Spectrum Analyzer Extenders at 300 GHz Enabling Complex 16-QAM Modulation

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- 220-330 GHz Sub-Harmonic mixer
- 220-330 GHz spectrum analyzer extender
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- 64-QAM setup
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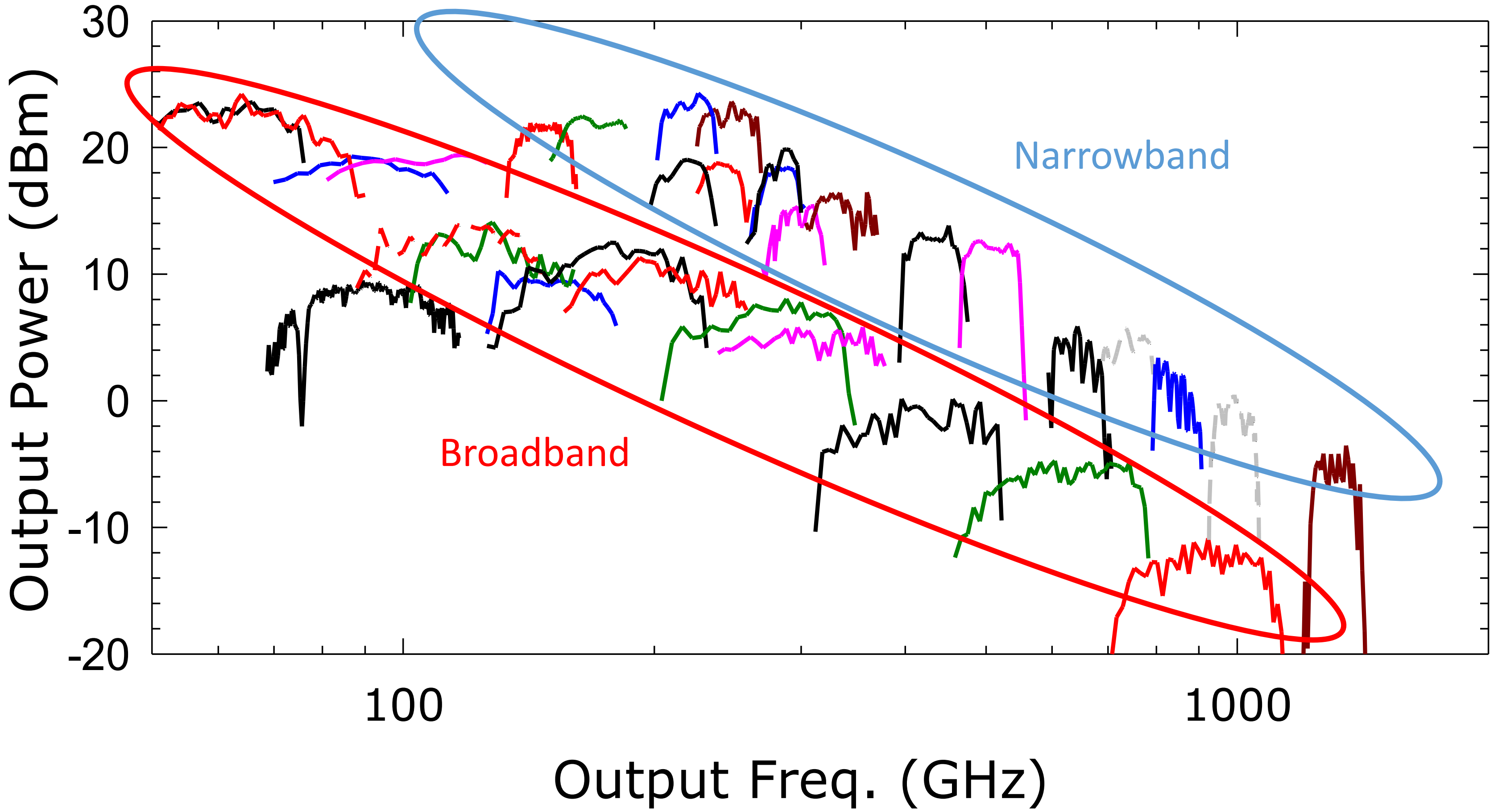
Introduction

- Traditional spectrum analyzers operate effectively up to 100 GHz, but as communication technologies push toward THz frequencies, this limitation becomes a challenge.
- Spectrum analyzer extenders bridge this gap by enabling measurements at frequencies well beyond standard analyzer capabilities.
- These extenders use frequency multipliers and mixers to convert high-frequency signals into a range that standard spectrum analyzers can process.
- Without extenders, accurate signal analysis in the THz range would be extremely difficult due to the lack of commercially available full-range analyzers.

