

Analog to Digital Conversion

Driving System Cost & Performance Trades

a teledyne marine company

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A/D in Teledyne Multibeam Sonars

24 Bit



16 Bit



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Digital Backscatter Acquisition in Teledyne Multibeams

- » Why do some Teledyne Multibeam sonars have 16 bit Analog to Digital conversion while others have 24 bit?
- » Why do some systems use 8 bit convertors?
- » How does a sonar manufacturer make sure that the backscatter is “True”?
- » What are the trade-offs between various systems?

Design Considerations

» 16 Bit A/D

- Low power consumption per channel
- Low heat
- Low cost per channel
- Low communication bandwidth required
- Lower dynamic range
 - Analog TVG required
- More user interaction or smarter software
- Favors high channel counts

» 24 Bit A/D

- High power consumption per channel
- High heat
- High cost per channel
- High communication bandwidth required
- Higher dynamic range
 - Analog TVG not required
- Less User Interaction
- Favors low channel counts

Backscatter recovery from a signal

- » Goal: Map amplitudes to within 0.5 dB of true backscatter amplitude.
- » Issues
 - Sample Rate and Dynamic Range
 - Dynamic Range and TVG
 - Price and Performance Trades

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Sample Rate (DISCRETIZATION IN TIME)

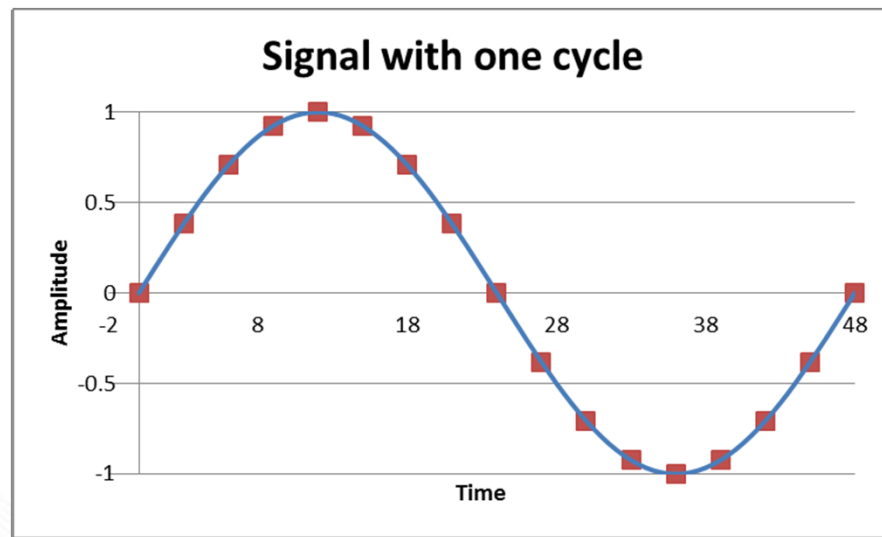
» Nyquist Rate:

- If the maximum frequency of a signal is f , sampling at $2f$ will ensure that you can recover the signal frequency, f .

» To improve SNR increase sample rate

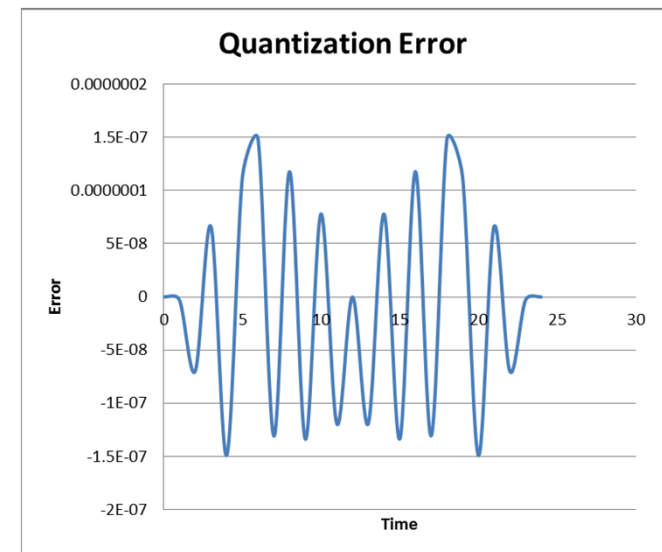
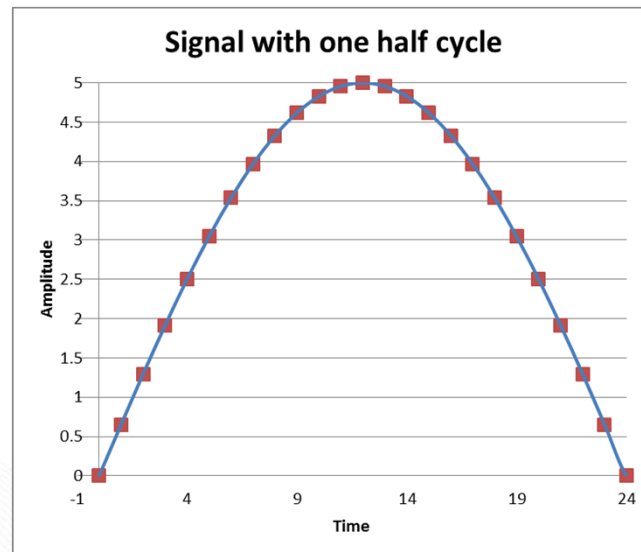
- The signal adds linearly, but the noise adds with a square root

