

Influence of 500 Ohm Resistor's Bandwidth on HBM Calibration

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Topics

- Investigate the effect of 500 Ω resistor bandwidth on verification current waveforms

500 Ohm resistor Bandwidth comparison

- In the JS-001 standard, there is only one sentence describing the 500 Ohm evaluation load. However, the high-frequency characteristics of the resistor may vary significantly, and this variation can affect the verification of HBM current waveforms.

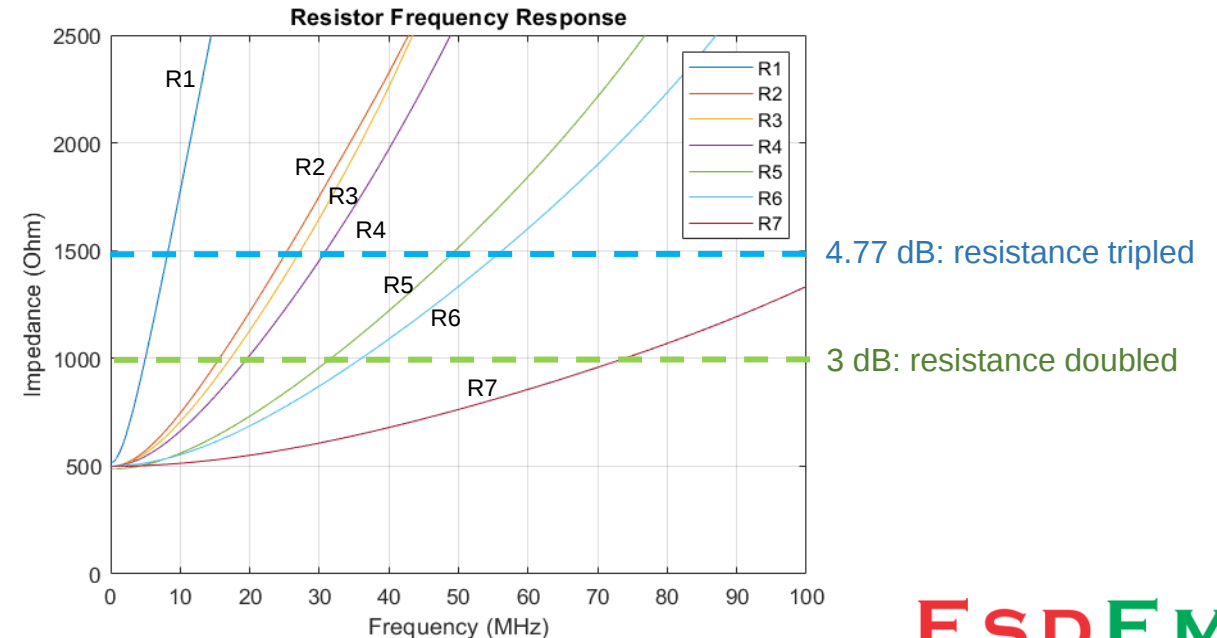
4.1.3 Evaluation Loads

Two evaluation loads are necessary to verify tester functionality:

