DATV for ARES

Matt Holiday, KØDVB
BCARES — Summer 2017

Why Amateur Television?

Why Amateur Television?

Why Digital?

1   Weak-signal performance

2   Picture quality

3   Higher resolution

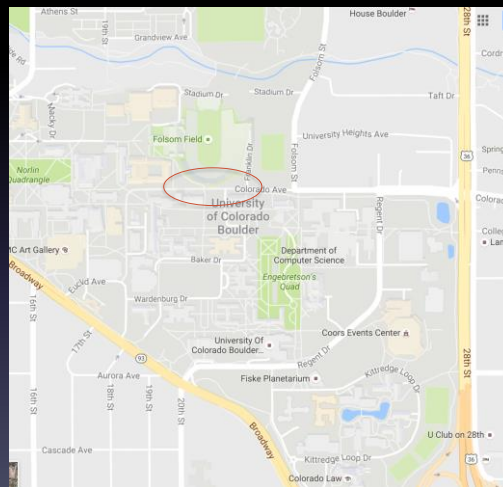Digital ATV works better in our environment

We Went Digital in 2015
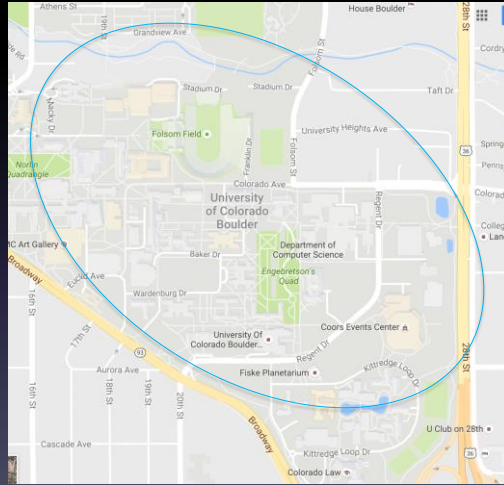
Digital allowed us a much larger footprint at CU

Also, digital enabled new technologies

- HD quality
- IP streaming

Analog Footprint

Digital Footprint

ATV Spectrum

It's mostly in the UHF 70cm band

It's mostly line-of-sight & low power

57	58	59*	60	
423	**429**	**435**	**441**	
420 - 426	426 - 432	432 - 438	438 - 444	444 - 450

Digital ATV Technology

DVB-T — better for weak-signal operation

It works with our existing spectrum & cameras

It takes care of station identification ☺

Working the Camera
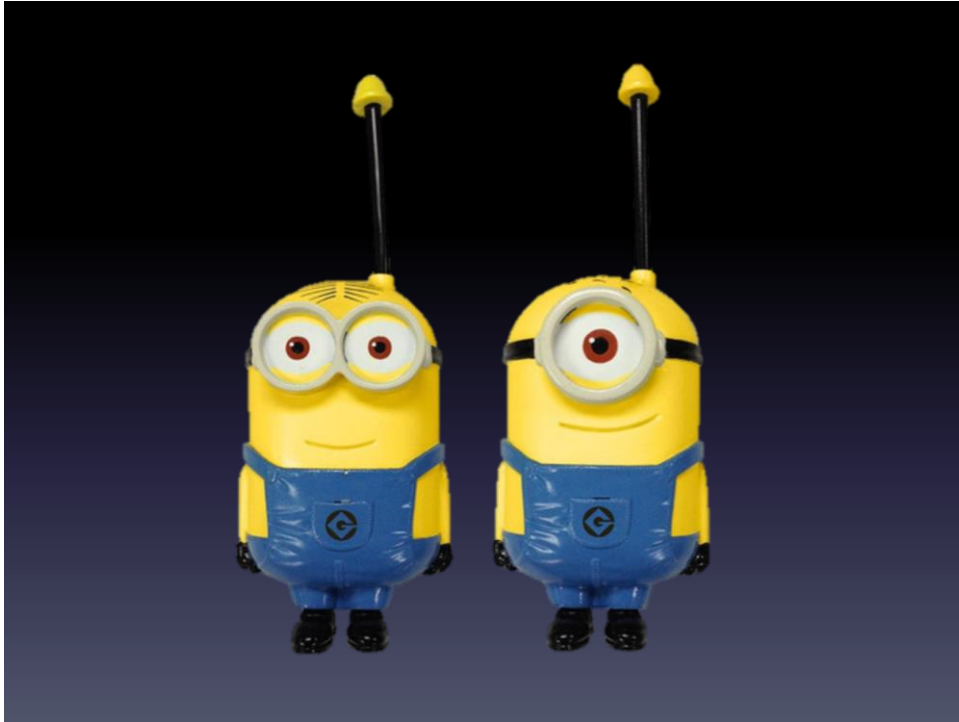
In the Press Box

Camera Teams

One person operates the camera

One person maintains situational awareness

Safety & professional behavior matter

Analog ATV Equipment

Transmitted using Vestigial Side Band (VSB)

