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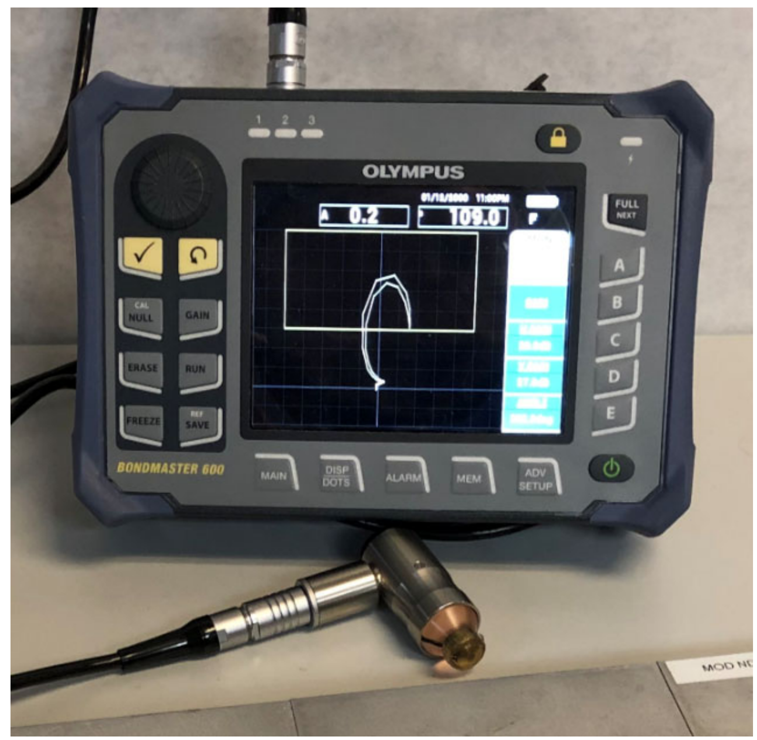
Bond Testing Technology, Improved MIA Mode

Prepared by James Bittner



Olympus America Inc.

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Portable Bond Testing technology has been around for the last 40 years. Over the years, many improvements have been made to increase the instrument's performance and to meet the challenges of developments in composite material and structures. Advancements in the BondMaster™ 600 have increased reliability in the mechanical impedance analysis (MIA) method.

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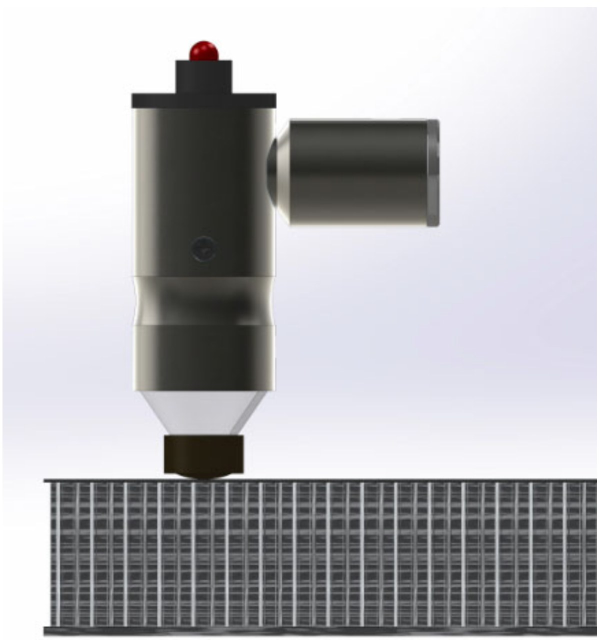
The bond testing mechanical impedance analysis (MIA) method, measures the mechanical impedance or stiffness of a composite structure. MIA probes emit a fixed, audible frequency. Changes in the structure's stiffness are indicated as signal amplitude and phase changes in the X-Y view of the BondMaste 600.



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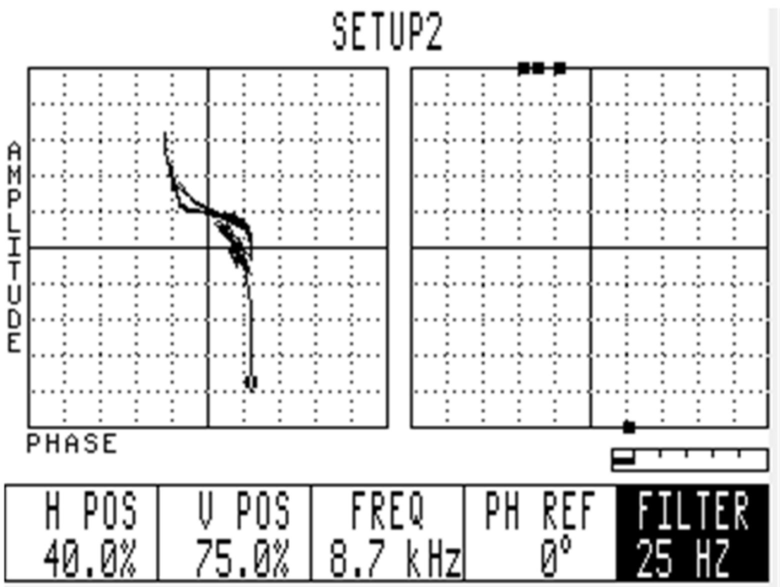
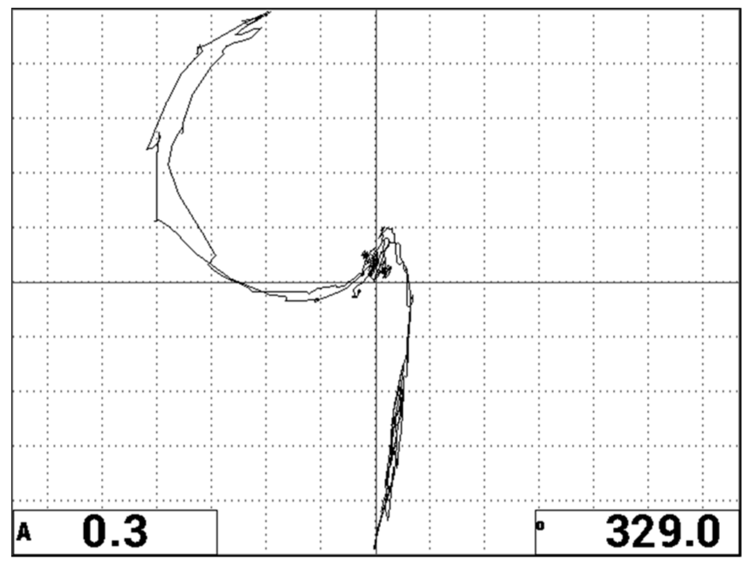
Let's step back and take a quick look at the previous BondMaster 1000 series MIA mode.

Due to the limited frequency range of the BondMaster 1000 (2-8kHz.), often the instrument would be operating in saturation, with only a limited signal indication and/or response.

BondMaster 1000 MIA



BondMaster 600 MIA



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Better results are obtained with the BondMaster 600 extended MIA frequency range of 2 kHz to 50 kHz. The single contact tip probes used with MIA, coupled with the high-performance of the BondMaster 600, make detecting very small disbonds in honeycomb composite much easier than with other methods.

