MTS Systemtechnik

Air Interface Emulators

An overview of the systems from
MTS Systemtechnik GmbH

Individual high-frequency technology

Concepted and build in Germany.

Your partner for customised solutions -
„Development, Production & Service“
all from a single source.

// High frequency technology
// EMC technology
// CNC milling technology

// Content

// About MTS Systemtechnik

Tailor-made solutions for high frequency technology, EMC, electronics and mechanics

Our customers include manufacturers of highly sensitive equipment in the market segments of mobile communications, telecommunications, aerospace, defense, medical, automotive and electronics. Our devices, systems and components are used worldwide by leading, internationally active companies.

For over 25 years, MTS Systemtechnik stands for state-of-the-art technology, absolute reliability, discretion, transparent processes and certified quality according to DIN EN ISO 9001.

With about 50 employees we develop and manufacture individual and high-quality devices, systems and components „Made in Germany“, as well as customer-specific products.

Our electronic products include coax relays, attenuators, power splitters, systems for the distribution of LF-, video-, RF-signals, RF matrices, assembled coax cables, etc. complex switching and distribution tasks in the high frequency range have made us a leading manufacturer of relay switching units, air interface emulators, power splitter units and matrices.

For the mobile radio and telecommunications industry we supply customised shielding boxes, air interface emulators for various test scenarios and smart antenna simulators.

With our modern CNC production centre we manufacture customer-specific precision milled parts for the aerospace, optical and high-frequency industries.

The distribution of coaxial connectors from IMS Connectors and the assembly of coaxial cables complete our product range.

Systems for the distribution of LF, video and RF signals in the fields of tele- and satellite communication and radio surveillance

Production of mechanical components for the aerospace, optical and high-frequency industries

Development and production of active and passive components for high frequency technology

// Introduction

Air interface emulators like Air Interface Adapter (AIAD) and Standard Coupling Field (SCF) from MTS Systemtechnik offer the possibility of testing mobile radio base stations and mobile stations in the lab via the air interface. Reproducible RF tests can be carried out independent of radio interference from the environment by using emulators, cables and shielding boxes.
Engineers get the opportunity to efficiently emulate a variety of specific wireless network handover scenarios. The MTS air interface emulators were designed for mobile radio test from 2G up to 5G FR1, but can also be used for Wi-Fi, Bluetooth and other radio technologies (f.e. TETRA).

How does it work?

Via semiconductor switches, different attenuators (1 dB, 2 dB, 4 dB, 8 dB etc.) can be switched into the signal path whereby all attenuation values in the range from 0 to 95 dB are possible in 1 dB-steps (0,5 dB or 0,25 dB-steps on request possible). A built-in logic selects the required attenuation steps. In these programmable attenuators the RF is transmitted bidirectional (uplink and downlink has the same attenuation). The internal attenuator-switchovers are continuously and without breaks. Several programmable attenuators are built into the AIAD together with different signal splitters and signal combiners to emulate the radio field by an attenuation network. It is controlled via various interfaces (LAN, USB, RS-232 etc.) using SCPI-like command strings.

A Windows program which allows to quickly program ramps for handover tests is available as an accessory.

What kind of tests can be performed?

// Different mobile radio handover test scenarios (inter cell-, inter system- etc.) are possible. Switching time <10 ms (TTL-version with 50 µs switching time is available).

// Feeding of a disturbing source e.g. for bit error rate tests.

// Tests in the life-net with portable Frequency Selective Attenuation Network (FSAN) models (see below in chapter „Other Air Interface Emulators).