Which must be filtered at the transmitter

So each pack set is specific to a channel

Digital ATV Equipment

Transmitted without filters

Any pack set can use any channel

There may be other settings for best operation

Equipment Changes

Modulator

Amplifier   Changed
                                             from ATV

No filter on transmitter

Camera, tripod & antenna mount

                                             Unchanged

Battery, power adapters

Modulator

Hi-Des HV-100 / 102

Outputs from 70cm up to 33 cm (13 cm)

HDMI, SDI and/or analog input

Front panel allows channel change without PC

Modulator Control

Modulator Connections

Hi-Des HV-100

Amplifier

KH6HTV 70-7B
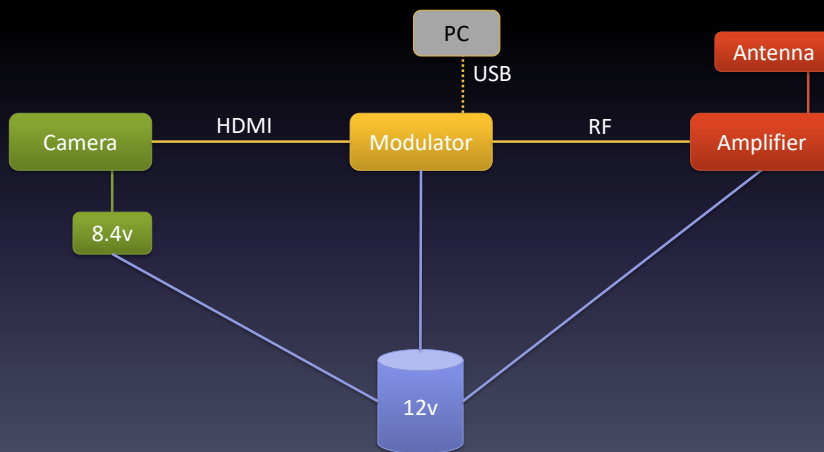

Outputs on 70cm only

Three power levels: 0.3, 1.0, 3 watts

Fan doesn't need to run at low power!

Camera

Same Sony CX-430V (for CU)

Equipment Connections

PC		Antenna

Camera —HDMI— Modulator —RF— Amplifier

USB

8.4v

12v

Packaging

One way to package: sling bag, rain cover

Receiver

Hi-Des HV-110 or -120

Receives from 70cm up to 33 cm

HDMI and analog output

HV-110 requires fragile remote control
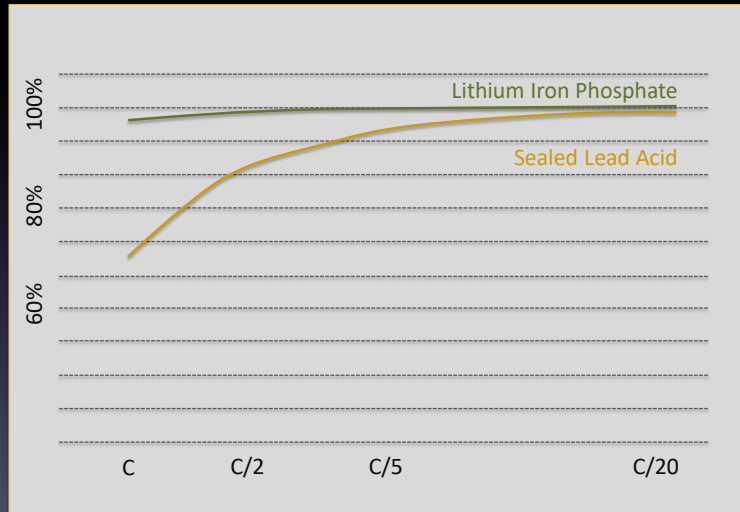
Receiver Connections

