

HDMI Noise Update

2021 Fellowship - DUNE

The Project - Test HDMI noise threshold

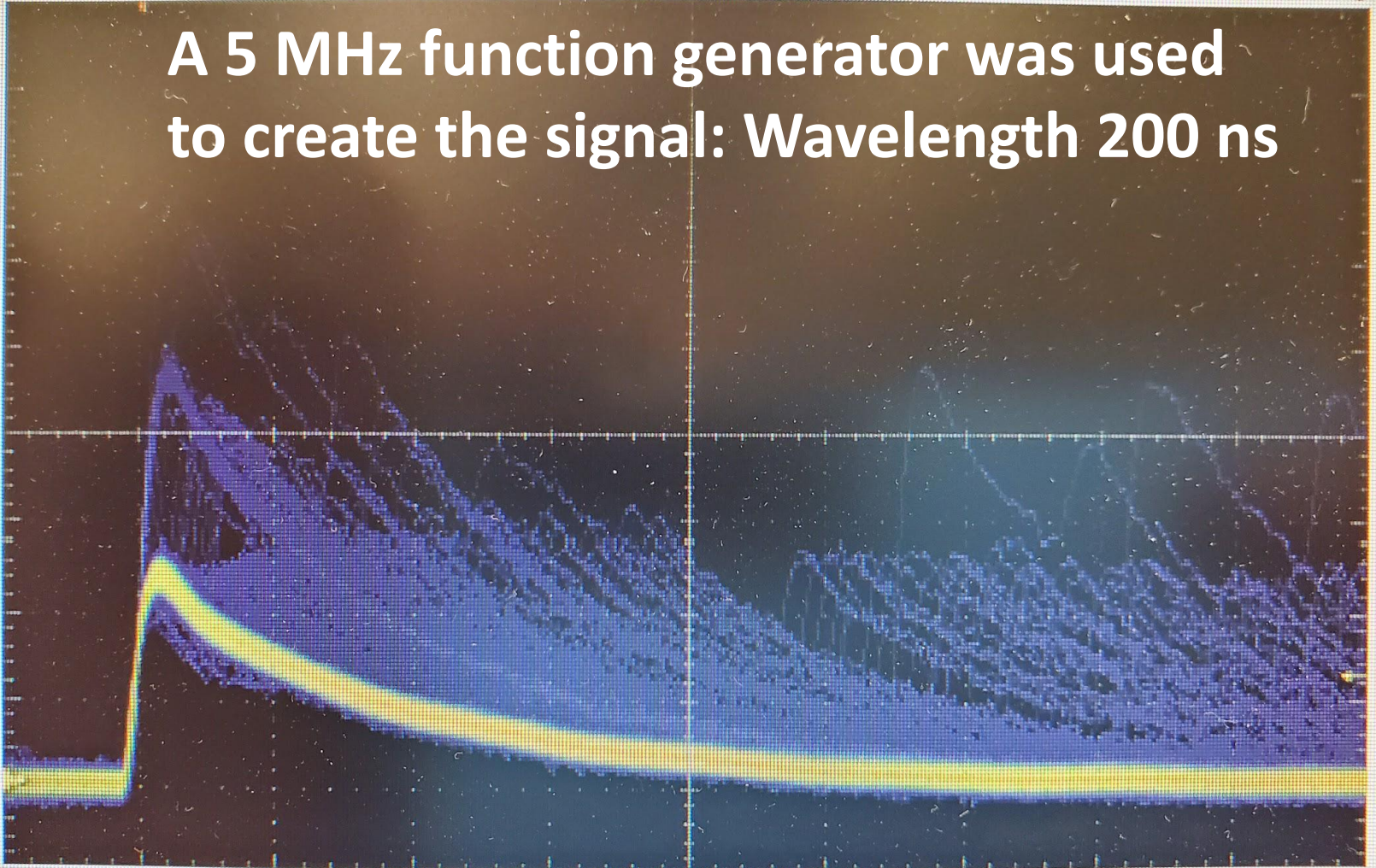
- TMS Electromagnet may create interference in signal from SiPM
- Common, inexpensive data transfer would be preferred
- Long runs of HDMI near coils of electromagnet are in question

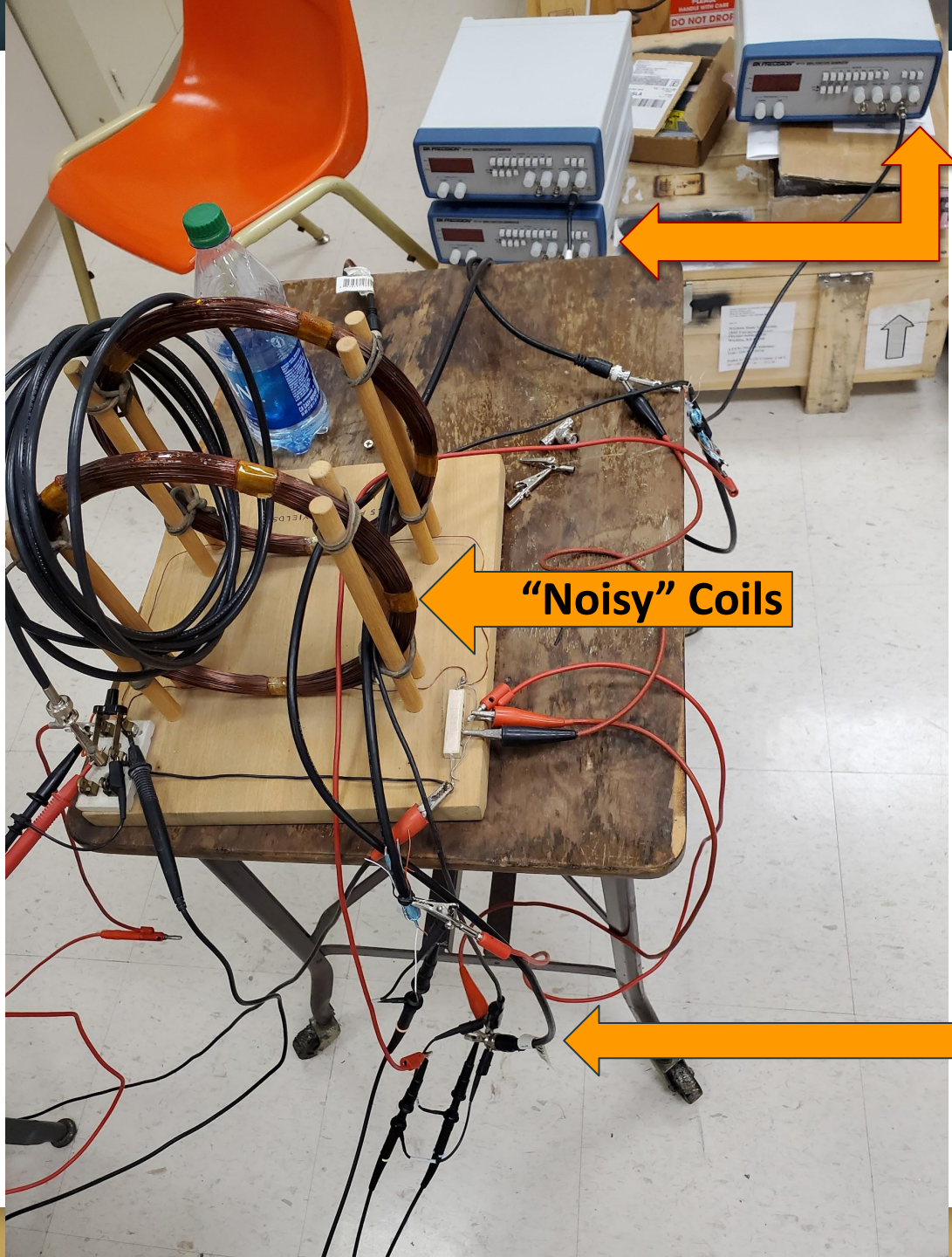
($M=1.25 \times 10^6$)

A 5 MHz function generator was used to create the signal: Wavelength 200 ns

50 mV

10 ns





3 separate signal generators to avoid interference.

Each set to 5 MHz.

$\frac{1}{2}$ Wavelength equal to 100 ns.

Each set to \approx 220 mV peak to peak (p2p)

“Noisy” Coils

3 probe channels, one for each cable.

- **Generic Power Cable**
- **Coax Cable**
- **HDMI (1 of 5 shielded pairs)**

File Utility Help

3 triangular signals for analysis:

Yellow: Unshielded power cable

Blue: Shielded Coax Cable

Red: HDMI (One signal wire of 5)

Δt : 52.00 ns
 ΔV : 108.0 mV $\Delta V/\Delta t$: -2.077 MV/s
t: -396.0 ns
V: 32.00 mV

