RELIABLE BLAST TESTS

WITH THE TRION3-1850-MULTI MODULE

DEWETRON

- **> High sample rate of 5MS/s for gapless data recording and storing**
- **> Highspeed pressure and temperature recording**
- **> 2 MHz bandwidth**
- **> IEPE® excitation current up to 20 mA**
- **> Perfect synchronization of all channels of different sensor types**
- **> Reliable measurement system for valid results**

FURTHER INFORMATION?

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INTRODUCTION

Air Blast tests are an important part not only in the Aerospace and Defense segment, but also in other market segments where explosions are part of a test procedure. Nowadays, threats can come from any direction, thus, blast tests are also used to test the structural integrity for example for vehicle protection.

The analysis of the shock wave of air blast tests is significant to characterize the rapid release of energy which generates the pressure wave and the return to normal ambient conditions. Thereby, different kind of tests can be performed, like a free air, directed or contained air blast to measure the generated shock wave. This process is a highly dynamic event which, therefore, demands highly dynamic measurement systems to capture all the data for a significant evaluation. Incomplete or loss of data is an unwanted and unacceptable effect and must be avoided in any way possible. Highly reliable measurement systems with a highspeed sampling rate are desired to fulfill all those requirements.

CHALLENGES AND SOLUTION

There are many things to take care of to avoid measurement errors like choosing the right sensor in this harsh environment but also choosing the right measurement system facilitates the measurement procedure. Knowing to be able to perform a reliable measurement without any loss of data can prevent frustration since there is only one opportunity to perform a blast test.

For a blast test different kind of sensors are used. Accelerometers (like the PCB 3503A1160KG, DTS 6DX PRO, Endevco 7270A), force and strain sensors are typically required to measure the displacement of the DUT (like the PCB 740B02) and pressure sensors (like the PCB 137B24B) or temperature sensors (like the Exergen IRt/c.100A) in defined distances are used to measure the wave propagation.

To achieve successful results, all these sensors can be used with the TRION3-1850-MULTI module. The high sample rate of 5 MS/s per channel guarantees capturing all the important data which is generated by the air blast. The event of the pressure wave to reach a peak only lasts some microseconds and is not a linear process, therefore, it is important to have as much information as possible to reconstruct this event. Hence, the high sampling rate with outstanding AC accuracy and high dynamic range (140 dB SNR) is essential.

The effect of different sampling rates can be seen in Figure 1. In addition to the high sample rate for each channel, all the data of each channel with different types of sensors (like IEPE®, voltage, bridge ect.) is measured with the same measurement amplifier and, thus, ensures the perfect synchronization as the channel to channel phase mismatch is below 10 nsec. This is one of the key features of the TRION3-1850-MULTI module and is a great benefit for successful measurements and results.

