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Applying the Furaxa IP Core to UltraWideBand

A novel method of pulse generation yields dramatic engineering, manufacturing and market advantages.

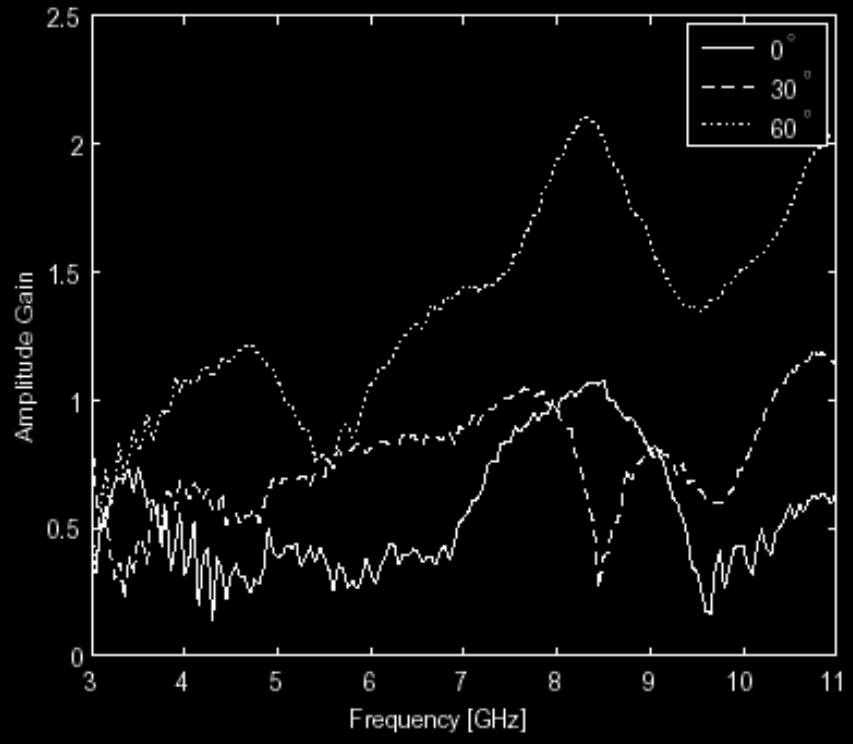
UWB antenna distortion

UWB antennas must cover multiple-octave bandwidths in order to transmit pulses that are of the order of a few nanoseconds in duration. Since data may be contained in the shape of the UWB pulse, antenna pulse distortion must be kept to a minimum.
http://www.mwrf.com/Articles/Print.cfm?ArticleID=5419

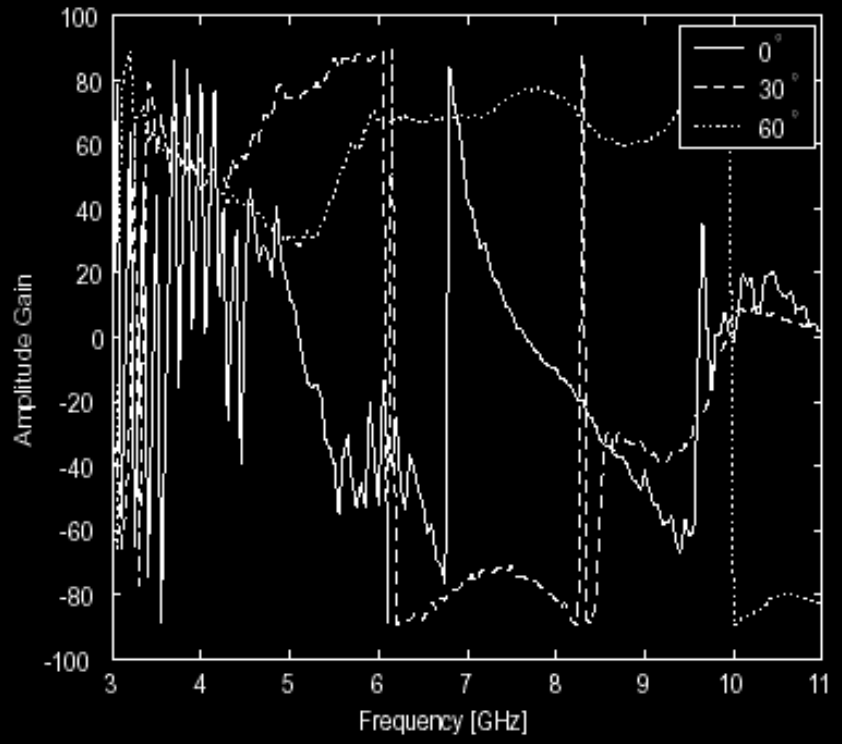
In UWB Communications, the antennas are significant pulse shape filters. Any distortion of the signal in frequency domain (filtering) causes distortion of the transmitted pulse, therefore increasing the complexity of the detection mechanism at the receiver. The radio propagation channel introduces additional signal distortion due to the multipath effects and frequency dependent attenuation.
The dependency of the received pulse shape on the actual radio channel – terminal antenna combination raises technical challenges when implementing receiver structures and has a crucial impact on the whole communication link. At the UWB receiver, an optimal template waveform is required to capture the most energy with the least computational complexity.
http://www.imec.be/pacwoman/publications/CPK-UWBWS03_Oulu-02-06-2003.pdf