Sample Rate
 $2f$



Quantization (DISCRETIZATION IN AMPLITUDE)

- » Quantization determines **Dynamic Range**
 - The resolution of the amplitude samples or
 - The full range of the amplitude samples at a given resolution
- » Quantization is determined by the number of bits in the Analog to Digital convertor.



20 Bits

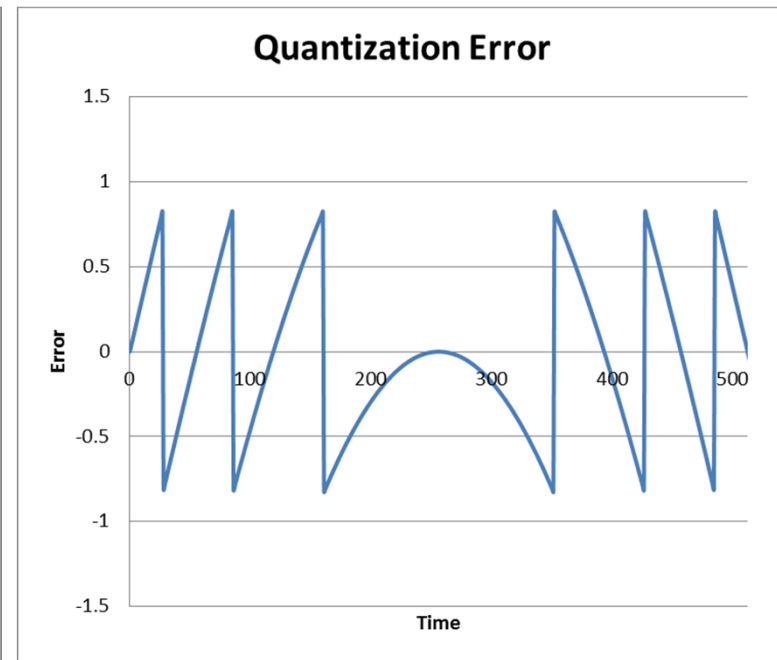
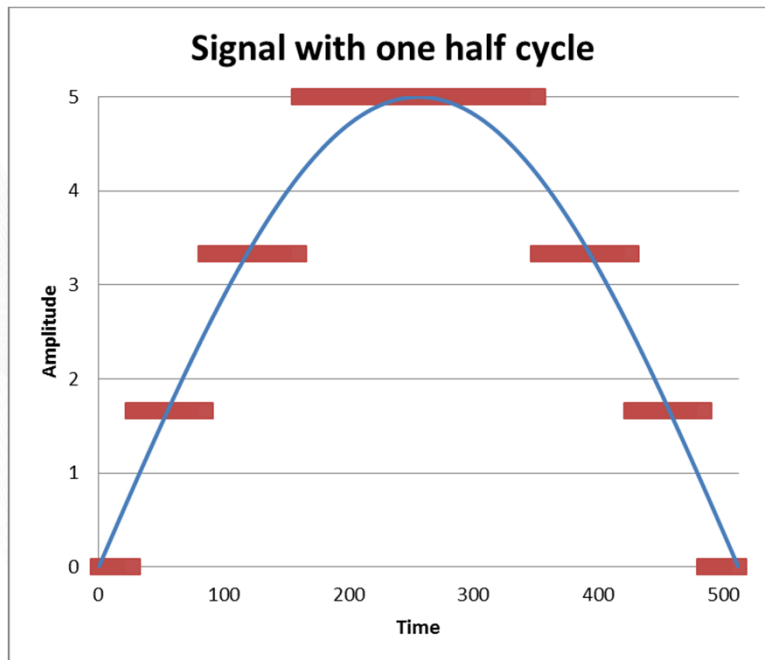
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Quantization Error

