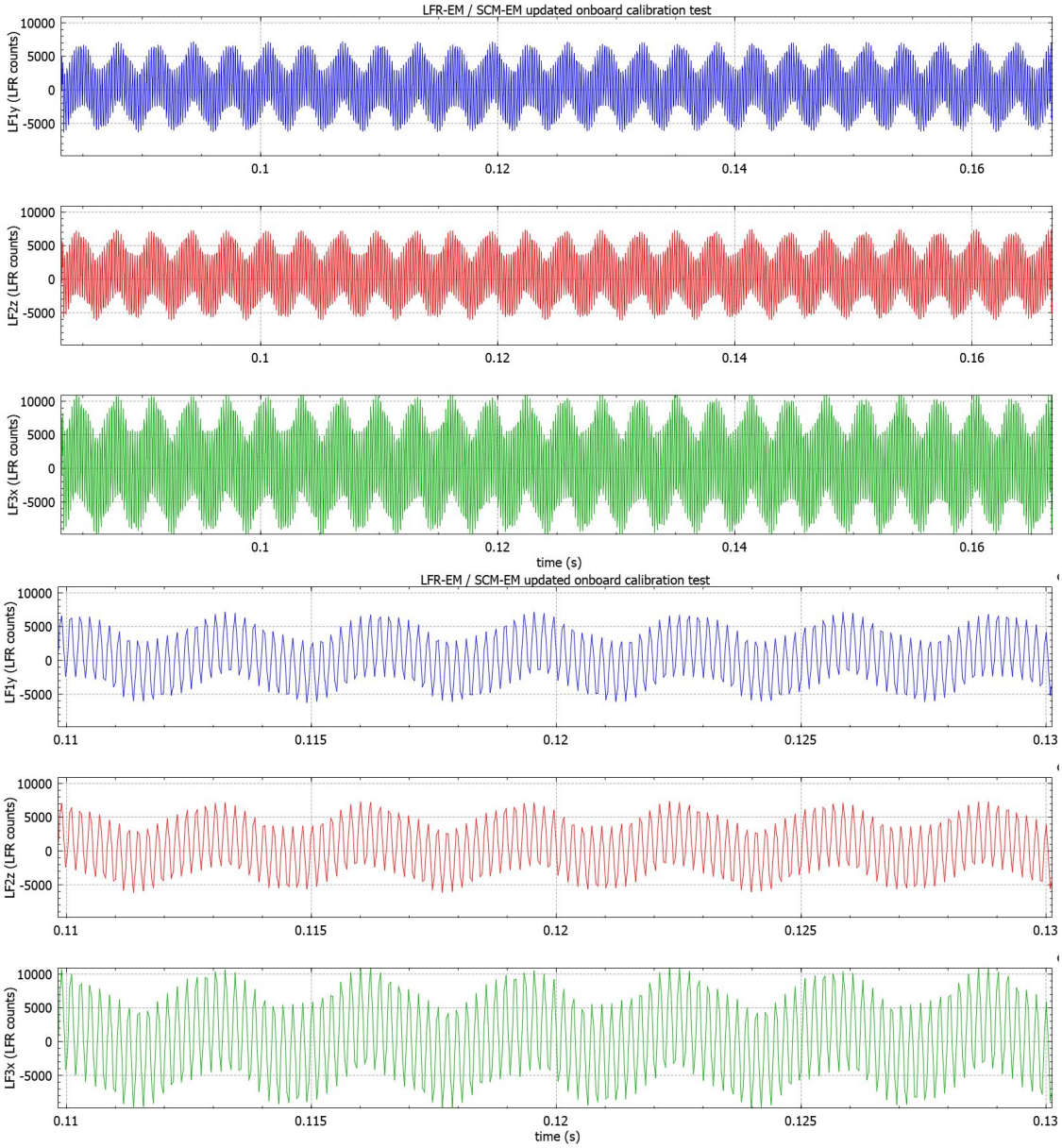


Figure 4.13 – 5kHz-313Hz signal at f0 (full sweep and zoom)

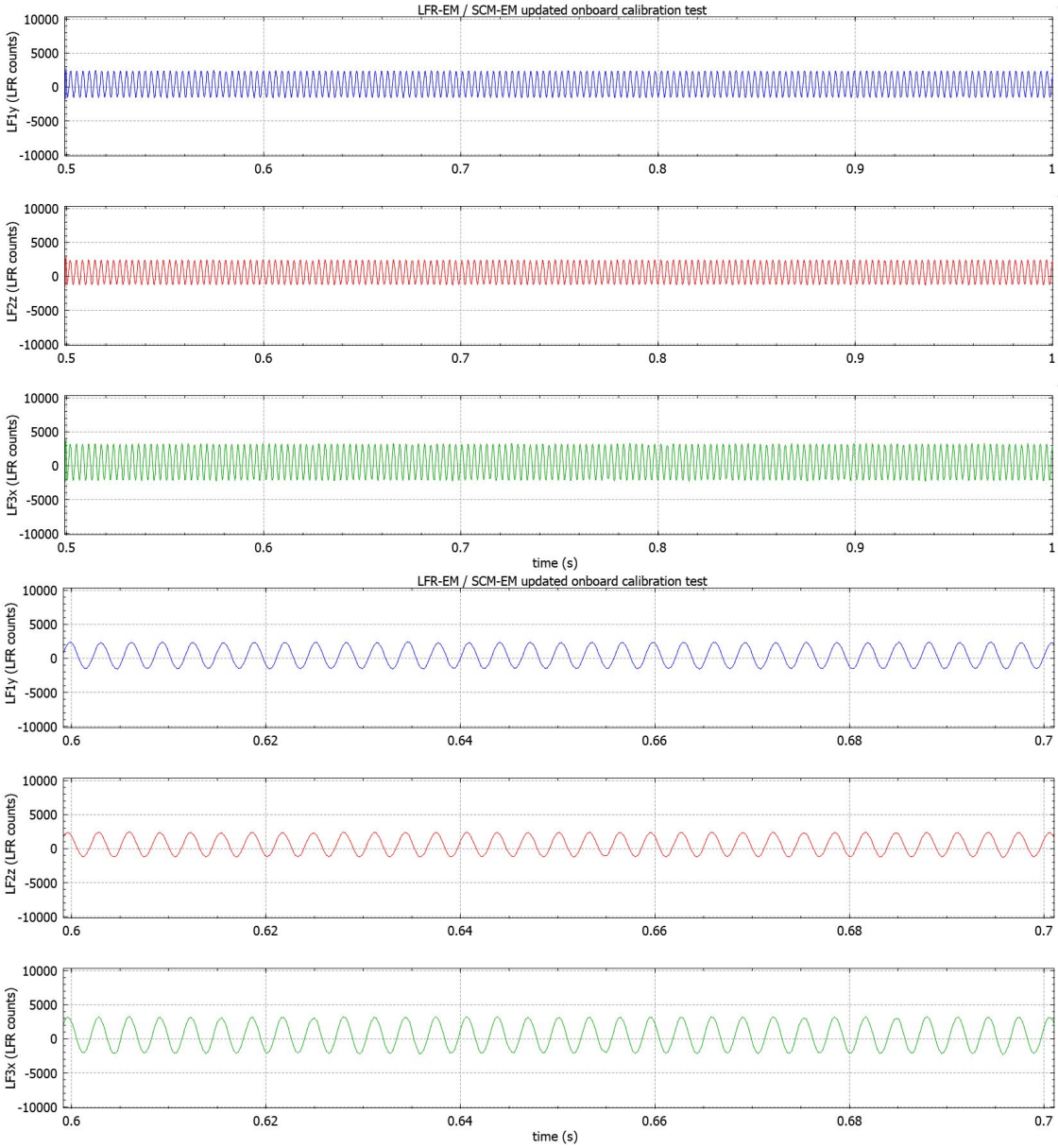


Figure 4.14 – 5kHz-313Hz signal at f1 (full sweep and zoom)

f2 data are not presented since the sampling frequency is 256Hz, none of the 2 frequencies is visible, there is only the background noise.

