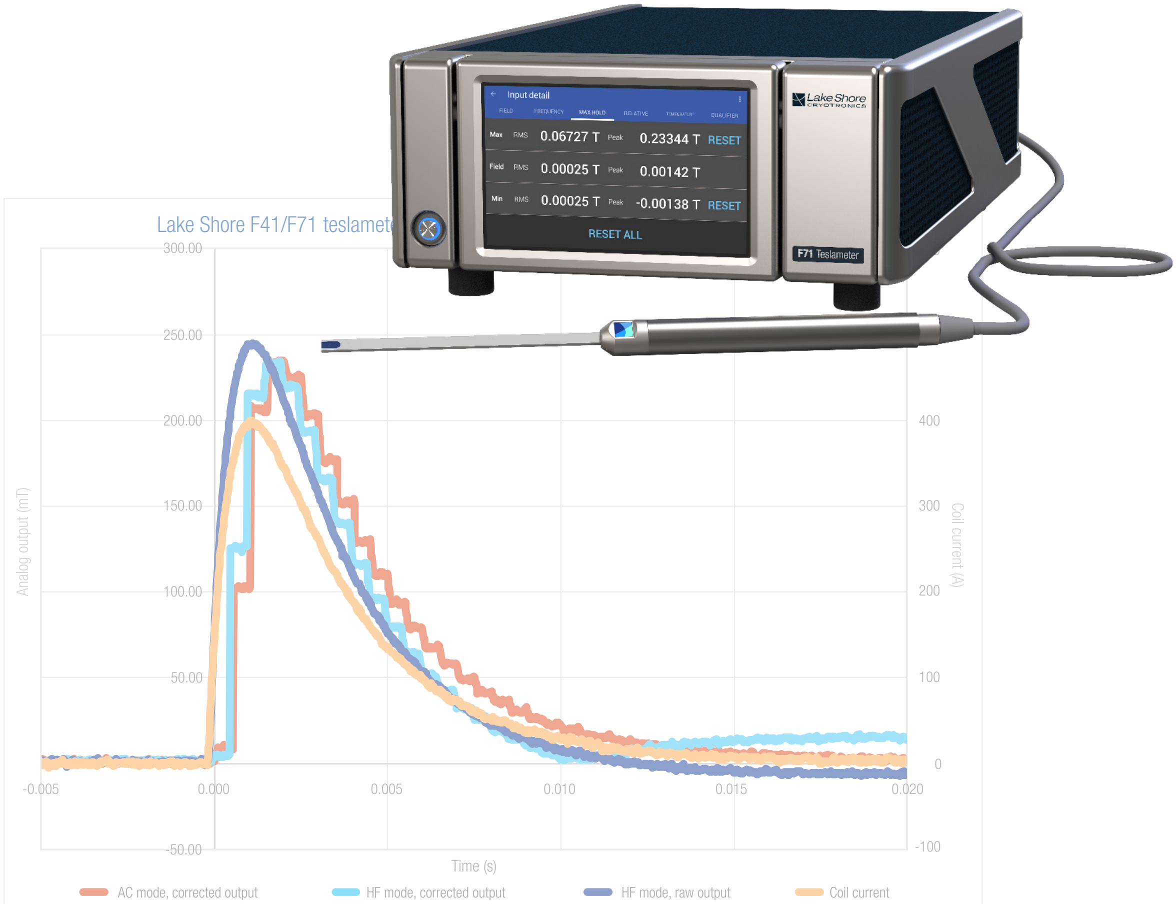
APPLICATION NOTE

Magnetic Pulse Capture with an F41 or F71 Teslameter

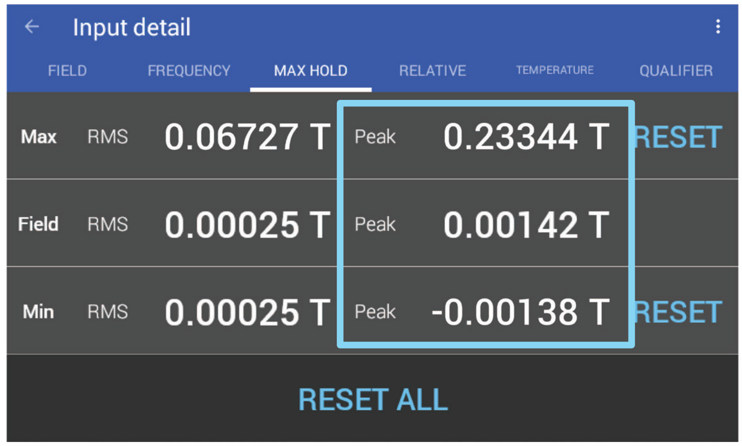


Requires teslameter firmware version 1.7 or later for functionality demonstrated in this application note. See downloads section of teslameter page on www.lakeshore.com for upgrade instructions.

Lake Shore CRYOTRONICS

Measuring the field peak

The easiest way to measure pulse peak is with the peak hold reading. View it on the front panel by tapping the max hold card in AC or high frequency (HF) mode. The peak hold feature will show both the most positive and the most negative peak value since the last reset. The peak values can also be queried from a remote interface.