- » Quantization error is estimated using an infinite, or continuous sample rate.
- » **SQNR** $\approx 6 \cdot b$ where **b** is the number of bits and SQNR is in dB

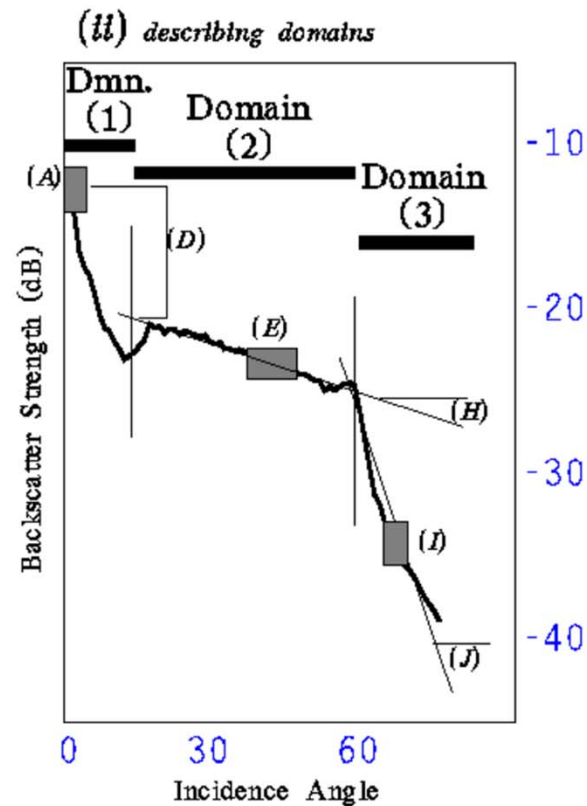
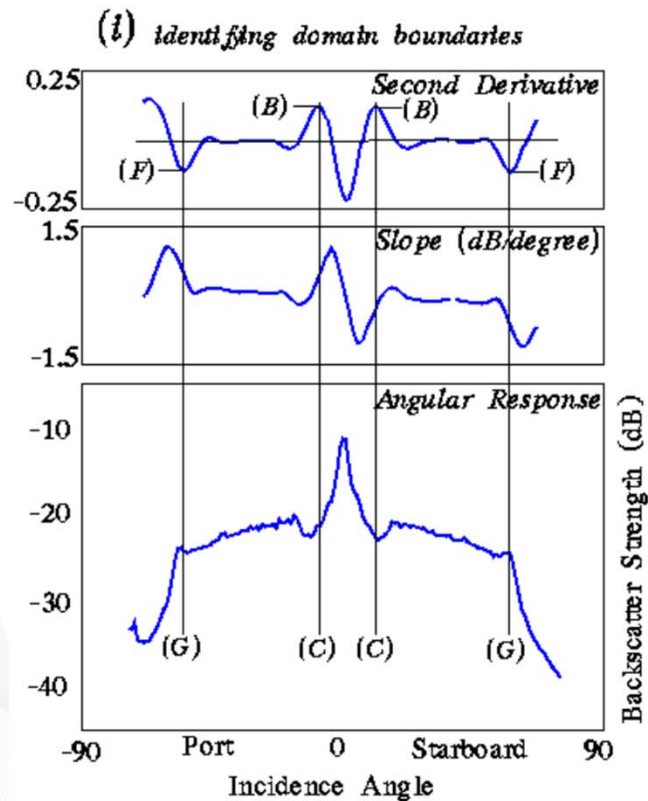


Quantization Error (QSNR)

A/D Bits	Values	SNR (dB)
8	256	-50
12	4096	-74
16	65536	-98
24	16777216	-146

- QSNR defines our maximum possible instantaneous dynamic range.
 - We must also account for other noise sources

How much dynamic range do we need?



