TI Solution for Medical Ultrasound

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TI Shenzhen Medical Seminar

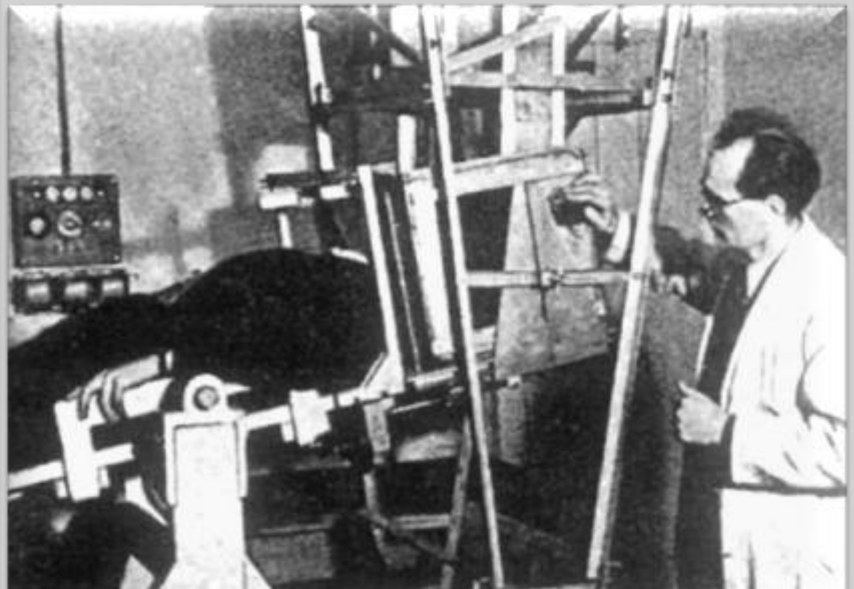
2012-6-12

Texas Instruments

Agenda

- Ultrasound Basic
- TI AFE in Ultrasound
- TI Clock and Power in Ultrasound

Bringing ultrasound to the P*oint-of-Care*



Karl Dussik's apparatus
for scanning the head, 1940

Remote/Triage

Military

Images courtesy of Sonosite

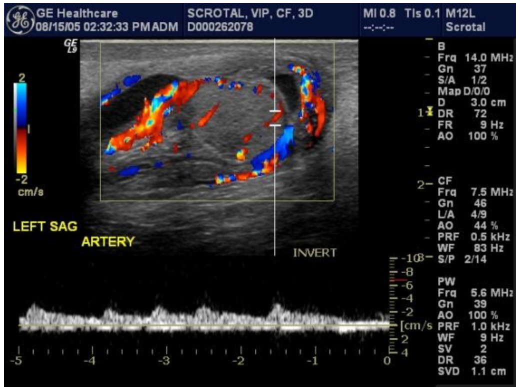
Overview of Ultrasound

- Ultrasound Basics
  - Advantages
    - Real-time & Non-invasive
    - Inexpensive
    - Multi-channel in a single system
    - Growing market of >4 billion worldwide

  - Operation Principles
    - Sound vs Ultrasound ~ 20Hz-20KHz vs 2-20MHz
    - Transducer ~ Loudspeaker & Microphone
    - US AFE ~ Power Amplifier & Signal Amplifier
    - US System ~ Radar System

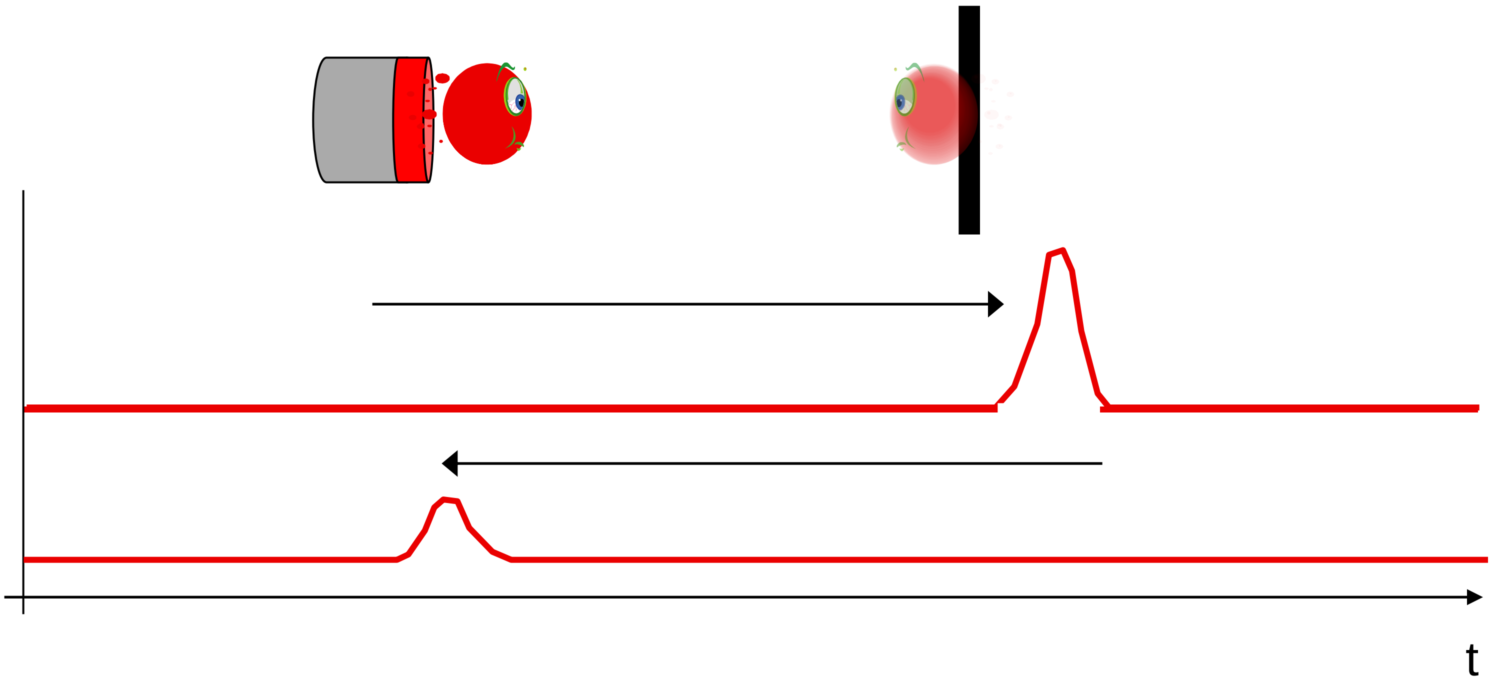
Ultrasound Basics

- Ultrasound Basics
  - Imaging Modes
    - Brightness Mode (B-mode) *64-256 channels*
    - Doppler Mode (D-mode) *1-64 channels*
    - Color Doppler mode (2-D Doppler) *64-256 channels*
    - 3D & 4D Ultrasound *1024-4096 channels*

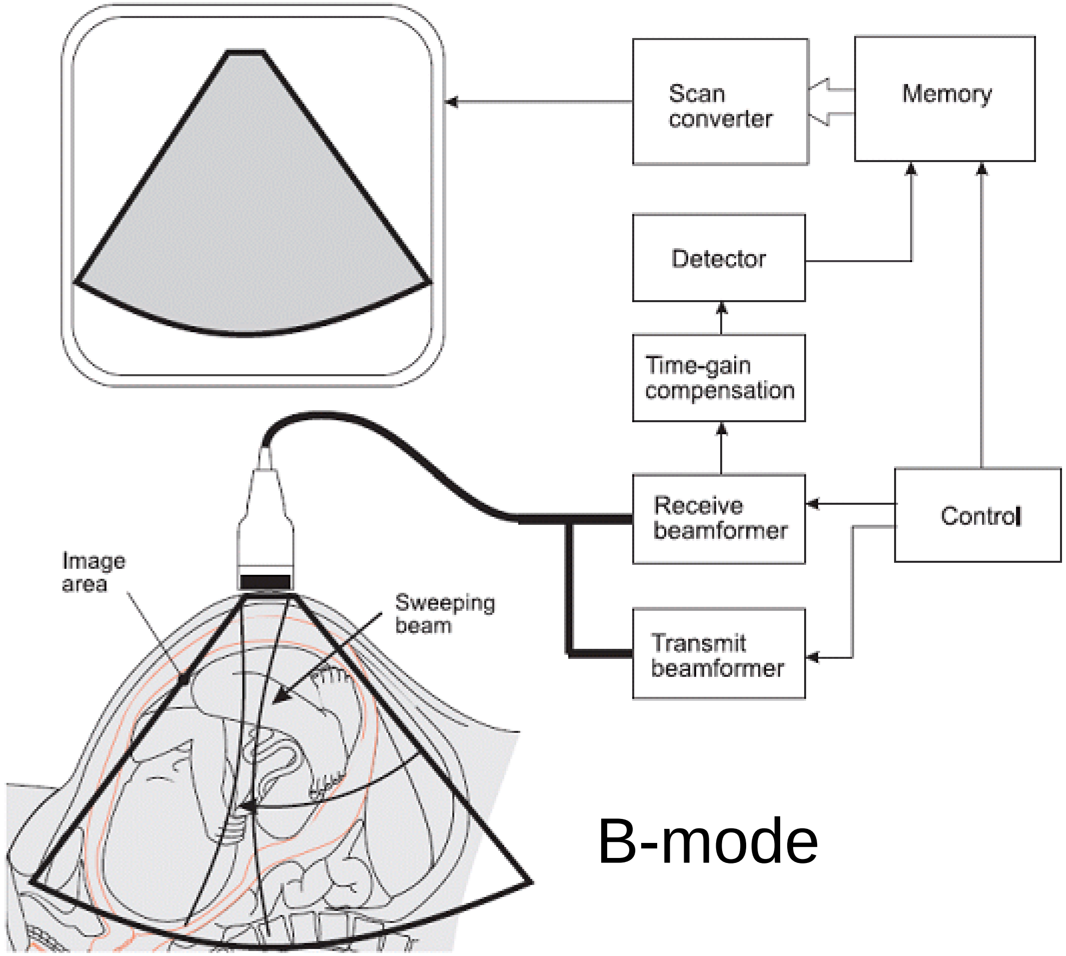


Courtesy of GE

Principle



The machine – Top level



B-mode

Physics (I)

Substance	c [m/s]	ρ [g/cm^3]	Z = ρc [10^5 Rayl]	**Attenuation [dB/MHz.cm]**
Fat	1470	0.97	1.42	**0.5**
Muscle	1568	1.04	1.63	**2**
Compact bone	3600	1.7	6.12	**4-10**
Air	331	0.0013	43.10^{-5}	

Position
Frame rate

Reflections
Strong or weak

Depth

Imaging Systems for Medical Diagnostics - Siemens

Physics (II)

c = 1560m/s

$$R_{Axial} = \frac{\lambda}{2.FBW} = \frac{c}{2}\tau_{-6dB} \propto \frac{c}{2f}$$

Frequency [MHz]	Wavelength [mm]	Penetration depth [cm]	Lateral resolution [mm]	Axial resolution [mm]
2	0.78	25	3	0.8
5	0.31	10	1.2	0.35
10	0.16	5	0.6	0.2
15	0.1	3.3	0.4	0.15

f.2.x.α = 100dB
α = 1dB/(MHz.cm)

$$R_{Lateral} = \frac{c}{f}\frac{2r}{w.\cos\theta}$$

Imaging Systems for Medical Diagnostics - Siemens

Frame rate

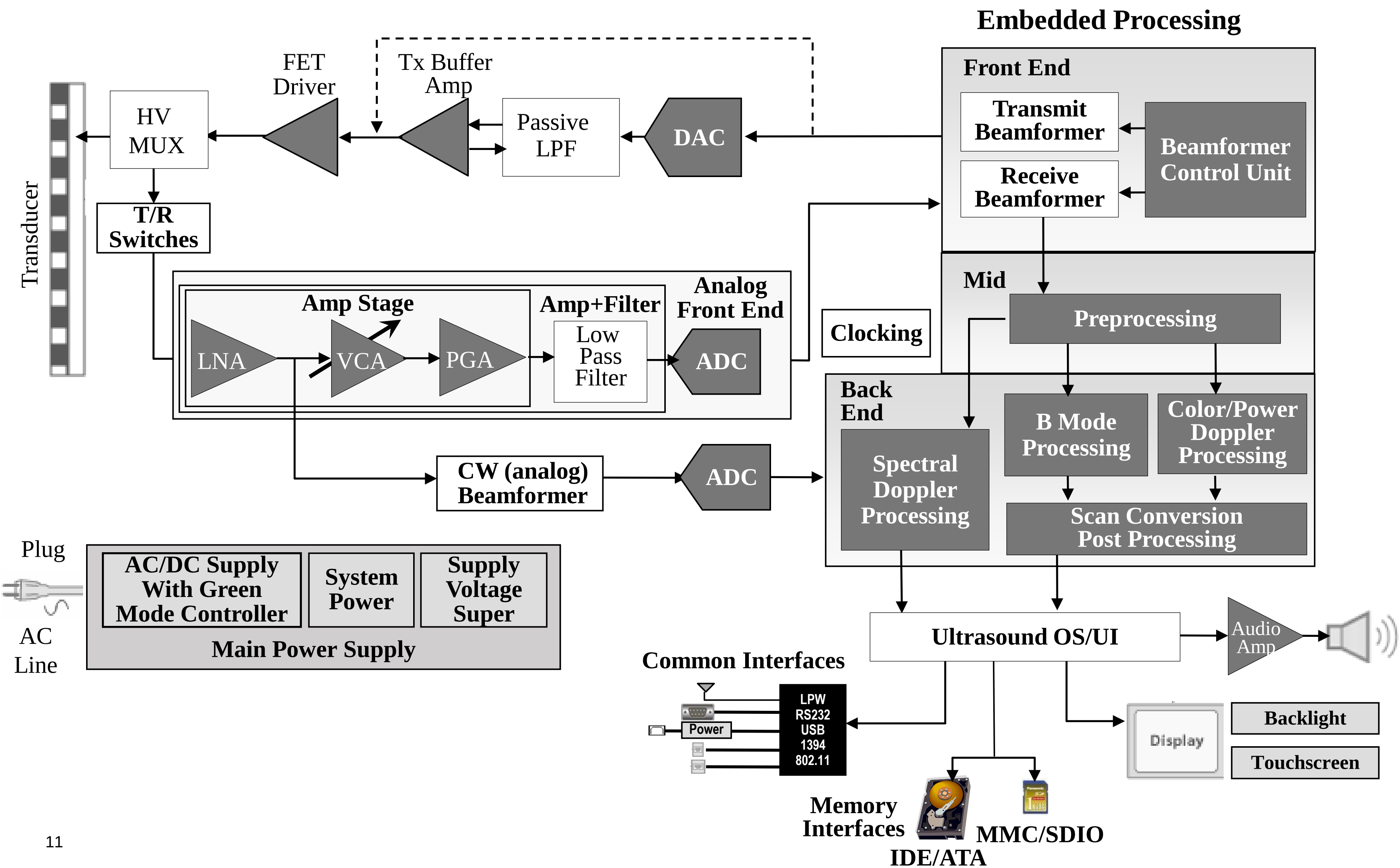
Example:

c = 1540m/s
60^o sector
0.5^o beam spacing
25cm depth

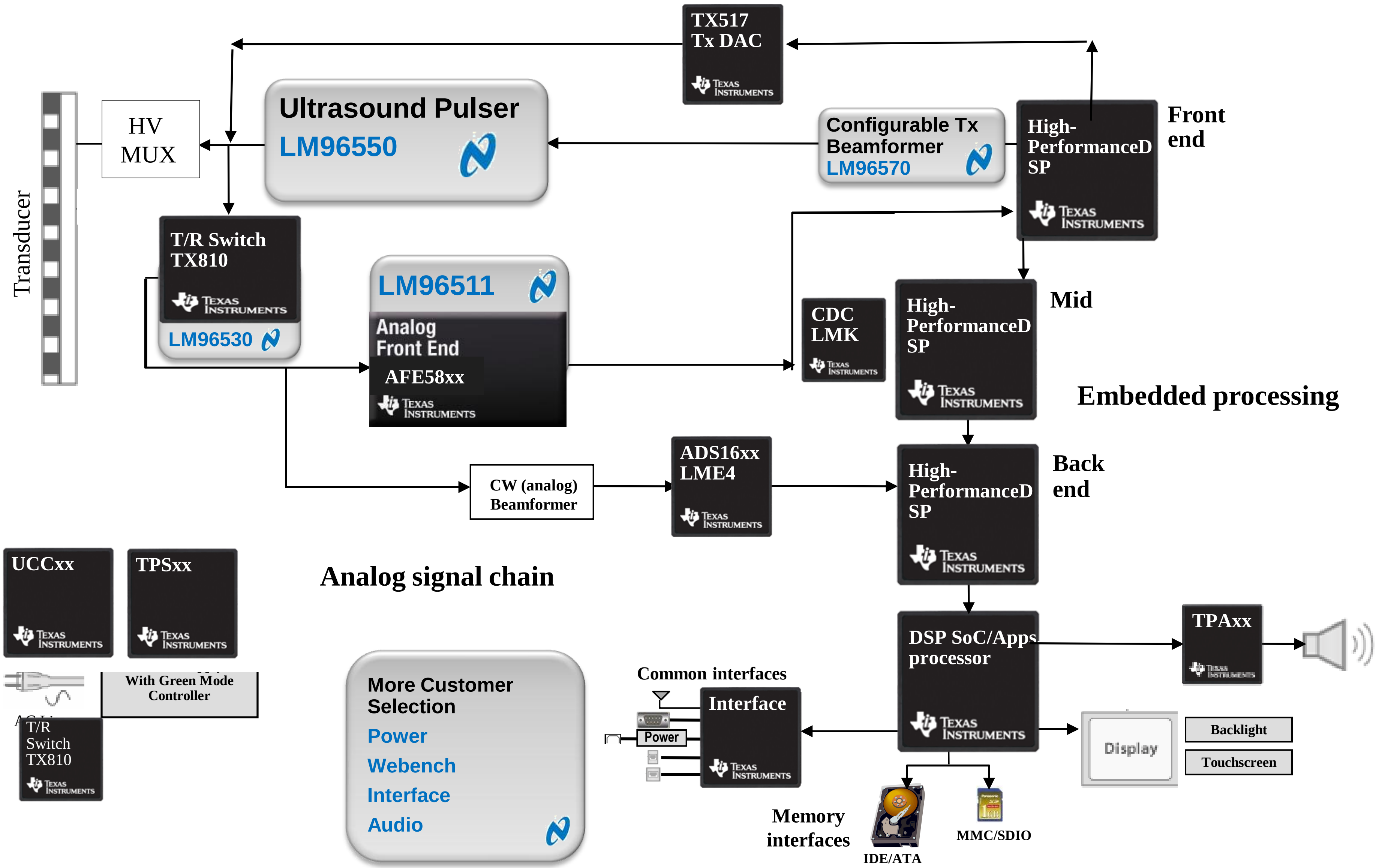
120 beams
25cm x 2 / 1540m/s =320us / beam

