European Research Project ‘HF-Circuits’:

‘Metrology for New Electrical Measurement Quantities in High-Frequency Circuits’

Overview and Update of Activities

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03 June 2015
Overview

- EMRP
- SIB62 / ‘HF-Circuits’ project
- Work Package reviews
- Project – Mid-term Review
- Summary
EMRP – European Metrology Research Programme

The EMRP is a metrology-focused European programme of coordinated R&D that facilitates closer integration of national research programmes.

The EMRP is jointly supported by the European Commission and the participating countries within the European Association of National Metrology Institutes (EURAMET e.V.).

The EMRP will ensure collaboration between National Measurement Institutes, reducing duplication and increasing impact.
The principal goal of this project is to develop the SI system in a way that impacts emerging areas of technology that utilise RF, microwave, millimetre-wave and submillimetre-wave electromagnetic science and technology.

Research and development is being undertaken to achieve traceability between existing SI units, and, the new and evolving quantities and units that are being used in these sectors of 'applied' metrology.
## SIB62 / ‘HF-Circuits’ Project

### Project Partners

| National Metrology Institutes (NMIs) | CMI, Czech Republic  
|                                      | LNE, France  
|                                      | METAS, Switzerland  
|                                      | NPL, UK  
|                                      | PTB, Germany  
|                                      | SP, Sweden  
|                                      | VSL, Netherlands |

| Industrial Partners                 | Agilent Technologies, Belgium  
|                                      | Rohde & Schwarz, Germany |

| Researcher Excellence Grants (REGs) | CTU, Czech Republic  
|                                      | FBH, Germany  
|                                      | KUL, Belgium  
|                                      | ULE, UK |
## SIB62 / ‘HF-Circuits’ Project

### Project Work Packages

<table>
<thead>
<tr>
<th>No</th>
<th>Title</th>
<th>Person Months</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Traceable Reflection and Transmission Measurements in Metallic Waveguides to 1100 GHz and Coaxial lines to 110 GHz</td>
<td>69 (28%)</td>
</tr>
<tr>
<td>2</td>
<td>Traceable Multi-port Vector Network Analyser Techniques and Automatic (Electronic) Calibration Techniques</td>
<td>36 (15%)</td>
</tr>
<tr>
<td>3</td>
<td>Traceable Differential S-parameter Measurements on Planar Circuits to Test Signal Integrity</td>
<td>27 (11%)</td>
</tr>
<tr>
<td>4</td>
<td>Traceable Nonlinear Measurements and Extreme Load Impedances</td>
<td>43 (18%)</td>
</tr>
<tr>
<td>5</td>
<td>Vector Measurement Uncertainty and Verification, and, International Guides and Standards</td>
<td>44 (18%)</td>
</tr>
<tr>
<td>6</td>
<td>Creating Impact</td>
<td>10 (4%)</td>
</tr>
<tr>
<td>7</td>
<td>Project Management and Coordination</td>
<td>14 (6%)</td>
</tr>
</tbody>
</table>
Work Package 1

Traceable Reflection and Transmission Measurements in Metallic Waveguides to 1100 GHz and Coaxial Lines to 110 GHz

Work Package Leader: PTB

Main research areas:

Metallic waveguides to 1.1 THz
- Participants: CMI, LNE, NPL, PTB, R&S, FBH, ULE

Coaxial lines to 110 GHz
- Participants: METAS, VSL, NPL, LNE, PTB, R&S
Work Package 2

Traceable Multi-port Vector Network Analyser Techniques and Automatic (Electronic) Calibration Techniques

Work Package Leader: SP

Main research areas:

Multi-ports
Participants: LNE, NPL, PTB, R&S

Electronic Calibration Units (ECU)
Participants: SP, METAS, NPL, PTB
Traceable Differential S-parameter Measurements on Planar Circuits to Test Signal Integrity

Work Package Leader: NPL

Main research area:

Multi-layer PCBs

Participants: CMI, LNE, PTB, R&S, CTU, FBH
Work Package 4

Traceable Nonlinear Measurements and Extreme Load Impedances

Work Package Leader: CMI

Main research areas:

Nonlinear measurements
  Participants: NPL, CMI, Agilent, KUL

Extreme load impedances
  Participants: CMI, NPL, CTU
Work Package 5

Vector Measurement Uncertainty and Verification

International Guides and Standards

Work Package Leader: METAS

Main research areas:

Vector measurement uncertainty and verification
Participants: PTB, VSL, LNE, METAS, NPL, R&S

International Guides and Standards
Participants: NPL, METAS, LNE, PTB, SP, VSL
Work Package 6

Creating Impact

Work Package Leader: LNE
Participants: All project partners

Main areas:
- Knowledge transfer
- Training
- Exploitation
WP6 – Knowledge Transfer

- Stakeholder Advisory Group (SAG)
- Project web-site
- LinkedIn social media page
- Publications: Metrologia, IEEE Trans-IM, IEEE Trans-MTT
- Conferences: ARFTG, IMS, CPEM, EuMC
- Trade journals: Microwaves & RF, IEEE Microwave Magazine
- Standardisation Committees: IEEE P287, IEEE P1785
- Technical Committees: EURAMET TC-EM
WP6 – Training

- European ANAMET meetings (six meetings scheduled)
- 3 Technical Workshops; 3 Training Courses
  - ECUs
  - VNA Best Practice
  - Revised EURAMET VNA Guide
  - Multiport VNA measurements (this meeting)
- Guest working
  - KU Leuven → NPL
  - University of Leeds ↔ NPL
  - VSL → METAS
  - Others from outside the Consortium
Mid-term Review

- Review meeting held at PTB, Berlin
- 24\textsuperscript{th} March 2015
- 10 projects were reviewed (including HF-Circuits)
- All projects were in SI Broader Scope
- 5 ‘external’ Reviewers
- Also, EMRP and MSU staff were present
Mid-term Review

Reviewers’ comments of HF-Circuits:

“The reviewers considered this to be a very good project and acknowledged the end user need for metrology in high-frequency devices. They were also pleased to note the good links with instrument manufacturers”

“The reviewers were pleased with the ongoing dissemination of the project results to standardisation bodies and asked if the consortium had good links with those. The coordinator clarified that some of the partners are chairing relevant standardisation bodies and contributing as appropriate”

Reviewers’ recommendations:

“The Consortium should continue the good work but look for more opportunities for training early stage researchers”
Mid-term Review

- Reviewers’ evaluation (i.e. ‘scores’):

<table>
<thead>
<tr>
<th>Category</th>
<th>All reviewed projects</th>
<th>HF-Circuits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technology Position</td>
<td>6 to 9</td>
<td>9</td>
</tr>
<tr>
<td>Impact</td>
<td>2 to 4</td>
<td>4</td>
</tr>
</tbody>
</table>

9 = “dominant”
4 = “high”

‘HF-Circuits’ was one of only two projects to receive these maximum scores 😊
Summary

- Project launched: July 2013
- Web-site (www.hfcircuits.org)
- LinkedIn Group ‘HF-Circuits: EMRP Project’
- Stakeholder Advisory Group – 6 key ‘industrialists’
- Many presentations and papers already given
- Good progress to date (Mid-term review)
- Future meetings: Nov/Dec 2015 – venue??
  June 2016 – NPL, UK

- Project completes: June 2016
Acknowledgement

This work was funded through the European Metrology Research Programme (EMRP) Project SIB62 ‘Metrology for New Electrical Measurement Quantities in High-frequency Circuits’.

The EMRP is jointly funded by the EMRP participating countries within EURAMET and the European Union.