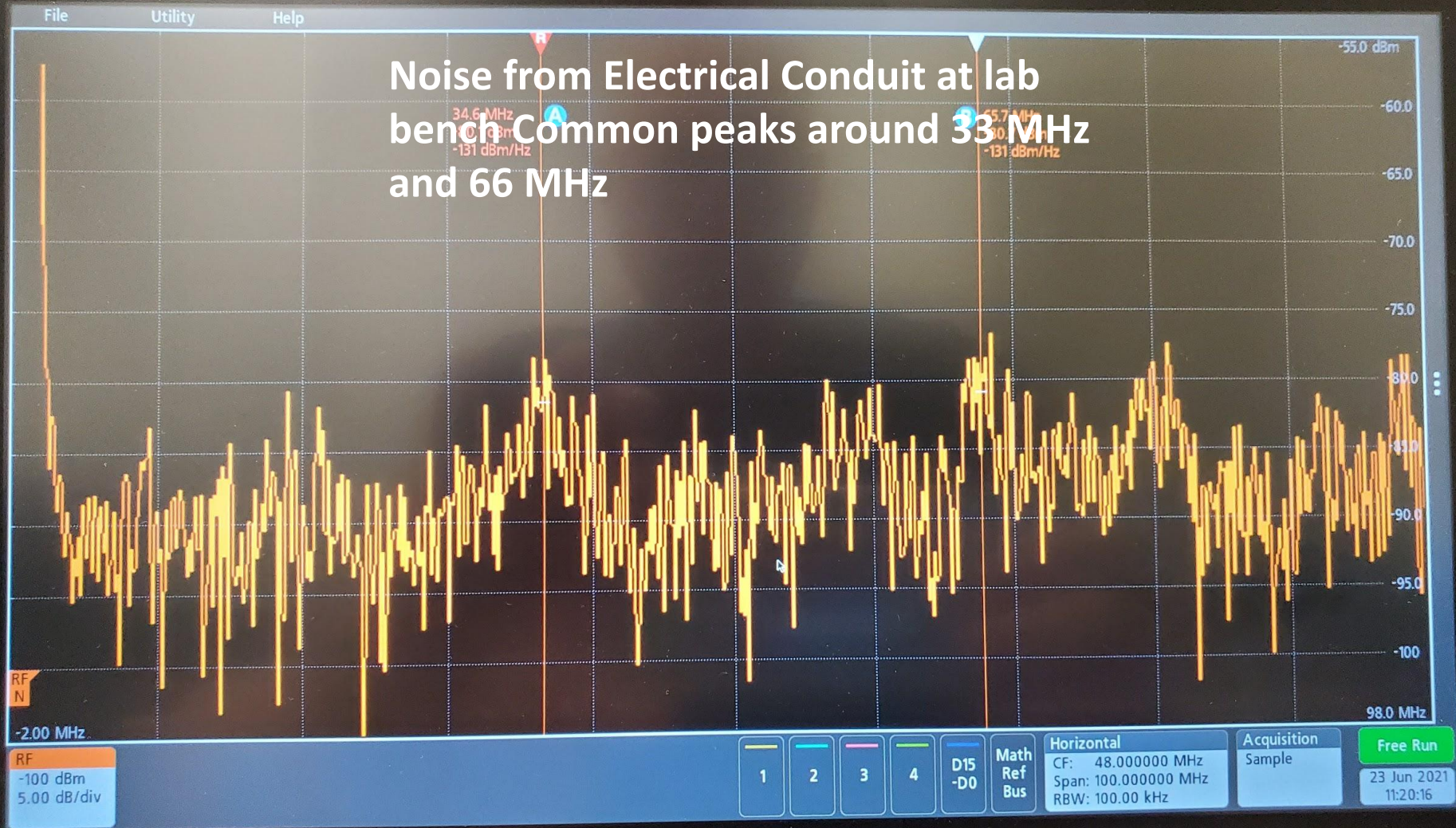
t: -344.0 ns
V: -76.00 mV

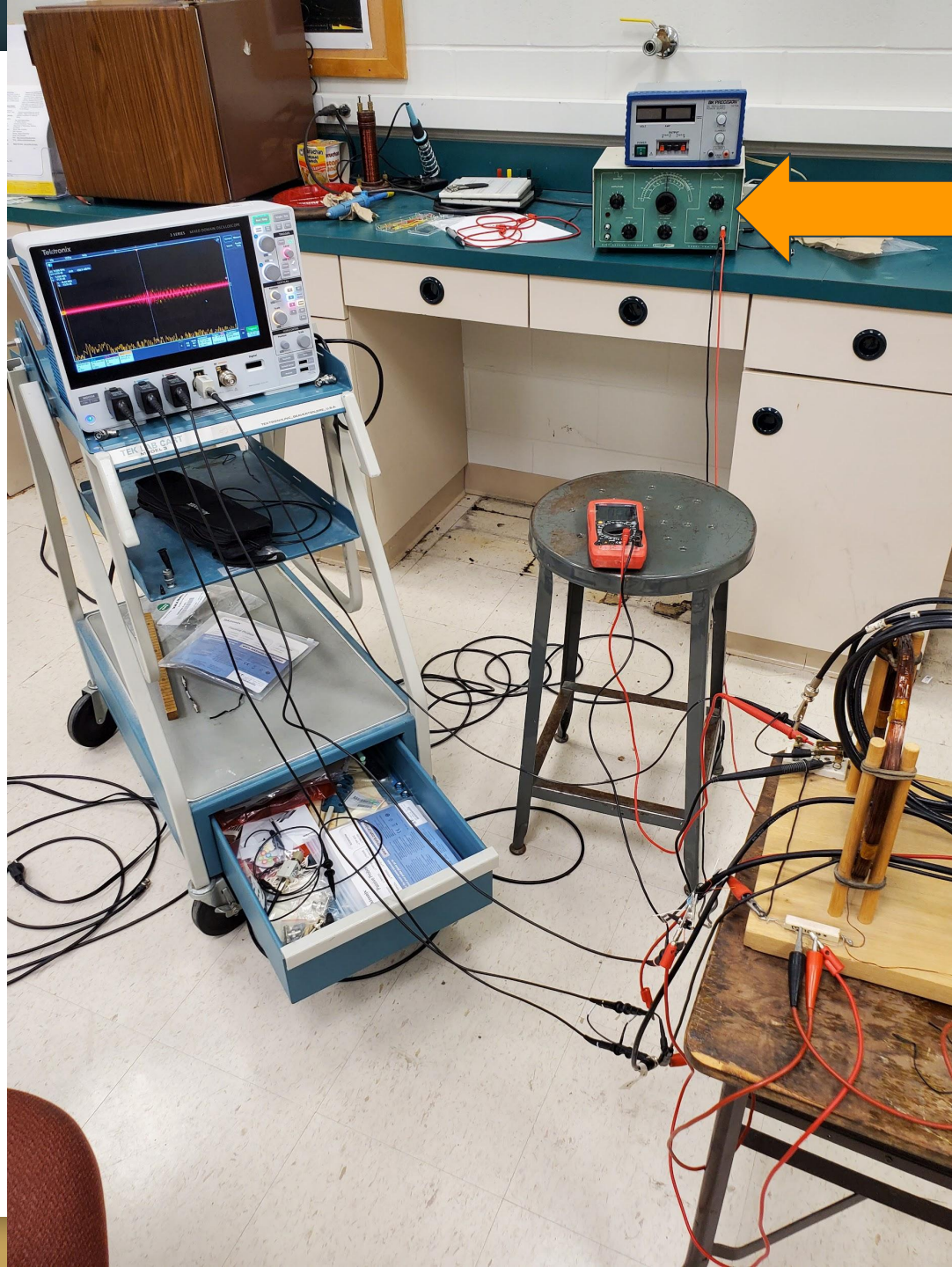
C1

100 ns

Ch 1 100 mV/div 1 GHz	Ch 2 50.0 mV/div 1 GHz	Ch 3 50.0 mV/div 1 GHz	Math 20.0 dB/div FFT(Ch 1)
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4	D15 -D0	Horizontal 80.0 ns/div SR: 1.25 GS/s RL: 1 kpts	Trigger 3 25.0 mV 00457 MHz	Acquisition Sample 2.320 MAcqs
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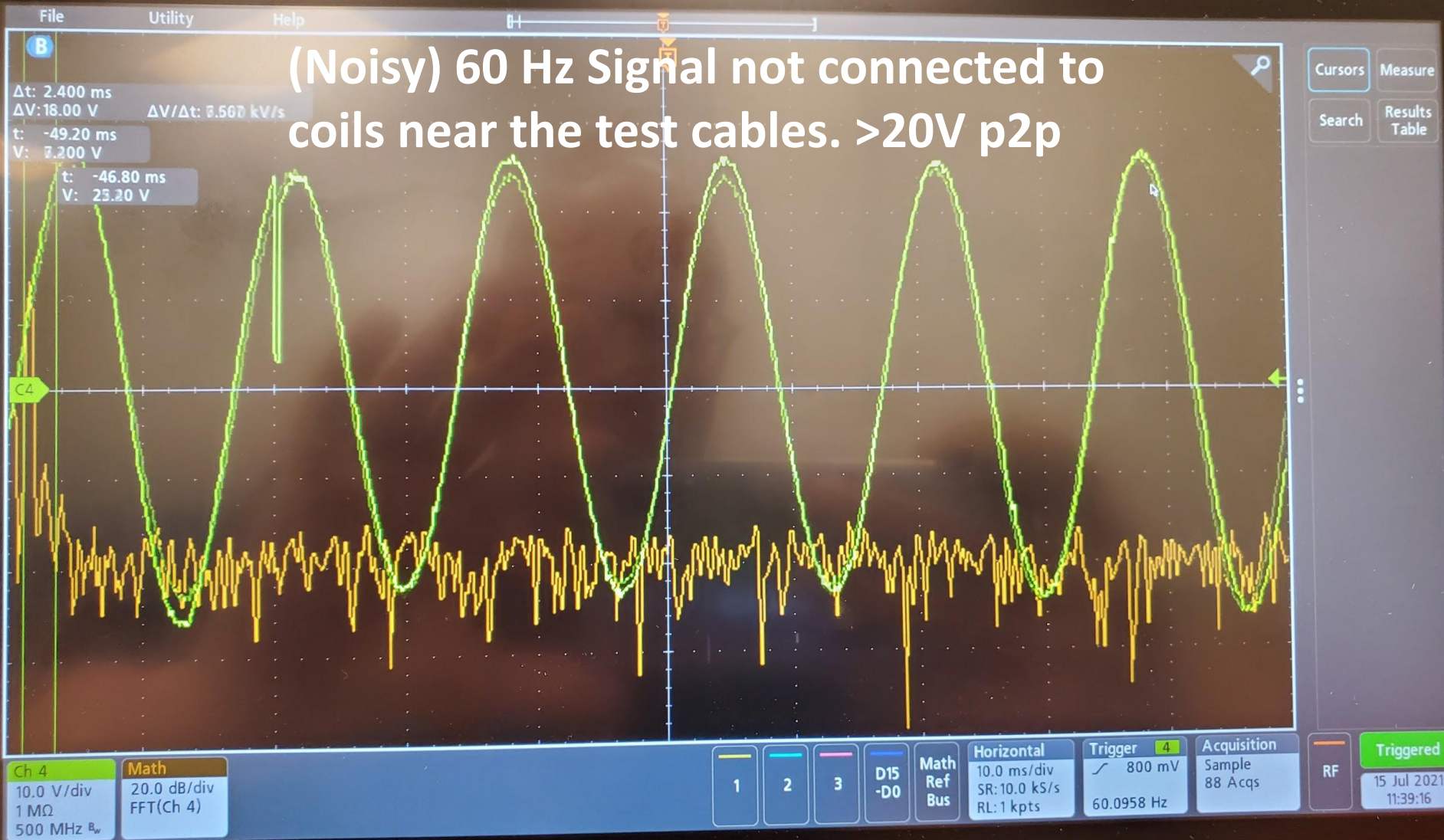




