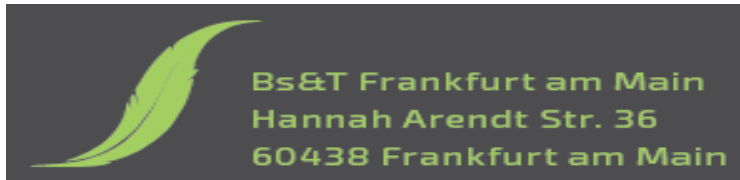
power loss under square wave excitation

JC Sun

San Antonio, 2018-03-03



Bs & T Analyzer

Sinus Magnetization AC

high excitation

IEC 62044-3

loss, μ_a driven by B mode

B_{peak}, loop driven by H mode

DC superposition

Pulse Magnetization

low excitation

IEC 62044-2

fast transit of magnetic state

dB/dt

BsT-Pro

loss map (f, B, T, H_{DC})

major, and biased minor loop

μ_{rev}

BsT-Pulse

differential and amplitude L

energetic L, power loss

PSMA 2016 Long Beach

PSMA 2017 Tampa

Bs & T Analyzer

Pulse Magnetization

fast transit of magnetic state

dB/dt

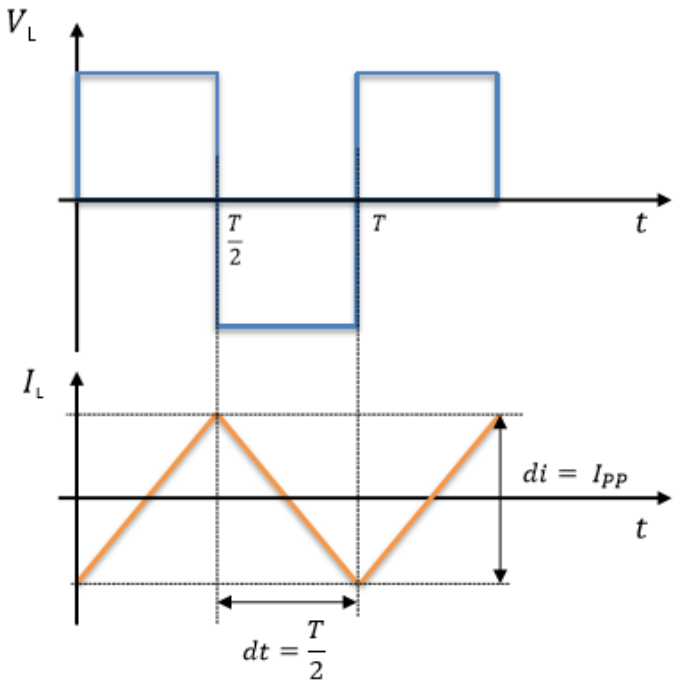
Single Pulse

BsT-Pulse

differential and amplitude L

energetic L, power loss

Square Wave



PSMA 2018 San Antonio

Outline 2018 pulse repetitive, square wave

- Discrepancy & Difficulty & Demand
- Driven by switching frequency
- Circuit
- Examples
- Conclusion
- Annex
  measuring data for simulation, loss map

Discrepancy

- Magnetic component almost driven by repetitive pulse, like square wave excitation
- But, magnetic material is typically specified under sinusoidal excitation, IEC 62044/3

- Electronic engineer need power loss with parameter as voltage and current in time domain
- Material manufacture provide power loss with parameter as frequency, flux density, IEC 62044/3

Difficulty

- Reasonable accuracy of AC power loss measurement is limited by switching frequency, approximately till 1 MHz
- Phase drift & off set error are fundamentally existent, no matter whether and how the data being processed (w/o FFT)
- Further investigation of system compensation methodology is needed, lack of high frequency linear reference

- Thermal equilibrium is hardly possible with ever increasing sw. frequency over MHz, power ferrite, as **semiconductor**, has typically resistivity of 0,1 Ωm @ 100°C & DC, and 1 inch ferrite toroid has temperature incease of 2 Kelvin under 1 MHz 100 mT for 1 second
- Consideration of nonlinearity of resistivity ?

Demand

- Power electronic design engineer for SiC/GaN needs

  power loss under repetitive pulse excitation,
  power loss parametrized by voltage, pulse width

  B = int U dt as [µVs] is different clowd of U [V] and t [µs]

  despite of all difficulty !

