EXAM FOR DRAFTING A PATENT APPLICATION (ELECTRONICS)

Bellow is a brief disclosure you received from an inventor. Please use this disclosure as a basis for drafting a patent application. If it appears that some details about implementation of the invention are missing or are unclear, you may include remarks and questions in the application draft requesting the inventor to clarify those details or provide additional information. If you would raise any general questions to the inventor, please also indicate them.

At this initial stage of drafting a first patent application, your client has not yet decided about a filing strategy, and depending on many factors the application will have to be filed as a US regular or US provisional or IL application. The application should thus be fully drafted in a manner to be suitable for filing in different jurisdictions. Thus, the drafting should be done in consideration of this fact. In particular, in case different claim formats are needed for different jurisdiction, all such claims should be included in the specification already at this stage. It would help the client if you include a description on the claim strategy that you decided on.

BEHAZLACHA

THE INVENTOR'S DISCLOSURE

I am an engineer dealing mainly with development and assembling of measurement devices, including medical devices. One of the main tasks when using measurement devices is their calibration, which is an important process in any measurement technique: the higher the precision of calibration, the better are the measurement results, i.e. the higher the measurement system sensitivity to small measurement variations.

The RF calibration procedure is aimed at correcting measurement errors, ensuring that the response of a device under test (DUT) is recorded correctly. Typically, a vector network analyzer (VNA) including a signal transmitter/receiver is used; and a calibration device including a set of calibration loads which are measured when connected to the appropriate signal ports of the VNA.

The problem is that such connection between the calibration loads and VNA needs to be carried out each time the calibration is to be performed. The calibration consists of switching (manually or automatically) between the calibration loads for sequentially measuring the response of the VNA for each of these loads, and by this determining how the signal propagation between the signal transmitting/receiving plane and the DUT connection plane is affected by a signal transmitting media in between these planes. Upon completing the calibration procedure, the calibration device is replaced by the DUT (actual measurement device).

However, it is often the case that the specific application does not allow frequent disconnection of a measurement device to replace it by calibration device, or does not allow access to the measurement device. These applications include, for example, environmental monitoring, e.g. in oceans, in remote locations; geophysical, e.g. sensing in bore-holes, sensing in quarries; industrial, e.g. production line monitoring, monitoring in processing plants; medical: implantable devices, use in sterile environment, e.g. sensor position is variable relative to console; inaccessibility to sensor location; sensor is disposable; sensor is operated in a hazardous environment; sensor is sterile; sensor is operated in a range of temperatures.

So, I understood that a novel approach is needed to facilitate RF calibration procedure so as to, on the one hand, enable higher degree of precision of a calibration process, and, on the other hand, eliminate or at least significantly reduce a need for replacement between the calibration device and the DUT (measurement device).

According to my invention (**Fig. 1**), a calibration device is integral with a sensor device, which is to be periodically (at times) calibrated. Such a measurement device, formed by the sensor and calibration device, is connectable to any known suitable network analyzer, e.g. VNA.

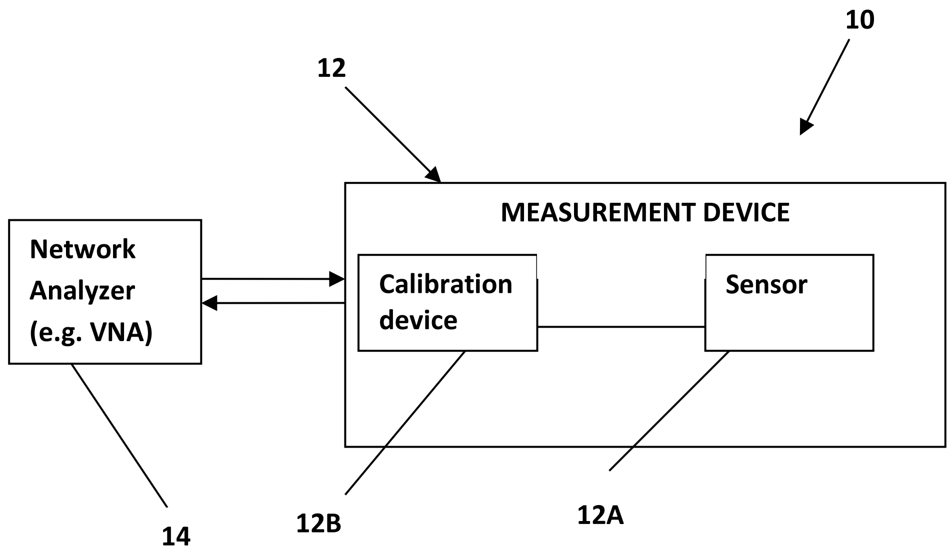


FIG. 1

Network analyzer (14): transmits and receives RF signals; analyzes the received signals; determines the amplitude (may be also phase) of the signal, which includes information about the signal interaction with calibration loads; delivers the calibration correction parameters; measures an RF response of the measurement device 12 using the calibration correction parameters.