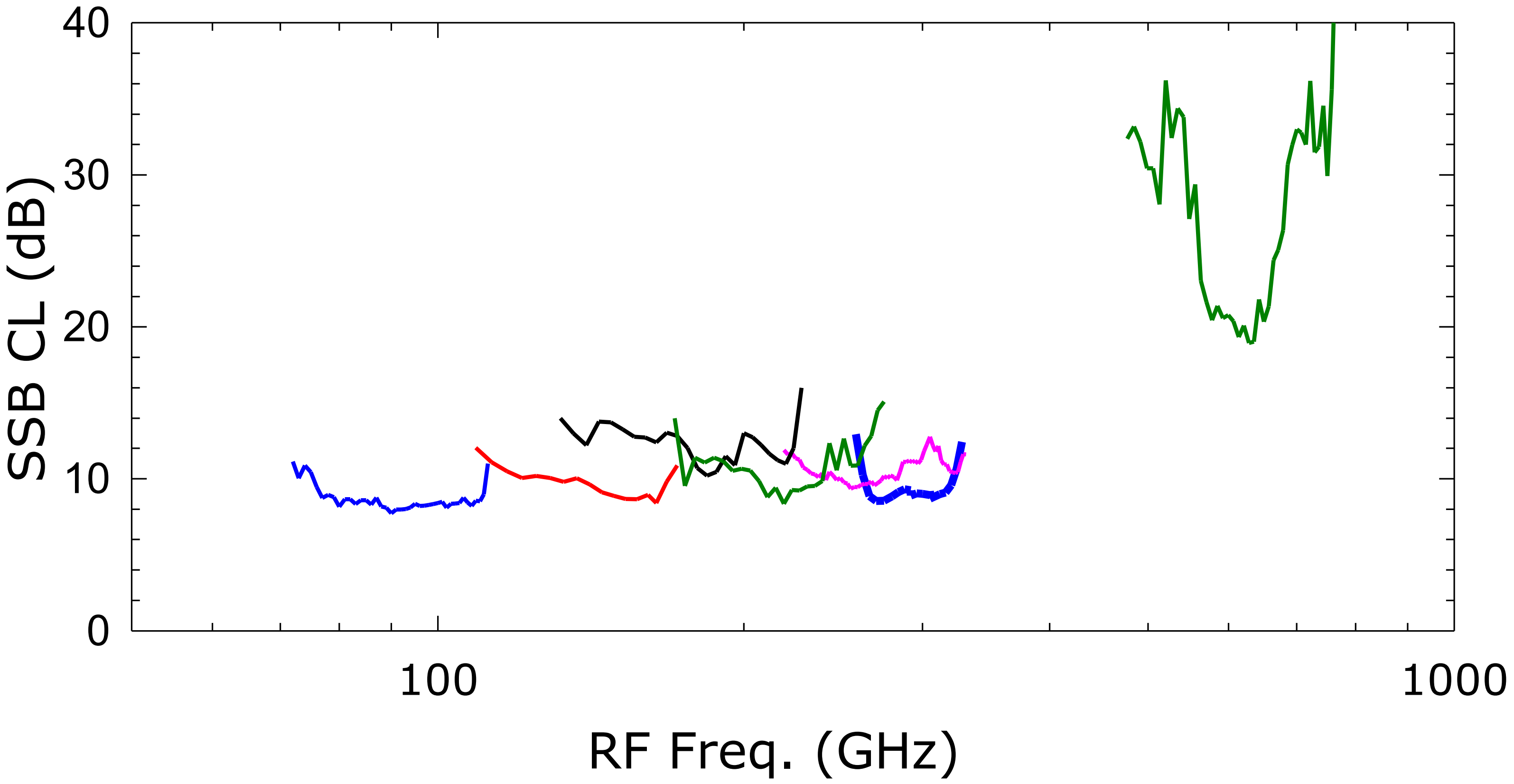
Overview of ACST THz sources and receivers

Sources



Overview of ACST THz sources and receivers

Receivers



- **Proven Technology & Expertise**: The spectrum analyzer extender is built upon ACST's established technology and know-how, already utilized in its sources and receivers.
- **Broad Frequency Coverage**: With ACST's current technology, extenders can be developed for all frequency bands up to 750 GHz.
- **Current Development**: Two additional mixers are currently under development to extend coverage from 300 GHz to 500 GHz, completing a full operational range from 100 GHz to 750 GHz.

220-330 GHz Sub-Harmonic mixer

TERAOPTICS A European Training Network

ACST THINK AHEAD

The main element of the spectrum analyzer is a high-power sub-harmonic frequency mixer based in Schottky diode technology, that can either up-convert a signal in the 220 GHz to 330 GHz frequency range given an IF frequency or down-convert an RF signal in the same frequency range into an IF signal.

The available IF bandwidth of the mixer spans from DC up to 40 GHz through a K-connector.

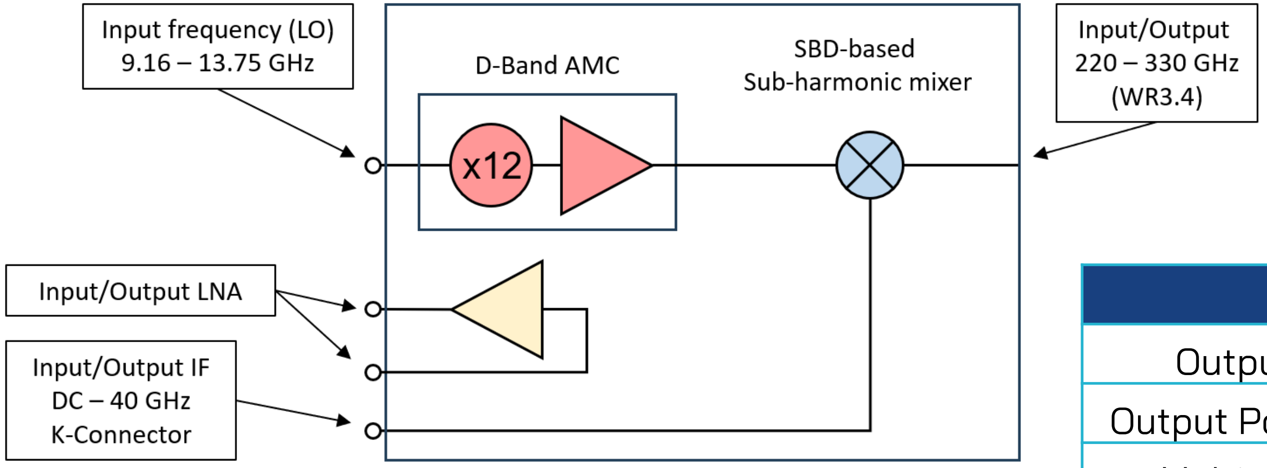
Application Areas

- **Laboratory instrumentation**
- **mm-wave FMCW-Radar**
- **Active imaging**
- **5G Telecommunications**
- **mm/Submm heterodyne receivers**