AC max hold detail page

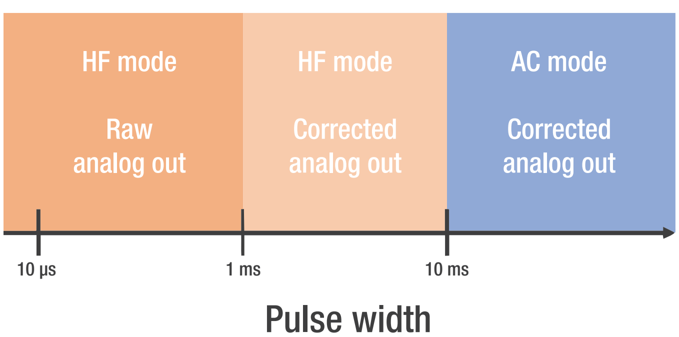
In AC mode

Highest accuracy for most pulses
AC mode uses modulated excitation and low pass filtering to provide the lowest noise and highest accuracy field peak measurements. However, it cannot measure magnetic pulse widths significantly narrower than 10 ms. For very fast pulses, use high frequency mode.

In high frequency (HF) mode

Good accuracy for very fast pulses
High frequency mode can measure the peak value of magnetic pulses with very narrow pulse widths. The 5 μs (200 kHz) time resolution measures extremely fast pulses, though with a reduction in accuracy and resolution compared to AC mode.