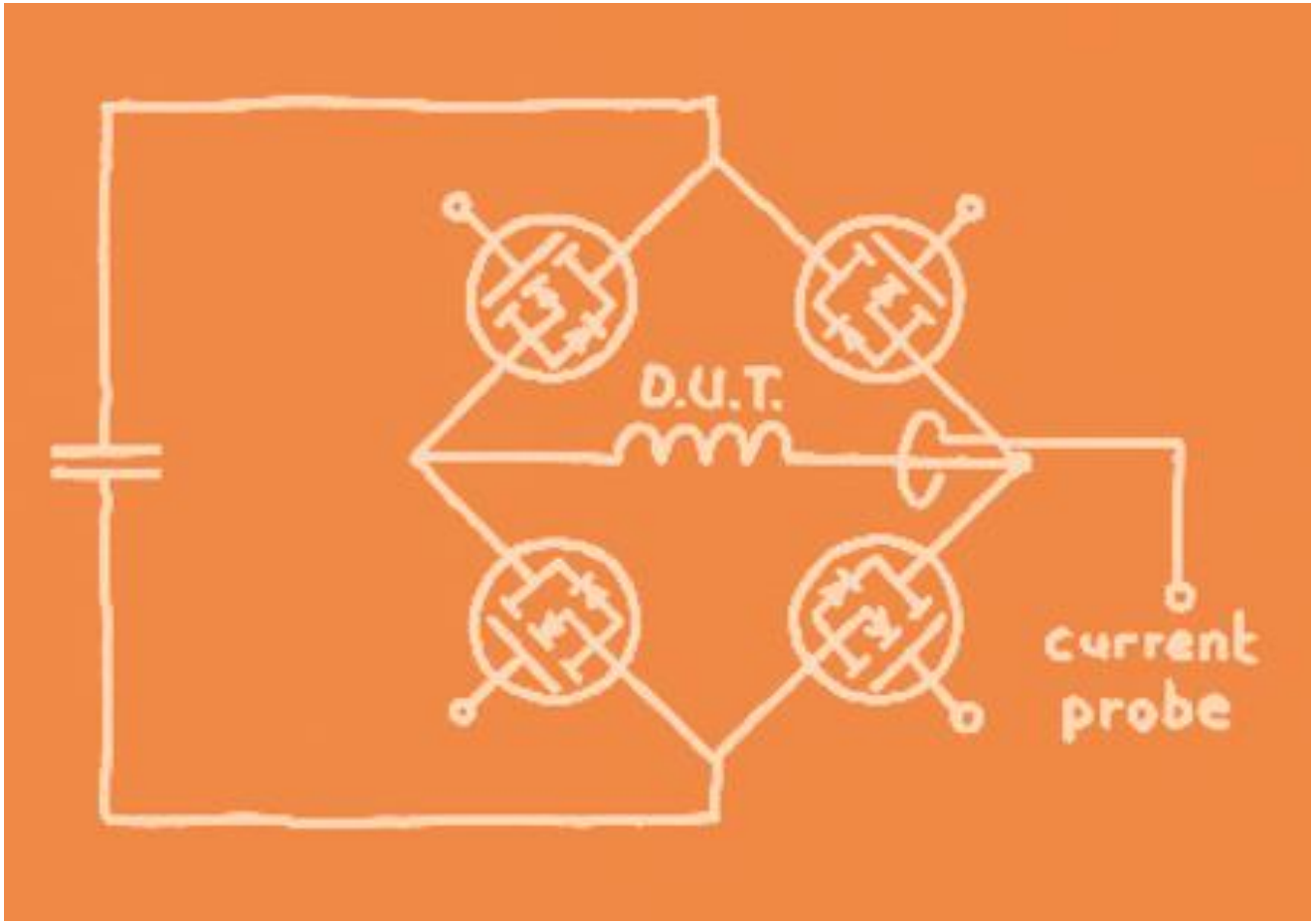
- Power loss of wire wound component above MHz under square wave excitation is possible

Solution with BsT-SQ

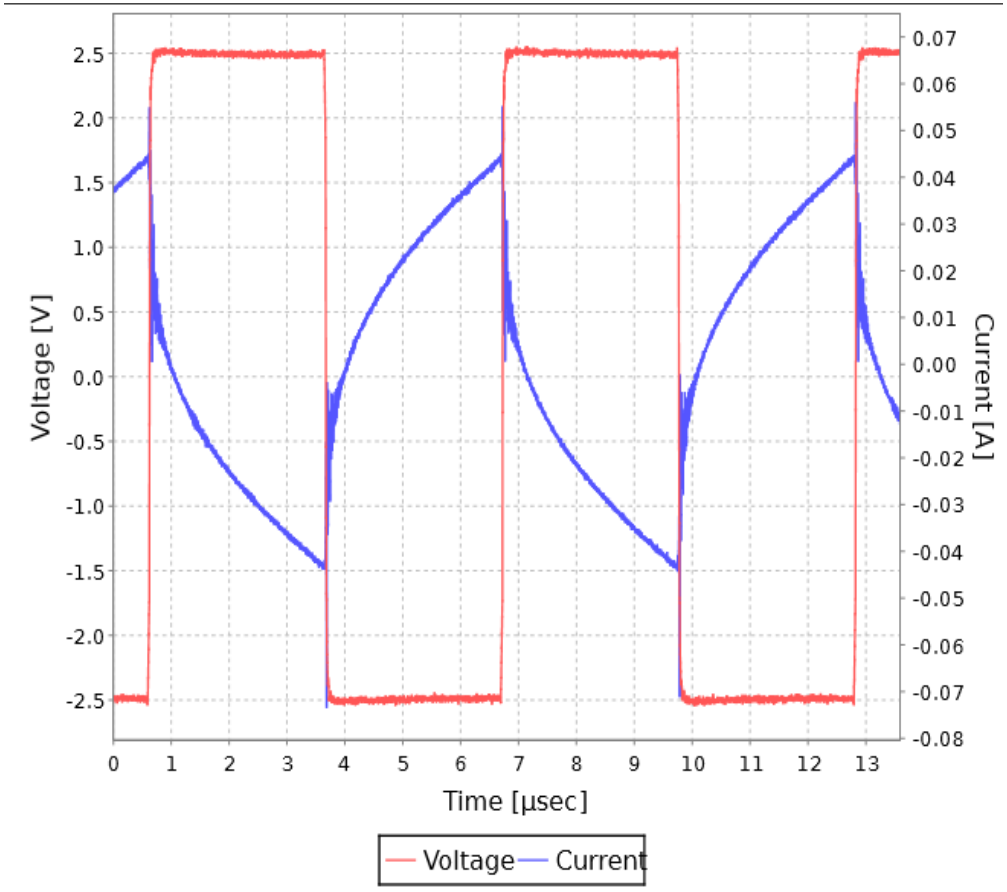
- BsT-SQ is designed to meet this challenge, with emphasize of loss output on consistency and convienence in operation
- BsT-SQ maps out the loss landscape under high frequency excitation, and provides the user friendly „Herbert“ curve
- BsT-SQ removes the material brand name and provides the maximal transparency among „high frequency“ materials and makes question unnecessary