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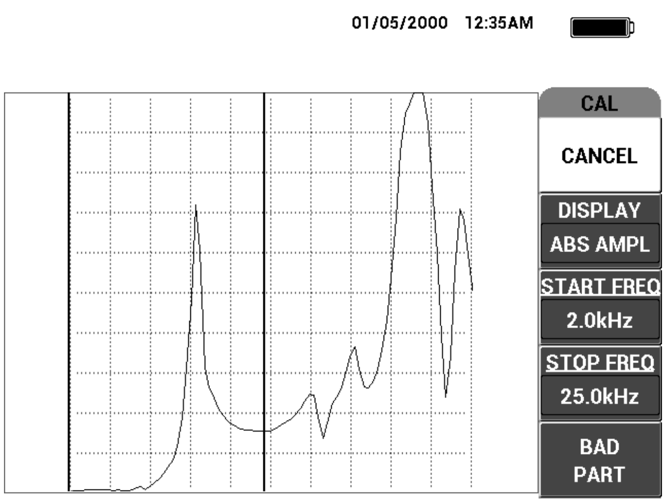
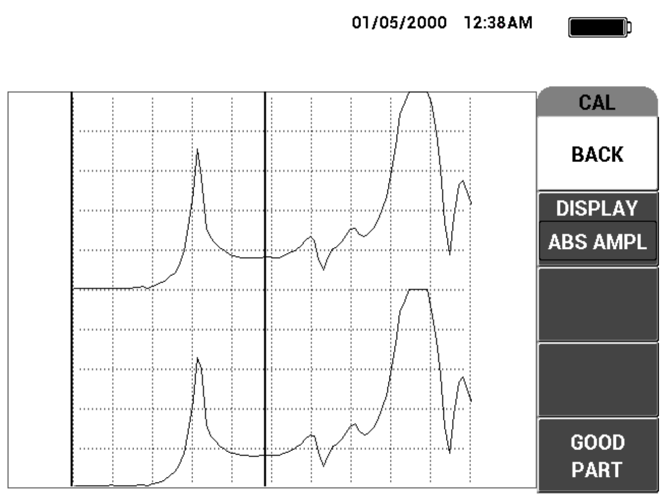
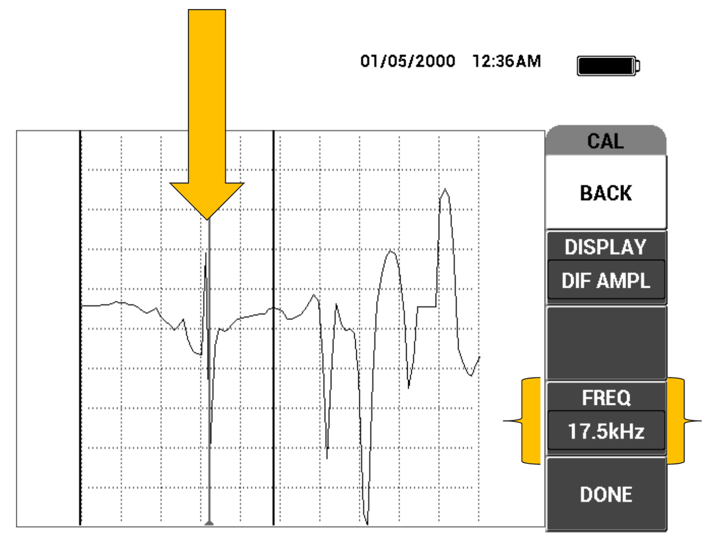
Calibrating for MIA Mode

Calibrating the B600 for MIA requires placing the probe on the standard’s “Bad Part”, then placing the probe on the standard’s “Good Part”. The B600 will sweep the start and stop frequency and determine the peak swept frequency difference and the calibration process is complete.

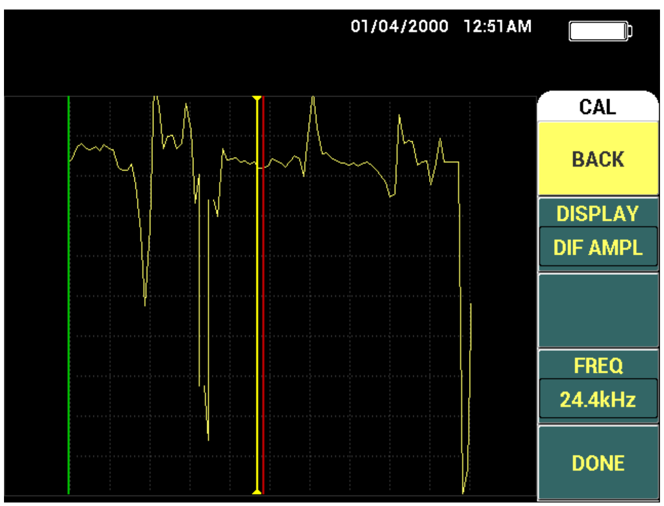


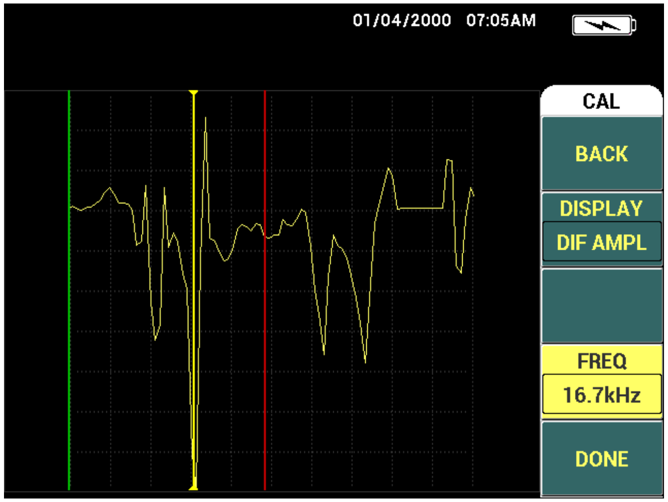


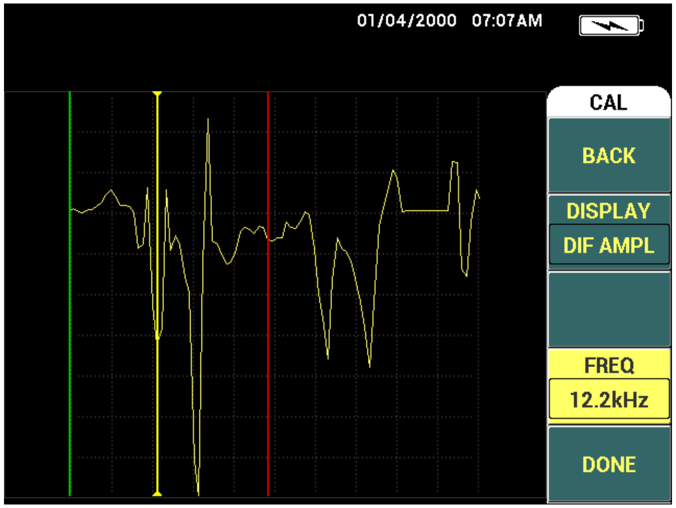


Selecting the best operating frequency

After extensive testing, evaluation, and feedback from customers, it has been determined that the best results will be the first negative pulse signal from the left side of the screen. In the example below 12.2kHz







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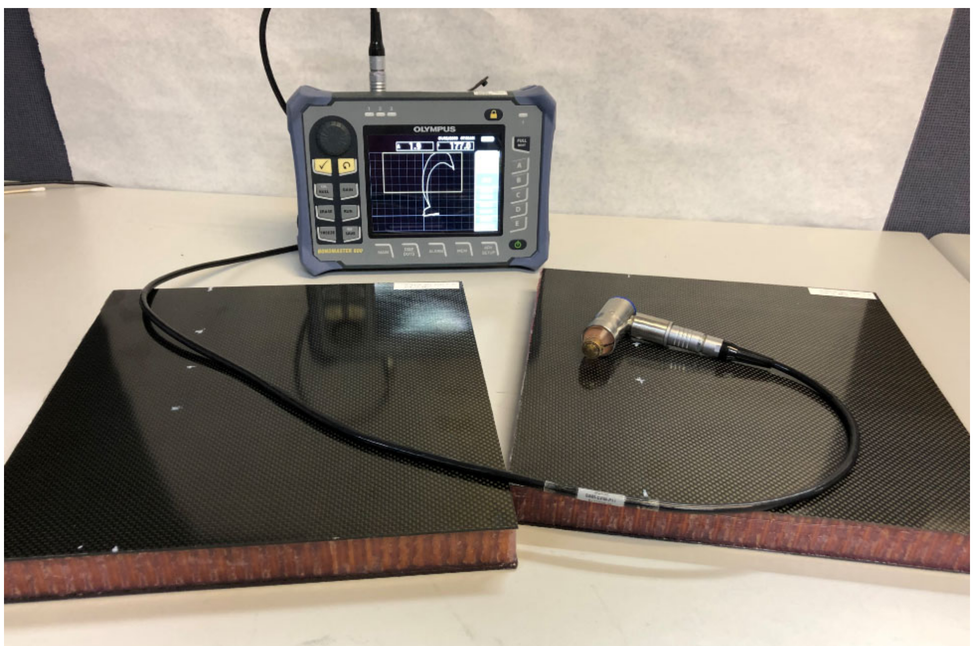
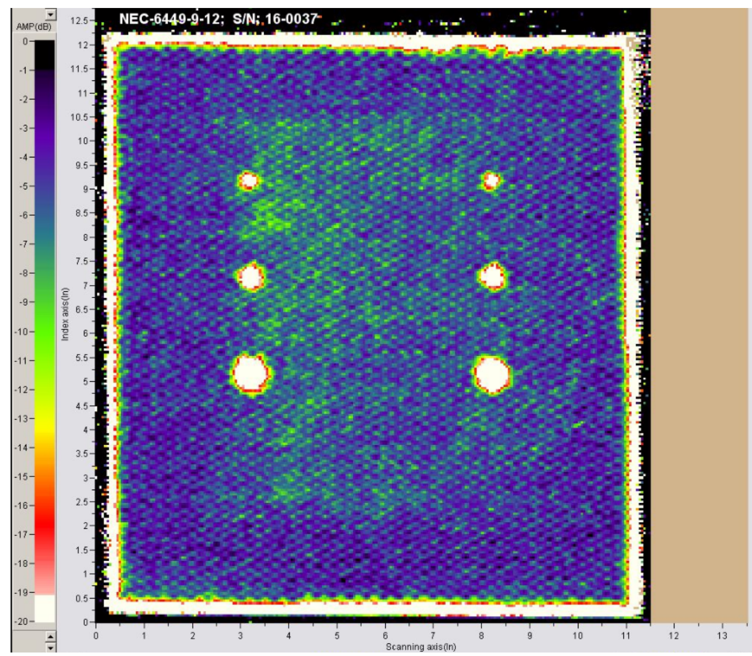
We will review a few examples where we are comparing MIA vs. Pitch-Catch on CFRP skin to core honeycomb samples.

