Pulse Shape Response Optimization (PSRO)

<u>Important Ultrasonic Technique breakthrough:</u>

- Modern Signal Processing Technique applied to Ultrasonic Measurements and Diagnostic
- Novel Solution to System Pulse Response Width Signal Shape Shrinking and Minimization
- Adaptable Technique to Multiple Sensors Situation
- Real-Time, Driving Pulse-Shape Automatic Adaptation
- Low Cost Hardware Implementation

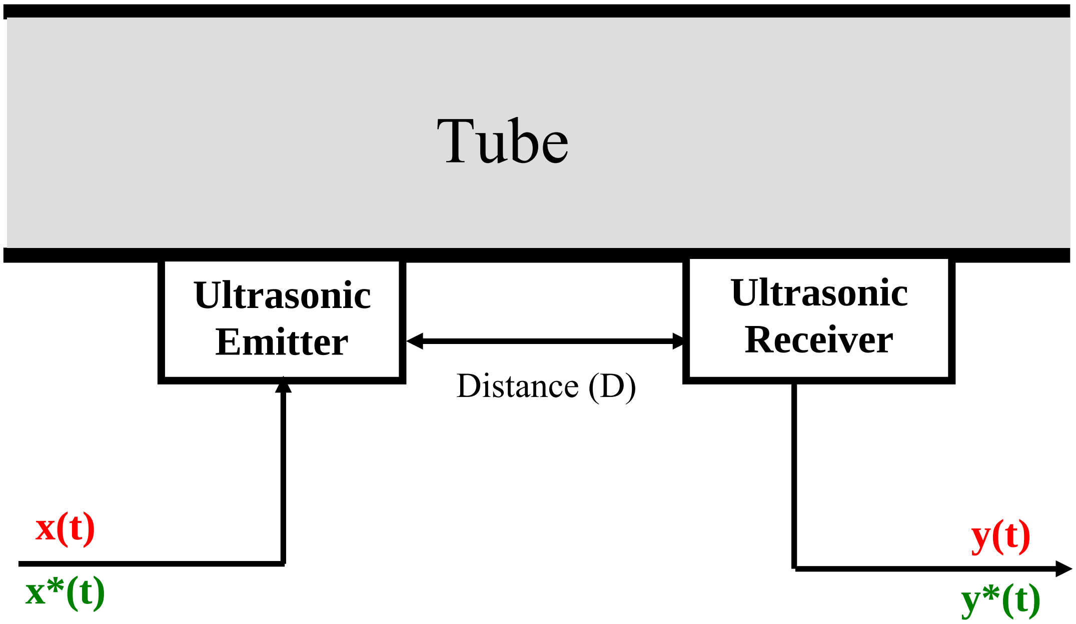
<u>Benefits:</u>

- Higher accuracy in ***"Time-Delay"*** measurements
- High performances achievable with ***"Low Cost"*** transducers
- Much larger equivalent ***"Channel Bandwidth"***
- Increased pulse transmission rate
- Robust in ***"Non-Stationary"*** operating conditions
- Highly simplify the ***"Mechanical Coupling"*** between the transducers and the container (e.g. pipe)
- *No more **"Hard Damping"** necessary to shorten the system pulse response: Transducer attenuation realized electronically in order to produce very short ultrasonic pulse response.*
- Applicable to all kind of ultrasonic transducers and sensors

