The **Broadband** Company

Understanding *Adaptive Equalization* for Digital Television Transmitters

Presented to -

PBS Technology Conference

Presented by -
Dan Dickey - April. 21, 2001

Adaptive Digital Equalization

- What is it?
- Why do you need it?
- How does it work in the real world?
- What can you do to make it work the best?

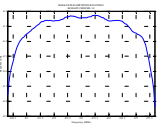
4/9/01

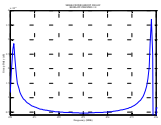
What is *Adaptive Equalization*?

- System for monitoring and compensating for linear and nonlinear distortion in the transmission system
- Maintains low distortion 8VSB signal
- Works even when you're not at the transmitter so changes in RF system performance are tracked and equalization adjustments are automatically made

What is Linear Distortion?

- Linear distortion exists when a system does not have the following characteristics:
  - Constant amplitude vs. frequency
  - Linear phase vs. frequency (i.e. constant group delay)





The Most Common Causes of Linear Distortion in 8VSB

- Tuned circuits:
  - Mask filter
  - Cavity amplifiers
  - Antennas
- VSWR
  - Antenna icing
  - Imperfect transmission line

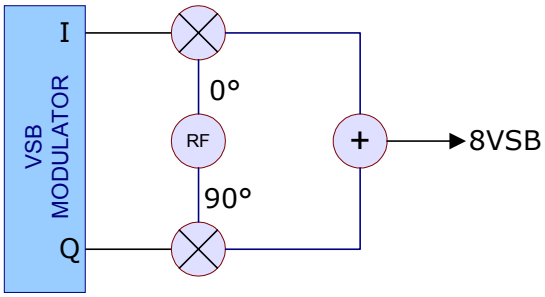
Why is Linear Distortion Bad?

- Linear distortion eats up the signal to noise margin of digital systems
  - Receiver equalizer must work harder to remove transmission system distortion
  - Linear distortion due to reflections at transmission site are harder for receiver to correct
  - Reduces coverage area

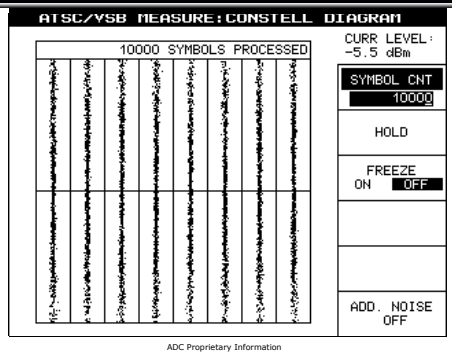
How to Recognize Linear Distortion ?

- Linear distortion causes random noise in the complex domain thus increasing EVM
  - Noise is independent of signal amplitude
  - Constellation diagram will be 8 fat lines instead of 8 skinny lines

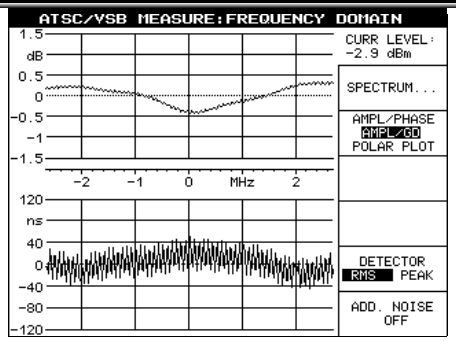
Understanding Vector Modulation



Understanding Vector Modulation



How to Recognize Linear Distortion ?



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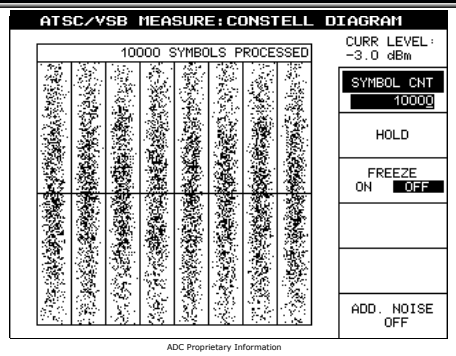

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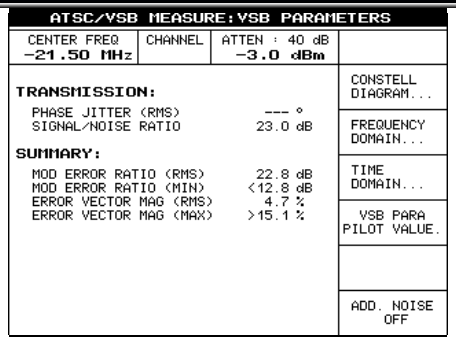
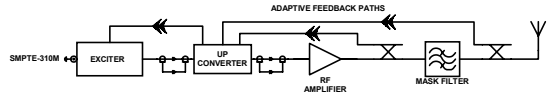


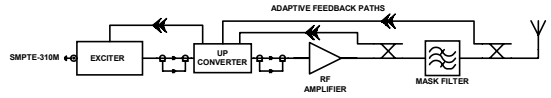
How Can Linear Distortion be Controlled?