Experimental setup (**Fig. 2**) of system 10 includes medical probe (sensor) 12A and calibration device 12B (printed circuit board) in a common housing 12C.

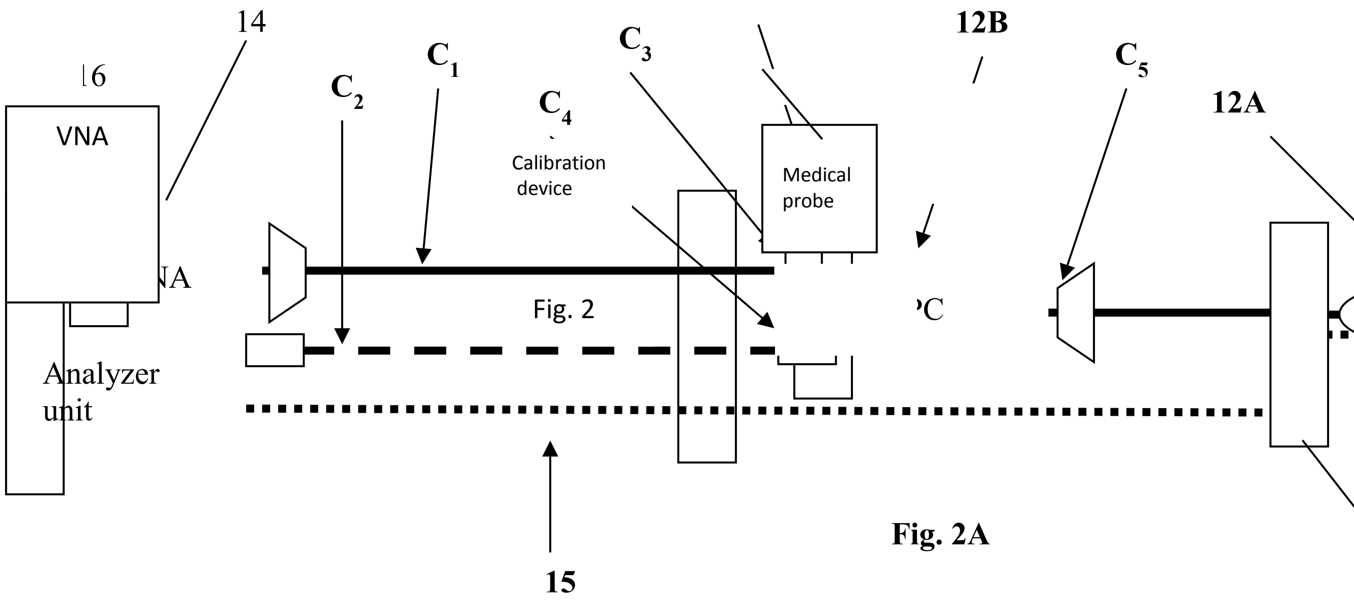


Fig. 2A

In the figure:

C_1 is RF signal transmission cable (e.g. coaxial cable),

C_2 is data transfer and control cable (e.g. USB cable, a coaxial cable, a cable for transmitting RS232 protocol data, a cable for transmitting GFSK protocol data, etc. for supporting digital and/or analog communication), and possibly also for electrical power supply to measurement device 12,

C_3 is an RF grade connector (for example, male SMA), for connecting calibration device 12B to cable C_1,

C_4 is a connector (for example SMA, or USB) for connecting calibration device 12B to cable C_2,

C_5 is an RF grade connector (for example SMA) for connecting calibration device 12B to the sensor 12A.

RF grade connectors (e.g. N-Type, BNC, SMA SMB, MCX, MMCX, U.FL.) connects all RF signal transmission ports between measurement device 12 and VNA 14, and between calibration device 12B and sensor/probe 12A, and provide interface defining a calibration plane and enabling repeatable measurement results. There may be any number *n* of RF signal connections (ports) between the VNA 14 and measurement device 12.