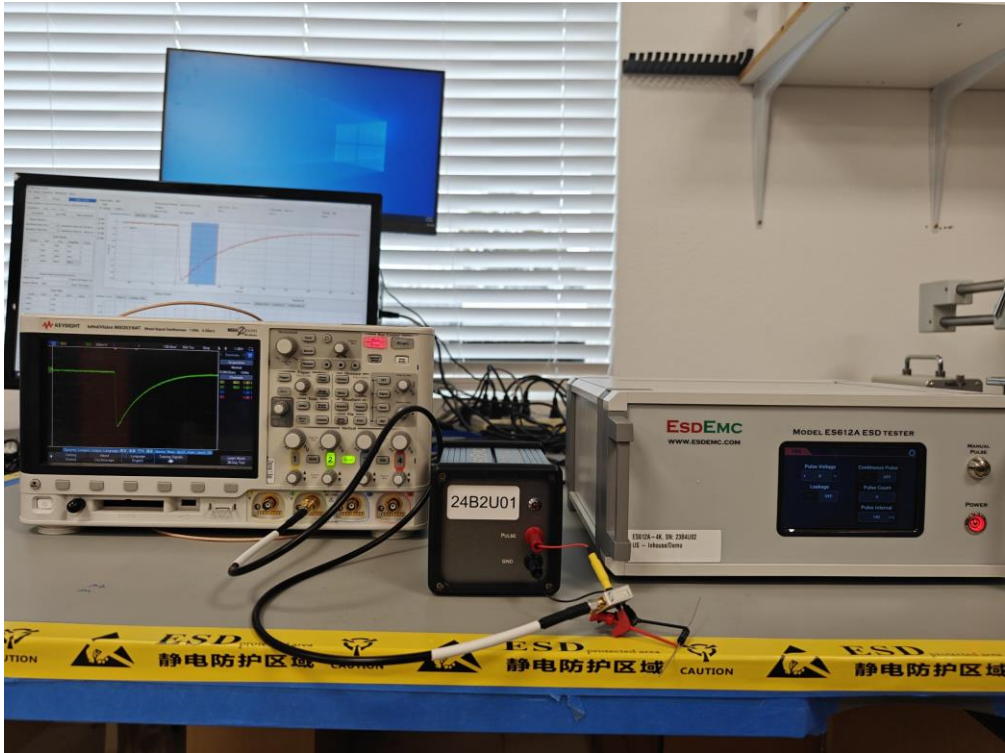
- Load 1: A solid 18-24 AWG (non-US standard wire size 0.25 to 0.75 mm² cross-section) tinned copper shorting wire as short as practicable to span the distance between the two farthest pins in the socket while passing through the current probe or long enough to pass through the current probe and contacted by the probes of a non-socketed tester.
- Load 2: A 500 ohm, $\pm 1\%$, minimum 4000 voltage rating.

- The frequency responses of 7 types of 500 Ohm resistors (R1 ~ R7) were measured by VNA.

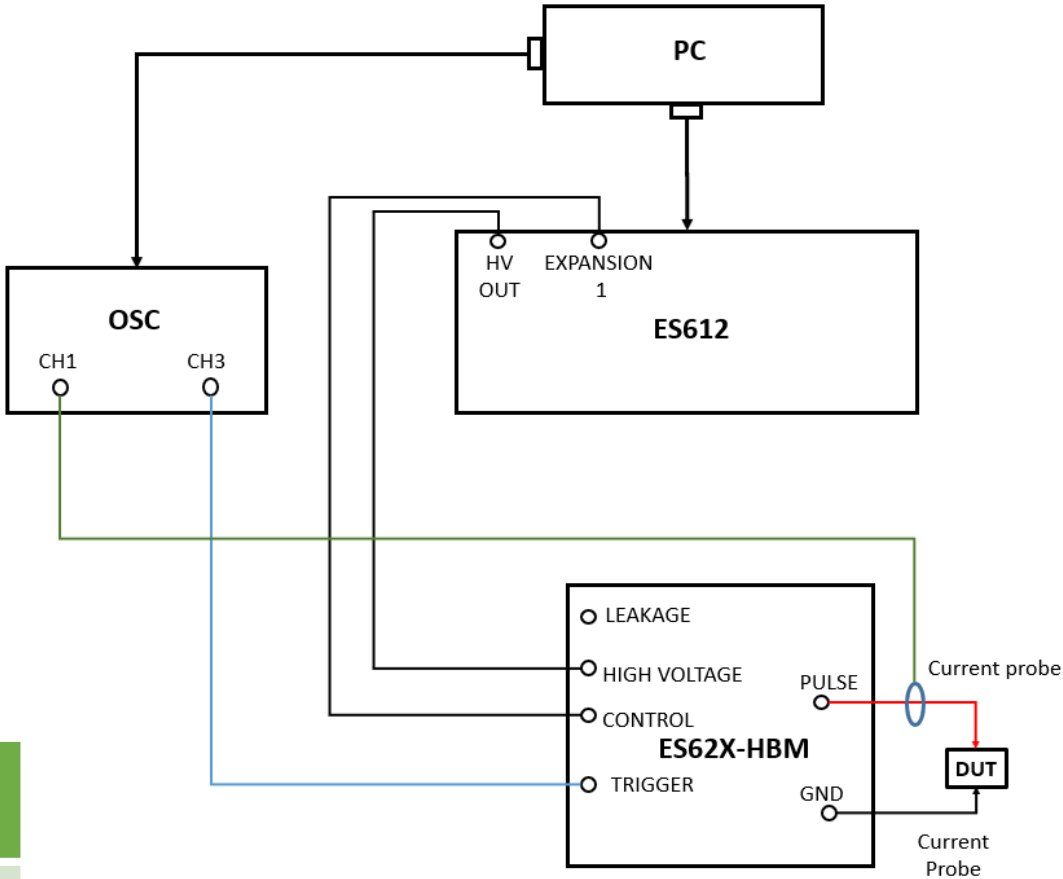
Resistor #	Datasheet Tolerance	Measured Resistance	Measured Tolerance	2X Bandwidth	3x Bandwidth
R1	5%	515Ω	3%	5MHz	8.1MHz
R2	5%	499.5Ω	0.1%	15MHz	25MHz
R3	±1%	497.8Ω	0.44%	17MHz	27MHz
R4	5%	500.2Ω	0.04%	19MHz	30MHz
R5	5%	484.6Ω	3.08%	31MHz	49MHz
R6	1%	498.5Ω	0.3%	35MHz	55MHz
R7	5%	495Ω	1%	72MHz	105MHz



