SAE International

SURFACE VEHICLE RECOMMENDED PRACTICE

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Measurement of Radiated Emissions from Integrated Circuits— Surface Scan Method (Loop Probe Method) 10 MHz to 3 GHz

RATIONALE

The technical revisions to this standard include updated recommendations for probe design.

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1. SCOPE

This SAE Recommended Practice defines a method for evaluating the near field electric or magnetic component of the electromagnetic field at the surface of an integrated circuit (IC). This technique is capable of providing a detailed pattern of the RF sources internal to the IC. The resolution of the pattern is determined by the characteristics of the probes used and the precision of the mechanical probe positioner. The method is usable over the 10 MHz to 3 GHz frequency range with existing probe technology. The probe is mechanically scanned according to a programmed pattern in a plane parallel or perpendicular to the IC surface and the data is computer processed to provide a color-enhanced representation of field strength at the scan frequency. This procedure is applicable to measurements from an IC mounted on any circuit board that is accessible to the scan probe. For comparisons, the standardized test board shall be used. This diagnostic procedure is intended for IC architectural analysis including functional floor plan and power distribution.

1.1 Measurement Philosophy

The electric and magnetic field scan over the surface of the IC yields information on the relative strength of sources within the IC package. This provides for comparisons between different architectures to facilitate reductions in RF emissions from the IC. The electric and magnetic field pattern over the surface of the IC is related to the electromagnetic radiation potential of the IC and of the electronic module of which it is a part. However, this procedure is intended to provide a comparative measure for ICs and not to predict far field levels for the IC or its circuit board.

2. REFERENCES

General information supporting this document is available in SAE J1752-1.

2.1 Applicable Publication

The following publication forms a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

2.1.1 SAE Publication

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

SAE J1752-1 Electromagnetic Compatibility Measurement Procedures for Integrated Circuits—Integrated Circuit EMC Measurement Procedures—General and Definitions

2.2 Related Publications

The following publications are provided for information purposes only and are not a required part of this SAE Technical Report.

2.2.1 IEEE Publications

Available from IEEE, 445 Hoes Lane, Piscataway, NJ 08854-4141, Tel: 732-981-0060, www.ieee.org.

Slattery K. P., Cui, W., "Measuring the Electric and Magnetic Near Fields in VLSI Devices", 1999 IEEE International Symposium on Electromagnetic Compatibility

Goulette R. R., Ottawa, Ontario, Canada, "The Measurement of Radiated Emissions from Integrated Circuits," 1992 IEEE International EMC Symposium Record, August 1992, pp 340-345

Iskra S. and MacFarlane I. P., "H-Field Sensor Measurement Errors in the Near-Field of a Magnetic Dipole Source," IEEE Transactions on Electromagnetic Compatibility, Vol. 31, No. 3, August 1989

3. DEFINITIONS

See SAE J1752-1.

4. TEST CONDITIONS

4.1 Supply Voltage

The supply voltage shall be as specified by the IC manufacturer. If other values are agreed to by the users of this procedure, they shall be documented in the test report.

4.2 Frequency Range

The frequency range of this radiated emissions procedure is 10 MHz to 3 GHz. This frequency range is directly related to the characteristics of the E-field and H-field probes used.

5. TEST EQUIPMENT

5.1 Shielding

The use of double shielded or semi-rigid coaxial cable is required. Depending on the local ambient conditions, operation in a shielded enclosure may be required.

5.2 RF Measuring Instrument

The spectrum analyzer or receiver resolution bandwidth is 9 or 10 kHz. For spectrum analyzer, sweep is to be in calibrated (coupled) mode (auto sweep). The instrument is to be set up for peak reading and max hold with measurements in dBµV [for 50 Ω system: (dBµV = dBm +107 dB].

5.3 Preamplifier

Typically, a 20 to 30 dB gain, low noise preamplifier is required.

5.4 Near Field Probes (E and H Field)

For H-field measurements, a single turn micro sized magnetic loop probe, either stand alone or generated as a PCB trace, is used. For E-field measurements, a micro sized electric field probe that is usually partially shielded, is used. These probes are typically fabricated from 0.034 to 0.047 in semi-rigid coaxial cable with as a loop as small as practical between the center conductor and shield. Commercially made probes are also available. See Figure 1.