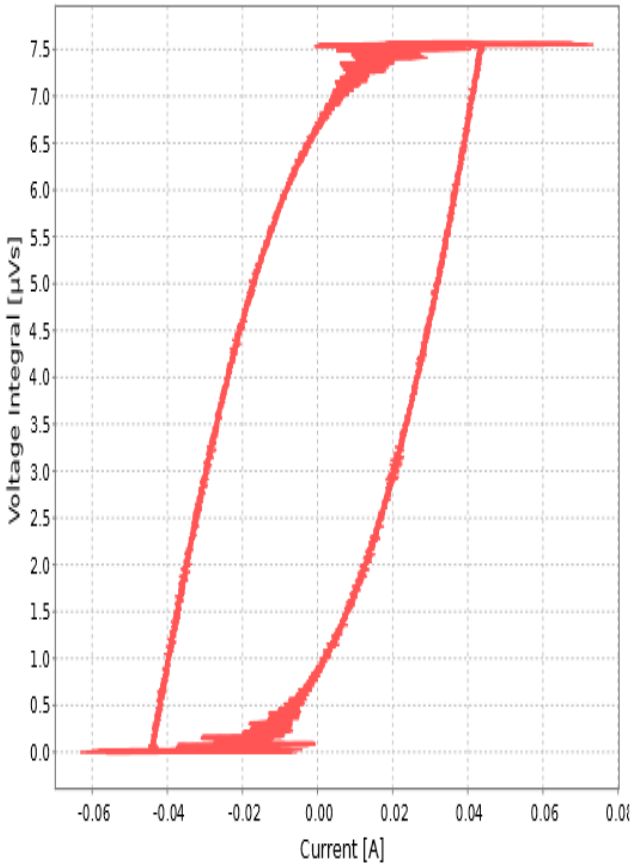
„do we need new HF material?“ or
„how do we optimize the existing materials?“

Circuit (with full bridge)

