

Receiver Types

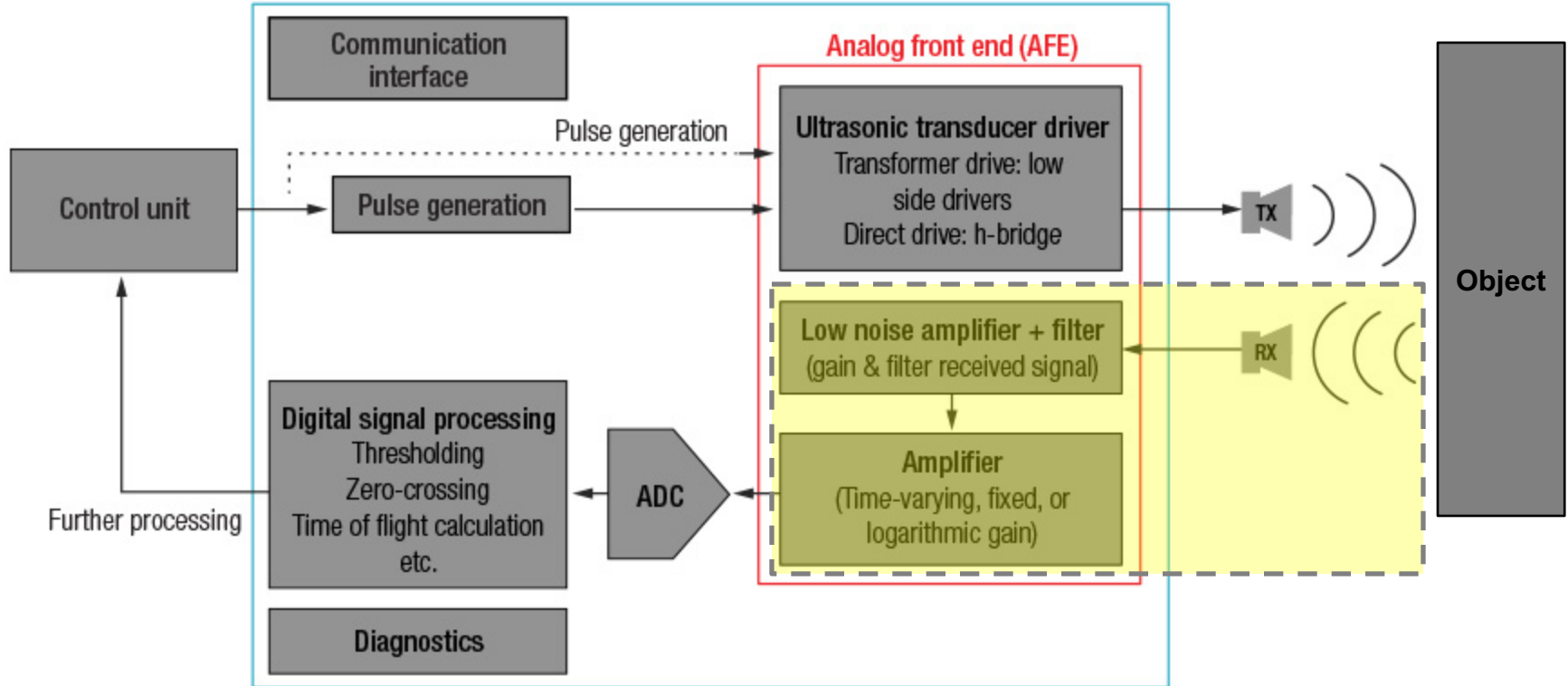
TI Precision Labs – Ultrasonic Sensing

Presented by Akeem Whitehead

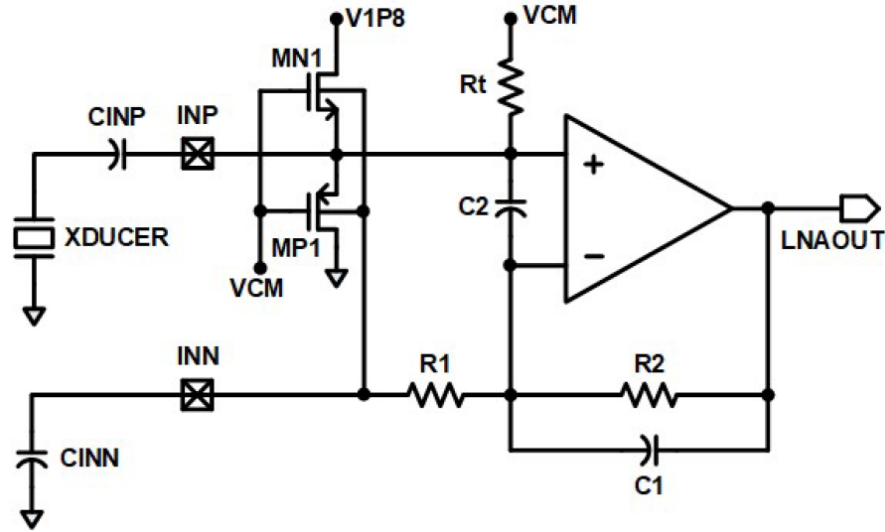
Prepared by Akeem Whitehead

Block Diagram of Ultrasonic System

Application specific standardized part (ASSP) - Integrated Solution

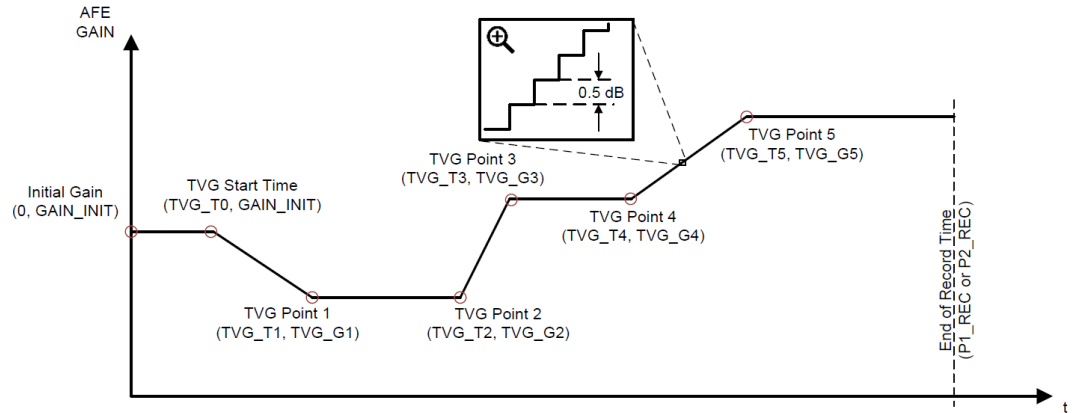
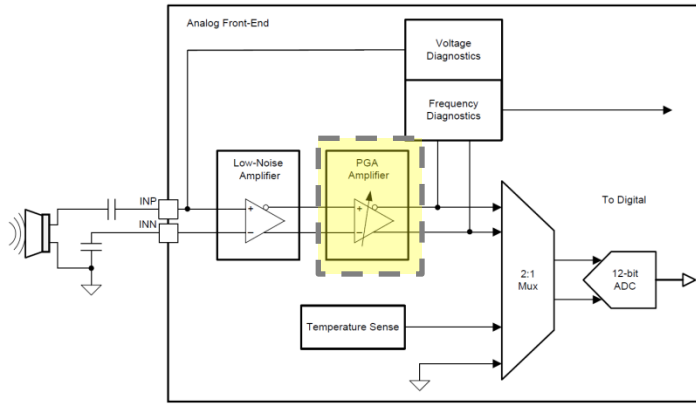


Low Noise Amplifier



