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Reducing Electromagnetic Emissions from SpaceWire

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Content

- Brief overview of SpaceWire physical layer
- Spectrum of emissions
- What causes that spectrum
- Measurement/test arrangement
- Mitigating techniques and their effects
- Guidelines for reducing emissions
- Conclusion

SpaceWire-links – Line Coding

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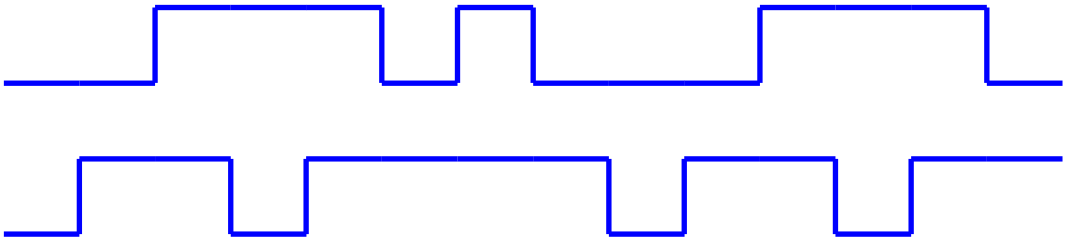
DS = Data-Strobe
Gray Code encoding

D = Data

S = Strobe



Needs 2 (pairs of) wires;
Clock is embedded in the signals

- Data rate is not fixed to any particular values (up to maximum silicon can support: >500Mb/s) and can change from bit to bit

DS-links – Character Level

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P	1	0	0	FCT – Flow control token
P	1	0	1	EOP – End of Packet
P	1	1	0	EOM – End of Message
P	1	1	1	ESC – escape, next token is interpreted as …

0	1	0	0	NULL
0	1	0	1	Undefined
0	1	1	0	Undefined
0	1	1	1	undefined

P	0	a	b	c	d	e	f	g	h	DATA (a is LSB, h is MSB)

SpaceWire 48.8Mb/s - NULLs

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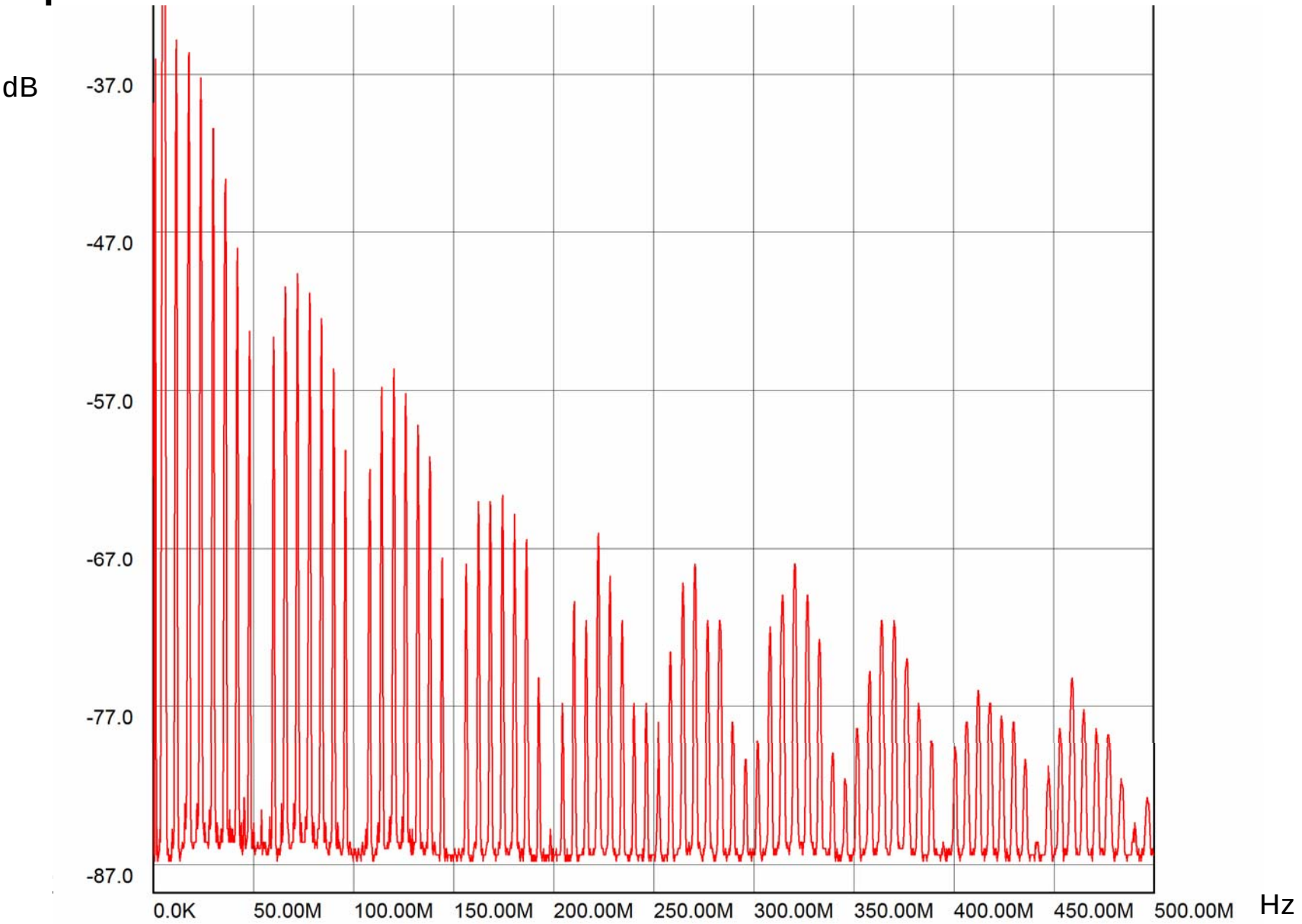

