IC 1407 ACCREDIT

Cyclostationary source extraction and separation from the near-field radiations of the electronic device

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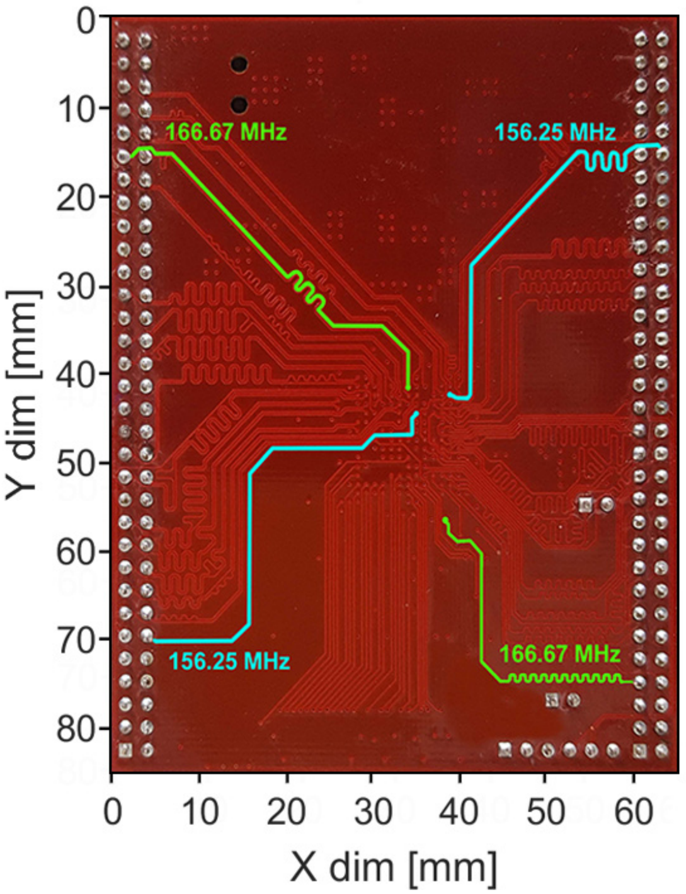
Outline

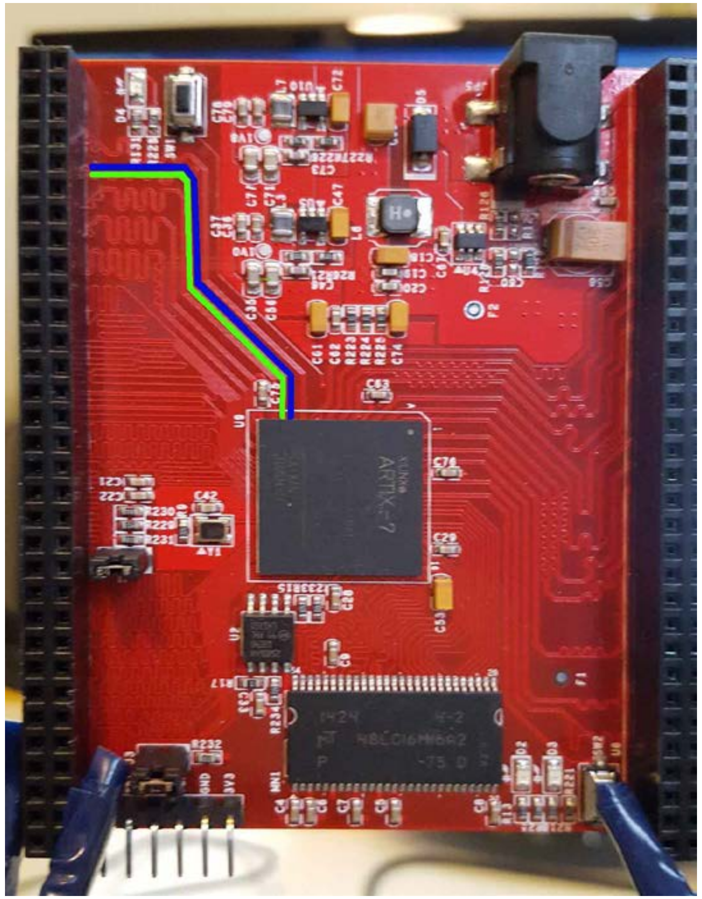
- **Xilinx FPGA Development Board Artix-7 XC7A35T**
- **Analysis of second order moment and cumulant cyclic functions of the DUT's signals**
- **Cross-correlation cumulant analysis of the near-field measured signals**
- **Conclusion**