4.2.3. 2.5kHz – 156Hz snapshot

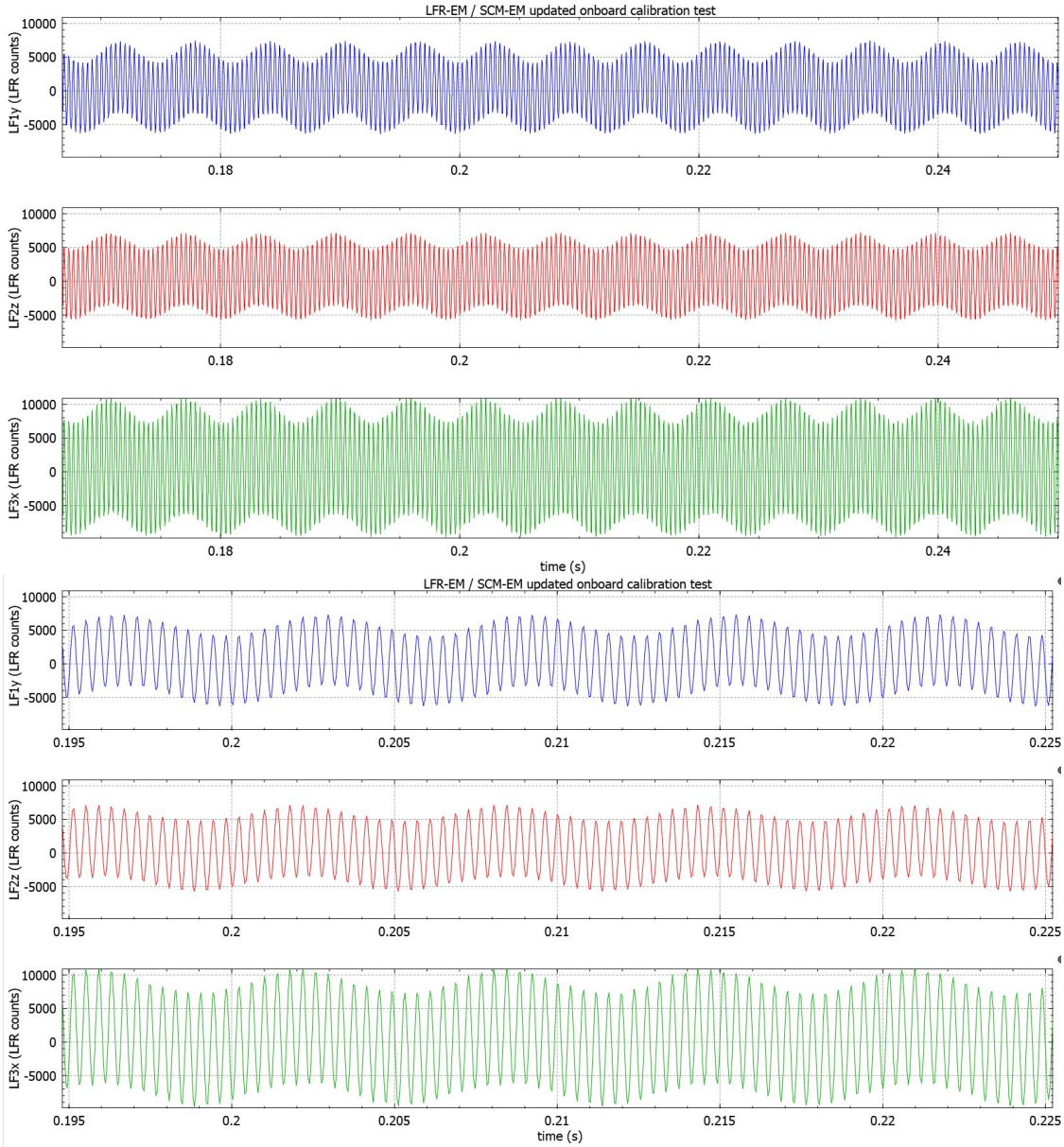


Figure 4.15 – 2.5kHz-156Hz signal at f0 (full sweep and zoom)

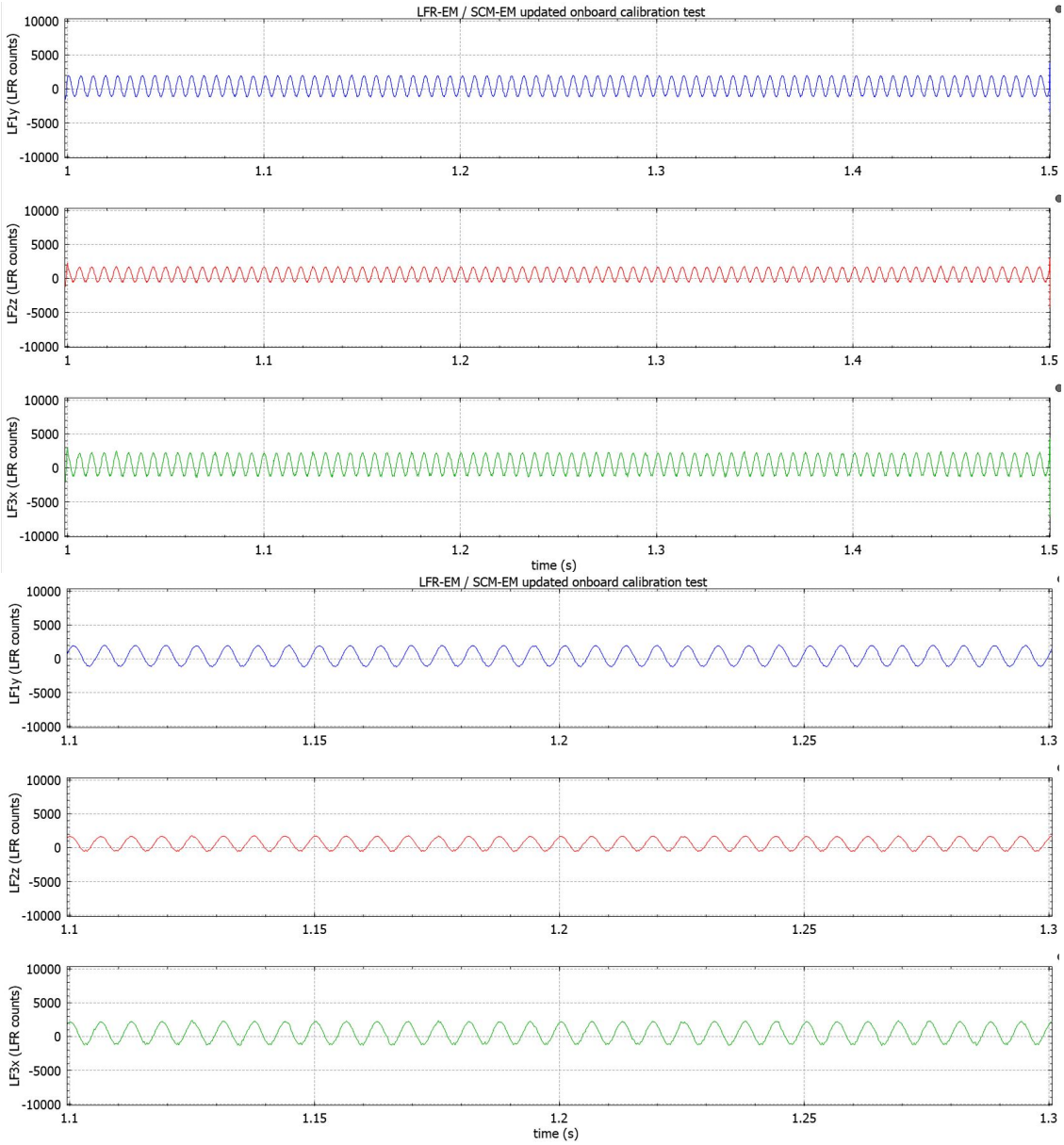


Figure 4.16 – 2.5kHz-156Hz signal at f0 (full sweep and zoom)

f2 data are not presented since the sampling frequency is 256Hz, none of the 2 frequencies is visible, there is only the background noise.