26 frames/s

System level ultrasound

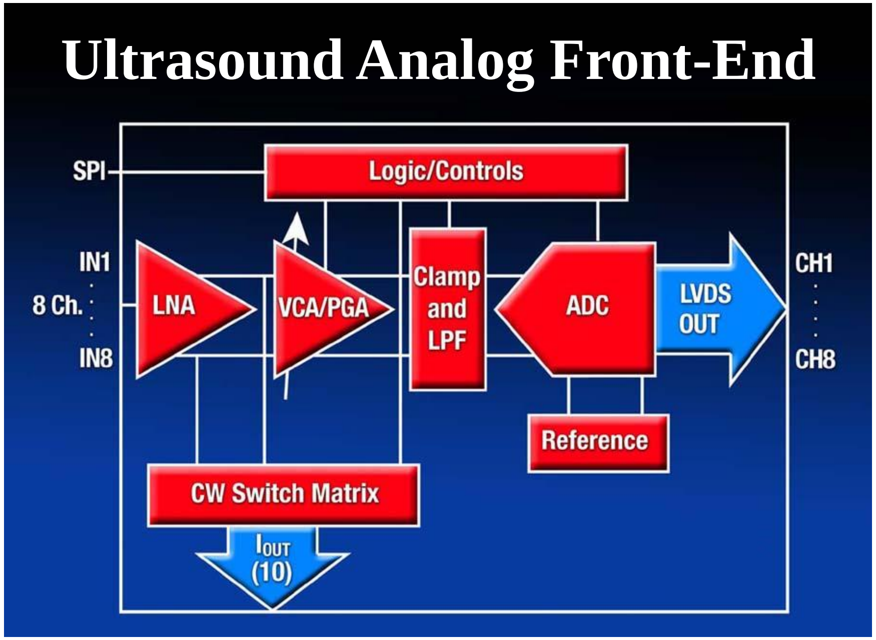


A Basic Ultrasound Machine Has…



Defining the AFE

- **LNA**
  - Low-noise amplification for good sensitivity and noise floor performance.
- **VCA and PGA are considered the Time Gain Control (TGC) blocks**
  - Improve the system's dynamic range.
  - Allow the gain to be increased with time to compensate for the increased attenuation of the signal as it passes through the body.
- **Filter**
  - Improves its signal-to-noise ratio
- **ADC**
  - Converts signal into digital format through an ADC and is processed by the receiving beamformer.



The performance of the AFE significantly drives the ultrasound system's characteristics in terms of size, weight, battery-life, and image quality.

Valuable Specs in Ultrasound

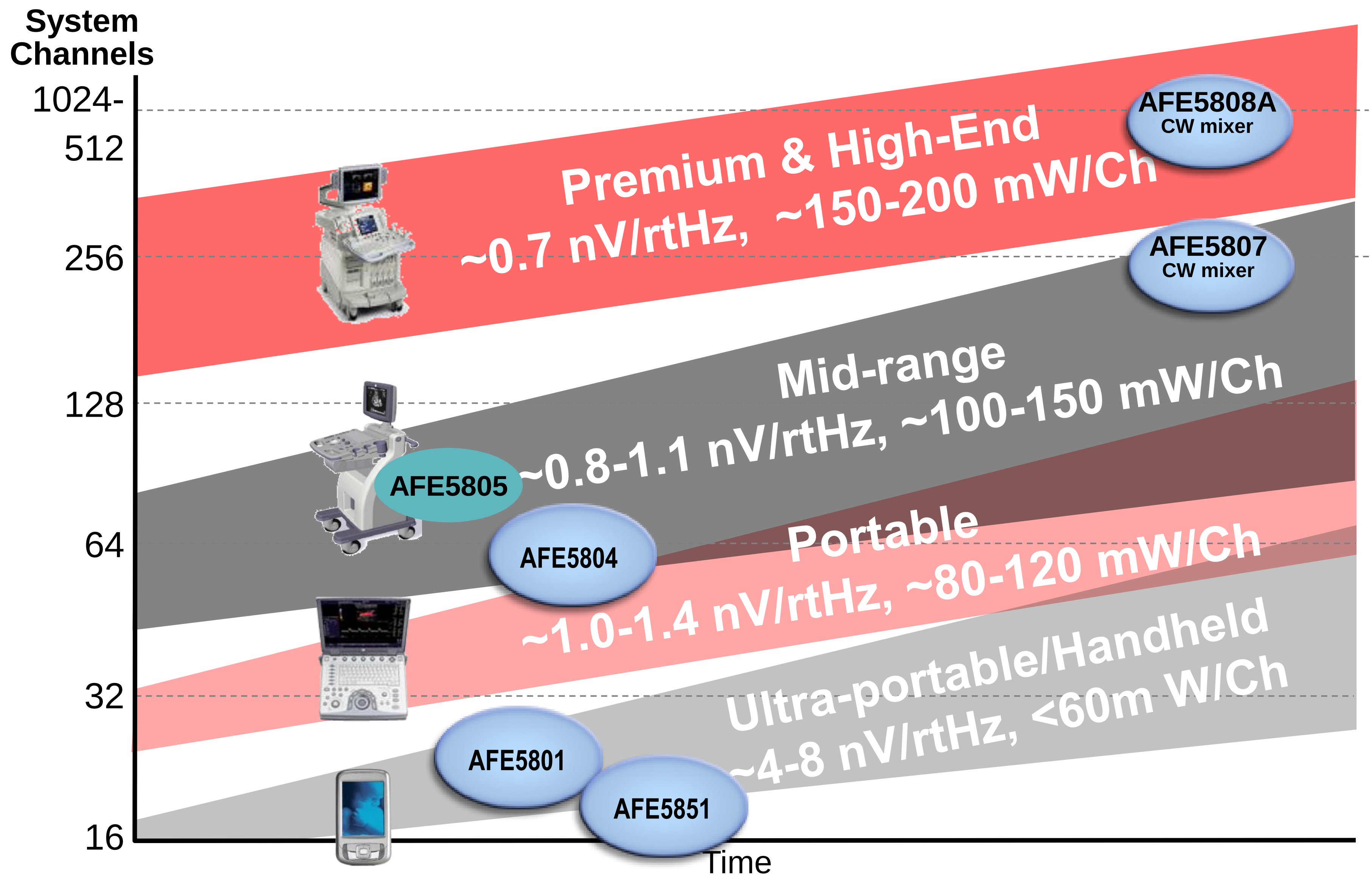
- Power/Noise
- Overload Recovery
  - Recovery time & recovery consistence.
  - Consistent recovery char leads to less color noise.
  - Overload recovery reports for AFE580x are available.
- Power up/down speed
  - Related to VCA shut down duration
  - Better power saving and more flexibilities for users
- Input Termination vs system performance
  - Active termination vs Passive termination
  - No external resistor needed for active termination

Valuable Specs in Ultrasound

- Matching among channels and chips
  - Considered probe sensitivity variation
  - Chip matching is a guaranteed number at ATE.
- Harmonic Distortion(HD2 and HD3)
  - Harmonic Imaging (HD2)
  - CW demodulation (HD3)
- Jitter vs Color Noise
- CW IQ Matching
  - Affect the forward and backward flow detection
- SNR at low gain i.e. SNR at near and mid range
  - Related to VCA IRN and PGA gain specs

Detail information can be obtained from TI MBU

Analog Front End Trends and Requirements



AFE5808A

AFE with Passive CW Mixer for Ultrasound

Features

- Integrated LNA, VCA, PGA, LPF, 12/14-bit ADC with LVDS output up to 65 MSPS and CW doppler mixer and summing amplifier
- Low-noise optimization of 0.75nV/rtHz, 153mW/ch, 65 MSPS and an ADC with 77dBFS SNR
- Low close-in phase noise better than -155dBc/Hz at 1KHz off a 2.5 MHz carrier
- Total Max Gain: 54 db and 0.25/0.5/1 Vpp Linear Input Range
- 3rd order linear phase LPF with selectable bandwidth of 10, 15, 20, and 30 MHz and 50, 100, 200 or 400Ω active termination
- Package: 135-pin 15x9 mm BGA

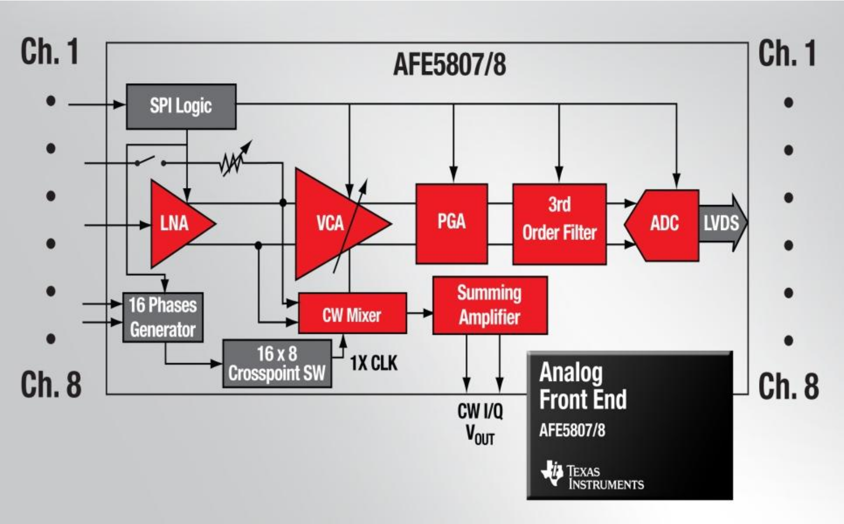
Applications

- Ultrasound
- Sonar

AFE5808EVM

Benefits

- Fully integrated AFE with CW for ultrasound
- High-performing solution for low-noise optimization and premium image quality
- Eases design with CW beamforming for Doppler Systems
- Optimized dynamic range for optimum image quality
- Supports a range of input amplitudes for different class of transducers
- 25 % smaller size for ease of design, smaller system footprint and increased channel count



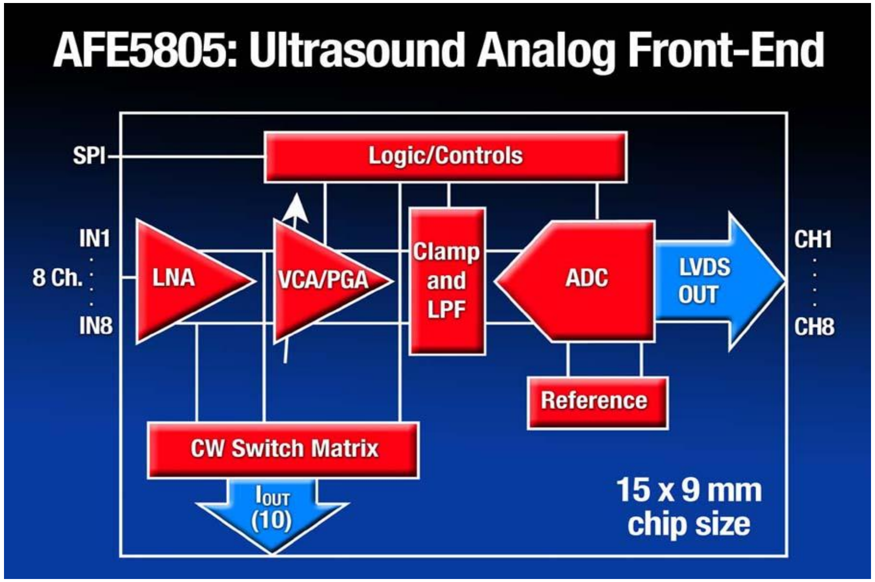
AFE5805: 8-Channel Analog Front-End

Features

- Integrated LNA, VCA, PGA, LPF, ADC
- Low power: 122 mW per channel at 40MSPS
- Low Noise: 0.85nV/rtHz
- Gain control range: 46dB
- PGA Gain Settings: 20dB, 25dB, 27dB, 30dB
- Fast overload recovery
- Package: 135-pin 9x9 mm BGA

Benefits

- Complete Analog Front End
- Best in class noise & power performance
  - 20% Lower Power
  - 40% Lower Noise
- Improved dynamic range
- Enables portability with 47% smaller size