Device under test

➢ **Xilinx FPGA Development Board Artix-7 XC7A35T**

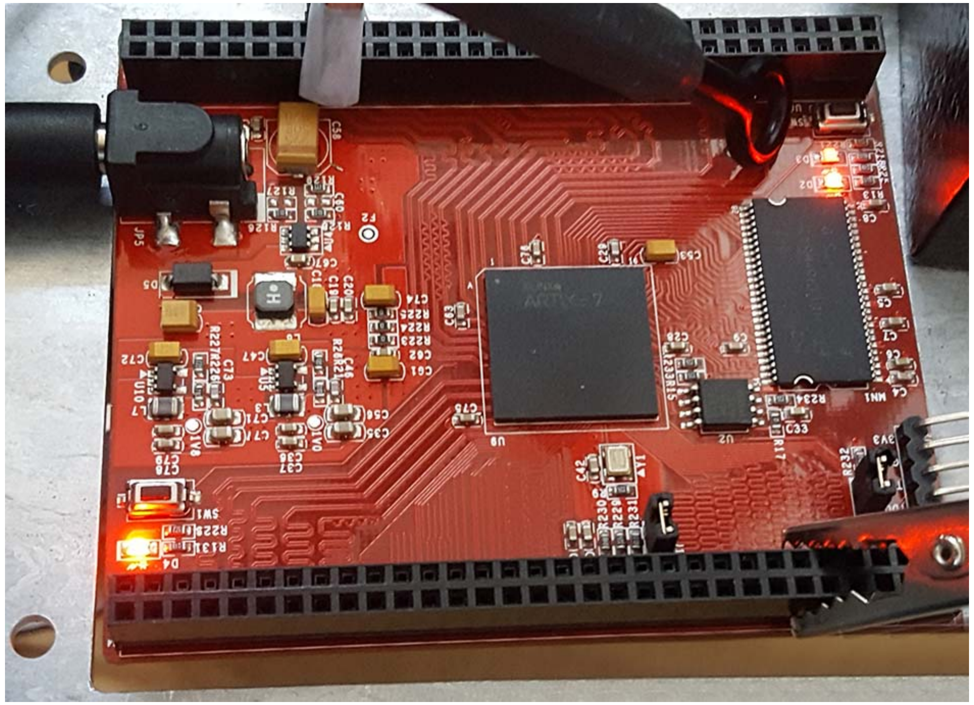


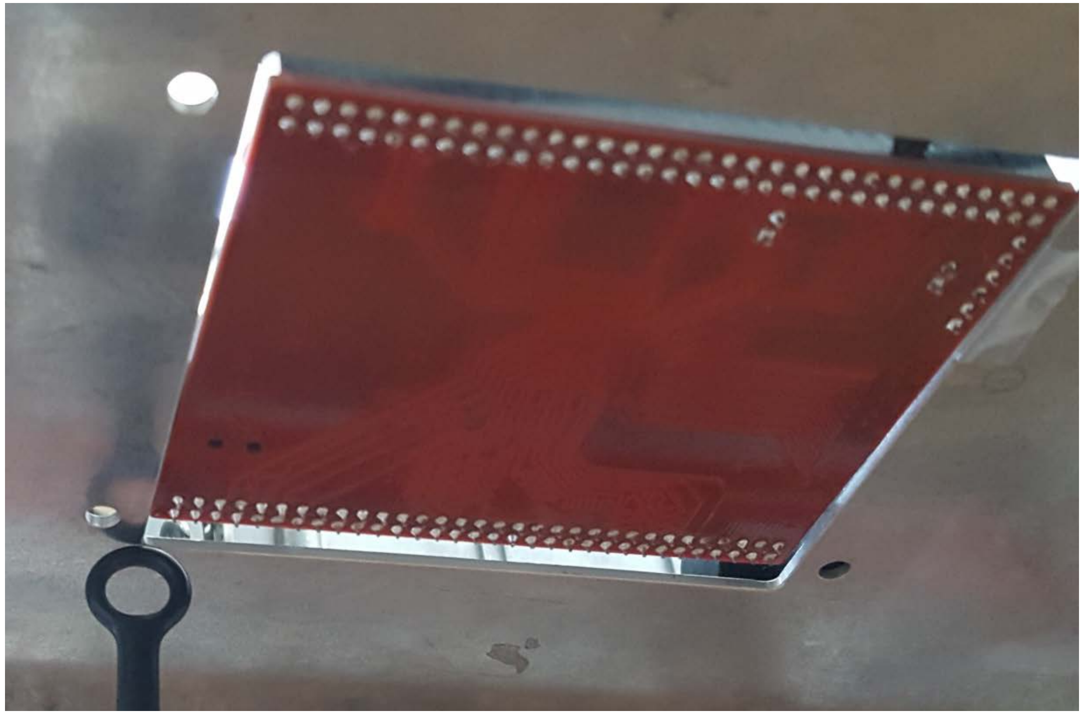
✓**Bottom side**



✓**Top side**

Near-field measurement setup

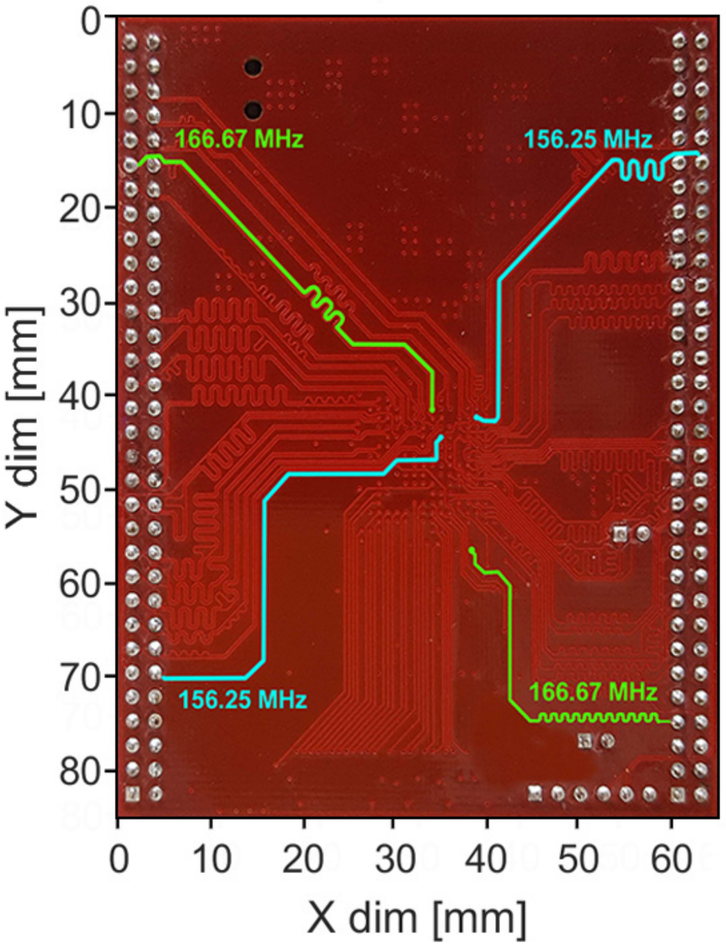


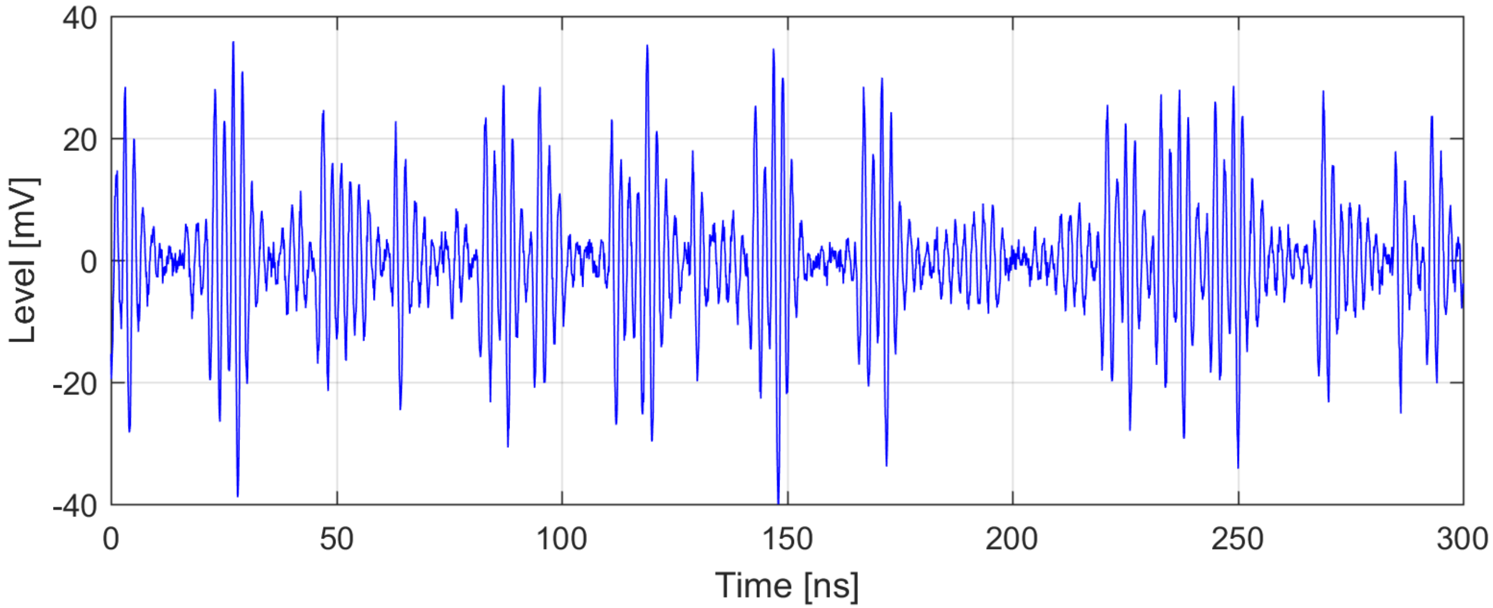