The core is Nomex and CFRP skins ranging from 3 plies up to 12 plies. These are common skin ranges that would be encountered by an NDI technician in the field.

Each sample has a .375in “9.52mm”, .500in “12.7mm” and .750in “19.05mm” simulated skin to core disbonds.





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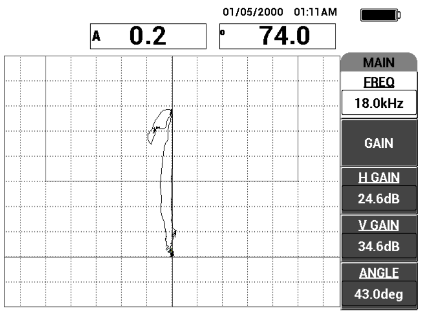
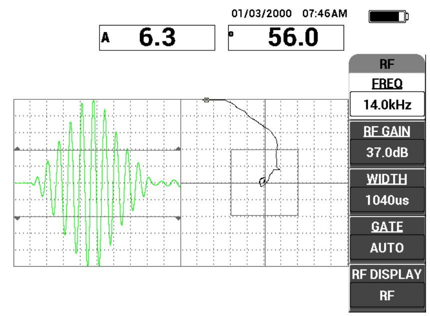
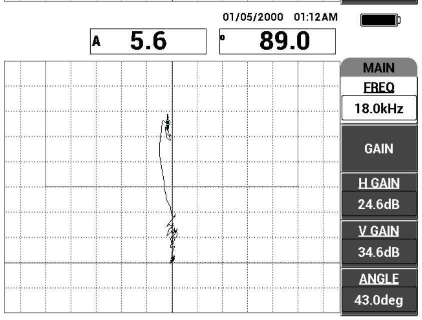
Comparing MIA vs. Pitch-Catch on CFRP skin to core honeycomb samples. Three-ply sample-

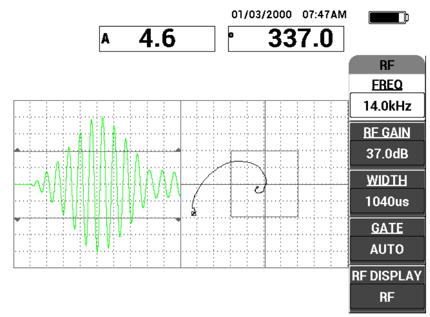


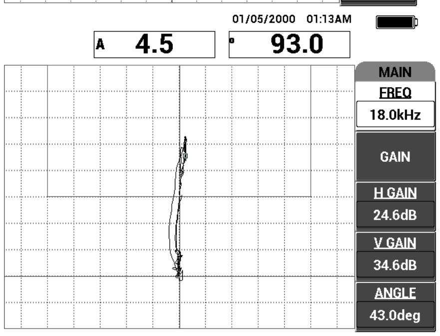
3 plies .75in



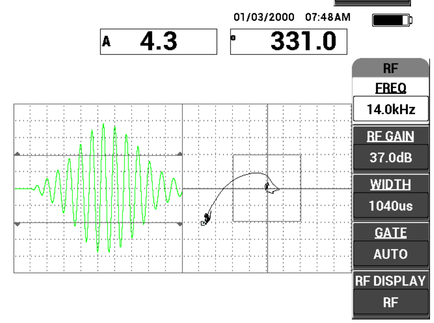


3 plies .50in





3 plies .375



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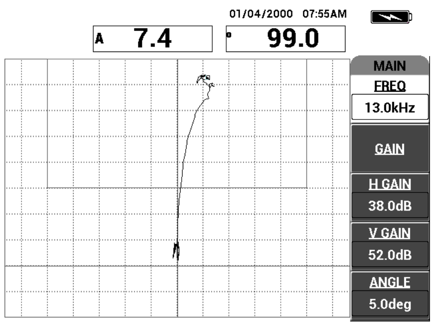
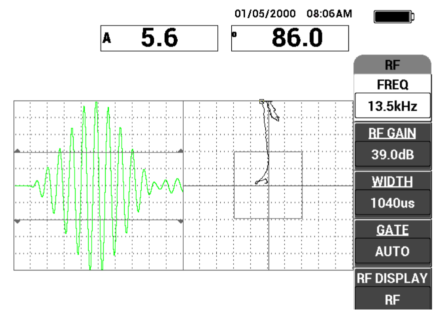
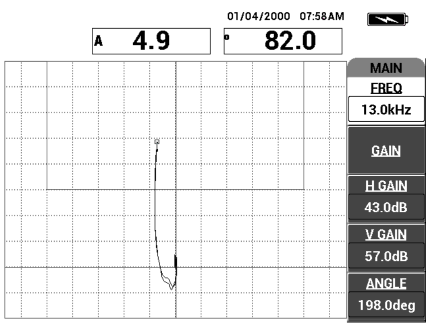
Comparing MIA vs. Pitch-Catch on CFRP skin to core honeycomb samples. Six-ply sample-

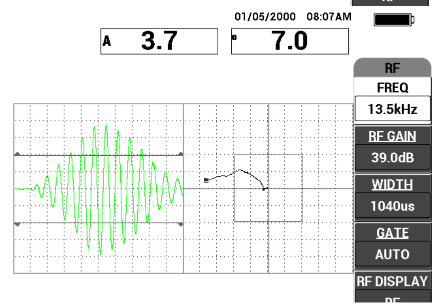


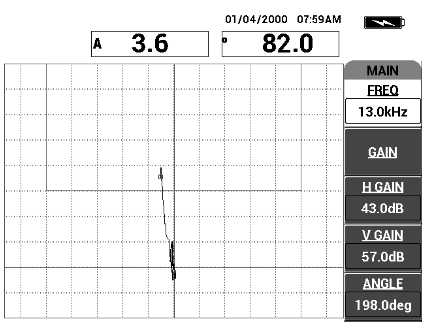
6 plies .75in



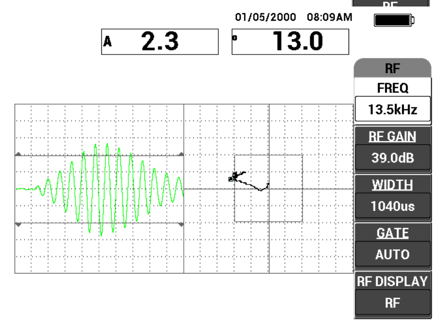


6 plies .50in





6 plies .375



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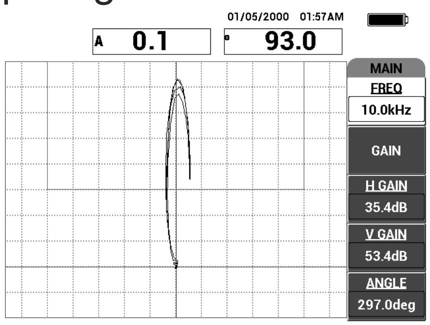
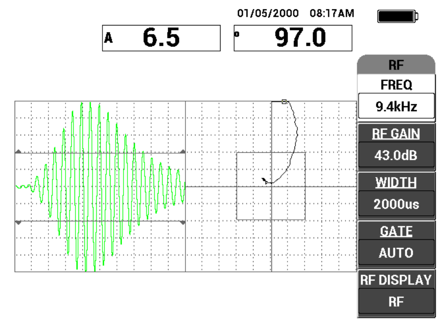
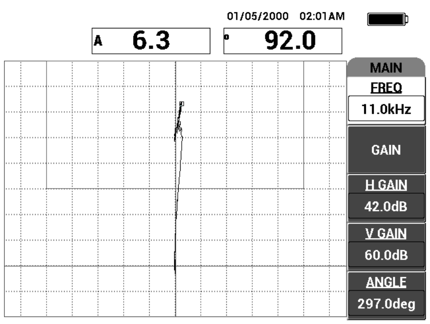
Comparing MIA vs. Pitch-Catch on CFRP skin to core honeycomb samples. Nine-ply sample-