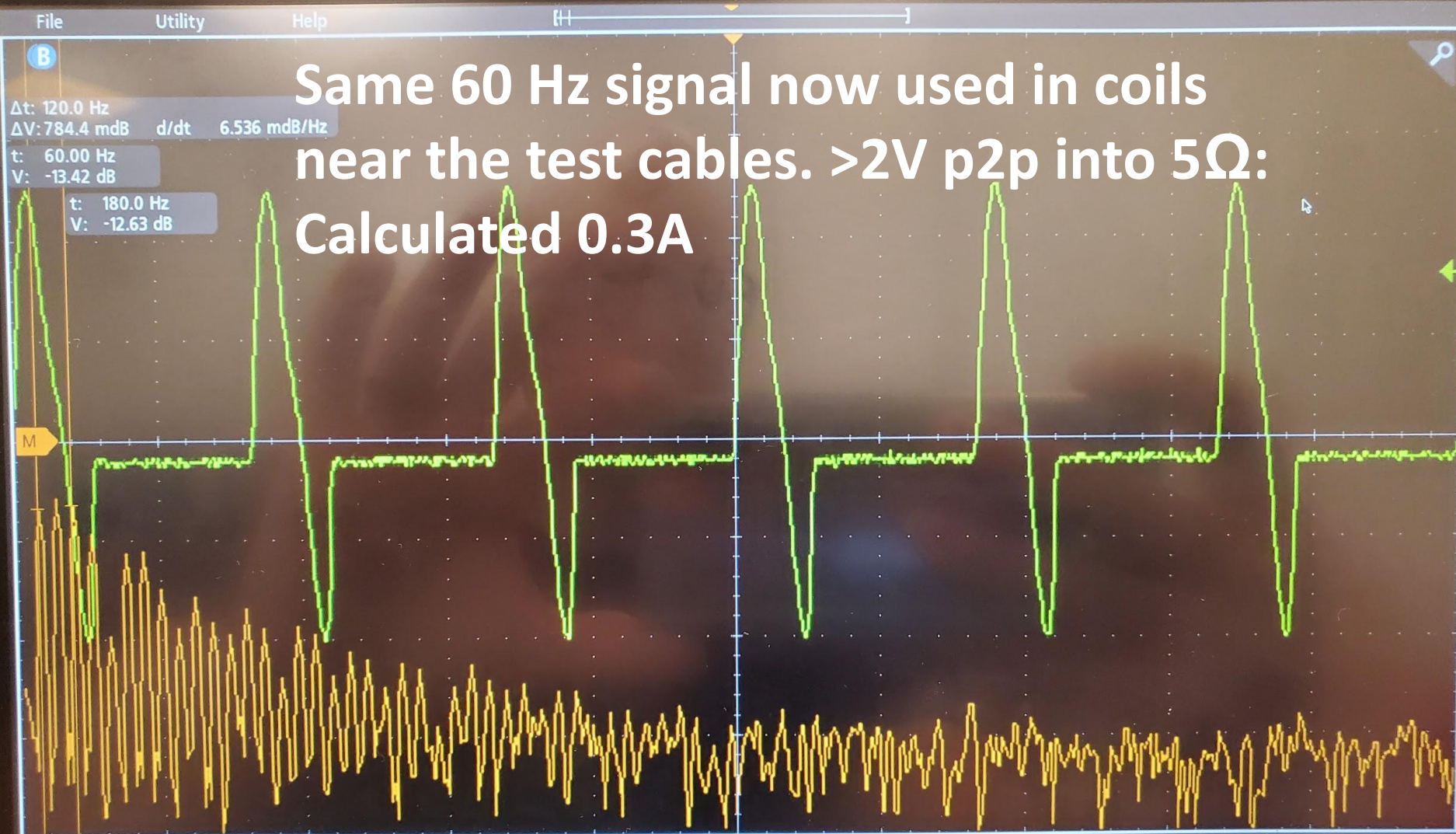
“Vintage” frequency generator capable of higher, but noisier output (vacuum tube driven) than modern digital models.

This signal to be used in a pre-constructed Helmholtz coil.

(Noisy) 60 Hz Signal not connected to coils near the test cables. >20V p2p



Same 60 Hz signal now used in coils near the test cables. >2V p2p into 5Ω:
Calculated 0.3A



Δt: 120.0 Hz
ΔV: 784.4 mdB d/dt 6.536 mdB/Hz
t: 60.00 Hz
V: -13.42 dB
t: 180.0 Hz
V: -12.63 dB

Ch 4
500 mV/div
1 MΩ
500 MHz Bw

Math
20.0 dB/div
FFT(Ch 4)

1 2 3 D15 -D0 Math Ref Bus

Horizontal
10.0 ms/div
SR: 10.0 kS/s
RL: 1 kpts

Trigger 4
810 mV
59.9984 Hz

Acquisition
Sample
1.864 kAcqs

Tektronix

3 SERIES MIXED DOMAIN OSCILLOSCOPE



Run / Stop Single / Seq

Cursor Fast Acq High Res Clear

TRIGGER

Force Ready Level

UNI-T UT58A

AC 0.34 V

Connect Test Leads

POWER 200k 20k 2M 20M 200M 2000M

20mA 200mA 2000mA 20000mA

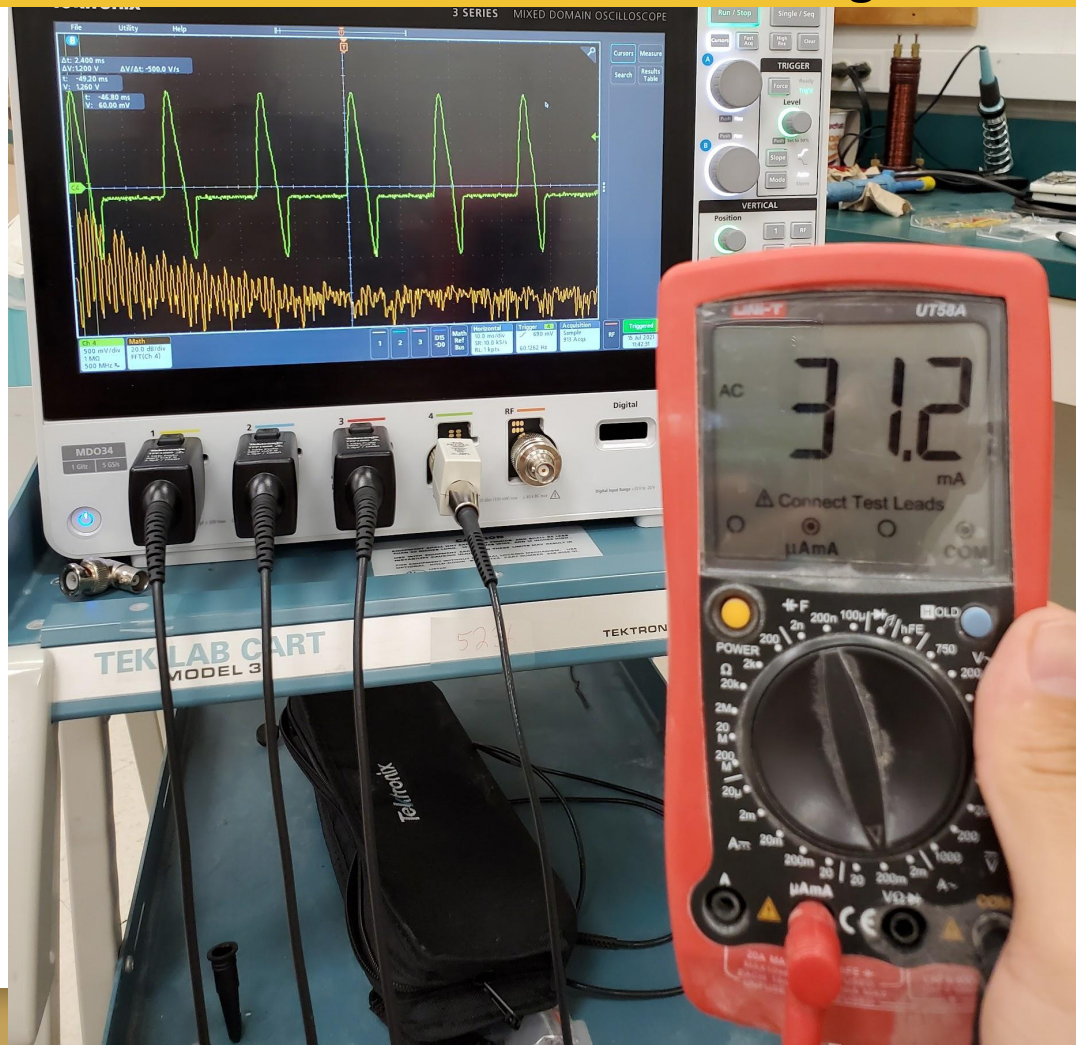
20A MAX EACH 15min UNFUSED

TEK LAB CART MODEL 3

523

TEKTRONIX, INC., BEAVERTON, OR, U.S.A.

Green Signal is 60 Hz Noise through coils
Because of the odd shape of the waveform, the meter
measures 10x less current than calculated through the coils.
FFT shows harmonics of 60 in lower range: 60 - 900 Hz



File Utility Help

A B

Δt: 20.25 MHz
 ΔV: 25.88 dB
 d/dt -1.278 μdB/Hz
 t: 5.000 MHz
 V: -23.26 dB

t: 25.25 MHz
 V: -49.14 dB

4 signals:

Green Signal is 60 Hz Noise through coils

Yellow: (Shown behind blue) Unshielded power cable

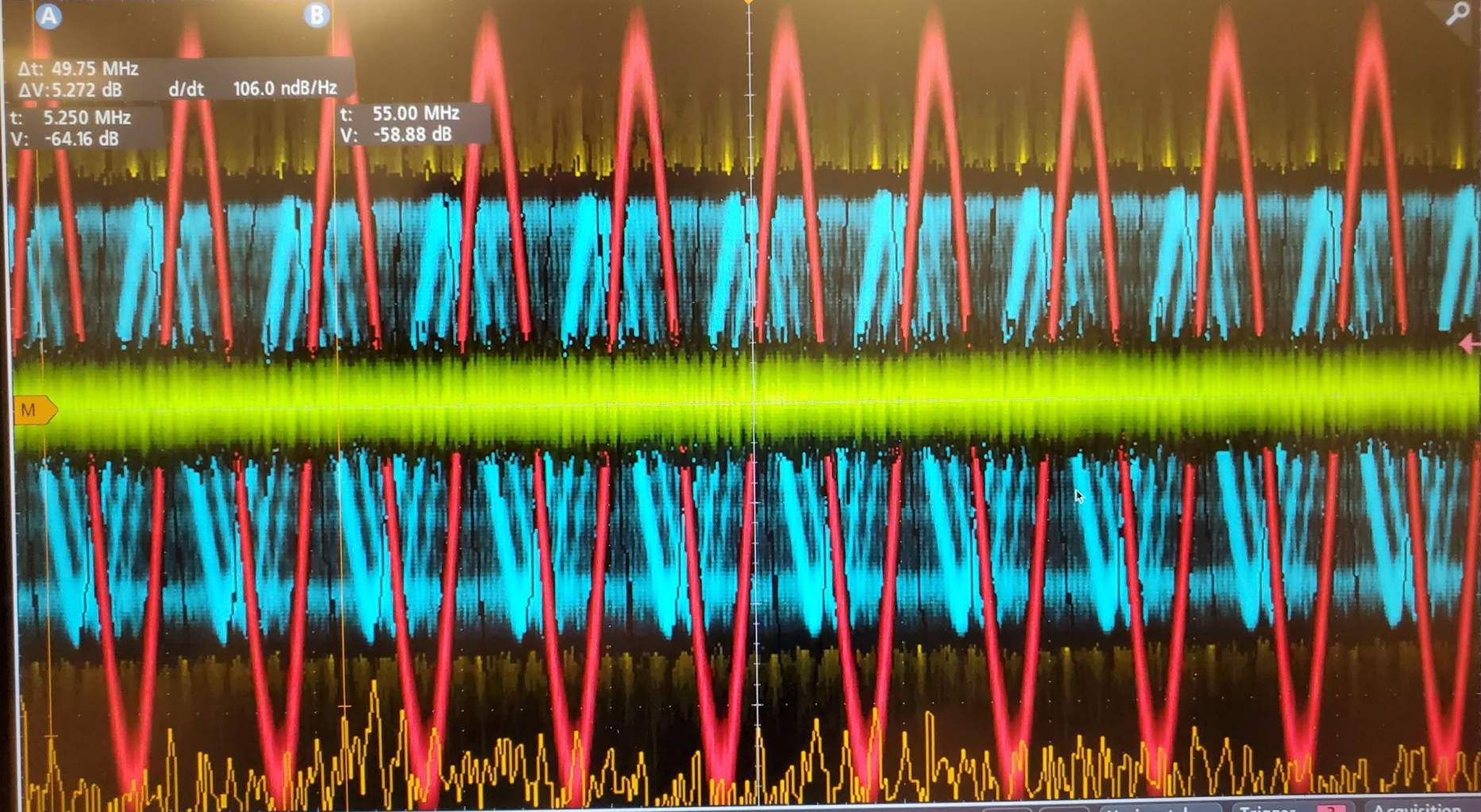
Blue: Shielded Coax Cable

Red: HDMI (One signal wire of 5)