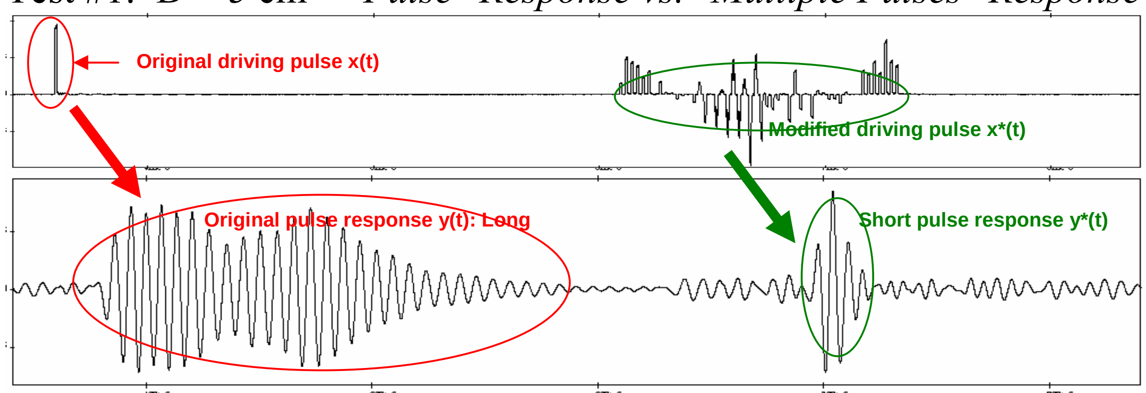
<u>Typical Application Domains:</u>

- Flow measurements
- Evolving material properties monitoring
- Ultrasonic surveillance systems
- Ultrasonic Communications, Sonar and Radar
- Seismic detectors
- Monitoring Structural Stability of Complex Mechanical Systems
- Non-destructive testing (NDT), monitoring and characterization
    - ***Real-Time Continuous Ultrasonic Monitoring***
    - ***Vibrothermography***
    - ***Diagnostic by Forced Acoustic Emission***
- Medical applications
- Military

Example #1: System Pulse Width Narrowing (lab. experiment)

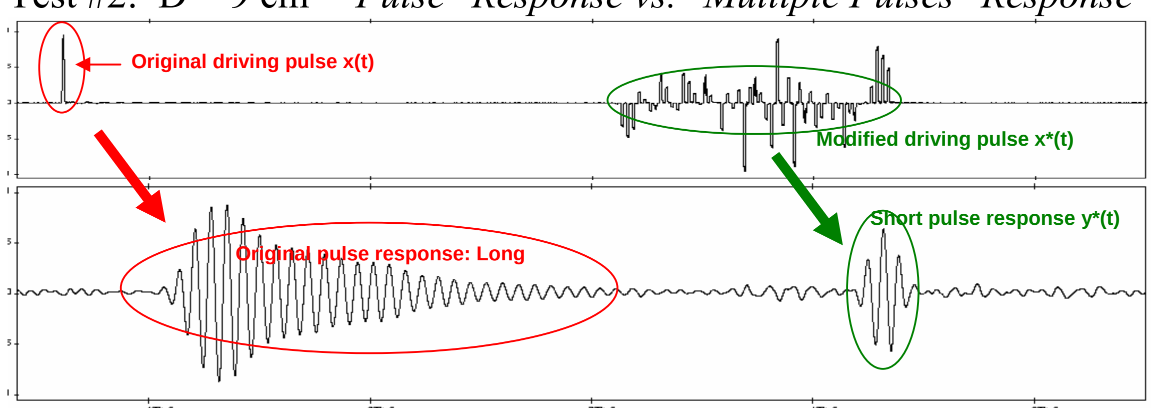


Test #1: D = 5 cm *"Pulse" Response vs. "Multiple Pulses" Response*



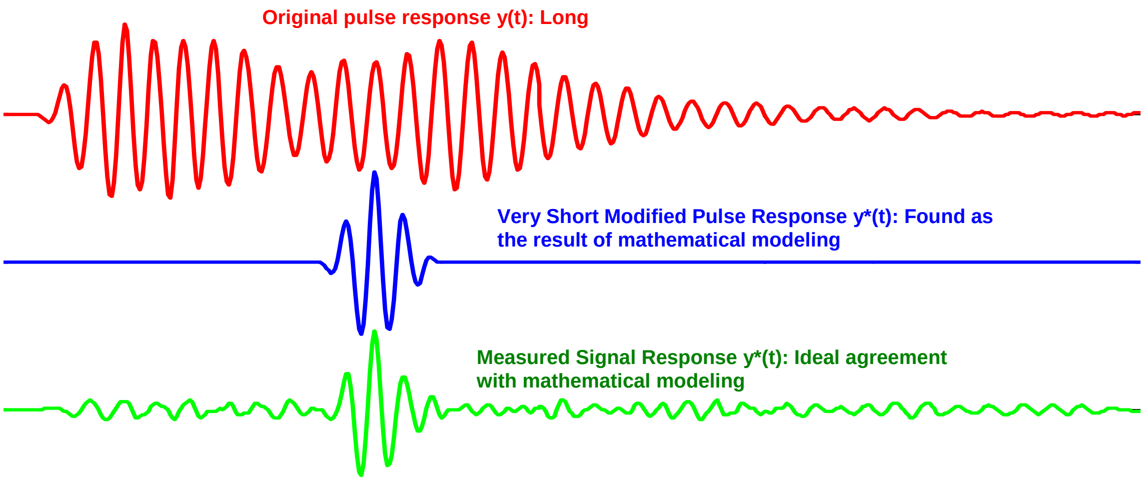
Top: x(t) - Bottom : y(t)