Technical Specification

	Minimum	Typ	Maximum
LO Input Port (UG 387/U-M)		WR-6.5	
LO Input Frequency (GHz)	110		165
LO Input Power (dBm)	+7	+9	+12
RF Input Port (UG 387/U-M)		WR-3.4	
RF Input Frequency (GHz)	220		330
RF Input Power (dBm)*			-10
DSB Conversion Loss (dB)	6.5	8	9.5
IF Output Port (Coaxial)		K-Type	
IF Output Frequency (GHz)	0		40
Material		Brass	
Finishing		Gold-Plated	

System schematic



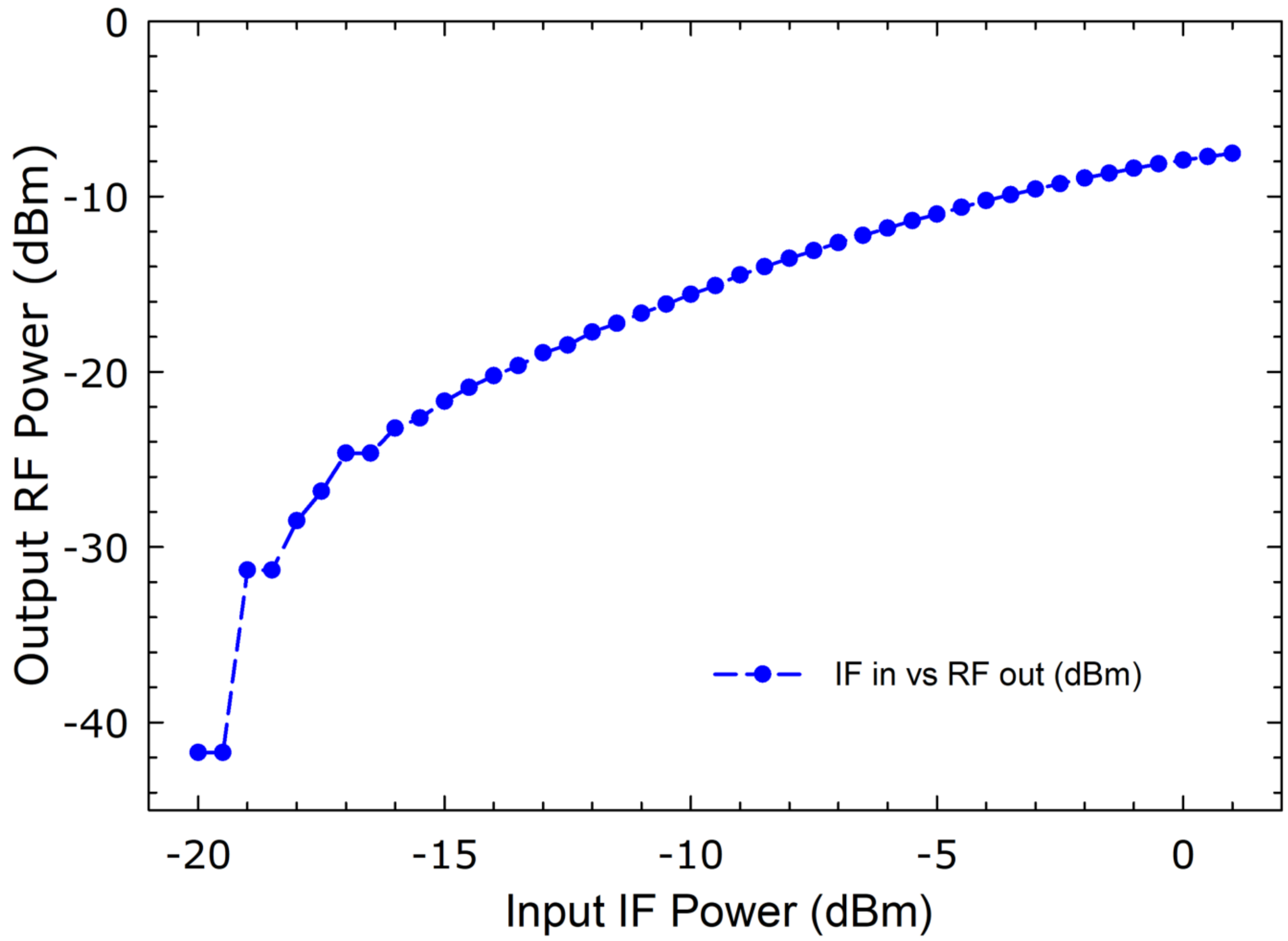
The integrated LO chain in the CUD consists of an AMC with a multiplication factor of 12 that is capable of up-converting a 0-5 dBm signal into the D-Band frequency range (110-170 GHz), and provide +10 dBm to +12 dBm at the input of the mixer