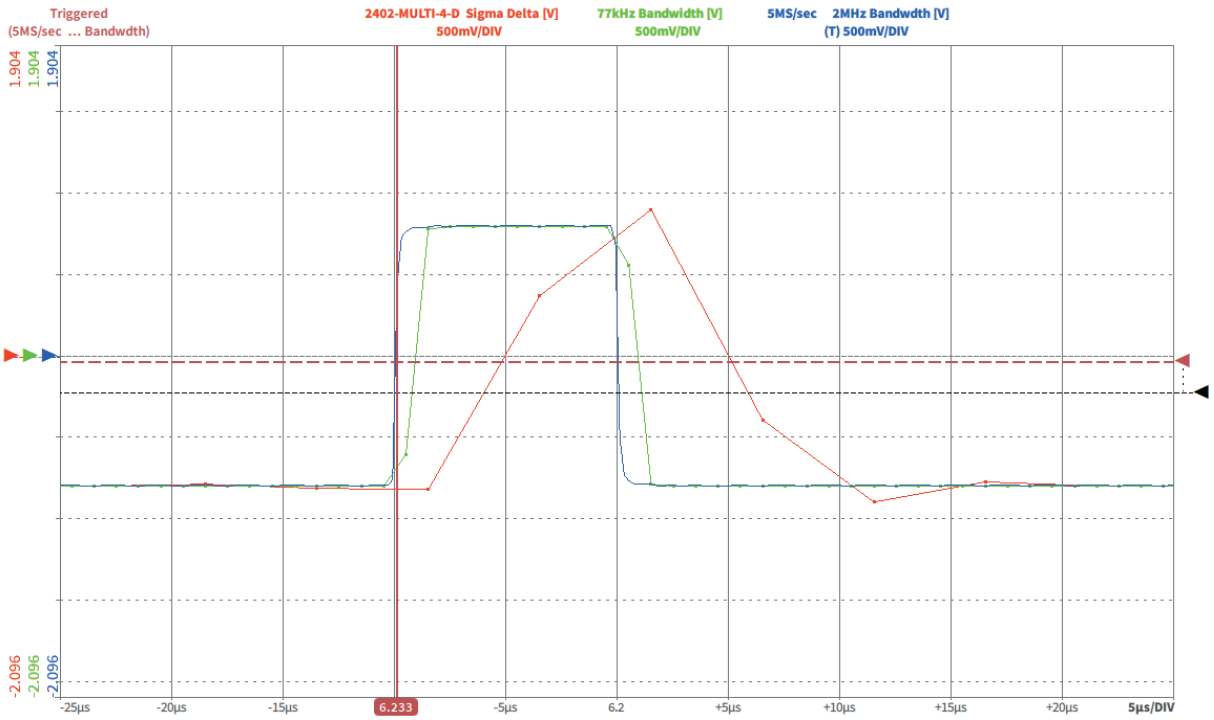

Figure 1: Effect of different sample rates on an example of a step response - shown in OXYGEN

To measure the expansion of this shock wave, sensors can be distributed over several locations. Therefore, long cables must be used in this harsh environment. When using IEPE® (Integrated Electronics Piezo Electric) sensors a high current is necessary to drive the signal from the source to the measurement system without limiting the slew rate. In order to do so, high currents are demanded, otherwise the signal will be attenuated and distort the measurement results.

For a test, which can only be performed once, this is a highly undesirable effect. Usually the internal electronics of an IEPE® sensor is powered by a 4 mA or 8 mA constant current source of the data acquisition system. Considering that the sensor itself needs about 1 mA, not much is left to drive the signal through the line. As seen in the equation below, there is an inverse relation between the voltage and capacitance, as C would be the cable capacitance.

$$v(t) = \frac{1}{C}\int i(t)dt$$

To calculate the maximum distortion-free frequency for a specific signal amplitude the following equation represents an approximation.

$$f_{max} = \frac{10^9}{\frac{2 * \pi * C_{Cable[pF]} * V_{SensorSignal}}{(I_{IEPE[mA]} - 1)}}$$

$V_{SensorSignal}$ ..... Sensor output Voltage
F_{max} ..... Highest frequency without distortion
C_{Cable} ..... Cable Capacity; typical 100 pf/m

The TRION3-1850-MULTI has a bandwidth of 2 MHz and a freely programmable IEPE® excitation current of up to 20 mA, in order to avoid any unwanted effect of attenuation of the voltage signal.
Strain gages and bridge circuits are also used to record data from an air blast test. For such highspeed measurements it is recommended to use full bridge circuits. The reason for this, is the resulting differential output signal. The advantage of differential signals is that external disturbances appear as common mode interference and can, therefore, be damped by the common mode rejection.

The TRION3-1850-MULTI supports not only different bridge types like quarter, half and full bridges but also different wiring connections, depending on the bridge circuit. For example, the module supports 2-, 3- and 4-wire connections for quarter bridges with internal bridge completion of 120 Ω, 350 Ω and 1000 Ω.