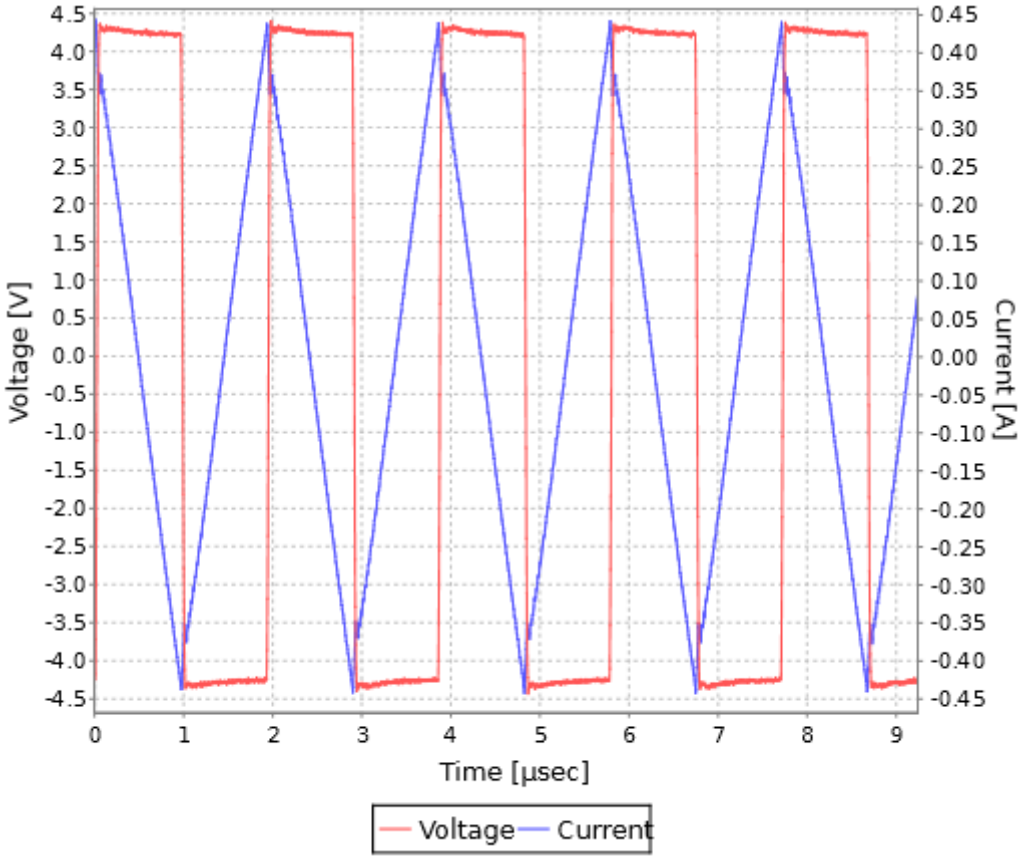


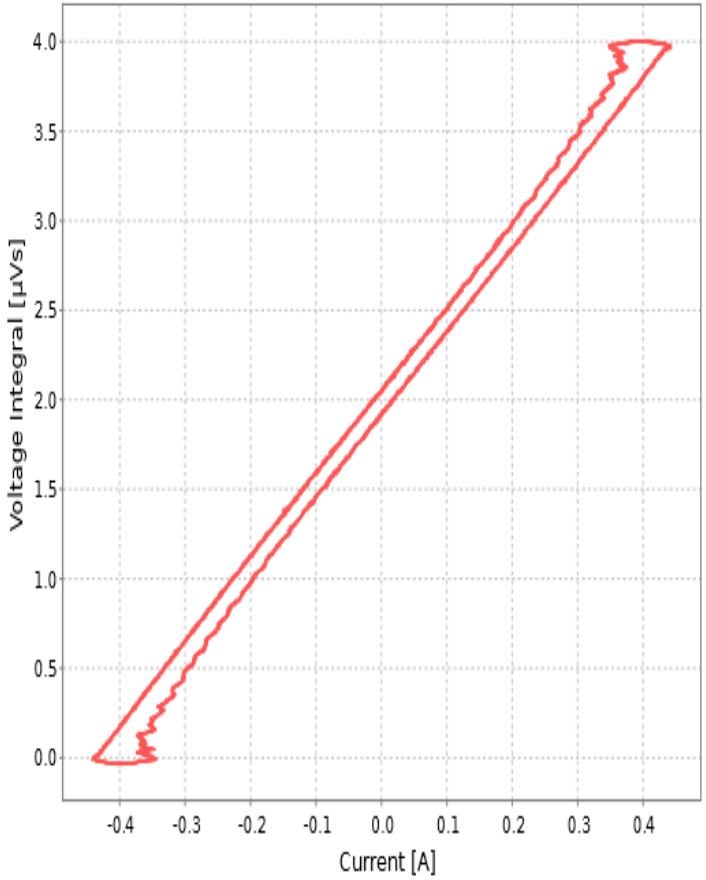
Typical cycle of measurement [1]





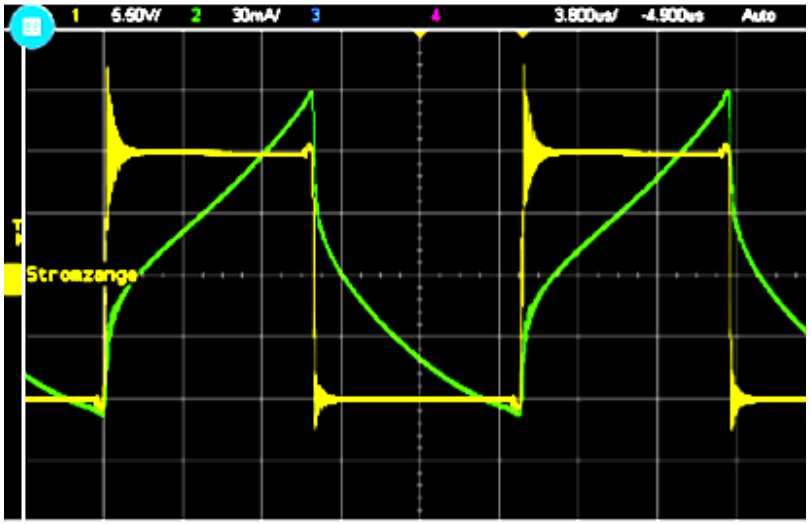
Typical cycle of measurement [2]