Typical UWB antenna transfer functions = *non-ideal RF behavior*

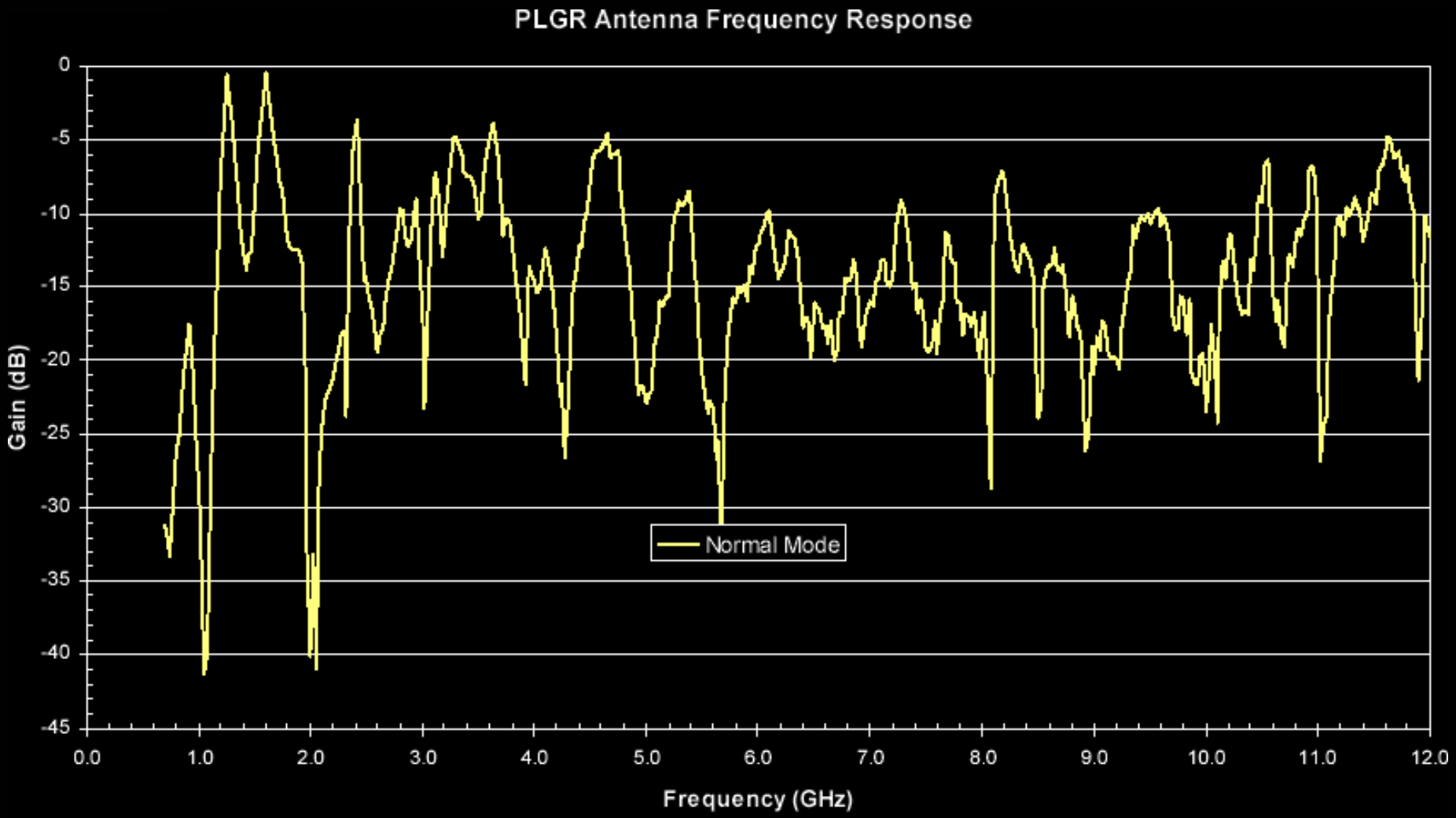
amplitude



phase



Typical UWB antenna frequency