// Description

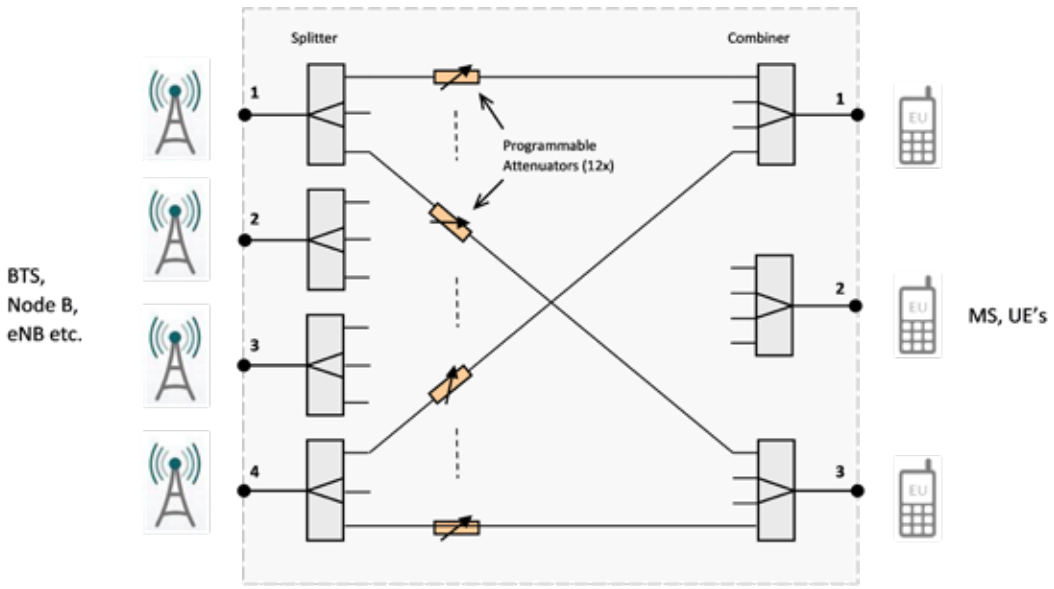
AIAD-X/Y (X/Y = number of inputs/outputs)

A number of programmable attenuators are combined to one matrix (full-fan-in / full-fan-out attenuation matrix) to emulate different radio conditions of the air interface.

The AIAD is connected at one side to different signals from base stations (BTS, NodeB, eNB or gNB) and at the other side with a number of mobile devices (MS or UE). If the mobile devices have no RF-connector, they should be placed into separate shielding boxes (available from MTS Systemtechnik too) and connected via antenna (accessory) each. This allows tests without radio interferences from the environment. The desired attenuation values can be adjusted for each path between base stations and mobile devices separately. The adjustments can be done remotely via LAN or USB interfaces. A manual control (touchpanel display) is available on request.

- // Robust design due to solid state switched attenuations
- // No calibration is required
- // Frequency range 400 - 8000 MHz

Block diagram, example AIAD-4/3:

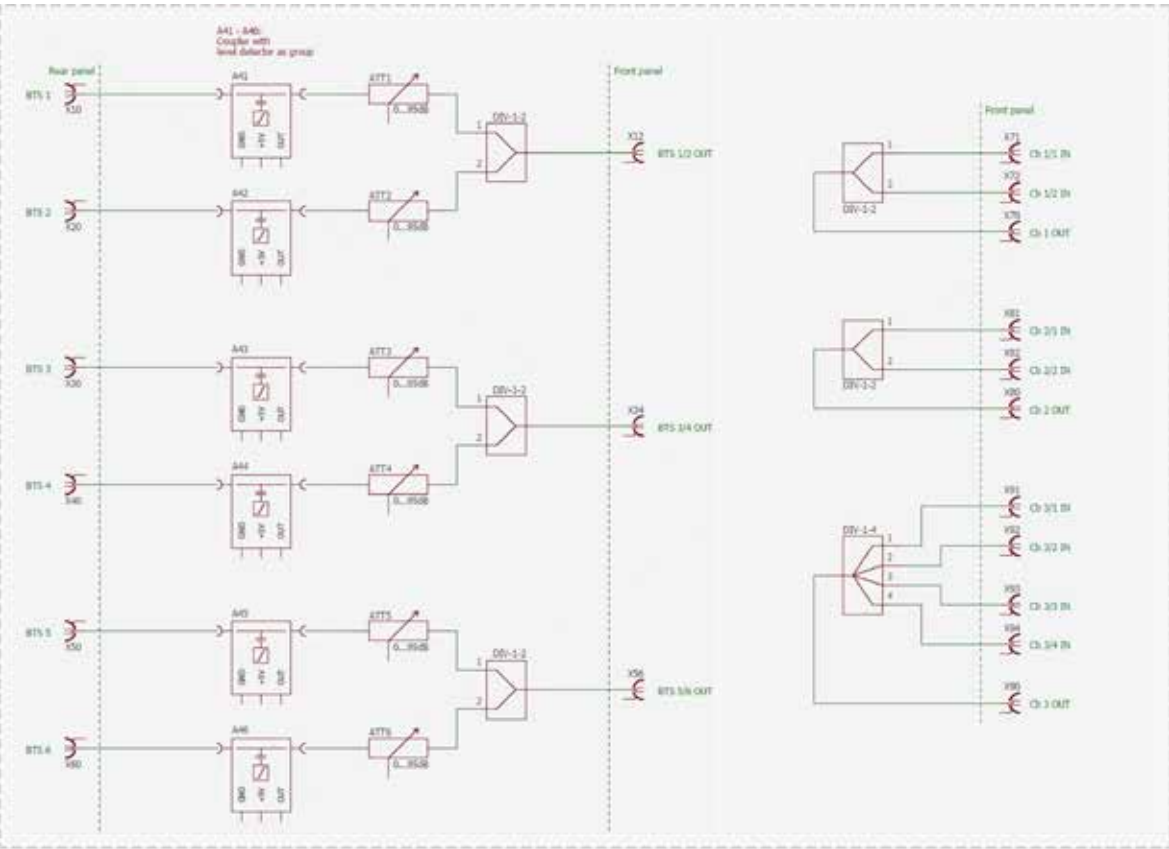


SCF-0300/SCF-0350-4G

The SCF-0300 can be used for the GSM, UMTS and LTE frequency ranges.
The SCF-0350-4G operates up to 4 GHz covering most 5G FR1 bands additionally.
Two BTS, NodeB, eNB or gNB input signals can be attenuated separately with programmable attenuators and are combined to one output connector (BTS x/y OUT).
On the output connector the MS or UE can be connected. If the MS or UE has no RF-connector, it can be used inside of a MTS Systemtechnik shielding box, series MSB and connected via antenna (accessory) to test it without radio interferences from the environment however.
For each input connector (BTS1 - BTS6) a level detector distinguishes two different signal power threshold levels. A green LED glows if the signal is in the range between -40 dBm and +15 dBm and a red LED glows if it is above + 15 dBm and potentially too high.
As visible on the block diagram below there are totally 3 of the above described 2/1-programmable-attenuator-stages included in one SCF-300 device. The additional included power splitters 2x 1/2 and 1x 1/4 at the right side of the block diagram can be used as needed for further signal combining or distributing.

// Robust design due to solid state switched attenuations
// No calibration is required

Block diagram, SCF-0300/SCF-0350-4G:



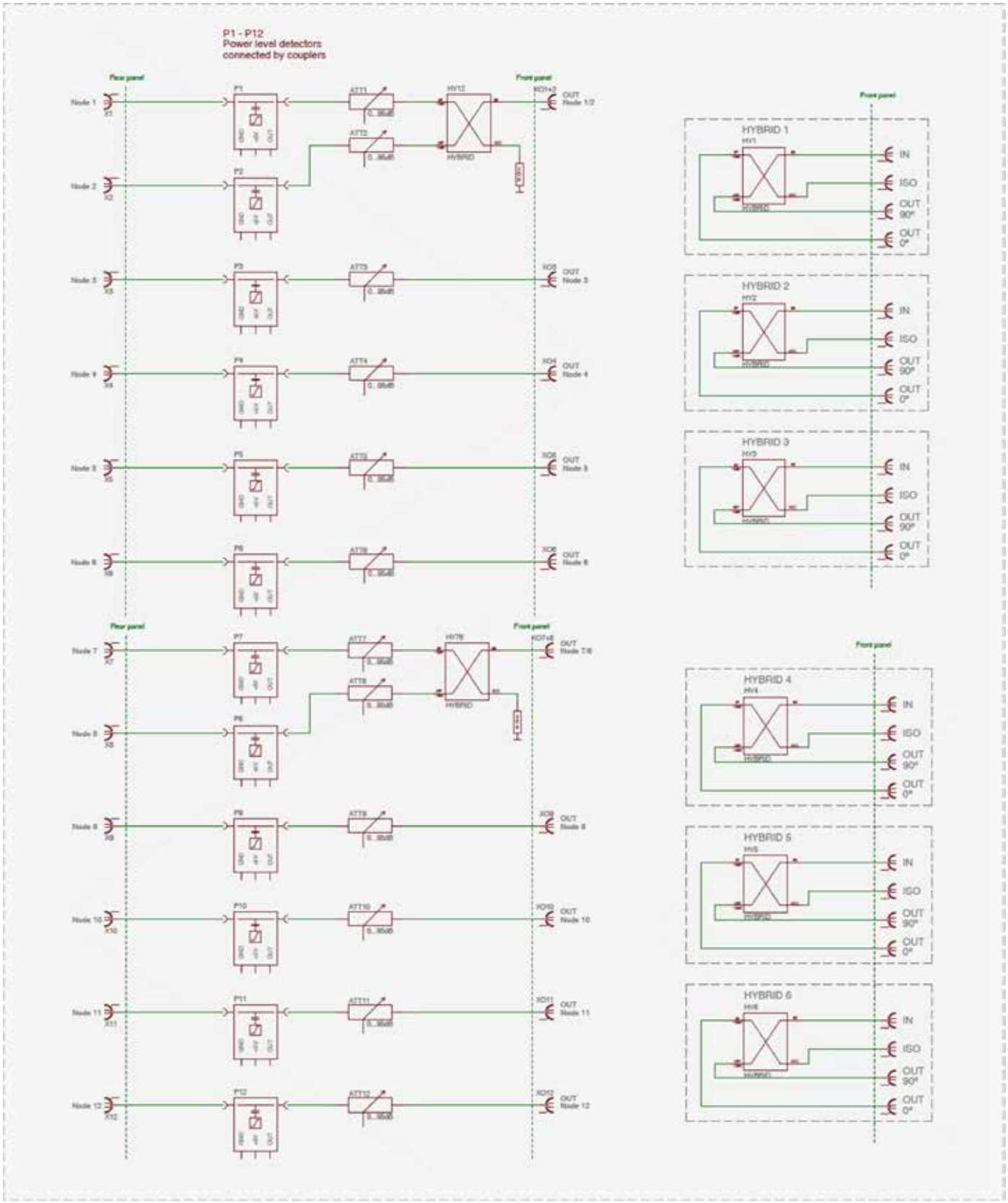
SCF-0600-6G/SCF-0601-6G

This new device covers the frequency range from 700 MHz to 6 GHz, and thus even offers the 5G FR1 and Wi-Fi 5GHz range.

The SCF-0600-6G is an extended version of an SCF for more signal paths, greatly expanded frequency range and higher input power. It emulates air interfaces between 12 input- and 10 output-connectors. Each signal path can be attenuated separately by programmable attenuators. For each input connector a level detector distinguishes two different signal power threshold levels. A green LED glows if the signal is in the range between -45 dBm and +10 dBm and a red LED indicates potentially too high power above +10 dBm (the threshold levels at the SCF-0601 are -40 dBm and +15 dBm). The desired attenuator values can be adjusted by manual control (via up/down-buttons and display) and remote via RS-232, LAN and USB interface. The additional included RK3 hybrid couplers (3dB couplers) can be used for further signal combining or distributing as required. See below for further details and schematics.

// Robust design due to solid state switched attenuations
// No calibration is required

Block diagram, SCF-0600/SCF-0601:



Possible Testing Problems

The test environment of air interface emulators consists usually of a number of base stations and mobile stations to reproduce test scenarios at laboratory conditions. By means of shielding boxes, the mobile devices can be shielded from radio interferences of the surrounding area. The RF-signals are distributed by coaxial cables. Everything seems safe - nevertheless problems can arise due to the test layout. To overcome the air interface also under difficult conditions, the mobile radio systems have a huge radio link budget.
Example of the GSM power margin (without regarding the TX antenna gain):

maximum output power of a BTS (approx.):	+ 45 dBm
sensitivity of a mobile device (approx):	- 105 dBm
Max. power margin:	150 dB !!!

This is a relation in power of 1:1 quadrillion (= $1:10^{15}$). If we consider other radio technologies, such as IoT, the radio link budget is even much higher!

The following risks may arise:

// Interference in the surrounding area of signals that leak through the shielding braid of the RF cables connected to the base station (cable shielding ≤100 dB normally).
// Reduced shielding of the device under test (e.g. by poorly shielded USB or RS-232 cables in connection with the shielding box)