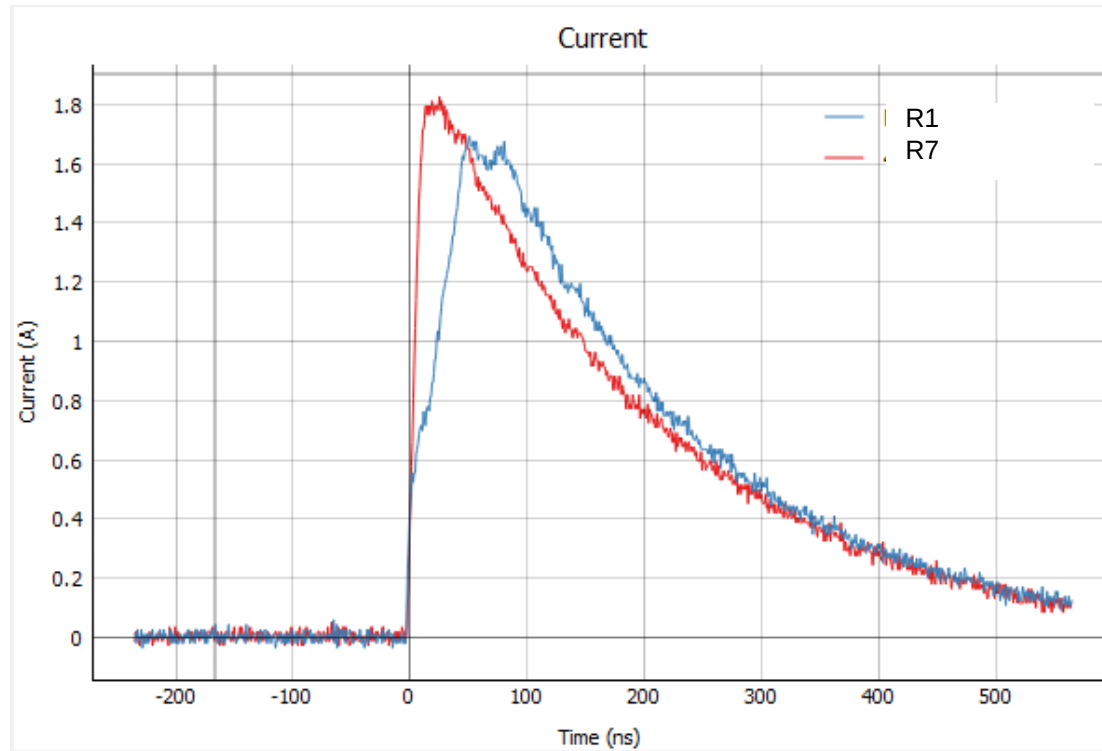
HBM current waveform evaluation test setup (Two-pin tester)



