Technical Paper

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Raztec Current Sensor Speed

Background:

With the trend towards higher switching speeds in electronic devices and the increasing usage of very fast solid-state overload management there is a need for current sensors to perform above 1MHz. Many devices on the market presently don't output frequencies near 1MHz; particularly cored versions. Raztec has available to us, magnetic field sensors with frequency responses well above 1MHz which we can incorporate into our current sensors. In consequence, these current sensors can economically give good indication of high frequency switch-mode current and allow the very fast and economic detection of overload.

RAZC

SUPER COMPACT MODEL

Raztec Sensors
NEW ZEALAND LTD
Custom Current Sensing Solutions

How Fast is Fast?

Frequencies above 3MHz are possible.

State of the art is a few hundred kilohertz to 1MHz.

What are the issues?

The likelihood:

In practice in takes considerable voltage to drive high frequency currents.

The voltage across an inductor is V = Ldi/dt where L = inductance (H), i = current (A)

Or V = omega L I (omega being the radial frequency = 2 pi f)

Now any wire with a finite length has inductance. As a rule of thumb the inductance is 1nH/mm. One may think that this is negligible, and in most situations it is, but when we are at RF frequencies, it can become appreciable. Let's quantify –

Say a connecting cable is 1m long and carries 100 amps at 1MHz. What is the voltage across it ends?

$V = 2 Pi \times 10^{6} \times 1000 \times 10^{-9} \times 100 = 628V$

This means that very high rates of di/dt will be rare but they can be important in some circumstances.

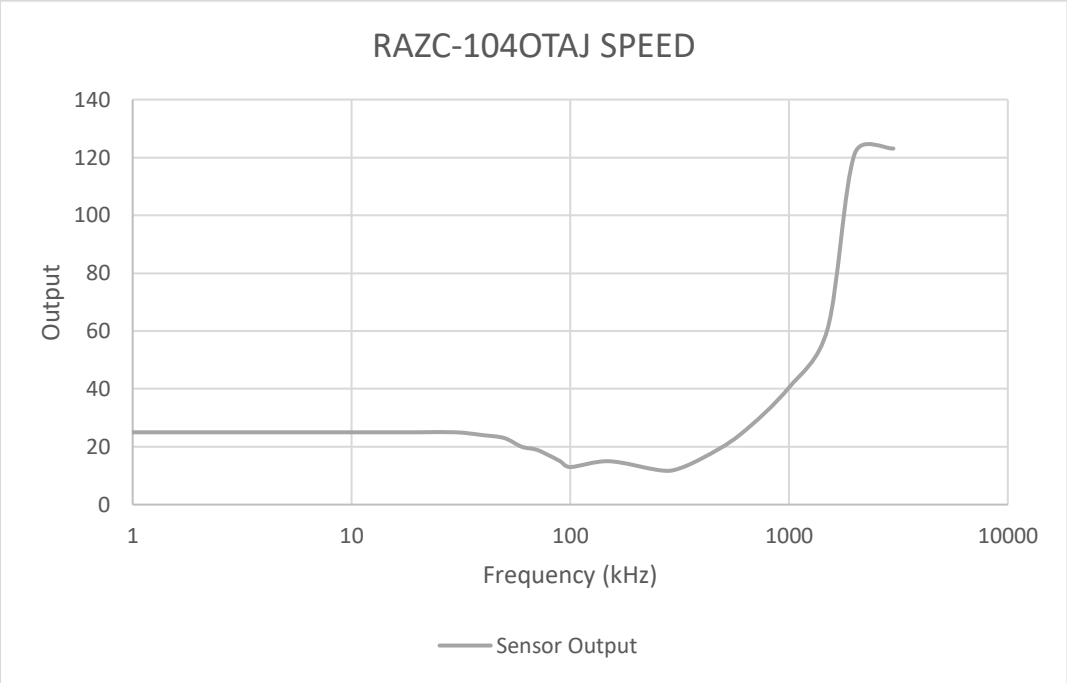
The means to measure high frequency current

a. The most common is a Rogowski coil in conjunction with a precision, high frequency integrator. However, if there is a DC component, Rogowski won't work.
b. In some circumstances a shunt resistor may work but because a resistor has to have some length it will have inductance and its associated di/dt voltage which can easily be larger the its ixR voltage.
c. Current transformers may work but these need a magnetic core which can corrupt the integrity of the signal. Additionally, current transformers cannot measure DC. Closed-loop current sensors effectively use the current transformer effect for their high current measurement so the core limits the practical upper frequency.
d. Open-loop hall sensors are definitely an option provided the magnetic field sensor has a high frequency response. The Raztec RAZC range which utilises a high frequency ferrite core is a good option. Another option is our range of coreless sensors which allow the measurement of high currents from hundreds of amps to thousands. Response times are much less than 1us.