4.2.4. 1.25kHz – 78Hz snapshot

The 3 types of data f0, f1 and f2 are available.

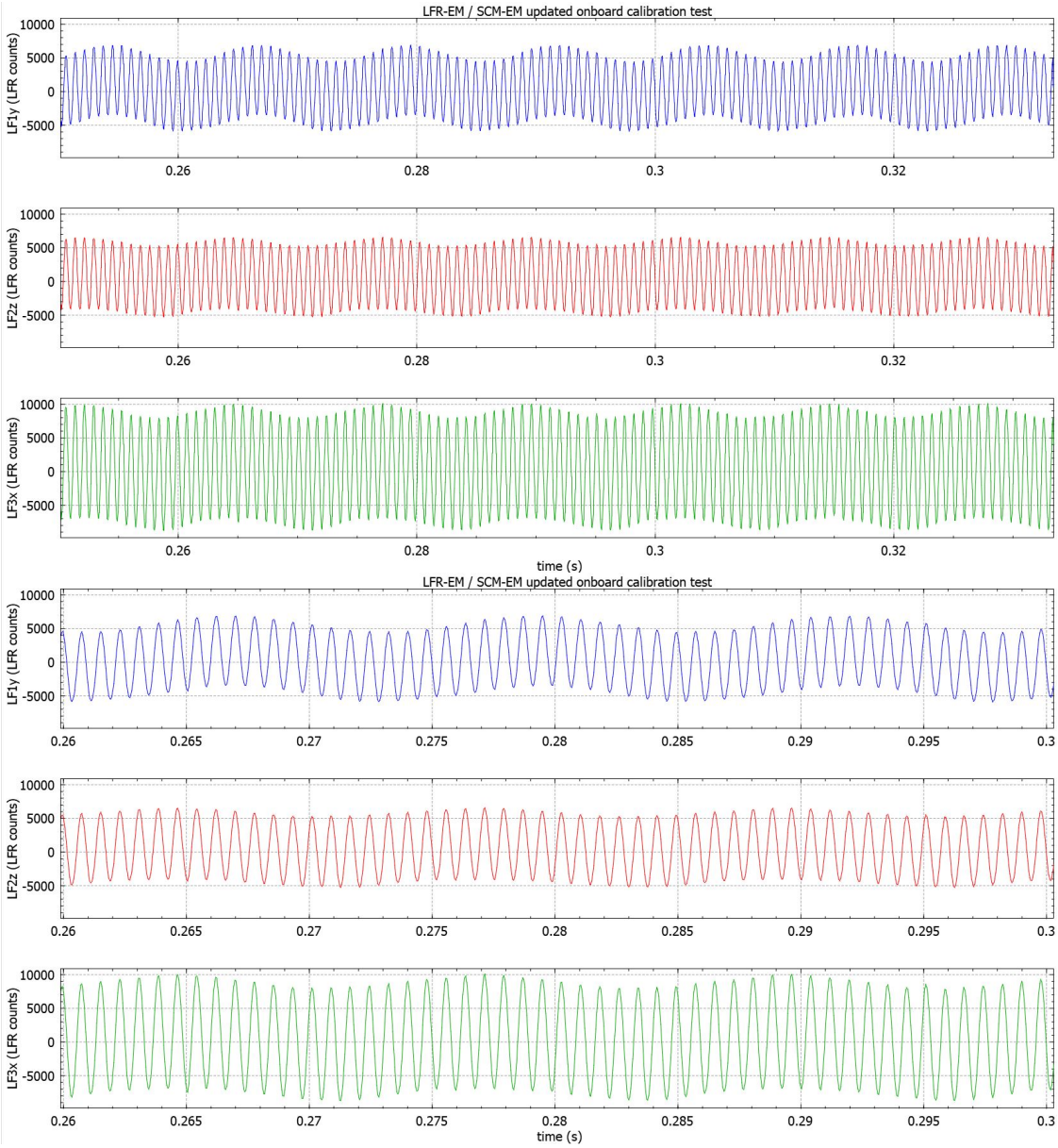


Figure 4.17 – 1.25kHz-78Hz signal at f0 (full sweep and zoom)

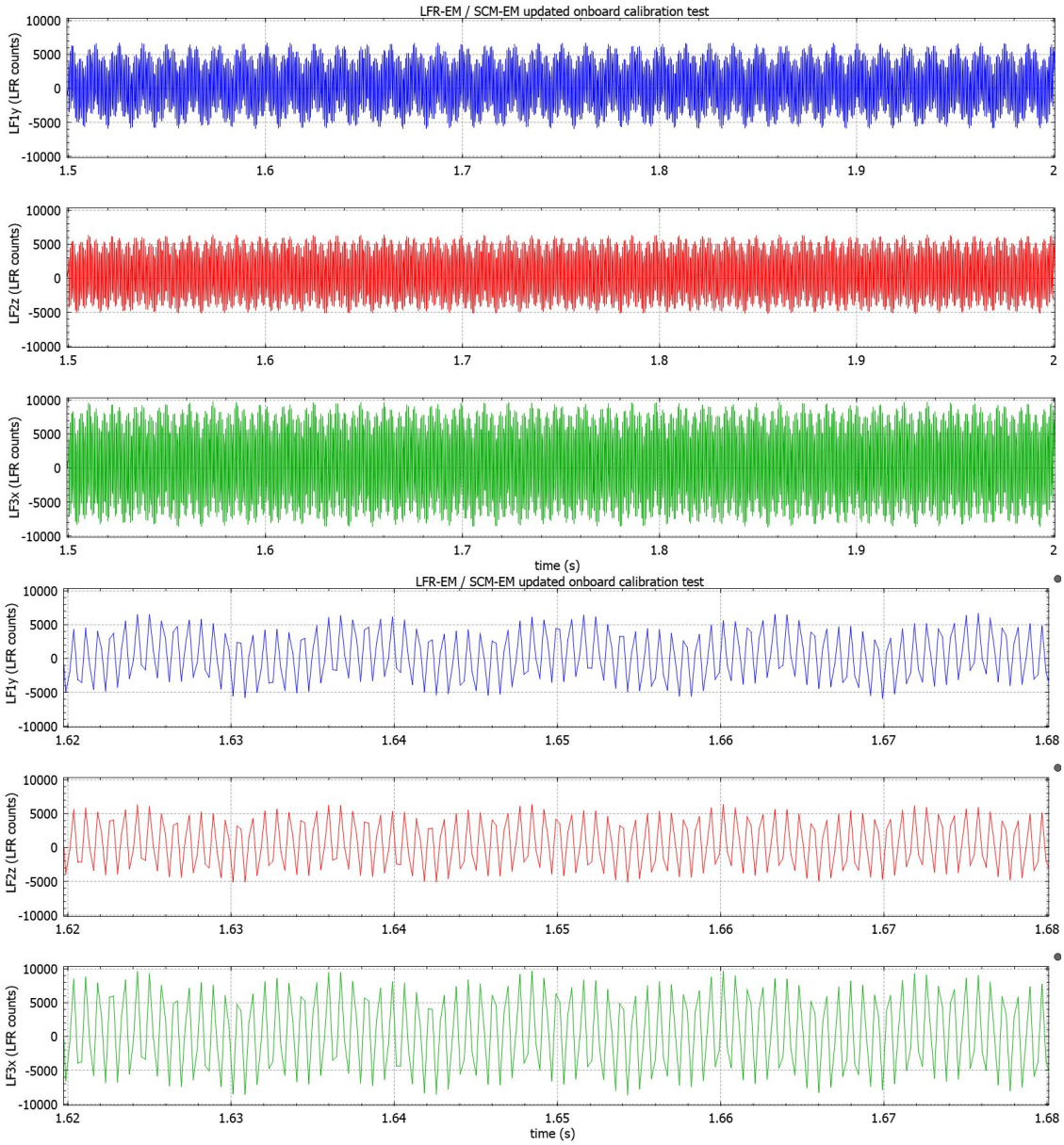


Figure 4.18 – 1.25kHz-78Hz signal at f1 (full sweep and zoom)