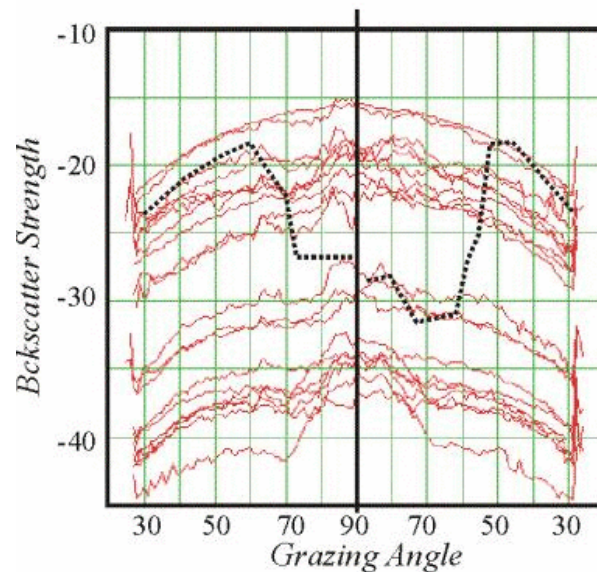
Areal Seabed Classification using Backscatter Angular Response at 95kHz
 J.E. Hughes Clarke (1), B.W. Danforth (2) and P. Valentine (2)

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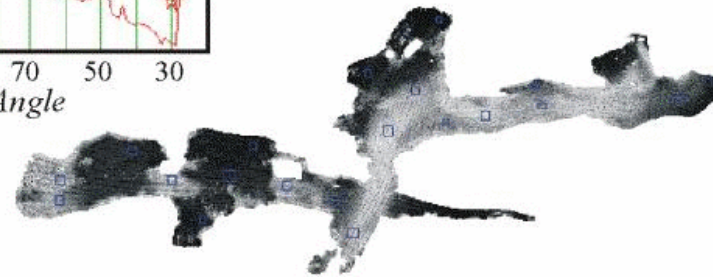
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Another Look: 40dB is a good starting point



With only a narrow range of available grazing angles, organically enriched sediments are **not statistically distinct** from other high mean BS sediments



Representative Angular Response Curves from around the Letang Estuary

Acoustic Imaging of Salmonid Mariculture Sites: J. E. Hughes Clarke, David Wildish, Anya Duxfield