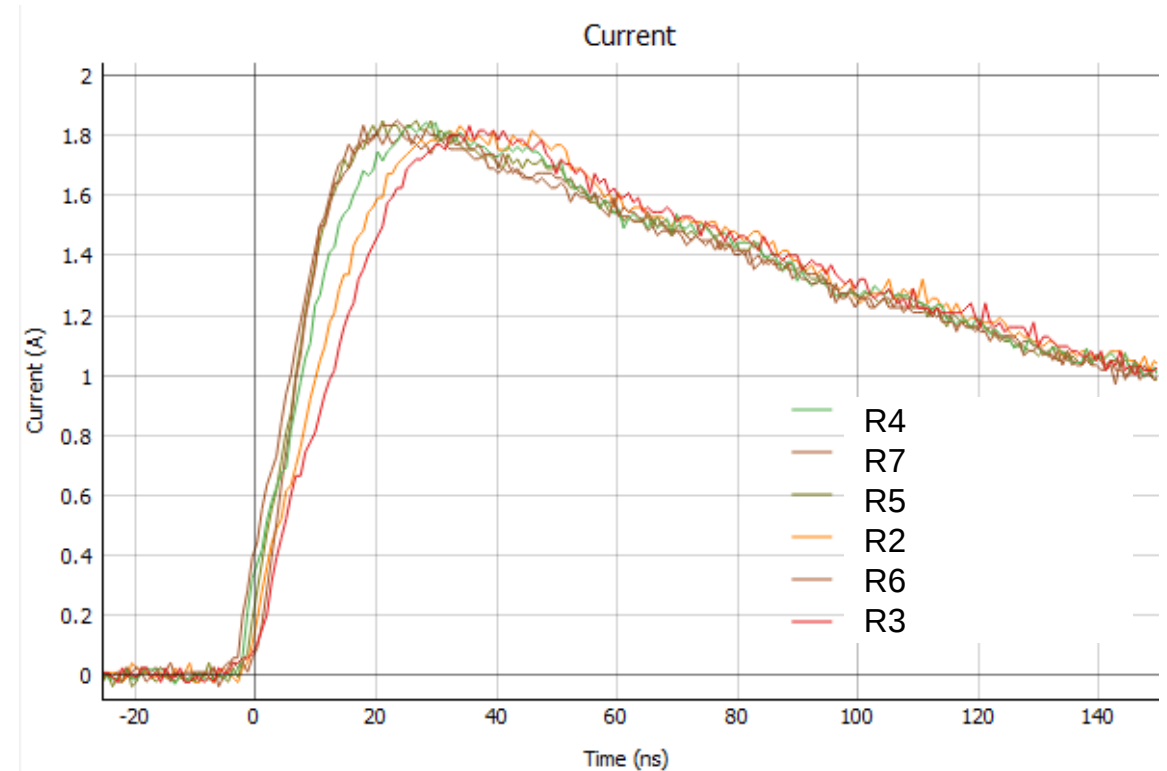
Equipment	Brand	Model #	Main spec
HBM tester	ESDEMC	ES612A	up to $\pm 8\text{kV}$
Oscilloscope	Keysight	MSOX3104T	1GHz, 5Gs/s
Current probe	ESDEMC	CT-T03-0p5	2kHz–2GHz, 0.5V/A



