

## Measuring Photonic, Optoelectronic and Electro-optic S-parameters using an advanced photonic module

This application note describes the procedure for electro-optic measurements of both passive and active photonic, optoelectronic and electro-optic devices by means of a complete combined solution composed of a *Vector Network Analyzer (VNA)* and *an advanced photonic module*.

It also shows the key features and performance of this advanced photonic module.

The advanced photonic module is compatible with any VNA from any manufacturer in the market.

### Scope and Overview

Microwave photonics (MWP) is a field that combines the worlds of radiofrequency engineering and optoelectronics. MWP has attracted great interest from both the research community and the commercial sector over the past 30 years as it supports a considerable number of applications, ranging from telecommunications to sensing, security and image processing. While initially the research activity in this field was focused towards defense applications, MWP has recently expanded to address a considerable number of civil applications, including cellular, wireless, and satellite communications, cable television, distributed antenna systems, optical signal processing and medical imaging. The exponential growth and spread of this technology has led to the increase in the activity related to the design and development of photonic, optoelectronic and electro-optical devices and systems.

In this application note, a compact solution for measurement and characterization of the S-parameters in this type of devices is presented. The combination of a VNA and an advanced photonic instrument, which performs different opto-electronic and electro-optical conversions, permits to carry out this type of measurements. Fig. 1 shows the advanced photonic module.

- Operation frequency up to 67 GHz
- Available for 1550 and 1310 nm
- Internal optical source and external optical input
- High OMI efficiency
- Two receivers for low and high power optical inputs
- Protection system for electronic and optical internal components
- Uncertainty reduction in measurements of linear DUTs
- Amplitude and delay characterization as a function of wavelength (using a tunable optical source)
- Proper addressing of measurements for non-linear DUTs



Fig. 1. Front panel of the advanced photonic module.

Featuring a modulation bandwidth of up to 67 GHz and ready for using either fixed or tunable optical sources centered @ 1550 and 1310 nm, this external optical instrument upgrades the functionality of the VNA to carry out measurements and characterization of the S-parameters of a variety of components and devices such as electro-optic modulators (EOMs), photodiodes, optical amplifiers, Radio over Fiber subsystems (RoF subsystems) and any other passive or active, Photonic, opto-electronic or electro-optical devices and systems.

## System description

### Block diagram

The presented solution is composed of a VNA and an advanced photonic module. Fig. 2 shows the block diagram of the complete system featuring different S-parameter measurements of a DUT by means of an optical-optical (O/O), opto-electrical (O/E) and electro-optical (E/O) configuration.

The external optical system acts as an interface between DUT's optical domain and VNA's electronic domain. In the first stage, the electro-optic converter modulates an optical signal with the electronic signal from VNA. The optical signal can come from either the internal source or the external source through external optical input. In the second stage, the opto-electronic converter returns the electronic signal to the VNA.

Electrical and optical paths are implemented by RF cables and optical patch-cords respectively.