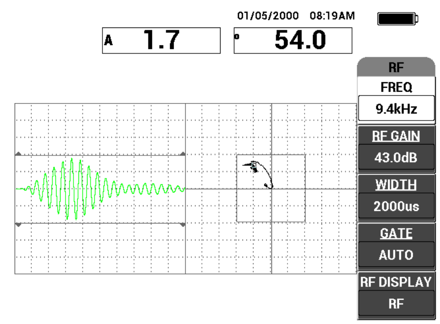


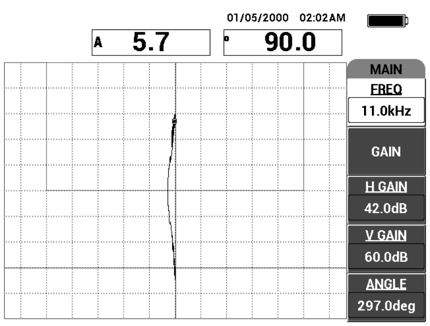
9 plies .75in



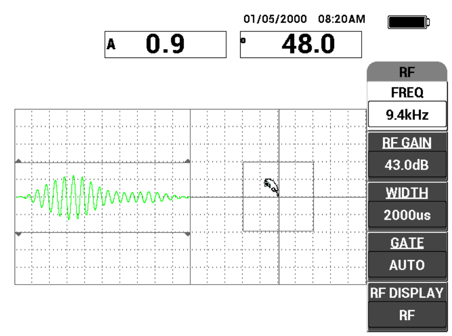


9 plies .50in





9 plies .375



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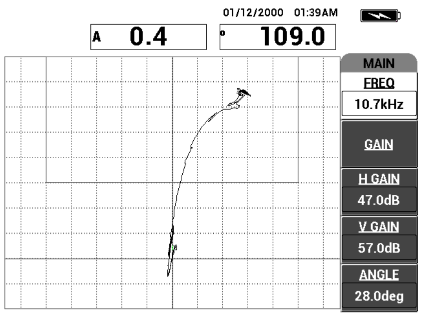
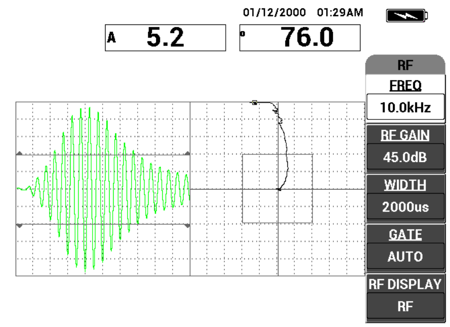
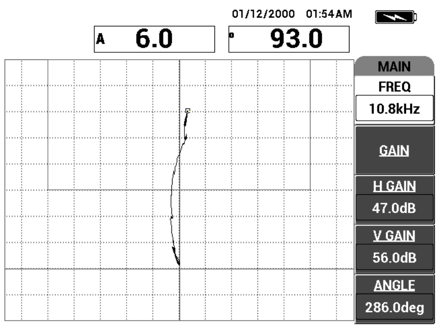
Comparing MIA vs. Pitch-Catch on CFRP skin to core honeycomb samples. Twelve-ply sample-

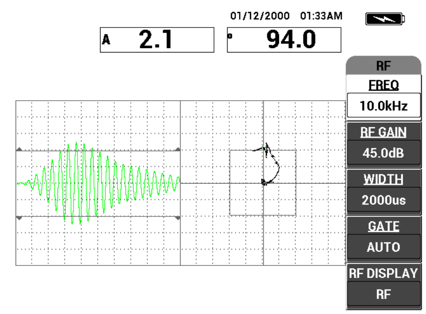


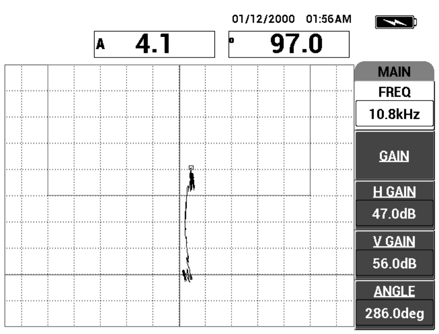
12 plies .75in



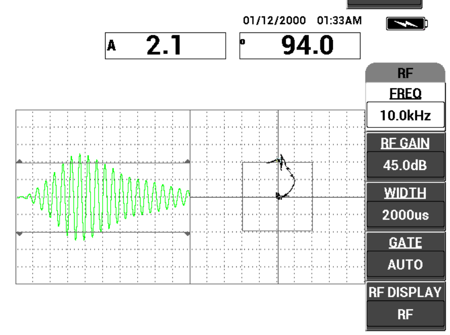


12 plies .50in





12 plies .375



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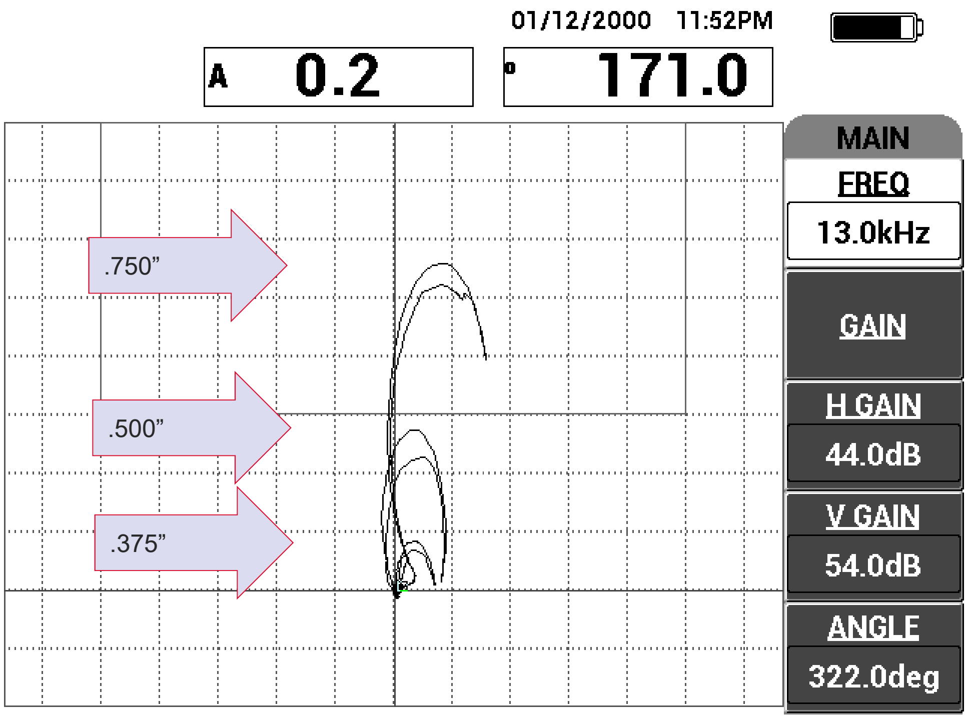
As we scan over all three simulated disbonds, we can clearly identify and interpret the signals. This is what an NDT technician would view while using eddy current inspection.