Causes

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The concentration into a small number of frequencies is caused by the regular appearance of edges

- The fixed bit-rate
- Regular bit patterns
  - NULL

The long tail into high frequencies is caused by fast edges

- Many LVDS buffers are rated to >2Gb/s

Is this a problem?

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- Should be OK …
  - LVDS and balanced lines
  - Screened cable
- But …
  - Connectors poor balance at higher frequencies
  - Cable length = Aerial
- Observation from EMC tests …
  - Signals related to link speed are detected

Test setup

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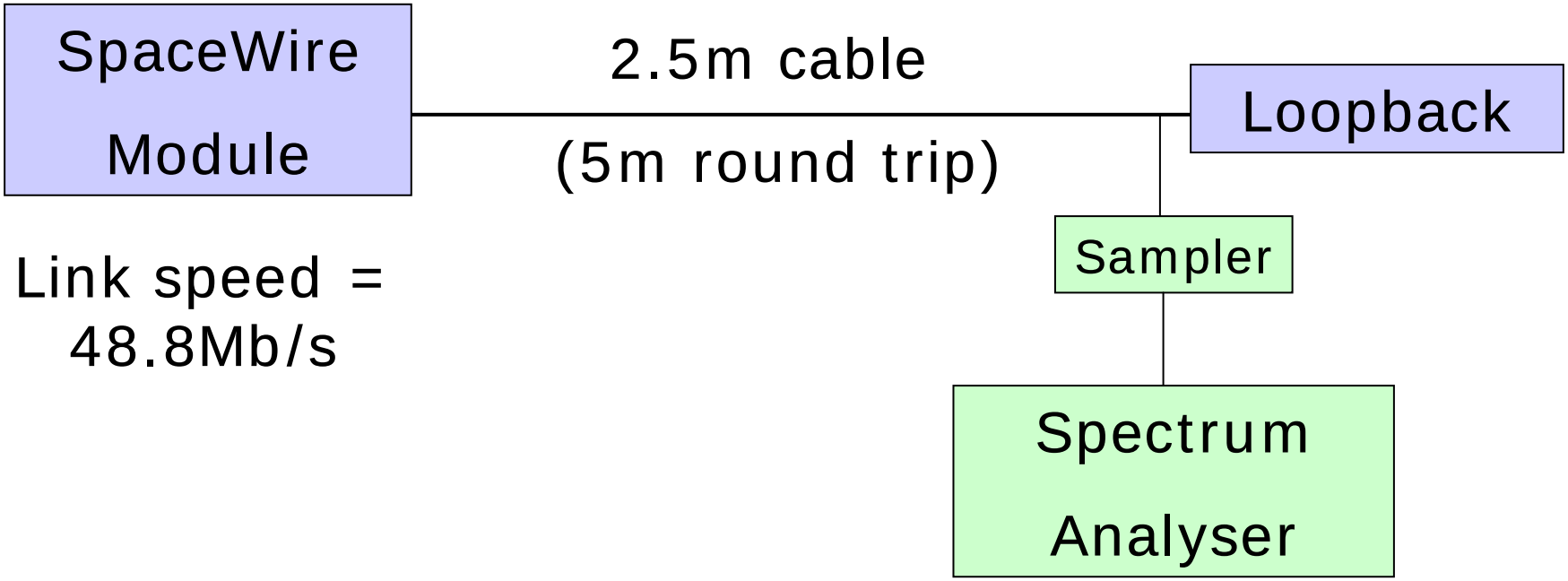