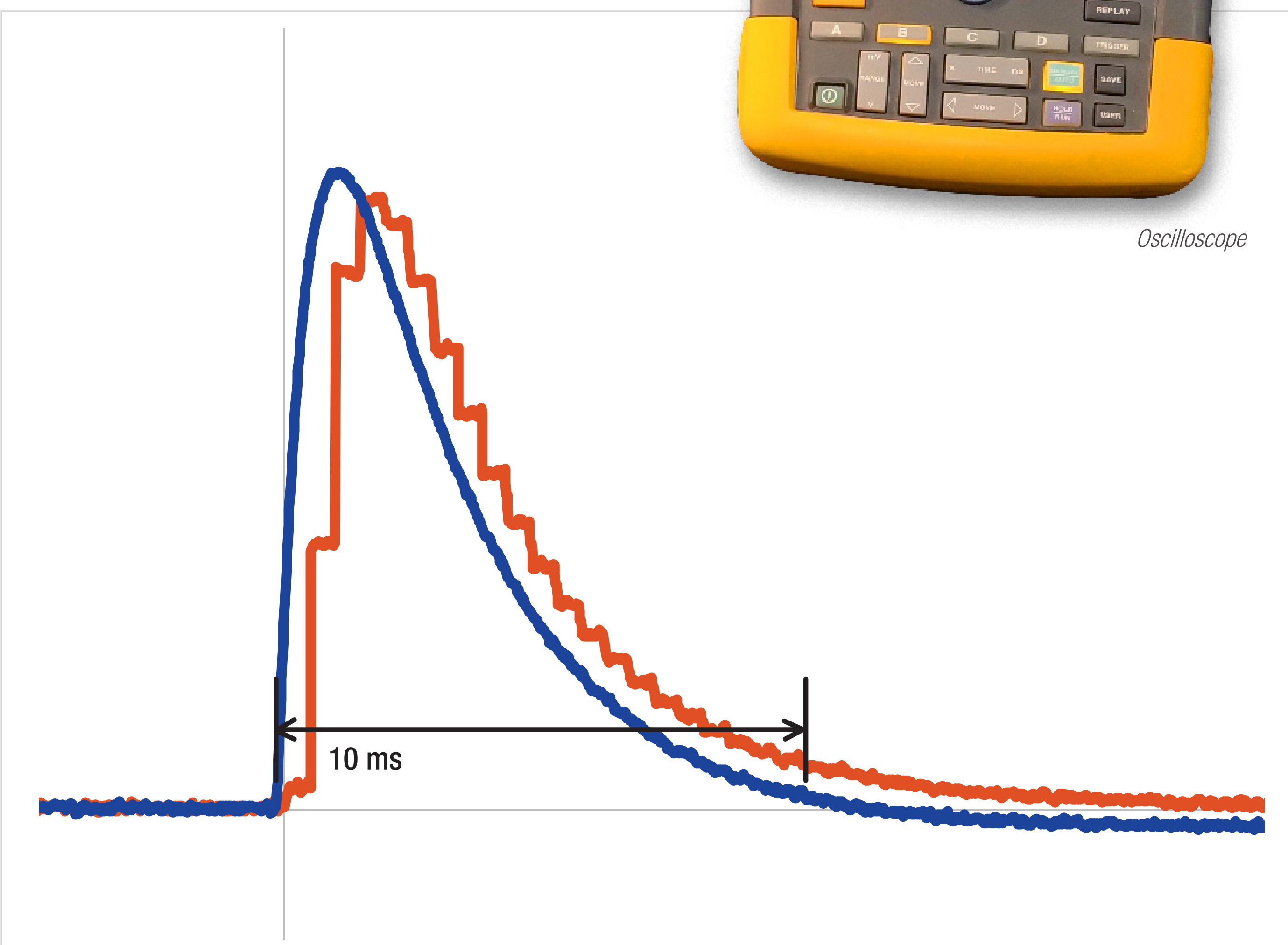
Recommended operating mode for a given pulse width



Viewing pulse shape

The best way to view the detailed shape of the pulse is to use the analog output. It provides a fast moving voltage that has a greater time resolution than the digital values. Connecting the output BNC to an oscilloscope (or some other high-speed voltage capture device) will provide a detailed view of the pulse shape.

Oscilloscope



Teslameter analog output of a field reading

Corrected output

View field pulses as a voltage with the best accuracy

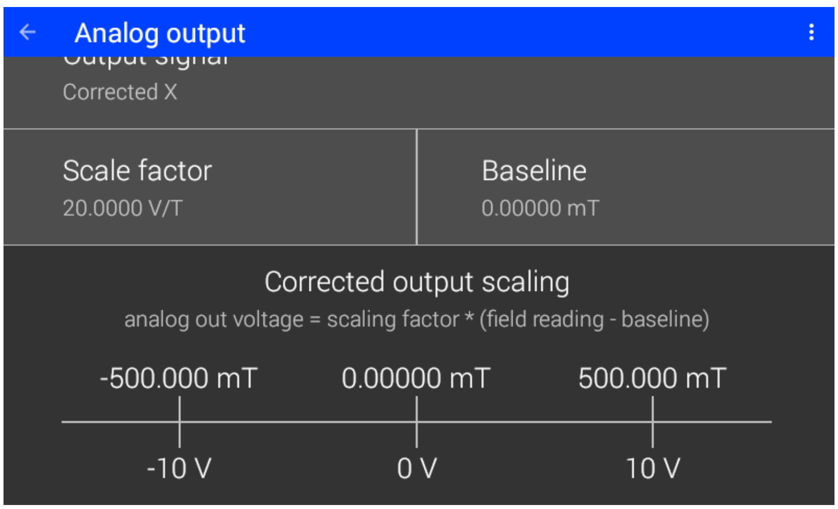
The corrected analog output is the best option for viewing most pulses. Output voltages are corrected to produce calibrated field values that update 2,000 times per second. The corrected output voltage scaling is customizable to maximize measurement resolution.