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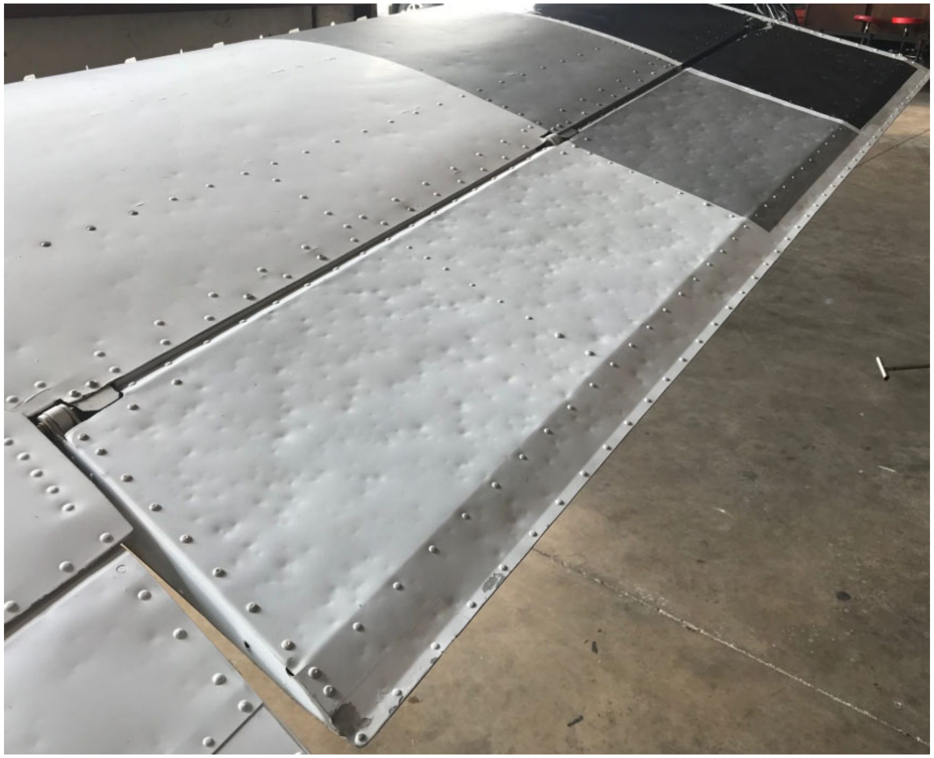
Impact damage is a common occurrence during an aircraft's operation. Hail, dropped tools, and other objects can impact the structure. These impacts can affect an aircraft's performance and structural integrity.



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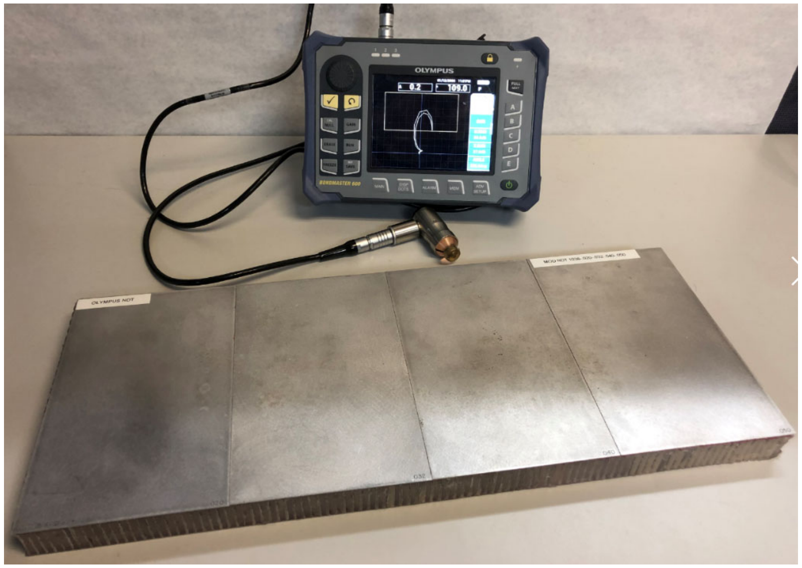
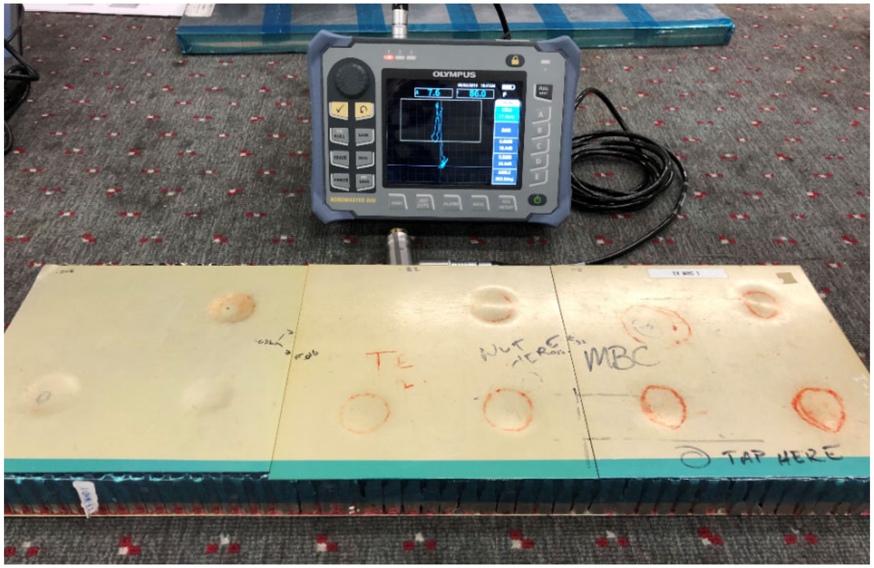
We will now evaluate impact damage in aluminum skin to core honeycomb samples using MIA inspection method.

Calibration standard of aluminum skin to core honeycomb.



Engineered sample with simulated crushed cores and disbonds.



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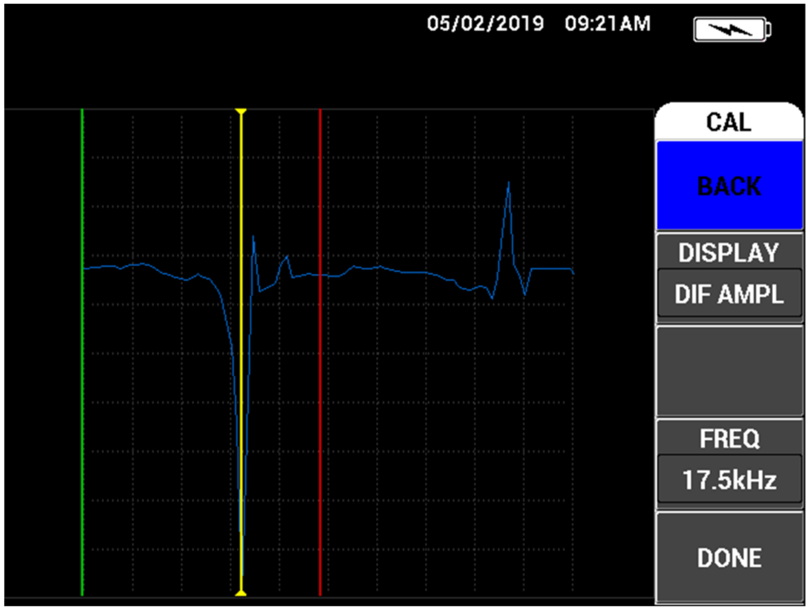
Calibration of the MIA

Using the aluminum honeycomb standard, we will calibrate on the “BAD” then “GOOD” areas.

At the conclusion of the calibration we will view the final swept frequency.

Note: best results will be achieved if adjusted to the first negative peak on the left side of the screen.



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The MIA probe’s curved tip allows the probe access into an impacted area, even in small indentations.

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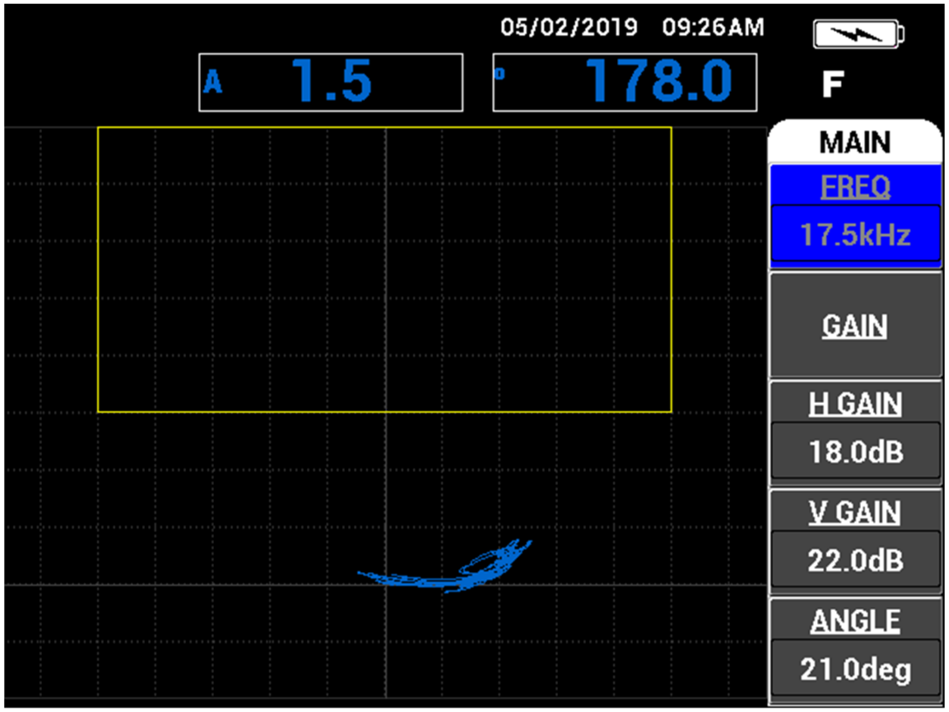
As we scan inside one of the impact damaged samples, we can see there appears to be no disbond indication and this would suggest the crushed core is still bonded to the impacted skin.