M

Ch 1 50.0 mV/div 1 GHz	Ch 2 50.0 mV/div 1 GHz	Ch 3 50.0 mV/div 1 GHz	Ch 4 50.0 mV/div 1 MΩ 500 MHz B_w	Math 20.0 dB/div FFT(Ch 1)	D15 -D0	Math Ref Bus	Horizontal 200 ns/div SR: 500 MS/s RL: 1 kpts	Trigger 3 25.0 mV 5.00589 MHz	Acquisition Sample 29.94 MA
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File Utility Help



Ch 1
50.0 mV/div
1 GHz

Ch 2
50.0 mV/div
1 GHz

Ch 3
50.0 mV/div
1 GHz

Ch 4
50.0 mV/div
1 M Ω
500 MHz B_w

Math
20.0 dB/div
FFT(Ch 4)

D15
-D0

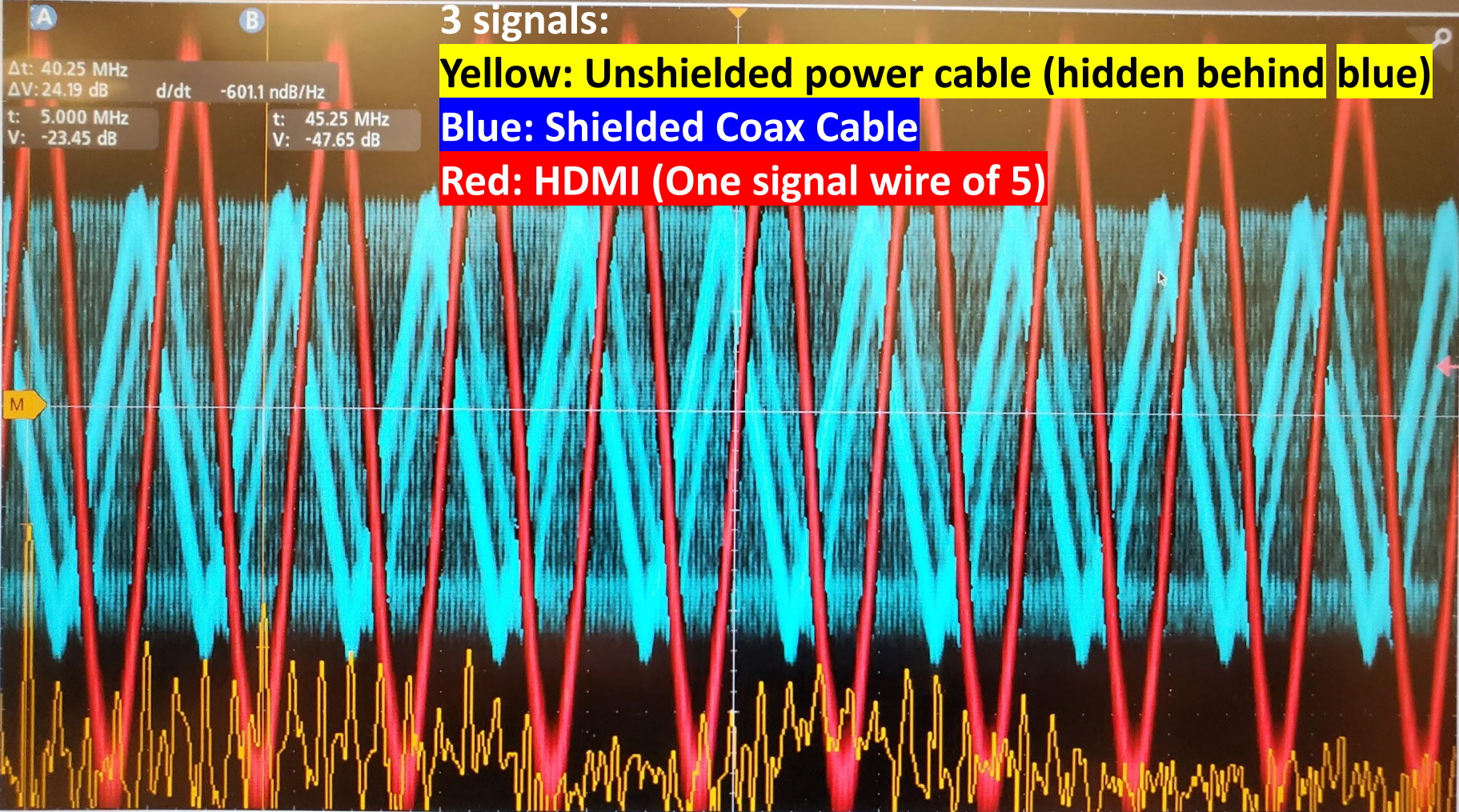
Math
Ref
Bus

Horizontal
200 ns/div
SR: 500 MS/s
RL: 1 kpts

Trigger 3
25.0 mV
5.00424 MHz

Acquisition
Sample
32.81 MAcqs

File Utility Help



Ch 1 100 mV/div 1 GHz	Ch 2 50.0 mV/div 1 GHz	Ch 3 50.0 mV/div 1 GHz	Math 20.0 dB/div FFT(Ch 1)
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4	D15 -D0	Math Ref Bus	Horizontal 200 ns/div SR: 500 MS/s RL: 1 kpts	Trigger 3 25.0 mV 5.00274 MHz	Acquisition Sample 2.564 MAcqs
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File Utility Help

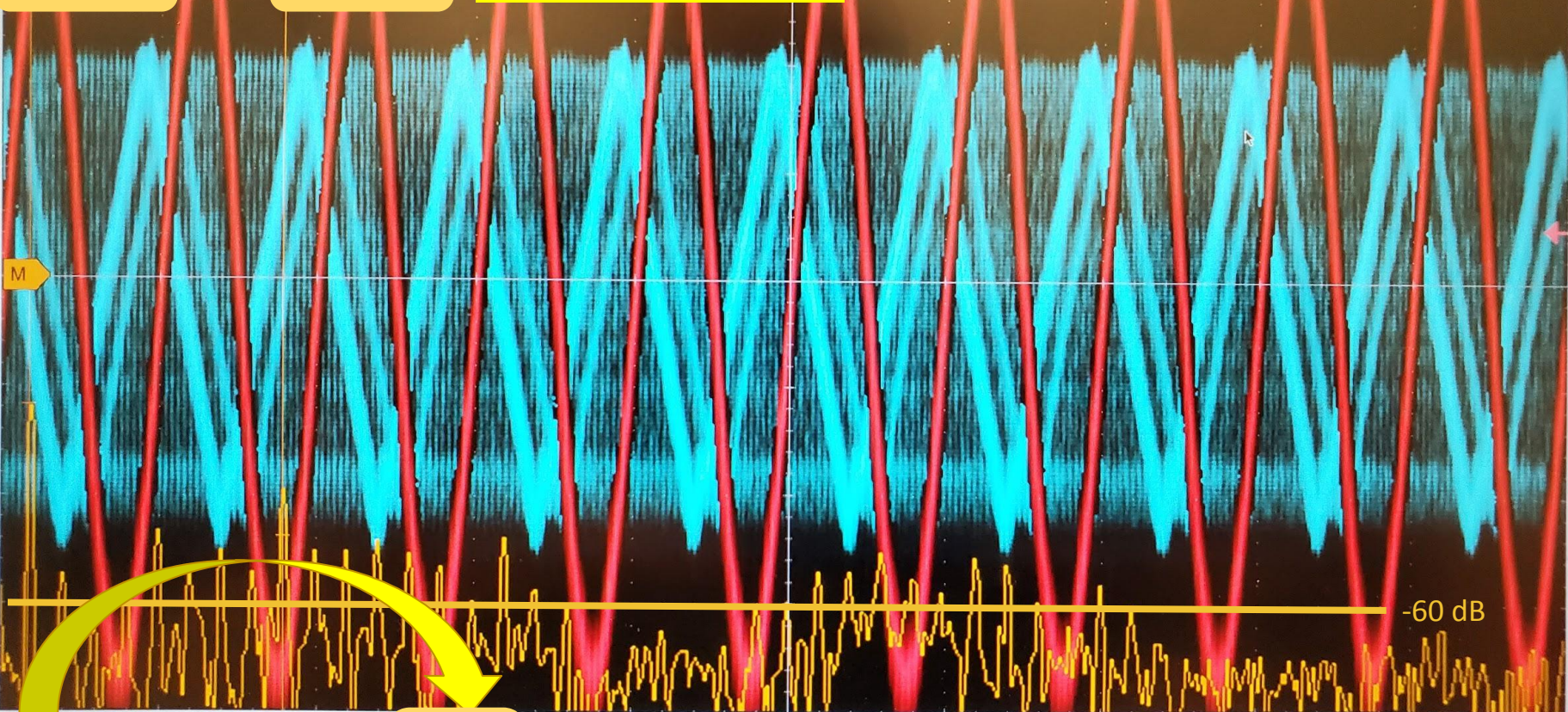
60 Hz Noise analysis:

**Yellow (power cable): 200mV p2p
(signal not shown)**

Δt: 40.25 MHz
ΔV: 24.19 dB
d/dt -601.1 ndB/Hz

t: 5.000 MHz
V: -23.45 dB

t: 45.25 MHz
V: -47.65 dB



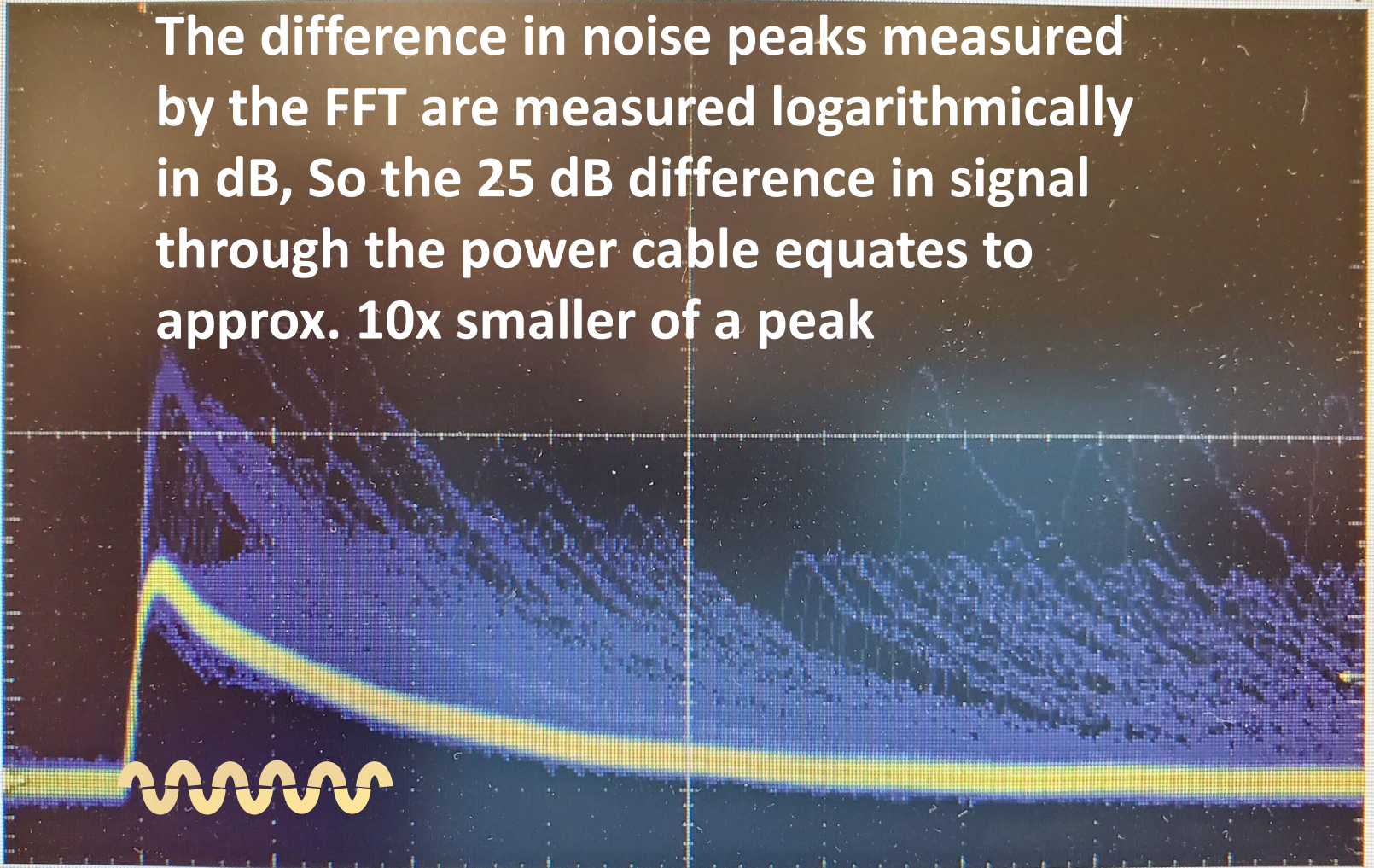
Ch 1 100 mV/div 1 GHz	Ch 2 50.0 mV/div 1 GHz	Ch 3 50.0 mV/div 1 GHz	Math 20.0 dB/div FFT(Ch 1)
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4	D15 -D0	Math Ref Bus	Horizontal 200 ns/div SR: 500 MS/s RL: 1 kpts	Trigger 3 25.0 mV 5.00274 MHz	Acquisition Sample 2.564 MAcqs
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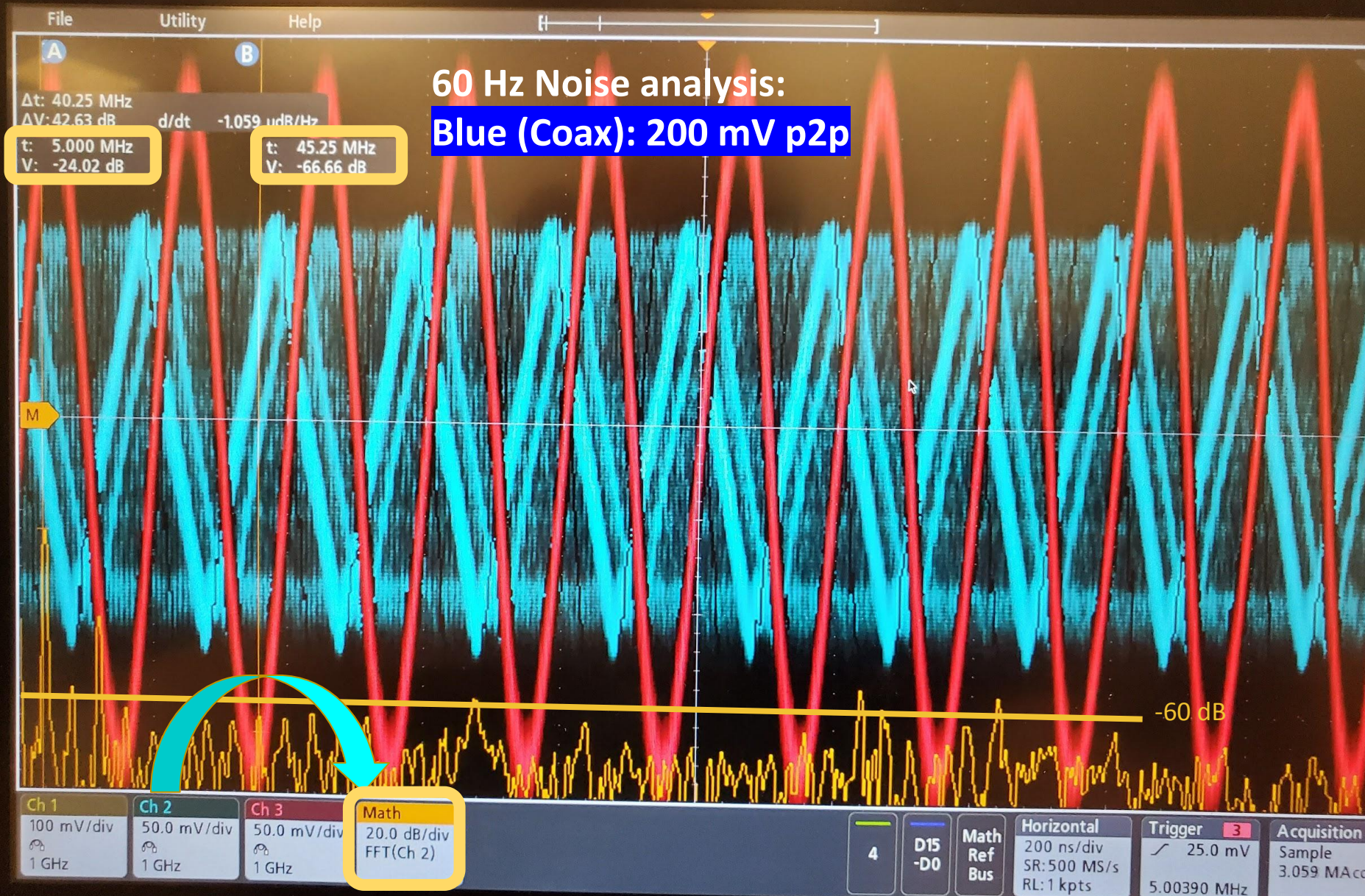
$$(M=1.25 \times 10^6)$$

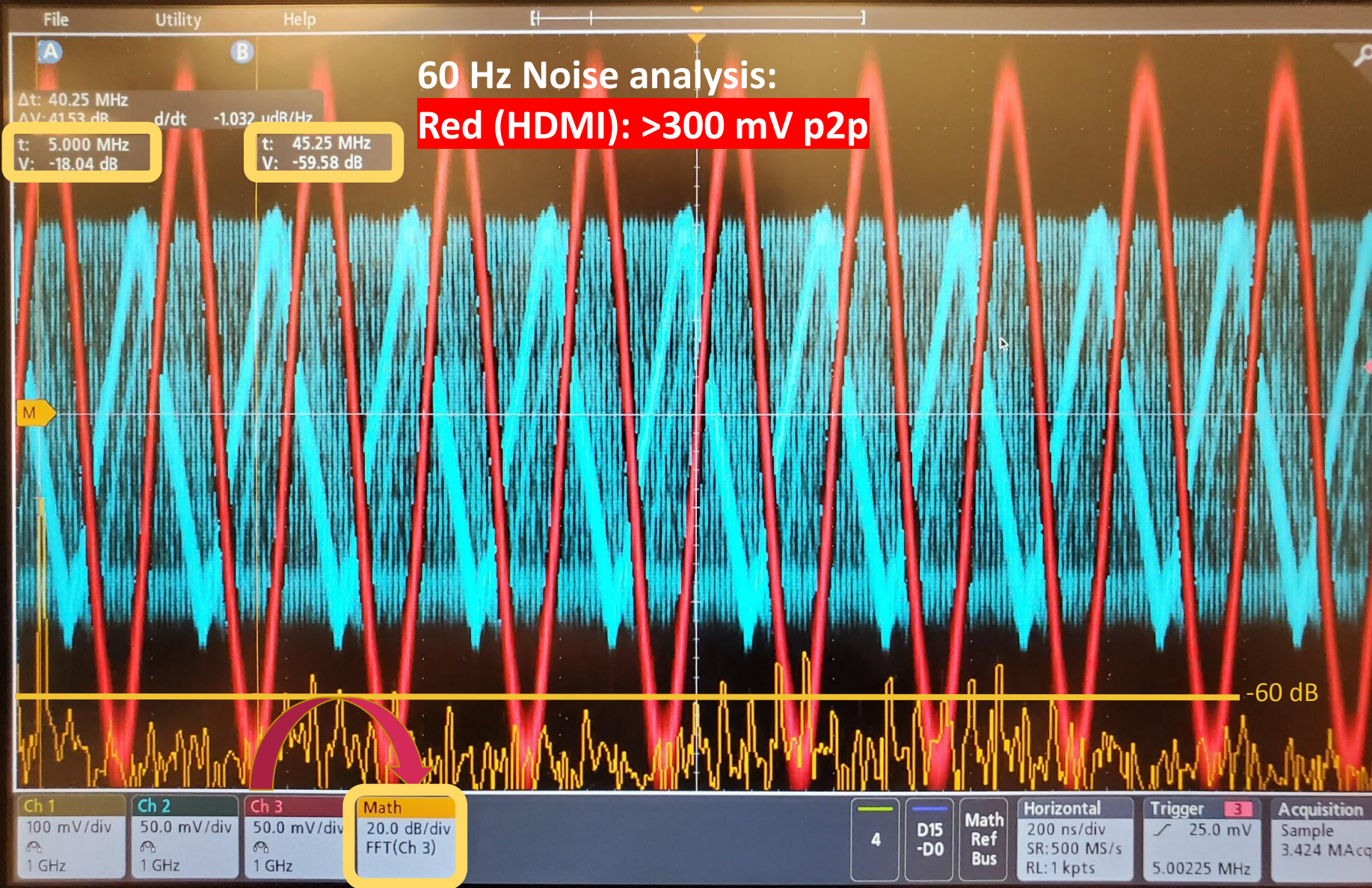
The difference in noise peaks measured by the FFT are measured logarithmically in dB, So the 25 dB difference in signal through the power cable equates to approx. 10x smaller of a peak