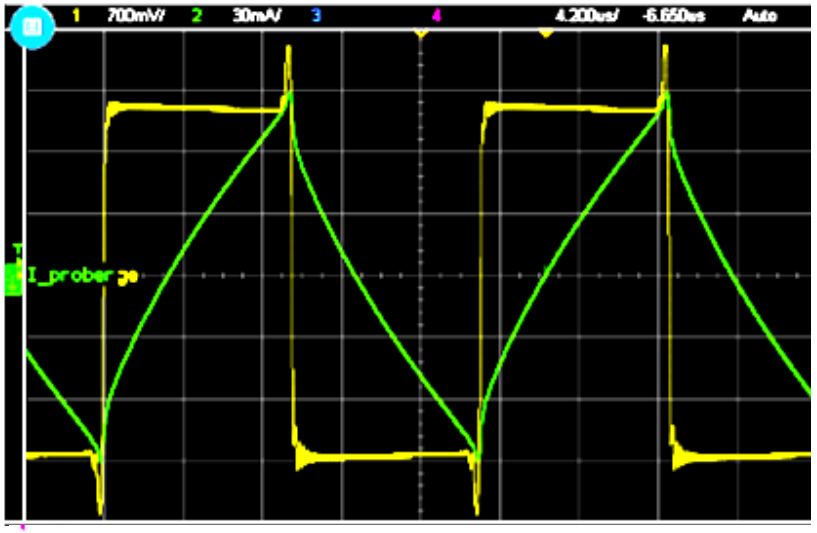


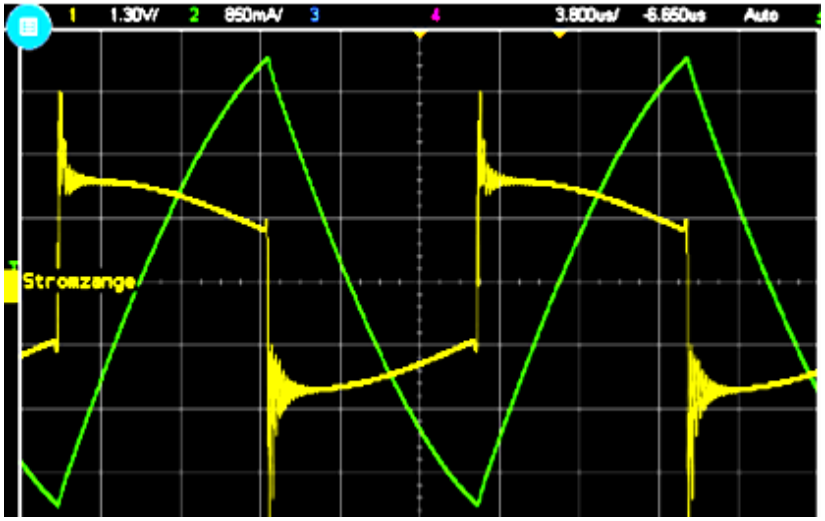
Diverse D.U.T.s

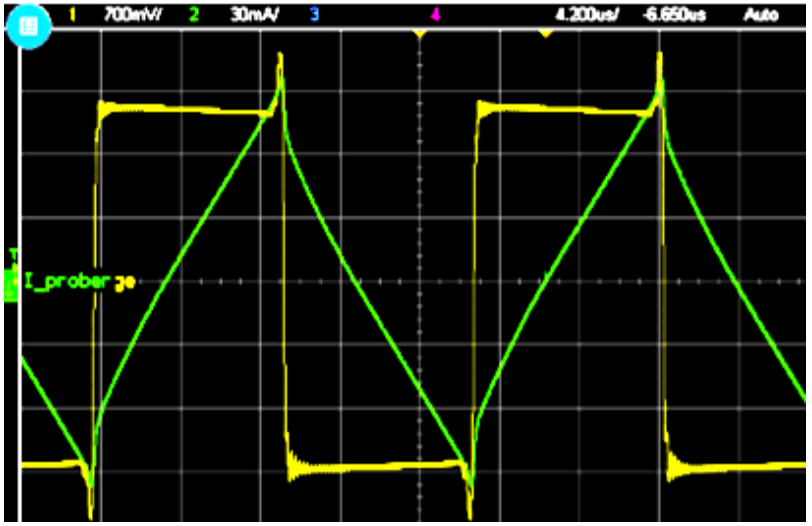
Power ferrite



Fe amorphous







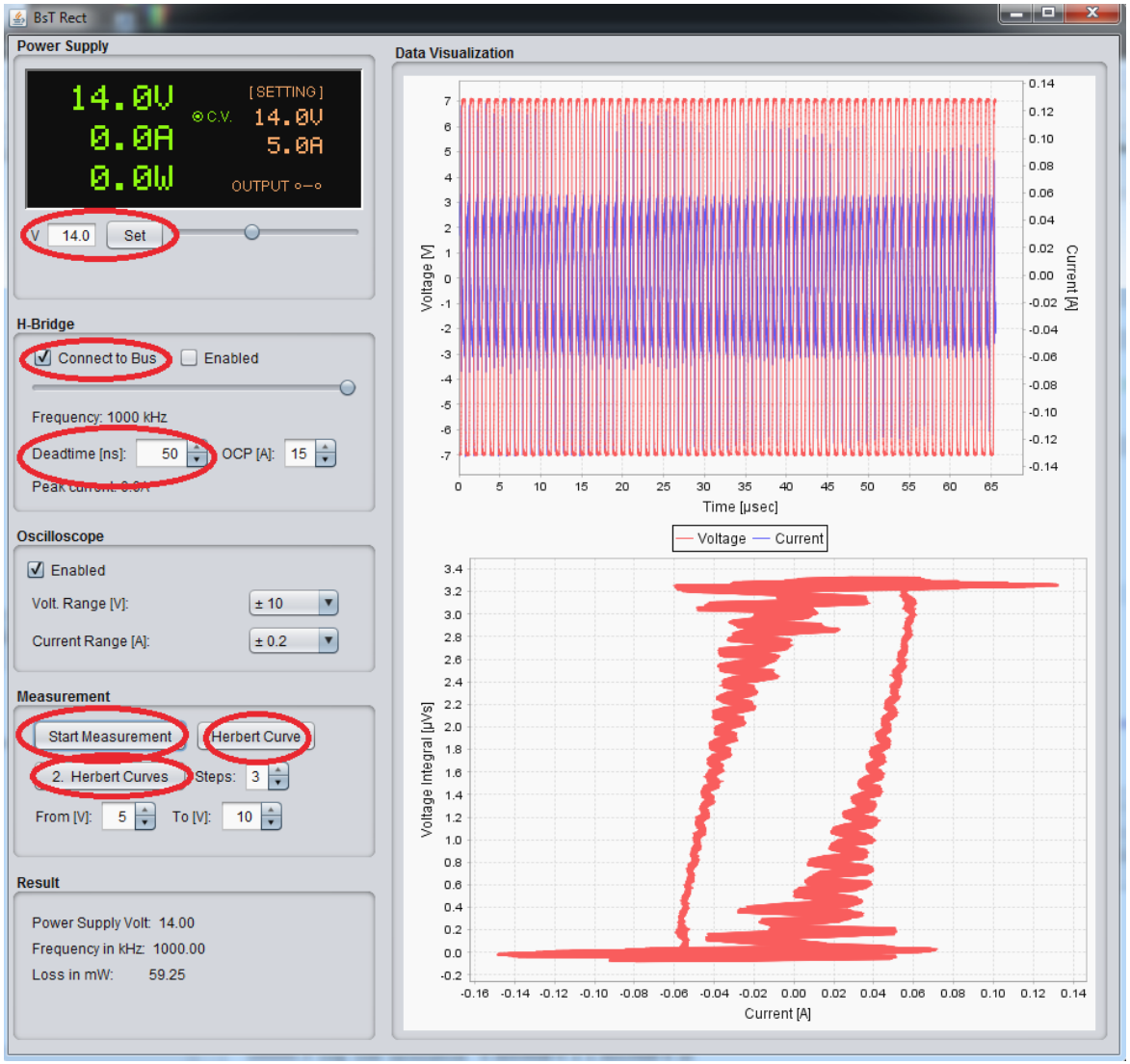
metal alloyed powder

“HF” ferrite

Output BsT-SQ

DC voltage

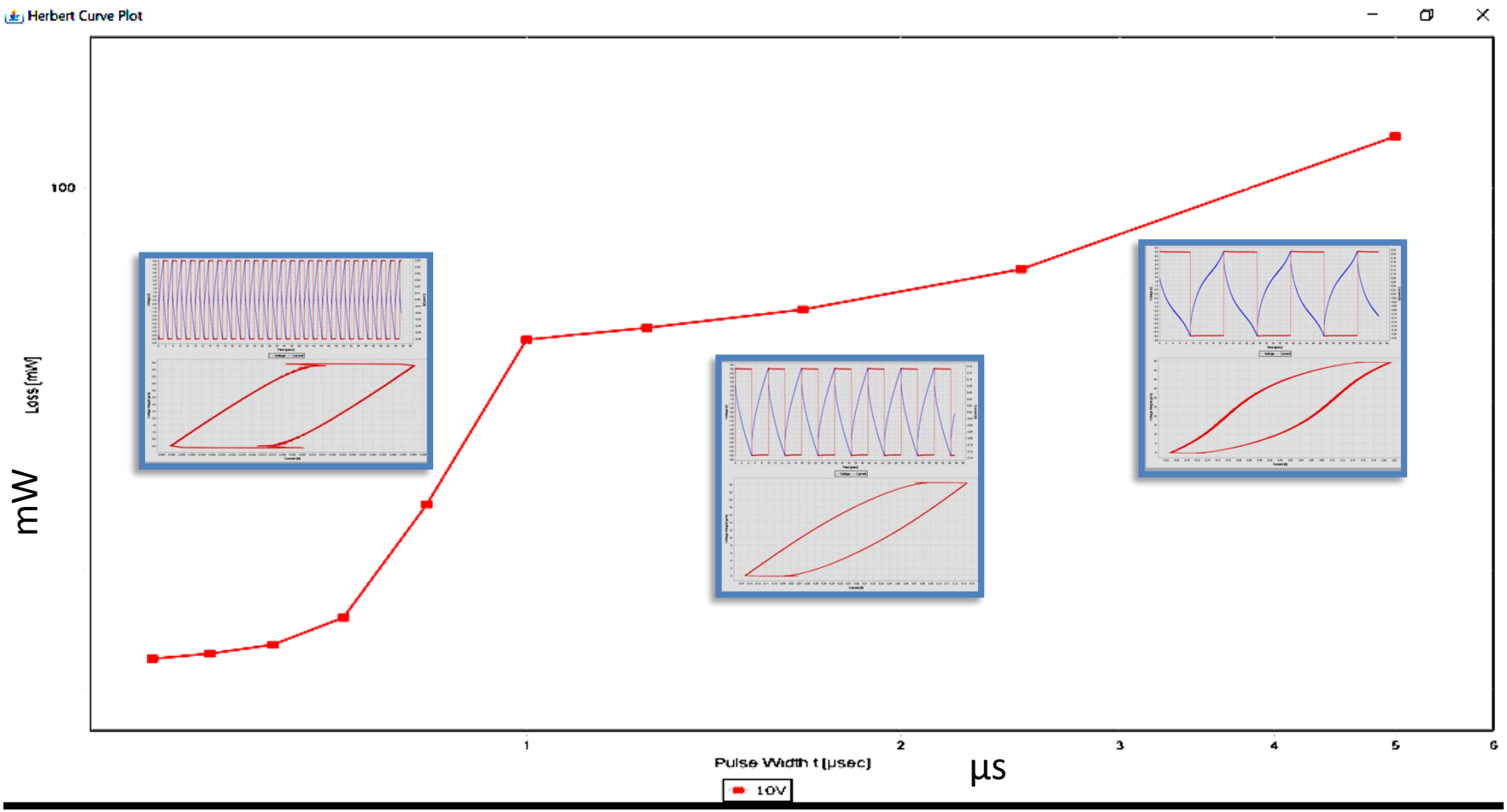
