Measurement of TMR (Tunnel Magneto Resistance Effect)

- Inelastic Electron Tunneling Spectroscopy (IETS Method) -

KEY WORDS
• Spintronics • Magnetic interface measurement • Tunnel junction • Modulation method

PRODUCTS

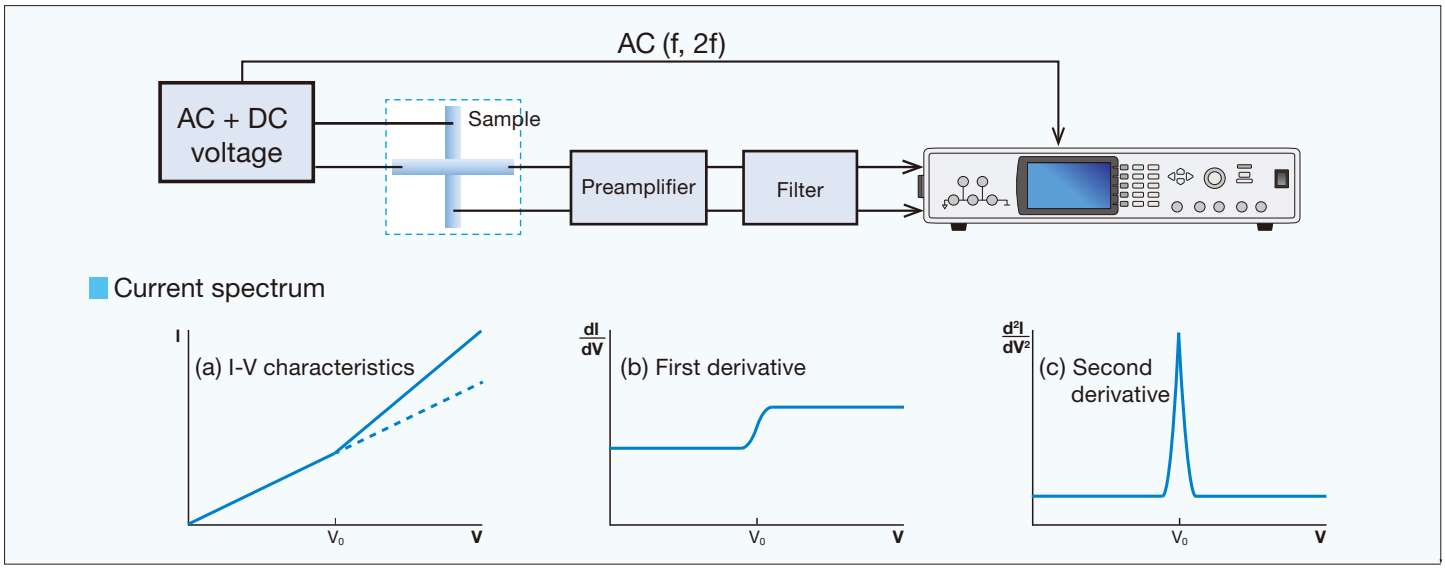
Lock-in Amplifier: LI5660 / LI5655 / LI5650 / LI5645

Inelastic Electron Tunneling Spectroscopy (IETS method) is to investigate the interface state of Ferromagnets and insulators.
This IETS method evaluates conduction characteristics in tunnel junction.
Generally, the Lock in amplifier output is a differential characteristic.
But NF Lock in Amplifiers (LI5660/5655/5650/5645) directly output the second derivative.
The IETS method uses this second derivative output.

If you use NF lock-in amplifier

- Second derivative output by "fractional harmonic measurement function"
- Highest measuring frequency: 11 MHz (LI5660)
- Maximum input voltage of 10 V (LI5660)

Measurement Example



NF Corporation
NF Techno Commerce Co., Ltd. / NF Techno Commerce Inc. (USA)

- Easy measurement of the characteristic change of the derivative of the current change (b) or the second derivative (c),rather than the I-V characteristic because its change is small.
- The sample structure is an insulator sandwiched between conductors.
- Measure voltage with lock-in amplifier applying voltage superimposed alternating current on direct current to the sample
- Use the frequency of the AC signal superimposed on the sample as the reference signal.
- The harmonic measurement function enable to measure twice the frequency of the reference signal using second derivative output.

Measuring Equipment

Digital Lock-in Amplifier LI5660 / LI5655 / LI5650

LI5660
Maximum measurement frequency 11 MHz
10 V input equipment

LI5660

- LI5660 0.5 Hz - 11 MHz HF input (10 kHz - 11 MHz), 10 V input (0.5 Hz - 3 MHz)
  LI5655 0.5 Hz - 3 MHz
  LI5650 1 mHz - 250 kHz
  LI5645 1 mHz - 250 kHz
- Fractional harmonic measurement
  Measured at frequencies (1 - 63) / (1 - 63) fractionally multiplied by the fundamental wave

Lineup

○: Equipped –: Not equipped

	LI5660	LI5655	LI5650	LI5645
Frequency range	0.5 Hz - 11 MHz	0.5 Hz - 3 MHz	1 mHz - 250 kHz	1 mHz - 250 kHz
Signal input	Voltage (A, A-B, C, HF), current	Voltage (A, A-B), current	Voltage (A, A-B), current	Voltage (A, A-B)
10 V input	○(C input terminal, 0.5 Hz - 3 MHz)	-	-	-
High frequency input	○(HF input terminal, 10 kHz - 11 MHz)	-	-	-
Sensitivity	A, A-B: 10 nV - 1V F.S (0.5 Hz - 3 MHz) C: 1 mV - 10 V F. S (0.5 Hz - 3 MHz) HF: 1 mV - 1 V F.S (10 kHz - 11 MHz) I: 10 fA - 1 μA F. S.	10 nV - 1 V F.S. 10 fA - 1 μA F. S.	10 nV - 1 V F.S. 10 fA - 1 μA F. S.	10 nV - 1 V F.S. -
Input conversion noise	4.5 nV / √Hz (reference value)	4.5 nV / √Hz (reference value)	4.5 nV / √Hz (reference value)	4.5 nV / √Hz (reference value)
PSD (phase detection)	Two phases / Two frequencies	Two phases / Two frequencies	Two phases / Two frequencies	Two phases / One frequency
Dynamic reserve	100 dB	100 dB	100 dB	100 dB
Time constant	1 μs - 50 ks	1 μs - 50 ks	5 μs - 50 ks	5 μs - 50 ks
Analog output maximum update rate	About 1.5 M samples / sec	About 1.5 M samples / sec	About 780 k samples / sec	About 780 k samples / sec
Fractional harmonic measurement	○(1 - 63) / (1 - 63) of the fundamental wave	○(1 - 63) / (1 - 63) of the fundamental wave	○(1 - 63) / (1 - 63) of the fundamental wave	○(1 - 63) / (1 - 63) of the fundamental wave
Simultaneous measurement of two frequencies	○	○	○	-
External 10 MHz synchronization	○	○	○	○
Measurement parameters	X, Y, R, θ, DC, NOISE	X, Y, R, θ, DC, NOISE	X, Y, R, θ, DC, NOISE	X, Y, R, θ, DC, NOISE
External control	USB, GPIB, RS-232, LAN	USB, GPIB, RS-232, LAN	USB, GPIB, RS-232, LAN	USB, GPIB, RS-232, LAN