Link speed =
48.8Mb/s

SpaceWire 48.8Mb/s - NULLs

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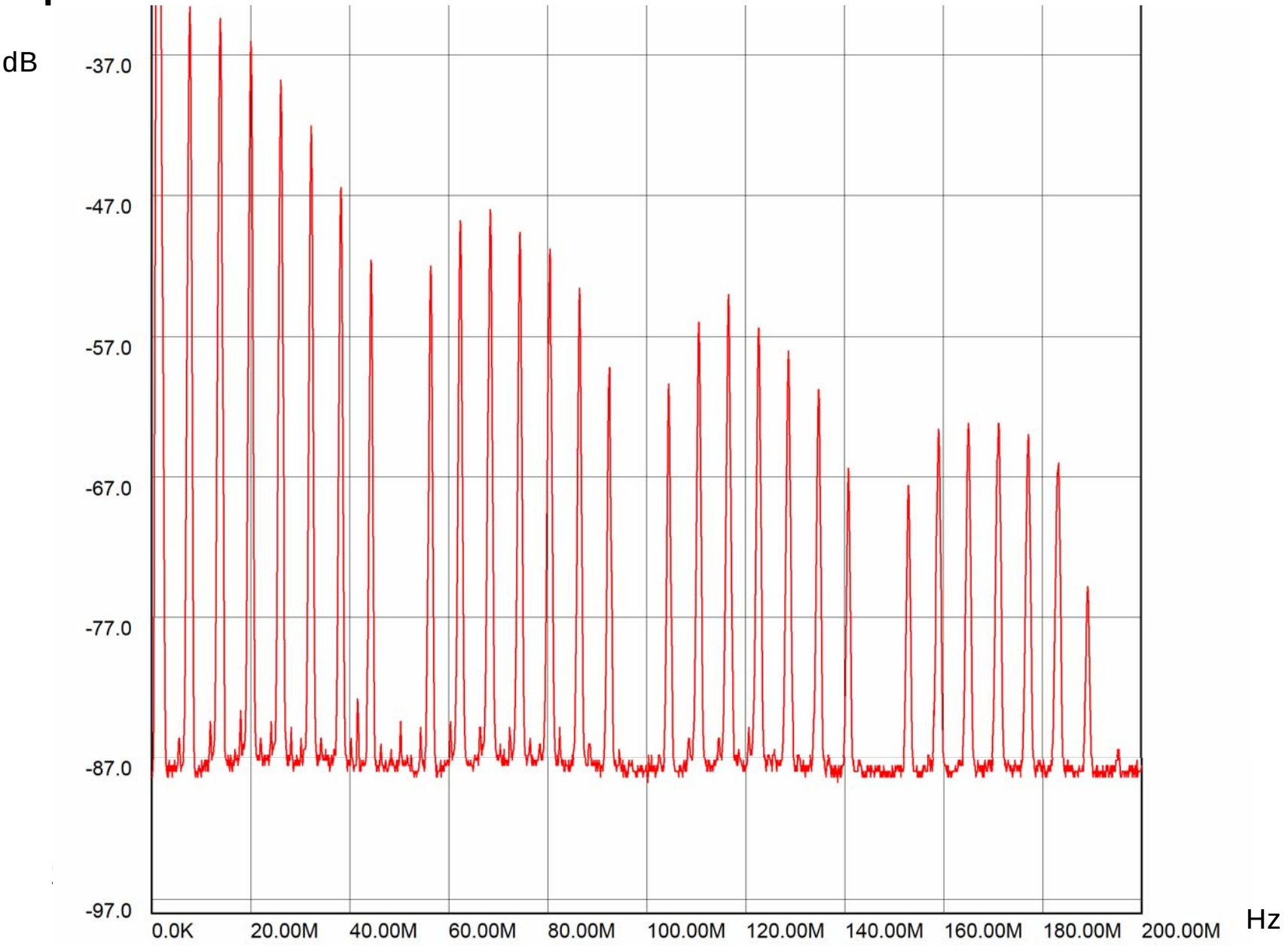