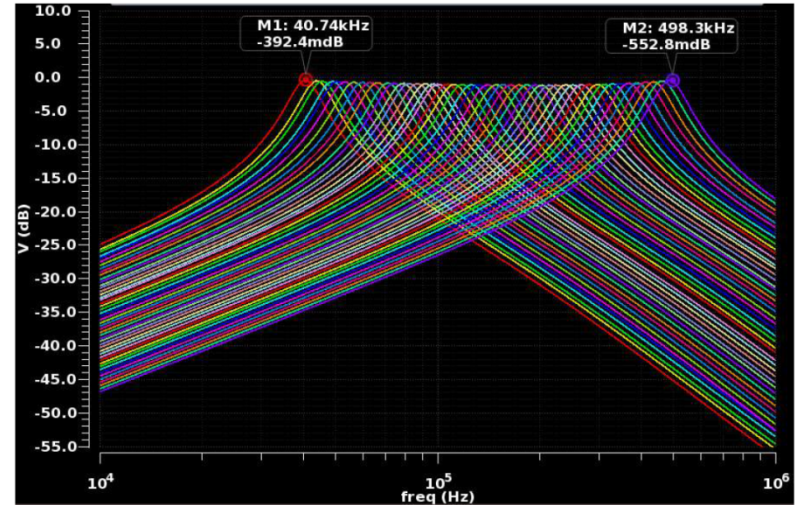
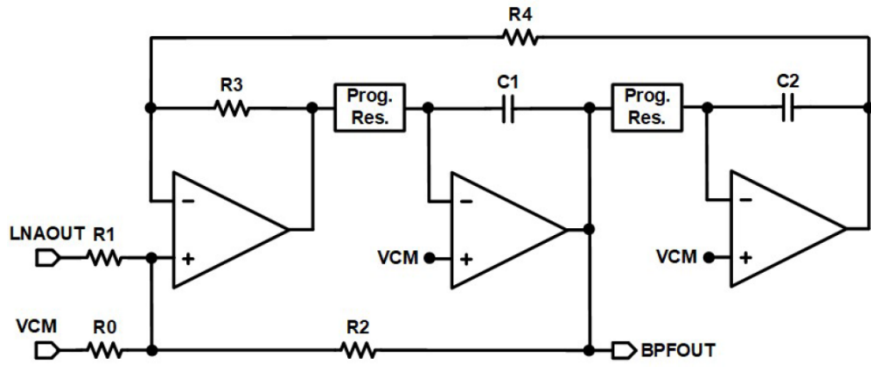
- First stage of AFE which is a single-ended input non-inverting amplifier
- Implements internal protection for the large driver voltage at the transducer:
 - C_{INP} is an AC coupling capacitor to limit current flow at INP
 - C_{INN} provides high-pass filtering to remove 1/f noise and DC offset voltage