The below example is set for positive or negative pulses peaking at 500 mT or less. If the pulses were known to always be positive, resolution could be improved further by setting Baseline to 250 mT and doubling Scale factor to 40 V/T. This would result in -10 V output at 0 T and +10 V output at 500 mT.

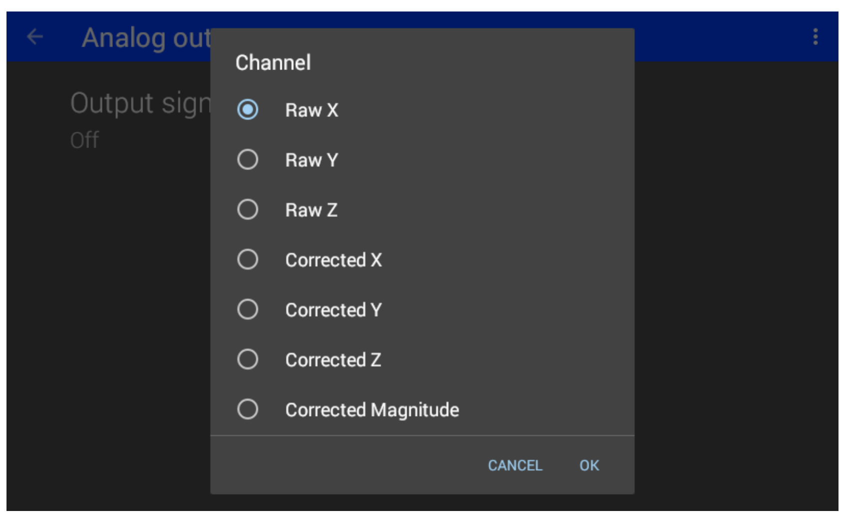
Raw output

View field pulses as a voltage with the best resolution

The raw analog output is useful when the pulse shape requires high time resolution (high bandwidth). This option connects the amplified Hall voltage directly to the output BNC. However, this makes it more difficult to convert the voltage back into field readings. The conversion factor can be calculated by referencing the digitally measured peak-to-peak values and dividing it by the peak voltage measured during that pulse. The raw output must come from the X, Y, or Z channel. If measuring pulses using a 3-axis sensor, the raw output cannot provide the magnitude field value. Choose the channel whose sensor is orthogonal to the pulse field direction.



Corrected analog out scaling settings



Analog out selection screen

***Note** The raw output is only useful in high frequency mode. In AC mode, the raw signal is modulated and therefore not useful.*

Best practices

Range

Manually selected field range

Most magnetic pulses move too quickly to allow time for the teslameter to change ranges automatically. To avoid range transitions from interrupting your measurement, manually set the range of the teslameter to something larger than the expected peak of the pulse. However, avoid setting it so high that you unnecessarily sacrifice resolution. For example, a 1 T peak pulse should use the 3.5 T range rather than the 35 T range.