Random data + FCT

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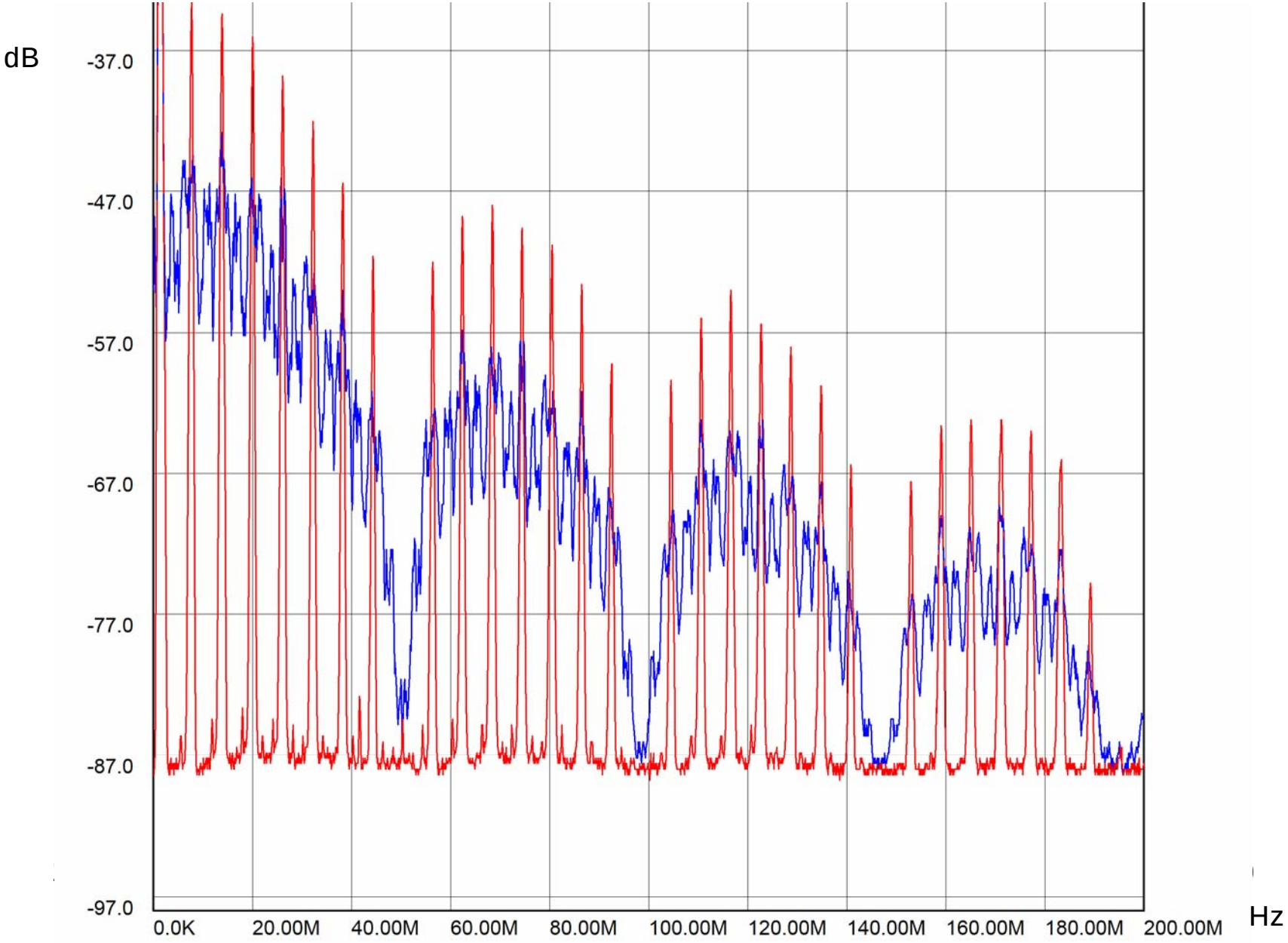