5.5 Probe Scanning System and Data Acquisition

Typically, a computer with software adapted to provide the desired scan parameters controls the precision stepper motors used for highly accurate placement of the electric and magnetic field probes, see Figures 2 and 3. With this system minimum spatial resolution across an IC under test is on the order of 100 to 150 µm depending on positioning step size. The minimum probe height above the IC surface is 100 to 200 µm. The minimum scan step size is 25 to 50 µm, 80 µm is a typical value over a die and 300 µm is typical over an IC package. This procedure may be adapted for use with other positioning systems if this level of resolution is not required. A typical scan may accumulate 10 000 data points across a scanned area of approximately 35 mm^2. Characterizing an IC involves a series of spatial scans, typically at harmonics of the clock frequency. The scan software controls the stepper motors and acquires the data. Dwell times are typically of the order of 30 ms and the data is acquired in maximum hold.

6. TEST SET-UP

6.1 System Calibration

All test equipment requiring calibration shall be calibrated on a regular basis. The magnetic field probe may be calibrated so that the measured voltage can be converted to magnetic dipole moment or magnetic field intensity.

6.2 Circuit Board Under Test

The test circuit board, which may be the universal IC test board, or any other circuit board, shall be fixed in location on a ground plane to facilitate test repeatability. This may be accomplished by the use of a non-conductive locking fixture or careful marking and placing of the board under test during test set-up.

6.3 Scan Software Set-up

After the IC and its circuit board have been set-up, verify that the scan software is set-up for the desired scan parameters and checkout the scan limits relative to the package of the IC under test.

7. TEST PROCEDURE

7.1 Ambient

Measure ambient levels to assure that any ambient signals present are at least 6 dB below the target measurement level or are easily identifiable and consistent ambient signals which will not present a problem in later testing. This is accomplished by placing the probe in the measurement position on the IC, with no power to the IC. If the ambient is excessive check the integrity of the overall system, especially the interconnecting cables and connectors. If necessary, use a shielded enclosure, a lower noise preamplifier or a narrower spectrum analyzer resolution bandwidth.

7.2 Operational Check

Energize the circuit board under test and complete an operational check to assure proper function of the IC (i.e., run IC test code).

7.3 Scanning Technique

The electric (non polarized) or magnetic field probe shall be scanned over the surface of the IC using scan software to control the stepping of the probe to provide a repeatable pattern. For the magnetic field probe two series of data are taken; first the IC is scanned with the probe loop oriented along one axis of the device then it is scanned with the probe loop rotated 90 degrees about its axis perpendicular to the IC surface. These two sets of data are then combined. Data from these electric and magnetic field probe scans is captured and processed to evaluate the near E or H-field environment over the IC package. Scans can be in a parallel or perpendicular plane to the IC surface or in a series of planes to form a three-dimensional mapping. This mapping is typically repeated at multiple frequencies to evaluate the effect of frequency on the internal source pattern of the IC.

8. DATA PRESENTATION

Data shall be presented as a matrix of frequency, spatial position and corresponding measured amplitude and/or as a plot of this matrix.

8.1 Documentation

The test report supporting testing to this procedure shall include information on the IC under test, frequency of scan, definition of scanned area, scan height, scan step size, description of probe and probe orientation. This information is useful in interpreting the data and in facilitating comparisons.

8.2 Scan Data Analysis

The scan arrays that arise from these measurements contain a lot of data. Typically, this scan data is processed and color enhanced to facilitate display of the measured fields. Data processing may include taking the linear mean of each array and mean normalizing to eliminate the bias due to probe response as a function of frequency. Using the probes described in this procedure, detail in the 100 to 150 µm range can be resolved. This technique allows investigation of internal IC current flow and magnetic coupling as well as electric charge distribution and capacitive coupling to adjacent metal structures. This information provides for comparisons between different IC architectures and packaging to facilitate reductions in RF emissions from the IC. A description of any data processing used shall be a part of the test report. See Appendix A for data processing examples.