Time Varying Gain Amplifier



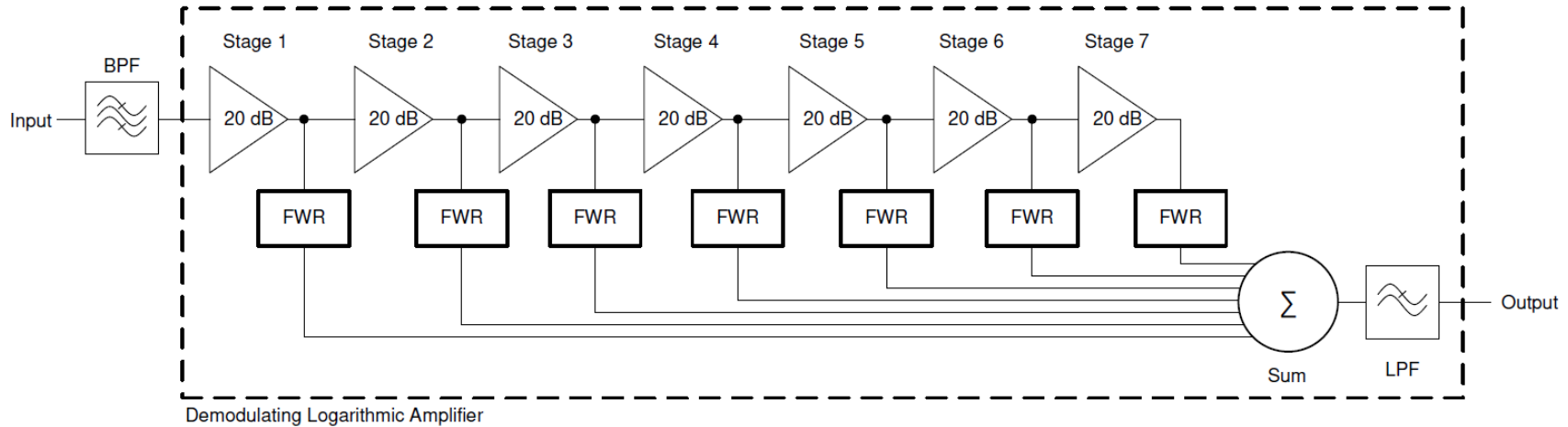
- Allows user to set different static gains over the record time
- 32dB to 90 dB (0.5 dB/Step) programmable gain amplifier:
 - Time Varying Gain in 6 time assignments
 - Settings stored in device memory