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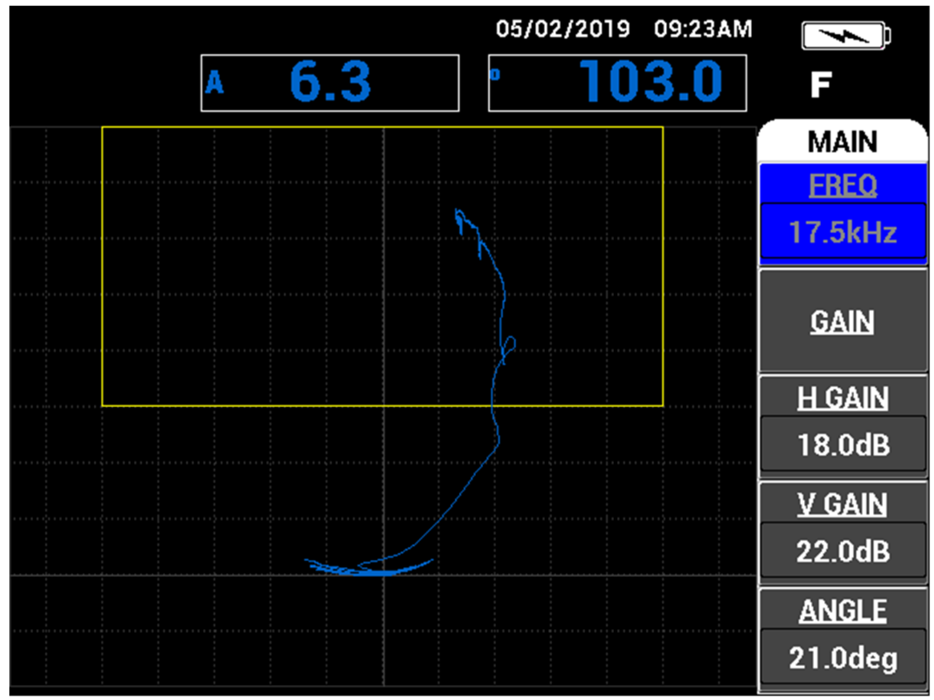
Here is an example of a crushed core with skin to core separation. There is a clear signal response with amplitude and phase changes.



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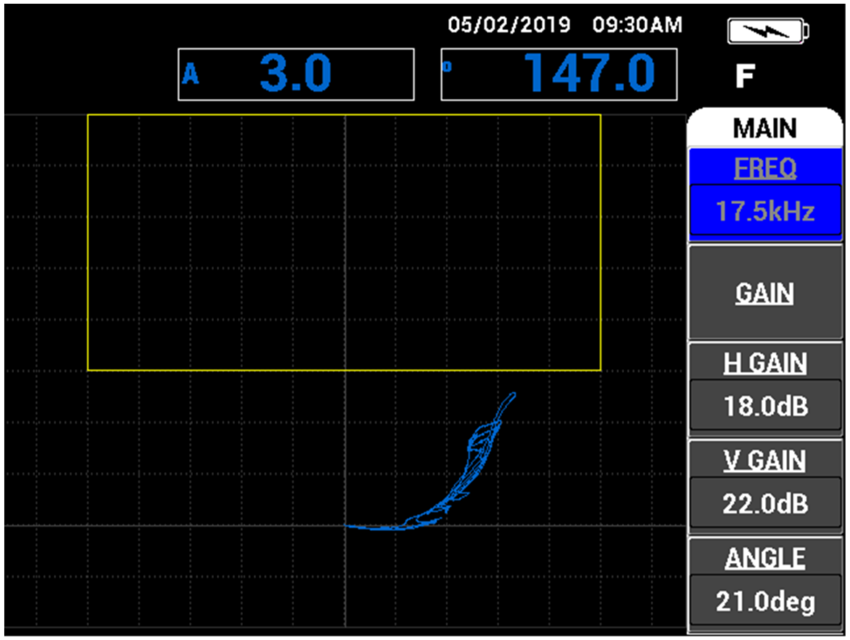
Here is another example of an impact damaged sample with a crushed core. This time, we are getting a greater signal response, but still no core separation. This may indicate a possibility of greater deformation or displacement to the crushed core, or nearing an area of core separation.



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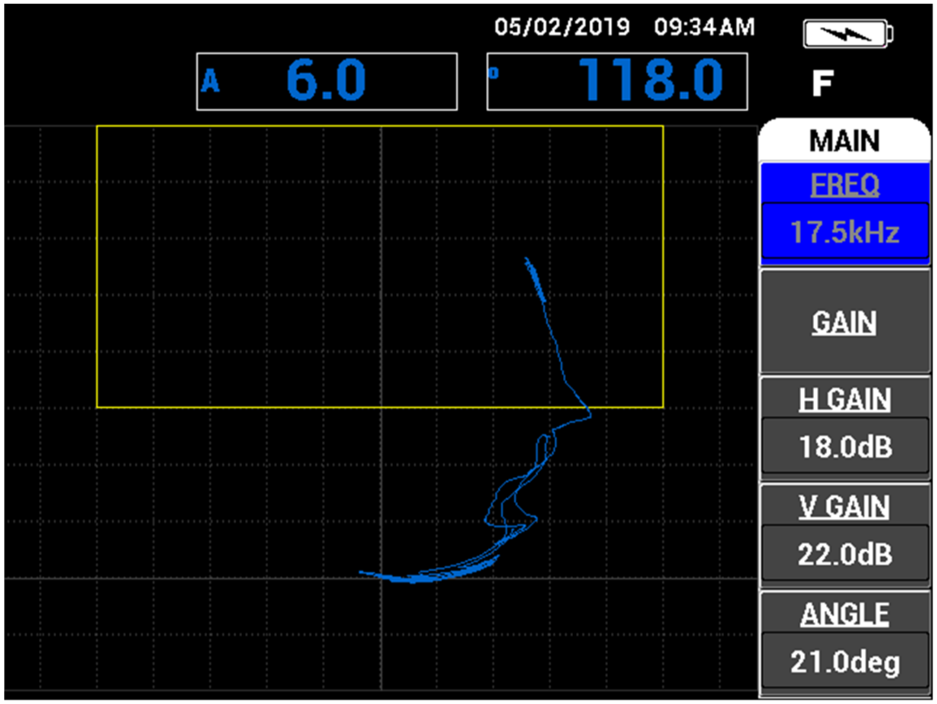
Inside the same impact damaged sample from the previous slide, we are now seeing skin to core separation.