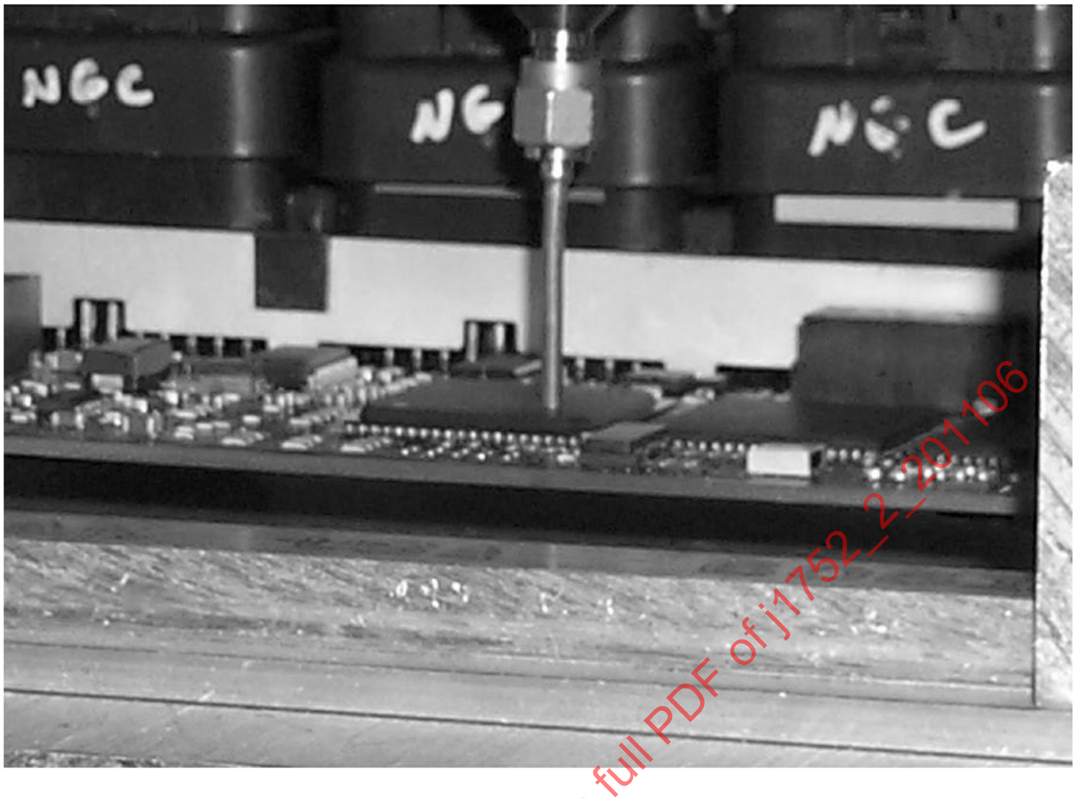

FIGURE 1 - CLOSE UP OF SCAN PROBE OVER IC

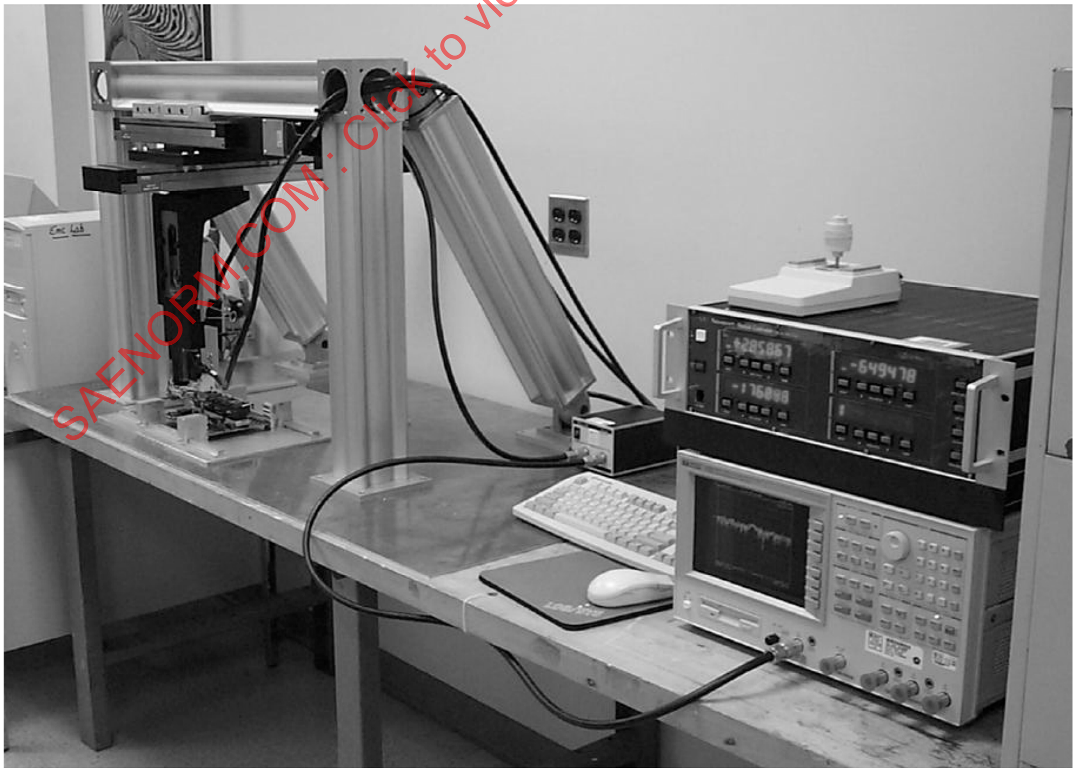

FIGURE 2 - SURFACE SCAN SET- UP AND INSTRUMENTATION