Applications

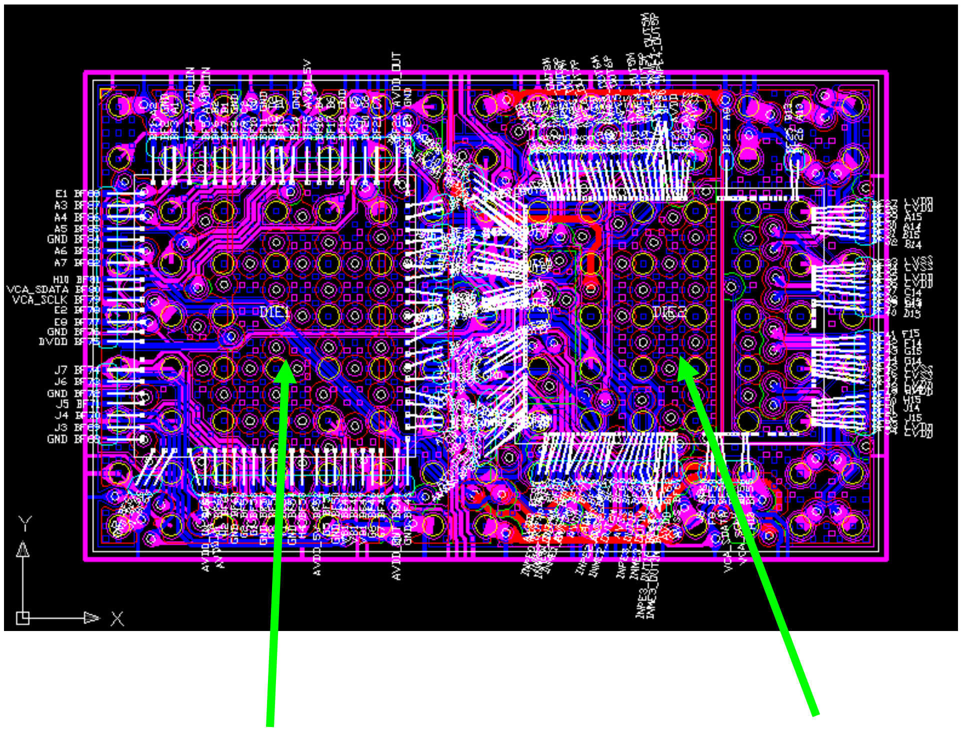
- Ultrasound
- Sonar

EVM

AFE5805EVM

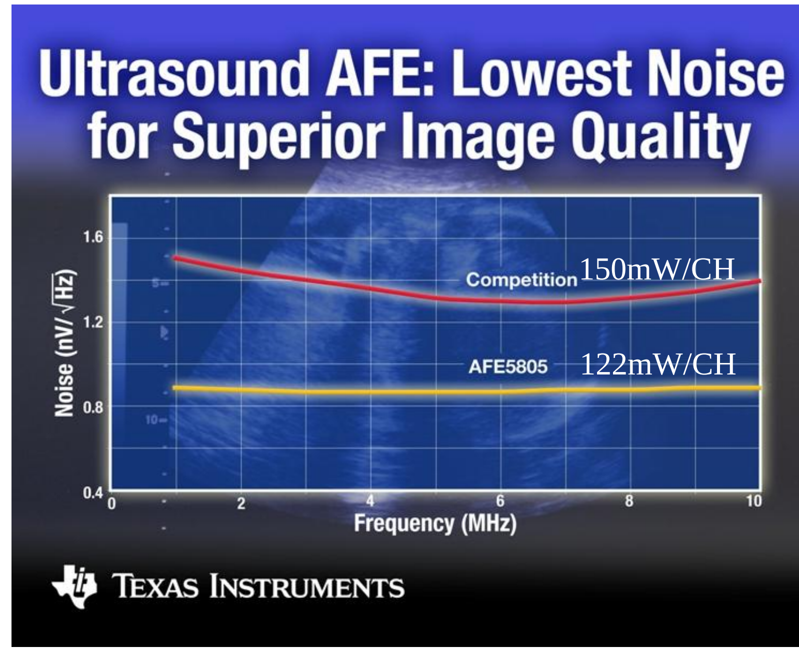
Low Power Low Noise Rx Solutions

- Suitable process for each block

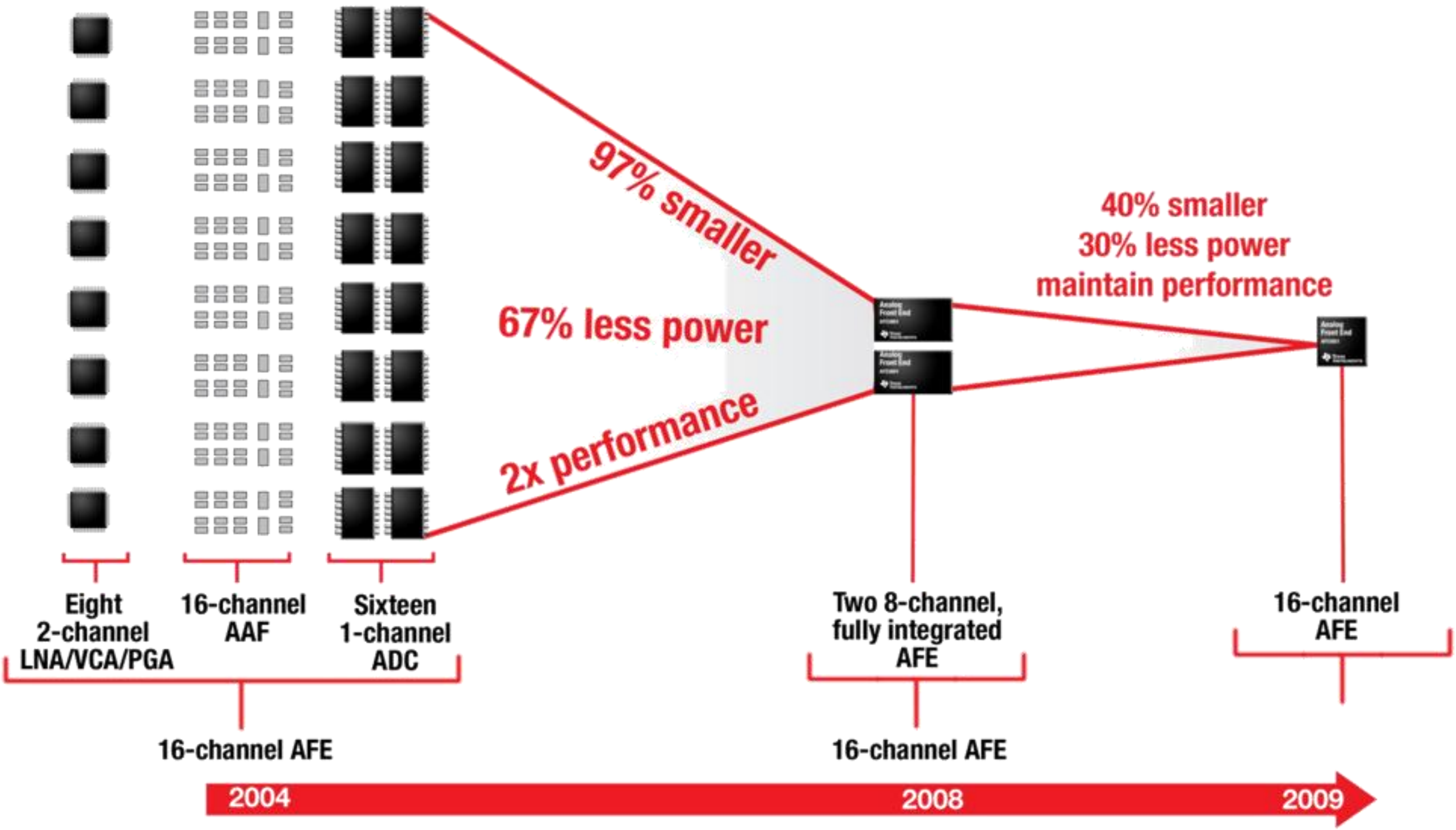


VCA: SiGe BiCOMS technology

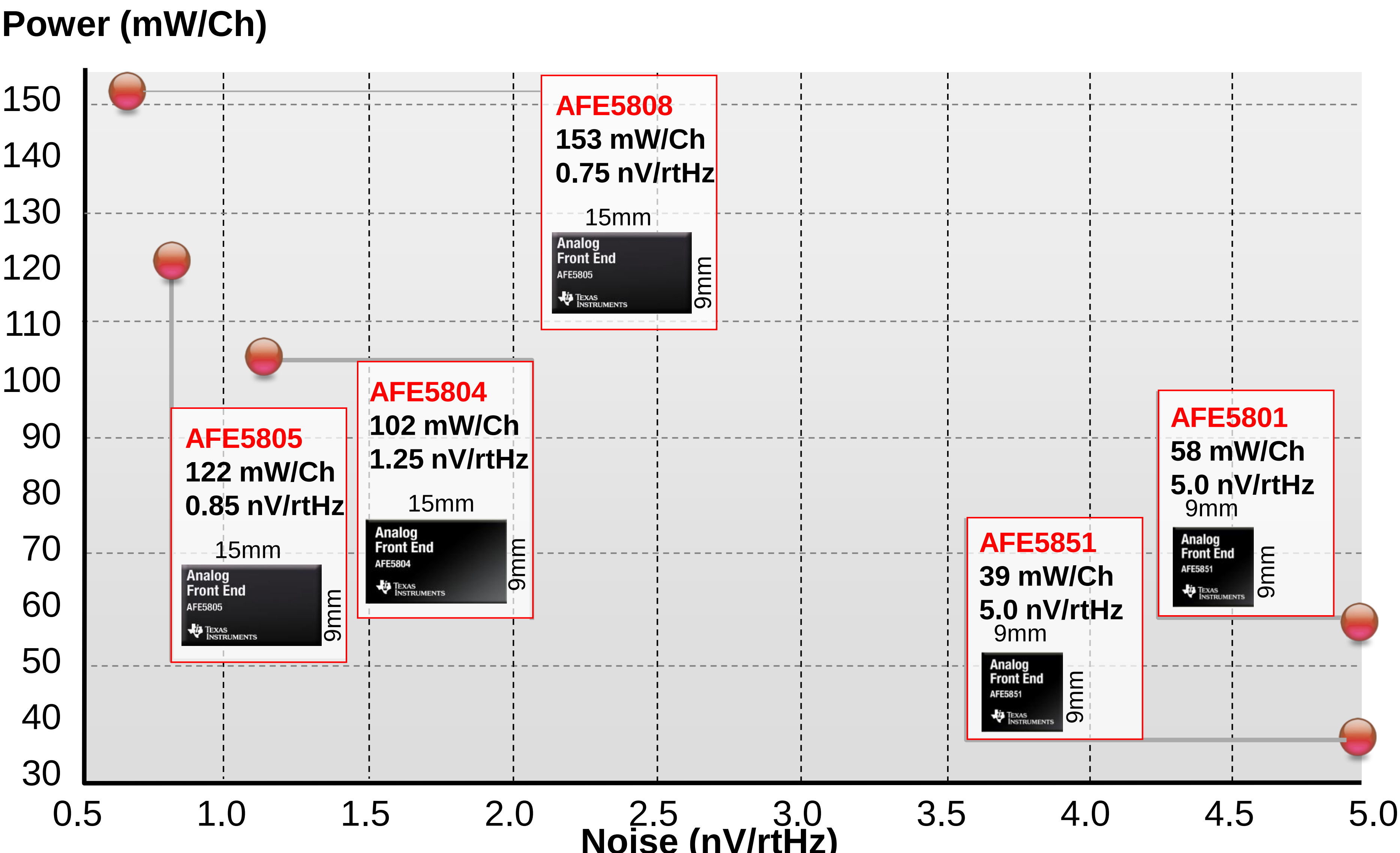
ADC : 0.18um CMOS



Evolution of Numbers of Channels / Chip

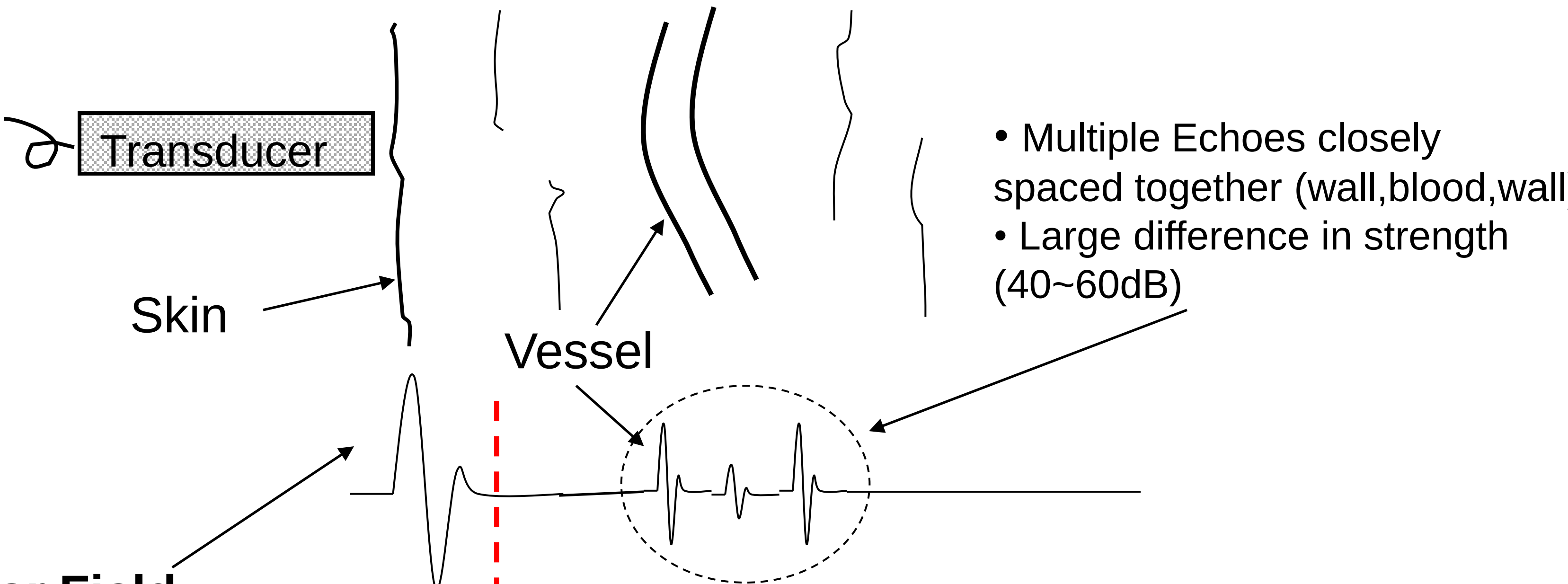


Noise versus Power Trade-offs



Overload Recovery

- Signal Path & VCA Requirements



Near Field

- Low TGC Gain setting
- Large echo likely to overload LNA

Need: Fast overload Recovery of LNA

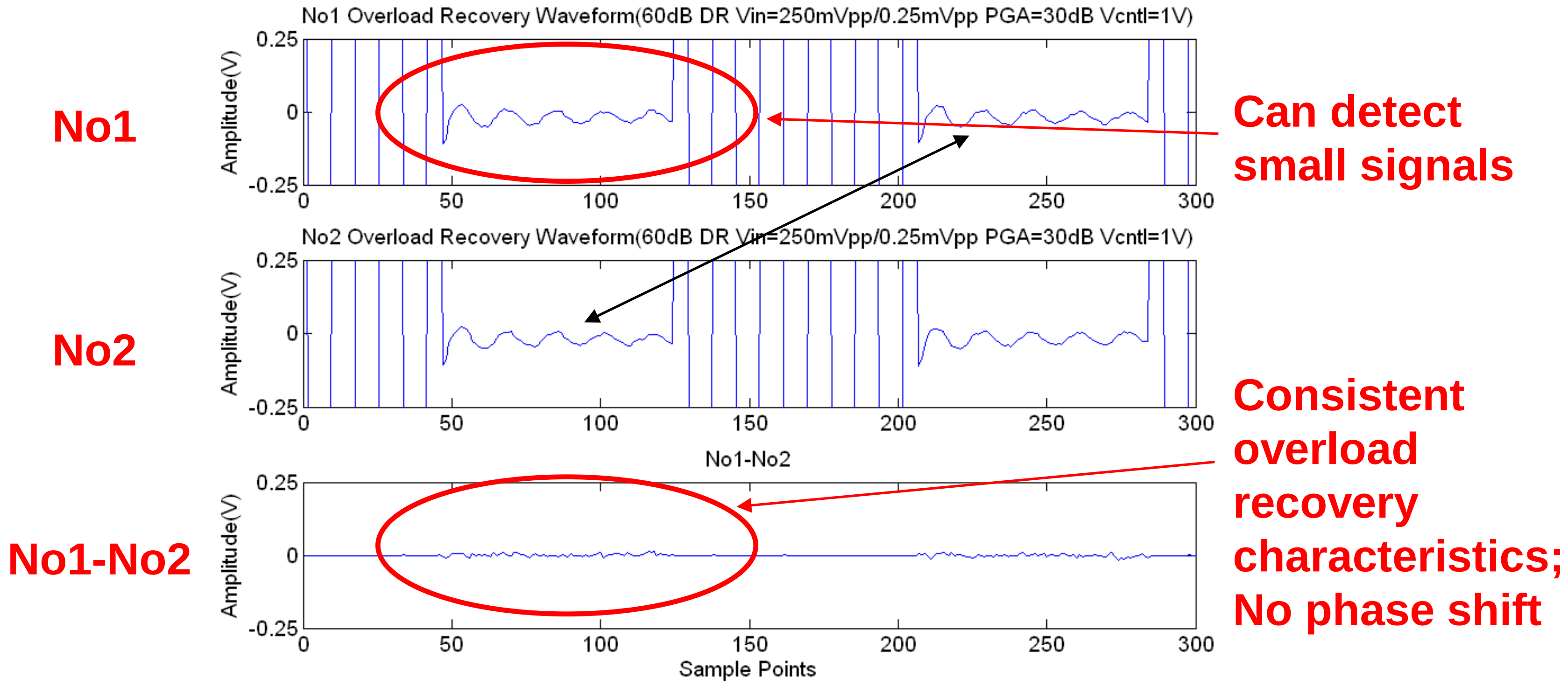
Mid-far Field

- Increasing/High TGC Gain setting
- Potential overload of LNA and PGA

Need: Fast and Repeatable overload recovery characteristics

Overload Recovery

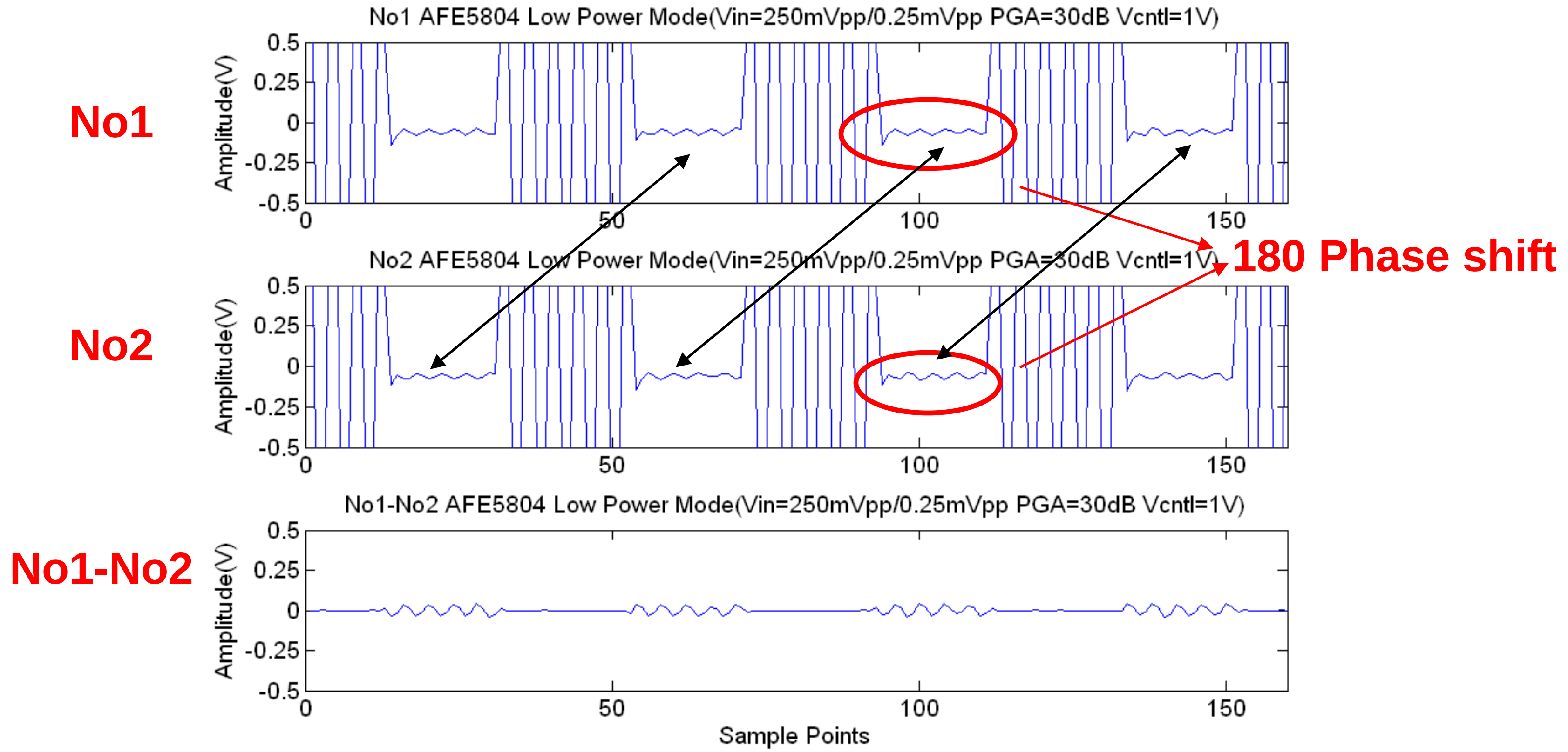
- **AFE5805: Proof of zero phase shift**
  - PGA=30dB, Vcntl=1V, No Clamp, 15M LPF,Gain~45dB
  - Signals: 250mVpp/**0.25mVpp**