+4kV HBM current waveforms on R1 ~ R7



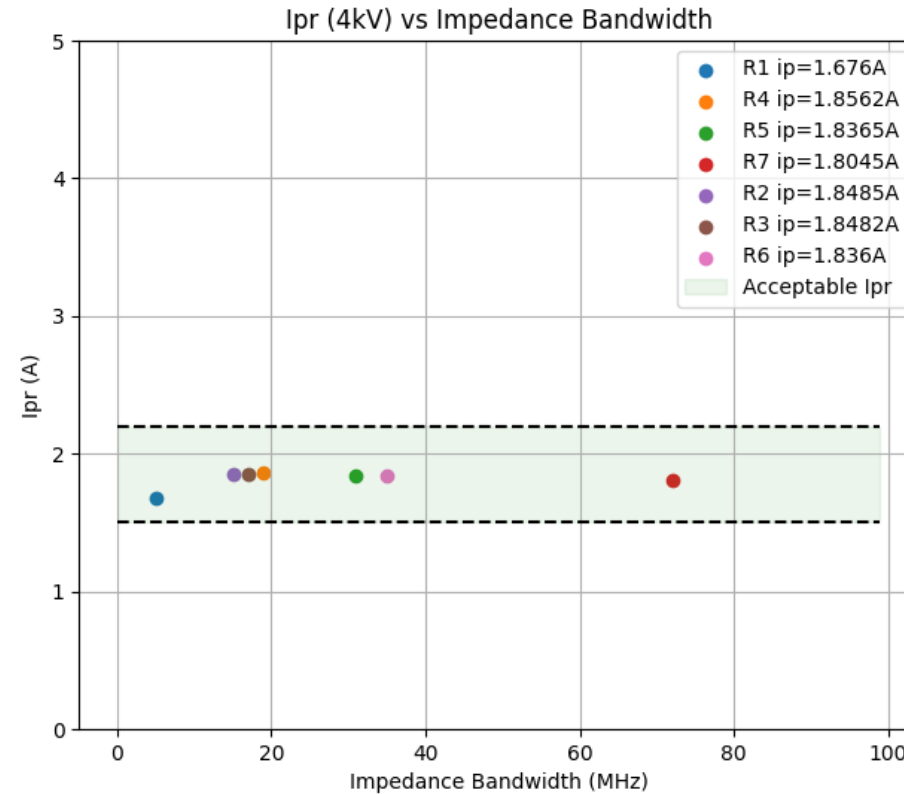
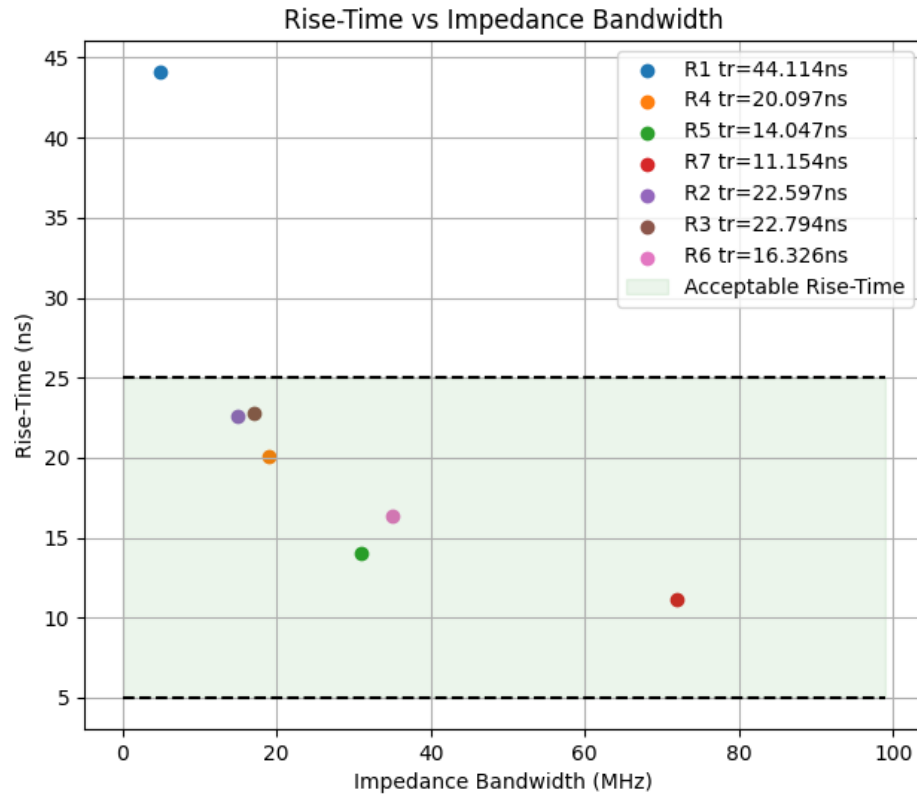
Best vs worst resistor performance



Waveform rising edge comparison

The rise time t_{rr} varied greatly between the different resistors, with the highest (R7) and lowest (R1) bandwidth resistors having a 33ns disparity (11.15 ns vs. 44.11 ns) in rise time.

R1 ~ R7 Current waveform analysis



- As the frequency response of the 500 Ohm resistor improves, the HBM current waveform will better meet the JS-001 standard requirements.
- A resistor with poor frequency response may cause the rise time t_{rr} of the HBM current waveform to not meet the standard requirements.
- The I_{pr} values of the seven tested resistors are all within the standard requirements.

Conclusion

- Even if the 500 Ohm resistor parameters meet the JS-001 requirements, same HBM tester's current evaluation results may pass or fail the standard specifications with different resistors.
- The standard should include additional requirements for the frequency response of the 500 Ohm resistor.