Another advantage of the TRION3-1850-MULTI module are the easy-to-use filter settings. By default, the input signal is low pass filtered with a Bessel filter of 8th order with a cut-off frequency of 30% of the sample rate. With these settings it will be made sure that no aliasing effects occur, and the signal will not be distorted. While the Butterworth filter might have a higher AC accuracy, it shows an oscillation for the step response. The Bessel filter is much more convenient for fast, transient events than the Butterworth filter, because of the better step response. An example of the step response with both types of filters, Bessel and Butterworth, can be seen in Figure 3.

Figure 2: TRION(3)-18xx-MULTI Series

Furthermore, the TRION3-1850-MULTI uses a SAR ADC instead of a Sigma-Delta (ΣΔ) ADC. This is a great benefit when measuring fast events. The SAR ADC has a much smaller latency between input and output compared to the ΣΔ ADC. Additionally, the SAR ADC has a very low noise floor which results in a high dynamic range and SNR of 140 dB, like mentioned previously. All these advantages make the SAR ADC a better choice when it comes to measuring fast, transient events like blast tests.

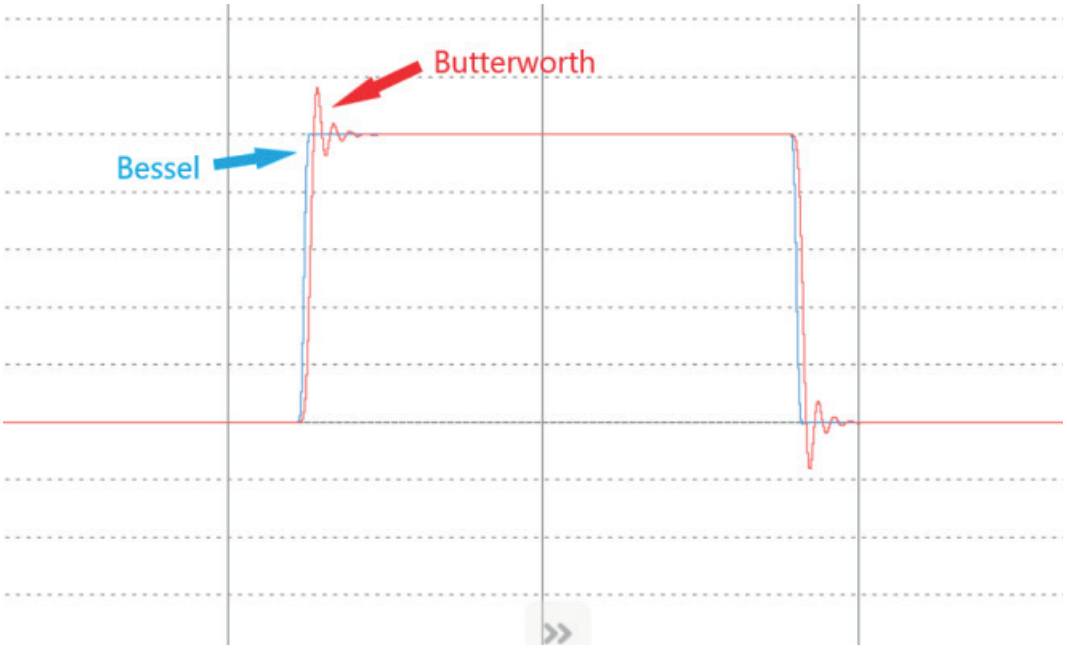

Figure 3: Comparison of the step response of a Bessel and Butterworth filter

CONCLUSION

Blast tests are not only done under severe conditions, but they also cannot be repeated without any effort. Especially because of that reason, it is important to not only have a good selection of sensors, but it is just as important to have a reliable measurement system.

To get the most out of the couple seconds of a blast test the high-end TRION3-1850-MULTI module is the perfect solution, in order to capture all the data with a high sample rate of 5 MS/s per channel. The bandwidth of 2 MHz, freely programmable IEPE® excitation current up to 20 mA, the easy filter settings and perfect synchronization of all channels with different sensor types guarantee the best possible measurement results an ensure the measurable difference.

THE EXPERT

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FURTHER QUESTIONS?
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