Test #2: D = 9 cm *"Pulse" Response vs. "Multiple Pulses" Response*



Top: x(t) - Bottom : y(t)

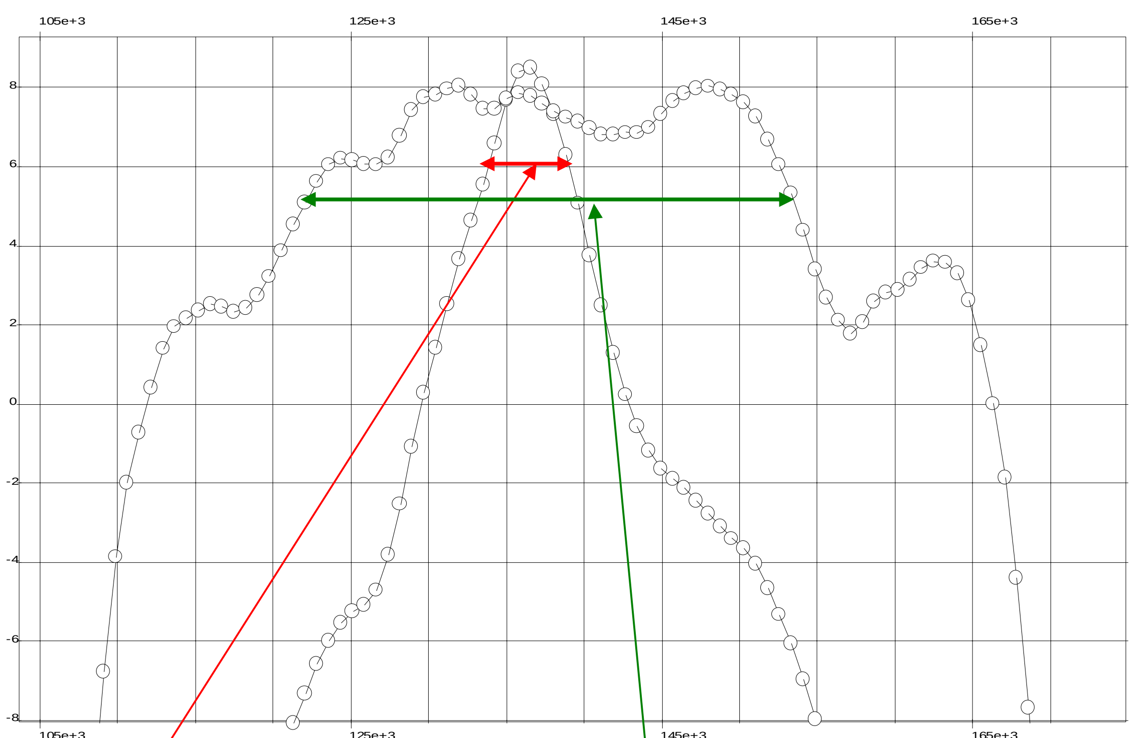
Test #1 mathematical solution:



Top: "Pulse" response Center: "Multiple pulses" Objective Bottom: Measured y*(t)

Comment: *Perfect agreement between modeling" and measured results.*

Example #2: Larger "Equivalent Bandwidth" (from test #2)