NULLs with 100pF at D, S Tx

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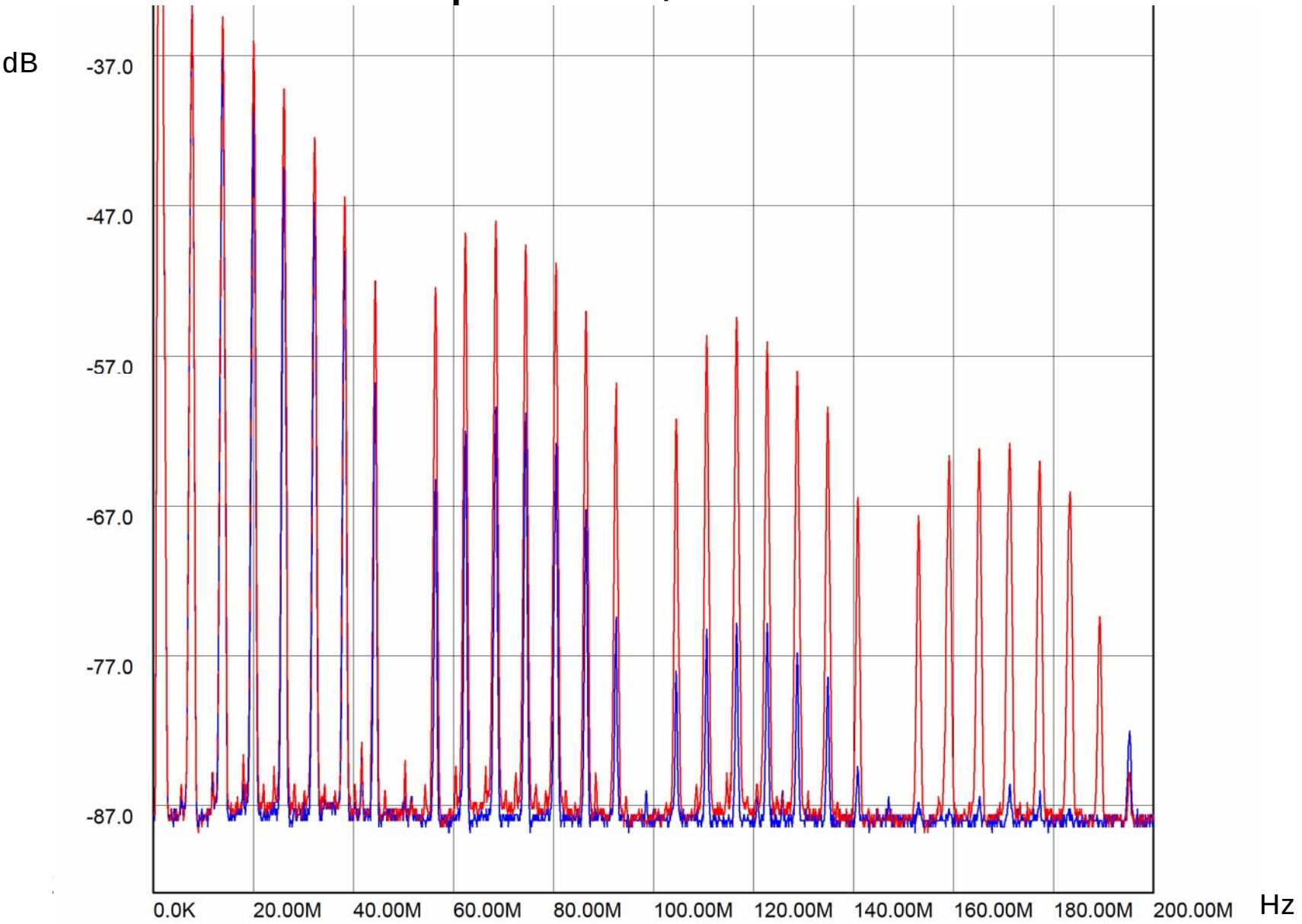

