

Building High-Performance NDT Systems with Ultrasound Transmitters and Receivers



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Introduction

Non-Destructive Testing (NDT) comprises of non-invasive methods to identify flaws, inconsistencies, or defects in materials, components or structures. These methods can be as simple as a visual inspection, or can be made much sophisticated with the use of X-ray, infrared thermography, and ultrasound technologies. NDT methods are used in several industrial, automotive, and military applications. Ultrasound testing has been adopted in the NDT space. This application brief discusses the basics of ultrasound NDT methods, the required components, and how a high-performance ultrasound NDT is designed.

Introduction to Ultrasound NDT Systems

Ultrasound systems send out high frequency sound waves, process any echoes that are returned, and identify issues. With frequencies higher than 200 kHz, these acoustic waves are beyond the audible range of humans. In addition to identifying structural defects, ultrasound systems can also measure flow, distance, and perform concentration analysis through techniques such as doppler or time of flight. These high frequency sound waves can pierce through various mediums without causing harm of any kind.

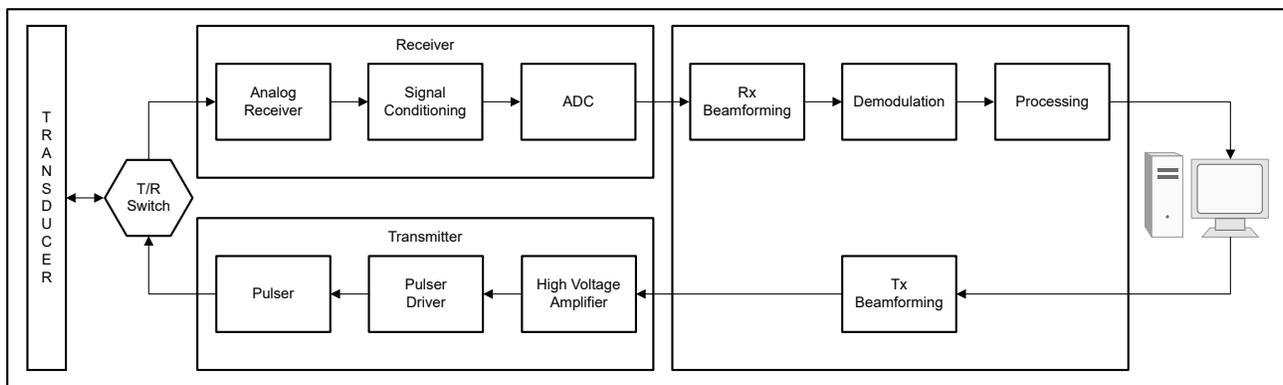


Figure 1. High-Level Block Diagram of How an Ultrasound System Operates

A typical NDT ultrasound system involves a transducer array, transmitter (pulsar) circuit, a receiver circuit and back-end hardware and software to capture, analyze, and display the measured ultrasound signal. As shown in Figure 1, the process begins with the user deciding the transmit waveform profile. The frequency of the transmit waveform and amplitude is determined by the depth of penetration and performance requirements of the system. Once the high-voltage waveform is generated, the digital pulsar drives the transducer in continuous wave (CW) or time gain compensation (TGC) mode through the transmit/receive (T/R) switch. A T/R switch is required to facilitate switching between transmission and reception so that the high-voltage waveform does not enter the low-voltage receive path. The transducer, which is in direct contact with the surface, converts the waveform to a high frequency radio wave. Once the wave reaches a surface, boundary, or opening, part of the wave is sent back as an “echo”. This echo is received by the transducer and is converted into an analog voltage. The analog voltage appears as a voltage input to the receiver and undergoes signal processing to enhance the desired signal and improve the dynamic range. This analog signal undergoes digital conversion, beamforming,

demodulation, and further processing to generate a clear image on the screen of the user, which can then be used to analyze the material.

Requirements for Ultrasound Transmitters in NDT Systems

An ultrasound system used for NDT applications requires a transmitter with a large number of channels to generate a transmit waveform. The beamforming of the waveform is dependent on the excitation of various transducer elements, with each waveform transmission having a different delay value that dictates transmission direction. A transmitter can benefit from a built-in T/R switch to protect the rest of the low-voltage system when the high-voltage (50 - 100 V) radio wave is transmitted. The transmitter must safety protocols in place to protect the system in the event of improper configuration or errors in the SPI writes.