✓Reference probe

✓Scanning probe

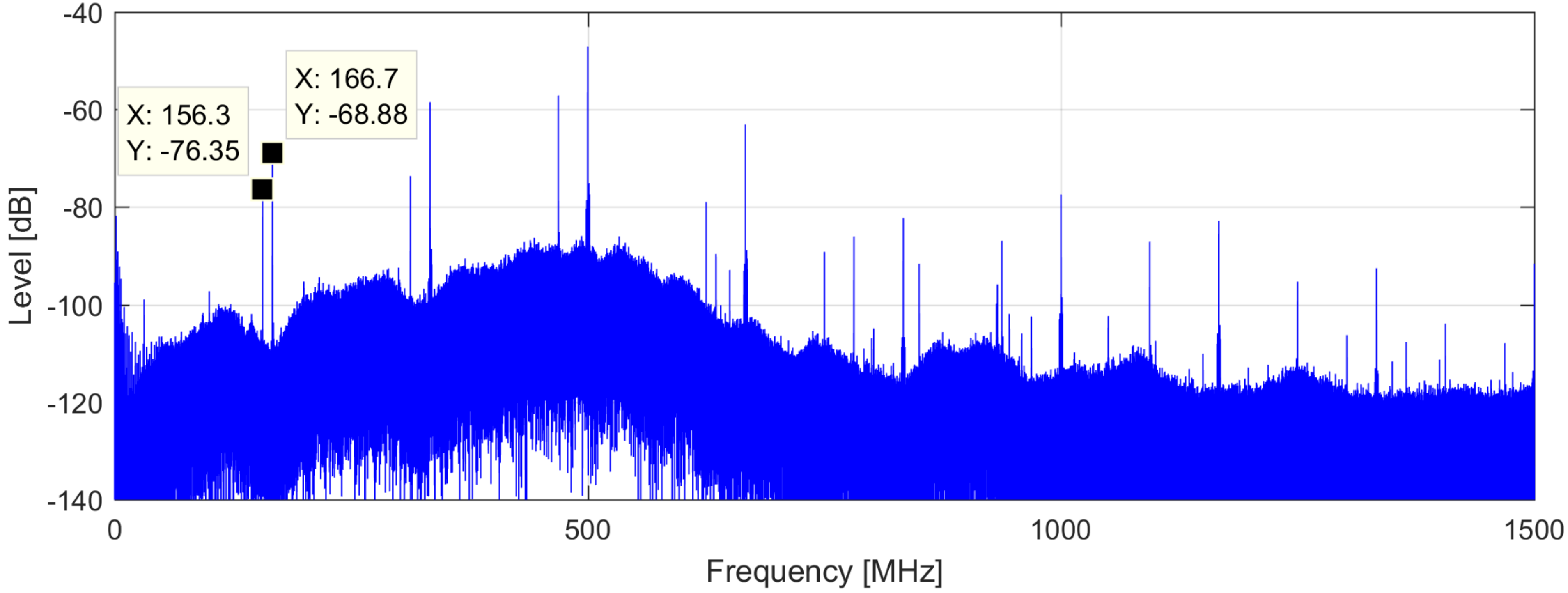
Near-field measurement setup





✓Bit frequencies are 166.67 MHz and 156.25 MHz

Near-field measurement setup



✓**Amplitude spectrum of the measured signal**

Cyclostationary sources characterization

The periodic sample mean function of the cyclostationary process

$$m_{\chi}(\alpha, t) = \lim_{N\to\infty} \frac{1}{2N+1} \sum_{n=-N}^{N} x\,(t + nT) = \sum_{k=-\infty}^{\infty} e^{\frac{j2\pi kt}{T}} \lim_{\Delta\to\infty} \frac{1}{\Delta} \int_{-\frac{\Delta}{2}}^{\frac{\Delta}{2}} x\,(\zeta)\, e^{-j2\pi\alpha k\zeta}\, d\zeta$$