Hi-Des HV-110
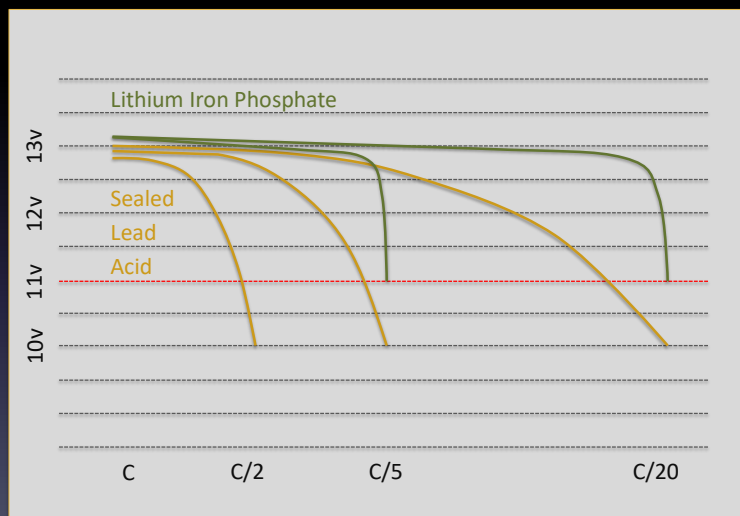

Equipment Settings

Modulator programmed via USB

Receiver must search each frequency

But it only needs to know channel bandwidth

Battery Capacity

Lithium Iron Phosphate

Sealed Lead Acid

100% 80% 60%

C   C/2   C/5   C/20

Battery Voltage

Lithium Iron Phosphate

Sealed
Lead
Acid

13v 12v 11v 10v

C   C/2   C/5   C/20

Current Draw vs Power

Camera	0.4 amps	
Modulator	0.4 amps	
Amplifier		
Low	0.6 amps	1.4 amps
Medium	1.1 amps	1.9 amps
High	2.8 amps	3.6 amps

DVB-T Choices

We can choose several parameters in DVB-T

– reduce video resolution & bandwidth

– reduce glitches

– get a low power signal through tough conditions

HD Resolution

1080p pushes the equipment and data rate

We operate at 720p in the field

We could run 480p in a very harsh environment

Remember Analog?

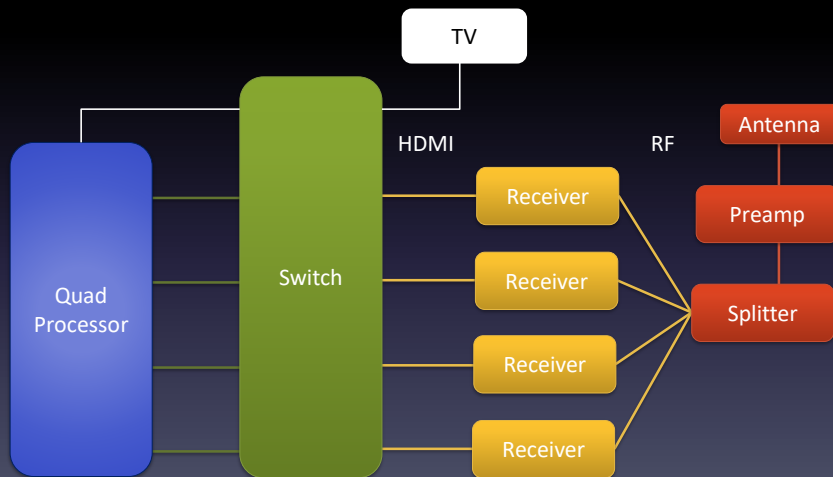| Ghosting | Noise | Electrical Interference | Transmitter Interference |

What If There's No Picture?

- ✓ Modulator: power, channel selection

- ✓ HDMI from camera to modulator

- ✓ Power level on amplifier

- ✓ RF cables: modulator — amp — antenna
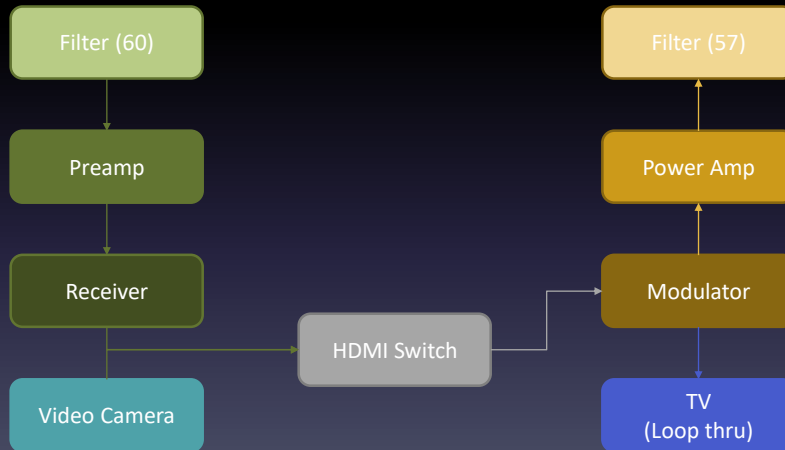
- ✓ Battery level & power connectors