Figs. 3 and 4 - Example:

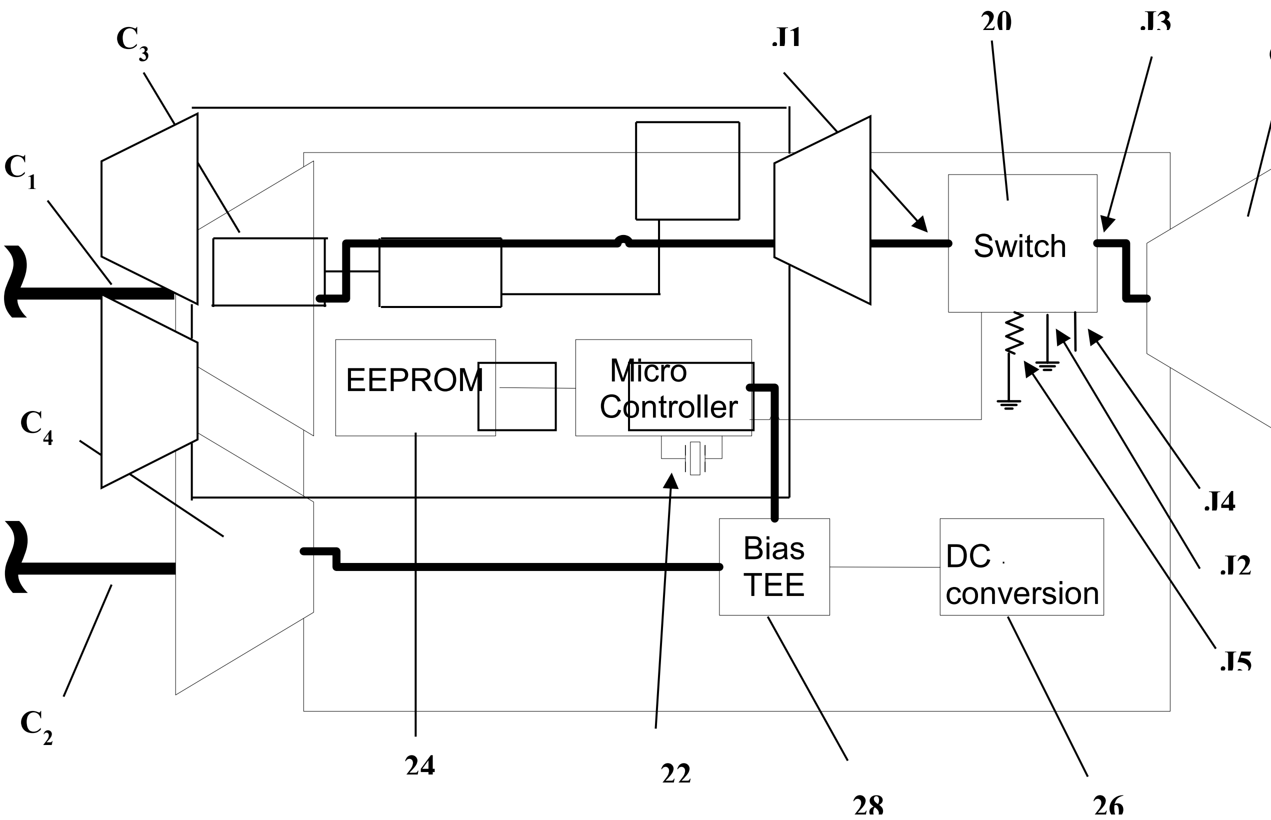

C3
J1
20
J3
C1
Switch
EEPROM
Micro
Controller
C4
J4
Bias
TEE
DC
conversion
J2
J5
C2
24
22
28
26