NULLs with Spread-Spectrum clock

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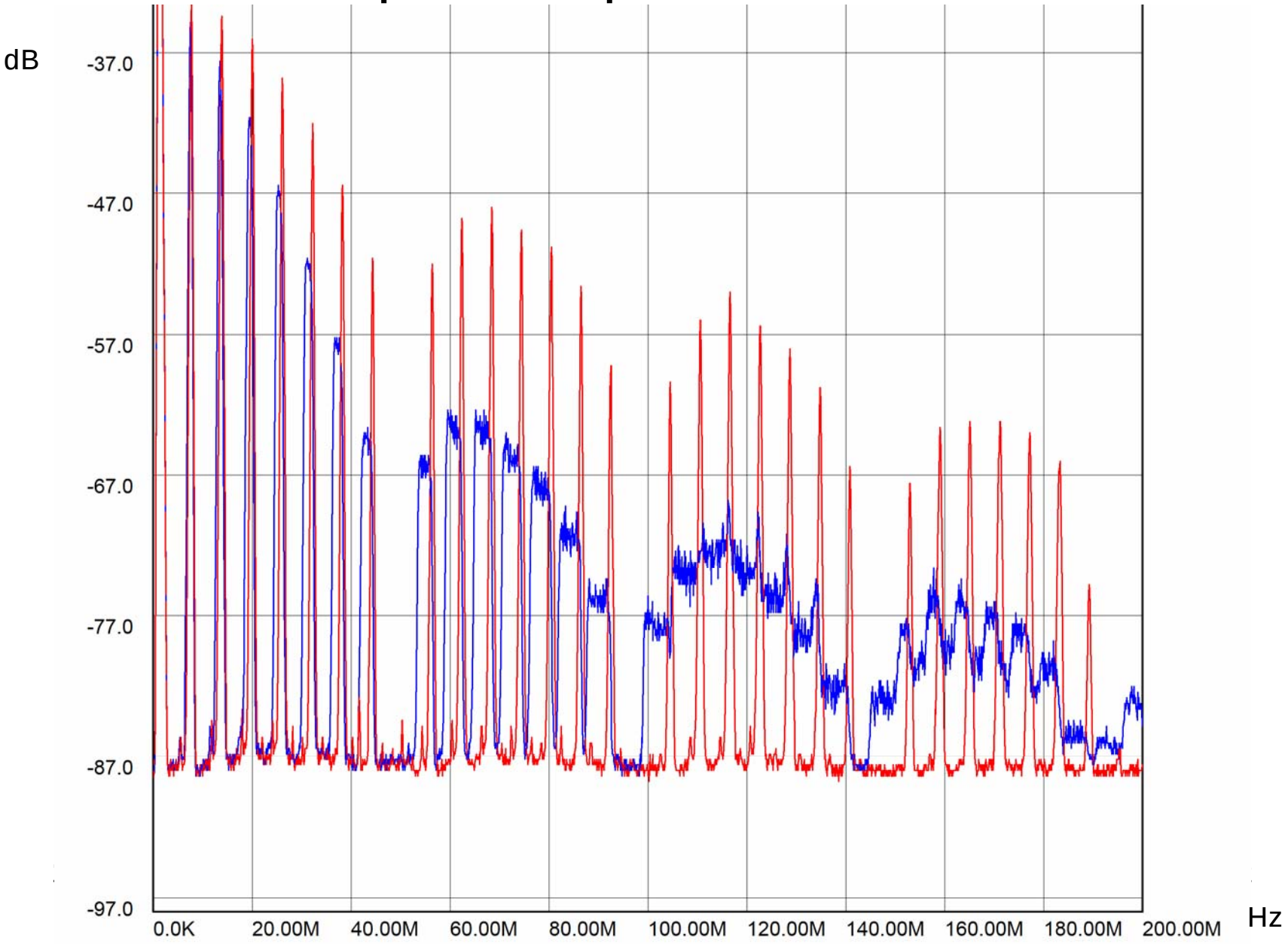

