Product Note 47

Integrated Load Pull System, ILPS

ILPS is an Integrated Load Pull System representing a "turn-key" solution for customers who prefer to purchase a complete system, integrated and tested at the factory, at least in respect with its most important elements, like the tuners, controller and signal conditioning and processing components. The integrated solution offered by Focus Microwaves includes the additional possibility of "in-situ" calibration on a Vector Network Analyser, without removing and disconnecting components.

System Description

Depending on the test requirements, a choice of components for different frequency ranges, input and output powers and DC bias requirements can be integrated into a "customised" solution. The resulting configuration includes all components between the signal source and the input tuner and the output of the output tuner and the test instruments like power meters, power supplies and spectrum analysers. In addition to the tuners, which must be connected as close to the DUT as possible only the test fixture or probe station is required to complete the test setup.

A basic Integrated Load Pull System, ILPS, typically includes the following signal conditioning components and connections:
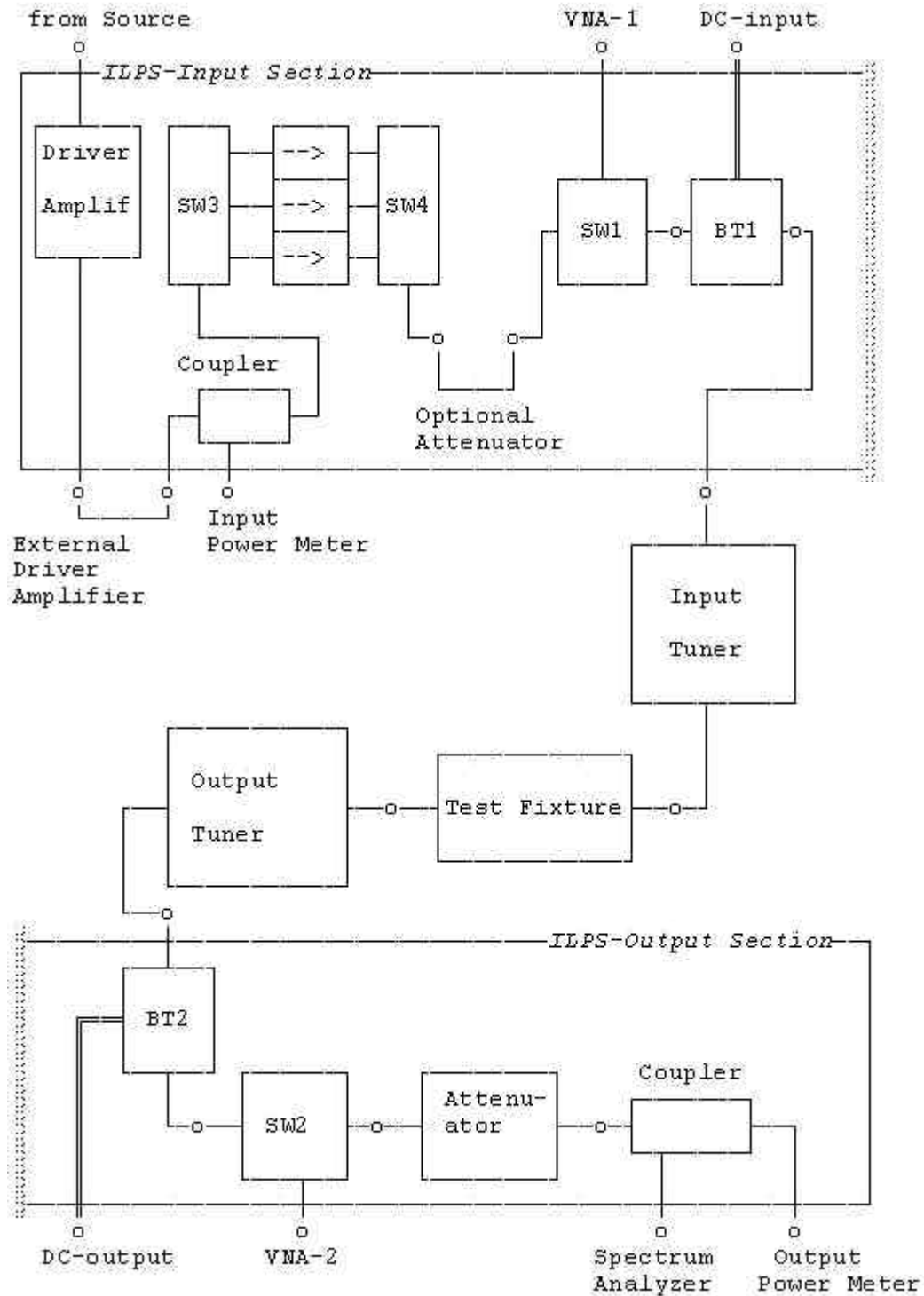
1. Input driver amplifier (User defined linearity, power level and frequency range),
2. Access to additional, User provided, input driver amplifier, for temporarily required higher power levels,
3.   Input directional coupler, to be connected to power meter,
4. Connection to input power meter,
5. Switch matrix with a set of input isolators, for instantaneous coverage of wide frequency ranges,
6. Optional "in series" input attenuator for suppressing parasitic oscillations,
7. Remote SPDT switch connected to input port of network analyser for "in-situ" calibrations,
8. Input bias tee, as required by DUT and power level,
9. Connection to input tuner, to be mounted close to DUT,
10. Connection from the output tuner into an output bias tee as required by DUT and power level,
11. Remote SPDT switch connected to output port of network analyser for "in- situ" calibrations,
12. Output attenuator,
13. Output directional coupler,
14. Connection to output power meter,
15. Connection to spectrum analyser for IMD, ACP and ICPT measurements.