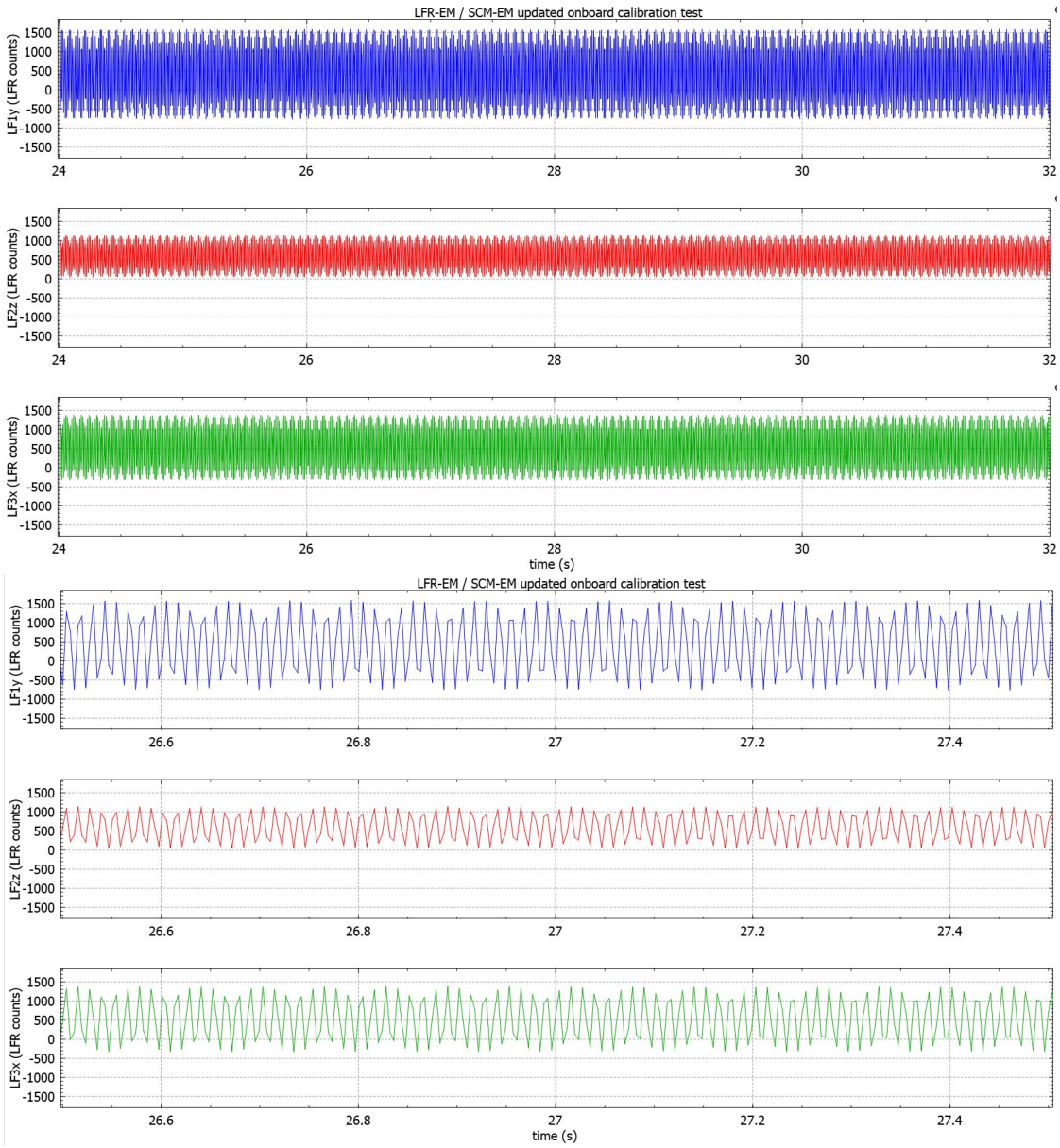


Figure 4.19 – 1.25kHz-78Hz signal at f2 (full sweep and zoom)

4.2.5. 626Hz – 39Hz snapshot

The 3 types of data f0, f1 and f2 are available.

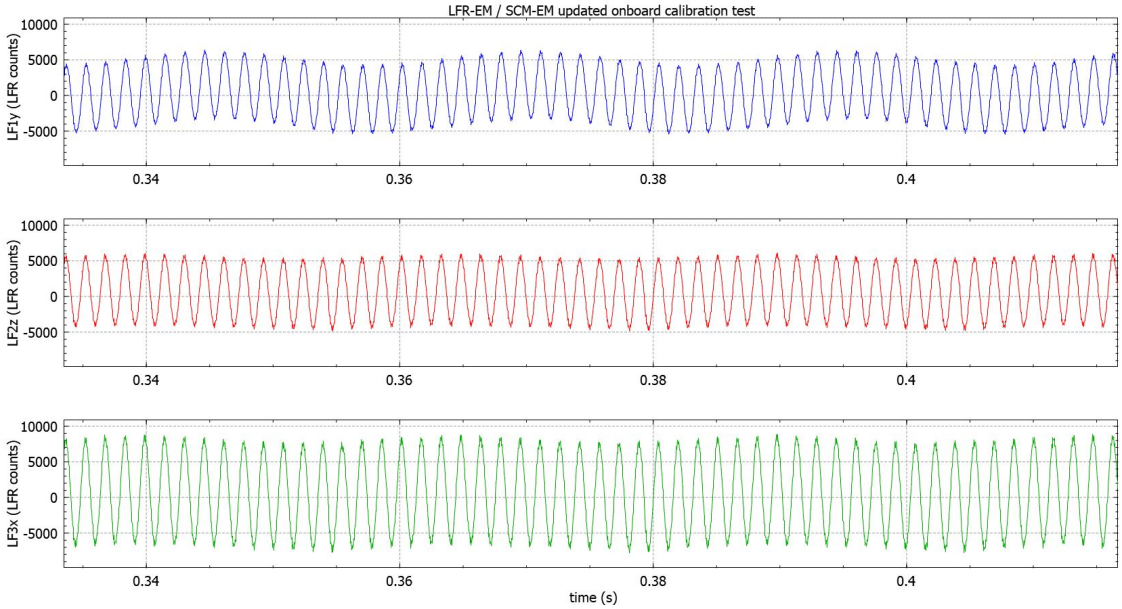


Figure 4.20 – 626kHz-39Hz signal at f0 (full sweep)