An example

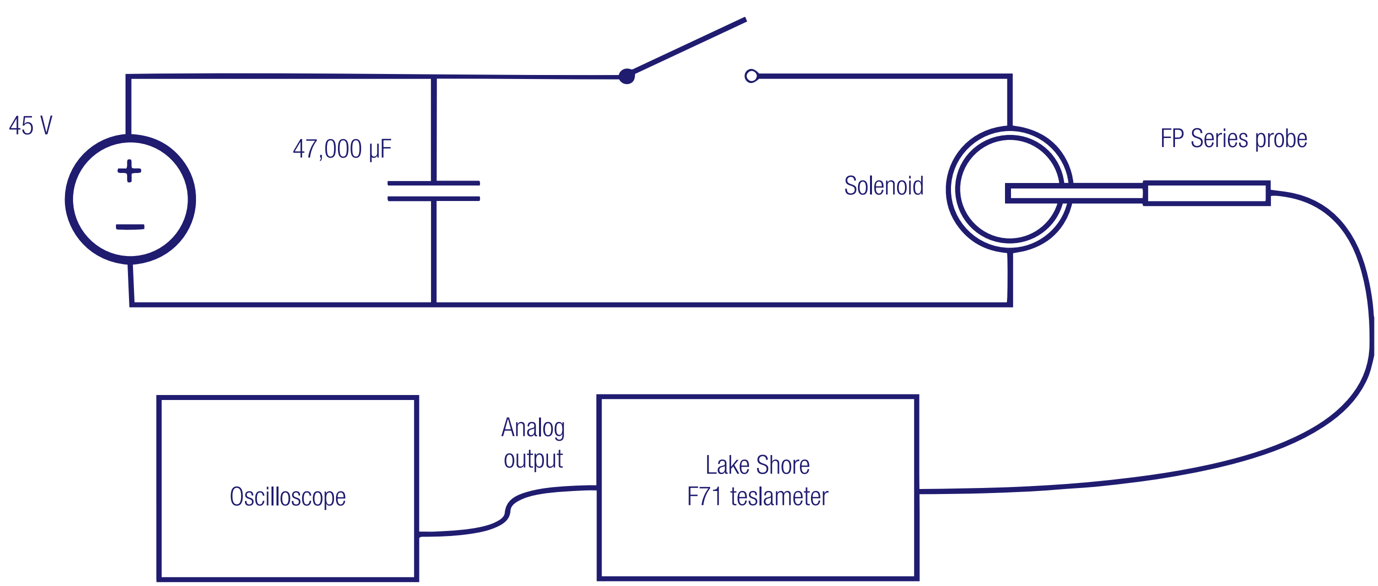
The following test demonstrates the pulse measurement capabilities of the F41 and F71 teslameters. These pulses were measured using different teslameter configurations to observe the difference beween these setups.

Hardware setup

A large capacitor is charged up to 45 V with a DC voltage source then discharged through a coil of heavy gauge wire to create a magnetic field pulse. Not shown in the diagram is a sense resistor used to measure current flowing through the coil.

Teslameter settings

The teslameter range is set to 350 mT because the field pulse is expected to be greater than 35 mT but less than 350 mT. The corrected analog output scaling is set to 20 V/T so that it matches the scaling of the raw analog out for easier comparison.

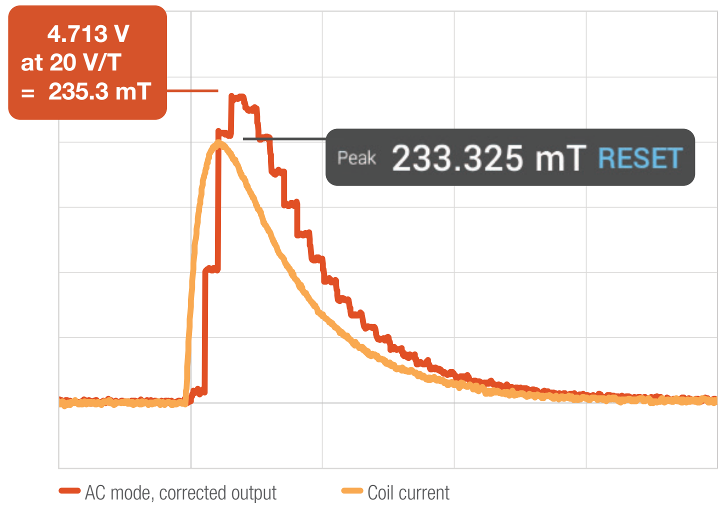


Results

The following data was collected from an oscilloscope and converted into field values.