Nonlinear inertialess shifted transformation of the signal

$$z(t, \tau) = x(t - \tau/2)x(t + \tau/2\,)$$

Cyclic autocorrelation function

$$R_{\chi}(\alpha, \tau) = \lim_{\Delta\to\infty} \frac{1}{\Delta} \int_{-\frac{\Delta}{2}}^{\frac{\Delta}{2}} z(t, \tau)\, e^{-j2\pi\alpha t}\, dt$$

Cyclostationary sources characterization

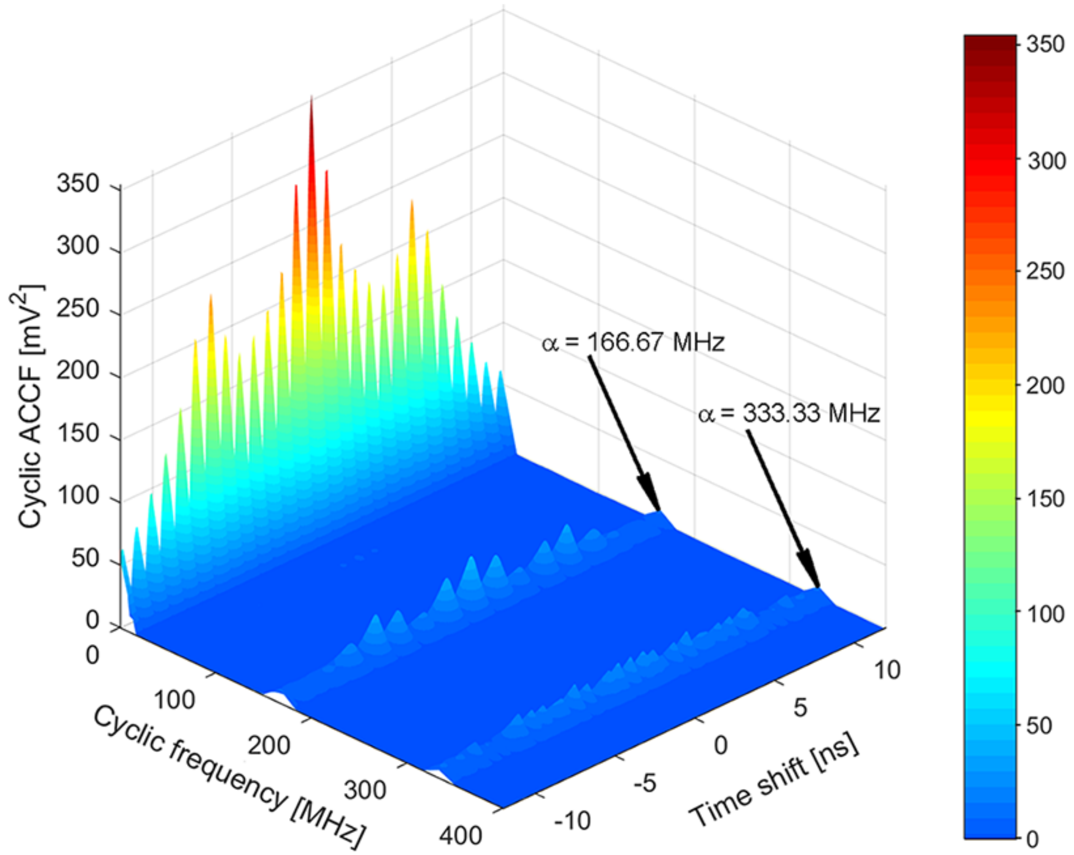
Non-periodic second order cyclic cumulant function