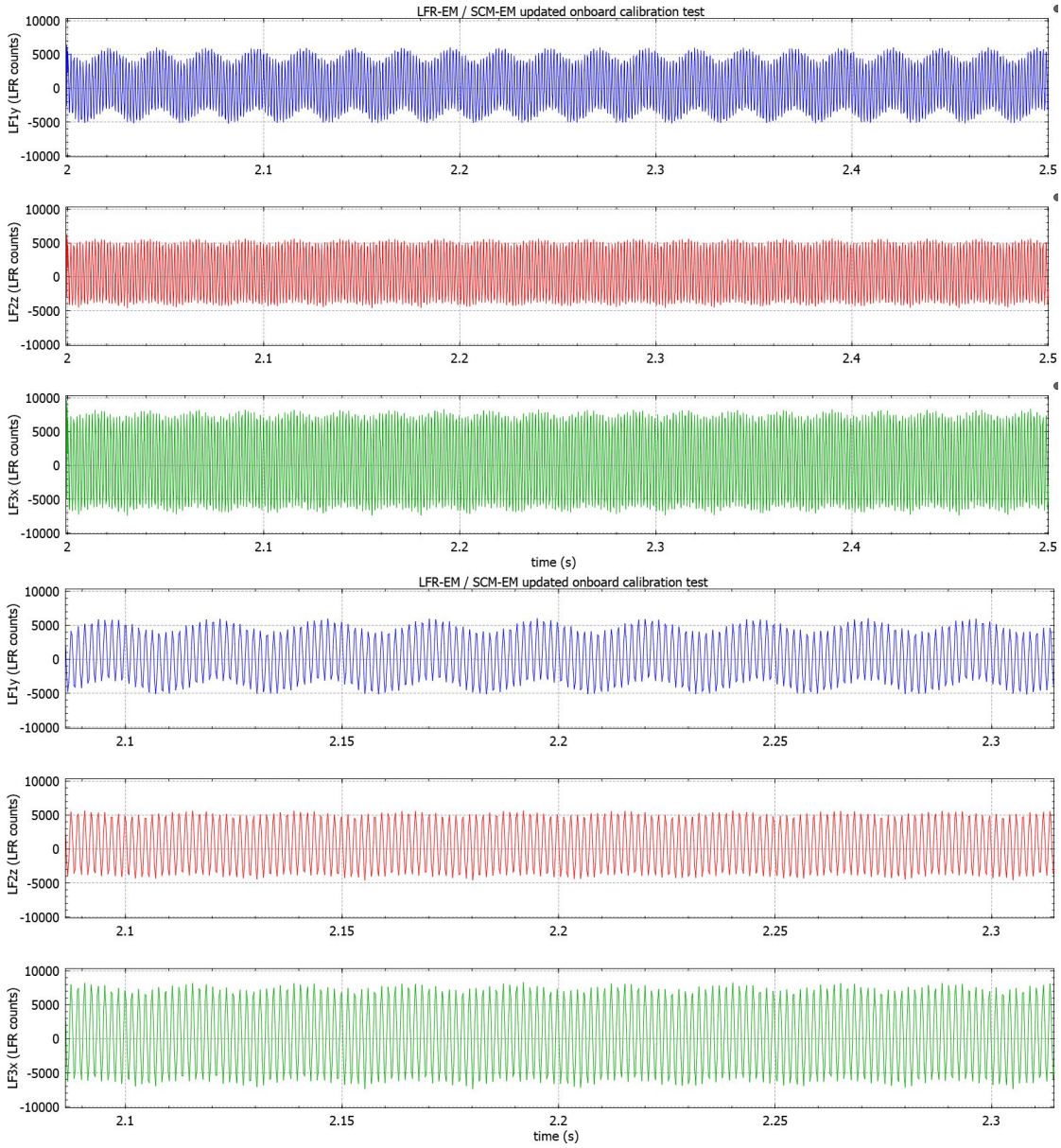


Figure 4.21 – 626kHz-39Hz signal at f1 (full sweep and zoom)

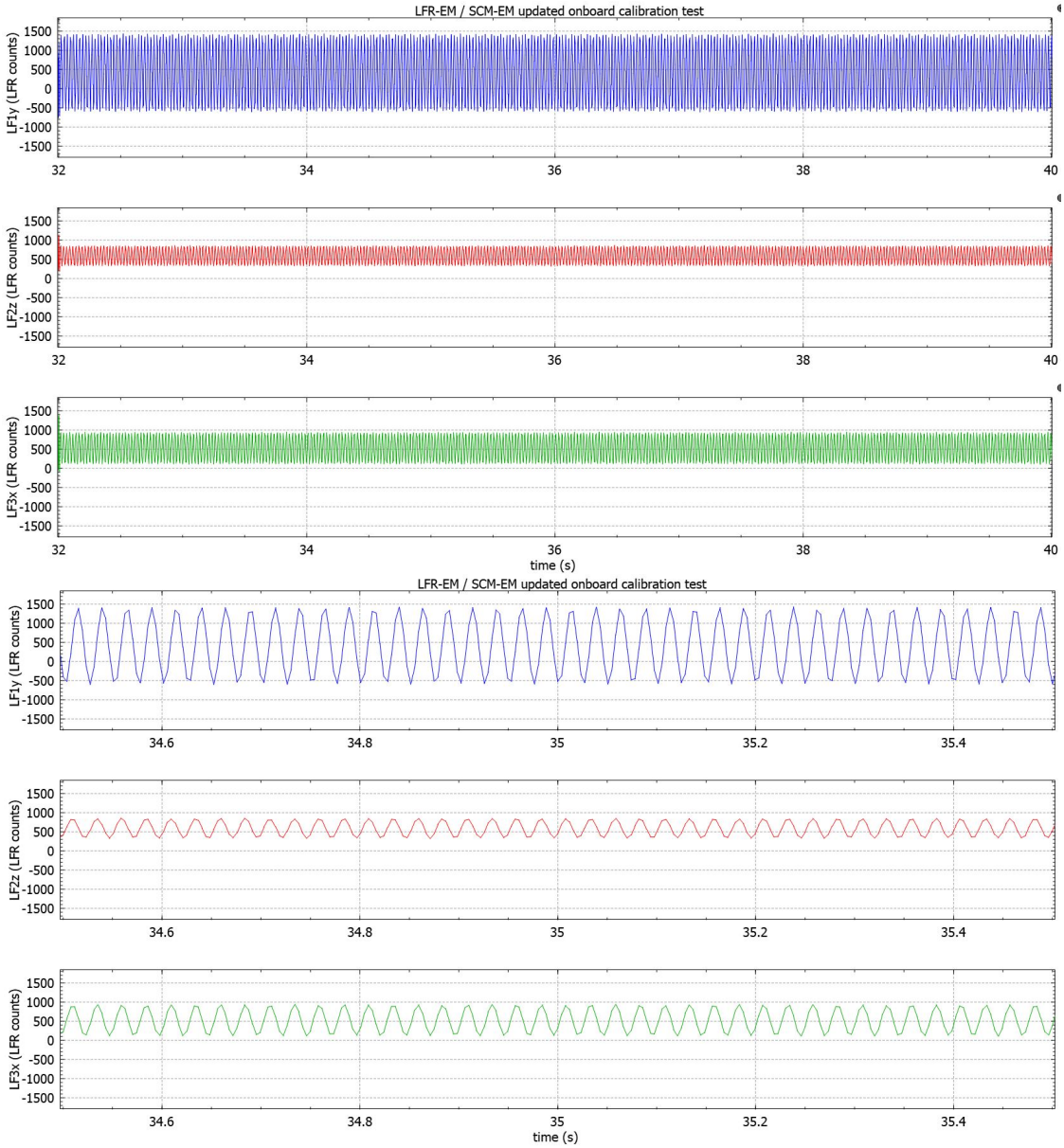


Figure 4.22 – 626kHz-39Hz signal at f2 (full sweep and zoom)

4.2.6. Spectral analyze

The following figure show the spectral analyze calculated on the 7 calibration sweeps with the 3 types of data. All the frequencies are identified and more or less visible depending on the sampling frequency f0, f1 or f2.

The only point to notice is that for f1 data, 2 spikes are visible around 626Hz. This frequency is sent 2 times by 2 different ways:

- in pair 1: 626Hz signal is generated with a few periods and many points per period
- in pair 5: 626Hz is produced by dividing the 10kHz frequency by 2 4 times. Thus there is only a few points per period.

As a consequence the 2 separated spikes.