Fig. 3

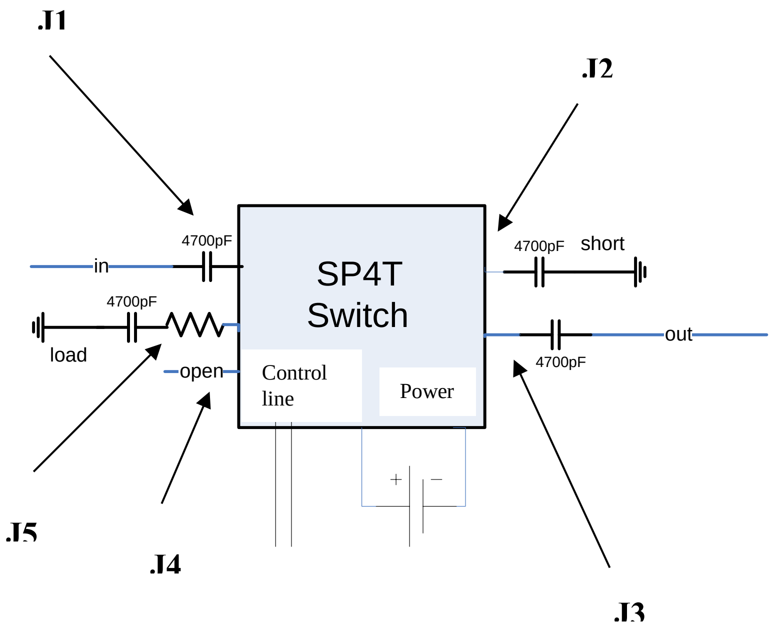

J1
J2
4700pF
in
SP4T
Switch
4700pF
short
4700pF
load
out
4700pF
open
Control
line
Power
J5
J4
J3

Fig. 4

C_2 – coaxial cable, connected to connector C_4, transmits data, and optionally provides power supply to measurement device 12.

Calibration device 12B includes:

- switch 20 connected to terminals (calibration loads),
- processor 22,
- memory 24 for code and data storage,
- power converter/stabilizer 26,
- bias (BIAS-TEE) 28 (optionally) for separating separates between the DC voltage from VNA 14 and data communication signals riding on the DC.

Switch 20 has connection ports J1 and J3 for connections C_3 and C_5, and is connected to three calibration load terminals: SHORT termination J2, OPEN termination J4, and LOAD termination J5.

Memory 24 stores data characterizing calibration device 12B. This data may include the full 2-port complex parameters, transfer coefficients, (S11, S22, S12, and S21) of the calibration device, and may also include data about the dependence of the calibration device response on environmental conditions (e.g. temperature, humidity, acceleration, mechanical agitation).

Memory 24 may store data characterizing the sensor 12A, e.g. RF calibration data for RF signal transfer between connector C_5 and sensor 12A.

Ports J1 and J3 of the switch 20 are connected to connections C_3 and C_5 (Fig. 3) via capacitors (to block the DC voltage); SHORT termination J2 is shorted to the ground through a capacitor, LOAD termination J5 is shorted to the ground through resistor and through capacitor; OPEN termination needs no capacitor. If there is no DC voltage, the ports of the switch, there is no need to use capacitors.

Calibration: Automated switching between terminations J2, J4 and J5 is done using the switch 20; *S* parameters, transfer coefficients, of the calibration controller (S11, S12, S21, S22) and the reflection coefficient of each calibration termination path (S11open, S11short and S11load) are stored in the memory 24; memory and switch operations are controlled by the microcontroller 22, which also communicates with the VNA 14 (internal controller of VNA) via matching circuits for transferring data between VNA 14 and measurement device 12, to be used for calibration.

Two-stage calibration procedure of the sensor 12A:

- preliminary calibration (phase 1) - carried out off-line, before integrating the calibration device 12B with the sensor 12A; and
- "actual" calibration (phase 2) – carried out on-line (after integrating the calibration device with the sensor), at any time during the device operation, without dissembling the calibration device.

As a result, the measurement plane is immediately/instantaneously transferred from the output plane of VNA 14 to the plane of connection to sensor 12A within the measurement device, contrary to known techniques, where the measurement plane is transferred from the VNA output to the input connector of a calibration device.

Figs. 5A-5B: example of calibration procedure ("CD" is calibration device):