response = *non-ideal behavior*



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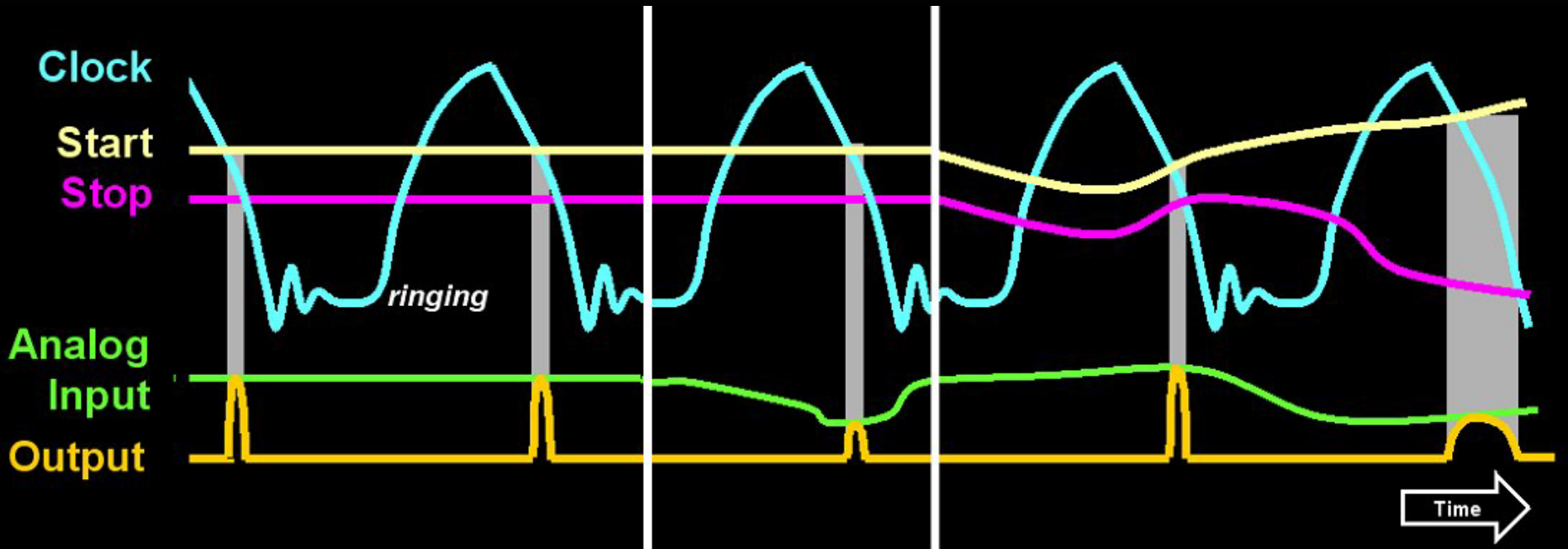
How does the Libove Pulser work?