Random data + FCT

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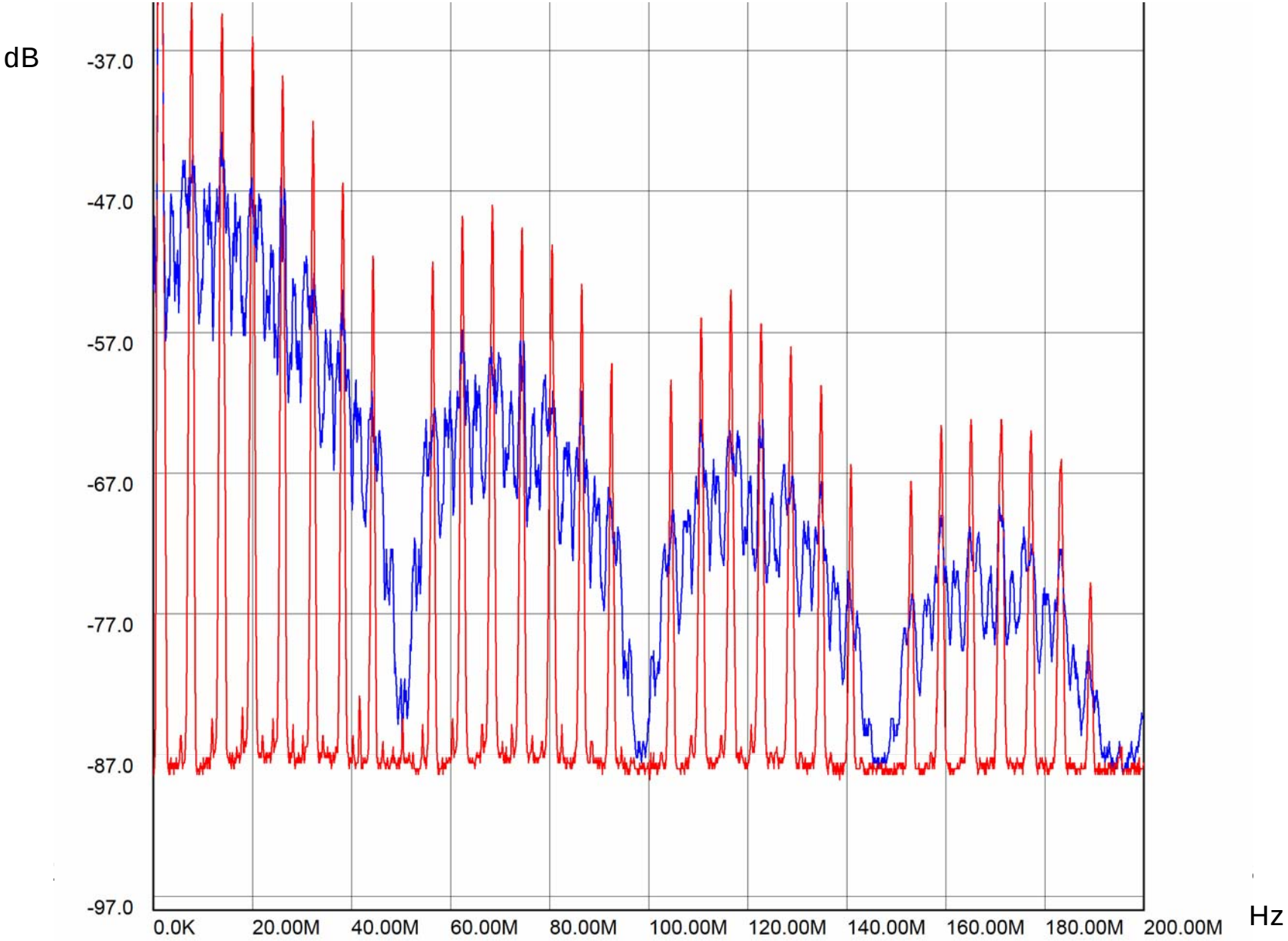