The system can both operates as Up and Down converter

Technical Specification

	Minimum	Typ.	Maximum
Output Freq. [GHz]	220		330
Output Port (UG 387/U-M)		WR3.4	
Multiplication factor		24	
LO Input Freq. [GHz]	9.166		13.75
Up-Conversion Loss (dB)*	5	7	11
Down-Conversion Loss (dB)**	8	10	22
RF Input Power [dBm]			-10
LO Input Power (dBm)	-10	-2	5
IF input power (dBm)		-10	-5
IF frequency (GHz)	0		40

Up-conversion saturation curve



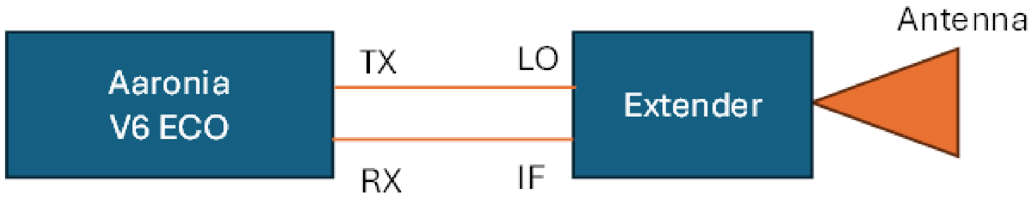
Output power up to -7.5 dBm could be achieved.

Saturation typically occurs for an IF power around -8dBm

After this IF power conversion loss increases

Spectrum analyzer extender

Setup schematic

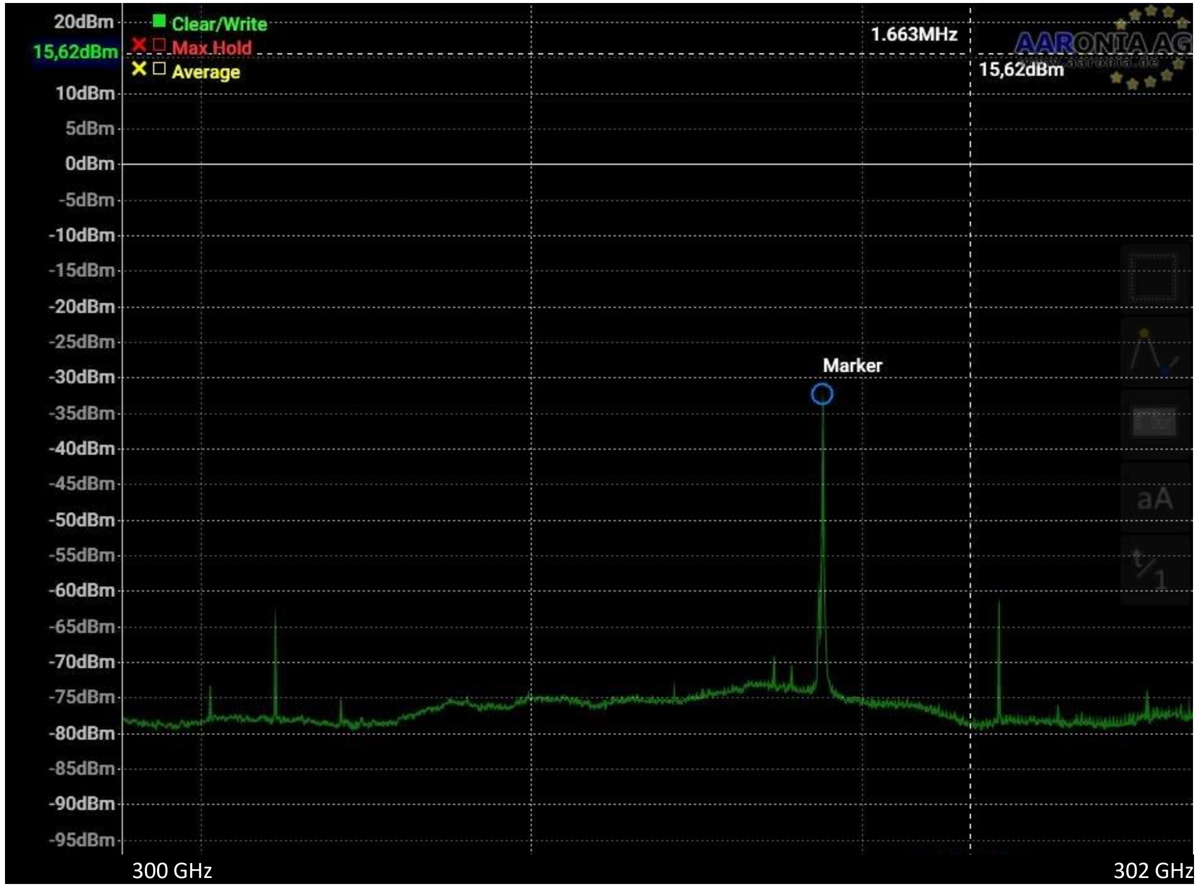


The system could be used as simple Spectrum analyzer extender.

For the test spectrum analyzer from Aaronia were used.