Quadrophenia

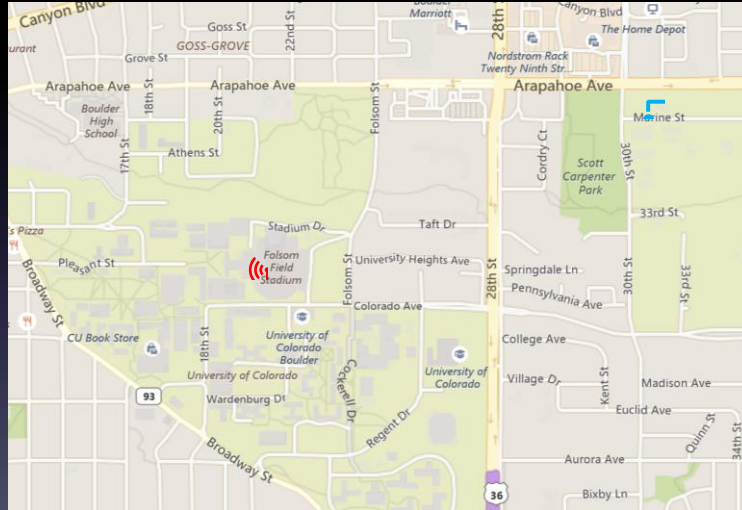# Quad Box Connections

TV

HDMI   RF

Antenna

Quad Processor

Switch

Receiver

Receiver

Receiver

Receiver

Preamp

Splitter

Portable Repeater

Portable Repeater

```
Filter (60)                        Filter (57)
    |                                  ^
    v                                  |
Preamp                            Power Amp
    |                                  ^
    v                                  |
Receiver  -----> HDMI Switch ---> Modulator
    |                                  ^
    v                                  |
Video Camera                      TV
                                  (Loop thru)
```

IP Streaming

When RF can't reach that far

Convert HDMI into a network-based stream

Command Post Moved ☹

Streaming 1: Laptop

Take HDMI into the laptop using an adapter

Either

– stream it using VLC

– using a videoconference, e.g., Google Hangouts

Device 1: Dongle

Streaming 2: Server

Take HDMI into an appliance

Use the appliance to serve clients via RTSP

Device 2: Appliance

Device 2a: Modulator

Streaming 3: Cloud

Take HDMI into an appliance

Use the appliance to push video to YouTube

Device 3: Webcaster

YouTube Streaming

Allows live streaming via device pairing

Streams can be private (by invitation only)

YouTube now offers ultra-low latency (1-2 secs)

Errors in Digital TV

In theory, digital TV is either P5 or P0
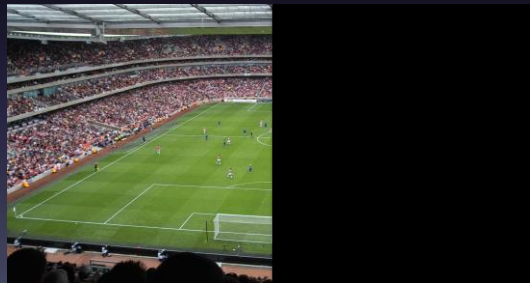
Is This P5 or P0?

We Have Key Tradeoffs

Video resolution and compression

Error handling for the RF channel

S/N ratio and power level

Battery life
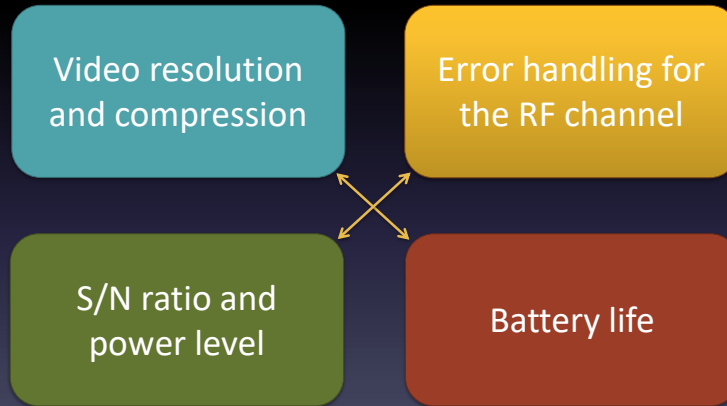
Quadrature Amplitude Modulation

