

# Automated station saves time in DPI measurements on ICs

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*Industries producing and using ICs need to know how they behave under radiated electromagnetic emissions. Manual measurements according to the Direct RF Power Injection method (DPI) are however extremely time-consuming. This article describes automated measuring technology.*

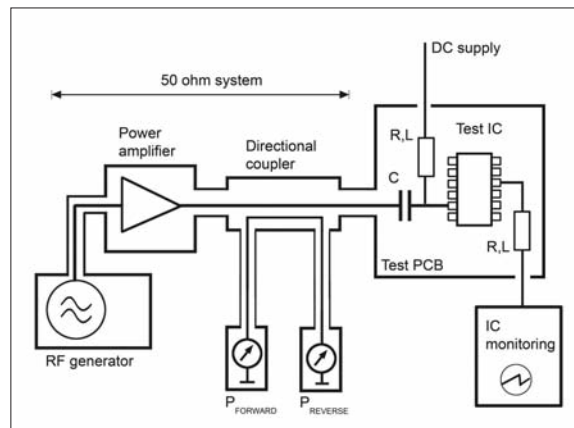


Figure 1. DPI method according to IEC62132-4

■ Measuring ICs according to the DPI (Direct RF Power Injection) method provides information on their behaviour under the influence of radiated electromagnetic emissions. Industries that produce and use ICs need comprehensive knowledge about this disturbance behaviour, to guarantee the function of an individual circuit or the entire electronics under the influence of RF disturbances. Measurements according to the DPI method, however, are extremely time-consuming. Automated and flexibly adaptable measuring stations are thus required.

The DPI method according to standard IEC 62132-4 defines the measuring procedure for the direct injection of conducted disturbances into a semiconductor pin. This disturbance injection simulates the share of a disturbance which is caused by field coupling into a cable harness or an antenna-like structure on the PCB. The DPI method is designed to inject RF current into IC pins according to a predefined measurement set-up. The power and frequency of this RF current are increased gradually. The measured result is the maximum RF power that can be injected into the pin as a function of frequency. The expectations for the results of an IC measurement have changed since the publication of the standard in 10/2006. A pin's compatible RF power is not the only IC information that is important. Infor-

mation on the maximum input RF voltage or on the IC pin's impedance is also crucial for IC manufacturers and users. An automated sequence reduces the duration of the measuring procedure and its susceptibility to errors. The DPI method will be briefly introduced and then further developed to an automated measuring station in the following.

The set-up principle for measuring the disturbance immunity according to the DPI method is shown in figure 1. The RF generator generates a sine-wave alternating voltage (RF signal). The power amplifier increases the power of the RF signal. This power is measured by the directional coupler and injected into an IC pin via a decoupling capacitor C. The capacitor C prevents useful signals from entering the power amplifier. The filters (resistance R / inductivity L) prevent RF current from leaking to control and supply lines. The IC is monitored for malfunctions by an appropriate device. The frequency and power of the disturbance threshold as well as the respective abort condition are recorded if a malfunction occurs. The measuring sequence on an IC pin is shown as a flow chart in figure 2. During a manual measurement, each IC pin is examined individually according to the flow chart. The measuring time depends on the number of frequency and power steps and takes several days. In the course of this procedure errors slip in as a rule.

An automated run of the flow chart (figure 2) overcomes these drawbacks. The automated measuring station controls the entire sequence according to the DPI method. This also includes the storage, evaluation and visualisation of the