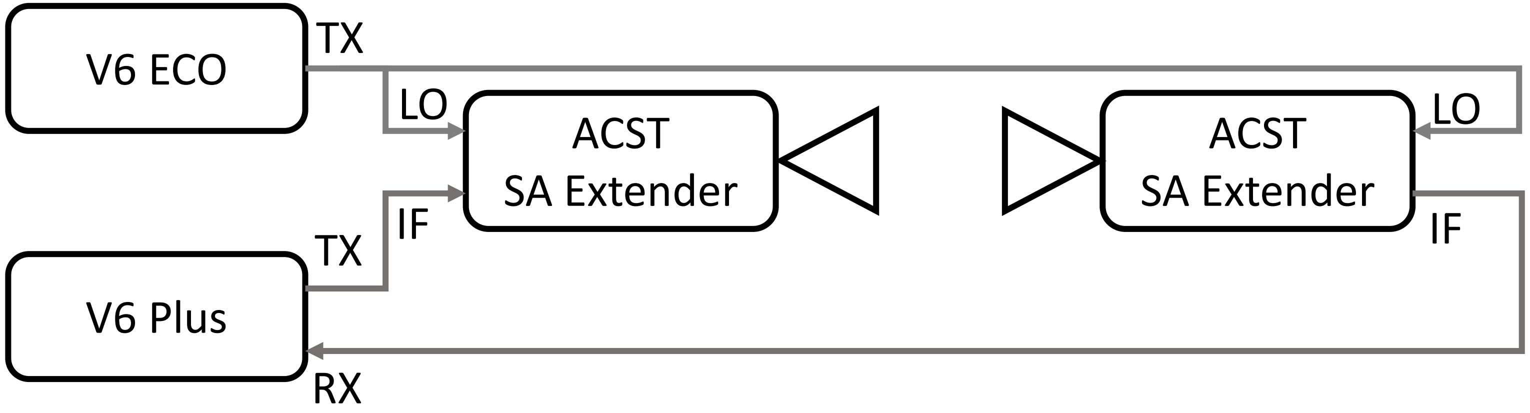
Very compact solution

Spectrum of a millimeter wave source operating around 300 GHz



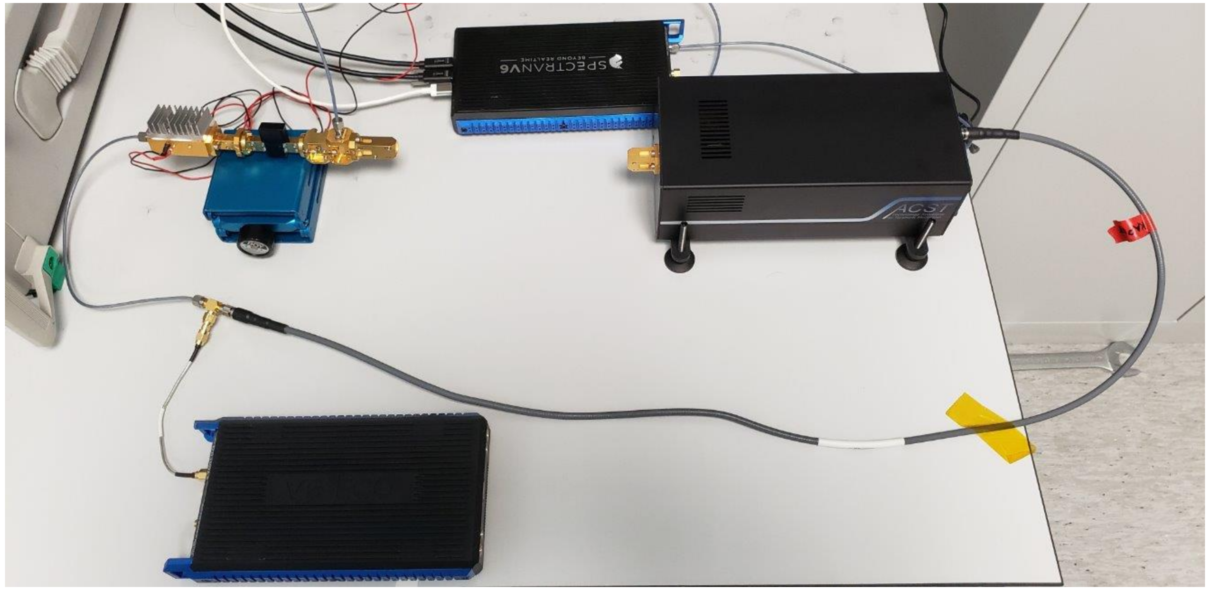
16-QAM transmission setup

Setup schematic



- A V6 ECO and V6 Plus spectrum analyzers were used for this setup
- The V6 ECO acts as the LO source for both converters.
- The V6 plus can generate modulated signals with different modulation schemes (BPSK, QPSK, 16-QAM, ...)
- One of the ASCT system up-converts a 16-QAM signal from the V6 Plus output up to a frequency of 300 GHz.
- The second system, receive the signal and down-converts the high-frequency signal, which is then analyzed by the V6 Plus.