Multiple bits per symbol

Modulation	States	Bits / symbol
QPSK	4	2
16-QAM	16	4
64-QAM	64	6

Amplitude + Phase = Symbol

1101	1001	0001	0101
1100	1000	0000	0100
1110	1010	0010	0110
1111	1011	0011	0111

25% @ 225° = 1010
75% @ 75° = 0001
75% @ 135° = 0111
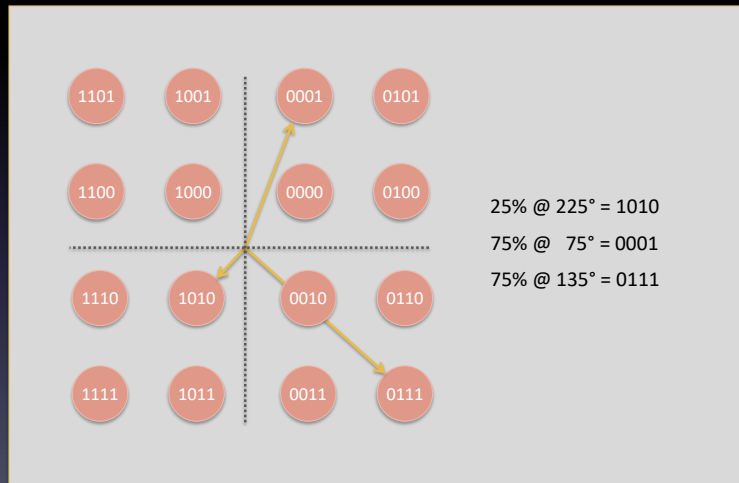
QAM Constellation
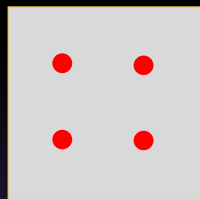
With low noise
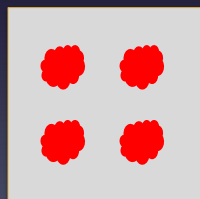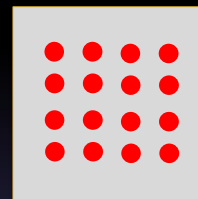
Too much noise?
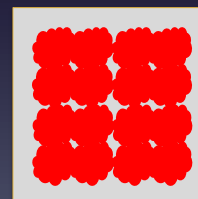
Modulation Error Ratio (MER)

MER = 10 · log (avg symbol power / avg error power)

Average error power

Average symbol power

High MER

Low MER
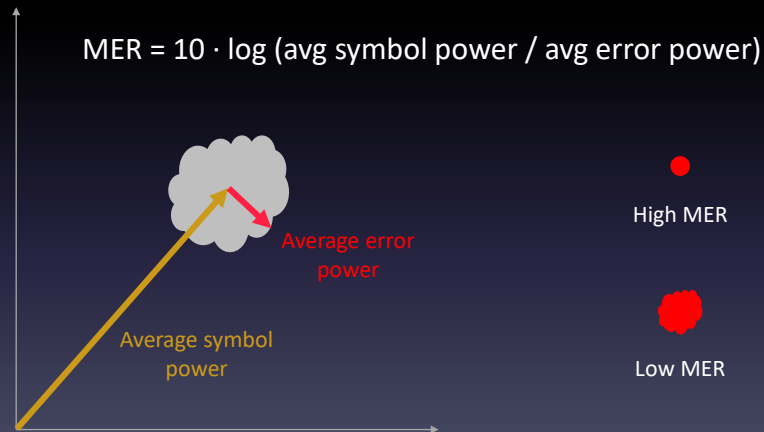
Bit Error Rate (BER)