1. AFE5805 can detect signals with DR>60dB.

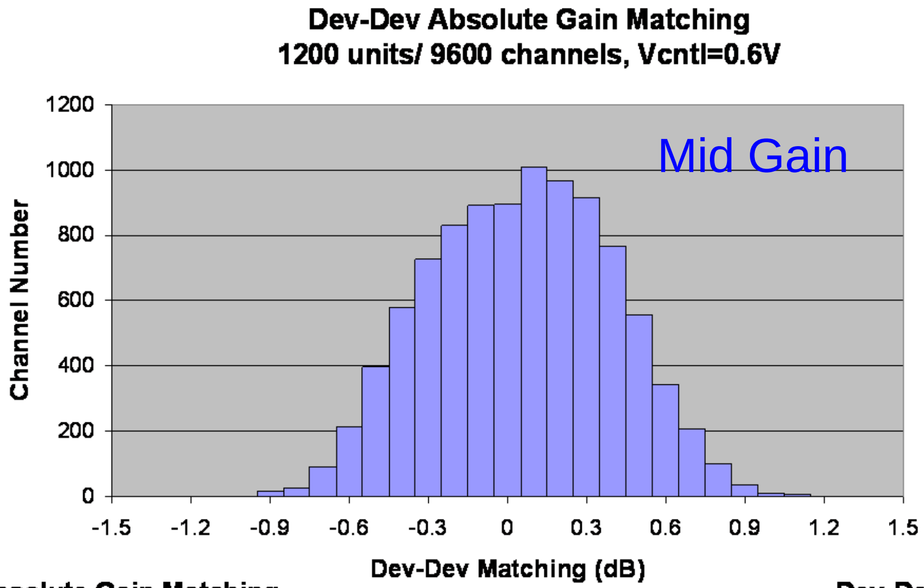
Overload Recovery

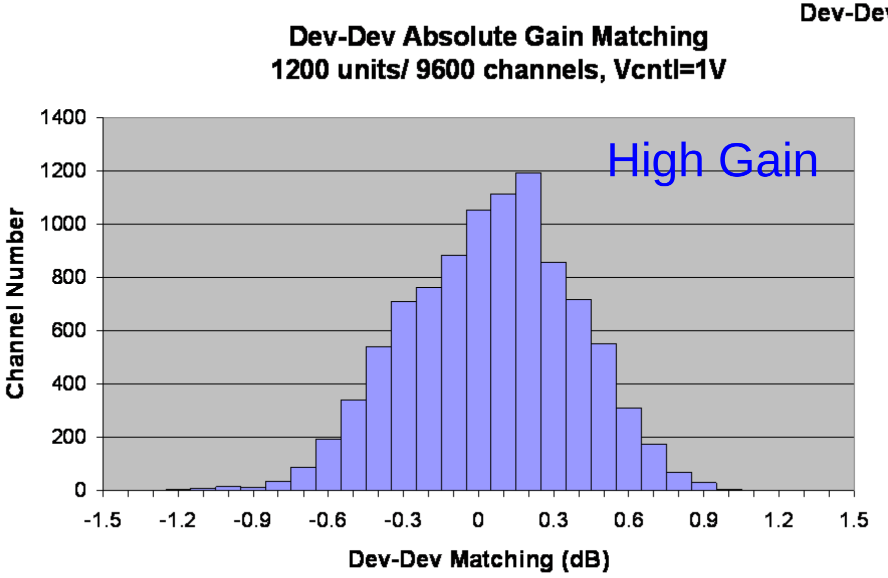
- **AFE5804: Proof of phase detection**

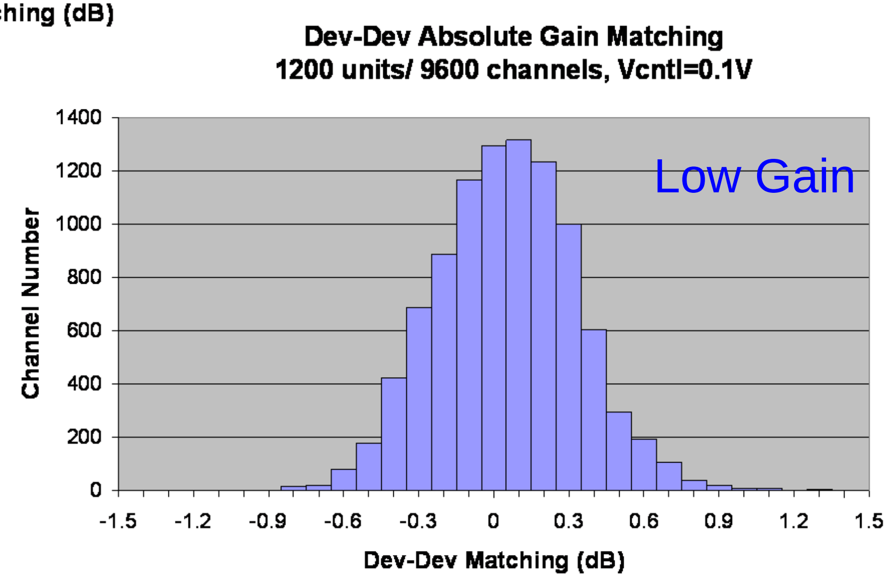


1. **The small signal amplitude in No1-No2 is doubled.**
2. **180 phase detection can be proved by amplitude doubling.**
3. **AFE5804 achieves excellent performance even at low power mode.**

Gain Matching & Range







Noise optimization
for low-, mid-, high-, end systems

AFE5805

VCA Attenuation	VCA Noise
45dB	69.9nV/rtHz
40dB	49nV/rtHz
30dB	**30nV/rtHz**
20dB	16nV/rtHz
10dB	5nV/rtHz
0dB	1.99nV/rtHz

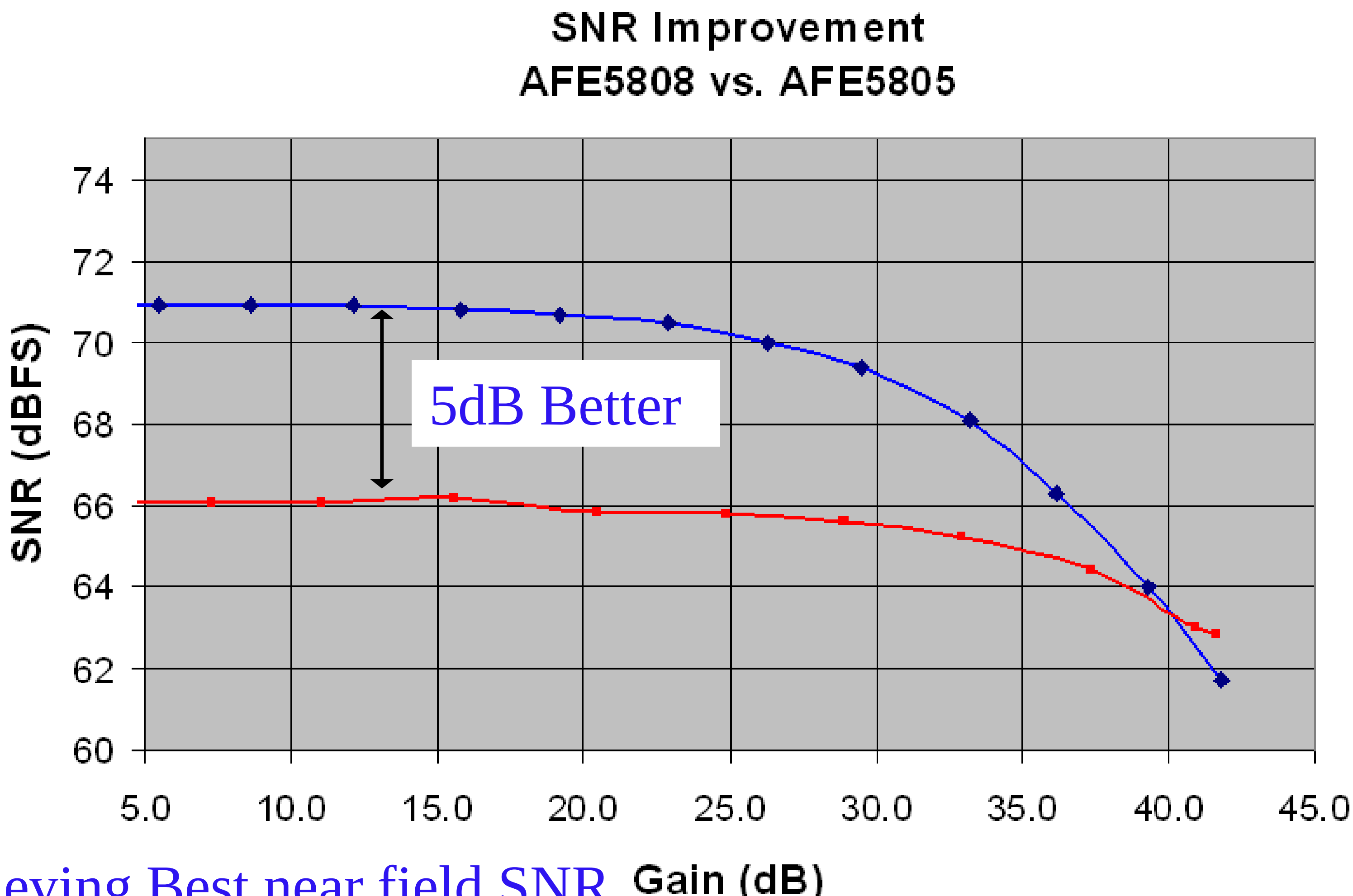
AFE5808/7

VCA Attenuation	VCA Noise
30dB	**8nV/rtHz**
24dB	8nV/rtHz
18dB	6nV/rtHz
12dB	4nV/rtHz
6dB	3nV/rtHz
0dB	2nV/rtHz

Note: VCA Noise is referred to the voltage controlled attenuator input noise, which will be amplified by the following programmable gain amplifier. Thus VCA noise will affect ADC SNR.

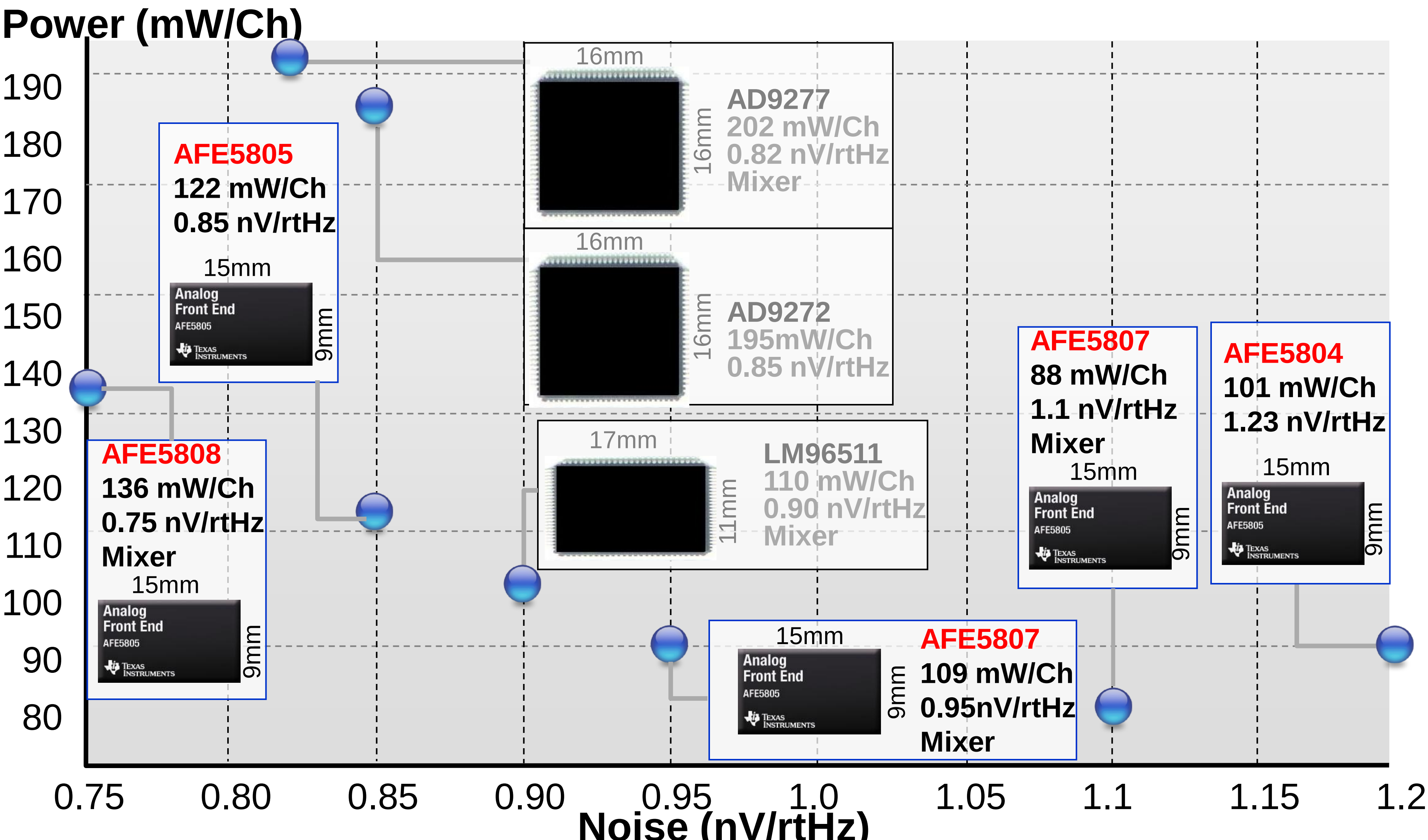
SNR improvement in near field

for low-, mid-, high-, end systems



Achieving Best near field SNR

AFE with CW Mixer: Spec Comparison



AFE with CW Mixer: Spec Comparison

TI offers best noise/power combination in smallest package with a superior CW phase noise.