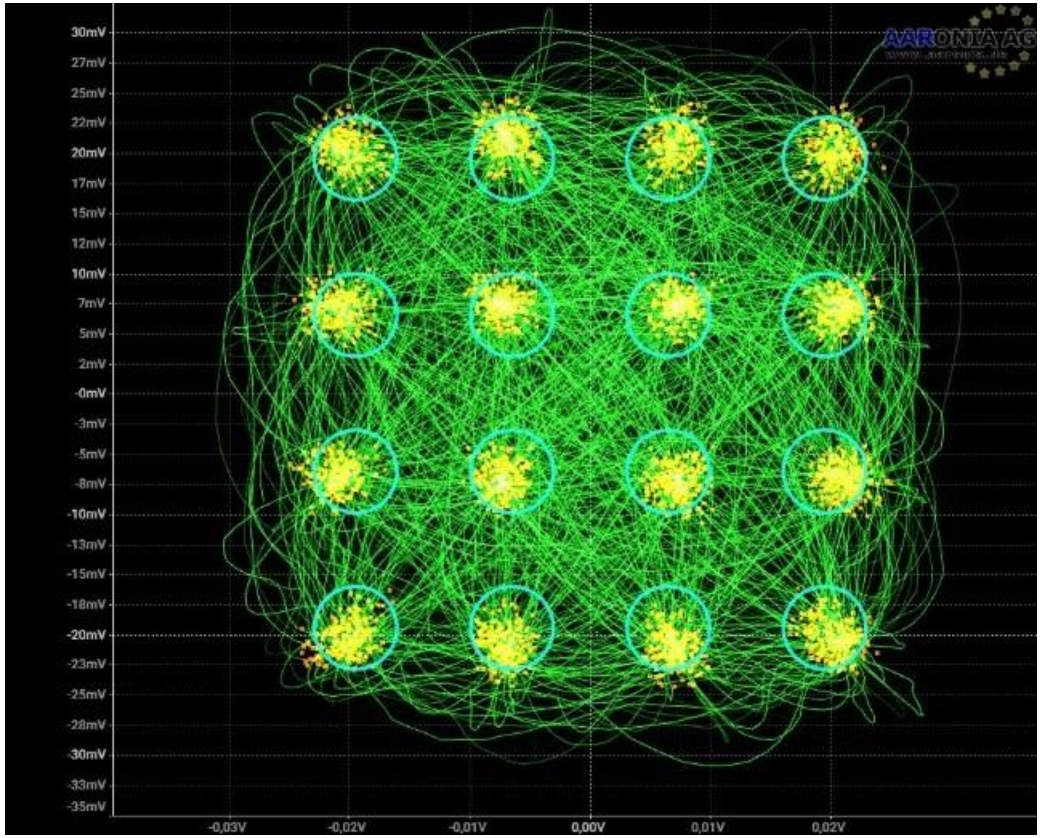
Picture of the setup

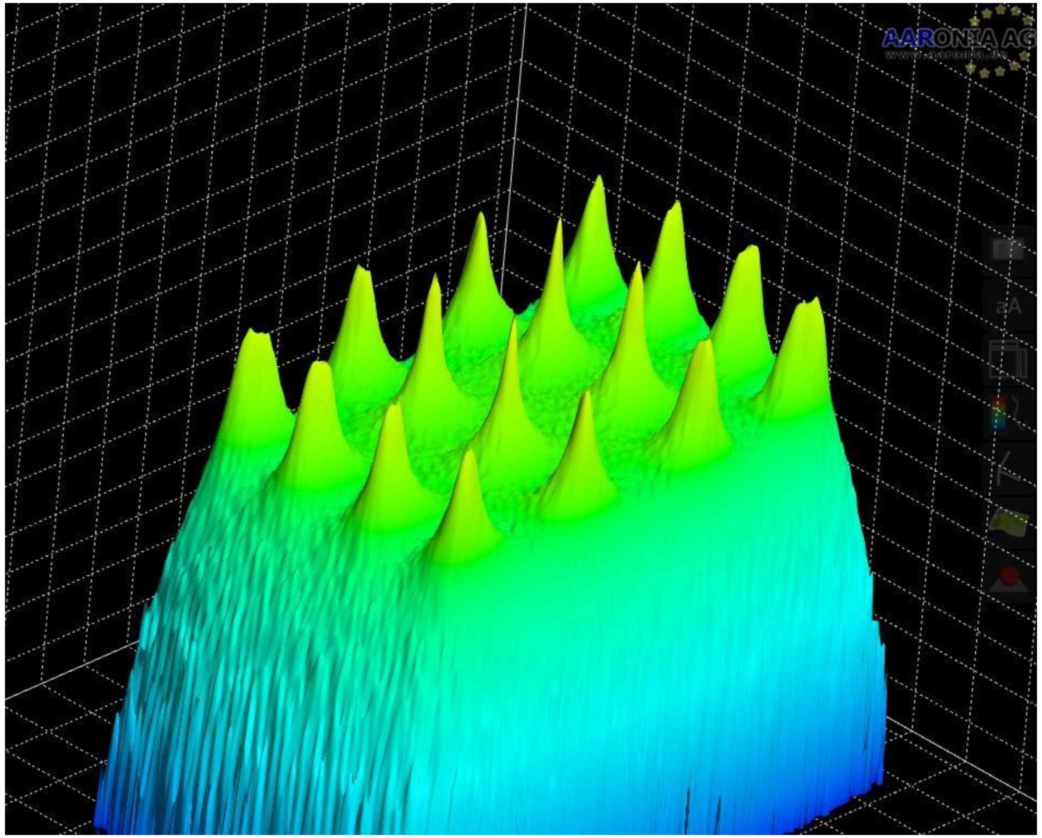


16-QAM transmission

Measurement results

Constellation diagram of the received 16-QAM signal
IF of 2 GHz was used, with a modulated signal bandwidth of 2 MHz