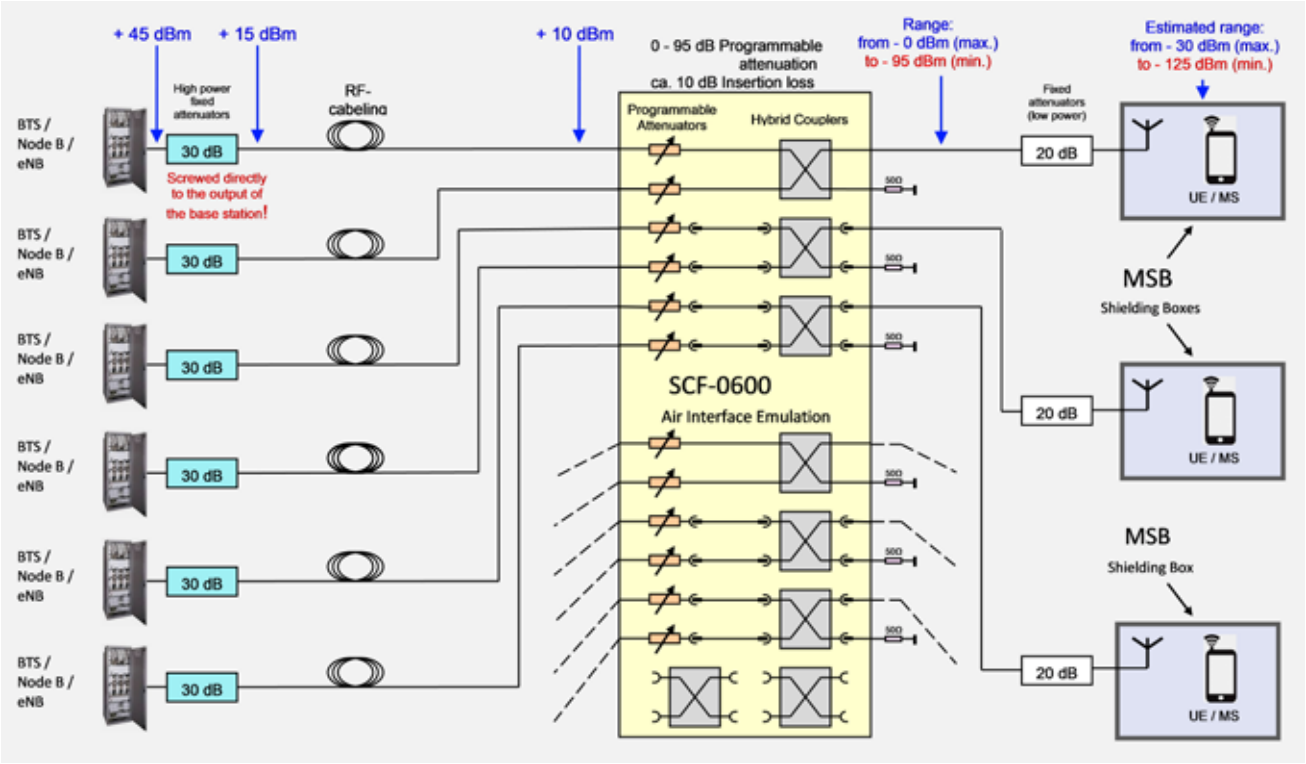
Solution:
The output signal of a base station should be routed via coaxial cables with such high power in no case! This can be easily avoided by using high power fixed attenuators that have to be screwed directly at all RF-connectors of each base station. For this purpose, 30 dB, 50W fixed coaxial attenuators have proved their worth.

Welcome side effects:

// 30 dB fixed attenuators prevent also from exceeding of the maximum input power of the SCF device.
// In order to suppress radio reception in the mobile device, it is anyway necessary to insert an additional attenuation into the signal path, since the SCF can not achieve a total attenuation of 150 dB.
SCF total attenuation = adjusted attenuation + insertion loss of SCF

The pre-attenuation at 30 dB reduces the signals sufficiently. A rough calculation of the power levels is shown in the following example.

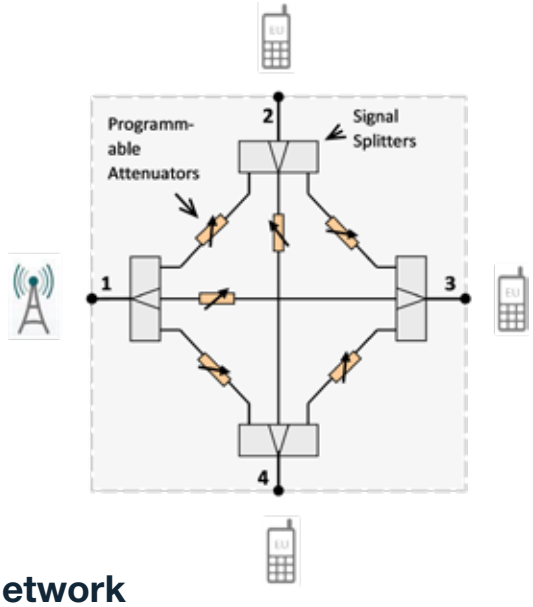
Typical dimensioning of a Testlab with SCF-0600



// Other Air Interface Emulators

AIAD-X+ (X = number of ports)

This extended topology with fully cross linked RF ports is required, for example, to test direct mode operation between terrestrial trunked radio stations (TETRA).