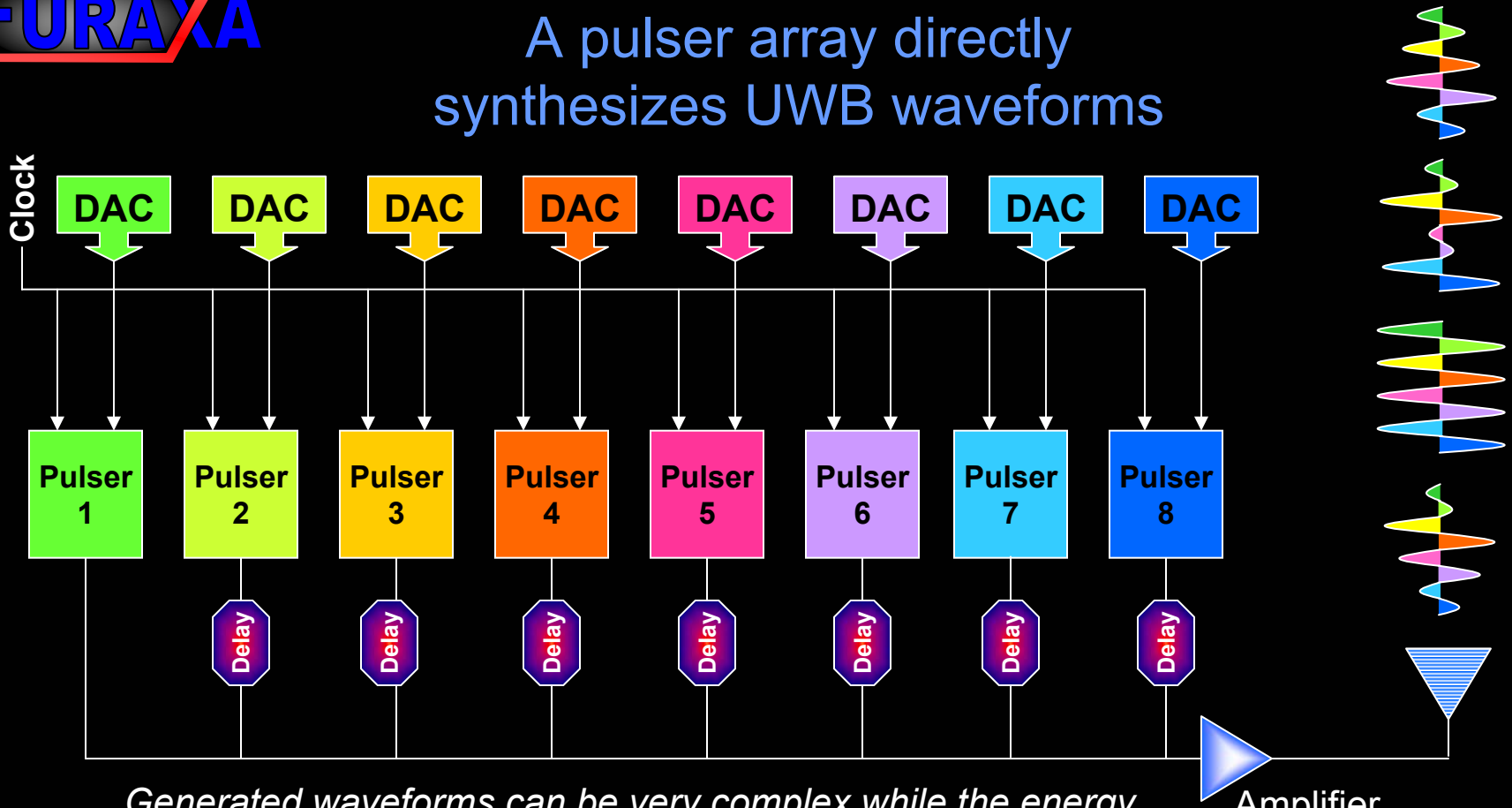
Output rises when Clock < Start
Output falls when Clock < Stop

Ringing has no effect

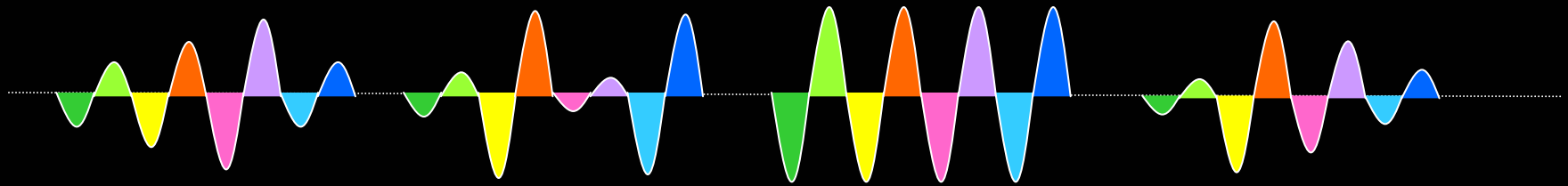
Output pulse amplitude = Analog Input amplitude

Stop, Start and Analog Input control pulse width, position in the Clock cycle and amplitude of the Output pulses.