Analog Bandpass Filter



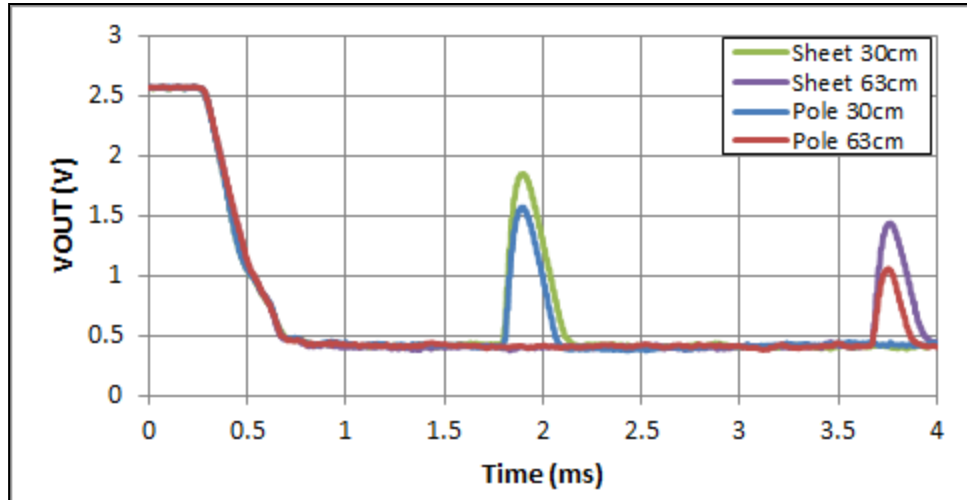
- Limits the bandwidth of the AFE to the transducer frequency to reduce noise from the LNA and external noise sources.
- Schematic diagram is a 3 op-amp state-variable filter with a Q of ~ 4 and gain of ~ 0 dB.
- Center frequency configurable between 40 and 500kHz in 48 steps.

Logarithmic Amplifier



- A demodulating log amp in the AFE provides input dependent amplification:
 - enables high sensitivity for weak signals
 - wide dynamic range over full signal range without saturating AFE chain.
- Simplifies system design as a form of automatic gain control and eliminates the need for manual gain and threshold calibration of varying echo strengths

Log Amp vs. TVG Amp: Log Amp Results



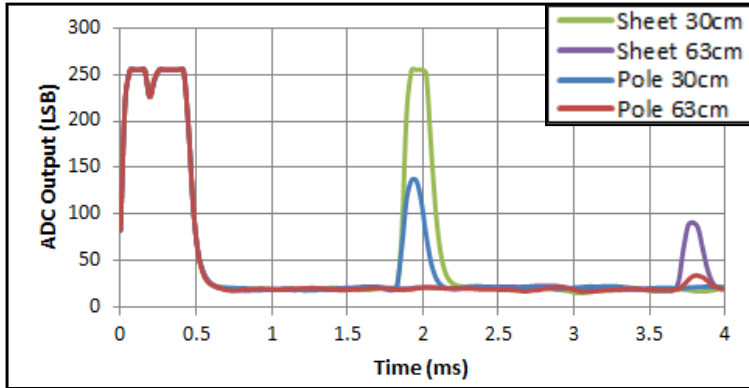
Log amp output during ToF Meas.

Test Conditions:

- 220kHz Transducer
- Object 1 is 7cm diameter metal pole
- Object 2 is a 24x32cm metal sheet
- Distance of 30 and 63cm
- Direct driver at 20V

- AFE does not saturate the object echo peak
- Pedestal level (noise floor) is constant across time
- Enables fixed threshold level

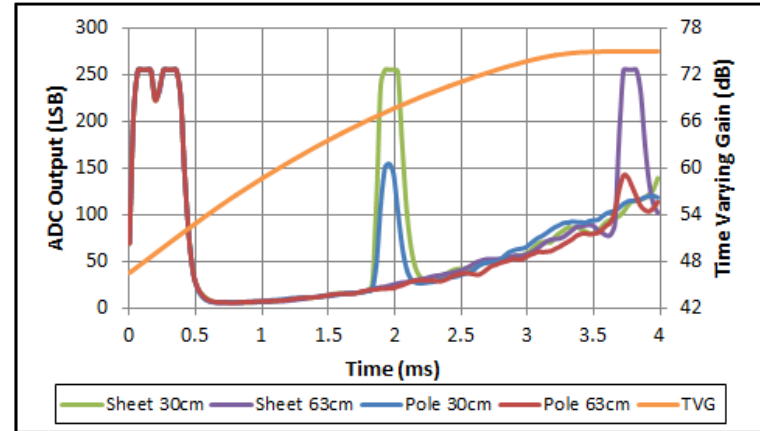
Log Amp vs. TVG Amp: TVG Amp Results



ADC output during ToF Meas. with fixed gain

Fixed Gain Results

- *Pro*: Enables simple fixed level threshold
- *Con*: Strong echoes at close range saturate the AFE and weak echoes at long range have insufficient SNR



ADC output during ToF Meas. with TVG gain

Rising TVG Results

- *Pro*: Allows sufficient SNR scaling of all objects
- *Con*: Requires a time varying threshold to compensate for the rising noise profile towards the end of the record cycle

To find more ultrasonic sensing technical resources and search products, visit ti.com/ultrasonic