sw. frequency



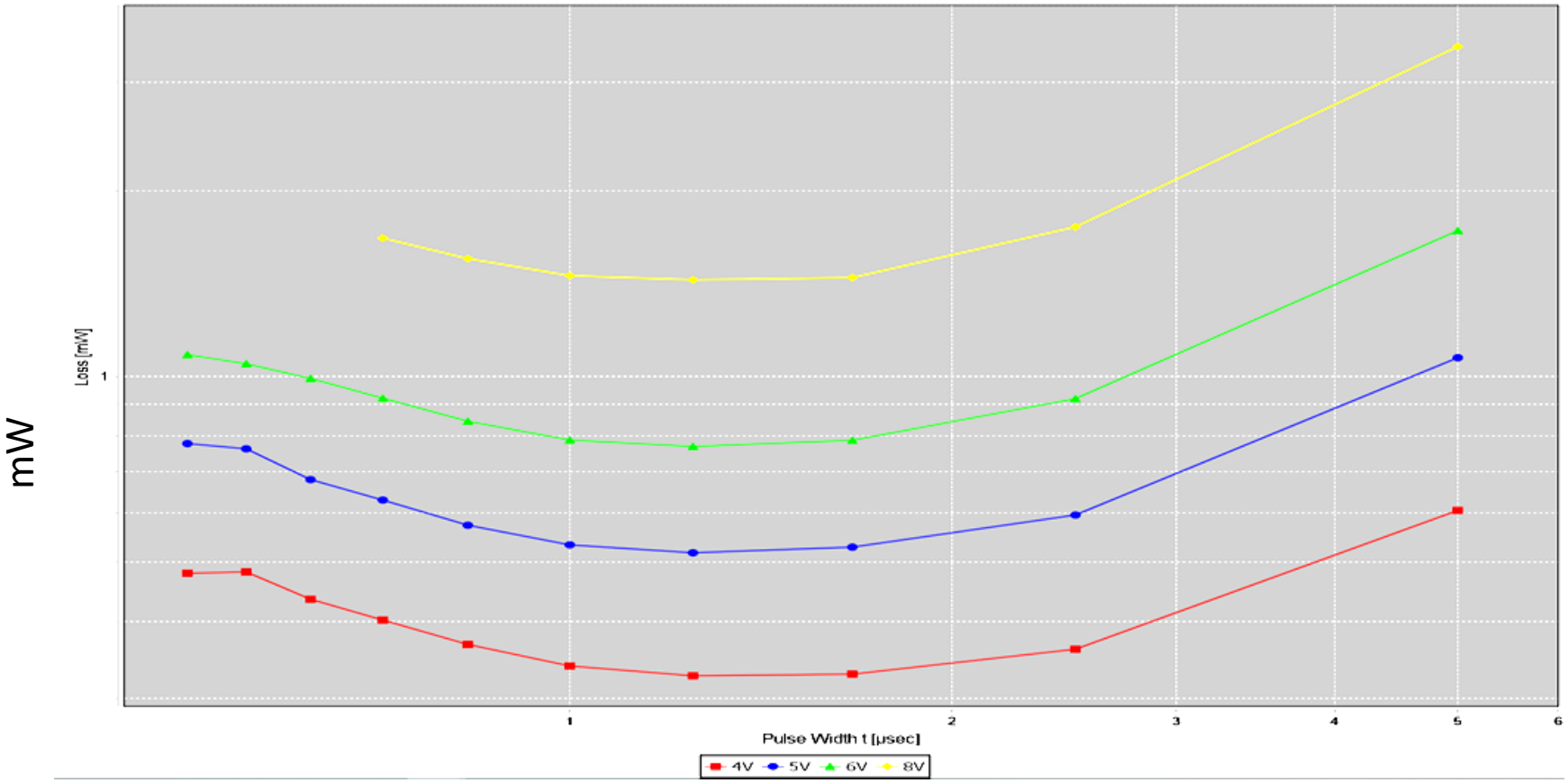
Time domain

µVs vs. I

Herbert Curve



Herbert Curves



Conclusion

- BsT-SQ maps out the AC loss under square excitation
- It is complementary to BsT-Pro loss measuring system under sinusoidal AC excitation
- It is easy, quick to operate and inexpensive
- It provides the vocabulary for material/core maker and user, and component maker and user, and for simulator
- Output can be read directly into material library for design and model of inductive component and part
- Further extention with loss dimensions with duty cycle and temperature is possible