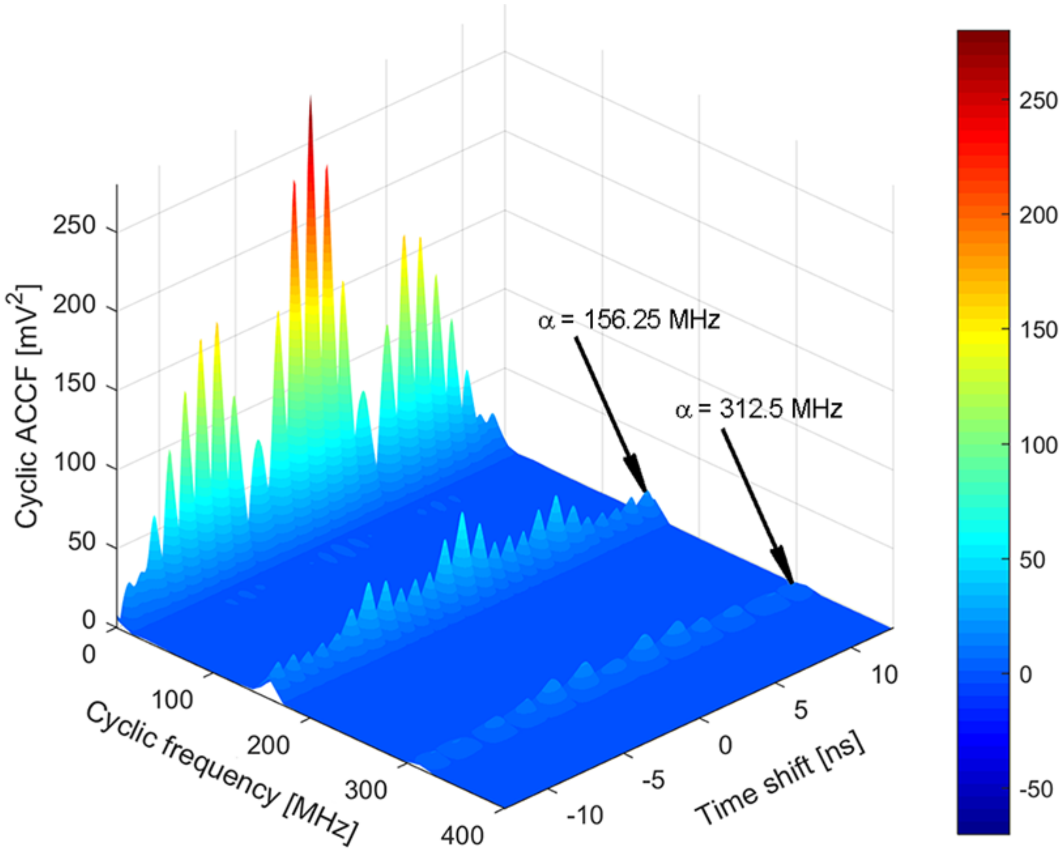
$$C_x(\alpha,\tau) = \lim_{\Delta\to\infty} \frac{1}{\Delta} \int_{-\frac{\Delta}{2}}^{\frac{\Delta}{2}} \left[x\left(t-\frac{\tau}{2}\right) - m_x\left(\alpha,\left(t-\frac{\tau}{2}\right)\right)\right]\left[x\left(t+\frac{\tau}{2}\right) - m_x\left(\alpha,\left(t+\frac{\tau}{2}\right)\right)\right] e^{-j2\pi\alpha t}\, dt$$

Cyclic cross-correlation cumulant function (cyclic CCCF)

$$C_{yx_{mn}}(\alpha_1,\tau) = \lim_{\Delta\to\infty} \frac{1}{\Delta} \int_{-\frac{\Delta}{2}}^{\frac{\Delta}{2}} \left[y\left(t-\frac{\tau}{2}\right) - m_y\left(\alpha_1,\left(t-\frac{\tau}{2}\right)\right)\right]\left[x_{mn}\left(t+\frac{\tau}{2}\right) - m_{x_{mn}}\left(\alpha_1,\left(t+\frac{\tau}{2}\right)\right)\right] e^{-j2\pi\alpha_1 t} dt$$