50 mV



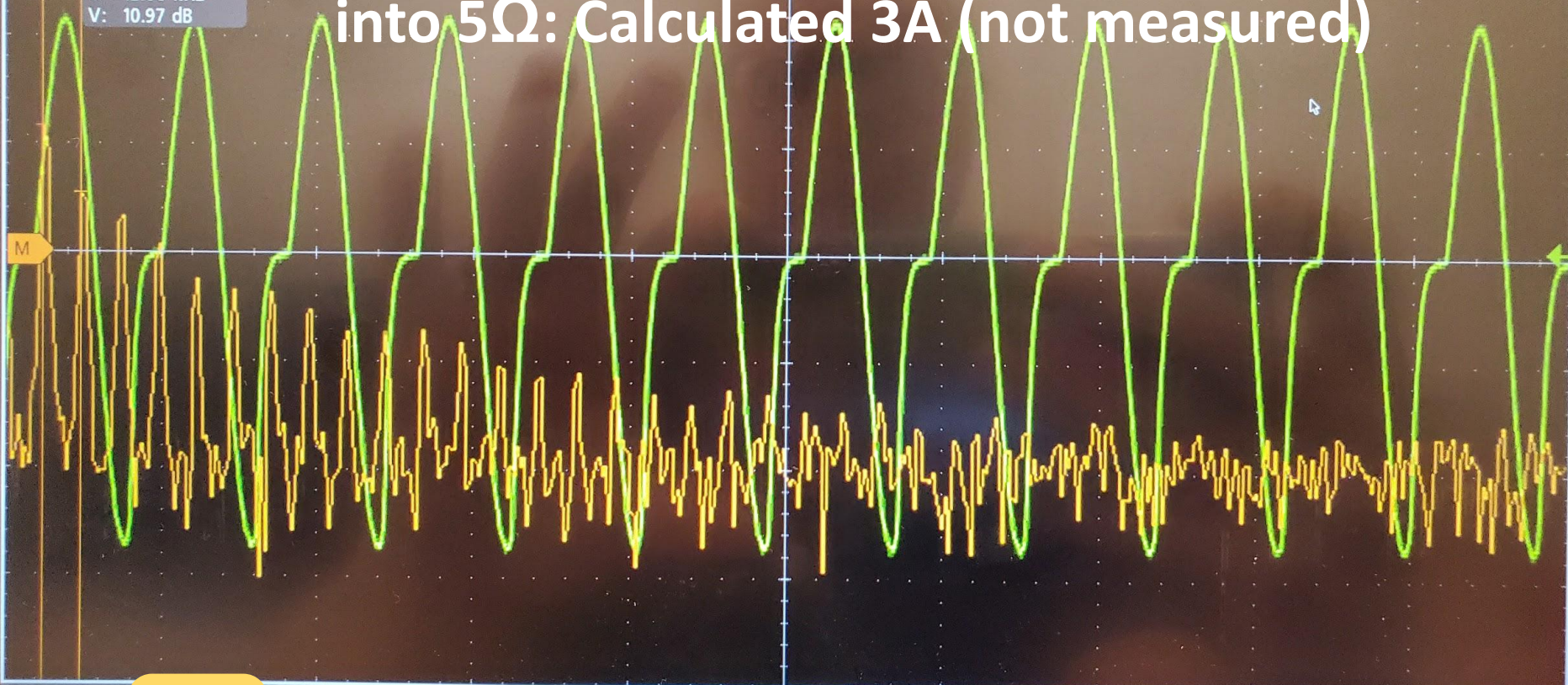
10 ns





Increase the noise frequency in the coils from 60 Hz to 6 kHz signal. >20V p2p into 5Ω: Calculated 3A (not measured)

Δt: 6.000 kHz
ΔV: 12.07 dB d/dt -2.011 mdB/Hz
t: 6.000 kHz
V: 23.04 dB
t: 12.00 kHz
V: 10.97 dB



Ch 4
10.0 V/div
1 MΩ
500 MHz BW

Math
20.0 dB/div
FFT(Ch 4)

1 2 3 D15 -D0 Math Ref Bus

Horizontal
200 μs/div
SR: 500 kS/s
RL: 1 kpts

Trigger 4
600 mV
6.09195 kHz

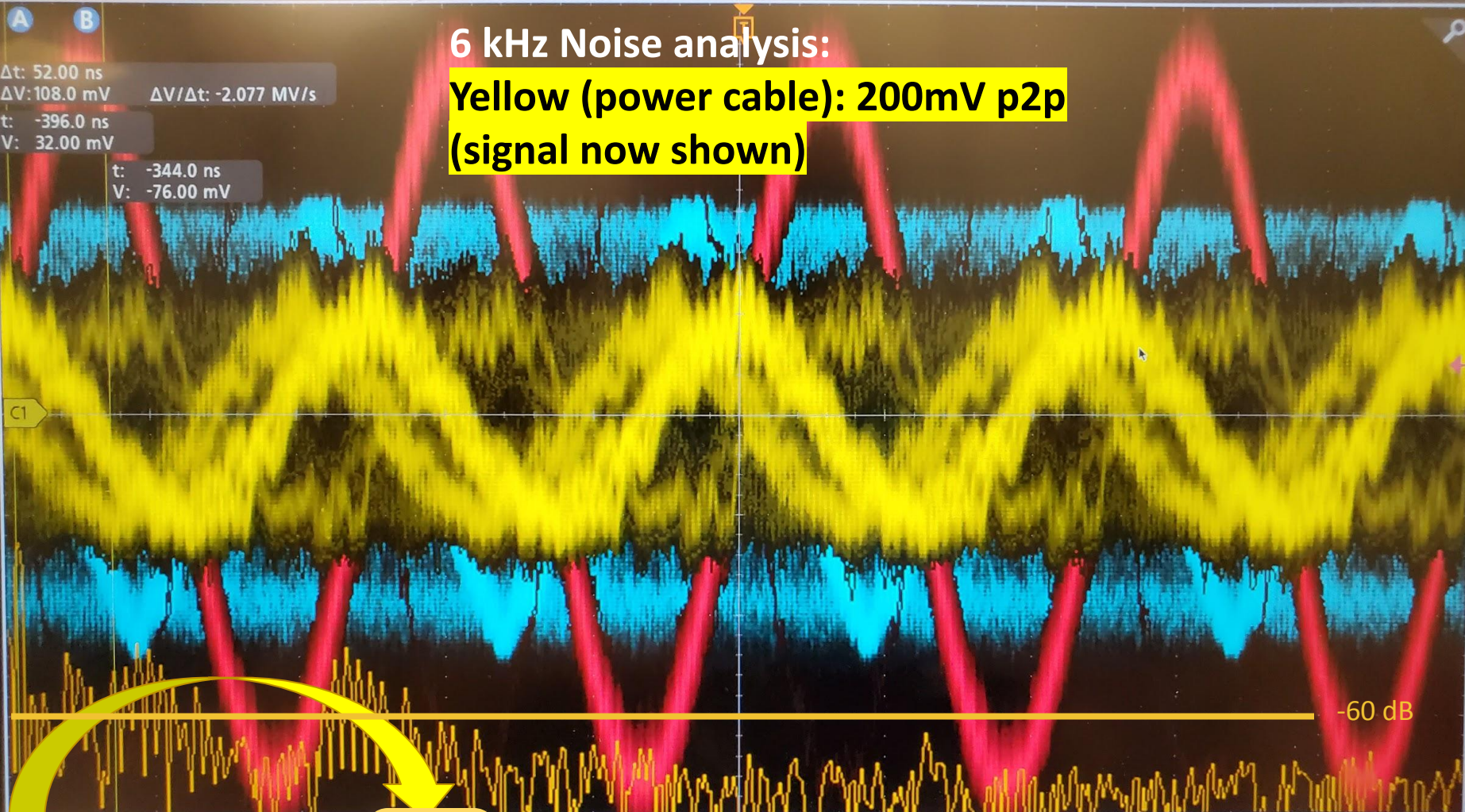
Acquisition
Sample
26.17 kAcqs

File Utility Help

6 kHz Noise analysis:

**Yellow (power cable): 200mV p2p
(signal now shown)**

Δt : 52.00 ns
 ΔV : 108.0 mV $\Delta V/\Delta t$: -2.077 MV/s
t: -396.0 ns
V: 32.00 mV
t: -344.0 ns
V: -76.00 mV