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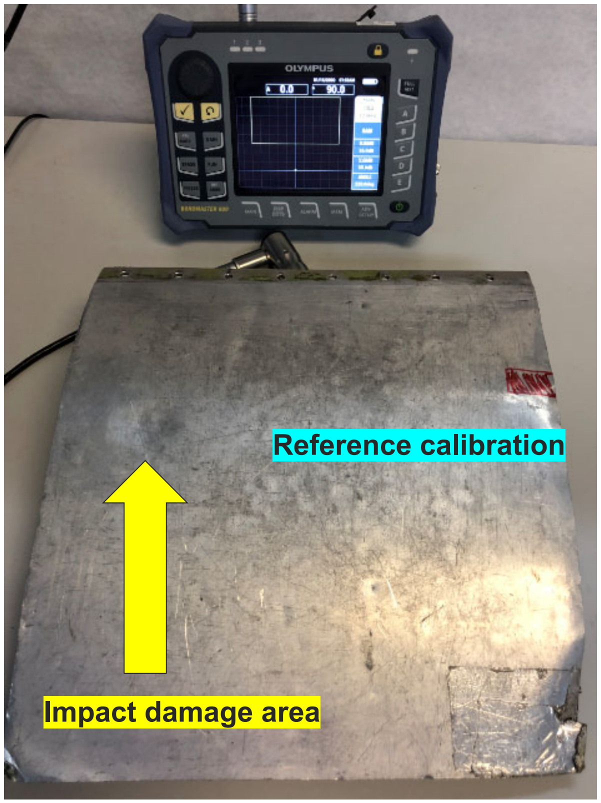
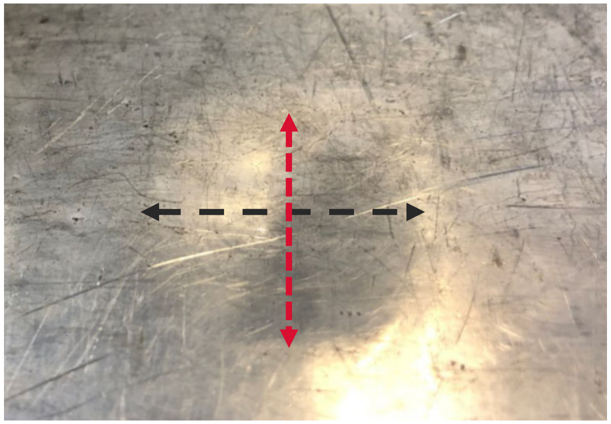
We will now take a look at a commercial aircraft control slat using MIA mode. The sample below has an impact damaged area as well as a reference calibration area.



The impact sample is approximately 1.6in (4.06cm) in length x 1.5in (3.81cm) in width x .072 in depth.



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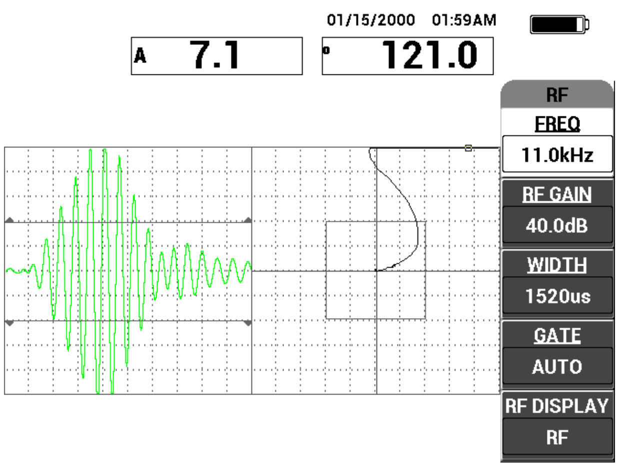
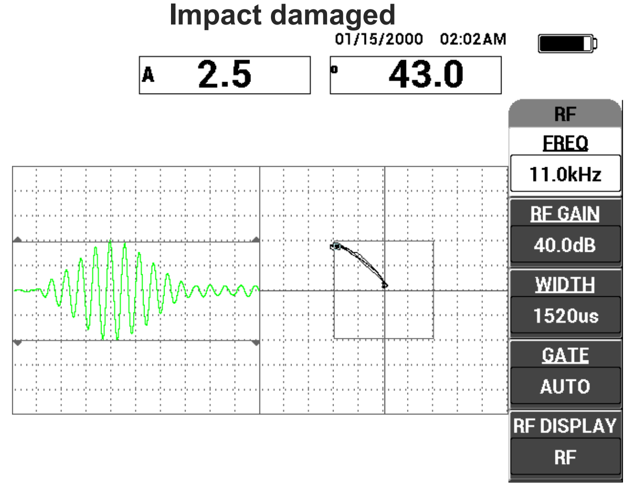
We will start by following common inspection procedure using Pitch-Catch method. When scanning over the impact sample, we get a slight indication and little detail can be obtained from this signal.

Reference Calibration



Impact damaged



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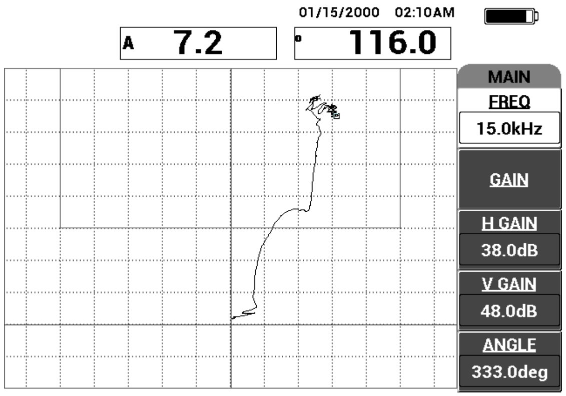
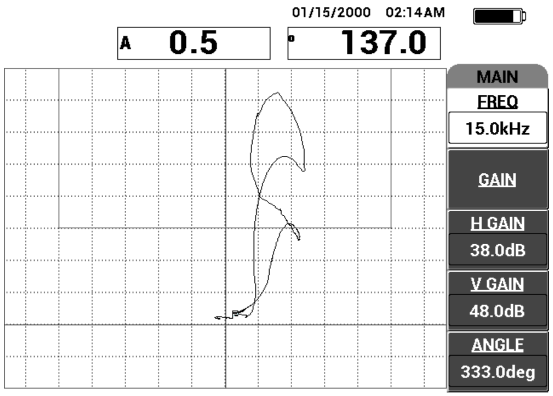
Using the MIA method, we are able to scan into the impact sample and get good indications. Extensive details of the damage inside can be obtained.

Reference Calibration



Impact damaged



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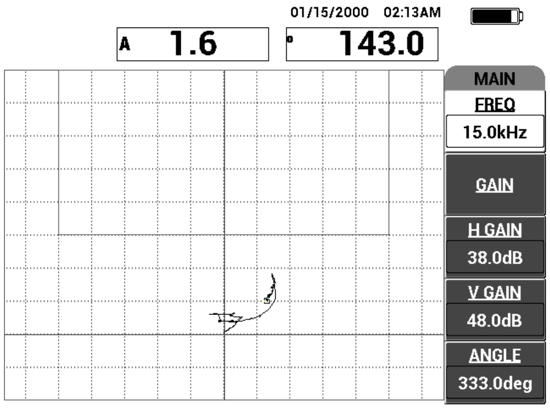
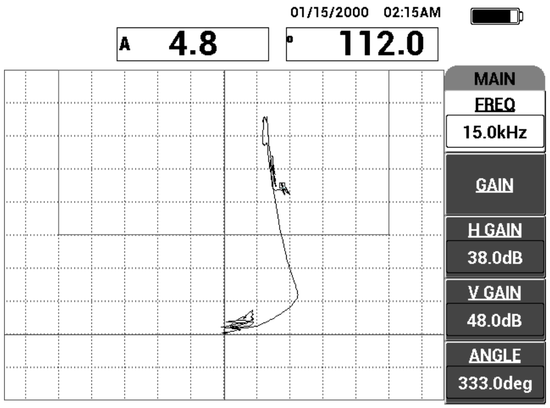
While scanning inside the impact area, we are able to differentiate between where there is a crushed core vs. crushed core with skin to core separation.