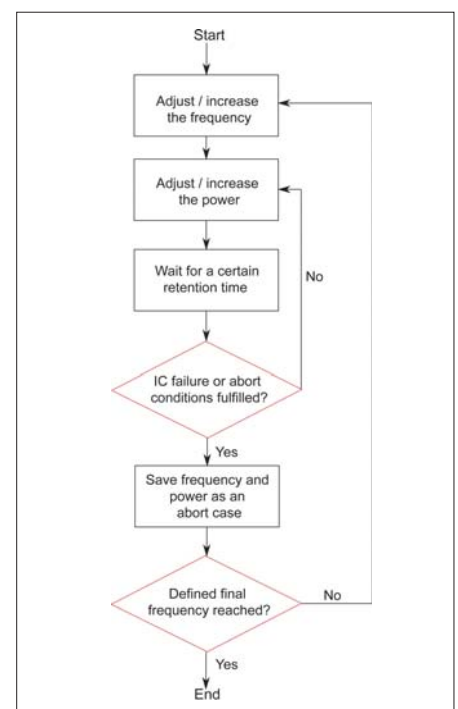


Figure 2. Flow chart for the DPI method as a basis for an algorithm

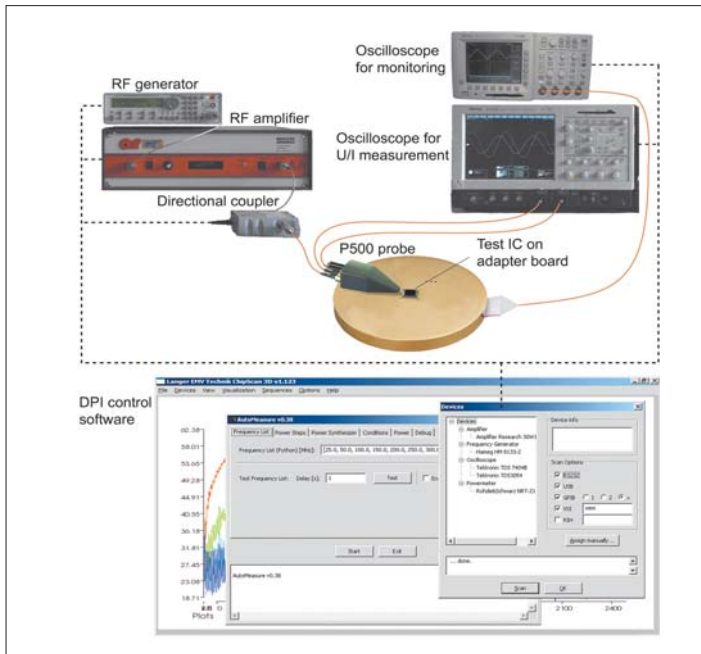


Figure 3. Automated measuring station with DPI control software

measured results. The measuring station (figure 1) described in the standard is supplemented by the following devices: a PC with DPI control software, a P500 probe as a RF ampere and voltmeter on the IC pin, and an oscilloscope for the visualisation of the measured current and voltage characteristics. The probe and oscilloscope measure the time characteristics of current and voltage. The DPI control software stores these time characteristics. The effective current and voltage values as well as the phase angle are determined in the oscilloscope. The DPI control software can calculate other electric parameters such as the impedance of the test IC, forward power of the injected RF signal, generator voltage etc, on the basis of these values. All measurement steps are stored in a SQL database and as an Excel file during the automated measurement sequence.

The measured results are evaluated using the database or MS Excel. The desired measured results can easily and quickly be visualised through an enquiry to the database. Measuring the time characteristics of the RF current and voltage provides a lot of additional information which is important for examinations in the course of development. Concrete statements about IC characteristics are possible. The current and voltage characteristics, for example, show when damping diodes release current paths to functional complexes and trigger error mechanisms. The information gained is important for both IC manufacturers and IC users. The IC manufacturer can use this information for IC development. IC users can derive EMC measures for circuit and layout design. Flexibility is another advantage of the automated measuring station. The software is eas-

ily expandable. The flow chart for the DPI control software can be adapted to individual needs. The retention time and frequency steps, for example, can be varied. More steps can be added to the sequence and the entire sequence can even be rearranged. Notification by e-mail, for example, can be added to the measuring sequence. Furthermore, various abort conditions are possible in the course of the measurement sequence. A wide variety of different IC faults that are recognized by monitoring can be used as an abort condition, such as: violation of the tolerance mask of signals, evaluation of digital information (restart, reading out of error registers), optical monitoring (via video camera and image processing), power supply monitoring, and results of an IC test software or firmware. There are also abort conditions not concerned with the proper functioning of the IC but intended to protect it, such as: reaching a maximum RF voltage on the IC pin (measured with the probe), reaching a maximum power on the IC pin (measured with the directional coupler or probe), and reaching a maximum IC temperature.

The measuring instruments can be changed to keep the measuring station flexible in terms of its hardware design. The software supports a multitude of measuring instruments. The measuring stations functionality is not bound to a special hardware. The measuring instruments are connected to the PC that hosts the DPI control software via standard interfaces such as USB, GPIB and Ethernet. The IC can easily be changed via an adapter board to adjust the measuring station to different measuring requirements (figure 4). The freely moving probe ensures the accessibility of each individual pin for injections. The time needed for a measuring sequence on an IC pin can be calculated by multiplying T, the adjusting time plus retention time plus evaluation time, by the number of power steps and by the number of frequency steps, as follows:

$$T = (\text{adjusting time for all devices} + \text{retention time} + \text{evaluation time})$$

- Number of power steps
- Number of frequency steps

Around 210 frequency steps are required for a measurement between 0.1 MHz and 1 GHz according to the recommendations of the DPI standard. The number of power steps has also to be taken into account, in this case assumed to be 40 steps based on reality. The time that is required for a measuring sequence on the pin was estimated as shown below:

Estimation of time per pin for a manual measurement:

$T = (10 \text{ sec adjusting time} + 3 \text{ sec retention time} + 10 \text{ sec evaluation time})$

- 40 power steps
- 210 frequency steps
- ≈ 54 h (7 working days) / pin

Estimation of time per pin for an automated measurement:

- 40 power steps
- 210 frequency steps
- ≈ 16 h / pin

The automated measurement reduces the time needed for a measurement by 70%. This time can be further reduced if the power steps are not executed on the basis of a fixed list but chosen intelligently. The DPI control software provides two additional methods:

- 1) The power at which the IC failed in the previous step minus X dBm is chosen at a new frequency;
- 2) A rough and a fine power run are organised one after the other. This considerably reduces the number of power steps. The time of a measurement run decreases in proportion to the number of power steps.

The automated measuring station in figure 4 has been proven and tested on many test ICs. The disturbance immunity of a LIN ICs is chosen as an example here. The measurement was taken using the following parameters: RF injection into the LIN pin via  $C = 4.7 \text{ nF}$ , fixed list for setting the frequency generator was in frequency steps [MHz]: [25, 50, 100, 150, 200, 250, ..., 950, 1000.0] (21 steps) and level steps (power of the RF generator) [dBm]: [-28, -27.5, -27, ..., -18.5, -18] (21 steps), Retention time was 3 sec, and during fault triggering the tolerance tube over signal RxD at: timing of  $< 7.5 \mu\text{s}$  and amplitude of  $< 0.9 \text{ V}$  was measured.

The PDirectional coupler power was measured by the directional coupler. The PProbe power was calculated on the basis of the time characteristics of current and voltage. This automated measurement run theoretically takes 51 min. But in practice the measuring run took no more than 21 minutes since not all power steps were carried out at each frequency. ■