- Linear distortion can be reduced or eliminated by measuring signal to noise (SNR) degradation and compensating for the transfer function of RF system through predistortion

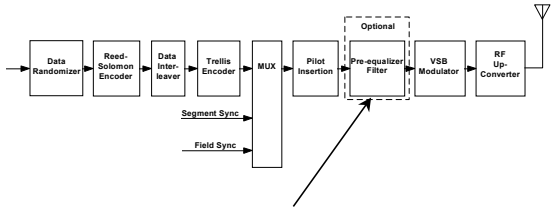


Adaptive Equalization to Correct Linear Distortion

- Adapative Equalization Process
  - Capture output of exciter
  - Capture output of mask filter
  - Demodulate transmitter output to same domain as exciter
  - Subtract both versions and adjust predistortion filter for least error



Adaptive Equalization to Correct Linear Distortion



- PREDISTORTION FILTER

What is Nonlinear Distortion?

- Nonlinear distortion exists when a system does not have the following characteristics:
  - Constant gain vs. output power
  - Constant phase vs. output power

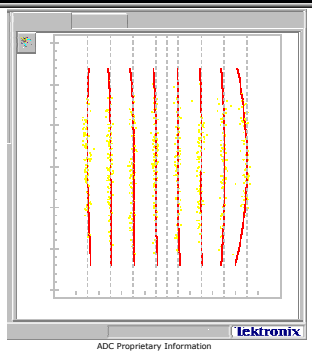
The Most Common Causes of Nonlinear Distortion in 8VSB

- Active circuits
  - AGC amplifiers
  - Solid state power devices
  - IOT amplifiers

Why is Nonlinear Distortion Bad?

- Nonlinear distortion eats up the signal to noise margin of digital systems
  - No receiver can correct for nonlinear distortion
  - Causes spectral regrowth both inside the channel and outside the channel
  - Reduces coverage area

How to Recognize Nonlinear Distortion ?



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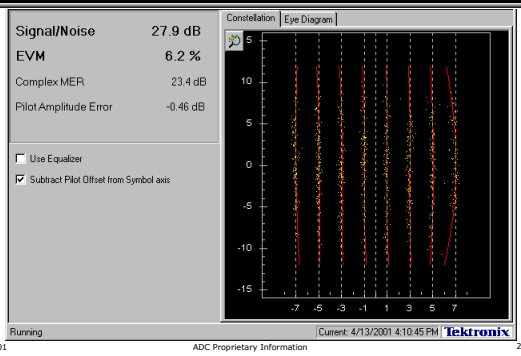
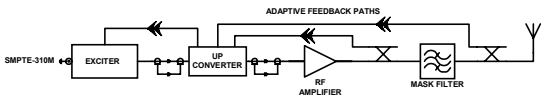


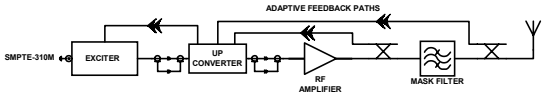
How Can Nonlinear Distortion be Controlled?

- Nonlinear distortion can be reduced or eliminated by measuring the error in the constellation as a function of output power and creating a predistortion system to compensate

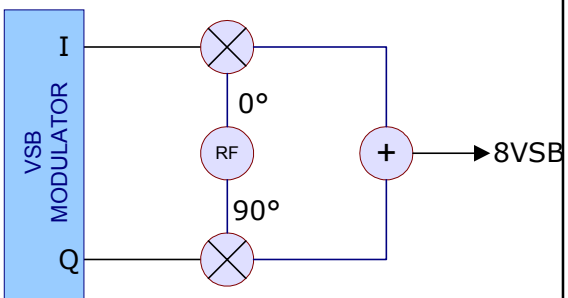


Adaptive Equalization to Correct Nonlinear Distortion

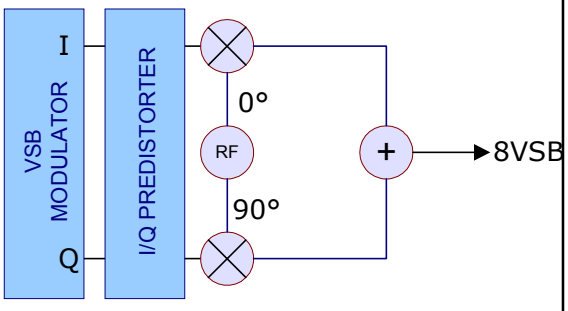
- Adapative Equalization Process
  - Capture output of exciter
  - Capture output of RF amplifier
  - Demodulate transmitter output to same domain as exciter
  - Compute phase and gain error at all envelope levels and adjust predistortion system for least error



How To Correct Nonlinear Distortion



How To Correct Nonlinear Distortion



Maximizing Performance of Adaptive Systems

- Eliminate as much VSWR as possible
- Reduce temperature variations of mask filter
- Maintain the quality of the adaptive sample points and cabling

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