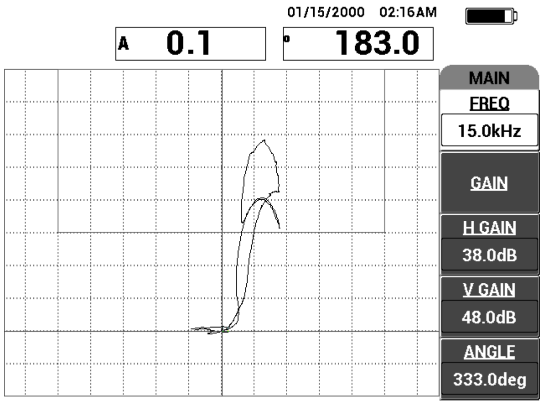
Crush Core



Crush core and skin to core separation



Crush core and skin to core separation



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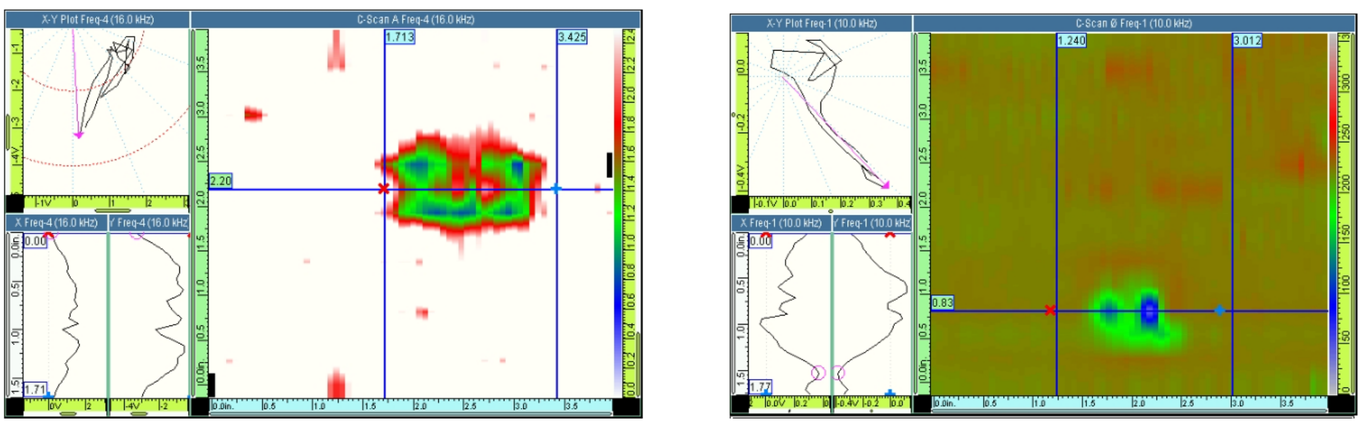
Using the OmniScan™ MXB software with the HSB-01 handheld scanner and a prototype MIA fixture, I was able to get a C-Scan image of the impact area and gather additional data.

C-scan looking at amplitude vs. Phase changes within the impact area.



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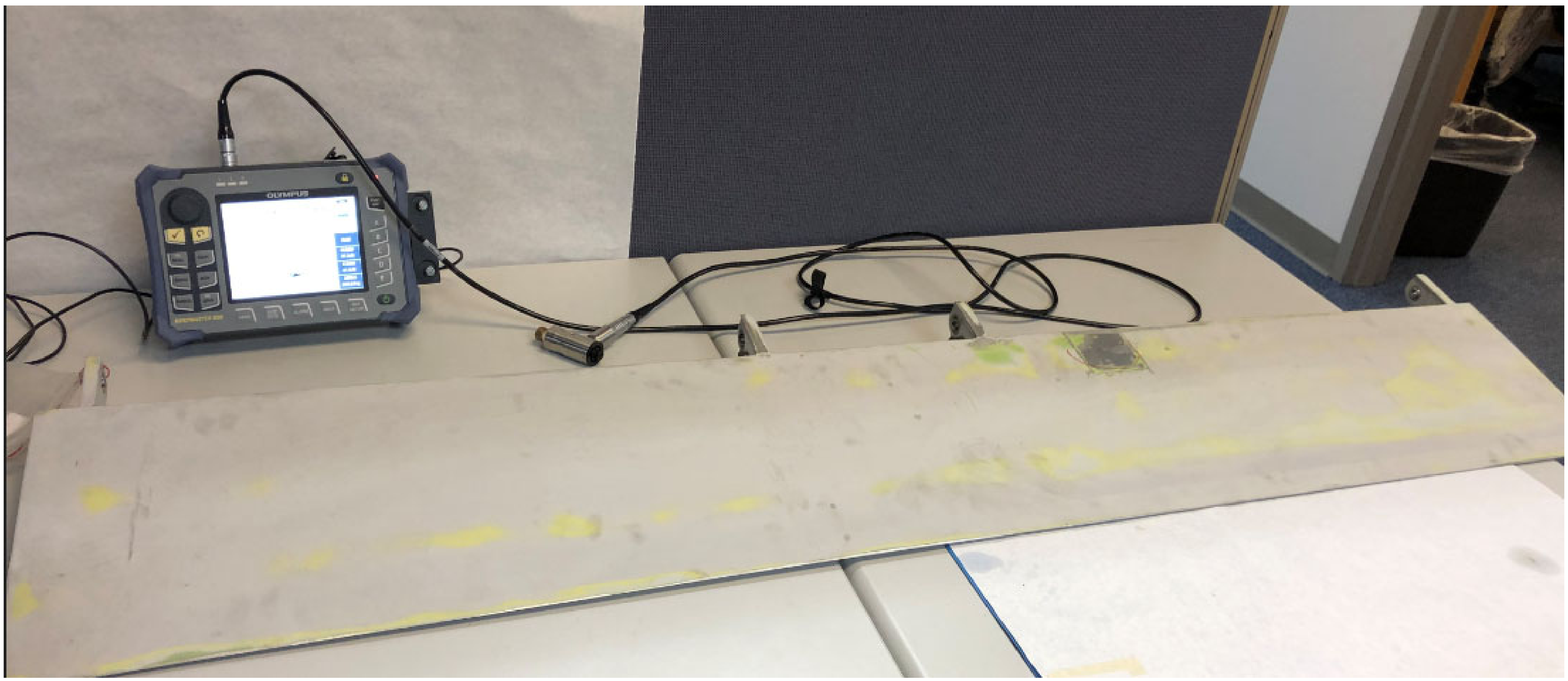
Here is another example using MIA mode on a spoiler from a regional aircraft. The spoiler appears to have no core and the attached control arms are bonded to the spoiler.



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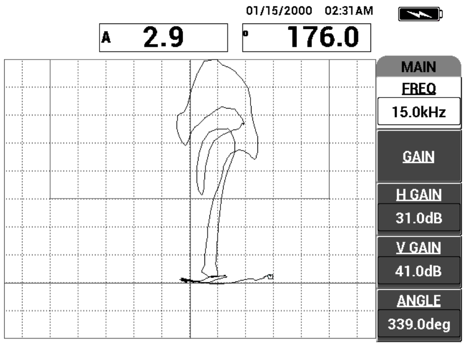
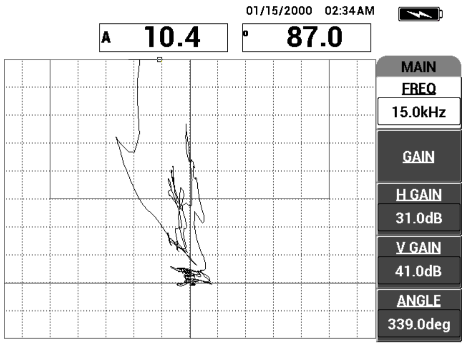
While examining the spoiler, there appeared to be indications of separation of the skin from the control arms.





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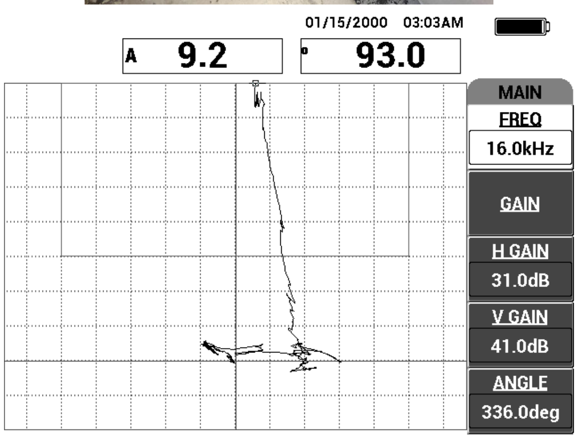
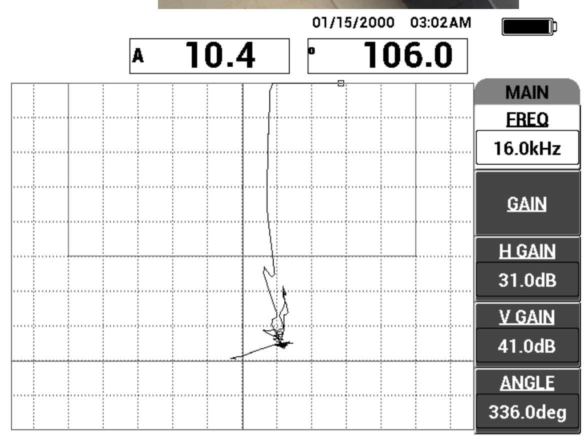
In the samples suppled, this separation appeared repeatedly over a number of the control arms.





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Bond Testing Technology, Improved MIA Mode

Conclusion

Improvements to the BondMaster™ 600 mechanical impedance analysis (MIA) mode will allow aircraft OEM and their operators another inspection tool for composite and bonded structures where other NDT or Bond Testing methods are not yielding good results.