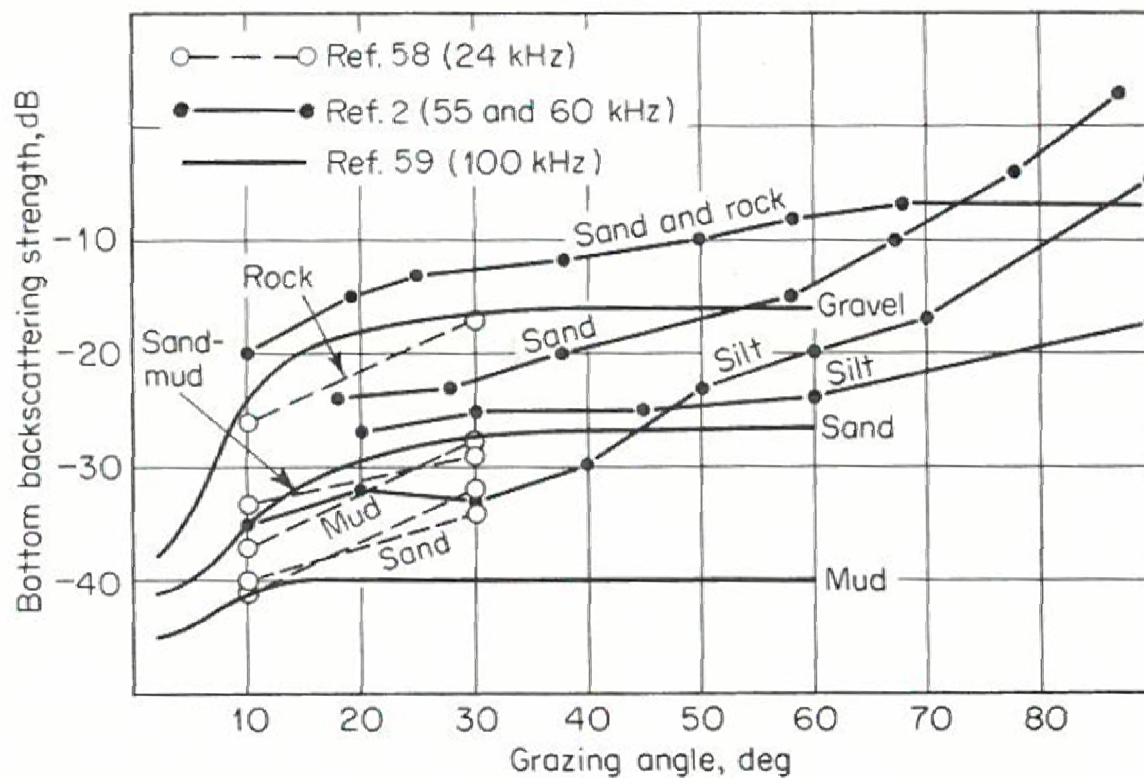


fig. 8.27 Measured backscattering strength of the seabed at various coastal locations.

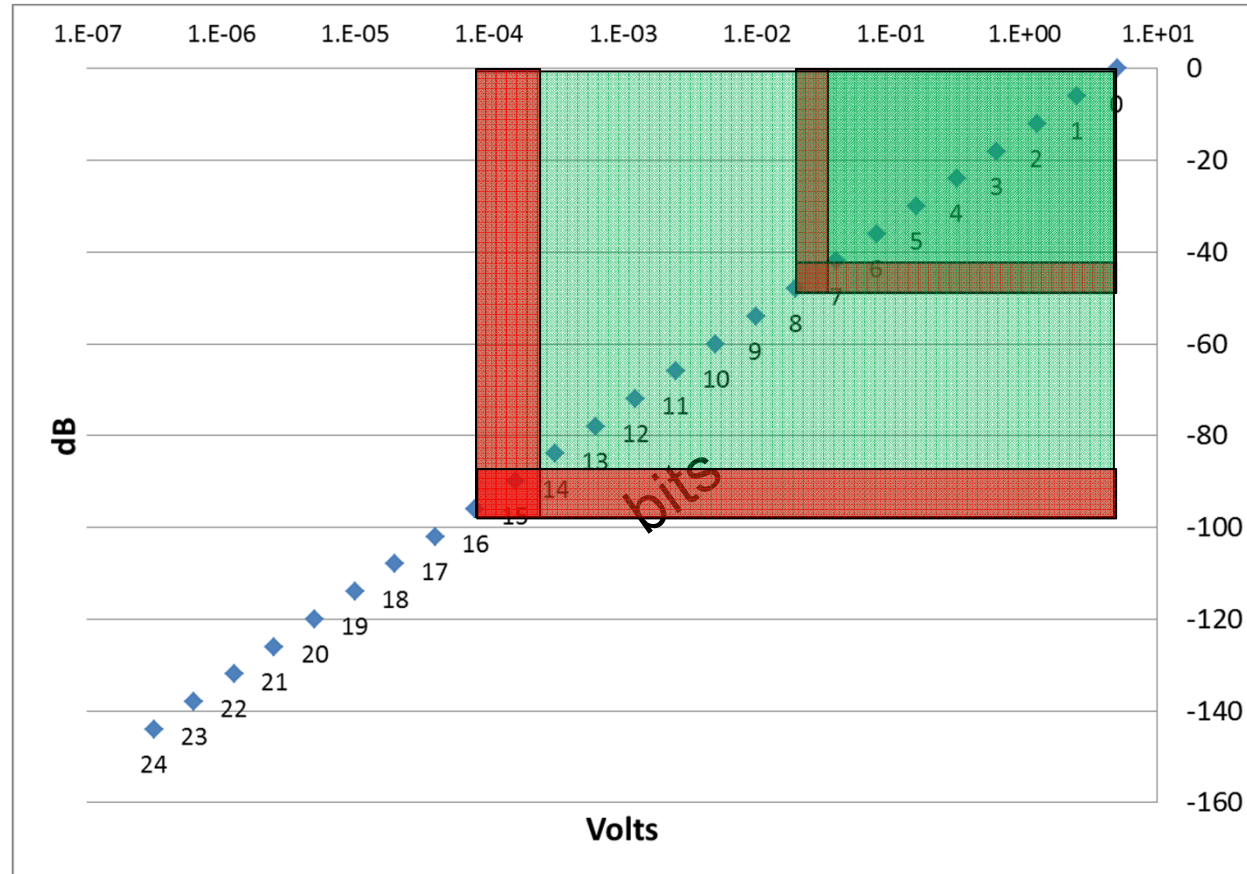
» **Urlick, 1967**
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Bits, Volts and dB