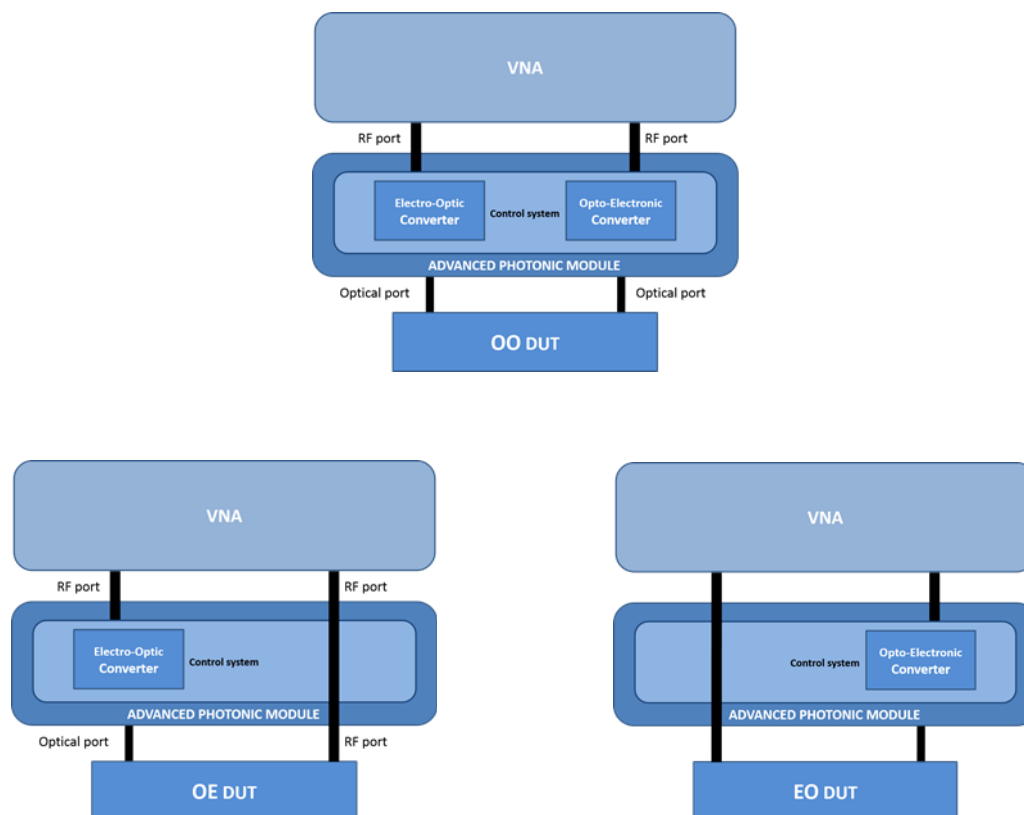


Fig. 2 Block diagram of the complete system for carrying out the optical-optical S-parameter measurement of a photonic DUT.

The communication between the VNA and the optical instrument is performed using LAN connection employing the respective ports, without penalizing the performance of the VNA.

### Types of Measurements

Interfacing the optical and electronic domains allows four types of measurements that can be distinguished in terms of the DUT subject to measurement. A traditional VNA carries out:

- **Electronic-Electronic (EE) Measurements**  
S-parameter of electrical devices and systems

However, combining the VNA with the advanced photonic module extends this range to allow as well:

- **Electronic-Optical (EO) Measurements**  
That can be used, for instance, for frequency and phase response of electro-optic, acousto-optic and electro-absorption modulators, laser modulation transfer functions, RoF links and systems, etc.

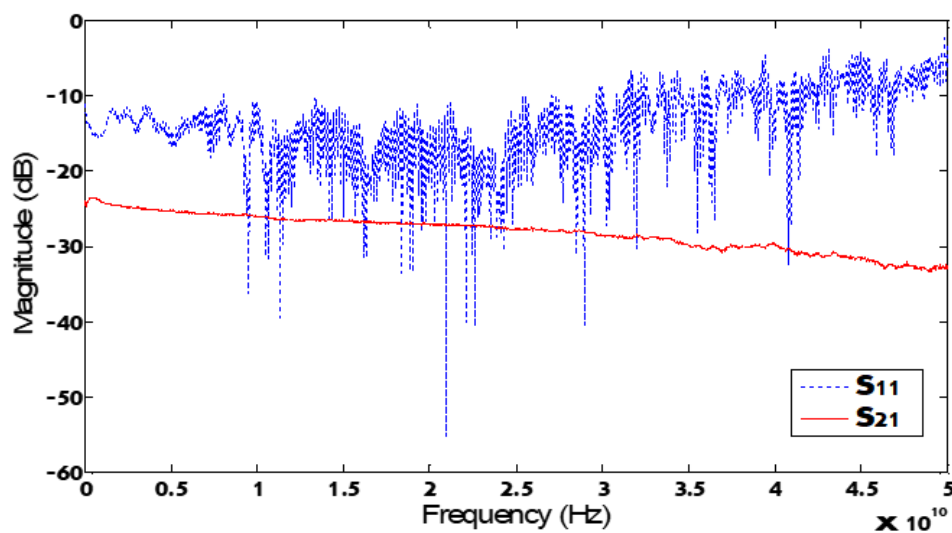


Fig. 3. Magnitude frequency response of an Electro-Optical intensity Modulator

- **Optical-Electronic (OE) Measurements**

This option is useful, for instance, in the characterization of the Responsivity of photodetectors such as PIN Diodes or APD's, etc.