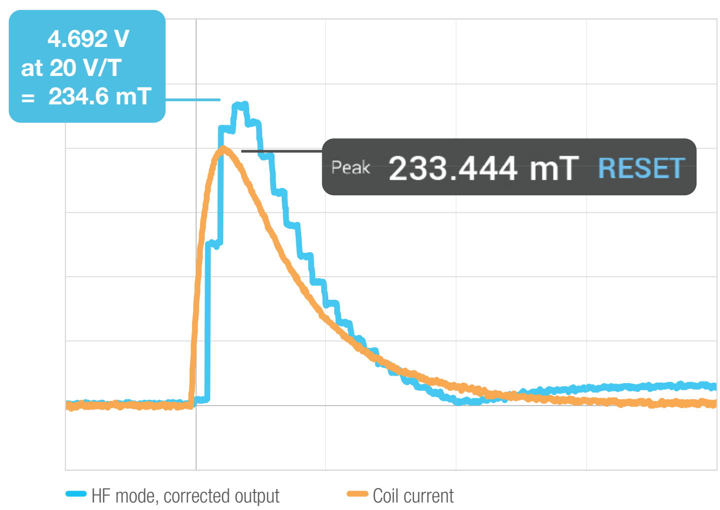
Test 1: AC mode with corrected analog out

- The 2,000 samples per second corrected analog output update rate is clearly seen in the discrete "steps" made by the signal.
- There is a small propagation delay between the current flowing through the coil and the corrected output update.
- The maximum output voltage hovered around 235 mT or within about 1% of the 233.325 mT peak field detected by the instrument.
- The pulse width is about 10 ms, which is just slow enough for AC mode.



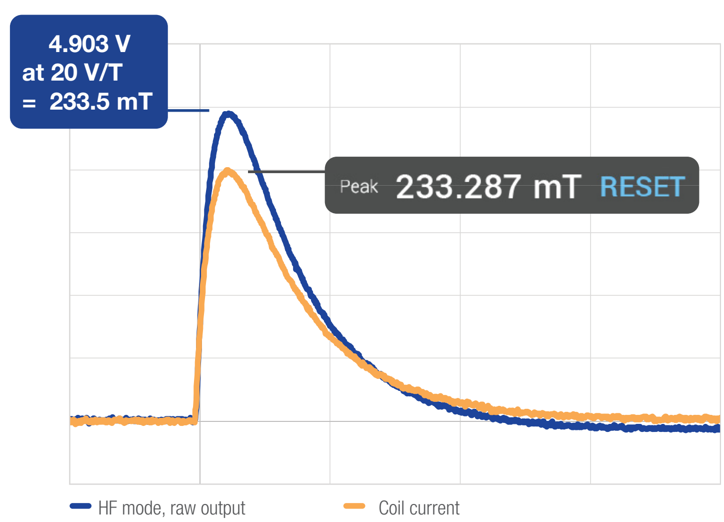
Test 2: HF mode with corrected analog out

