aixACCT
advanced customized characterization technologies

TF 2000

TF Analyzer 2000 Measurement System

The TF Analyzer 2000 is the most sophisticated analyzer of electroceramic material and devices. The test equipment is based on a modular idea, where four different probe heads can be connected to one and the same basic unit. Each of the four probe heads represents a different characterization method.

- Ferroelectric standard testing → **FE module**
- Fast pulse switching tests → **PS module**
- Relaxation current measurement → **RX module**
- Self discharge testing → **DR module**

By simply changing the module (probe head) you switch to a different test method.
The system can operate with different external equipment, such as oscilloscopes, temperature units, probing stations, high voltage amplifiers, laser interferometers etc. Communication via serial interface, IEEE interface, or Ethernet is supported.

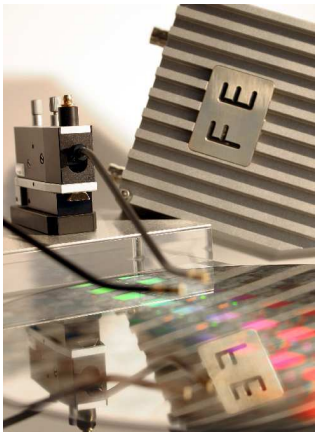
Features

→ **FE module**
The FE module is available in different performance levels.
The *standard* configuration offers a frequency range from 1 mHz to 1 kHz.
The *enhanced* configuration offers a frequency range up to 250 kHz.
Since 2005 a new version up to 1 MHz hysteresis frequency has been available for high speed applications.

The ferroelectric test module TF Analyzer 2000 FE is designed to make various measurements on ferroelectric materials to determine its main electronic characteristics.

Standard features of the FE-Module are:

- Hysteresis measurement
- PUND measurement
- Fatigue measurement
- Retention measurement
- Static hysteresis measurement
- Imprint measurement
- Leakage current measurement



and optional

- C(V) measurement
- Piezo measurement

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- Pyroelectric measurement
- Impedance measurement

As further options, which are essentially for testing ultra thin films and for ultra small capacitors, aixACCT offers as unique features of the TF Analyzer 2000 series:

→ **In-situ Compensation**, and

→ **Dynamic Leakage Current Compensation** (see below)

→ PS module

Investigation of the ferroelectric switching kinetics: pulse generation down to 50 ns pulse width and 1.2 ns rise time.

The pulse switching module - TF Analyzer 2000 PS is designed to measure the switching velocity of the ferroelectric polarization.

The system gives information on the current response in the 'switching' and the 'non-switching' case of the material. The user is able to investigate the difference of the polarization point which is reached in the switching case using the fast pulse switching module of the TF Analyzer 2000 and the point known from the hysteresis curve recorded with low frequency excitation.

The PS module includes a high precision analog output board, an external probe head containing the ultra fast switching unit, and the digital time base.

The system offers the test environment for ferroelectric materials close to real world application like FeRAM. The rise time of the pulses are in the 1 ns regime at ohmic loads. The minimum pulse width amounts to 50 ns and repetition rates of 100 kHz are available.

→ RX module

The relaxation module TF Analyzer 2000 RX is designed to investigate polarization and depolarization currents of dielectric and ferroelectric materials. This module uses the voltage step method with a six decade current amplifier, which allows measurements without changing the amplification range. It is especially designed to investigate the relaxation behavior and the leakage current of integrated capacitors.

It includes a high precision analog output board, and an external probe head containing the ultra fast voltage-step generator and the high resolution current amplifier.

→ DR module

Investigation of the self discharge behavior of dielectric materials: voltage pulse method with a charge amplifier offering 30 fF input capacitance.

The DRAM module TF Analyzer 2000 DR is designed to measure the self-discharge behaviour of charged

integrated capacitors to test the suitability of the material for DRAM applications and to check the minimum pulse width of a write operation.

It includes a high precision analog output board, and an external probe head containing the ultra fast, high insulating switching unit and the electrometer amplifier. The module uses the voltage-pulse method.

→ In-situ compensation

With small pad sizes, starting from approximately 10 µm squared capacitors the influence of the parasitic capacitance becomes increasingly important. For sub micrometer dimensions the compensation is essentially in order to derive correct and precise results. The only way to measure these data correctly is with the aixACCT patented method of a compensation of the influence during the measurement. Using a numerical calculation to compensate this influence does not work, because the recording amplifier is already saturated by the contribution of the parasitic capacitor to the current response.

→ Dynamic Leakage Current Compensation

With ultra thin films the influence of leakage current becomes significant on the results of the hysteresis curve of the ferroelectric material. A compensation based on static leakage current measurements is not very accurate and is very time consuming. Therefore a method has been developed by aixACCT to eliminate the influence of the leakage current on the results of the hysteresis curve. Using hysteresis measurements, the influence of the leakage current can be eliminated and the remaining material property is received.

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Specifications

1. Computer hard- and software:

- Pentium III, IBM PC-compatible computer
- VGA graphical interface
- USB port
- CD / DVD writer
- 40 GB hard disk or larger
- 128 MB RAM
- Operating system Windows XP / 2000
- aixACCT's sophisticated and highly flexible ferroelectric test software
- Remote and script control (optional)

2. Measurement Modules

FE module

Driving unit:

- Voltage range ±25 V
  (optional external amplifier up to 10.000 V)
- Output impedance 10 Ω
- Maximum hysteresis excitation frequency (load dependent) < 1 MHz*
- Min. pulse width 25 µs
- Min. rise time 10 ns
- Slew rate (typical) > 200 V/µs
- Maximum capacitive load (freq. dependent) 1 µF
- Maximum output current ±1 A

Current amplifier:

- Voltage virtual ground input
- Current range 1 pA - 1 A
- High-voltage protection
- Rise time ranges:

	Standard	Enhanced*
10 pA	10 ms	10 ms
1 nA	900 µs	900 µs
1 µA	50 µs	300 µs
1 mA	5 µs	65 ns
1 A	3 µs	25 ns

* min. values, with probe head adapted to sample

Fatigue parameter:

- Maximum frequency (special amplifier) 20 MHz

Test conditions: amplitude: 6 V peak to peak
capacitive load: 10 pF

PS module

Driving unit:

- Max. amplitude 10 V
- Minimum rise time (at ohmic load) 1,2 ns
- Repetition rate 100 kHz
- Output resistance 70 Ω

Return:

- Shunt resistance 100 Ω

Additional requirements:
A fast digital sampling oscilloscope with two active probe heads.

Oscilloscope data:

- Analog bandwidth 1 GHz
- Max. sampling rate 5 GS/s
- IEEE interface

Sample specification:

- Input capacitance 0,8 pF
- Input resistance 1 MΩ

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RX module	DR module
Voltage-step generator: • Max. amplitude ±10 V • Rise times 100 ns • Output resistance < 5Ω *Current amplifier:* • Range 100 mA - 10 pA • Bandwidth (I > 50 µA) 300 kHz, (I > 1 mA) 500 kHz	*Voltage-pulse generator:* • Maximum amplitude ±10 V • Minimum pulse length 50 ns • Maximum pulse length 640 µs *Switching properties:* • Turn-on delay time < 2 ns • R_{on} < 50 Ω • R_{off} > 10^{13} Ω *High impedance electrometer:* • Input resistance 10^{13} Ω • Input capacitance 30 fF

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