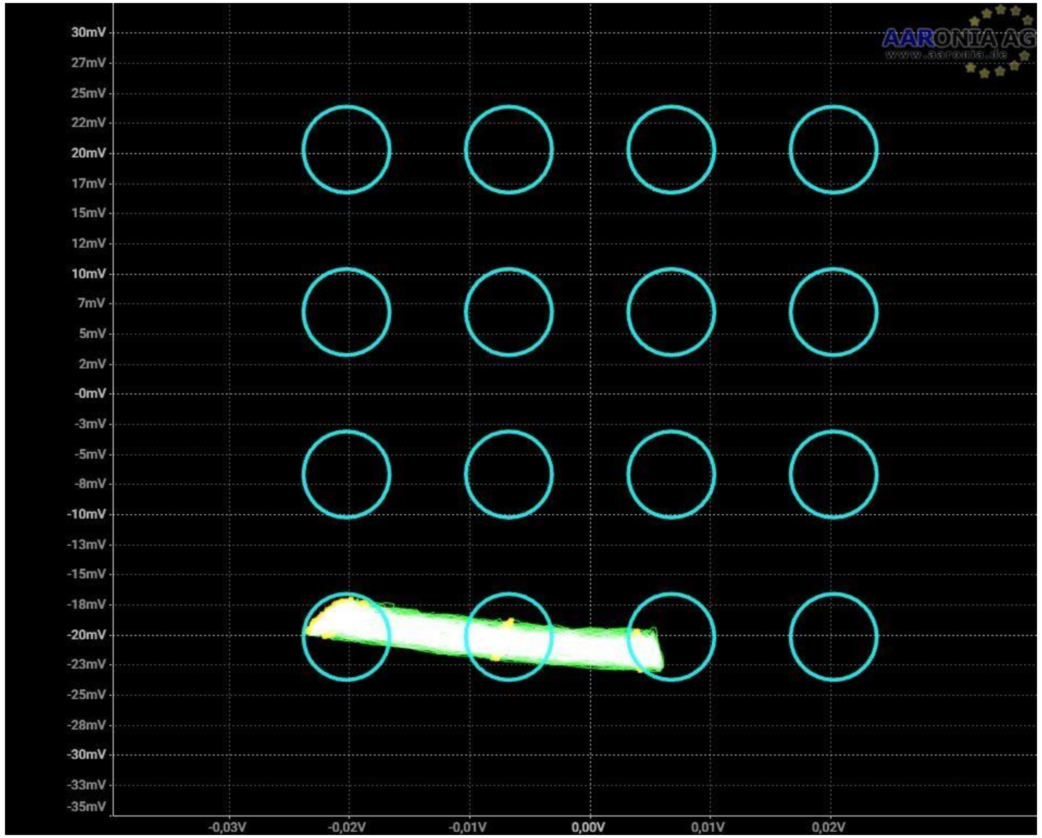
16-QAM transmission

Measurement results

The spectrum analyzer allows the transmission of single or multiple symbols as needed.