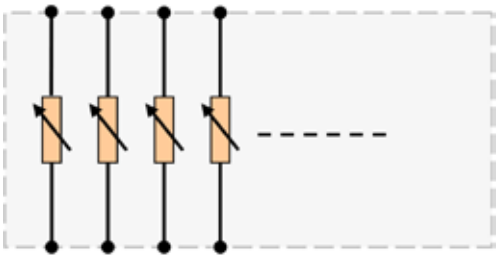


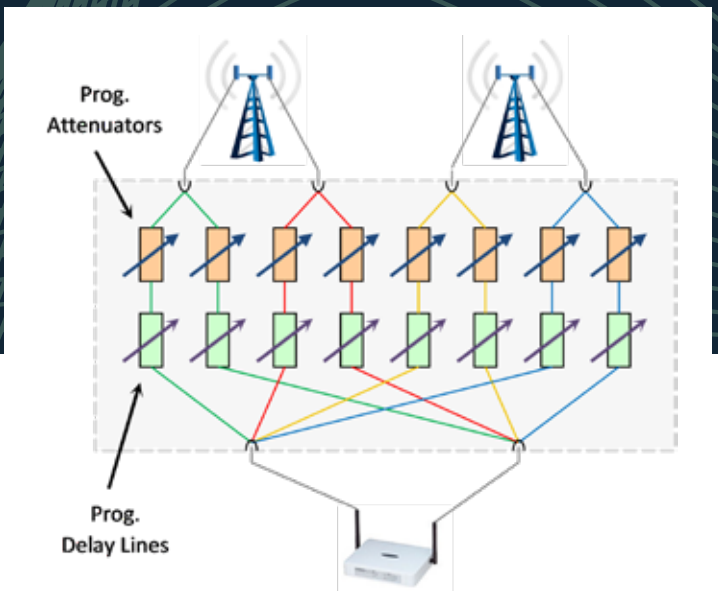
FSAN, Frequency Selective Attenuation Network

An antenna signal is divided into several frequency ranges via multiplex filters, attenuated separately by programmable attenuators and then combined with a second multiplex filter to form a single signal. It can be used for inter-system-handover tests. Portable versions of the FSAN can be built for drive tests in life mobile radio networks.

PAH-X, Programmable Attenuator Unit

(X = number of paths) Several programmable attenuators are built into one device.
All connections are accessible from the front or rear panel. Usually with built-in manual control.





MIMO-Tester

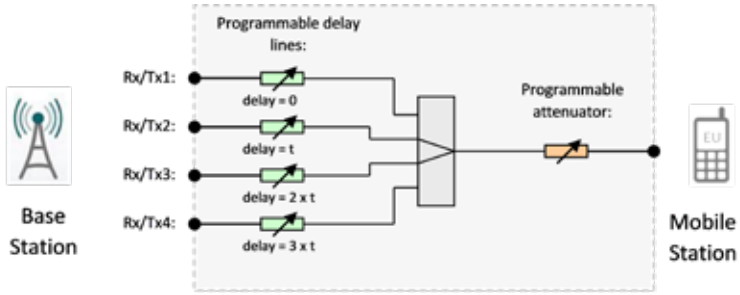
This device is suitable both for emulating antenna diversity and for beamforming. It can be used for HSPA+, LTE, or Wi-Fi tests. The channel matrix can be emulated by attenuators and delay lines, each of which can be digitally adjusted. Each level of a channel can be programmed in a range from 0 to 95 dB in 1 dB steps (0,5 dB or 0,25 dB steps on request possible). Phase differences between individual channels can also be emulated by corresponding time delays of up to 1600 picoseconds (ps).

AIAD with Extended Accuracy

Higher attenuation accuracy can be achieved by calibrating to a narrow frequency range.

SAS, Smart Antenna System Adapter

Emulation of beam forming by programmable delay lines for WiMAX. It is also used for MIMO.



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