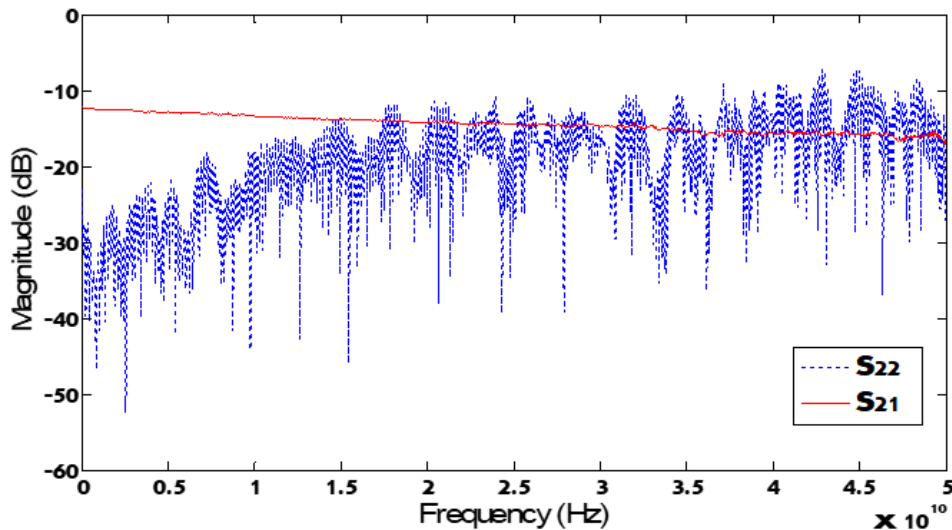


Fig. 4 Magnitude frequency of a Photodetector with a Bandwidth @-3db=50Ghz

- **Optical-Optical (OO) Measurements**

This option allows for the S-Parameter characterization of photonic components, such as optical attenuators, delay lines, dispersive fiber links, couplers, WDM multiplexers and demultiplexers and optical amplifiers as EDFAs and SOAs among other optical devices.

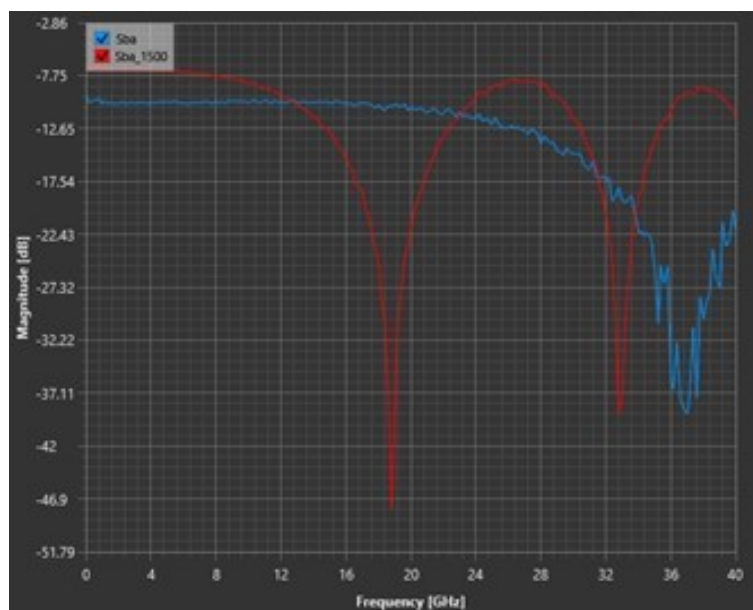


Fig. 5 . Magnitude frequency response of a -171.6 ps/nm fiber dispersion link for 1550 nm (red) and 1310 nm (blue), where carrier suppression effect and fiber transparency properties are shown

## Calibration Process

Calibration should be performed regularly according to desired measurement accuracy. The calibration process of the OVNA requires first an electrical calibration performed on the VNA in order to remove unwanted effects such as cables and other components in the measurement RF path. A calibration kit should be used to ensure the specifications of the OVNA.

The optical module contains the corresponding factory calibration to facilitate the use of the equipment in EO, OE and OO measurements, fully satisfying the specifications. Besides, users can perform an optical path deembedding in case of connecting additional optical elements (adapters, patchcords, etc) to DUT.

Furthermore, since the measurement accuracy depends on the temperature stability of the environment in which measurements are performed, a user calibration is automatically introduced in the system to improve the signal/noise ratio of the measurement if required.

## Highlighted features

### Protection system for electronic and optical internal components

In order to guarantee the safety of internal devices and subsystems of the instrument, a protection system is implemented in the instrument. Warnings and messages will be shown in the visual user interface that will help the user to proceed correctly in the configuration process of a measurement in case of a wrong procedure.

### Large output optical power range

Dynamic range of the output optical power is increased and easily controlled by means of the use of an internal optical attenuator. In this way, it is avoided the need of use of external components guaranteeing the calibration process.

## Additional information

For additional information, comments or questions, please contact us at the email address: [info@ephoox.com](mailto:info@ephoox.com)

## Ordering information

### OVNA Options

OVNA-P100-X-20-APC/PC	10 MHz to 20 GHz
OVNA-P100-X-40-APC/PC	10 MHz to 40 GHz

It is necessary to choose between APC and PC connectors. We recommend APC connectors since it is for this type of connectors that pre-specifications on this datasheet are guaranteed.

### Optical source options

-E	External optical source 1310/1550
-13	1310 nm internal optical source
-15	1550 nm internal optical source

### VNA Integration

The OVNA-P100-X must be integrated with a VNA to provide the OVNA solution. The software in the photonic module will control the whole system and therefore this integration must be carried out by Ephoox, being possible to integrate more than just one VNA.

The VNA model(s) that will be used must be detailed to us in order to consider the optimum type of integration that should be made.

### Warranty

Ephoox includes a one-year warranty in all of its products. Besides, it is possible to extend this warranty up to 3 or 5 years.