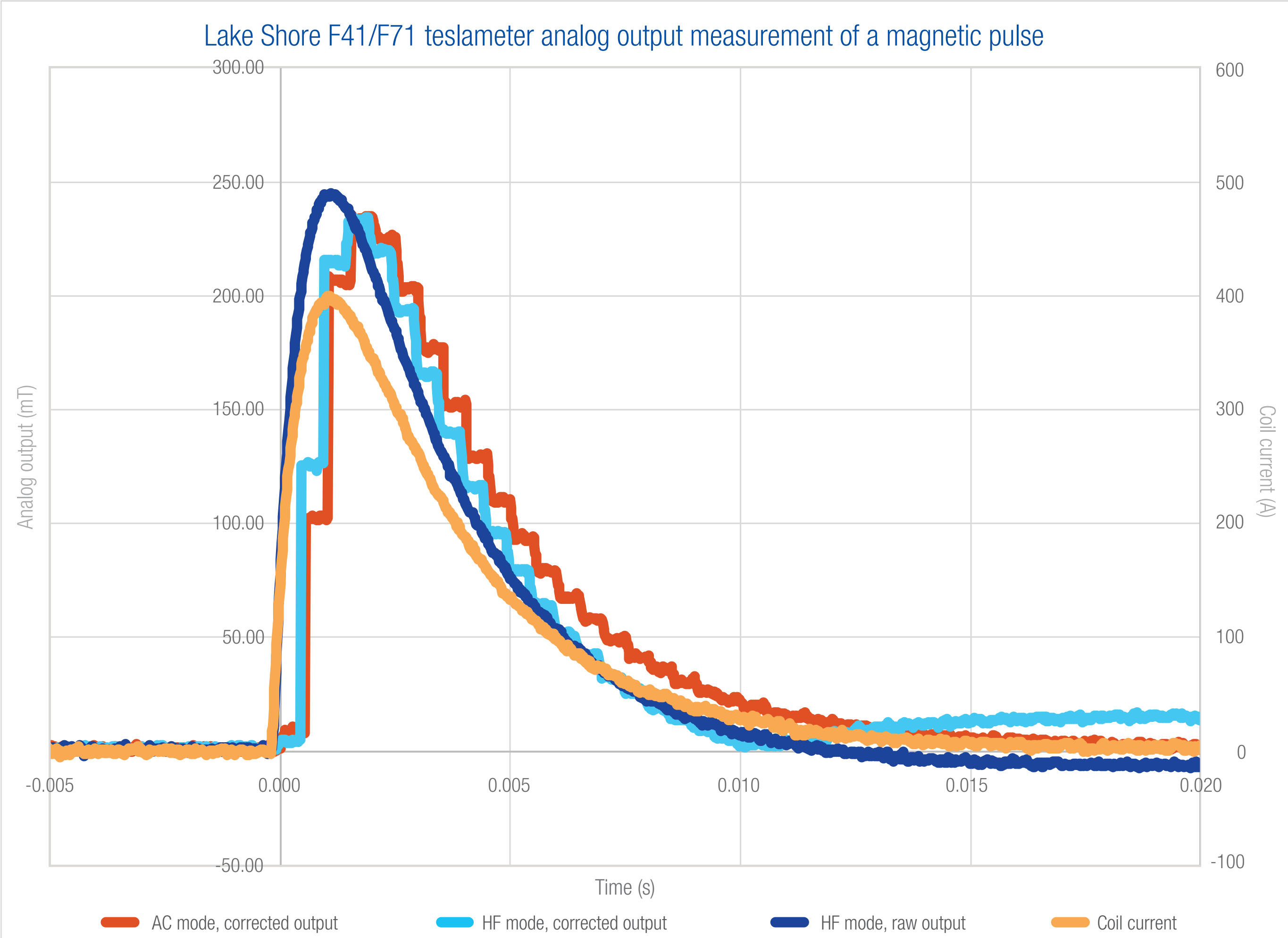
- Again, the update rate and propagation delay of the corrected analog output can be in the discrete time steps.
- The shape of the pulse is slightly different from AC mode due to the wider bandwidth and AC coupling.
- The 10 ms pulse width is fast enough to be observed with high frequency mode.
- For this particular pulse, the accuracy is similar between AC and high frequency mode.



Test 3: High frequency mode with raw analog out

- The curve is a purely analog signal, allowing for the highest possible time resolution and removing the propagation delay seen in corrected analog out.
- After this test, an adjusted conversion factor can be calculated. 20 V/T was used originally, resulting in a calculated peak value of 245 mT. Using 21 V/T would provide more accurate conversions for future pulses.
- The instrument peak hold measurement remains accurate.





	Test 1	Test 2	Test 3
Mode	AC	HF	HF
Analog output	Corrected	Corrected	Raw
Peak hold reading	233.325 mT	233.444 mT	233.287 mT
Analog output peak value	235.646 mT	234.596 mT	245.165 mT

For test 3, a peak voltage of 4.9033 V was measured, which converts to 245.165 mT using the initial correction factor of 20 V/T.

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Questions? Answers?

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