	AFE5808A TI	AFE5807 TI	AD9276 ADI	AD9277 ADI
Power in TGC	**136mW/ch** **40MSPS@12bit**	**97mW/Ch** **40MSPS@12bit**	195mW/ch *40MSPS@12bit*	207mW/ch *50MSPS@14bit*
Noise ***(full chain)***	**0.75nV/rtHz**	1.1nV/rtHz	0.82nV/rtHz	0.82nV/rtHz
ADC SNR/Bits	**77dBFS/14bit** **Up to 65MSPS**	74dBFS/14bit Up to 80MSPS	70dBFS/12bit Up to 80MSPS	73dBFS/14bit Up to 50MSPS
CW Phase Noise	**-155dBc/Hz at 1KHz off a 2.5 MHz carrier**	**-155dBc/Hz @ 1KHz off a 2.5 MHz carrier**	-155dBc/Hz @ 1KHz	-155dBc/Hz @ 1KHz
Max Gain	54dB	54dB	52dB	52dB
Termination	**Internal Active** **(50, 100, 200, 400 and high impedance)**	**Internal Active** **(50, 100, 200, 400 and high impedance)**	Active Need external components	Active Need external components
Package	**15x9mm**	**15x9mm**	16x16mm	16x16mm
Schedule	Production	Production	Production	Production

AFE5804/5 Comparison

	AFE5804	*AFE5805*
Power @ 40Msps (no signal)	TGC: 101mW/ch; CW & V/I:65 mW/Ch	TGC: 122mW/ch; CW & V/I:72 mW/Ch
Full chain IRN,nV/rtHz	1.23 nV/rtHz	0.85 nV/rtHz
SNR at 30dB Gain	65dB	65dB
LNA (RTI) [nV/rtHz]	0.75 nV/rtHz	0.7 nV/rtHz
CW (RTI) [nV/rtHz]	159dBFS/1.1nV/rtHz(5804)	158dBFS/1.1nV/rtHz(5805)
Input Range (mVpp)	280mVpp	250mVpp
LNA gain	20dB	20dB
LNA - Zin	High impedance	High impedance
Total Gain/Gain range	50dB max/46dB	50dB max/46dB
Standby PWR /Response	50us (complete power down) 2us (partial power down)	50us (complete power down) 2us (partial power down)
Overload Recovery	2 clock cycles (Measured)	2 clock cycles (Measured)
PGA gain	20, 25, 27, 30 dB	20, 25, 27, 30 dB
Low-pass Filter	12.5, 17MHz 2^{nd} Bessel	10,15MHz 2^{nd} Bessel
HD2 (5MHz, -1dBFS)	-40dBc(280mVpp) -65dBc(small signals)	-40dBc(250mVpp) -65dBc(small signals)
ADC clock	12bit: 10 to 50Msps	12bit: 10 to 50Msps
CW	8*10	8*10
Size ($mm^{2)}$)	135	135
Samples and RTM	Production	Production

AFE5851 and AFE5801 Lowest power AFE for handheld ultrasound

AFE5801/51:
16- & 8-Channel Analog Front-End

Features

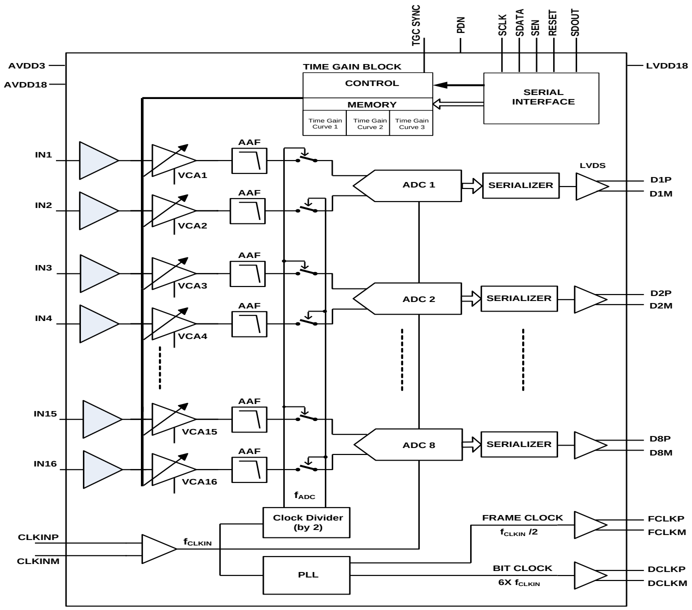
- •Integrated analog front-end: VCA, PGA, LPF, and ADC
  - •16-channel AFE5851
  - •8-channel AFE5801
- •Low Power:
  - •39mW/ch @ 32.5 MSPS (AFE5851)
  - •58mW/ch @ 50 MSPS (AFE5801)
- •64-QFN (9x9mm^2)
- •VGA
  - •5.5 nV/rtHz input noise @ 31dB gain
  - •Variable gain -5 to 36dB
  - •Digital gain control
- •3rd order AAF (anti-alias filter)
- •ADC
  - •12-bit, 65MSPS ADC (32.5 MSPS for max channels on AFE5851)
  - •Serial LVDS outputs

Applications

- Portable Ultrasound
- Sonar

Benefits

- New architecture enables new system partitioning for customers with their own or no low noise amplifier (LNA)
- 40% lower power for portable ultrasound
- 70% smaller size for higher channel density in portable systems
- Digital gain control removes external DAC for smaller footprint and minimized noise



AFE5851/01 vs AFE5805/4

	AFE5805	AFE5804	AFE5801	AFE5851
No. of Channels	8			16
Integration	LNA+VCA+LPF+ADC		VCA+LPF+ADC	
Power	TGC: 122mW/ch (40MSPS) CW: 72mW/Ch	TGC: 101mW/ch (40MSPS) CW: 65mW/Ch	TGC: 58mW/ch (50MSPS) CW: N/A	TGC: 39mW/ch (32.5MSPS) CW: N/A
Noise (full chain) [nV/rtHz]	0.85 nV/rtHz	1.23 nV/rtHz	5.5 nV/rtHz (Low noise mode: 5nV/rtHz w/ 45mW/ch)	
LNA (RTI) [nV/rtHz]	0.75 nV/rtHz	0.75 nV/rtHz	N/A	
Noise, CW (RTI) [nV/rtHz]	1.1 nV/rtHz		N/A	
Input Range	250 mVpp	280 mVpp	2 Vpp	1 Vpp
LNA gain	Fixed: 20dB		N/A	
Total Gain/ Attenuator range	50dB/ 46dB		31dB/ 36dB	
PGA gain	20, 25, 27, 30 dB		N/A	
Low-pass Filter (3dB BW)	10MHz and 15MHz, 2nd order	12.5MHz and 17MHz, 2nd order	7.5MHz, 10MHz and 14MHz, 2nd order	
HD2 (5MHz, -1dBFS)	-65dBFS		-56dBFS	
ADC clock	10 to 50 MSPS		5 to 65 MSPS	2.5 to 32.5 MSPS
CW	8x10		N/A	

TX Products

- **TX517 High-end Transmitter**
  – 17-level design for +/-60V operation
  – High-end applications with use of Transformers, Bridge configuration
  – Samples are available

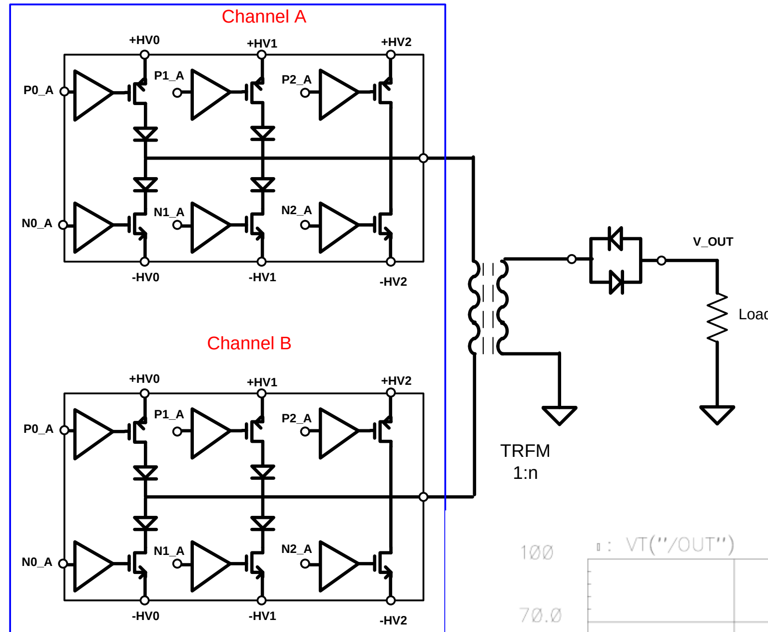
<u>Notes:</u>

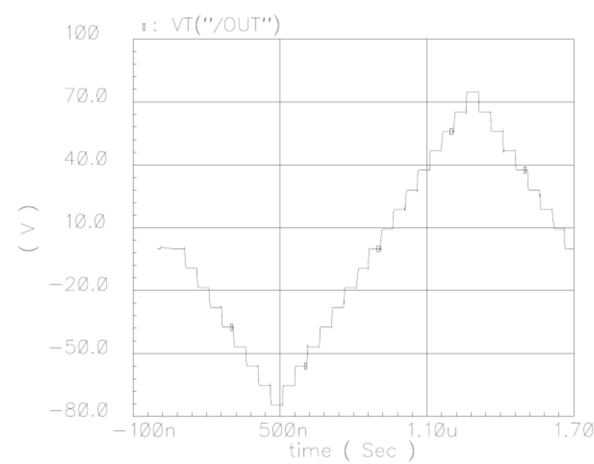
- Measurements performed with 100ohm//330pF load
- Special measurements can be made based on your system/transducer requirements

TX517 – Dual Channel, Integrated Transmitter for Multi-Level Waveforms

FEATURES

- **Dual channel**
- **Voltage: ±60V**
- **Peak Output Current: +/-2.5A**
- **Integrated:**
  - **Translator & Driver**
  - **HV1,2 Output Stages**
  - **Damping Stage (HV0)**
- **5-Level RTZ Waveform**
- **Low HD2 Distortion: -40dB, at 10MHz**
- **Low-Ron: 4Ω (N), 4Ω (P)**
- **Imaging Output Frequency: ≤ 20MHz**
- **Logic Inputs: 2.5V to 5V**
- **Matched Delay: +/-2.5ns**