A pulser array directly synthesizes UWB waveforms

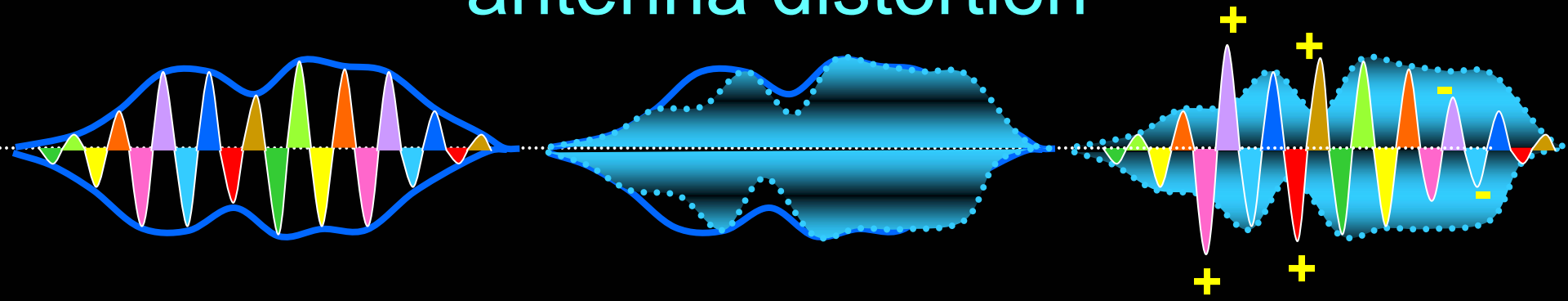


Generated waveforms can be very complex while the energy transmitted is in a very narrow band.



Low speed DACs control the amplitude of each output pulse through the analog input. The DACs are controlled by the transmitter processor. Each pulser generates pulses of common width with variations in amplitude of +/- 300 mV. The generated pulses are propagated along the tapped delay line, resulting in a burst sequence with only “in-band” components. Consequently ***little or no filtering is required.***

IP Core addresses antenna distortion



Waveform composed of many pulses as expected at receiver

Distorted antenna transmission

The pulser array compensates with
+ increased amplitude pulses or
- decreased amplitude pulses

Like a graphic equalizer in a stereo the waveform is compensated by the pulser array. Arrays with a large number of pulsers create waveforms comprised of many pulses so that any portion of the waveform that is distorted by the antenna can be compensated for. If an antenna design exhibits consistent / predictable distortion, then the distortion could be compensated for during the generation of the waveform.

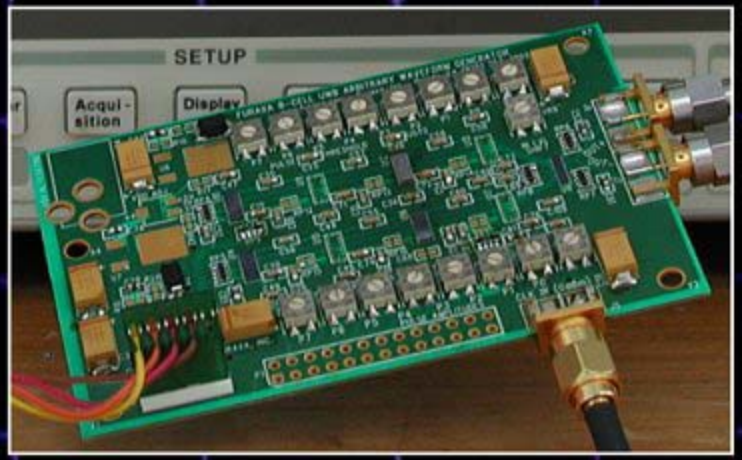
Each waveform in a UWB library is stored in corrected form. Specific stored waveforms are accessed by the transmitter processor which in turn drives the DACs.