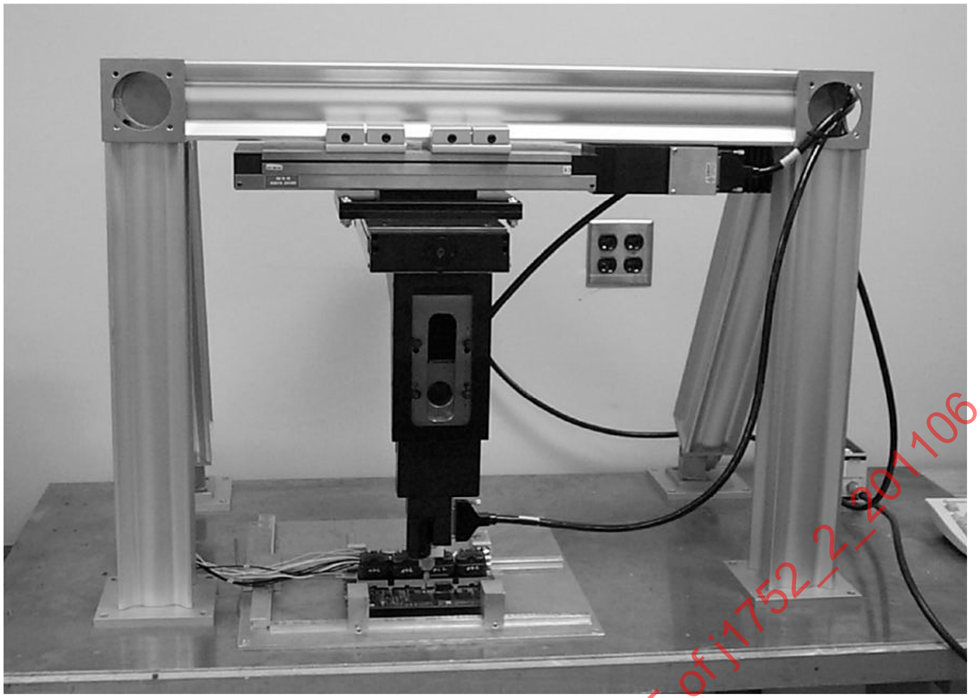

FIGURE 3 - X, Y AND Z POSITIONER

9. NOTES

9.1 Marginal Indicia

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