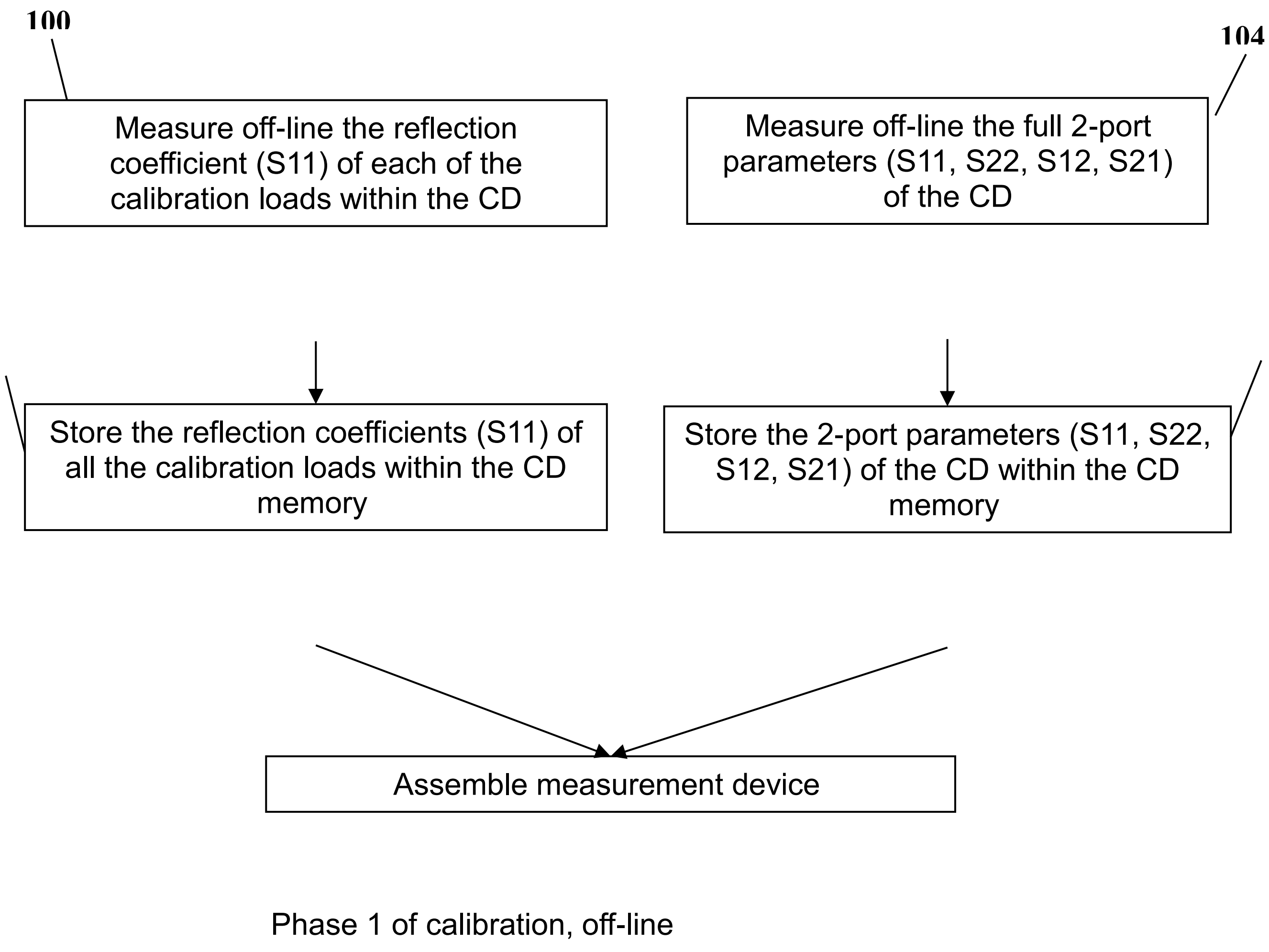
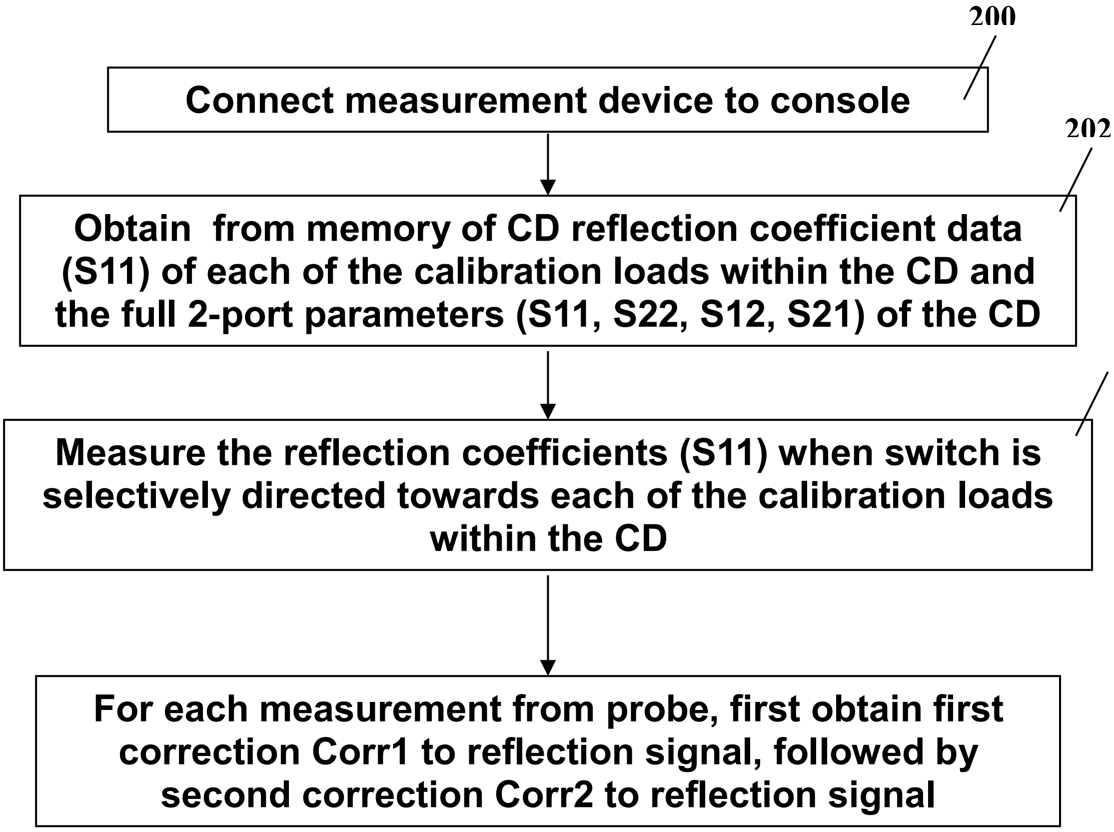