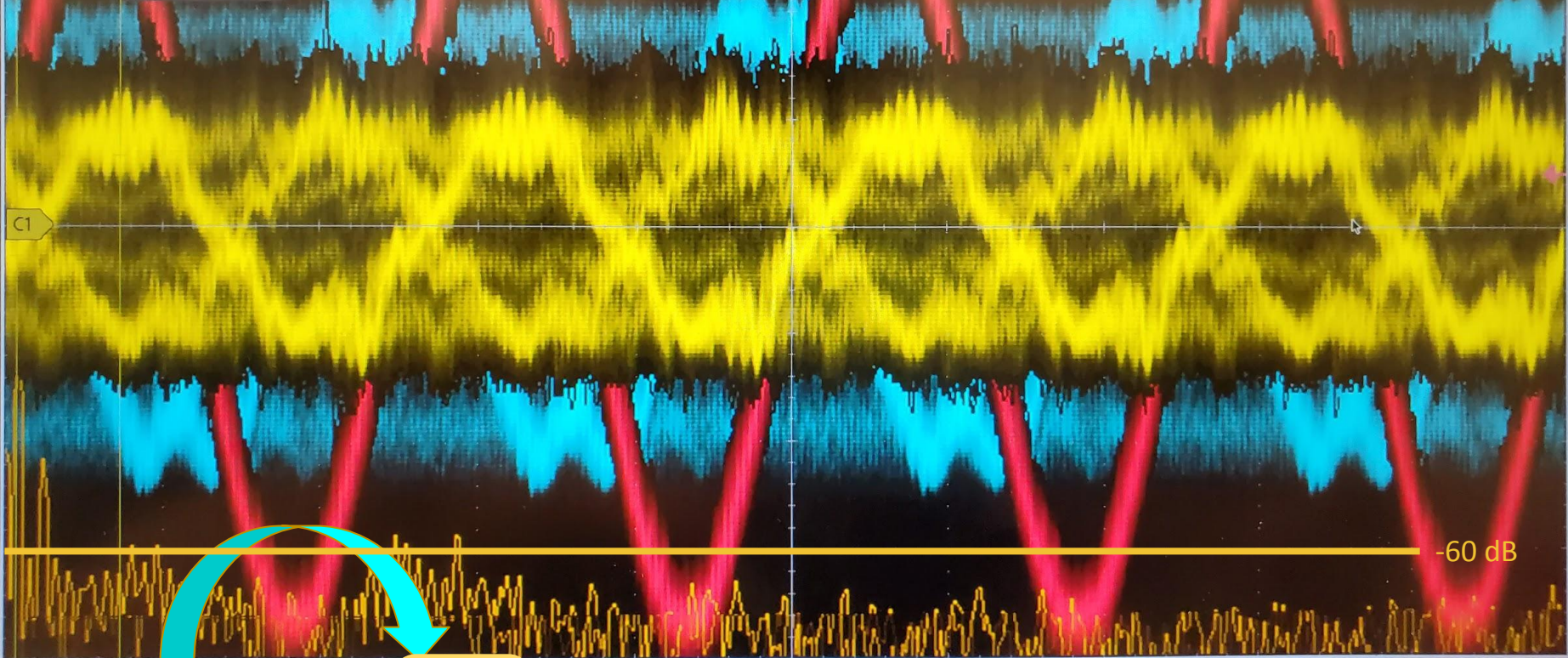


Ch 1 100 mV/div 1 GHz	Ch 2 50.0 mV/div 1 GHz	Ch 3 50.0 mV/div 1 GHz	Math 20.0 dB/div FFT(Ch 1)	4	D15 -D0	Math Ref Bus	Horizontal 80.0 ns/div SR: 1.25 GS/s RL: 1 kpts	Trigger 3 25.0 mV 5.00457 MHz	Acquisition Sample 2.320 MAcqs
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File Utility Help

A **B**
 Δt : 52.00 ns
 ΔV : 92.00 mV $\Delta V/\Delta t$: 1.769 MV/s
 t : -396.0 ns
 V : -28.00 mV
 t : -344.0 ns
 V : 64.00 mV

6 kHz Noise analysis:
Blue (Coax): 200 mV p2p



Ch 1 100 mV/div 1 GHz	Ch 2 50.0 mV/div 1 GHz	Ch 3 50.0 mV/div 1 GHz	Math 20.0 dB/div FFT(Ch 2)
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4	D15 -D0	Math Ref Bus	Horizontal 80.0 ns/div SR: 1.25 GS/s RL: 1 kpts	Trigger 3 25.0 mV 5.00342 MHz	Acquisition Sample 3.029 MAcqs
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File Utility Help

6 kHz Noise analysis:

Red (HDMI): >300 mV p2p

Δt : 52.00 ns
 ΔV : 152.0 mV $\Delta V/\Delta t$: -2.923 MV/s
t: -396.0 ns
V: 60.00 mV

t: -344.0 ns
V: -92.00 mV

C1

-60 dB

Ch 1
100 mV/div
1 GHz

Ch 2
50.0 mV/div
1 GHz

Ch 3
50.0 mV/div
1 GHz

Math
20.0 dB/div
FFT(Ch 3)

4

D15
-D0

Math
Ref
Bus

Horizontal
80.0 ns/div
SR: 1.25 GS/s
RL: 1 kpts

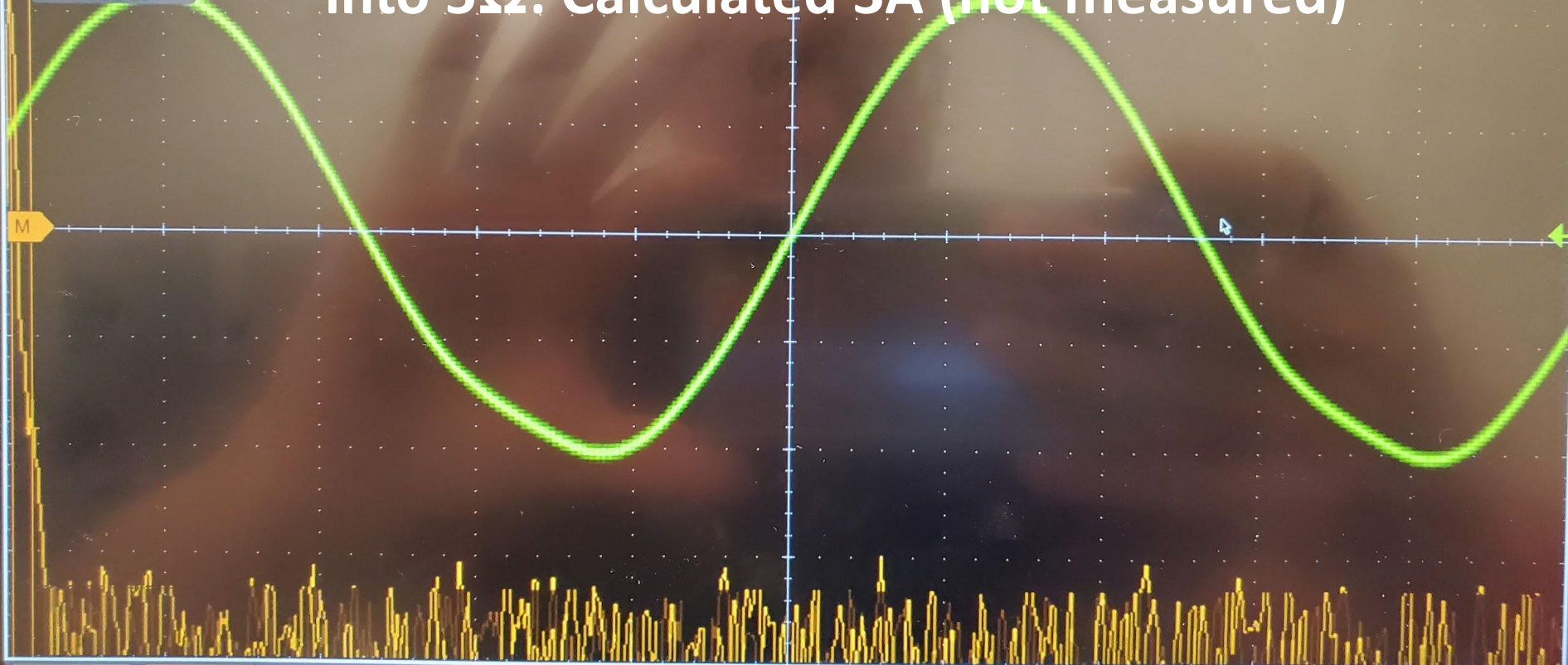
Trigger 3
25.0 mV
5.00530 MHz

Acquisition
Sample
3.513 MAcqs

File Utility Help

Increase the noise frequency in the coils from 6 kHz to 0.6 MHz signal. >20V p2p into 5Ω: Calculated 3A (not measured)

Δt: 1.525 MHz
 ΔV: 41.93 dB
 d/dt: -27.50 μdB/Hz
 t: 600.0 kHz
 V: 23.35 dB
 t: 2.125 MHz
 V: -18.58 dB



Ch 4
 10.0 V/div
 1 MΩ
 500 MHz BW

Math
 10.0 dB/div
 FFT(Ch 4)