The fraction of bits that are interpreted wrongly

A BER of $2 \cdot 10^{-4}$ means 2 bad bits per 10,000
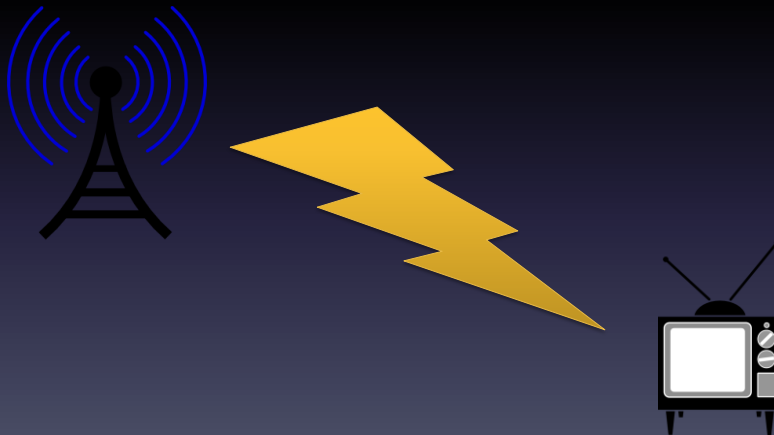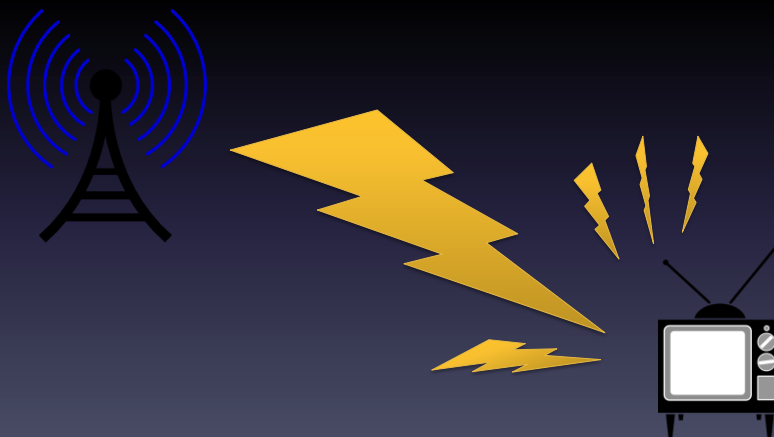
As MER goes down, BER goes up
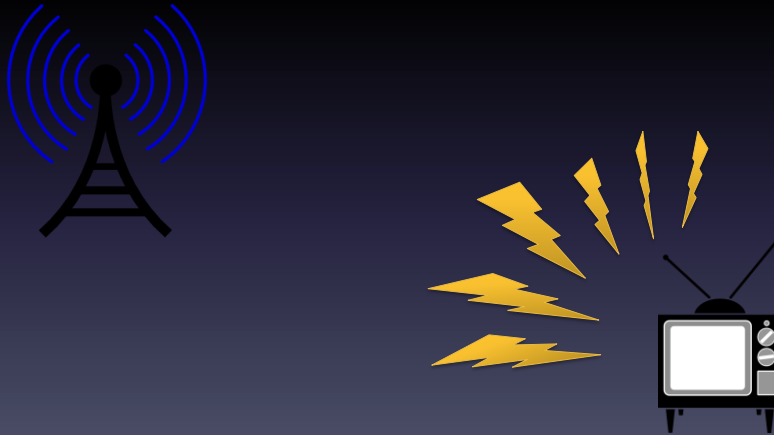
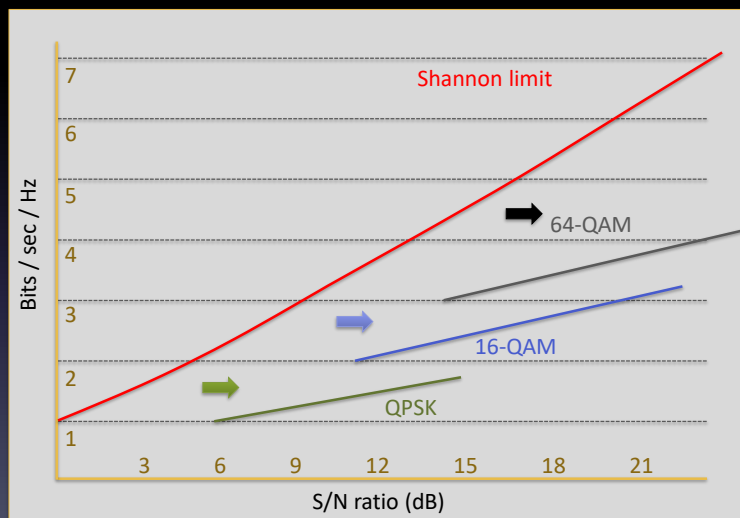# Modulation vs BER
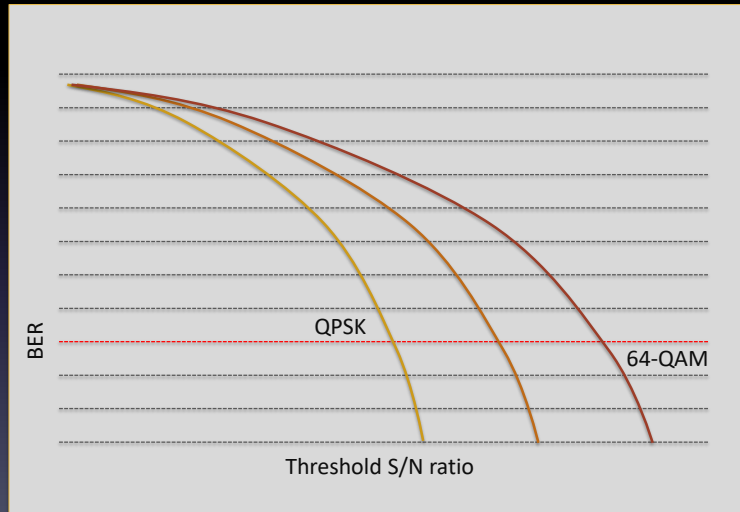
Gaussian Spectral Efficiency
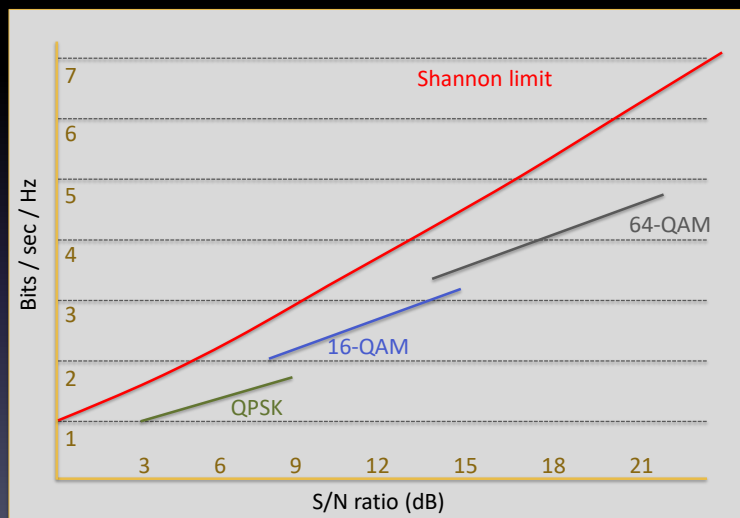
Gaussian Channels