Fig. 5A



Phase 2 of calibration, on-line

Fig. 5B

Calibration phase 1 is carried out off line, i.e. before the calibration device CD is integrated with the measurement device. In this calibration phase 1, the complex reflection coefficients (S11) of the calibration loads S11open, S11short, and S11load are determined, and then, the full 2-port complex parameters, transfer coefficients, (S11, S22, S12, and S21) of the CD 12B are determined (switch 20 is directed to port J3, i.e. RF signal path within the switch is from port J1 to port J3). S11open corresponds to S11 of J1 when connected to J4; S11short corresponds to S11 of J1 when connected to J2; and S11load corresponds to S11 of J1 when connected to J5. Data indicative of the S-parameters and the calibration loads (S11open, S11short, and S11load) is stored in memory.

Then, the measurement device is assembled, i.e. CD 12B is integrated with sensor 12A.

In operation of measurement device 12, when connected to VNA 14, phase 2 calibration is carried out on line, utilizing the stored parameters, to calculate the corrections to the measured RF signals in order to transfer the signal measurement plane from the analyzer output plane to the plane of connection to the sensor within the measurement device. The measured signal is corrected in two stages.

Measurement device 12 is connected to analyzer unit 14, switch 20 is operated to selectively direct the RF signal path from network analyzer 14 to each of the calibration loads (J2, J4 and J5), and network analyzer 14 concurrently measures the reflection coefficients of each of the calibration loads within the CD, and measured data is recorded in the analyzer 14.

*Corr*1 is the result of the first stage of the correction to the RF signal reflection, and it accounts to transferring the measurement plane from the network analyzer output plane to the entrance plane of the calibration device (C_3).

Following this correction, the signals measured when the switch was directed to the calibration loads within the calibration device are not used anymore, until an additional calibration sequences is initiated.

From this point on the switch 20 is directed to J3, that is, the RF signal path within the switch is from J1 to J3.

Corr2 is the result of the second stage of the correction to the RF signal reflection, and it accounts to transferring the measurement plane from the entrance plane of the calibration device (C_3) to the input plane of the probe (C_5). The *Corr2* corrected RF signal reflection is the final, fully calibrated, RF response signal for reflection.

Additional calibration sequences (re-calibration) may be initiated "at any time"; may be invoked by user, by analyzer (either on a periodic basis, or based on some inputs), and/or by measurement device (either on a periodic basis, or based on some inputs). calibration can be performed before each measurement ("calibration on the fly").

Thus, my invention is about a calibration technique eliminating a need for replacing the actual device that is to be calibrated (DUT), e.g. sensor, by a calibration device, each time the calibration of sensor is required.