1 2 3 D15 -D0 Math Ref Bus

Horizontal
 400 ns/div
 SR: 250 MS/s
 RL: 1 kpts

Trigger 4
 600 mV
 469.126 kHz

Acquisition
 Sample
 4.106 MAcqs

0.6 MHz Noise analysis:

**Yellow (power cable): 200mV p2p
(signal now shown)**

File Utility Help

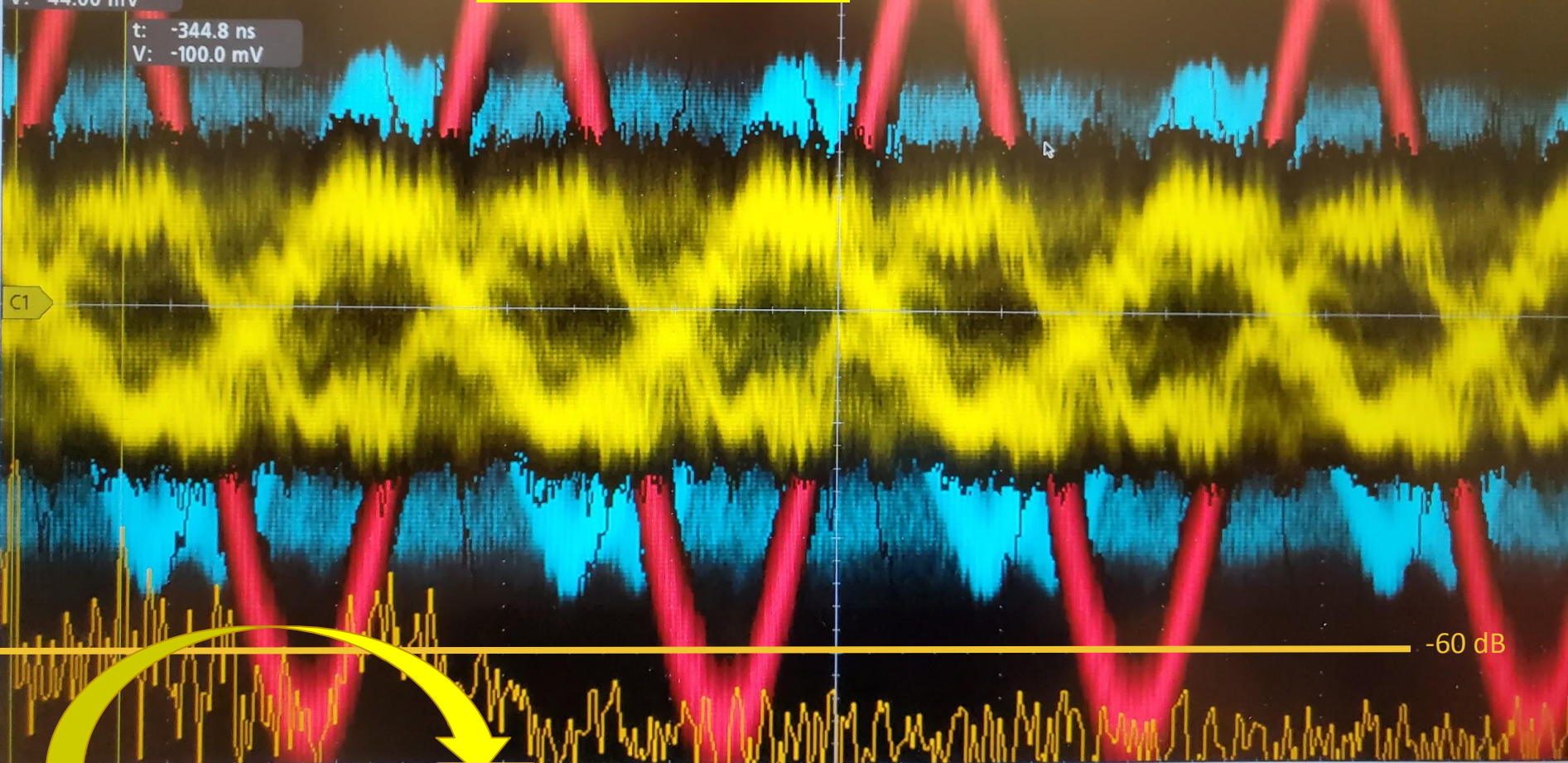
A **B**

Δt : 50.56 ns
 ΔV : 144.0 mV $\Delta V/\Delta t$: -2.848 MV/s

t : -395.4 ns
 V : 44.00 mV

t : -344.8 ns
 V : -100.0 mV

C1



-60 dB

Ch 1 100 mV/div 1 GHz	Ch 2 50.0 mV/div 1 GHz	Ch 3 50.0 mV/div 1 GHz	Math 20.0 dB/div FFT(Ch 1)	4	D15 -D0	Math Ref Bus	Horizontal 80.0 ns/div SR: 1.25 GS/s RL: 1 kpts	Trigger 3 25.0 mV 5.00156 MHz	Acqui 2.686
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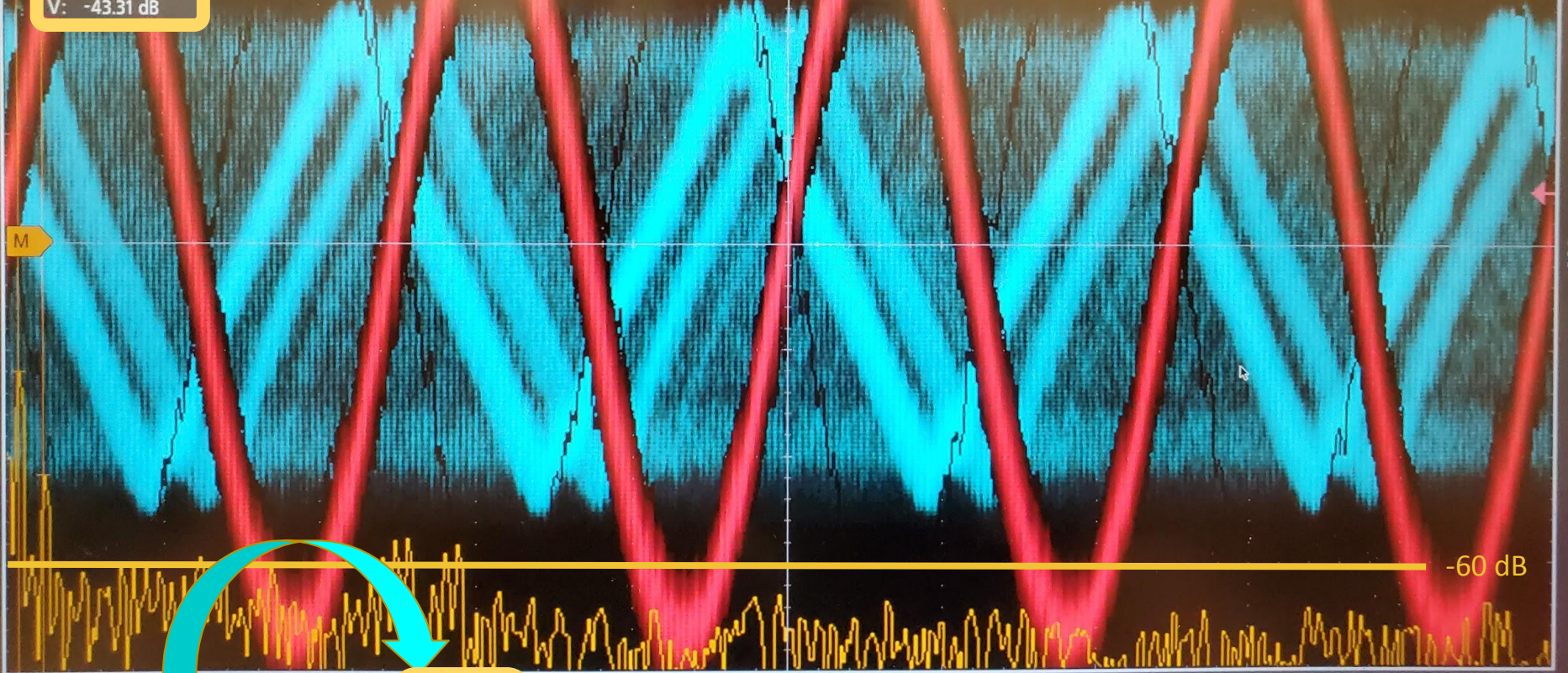
File Utility Help

0.6 MHz Noise analysis:
Blue (Coax): 200 mV p2p

Δt : 9.500 MHz
 ΔV : 19.27 dB
d/dt -2.028 μ B/Hz

t: 5.500 MHz
V: -24.04 dB

t: 15.00 MHz
V: -43.31 dB



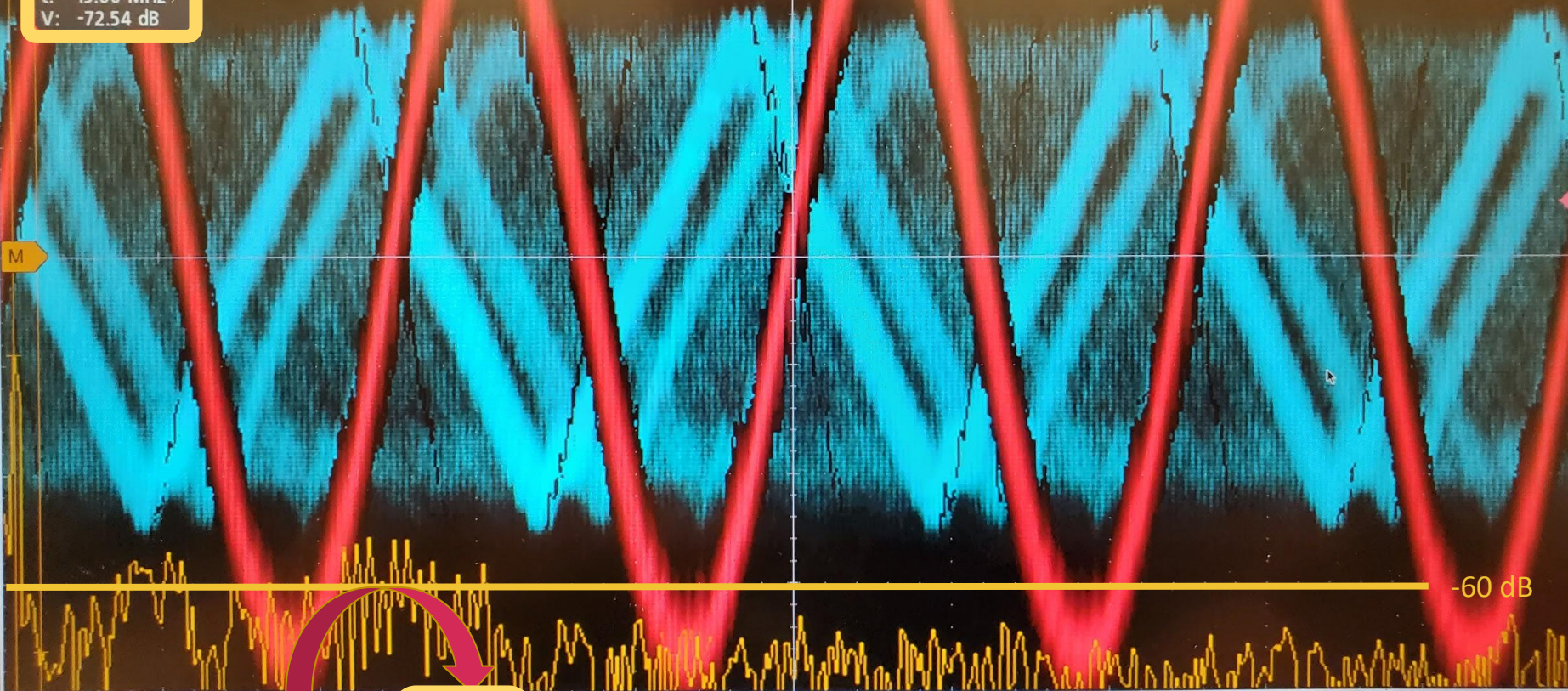
-60 dB

Ch 1 100 mV/div 1 GHz	Ch 2 50.0 mV/div 1 GHz	Ch 3 50.0 mV/div 1 GHz	Math 20.0 dB/div FFT(Ch 2)	4	D15 -D0	Math Ref Bus	Horizontal 80.0 ns/div SR: 1.25 GS/s RL: 1 kpts	Trigger 3 25.0 mV 5.00203 MHz	Acquisition Sample 3.826 MAcqs
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File Utility Help

B
Δt: 9.500 MHz
ΔV: 54.38 dB
d/dt -5.724 μdB/Hz
t: 5.500 MHz
V: -18.16 dB
t: 15.00 MHz
V: -72.54 dB

0.6 MHz Noise analysis:
Red (HDMI): >300 mV p2p



Ch 1 100 mV/div 1 GHz	Ch 2 50.0 mV/div 1 GHz	Ch 3 50.0 mV/div 1 GHz	Math 20.0 dB/div FFT(Ch 3)	4	D15 -D0	Math Ref Bus	Horizontal 80.0 ns/div SR: 1.25 GS/s RL: 1 kpts	Trigger 3 25.0 mV 5.00050 MHz	Acquisition Sample 4.572 MAcqs
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-60 dB

Next steps:

- The current measurement may have been off because of the distorted waveform in the circuit at 60 Hz.
 - A new current measurement should be taken with a higher frequency (less distortion in waveform) to ensure proper current.
- Try turning the coils by 90 degrees and remeasuring
- Increase the current in the coils when the waveform amp is available.
- Analyze non-used wire within shielding of HDMI pair for crosstalk.
- The Tektronics MDO34 scope is unable to measure FFT in the range of 0-5 kHz while displaying the waveform of the 5 kHz signal. It is unable to “zoom in” on that range while the window of waveform is so short.

Ordered for test bench:

- Accel Instruments Waveform Amplifier
 - 6 A/60 V amplifier
- Bulk HDMI cable with terminal ends



Thanks for your time