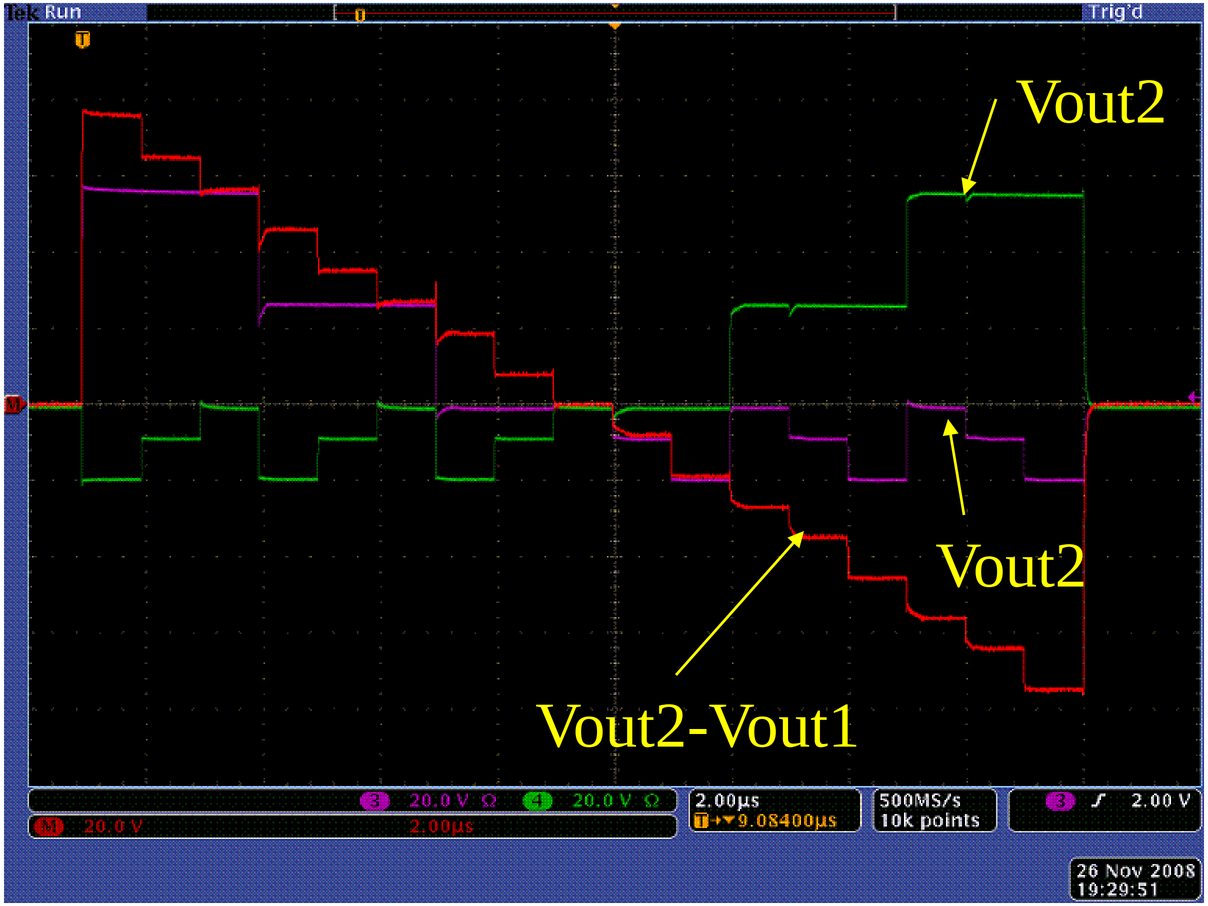




Suitable for Coded Excitation Applications

TX517: 2-CH 17-Level Pulser

- 17 Level Generation

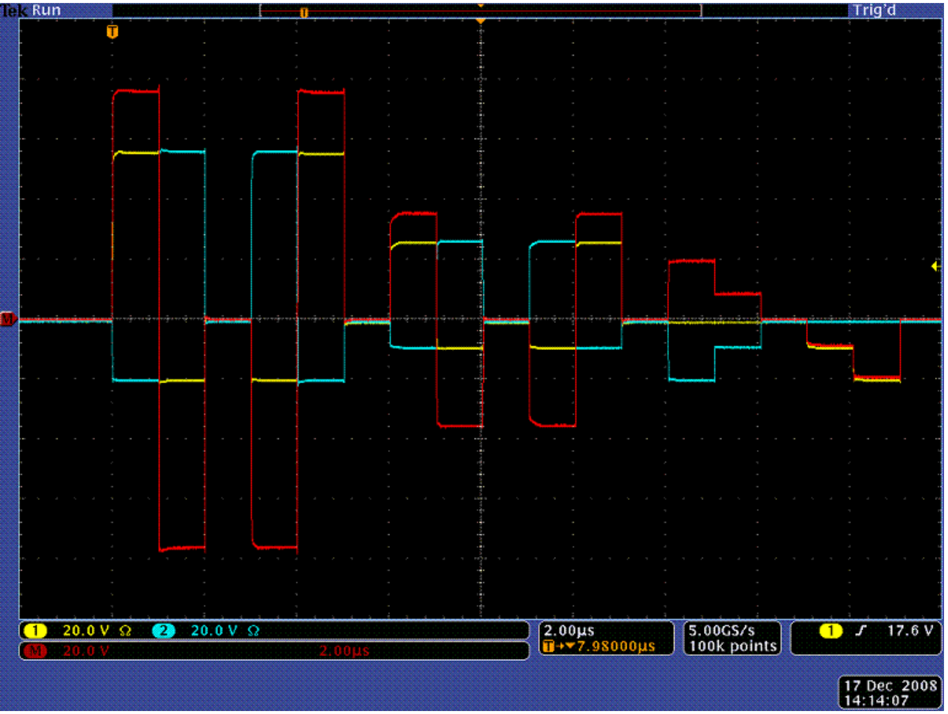


Texas Instruments

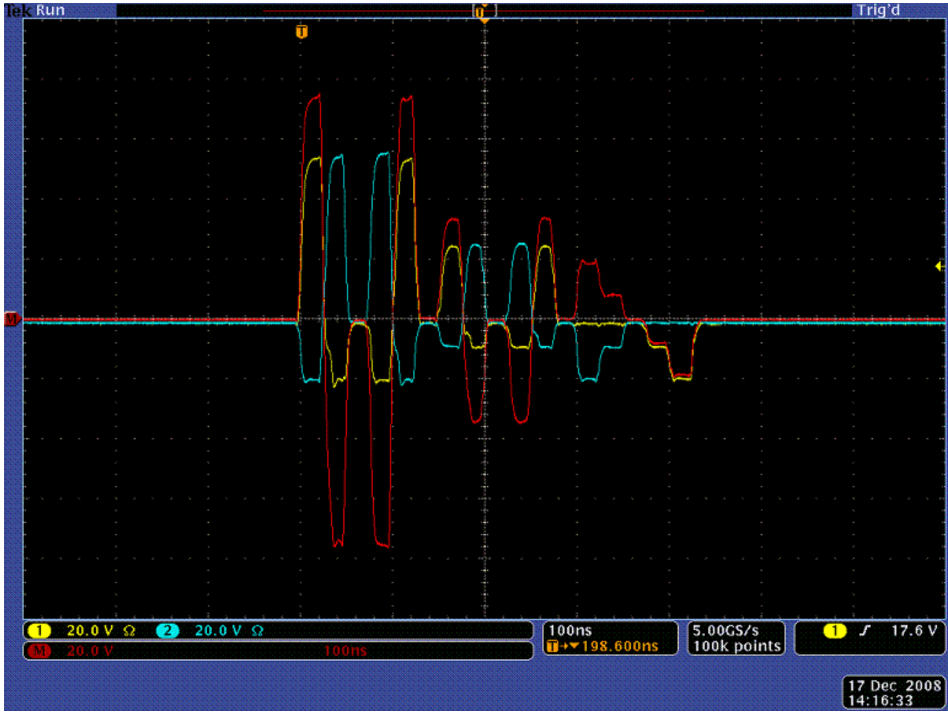
TX517: 2-CH 17-Level Pulser

- Performance at different pulse widths

Pulse width =1us



Pulse width =25ns



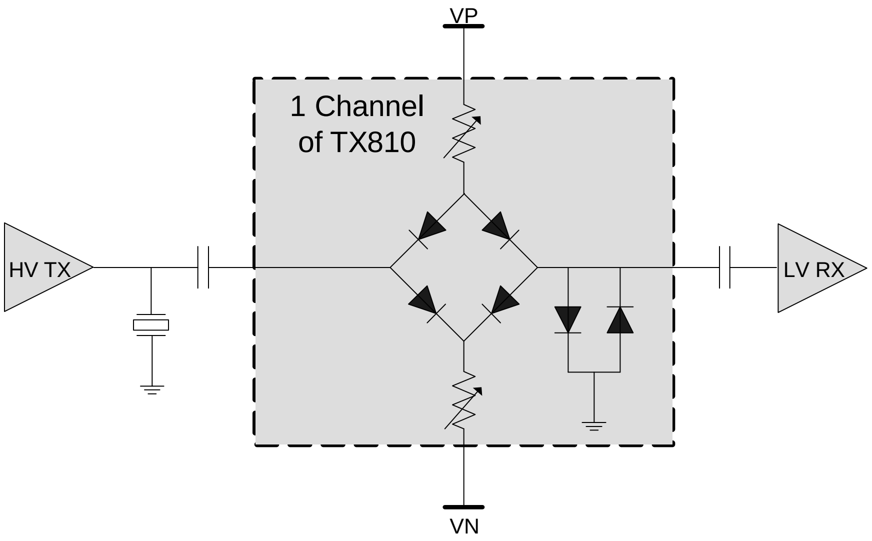
Texas Instruments

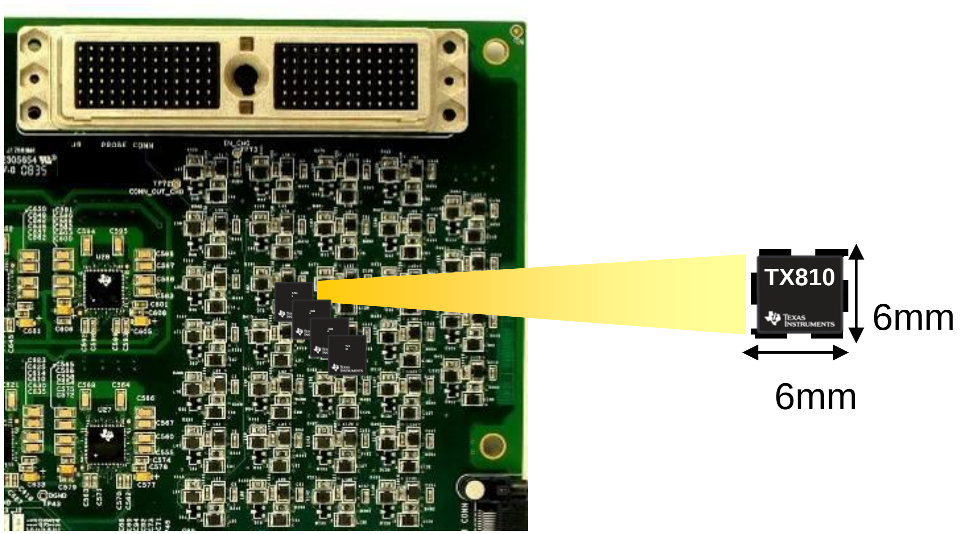
TX517 Performance Summary

- PW path (single ended unless otherwise noted)
  - HV1/LV1 path
    - Isat: 2.4A, Rdson: 4.5 ohms
    - 5MHz HD2 with transformer (at secondary coil): 40dBc
    - 5MHz HD2 single-ended: 31.5 dBc
    - SR: 10V/ns, tr/tf: 6ns/6ns,
  - HV2/LV2 path
    - Isat: 2A, Rdson: 10 ohms
    - 5MHz HD2 with transformer (at secondary coil): 35 dBc
    - 5MHz HD2 single-ended: 27dBc
    - SR: 4.6V/ns, tr/tf: 10.5 ns/7.5ns
- CW Path (single ended unless otherwise noted)
    - Rdson: 45 ohms
    - 5MHz HD2 with transformer (at secondary coil): 37.5 dBc

Protecting the Receiver with the T/R Switch

- The T/R switch toggles from transmit to receive mode and it prevents the high voltage pulses from damaging the receive electronics.
- Multi-channel, fully-integrated T/R switches are now available to minimize size.
- Trade-offs for T/R switch integration
  - Insertion loss
  - Capacitance
  - Cross talk
- Benefits of integration
  - Over 50% savings on board space, the pros for portability outweigh the cons.
  - Reductions in power consumption with programmable bias currents are an option to lower power consumption.





TX810:
8-Channel, Programmable T/R Switch for Ultrasound

Features

–Integrates a protection diode bridge and clamp diodes for each of its eight channels

– Programmable bias currents

- •3-bit interface used to program a 7-mA range of bias currents
- •Power-down mode to reduce power consumption

–Insertion loss at 400Ω load with 0.6 dB at 7-mA bias current and 1.6 dB at 1-mA bias current

Benefits

–Prevent the high-voltage pulses of the transmitter from damaging the receive electronics of the ultrasound systemIntegration allows for faster designs and higher reliability due to fewer devices and easier handling of components

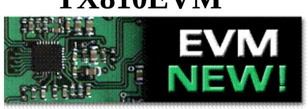
–Adjust and reduces power consumption

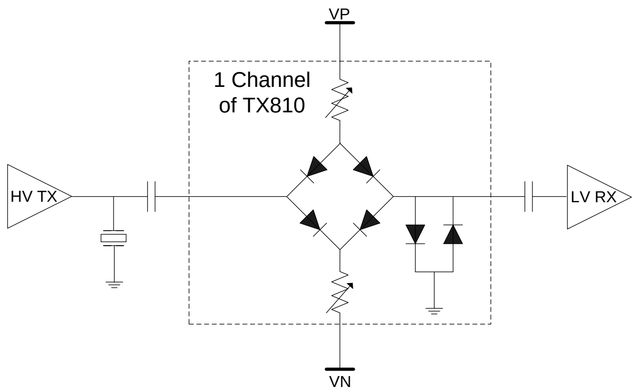
–Optimizes integrity of input/out signal relation

Applications

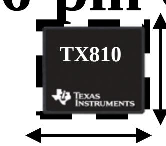
- **Portable Ultrasound**

TX810EVM





36-pin QFN



6mm

6mm

NSC differentiated Ultrasound products

Ultrasound Transmit/Receive Switch

LM96530

- 8-channel high-voltage receive side switches without charge-injection
- Can be used for receive protection and/or receive multiplexing with SPI™ compatible bus control
- Channel bandwidth supports 1MHz to 20MHz transducers
- Input accepts pulses and continuous-wave signals within ±60V
- Integrated output clamping diodes limit output to ±0.7V
- Low harmonic distortion HD2 at -75dBc at 5MHz

Ultrasound Receive Analog Front End (AFE)

LM96511

- Channel LNA, DVGA, and 12-bit Continuous Time ∑Δ ADC
- Programmable Active Termination LNA
- 8-channel, integrated CW Doppler Beamforer
- Low-power consumption
- Embedded ADC Digital Filter

Pulser

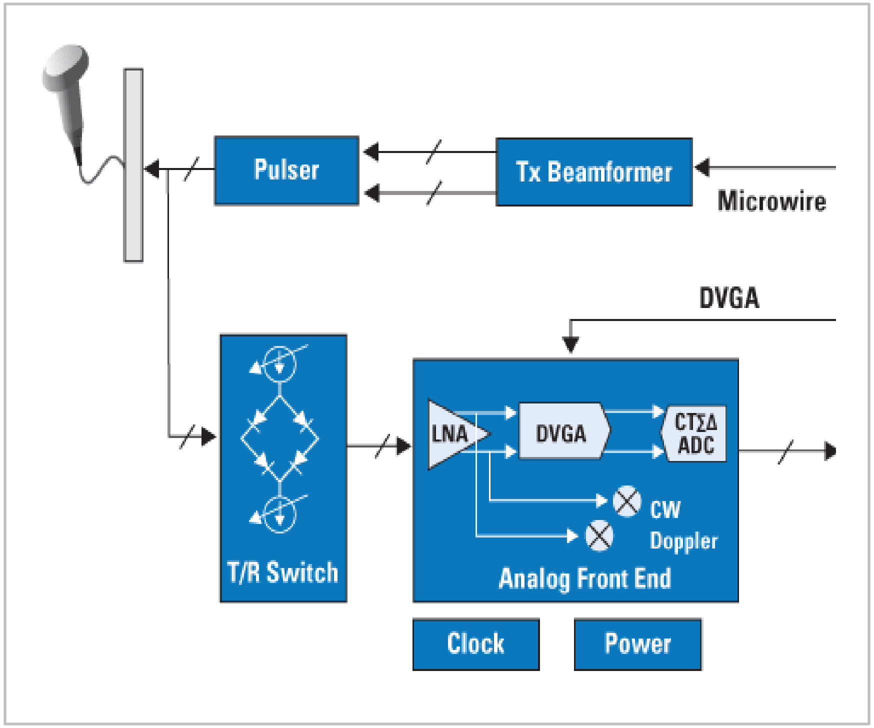
LM96550

- 8-channel high-voltage CMOS pulse generator
- Output pulses with ±50V and 2A peak current
- Active damper with built-in blocking diodes
- Built-in floating supply voltages for output stage
- Up to 15 MHz operating frequency
- Matched delays for rising and falling edges
- Harmonic performance enables harmonic imaging
- Continuous-wave (CW) operation down to ±3.3V

Ultrasound Configurable Transmit Beamformer

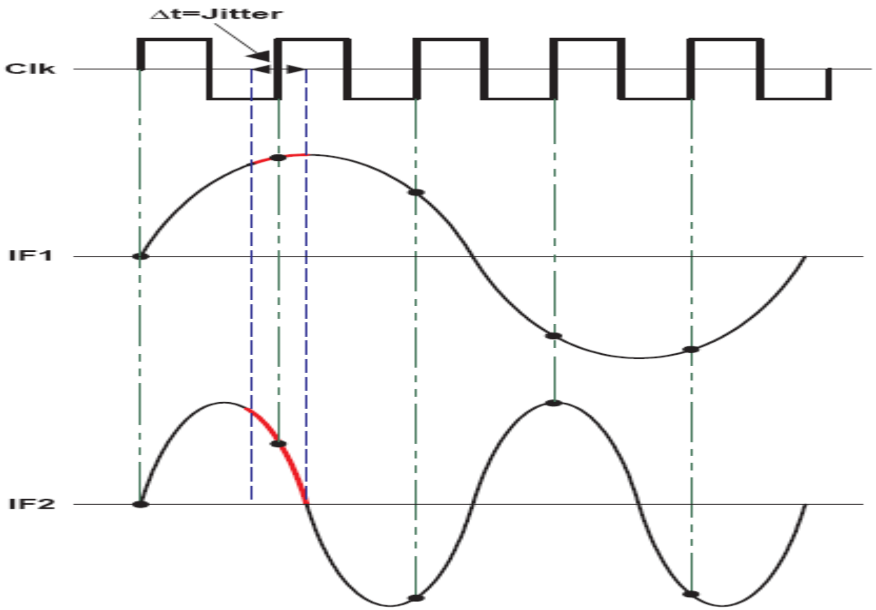
LM96570

- Full control over selecting beam directions and pulse patterns by programming individual channel parameters
- Outputs interface seamlessly with positive and negative inputs on octal high-voltage pulser ICs
- Beamformer timing provides:
- Delay resolution of 0.78 ns
- Delay range of up to 102.4 μs



Clock for High Speed ADC

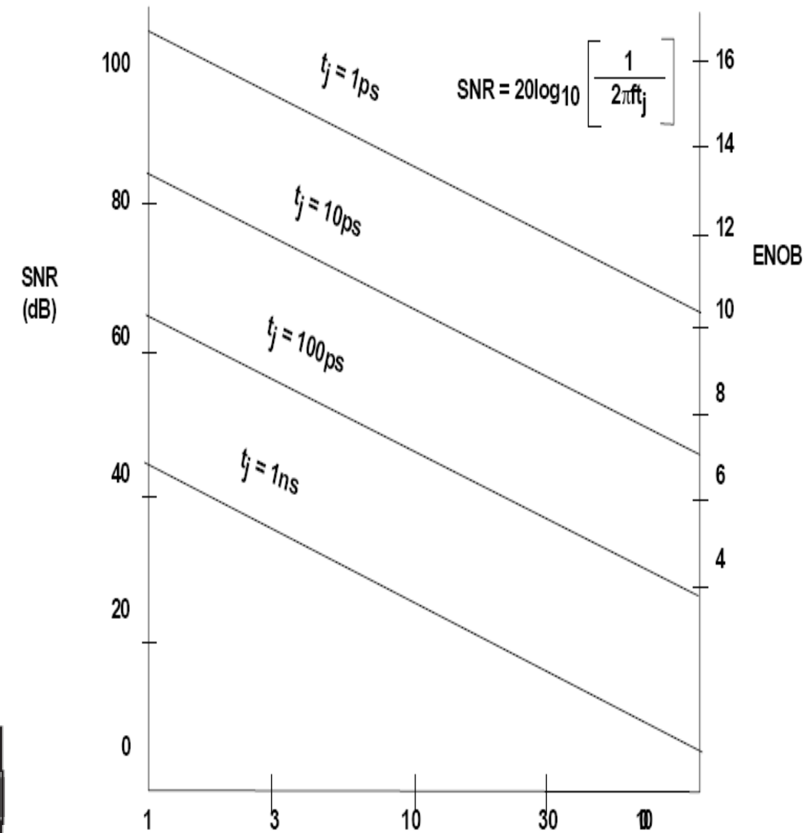
SNR Degradation Due to Jitter for HS ADC



SNRj = -20log(2pi f tj)

$$SNR_T = -20 \times \log\left[\sqrt{10^{\left(\frac{-SNR_{ADC}}{10}\right)} + 10^{\left(\frac{-SNR_j}{10}\right)}}\right]$$

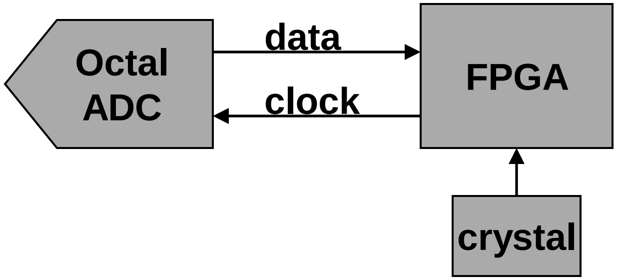
SNR DUE TO APERTURE AND SAMPLING CLOCK JITTER



Clock solution for HS ADC

Current solution:

high clock jitter from FPGA (about 3 -10ps rms), not good for 12bit, 40MSPS ADC for10Mhzinput



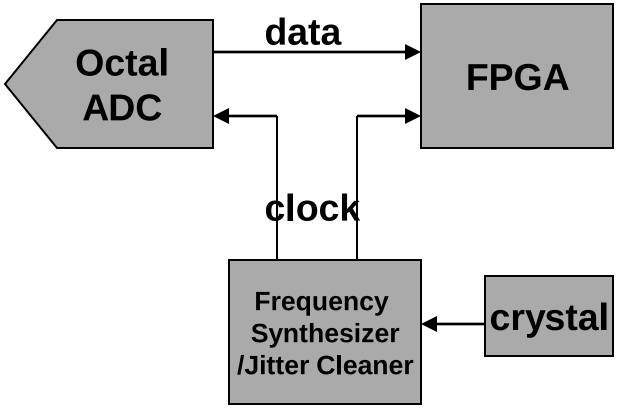
$$SNRj = -20\log 2 * \Pi * 10 * 10^{6} * 10 * 10^{-12} = 64dB$$

SNRadc=70dB

$$SNR_T = -20 \times \log\left[\sqrt{10^{(\frac{-70}{10})} + 10^{(\frac{-64}{10})}}\right] = 63dB$$

Suggest solution:

ADC clock is from Synthesizer, jitter <1ps, suitable for 12bit, 40MSPS ADC

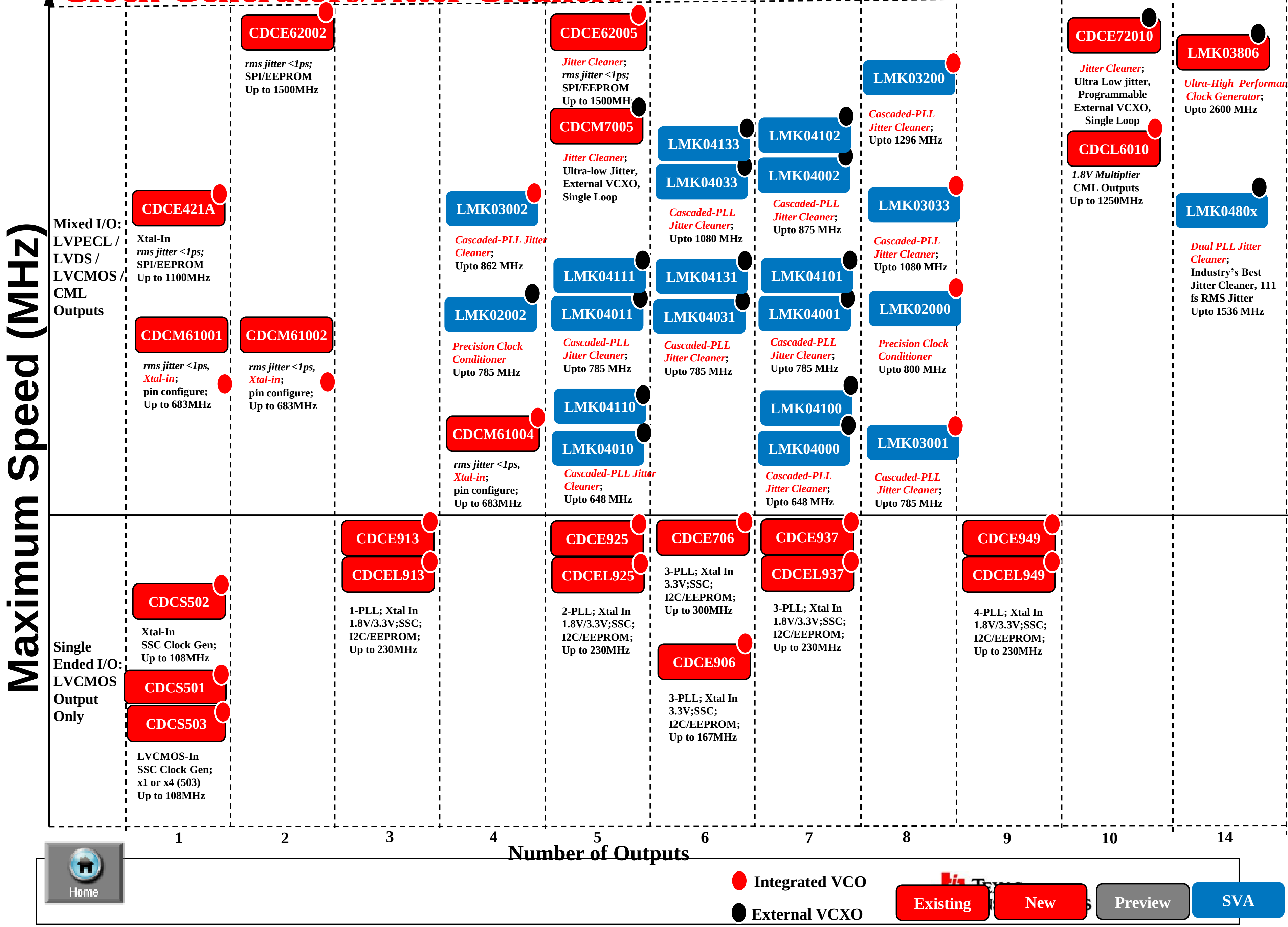


$$SNRj = -20\log 2 * \Pi * 10 * 10^{6} * 1 * 10^{-12} = 84dB$$

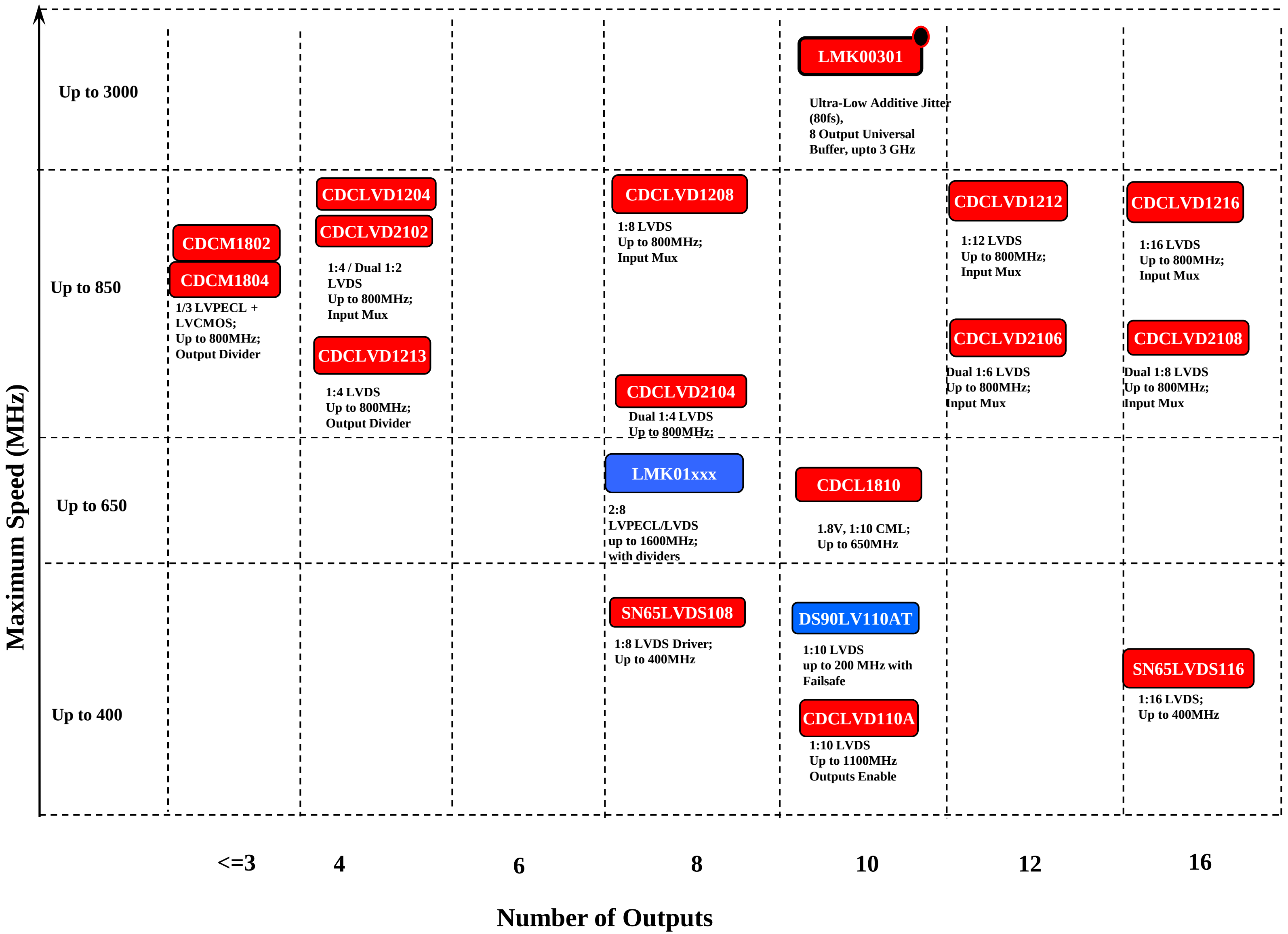
SNRadc=70dB

$$SNR_T = -20 \times \log\left[\sqrt{10^{(\frac{-70}{10})} + 10^{(\frac{-84}{10})}}\right] = 69.8dB$$

Clock Generators/Jitter Cleaners



Clock Distribution – LVDS Non-PLL Buffers



Universal Output (LVDS, LVPECL or HCSL)

EXISTING | NEW | ROADMAP | SVA

Home

LMK04803/5/6/8

Precision Clock Jitter Cleaner

Features

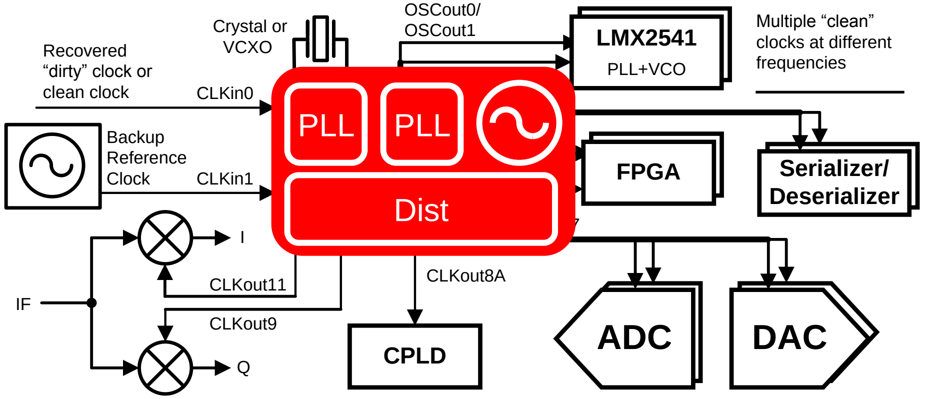
- Dual Loop PLL Architecture for ultra low jitter cleaning using low cost VCXO
- Total RMS Jitter 112 fs RMS jitter (12 kHz to 20 MHz) @ 245.76MHz
- Phase Noise –145dBc/Hz (800 kHz offset) @ 245.76MHz
- Programmable Digital Delay, Analog Delay and 0-delay mode
- Holdover mode when input clock is lost
- Output Clock rates of up to 1536 MHz
- 12 LVPECL, LVDS or LVCMOS programmable outputs

Applications

- Multi-Carrier GSM, WCDMA, LTE Base Stations
- Optical Transport Networks
- Video Broadcast Servers
- Clocking High Speed Data Converters

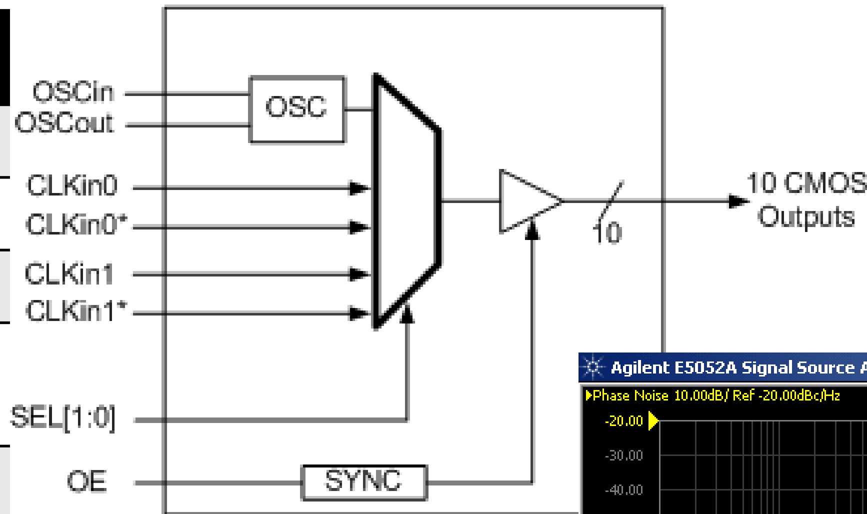
Benefits

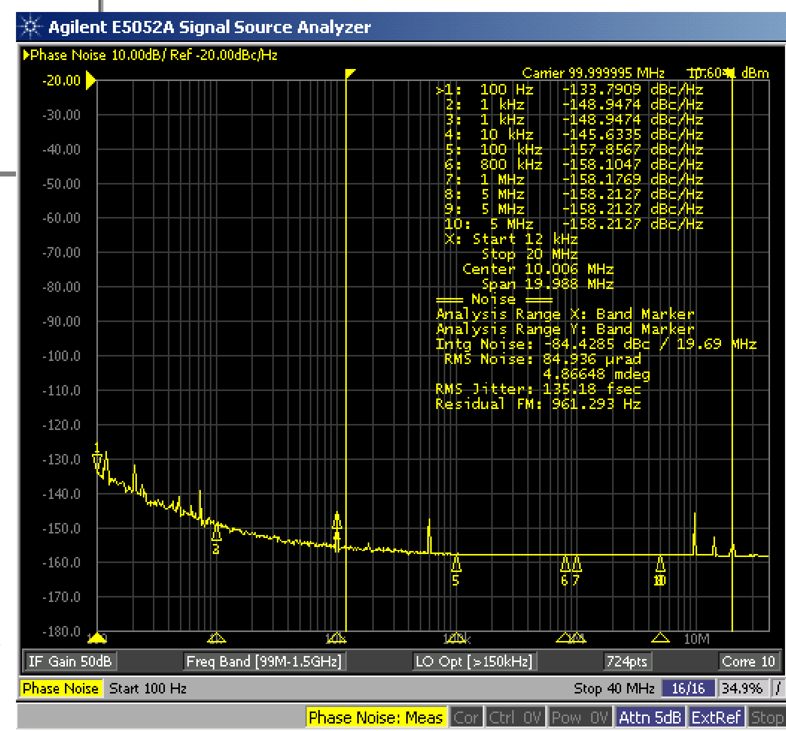
- 1.5x clock output rate than closest competitor
- **Lowest jitter and phase noise clock cleaner in the industry**
- Ultra-low phase noise enables MC – GSM in macro cell BTS
- Ultra-low jitter clocks enables
  - High sensitivity radios – Improves overall wireless coverage radius
  - Higher throughput of high speed SERDES – Improves the maximum data rate



LMK00101 – 10 LVCMOS Fanout Buffer Level Translator

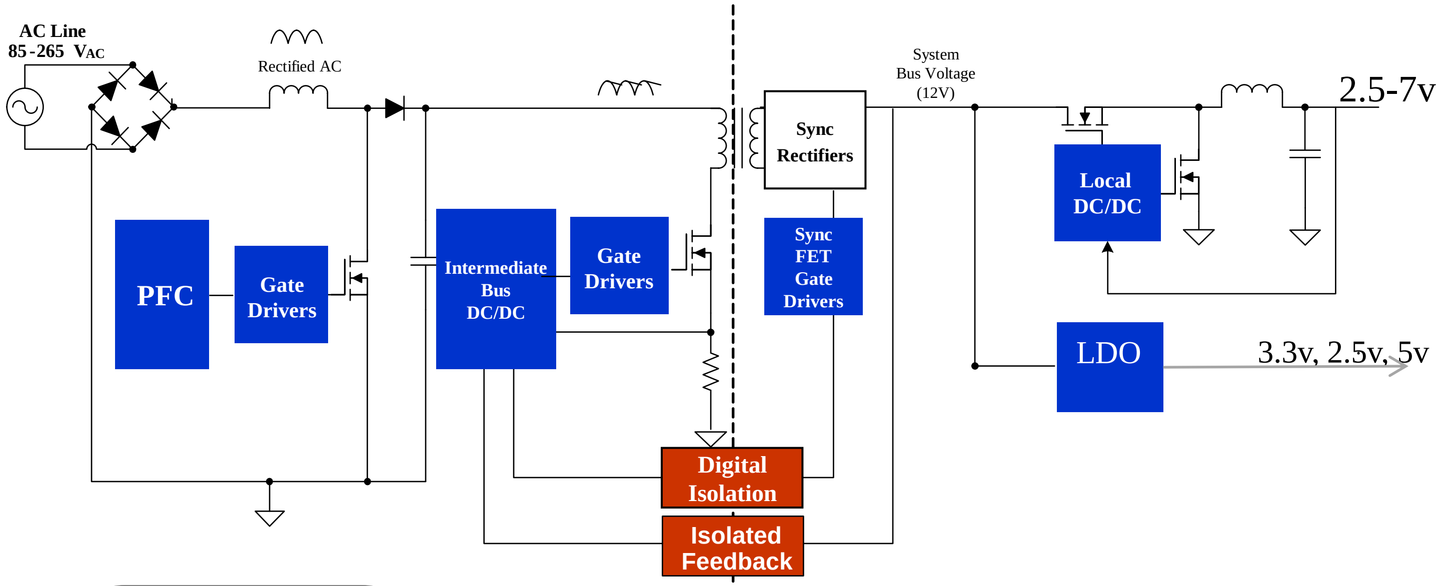
Features	
Additive jitter	< 37 fs @ 156.25
Max f_{IN}, f_{OUT}	200 MHz
Output Skew	<10ps
Input Formats	LVDS, LVPECL, HCSL and LVCMOS
Output Format	10 LVCMOS outputs
Crystal Interface	10 to 40 MHz
Output Operating Supply Voltage	3.3V/2.5V/1.8/1.5V





LMK00101 LVCMOS -158.2 dBc/Hz

AC/DC+DC/DC+LDO Power Architecture For Ultrasound



PFC
AC/DC

UCC28019A
UCC28950

Reduces harmonic content, lowers peak current and makes load look resistive. Topologies: Single Phase, Two Phase Interleaved, Bridgeless