Rician Channels

Rayleigh Channels

Rayleigh Spectral Efficiency

Shannon limit

64-QAM

16-QAM

QPSK

Bits / sec / Hz

7
6
5
4
3
2
1

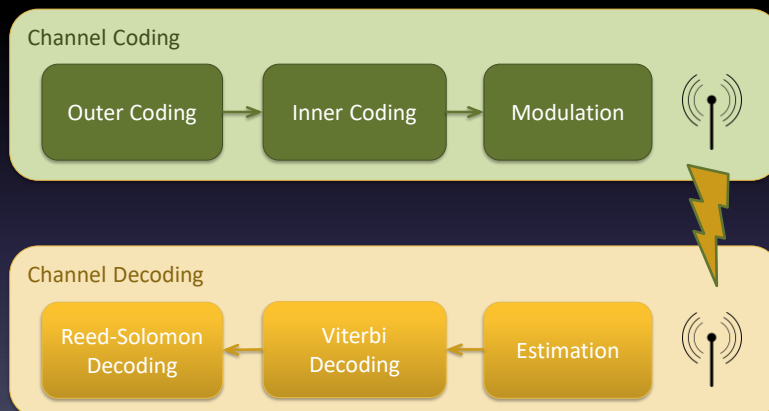3   6   9   12   15   18   21

S/N ratio (dB)

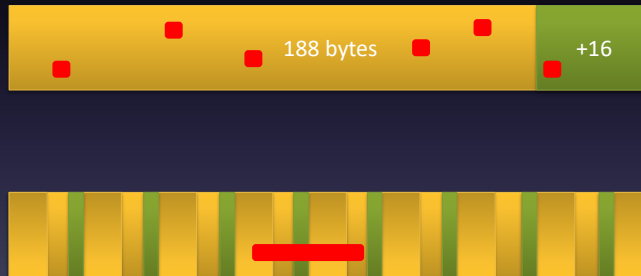# Forward Error Correction

We can't resend the data from the transmitter

Instead, we add error correction to the data sent forward, so the receiver can fix the mistakes