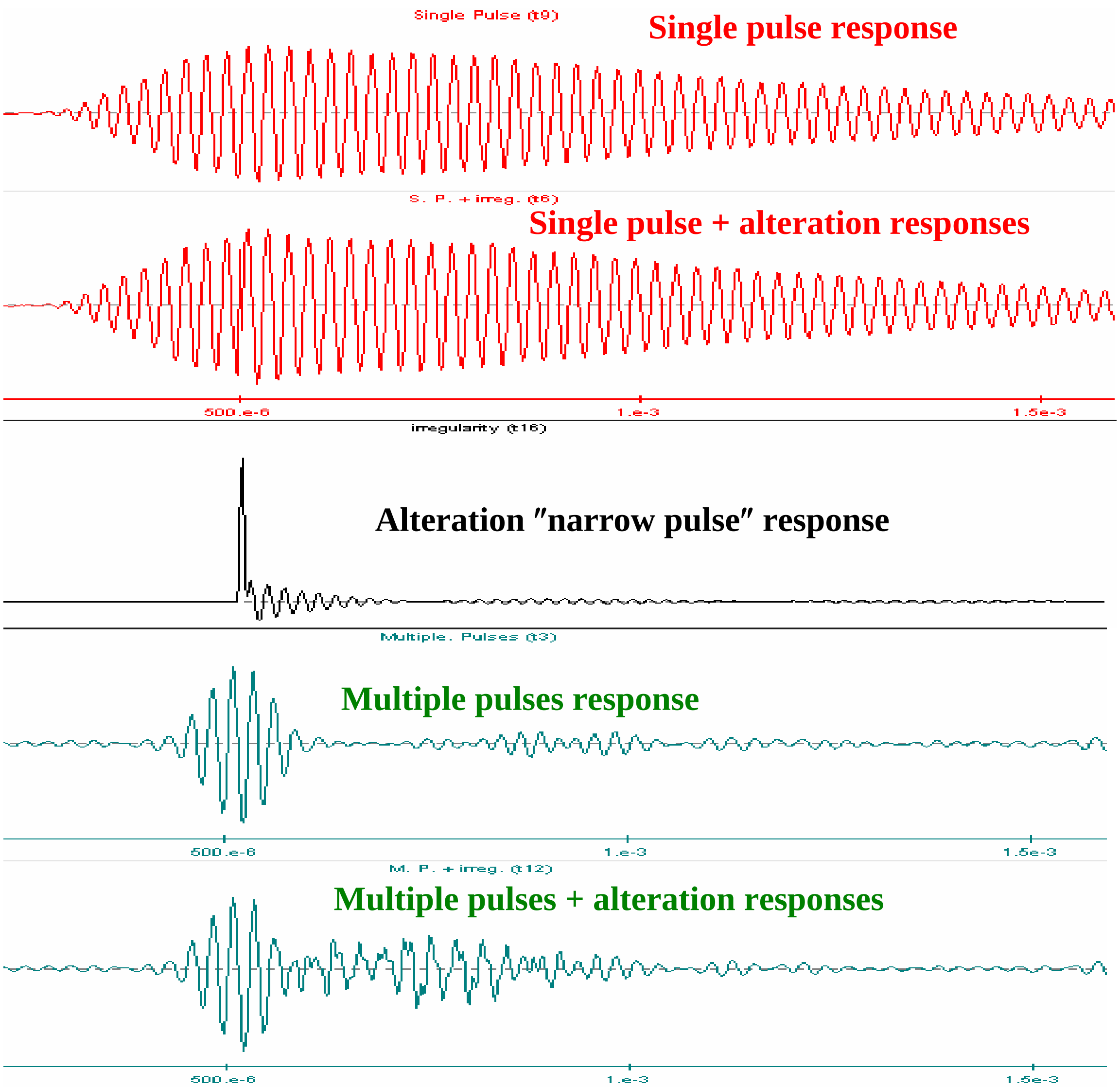
Single Pulse Frequency Spectrum vs. Multiple Pulses Frequency Spectrum

Comment: *In this example the "Multiple Pulses Equivalent Bandwidth" is more than* ***400%*** *larger than the "Single Pulse One".*

Example #3: Potential in Non-Destructive Testing (NDT)

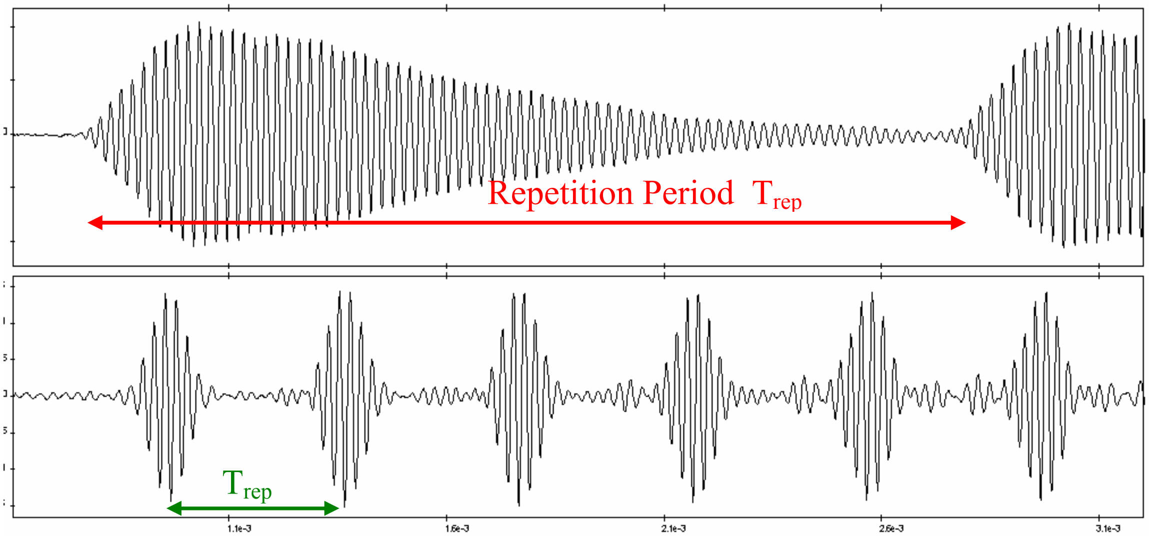
Simulation of a small alteration:

Channel Model: Two 40 kHz US transducers
Alteration model: Notch filter centered at 45 kHz (Bandwidth = 2 kHz)



Comment: *In the "Single Pulse" case, the channel alteration effect would be hard to detect whereas a ″simple″ energy measurement combined with a threshold detector would already provide a rudimentary ″Pass-Fail″ information.*

Example #4: Fast Repetition Rate (40 kHz US Transducers)

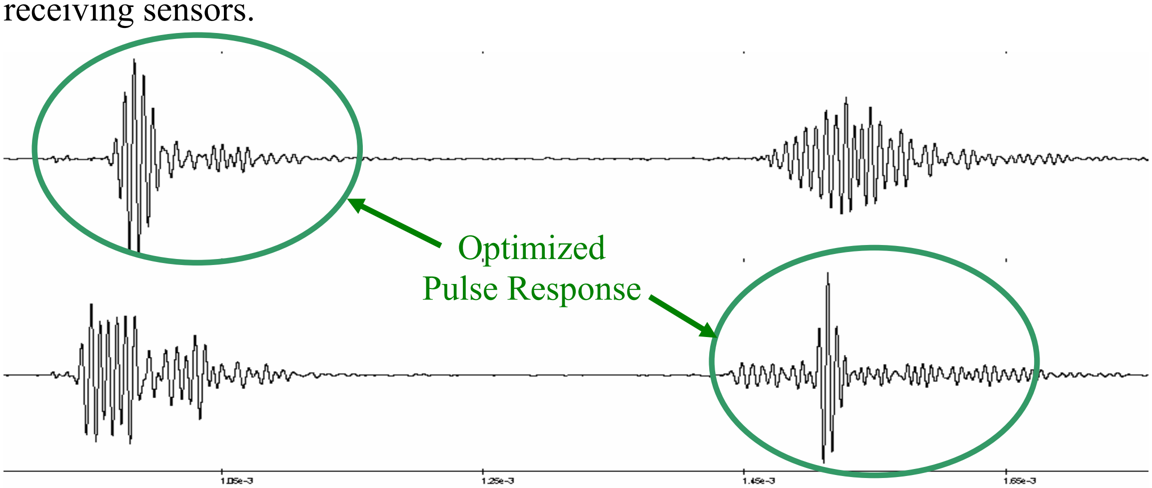


Top: Single Pulses Train Bottom: Multiple Pulses Train

Comment: *This example shows that the multiple pulses technique improves the repetition rate by a factor five.*

Example #5: Fast Switching for Multiple Sensors Situations

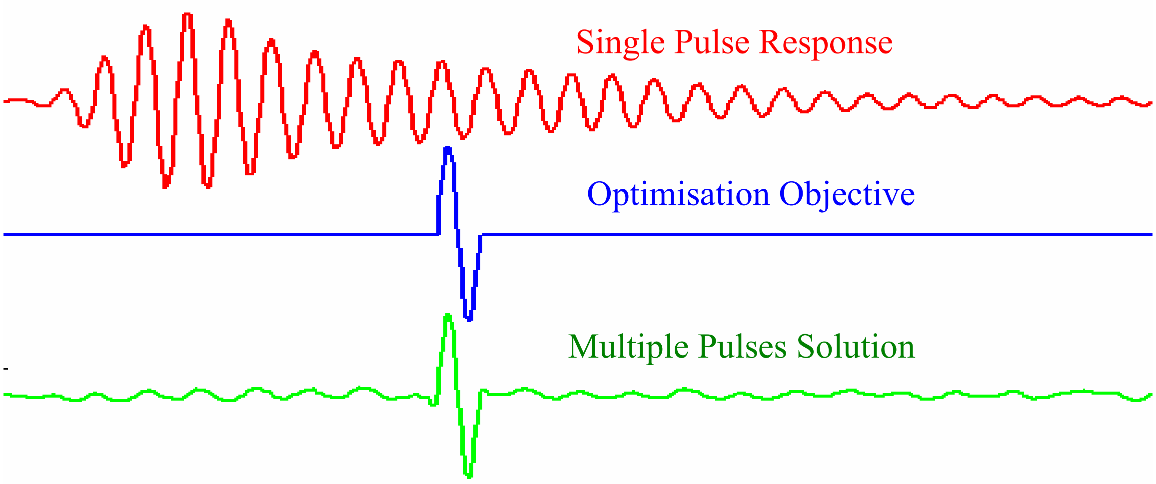
In this example (real laboratory experiment) the generator is alternatively driving the transmitting transducer with ″Multiple Pulses Train″ of both receiving sensors.