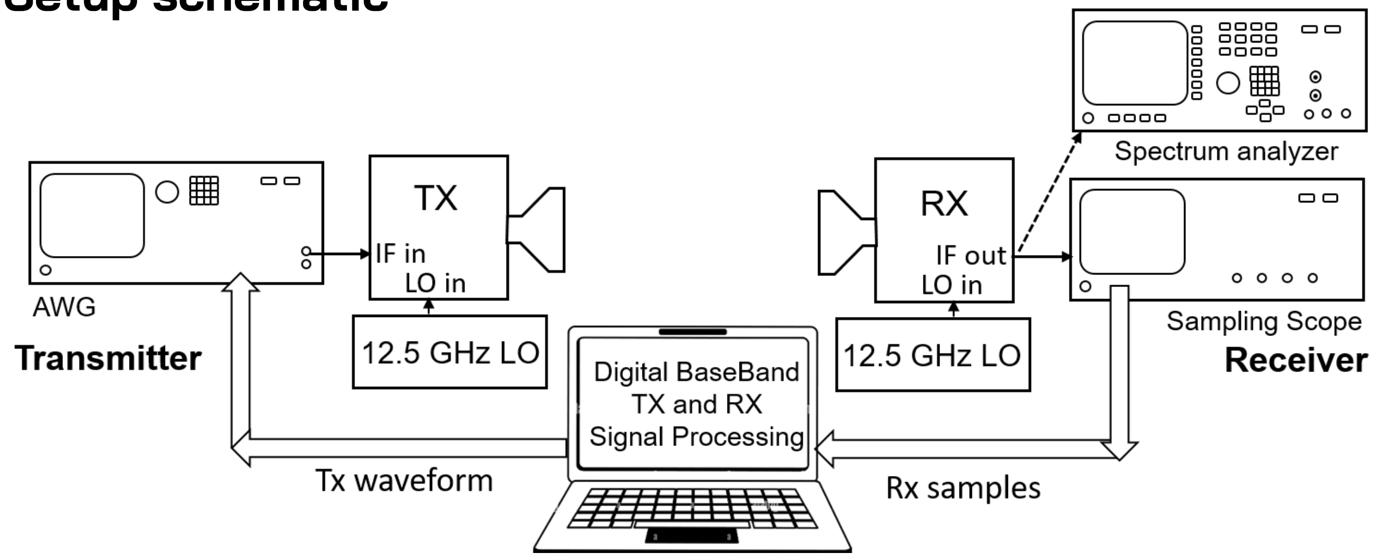
Transmission of a single symbol

Transmission of a three symbols



64-QAM setup

Setup schematic



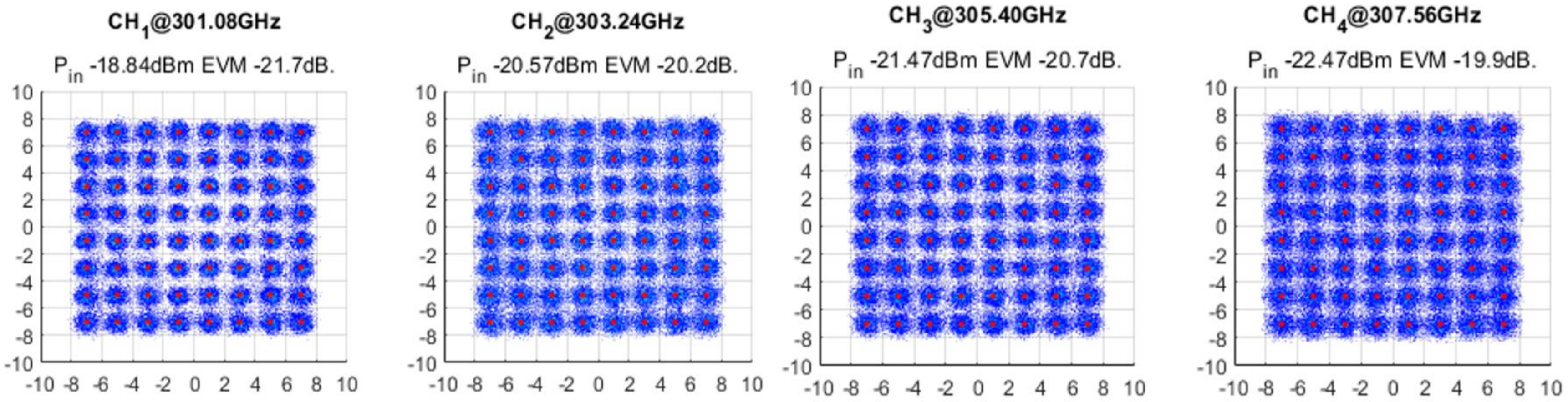
- Two extenders, one used as a transmitter and one as a receiver.
- 20 dBi WR3.4 antennas were connected to the RF ports of the extenders.
- The LO input frequency is provided by a signal generator and the IF or modulating signal, is generated by an Arbitrary Wave Generator (AWG).
- The LO input signal for the down-converter is provided by a signal generator.
- An additional LNA stage has been added to amplify the received IF signal and compensate for long cable losses.
- The received signal is processed by a 70 GHz oscilloscope.

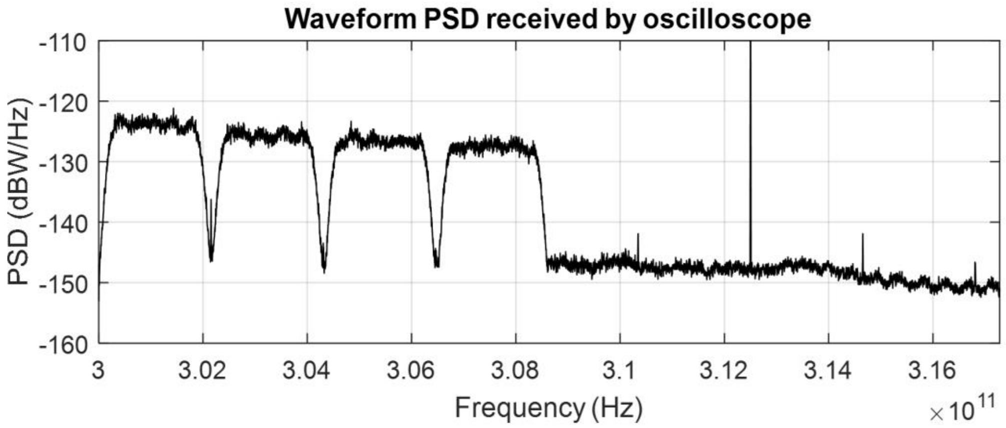
64-QAM data link

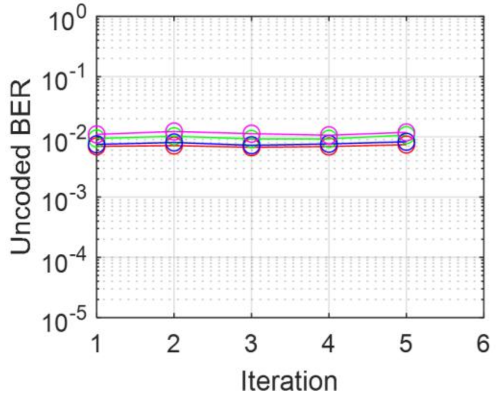
Results

Four channels with 2.16 GHz bandwidth per channel and a channel spacing of 410MHz (1.75 GHz of effective bandwidth/channel) have been generated by the AWG.

- An effective throughput of 42Gbps is achieved at 300 GHz with four channels.
- A raw BER of 10−2 is achieved
- Applying Forward Error Correction (FEC) or advanced Digital Signal Processing (DSP) to the received signal would definitely improve the metrics allowing for the inclusion of more channels to increase the throughput







Conclusion

- Spectrum analyzer extenders operating at 220-330 GHz were realized
- The extenders could both operate as Up and Down converter
- The systems were used as Spectrum analyzer extender
- The systems were used to realize wireless data transmission with 16-QAM and 64-QAM modulated signals demonstrating the possibility to transmit up to 42Gbps

Q/A

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