Pre-corrected waveforms are transmitted in a form expected by the receiver.

Real generated waveforms on the next pages

An array of Furaxa pulsers in GaAs generating real waveforms

An array of 4 pulsers generates 4 pulse waveforms



Pulse amplitudes are independently controlled by each pulser

Differential signal

Libove Pulser Sampler

500.0 ps/div

47.6750 ns

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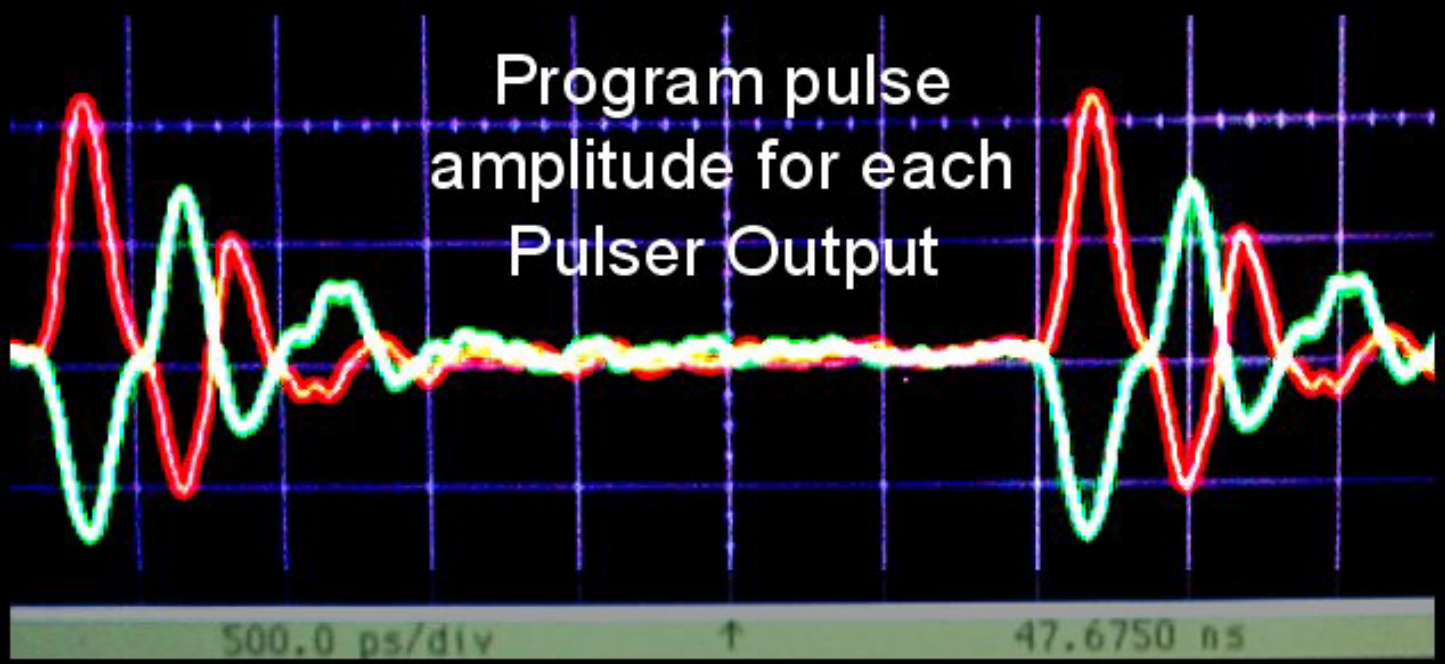
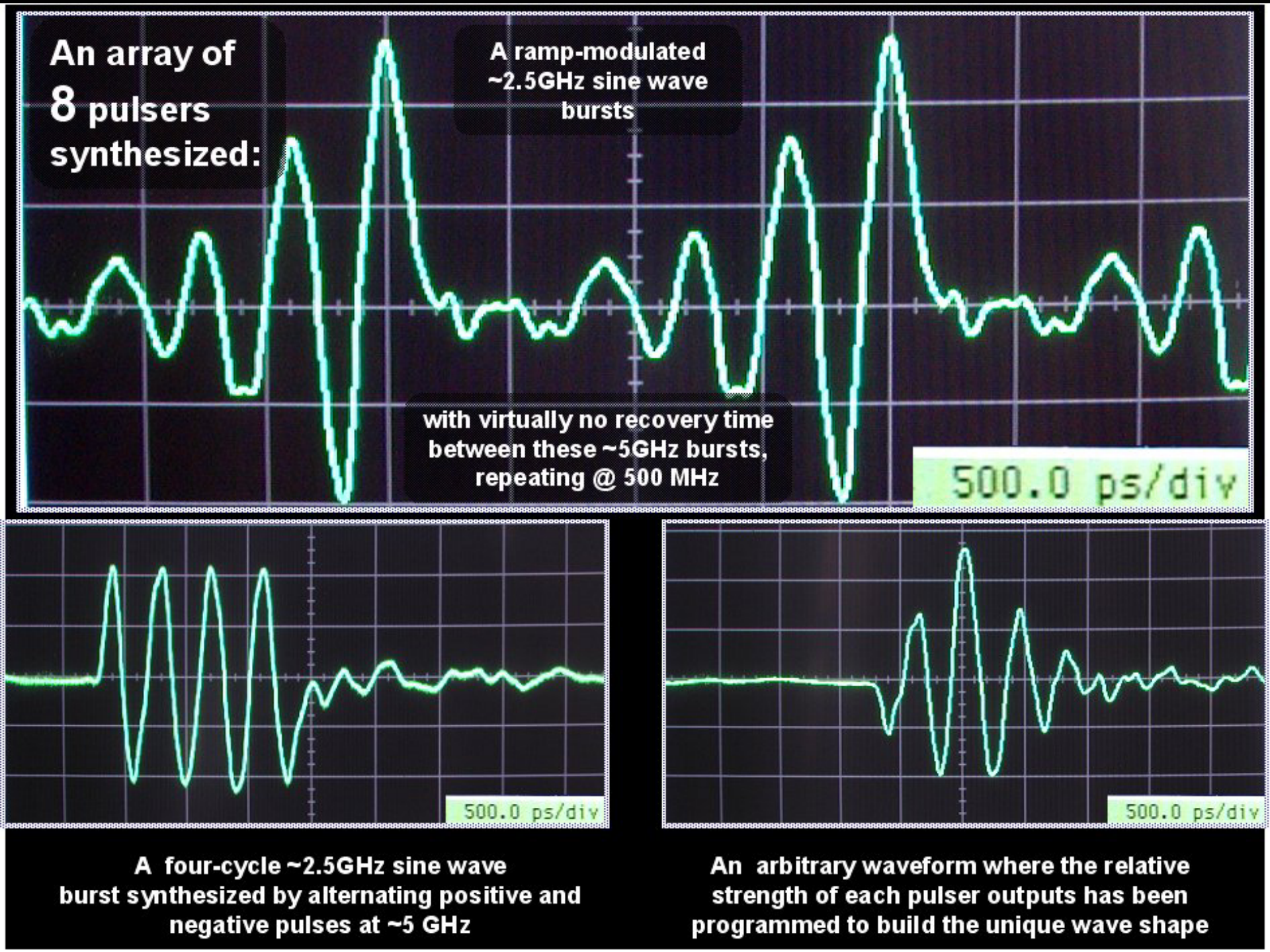
Four Pulser Outputs are
combined and repeated
at a 350 nsec rate
500.0 ps/div
47.6750 ns