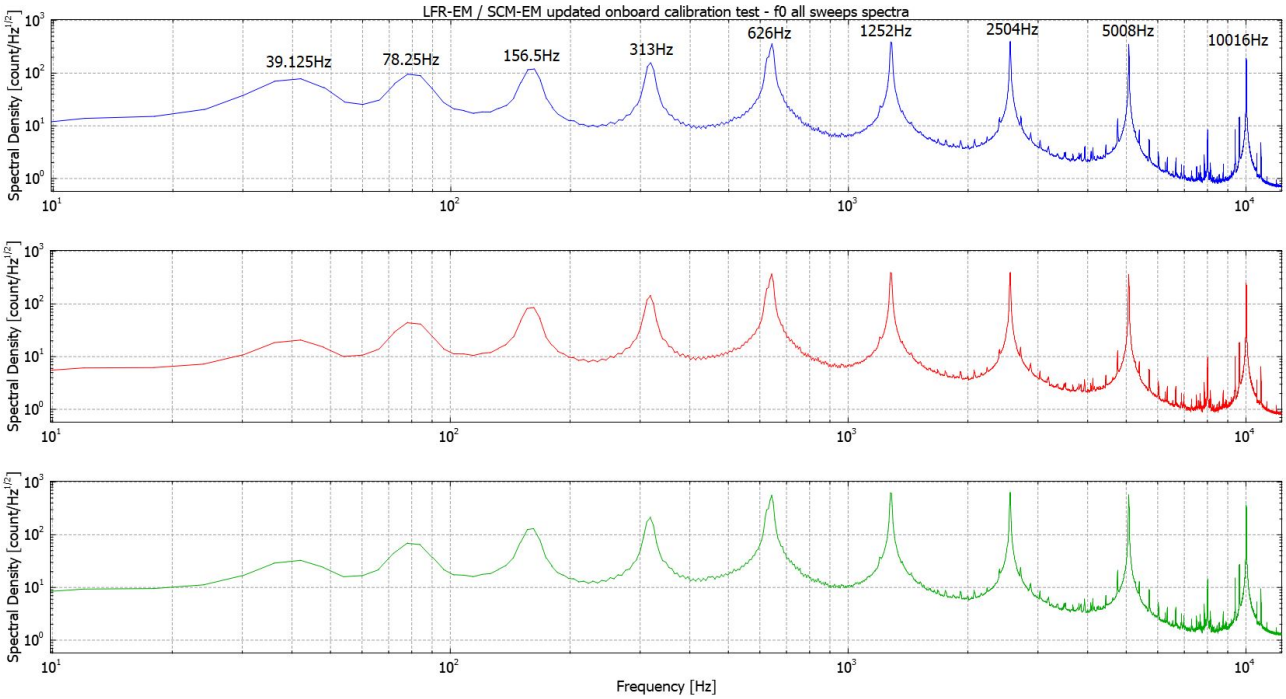


Figure 4.23 – Spectral analyze of the 7 sweeps with f0 data

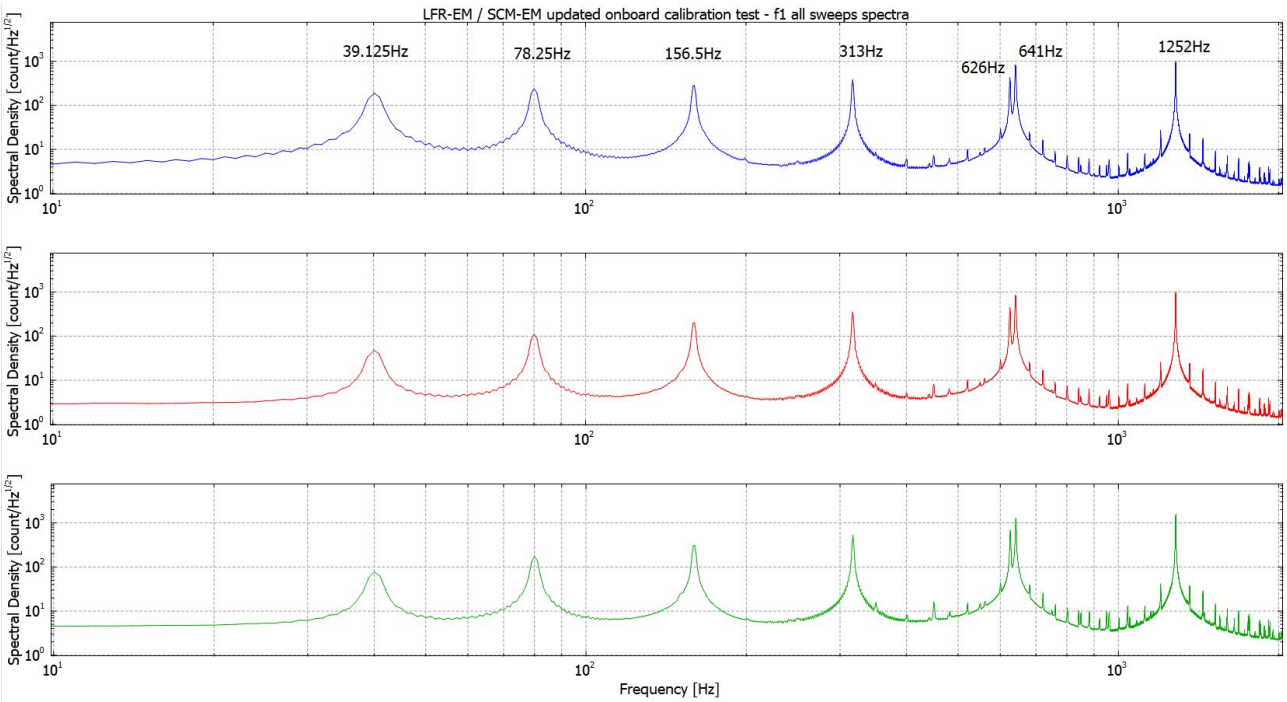


Figure 4.24 – Spectral analyze of the 7 sweeps with f1 data

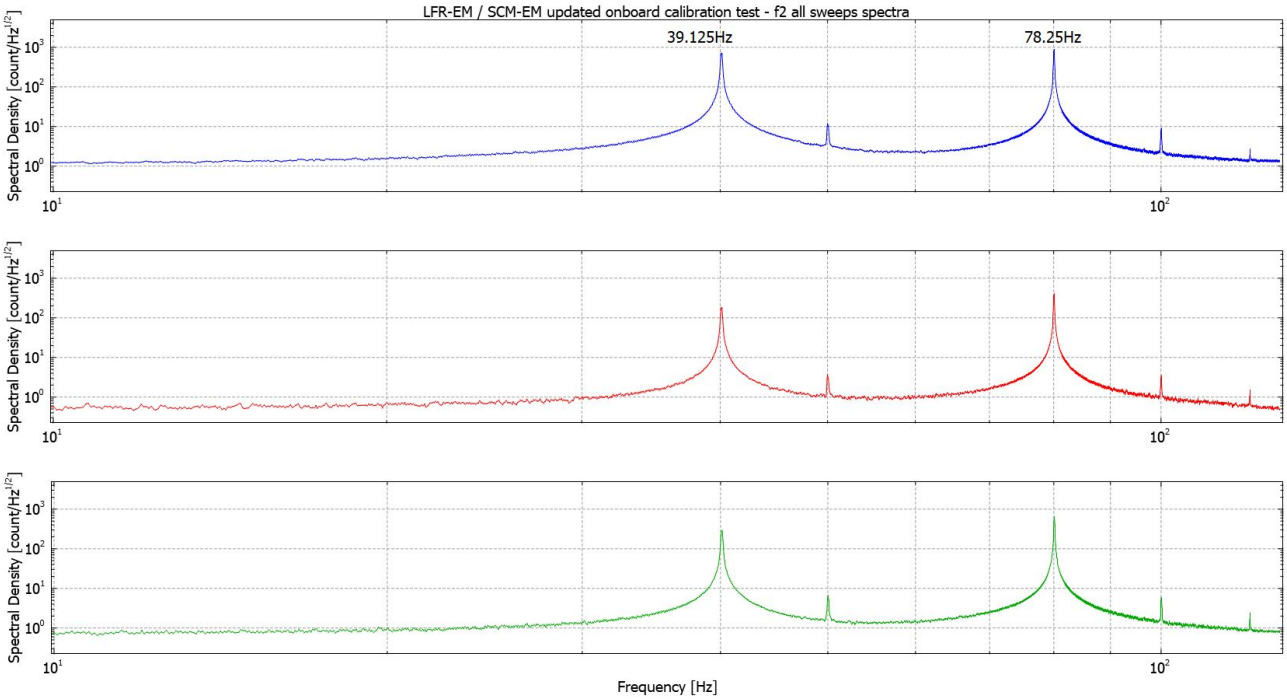


Figure 4.25 – Spectral analyze of the 7 sweeps with f2 data

The spectrum are given in annex with a larger size.