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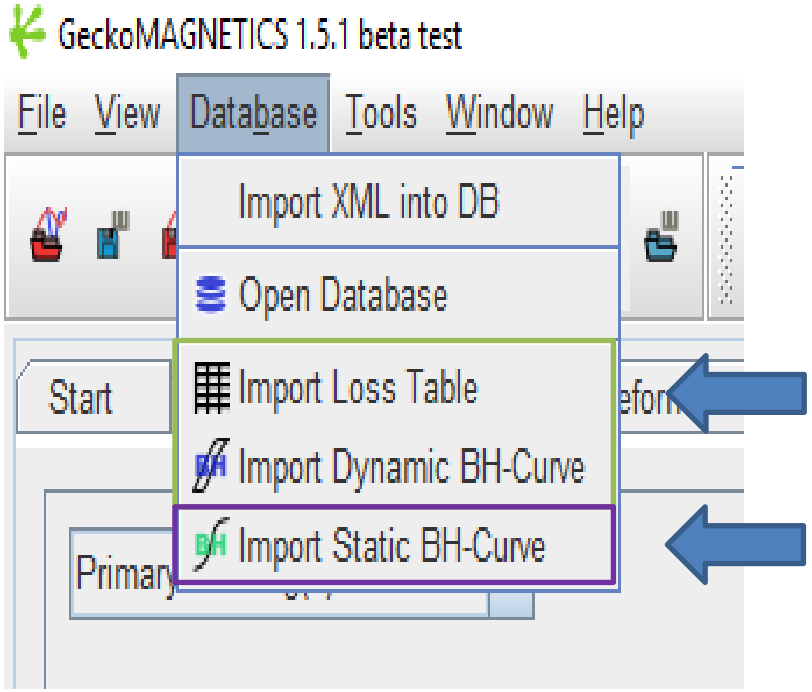
Annex 1 measuring data for simulation



BsT-Pro 2016

BsT-SQ 2018

BsT-Pulse 2017

BsT-Pro

BsT-SQ

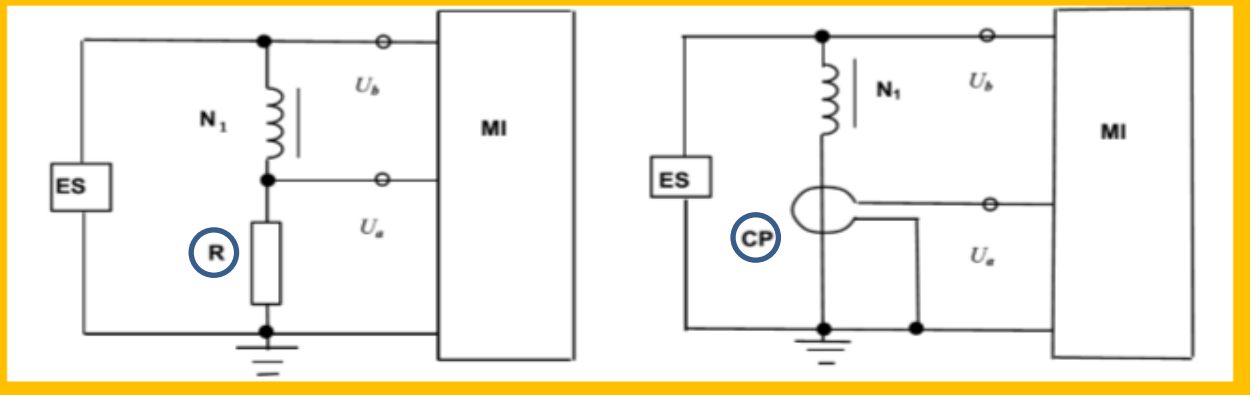
BsT-Pulse

Annex 2 Reliable to Accurate measurement

Power loss

Table 1 – Some multiplying methods and related domains of excitation waveforms, acquisition, processing

Measuring method	Domain of			Subclause of annex C
	useable excitation waveform	acquisition	processing	
V-A-W meter	Sinusoidal	Time	Time	C.1.1
Impedance analyser	Sinusoidal	Not applicable	Not applicable	C.1.2
Digitizing	Arbitrary	Time	Time	C.1.3
Vector spectrum	Arbitrary	Frequency	Frequency	C.1.4
Cross-power	Arbitrary	Time	Frequency	C.1.5



Part of IEC62044-3

Still part of IEC 62044/3 under arbitrary wave

Data processing still needs more transparency, **FFT is not solution**