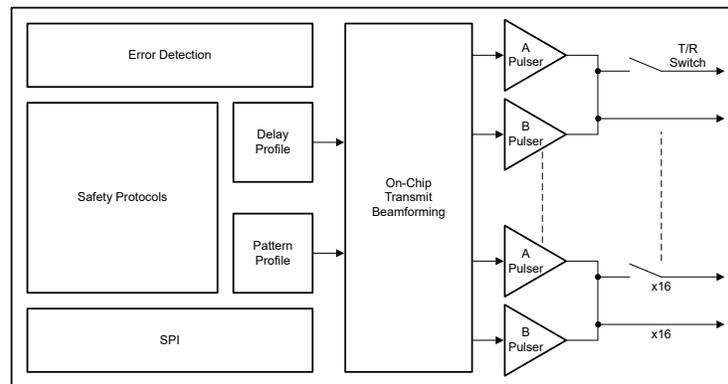


Figure 2. TX7516 Block Diagram

As an example, TX7516, a 16-channel ultrasound transmitter contains on-chip transmit beamforming and a built-in T/R switch for each of the 16 channel outputs. With built-in safety protocols and error detection, TX7516 decreases the number of parts that are required to create an ultrasound system and allows for more seamless integration. [Figure 2](#) shows the detailed block diagram of TX7516.

Requirements for Receivers in Ultrasound NDT System

Similar to ultrasound transmitters, an ultrasound receiver used for non-destructive testing must have a large number of input channels to receive the echoes. Through the use of a network of amplifiers and filters, the receivers must be able to enhance the analog waveforms from every angle that is tested while minimizing and filtering out noise. By configuring each channel to TGC or CW mode, the receiver can increase the intensity of received signal in proportion to the depth to reduce the impact of wave attenuation or simultaneously emit and receive a wave Doppler to calculate gradient, pressure, or flow. Portability is key to creating NDT ultrasounds, so to maintain low power consumption levels, the receiver must have low power consumption, but high speed and resolution. [Figure 3](#) shows the block diagram of the [AFE5828](#) 16-channel ultrasound receiver.

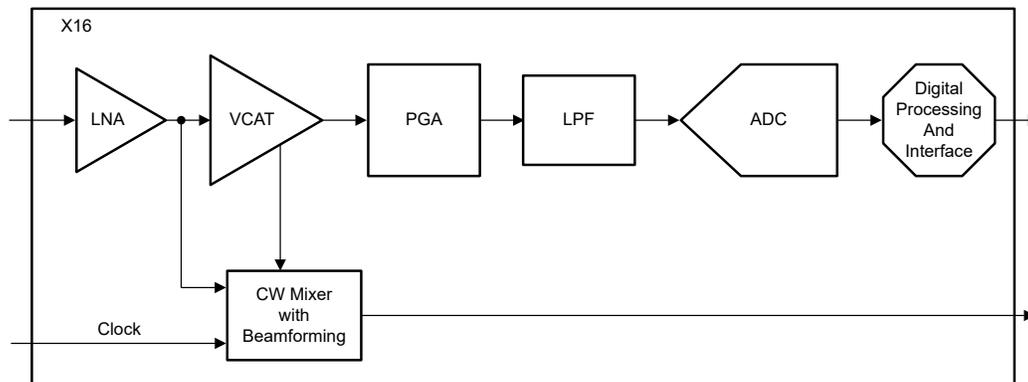


Figure 3. AFE5828 Block Diagram

A receiver such as the AFE5828 has a complex series of filters and amplifiers that makes sure that the waveform is processed and ready for analysis. This is accomplished while minimizing power consumption because the AFE5828 can change power scaling based on the sample rate.

Recommendation for Transmitters and Receivers in an Ultrasound NDT System

Figure 4 shows the block diagram of a 64-channel NDT system with four 16-channel ultrasound transmitter TX7516 and four 16-channel ultrasound receiver AFE5828. The integrated 16 pulsers, 16 T/R switches, on-chip beamforming, and pattern generator of the TX7516 combined with the low-noise 16-channel receiver AFE5828 enables users to build a high-performance low-cost ultrasound NDT system. A more detailed portfolio of Texas Instruments ultrasound transmitters and receivers can be found [here](#).

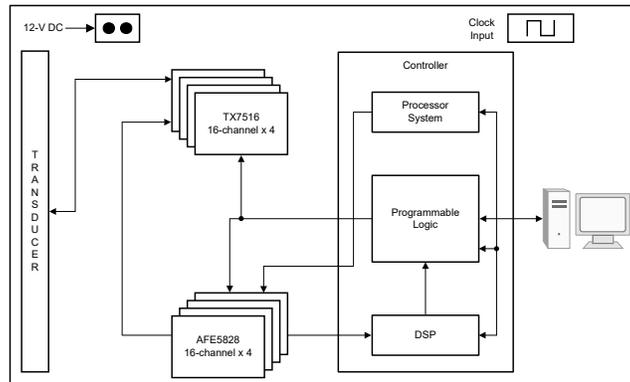


Figure 4. Texas Instruments AFE5828 and TX7516 in an Ultrasound NDT System

With the growth of aerospace, automotive, power, and oil and gas markets, the need for safe and effective testing methods has come to the forefront. With the high requirements for public safety in industrial practices, the adoption of ultrasound technology for NDT is growing.

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