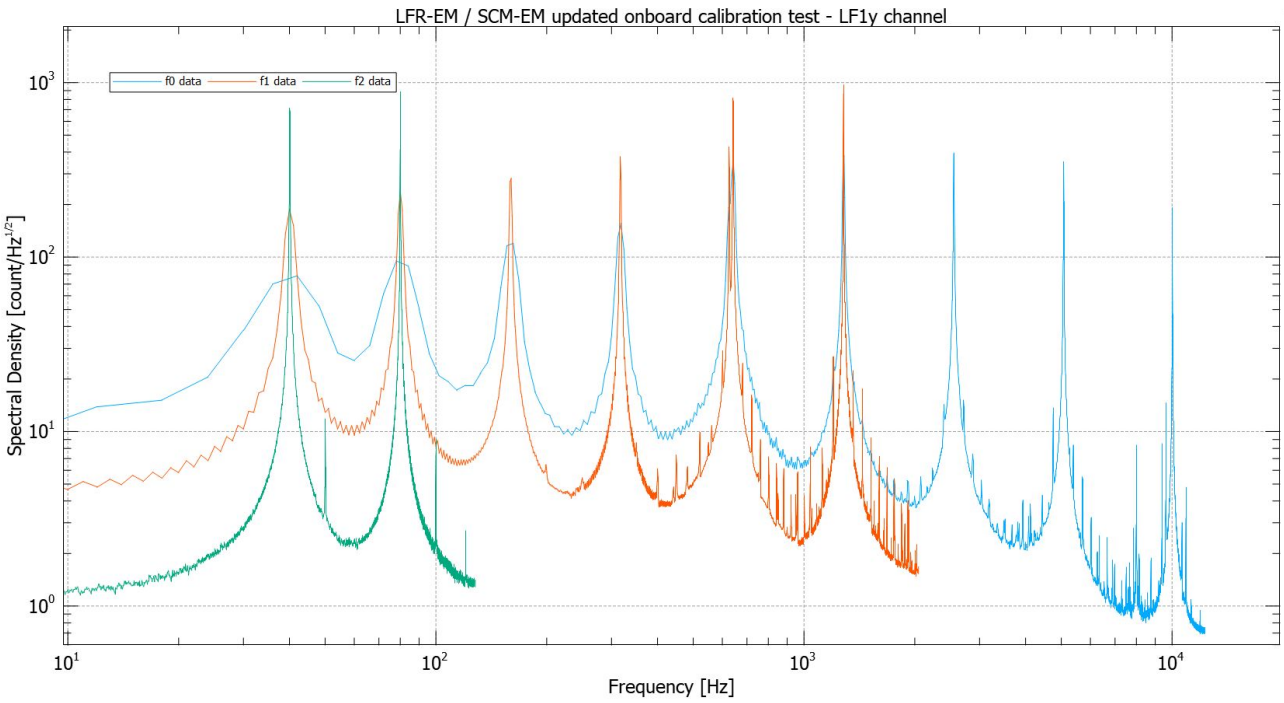


Figure 4.26 – Spectral analyze of the 7 sweeps on LF1y channel (all frequencies)

Some disturbances are observed (50Hz and 150Hz) on f2 data or around 1kHz on f1 and f0 data but they are low enough to avoid any influence on the calibration.