Raztec Offering

Raztec can utilise high frequency hall-effect magnetic field sensors into our products. The frequency response above the normally specified several hundred kilohertz is not linear but the non-linearity can be used to good effect. The chart below shows a typical response for our RAZC range with a ferrite core.

The high gain at high frequencies is very useful for very fast detection of overload.

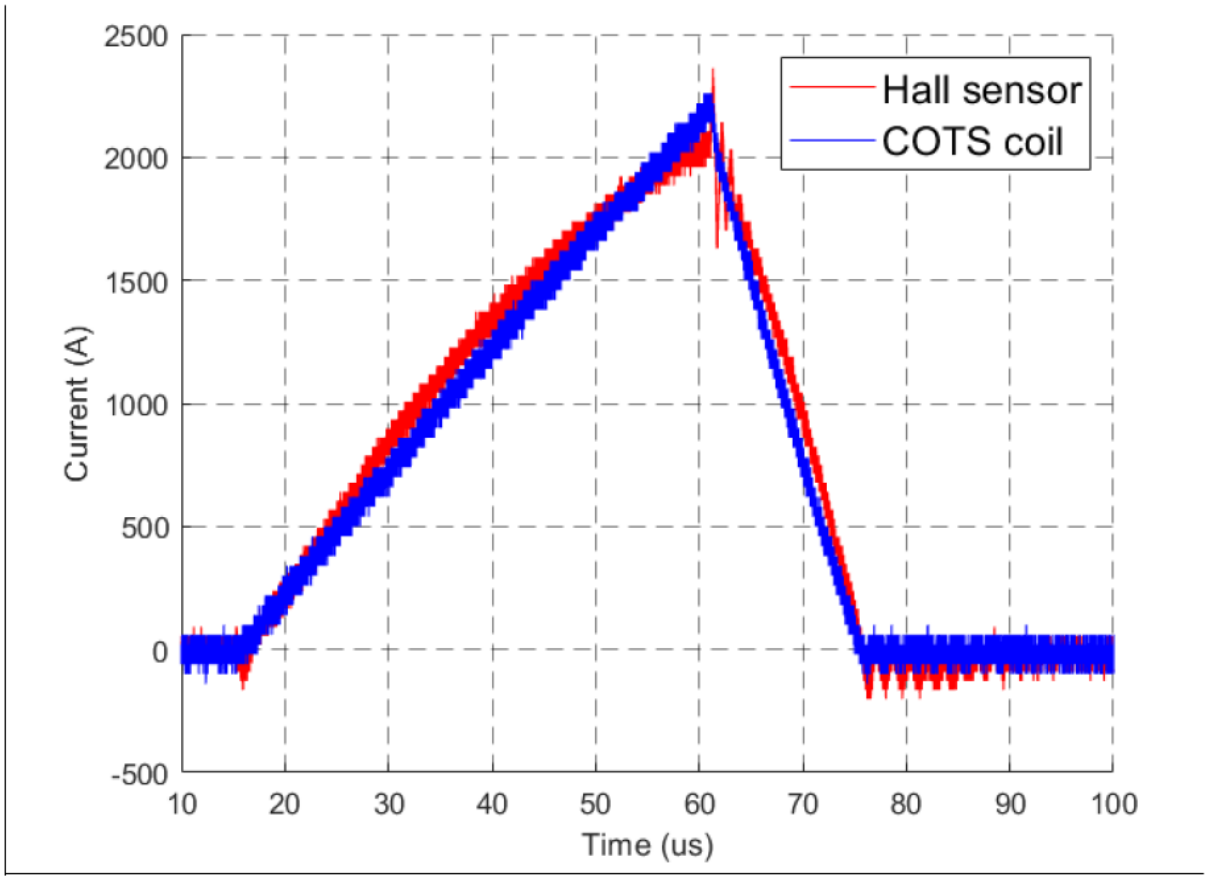


Comments on the frequency response:

The response is constant to about 70kHz, but then it dips to a minimum of about 50% before climbing to under 500% at 3MHz.

Without compensation this could distort high frequency currents – demonstrate inaccurately high output for the high frequency component. If this was an issue a simple RC filter would give good improvement.

However, the high, high frequency response is beneficial for the very fast detection of overload. If anything, it could detect too early. Again this is easily compensated.



TYPICAL RAZTEC CORELESS CURRENT SENSOR TRANSIENT RESPONSE

In the above response chart, the non-linearity of the sensor frequency response causes a slight distortion of the signal. Importantly, the signal delay is negligible on the 10us time base.

In practice, transient delays less than 1us are not particularly useful as the devices to turn the current off are much slower than this.

SUMMARY:

High frequency Raztec current sensors are particularly useful for detecting overload. Our high current coreless sensors provide a very economical means for accurately and reliably detecting high overload currents, bot AC and DC. This is particularly relevant in the aeronautical environment where small size and low weight are critical.