DC/DC

LM5642
TPS54XXX
LMZ12XX
X

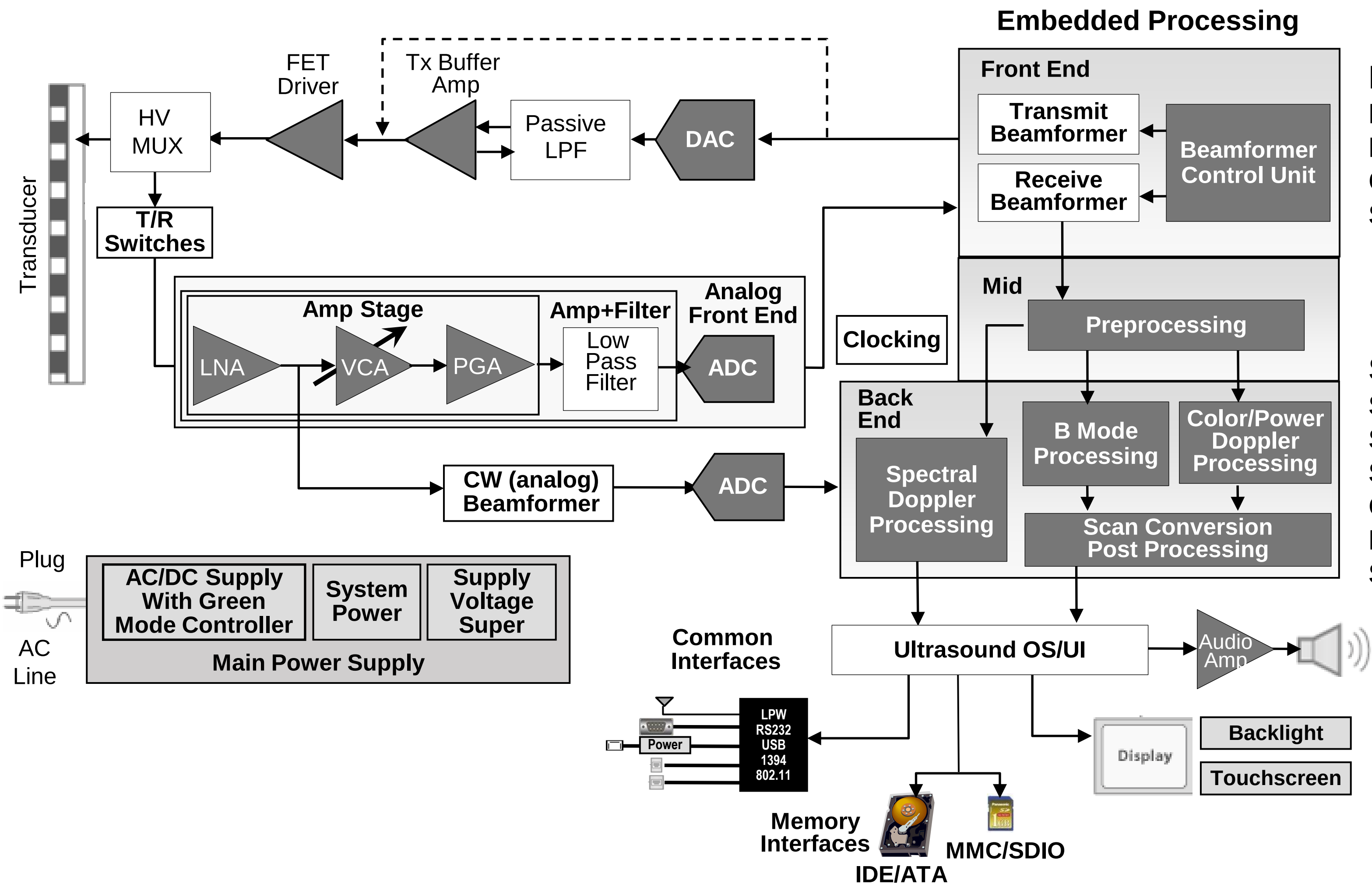
Converts intermediate bus voltage to an isolated system bus voltage. Topologies: Active Clamp Forward, Half-Bridge, Full-Bride, Phase-Shifted Full Bridge

LDO

TPS73701
TPS7Axxx

Converts System Bus voltage to POL (Core, Memory, I/O) Vcc rails. Topologies: Sync/Async Buck, LDO Linear

Ultrasound system – Where DSP fits



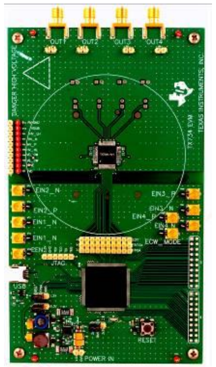
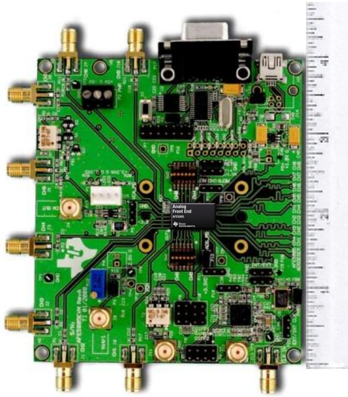
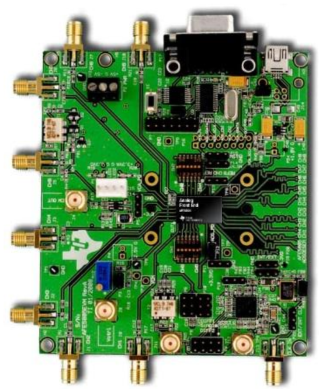
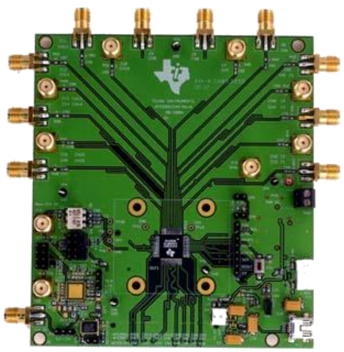
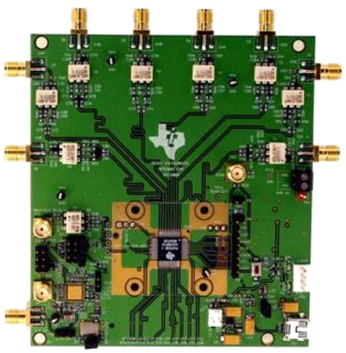
DSP
RF Demodulation
B-Mode
Color Flow
Spectral Doppler

SOC (DSP+MPU)
Scan Conversion
Speckle Reduction
System Control
O/S
Display
Storage

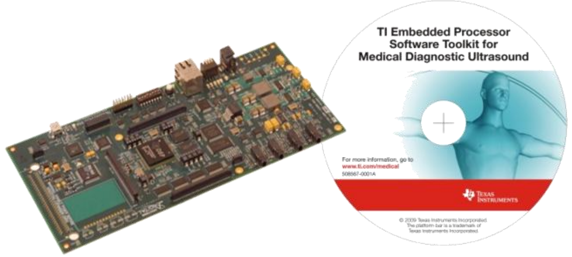
Texas Instruments

Tools for ultrasound developers

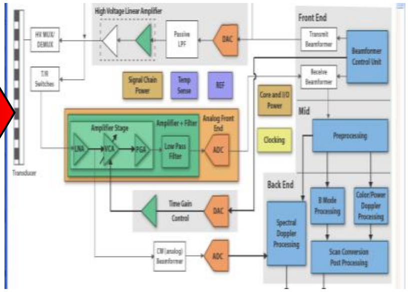
TX734	AFE5805	AFE5804	AFE5851	AFE5801

C6455 DSK and Embedded Processor Software Toolkit	System Block Diagrams



- Ultrasound System
- NEW Ultrasound System: Portable

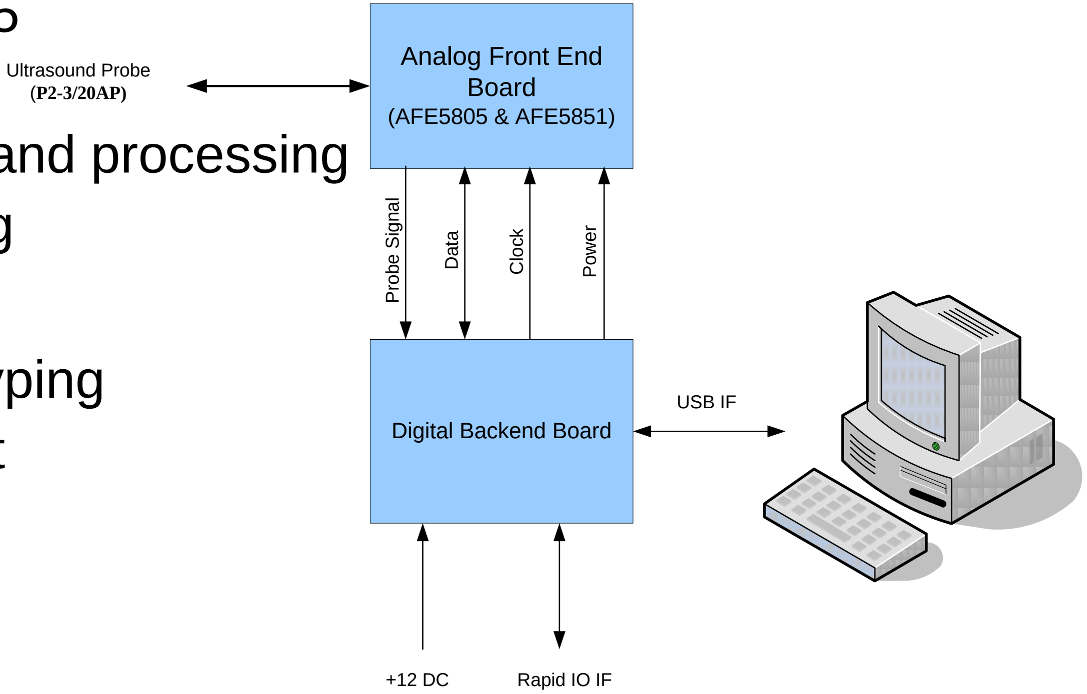


www.ti.com/medical

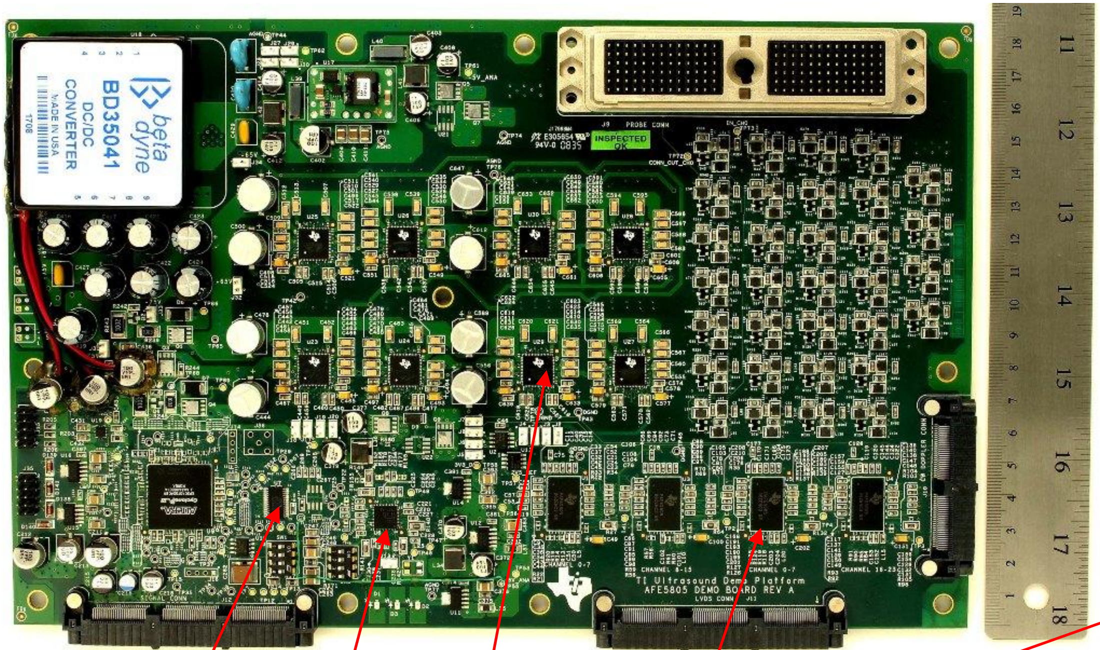
TI has several resources for custom power designs
-Your local TI AFA (analog field applications engineer)
-TI's centralized power supply design group which creates more than 800 designs every year
Contact your local TI salesperson for more information!

Demonstration Platform

- Complete Design
  - Ultrasonic Phase array
  - 32-Ch Transmitter TX734 with active damping
  - 32-Ch Receiver AFE5805
  - TI Power Management
  - DaVinci DSP for control and processing
  - Matlab Image Processing
- Benefits
  - Good platform for prototyping
  - Example Sch and Layout
  - Validate Cores
  - Configurable Algorithms

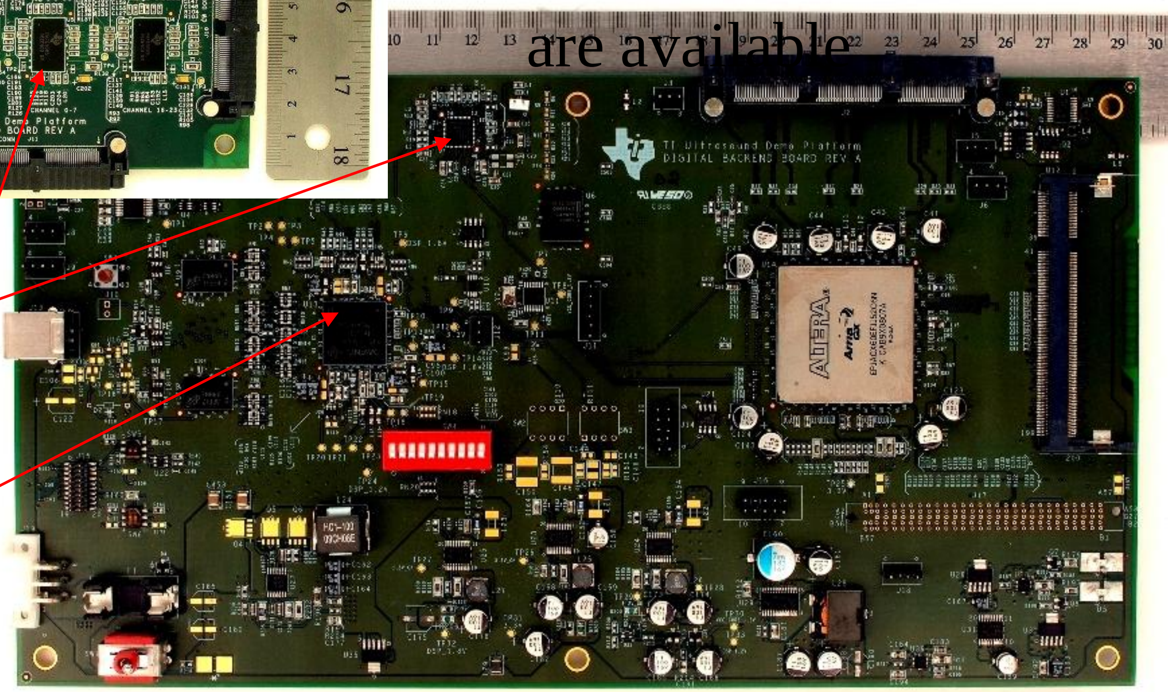


Demonstration Platform



Status

- •Fully Functional
- •Continue to improve
- •Work with DSP team
- •Support Customers
- •Sch and Gerber files are available



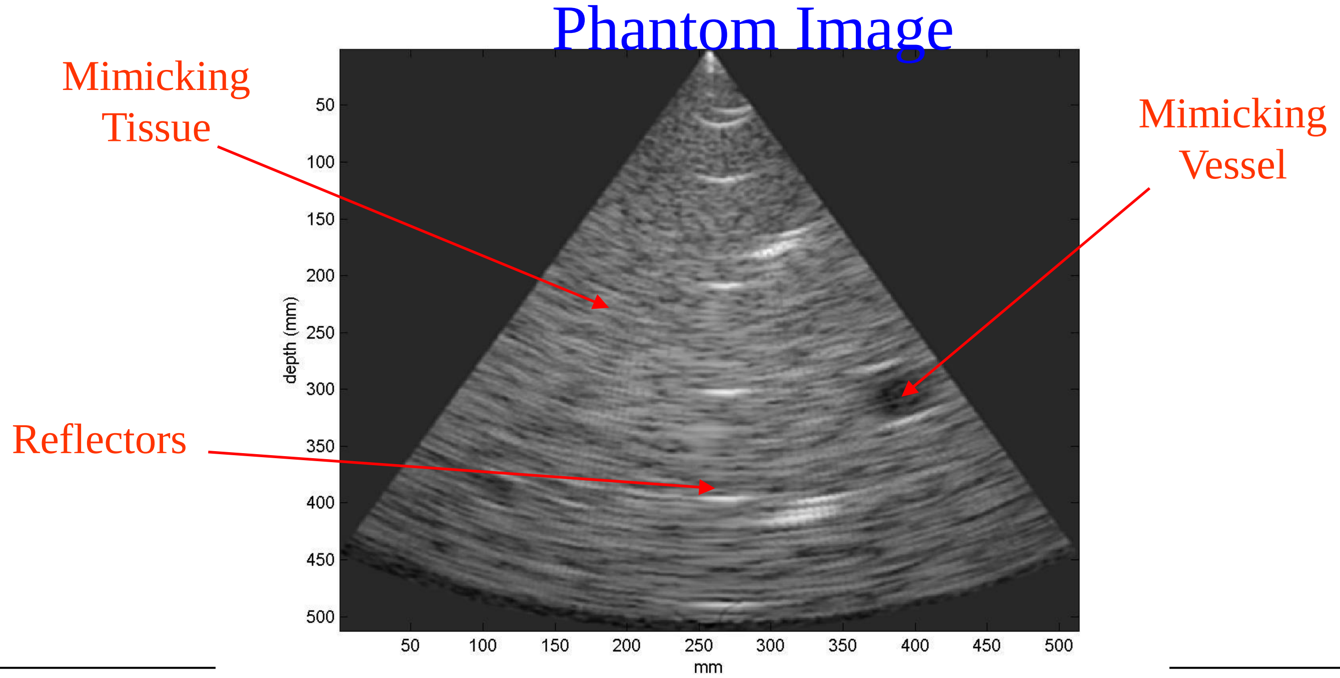
DAC902 TX734 AFE5805

CDCE62005

DM6446

Demonstration Platform

- Immediate Show-case for TI products
  - Demonstrate AFE5805 Power and Size reduction
  - Show TX734 Transmitter Advantages(Active Damping)
  - May use ultrasound DSP lib from DSPS
  - Support Universities to raise young TI product users



Thank You!