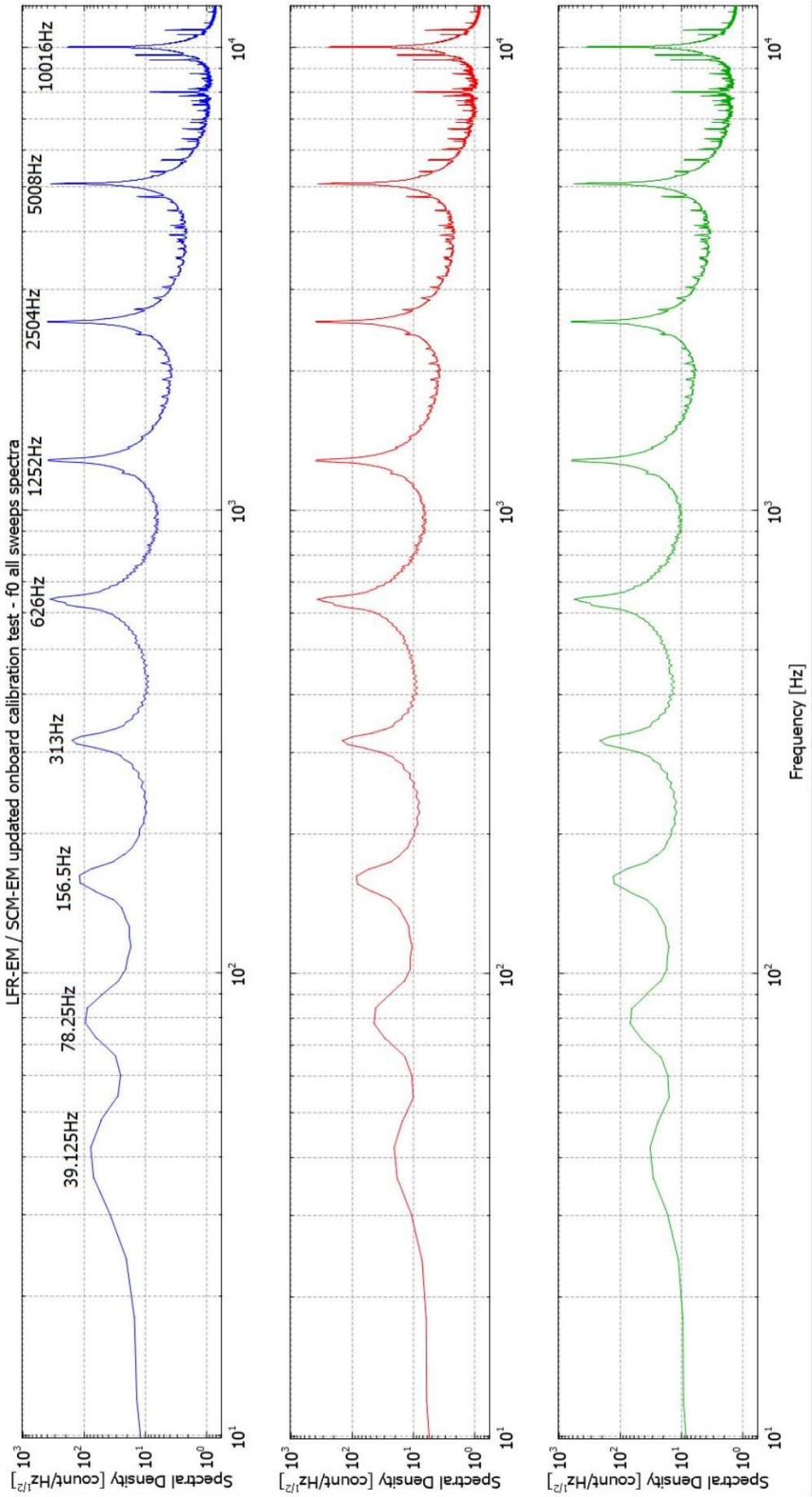
5. CONCLUSION

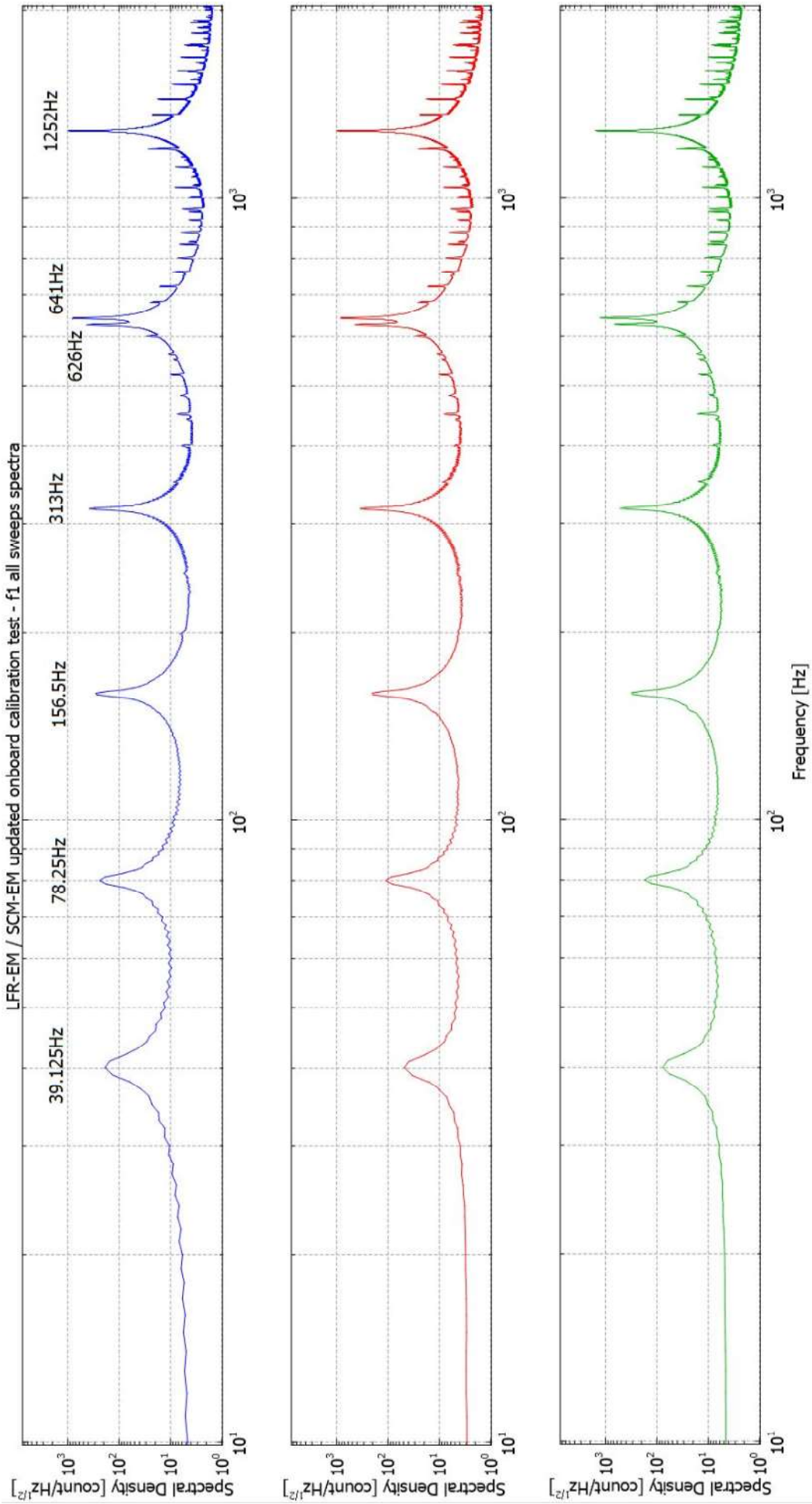
The update of LFR software for the onboard calibration signal is done to cover 2 points:

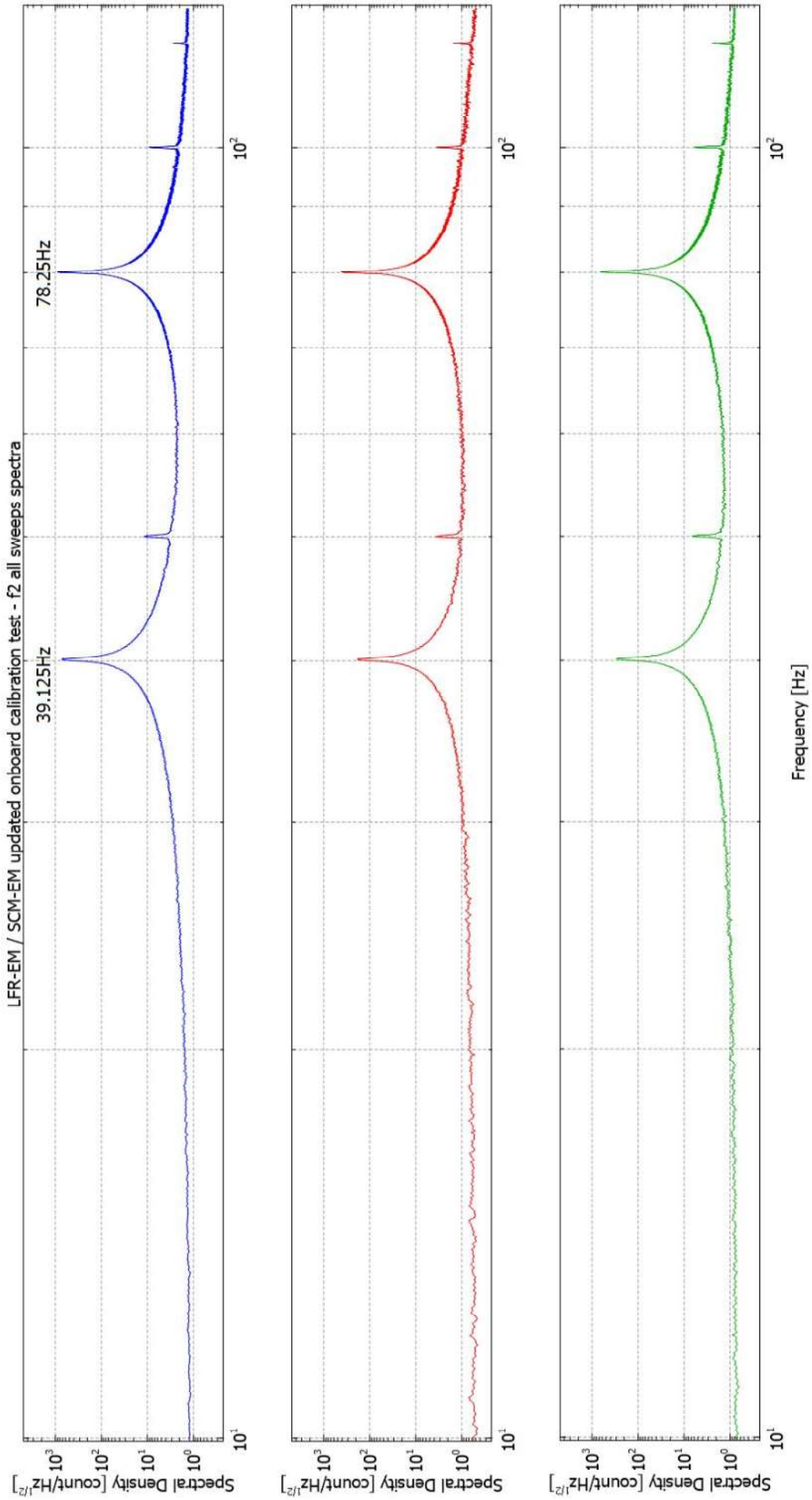
- Adding 4 additional pair of frequencies to have a better coverage of the frequency band. They are clearly visible on waveforms and spectral analyzes
- Multiplying by 2 the signal generated to ensure a signal at SCM output high enough (12mV and 4mV on EM). The measurements performed in January with SCM-FS and MEB-PFM gave ~80mVpeak and ~50mVpeak for the 625Hz and 10kHz signal which was already acceptable. The multiplication by 2 will lead to have about 1650mV and 100mV respectively which is high enough to performed the onboard calibration.

As a consequence, the update of the onboard calibration signal is validated by this test on EM, it is ok to implement it on PFM.

ANNEX. LARGE SIZE SPECTRUM PICTURES




LFR-EM / SCM-EM updated onboard calibration test - f1 all sweeps spectra
39.125Hz
78.25Hz
156.5Hz
313Hz
626Hz
641Hz
1252Hz
Spectral Density [count/Hz^1/2]
Frequency [Hz]


LFR-EM / SCM-EM updated onboard calibration test - f2 all sweeps spectra
39.125Hz
78.25Hz
Spectral Density [count/Hz^1/2]
Spectral Density [count/Hz^1/2]
Spectral Density [count/Hz^1/2]
Frequency [Hz]