Cyclic autocorrelation cumulant functions

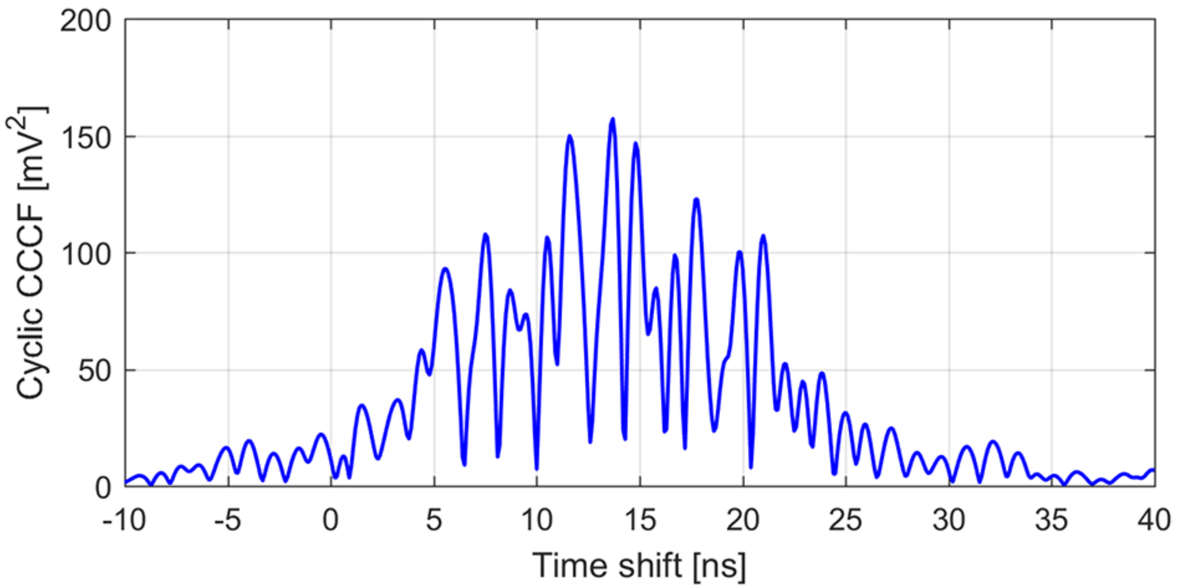


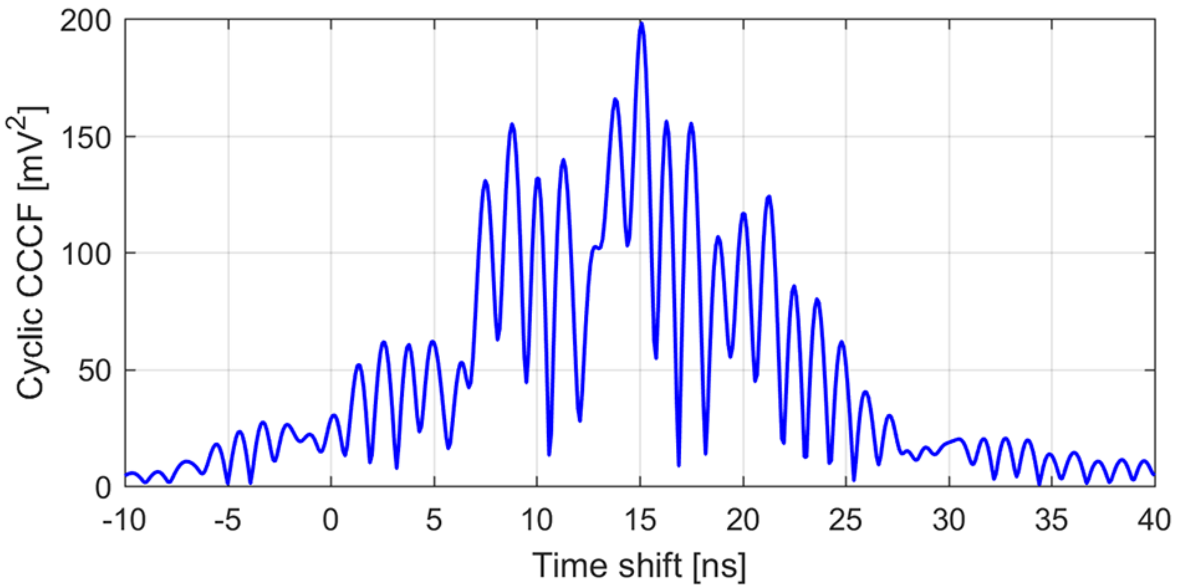


✓ $\alpha_1 = 1/T_{bit1} = 166.67$ MHz

✓ $\alpha_2 = 1/T_{bit2} = 156.25$ MHz

Cyclic cross-correlation cumulant functions

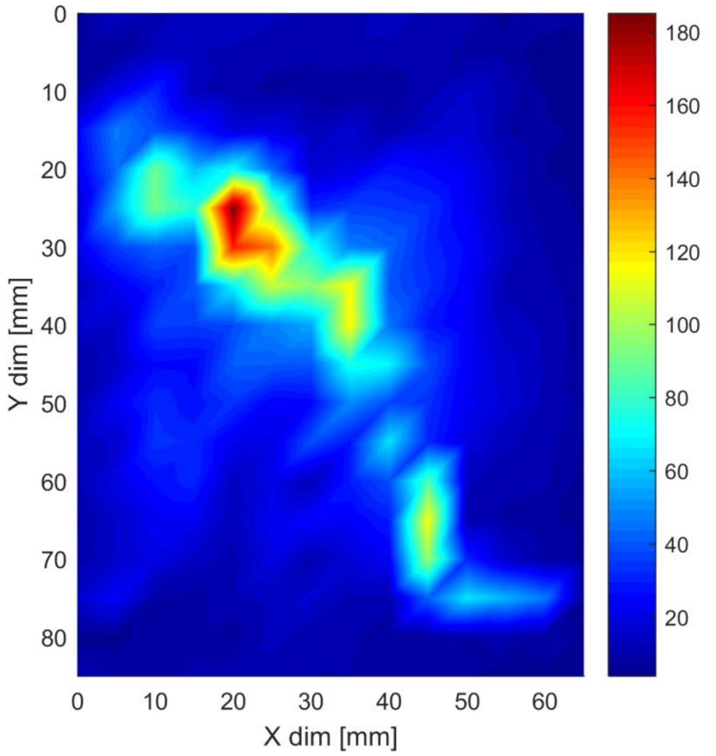


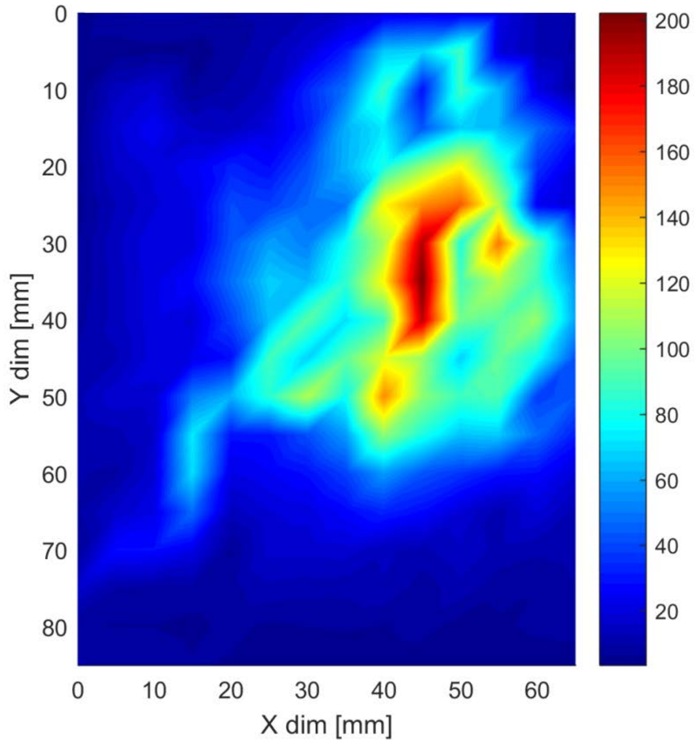


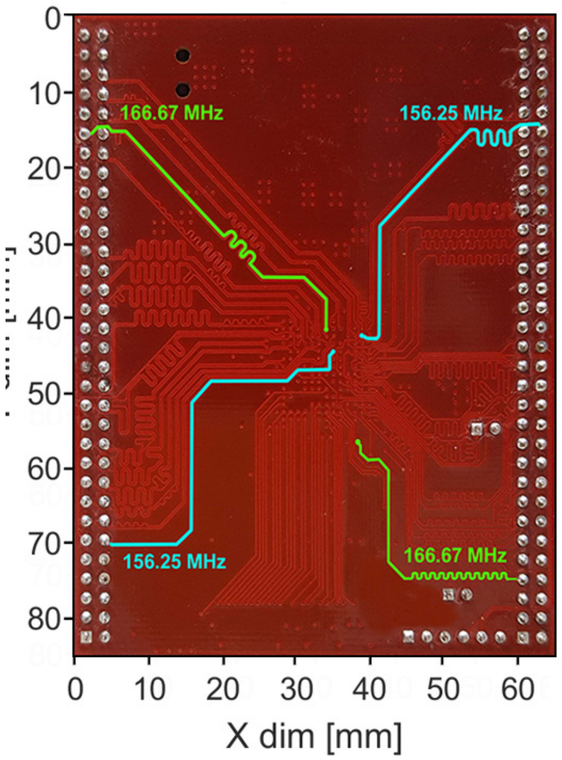
✓ $\alpha_1 = 1/T_{bit1} = 166.67$ MHz

✓ $\alpha_2 = 1/T_{bit2} = 156.25$ MHz

Spatial distribution of cyclic CCCF







✓ $\alpha_1 = 166.67$ MHz

✓ $\alpha_2 = 156.25$ MHz

Conclusion

- Cyclic cross-correlation cumulant functions can be used for separation of two different random bit sequences with different cyclic frequencies
- Special-time distribution was used for the localization of the transmission lines over the DUT surface
- For cyclostationary source separation the position of the reference probe need to be chosen for sensing radiations of both sources

Publications

- **EMC Europe 2018 Symposium, August 27-30, Amsterdam, Netherlands**
- **2018 Baltic URSI Symposium, May 14-17, Poznań, Poland**
- **2nd URSI AT-RASC, 28 May – 1 June, Gran Canarias**
- **European Microwave Week 2018, September 23-28, Madrid, Spain**