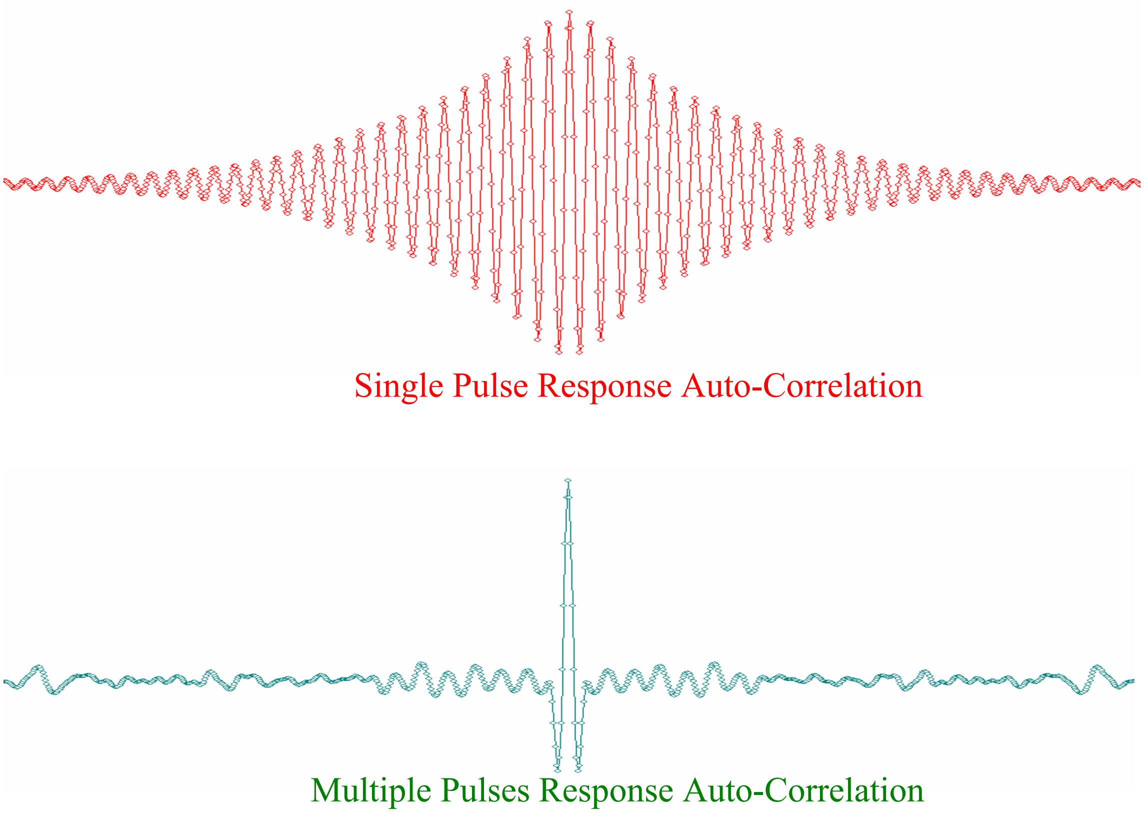
Top: ″D = 9 cm″ sensor Bottom: ″D = 5 cm″ sensor

Comment: *This concept can be easily extended to a higher number of sensors clamped on a tube or any other structure responding to ultrasonic excitation.*

Example #5: The dream becomes reality!



Auto-Correlation Functions Comparison:



Comment: *The "Multiple Pulses Response Auto-Correlation" has very desirable properties which are useful in most applications.*