Random data + FCT + Spread spectrum clock

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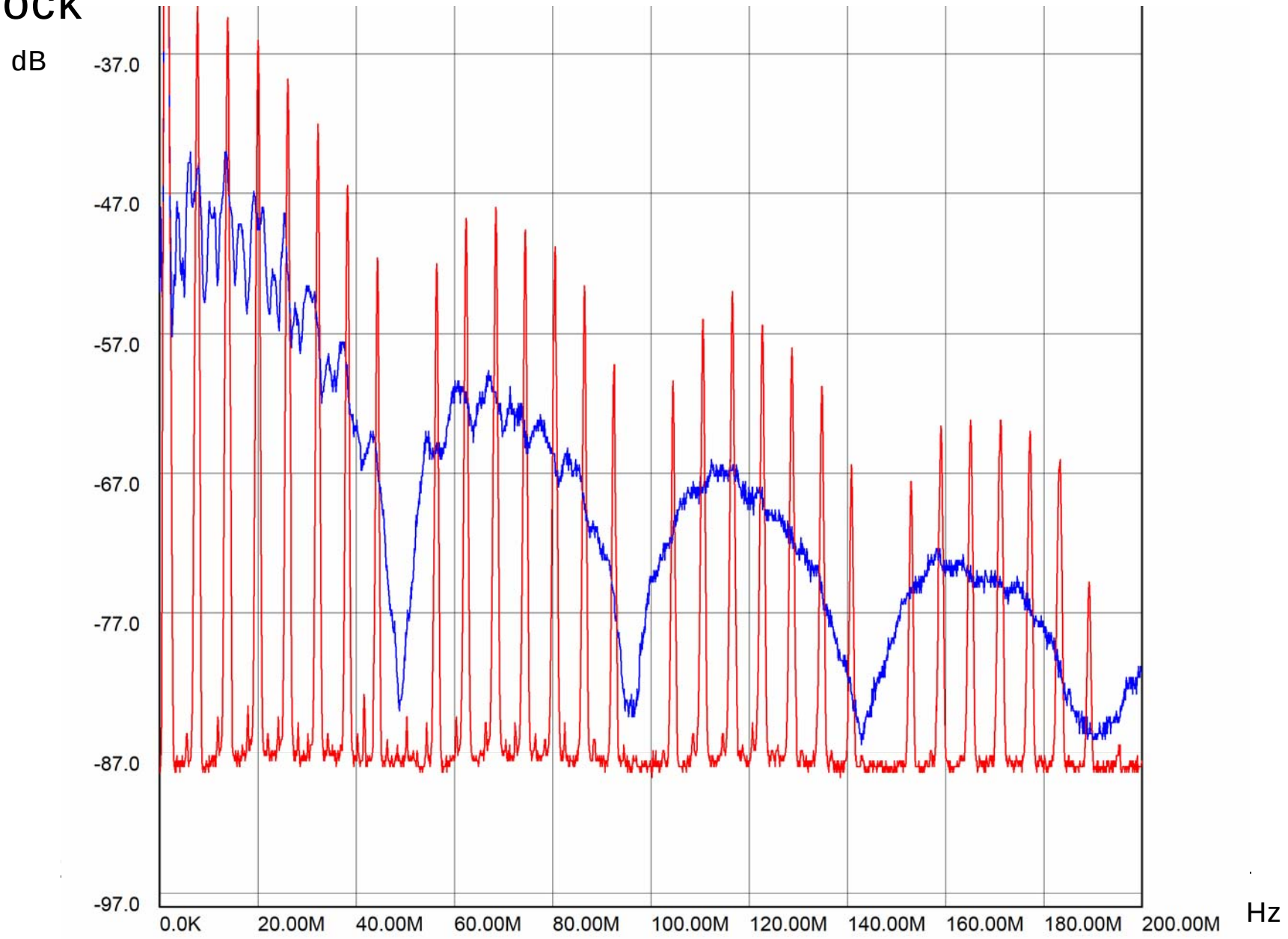

Notes and Guidelines

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Remember:

- SpaceWire cables are over-specified for <200Mb/s or <20m – there is margin to spare
- Rate changes are allowed

Therefore:

- Control edge rise/fall time
  - Don’t use drivers that are faster than required
- Consider spread-spectrum clocking
  - Deliberately adding jitter is OK

Conclusion (edge control + spread-spectrum)

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