Program pulse
amplitude for each
Pulser Output
500.0 ps/div
47.6750 ns



A four-cycle ~2.5GHz sine wave burst synthesized by alternating positive and negative pulses at ~5 GHz

An arbitrary waveform where the relative strength of each pulser outputs has been programmed to build the unique wave shape

Furaxa IP optimizes UWB applications

- **Dramatically reduce inefficient elements of the link budget in both design and manufacture. "Field or Factory programmable" synthesis and optimization of UWB TX waveforms relaxes the engineering specs for critical components of the TX chain such as the antenna.**

  - Direct, programmable synthesis of UWB waveforms pre-corrects for antenna, amplifier, or channel deficiencies and other sources of non-ideal behavior.

Furaxa IP optimizes UWB applications

- **Minimize TX filtering components count**
  - Direct synthesis of RF waveforms eliminates the need for most transmission related filtering components
    - Lower material costs
    - Reduced risk of failures or tampering

Furaxa IP optimizes UWB applications

- Relax high-precision part specifications, as non-ideal behavior can be accounted for by pre-compensation of the UWB waveform by the pulser array.
- Field programmable capability allows accommodation of modifications to current UWB specification.
- If the antenna design were to change, then only the waveform library needs to be modified while the hardware feeding the antenna remains unchanged.
- Field programmable capability “puts the hooks in” for advanced UWB concepts, such as dynamic link compensation where multi-path distortion and other “between antenna” distortions are compensated for by dynamic calibration.

PHY link budget & Silicon Germanium (SiGe)

The predicted 20pS aperture and pulse width with a SiGe rendering, yield a bandwidth capable of covering the entire allocated UWB spectrum. The effects on the link budget:

Transmitter Chain

This bandwidth could be efficiently utilized, as deficiencies in the TX chain (antenna, amplifier, etc.) could be pre-corrected within the synthesis array. Compensation is programmable based on antenna transmissions, reducing engineering risk. The UWB spectral envelope is packed tight, resulting in much high link efficiency.

Receiver Chain

Similarly, the RX chain could be corrected in a receiver with the high speed sample aperture (~ 20psec SiGe) of the Furaxa IP core. The “hooks are in” to attempt more aggressive implementations, without added costs to the basic UWB hardware.

Value to the UWB market

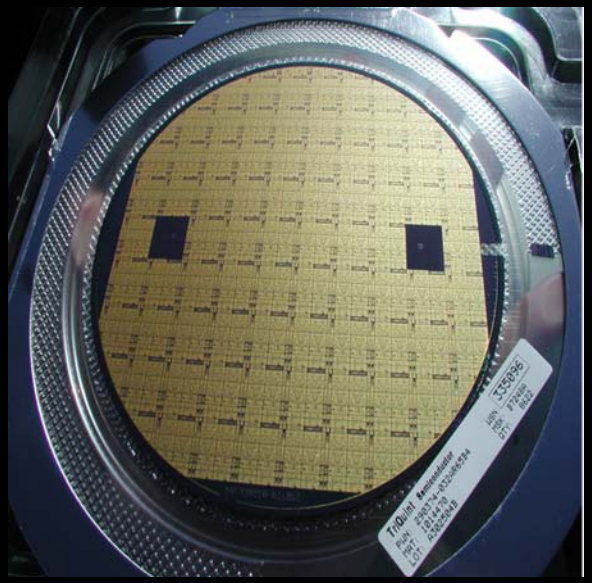
- **Risk, Cost, and TTM reduction**: Optimization allows error margin in engineering and manufacturing design.
  - Engineering:
    - Dramatically reduced filtering requirements and associated component count
    - Relaxation of technical specs
    - Tunability reduces risk of “DOA” fabrication, decreases number of design iterations.
  - Manufacturing:
    - Tunability increases manufacturing yield
    - Tunability allows inexpensive substitution for high cost high-precision parts

Value to the UWB market

- **Market Flexibility**: Can alter most parts of the system (burst timing, burst envelope, data rate, etc.) to accommodate changing UWB environments
  - FCC regulations and potential changes, as well as non-US requirements
  - Adapt to changing Market drivers (SOP, data rate, BER, etc.)

US Patent #6,433,720

Arrayable high speed pulse and sample aperture generation



- **Single edge aperture/pulse generation without use of differentiating elements**
- **Ultra-fast, stable, repeatable apertures and pulses**
- **Easy integration into large arrays of very low cost matched samplers/pulsers**
- **Unparalleled noise rejection and immunity from control signal imperfections and overvoltage conditions**
- **Dynamic control of the amplitude, position and duration of individual samples/pulses Superior linearity, jitter, and kick-out voltage performance**
- **Higher signal and control input impedances and lower drive requirements than existing technology**
- **Fully differential inputs and outputs, if desired**
- **Low power allows high density**

Next Steps

- Furaxa's next development step
  - Foundry run submission April '04
    - InP HBT
    - 6pS *simulated best aperture / pulse*
- Your steps
  - Evaluation of Furaxa technology as applied to your current UWB technology
  - Evaluation of Furaxa technology as applied to new UWB approaches

Furaxa is looking for UWB business partners whose technology is compatible with our IP core.
Please contact Furaxa to discuss your next step!!

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