ILPS employs a parallel type digital link to the system PC which allows to remotely control the positions of the calibration switches (SW1 and SW2 in figure 2) and the settings of the isolator array (switches SW3 and SW4).
The control of the calibration and isolator settings is fully taken care of by the calibration and measurement software.

Figure 2 shows a block diagram of the typical basic ILPS.
The internal design of the ILPS is such as to minimise the length of the interconnections at the input side of the setup, since any loss in this area must be overcompensated by additional gain and RF power of the driver amplifiers. Attenuation can be added on the input and output power meter ports to match with the sensitivity of the power detectors. The software is programmed to switch the RF power off when the switches SW1 to SW4 are activated (cold switching) in order to lengthen their lifetime. System calibration data will allow to measure also DUT S-parameters "in-situ" with both tuners set to zero. The optional input attenuator will be required only if "out-of-band" reflections of the isolators create parasitic oscillations with the transistors to be tested. It has to be as low as possible (3dB) and be able to handle about 3dB more power than required for the DUT input at saturation level. This is required in order to account for the input tuner loss at high VSWR.

from Source   VNA-1   DC-input

ILPS-Input Section

Driver
Amplif   SW3   -->   SW4   SW1 --o-- BT1 -o

           Coupler

                    Optional
                    Attenuator

External   Input
Driver   Power Meter
Amplifier

                                        Input
                                        Tuner

        Output   Test Fixture
        Tuner

                    ILPS-Output Section

    BT2

                    Coupler

        SW2   Attenu-
               ator

DC-output   VNA-2   Spectrum   Output
                             Analyzer   Power Meter

Calibration Procedure

One of the main reasons for using an ILPS configuration is to be able to calibrate all components of the setup, that may need recalibration, "in-situ", i.e. without disconnecting manually any components. Such components may include the tuners, for various frequencies and calibration parameters, or the test fixtures, for changing probes or test fixture substrates etc. This is possible by using the remote switches SW1 and SW2 (figure 2) and appropriate calibration techniques, which are tailored to this setup and include TRL (Through-Reflect-Line) and 3T (three Termination) techniques.

The complete calibration procedure is as follows:

1. Calibrate the network analyser on a coaxial reference plane using cables which allow to connect at different ports of ILPS, such as D, D1, D2, C2, and E as well as VNA-1, VNA-2. It is strongly recommended to use a coaxial TRL calibration kit for this operation.
2. Measure the S-parameters of the input section of the setup between ports D and D1 for all possible settings of the switches SW3 and SW4 and the switch SW1 in setup-thru position. The data are to be saved in S2P ascii files.
3. Measure the S-parameters of the output section of the setup between ports D2 and E and between ports D2 and C2 and the switch SW2 in setup-through position. The data are to be saved in S2P ascii files and the difference in transmission S21 is to be saved as Output Coupling Factor.
4. Connect the Tuners and the Test Fixture.
5. Use "in-fixture" or "on-wafer" TRL standards to calibrate the section between ports D1 and D2, with both tuners at zero position (=Through Line).
6. Use "in-situ" calibration software to calibrate both tuners, from DUT reference point of view.
7. Use CCMT setup software to retrieve data from S2P files and save in .STP binary calibration format.
8. The input driver amplifier can also be measured, and its gain can be saved in a parameter file, which is used to compute the maximum signal source power in order to avoid overloading or damaging the DUT.
9. Alternatively to using TRL standards in the fixture or the wafer, coaxial standards can be used between ports F1 and F2 (connect both tuners) and then the tuners can be calibrated connected back-to-back. This approach gives more flexibility into using the same tuner calibrations with more than one test fixture or pair of probes, which can be calibrated in a conventional way using the CCMT built-in TRL calibration routine.

In general the CCMT tuner and setup calibration software and the generic TRL routines offer more than one possibilities to calibrate the ILPS unit both "in-situ" and for various test-fixture arrangements, without having to re-calibrate the whole lot.