86 bit ADD
With Noise



Referenced to 5 VDC

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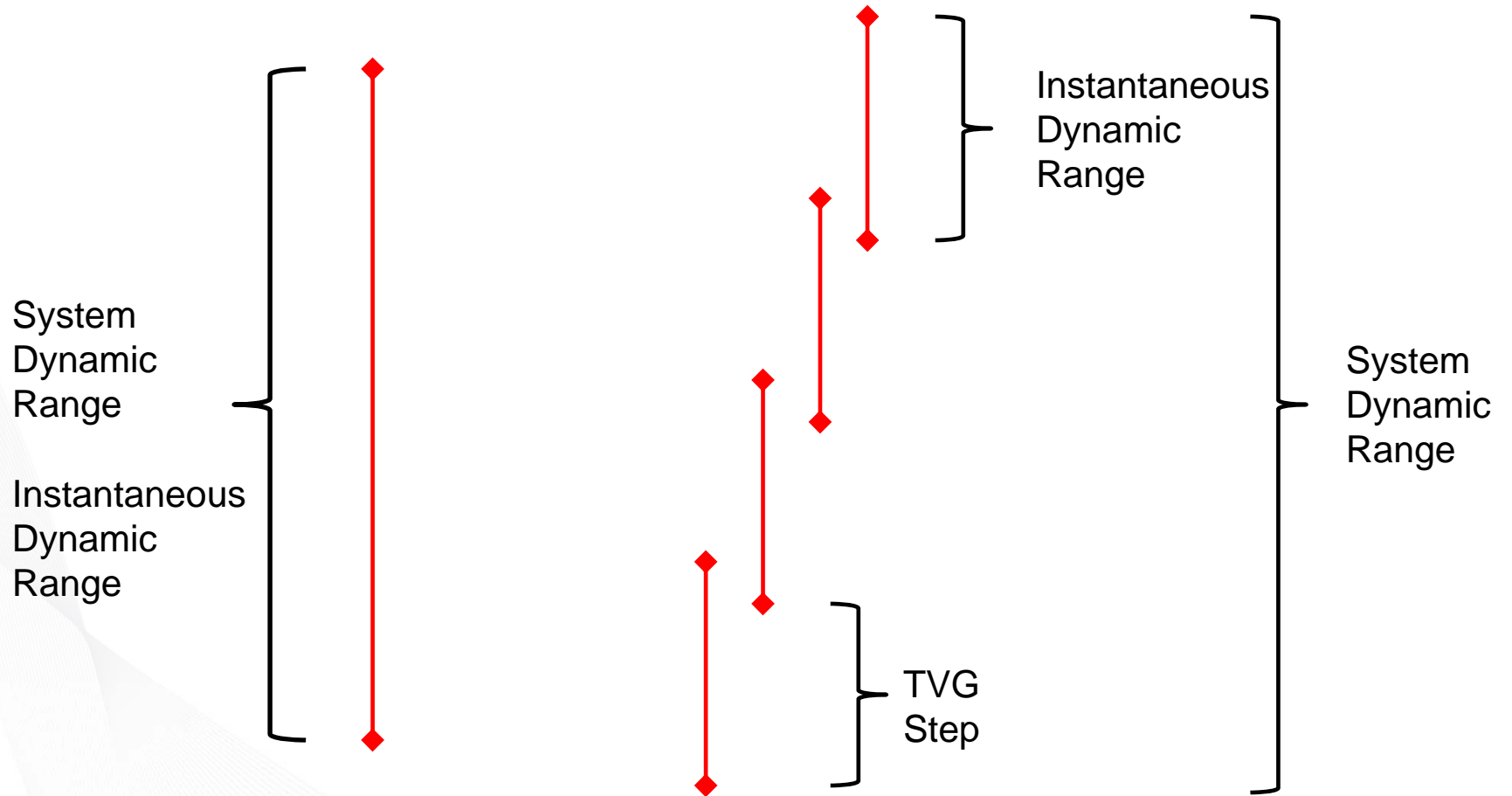
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System Dynamic Range

24 Bit, No TVG

8 Bit, With TVG



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