Transmission and Reception

Channel Coding

Outer Coding → Inner Coding → Modulation

Channel Decoding

Reed-Solomon Decoding ← Viterbi Decoding ← Estimation

Outer Channel Coding

Reed-Solomon block code + byte interleaving

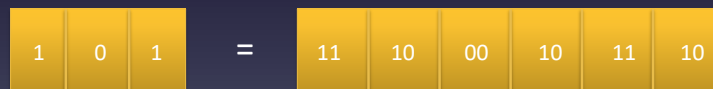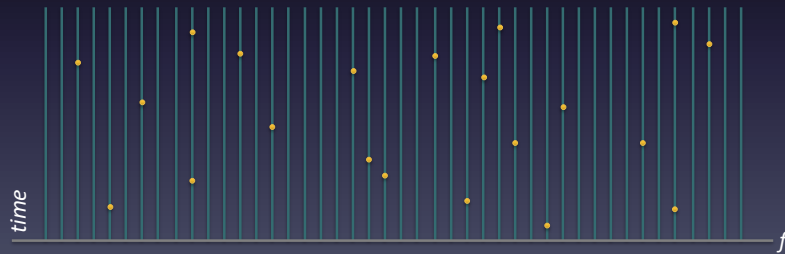# Inner Channel Coding

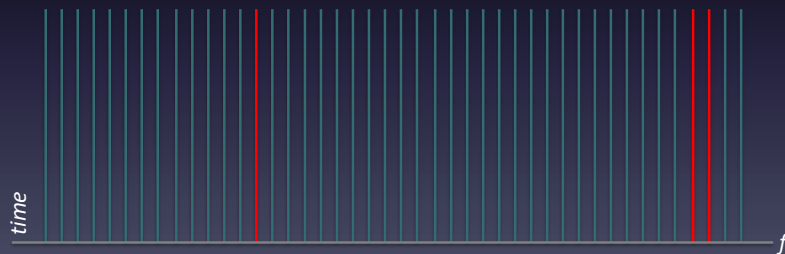Convolution code + symbol interleaving

- 1/2, 2/3, 3/4, 5/6, 7/8

- Content bits / encoded bits

Interleaving onto Carriers
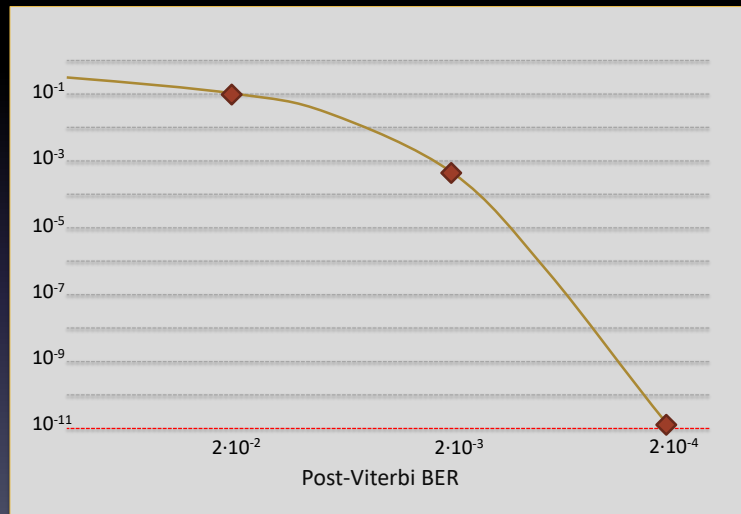

Effects of Channel Fading

BER After Reed-Solomon

$2 \cdot 10^{-2}$	$2 \cdot 10^{-3}$	$2 \cdot 10^{-4}$

Post-Viterbi BER

So What Can We Change?

Location — change the environment

Amplification — change s/n ratio

Code rate — change convolution code (and data rate)

Original Net Data Rate (Mbps)

Modulation	Code Rate	Guard 1/4	Guard 1/8	Guard 1/16	Guard 1/32
QPSK	1 / 2	3.73	4.15	4.39	4.52
	2 / 3	4.97	5.53	5.85	6.03
	3 / 4	5.60	6.22	6.59	6.79
	5 / 6	6.22	6.91	7.32	7.54
	7 / 8	6.53	7.26	7.68	7.92
16-QAM	1 / 2	7.46	8.29	8.78	9.05
	2 / 3	9.95	11.05	11.71	12.06
	3 / 4	11.20	12.44	13.17	13.57
	5 / 6	12.44	13.82	14.63	15.08
	7 / 8	13.06	14.51	15.37	15.83
64-QAM	1 / 2	11.20	12.44	13.17	13.57
	2 / 3	14.92	16.59	17.56	18.10
	3 / 4	16.80	18.66	19.76	20.36
	5 / 6	18.66	20.73	21.96	22.62
	7 / 8	19.59	21.77	23.05	23.75

Threshold S/N Ratio (dB)

Modulation	Code Rate	Gaussian	Rician	Rayleigh
QPSK	1 / 2	3.1	3.6	5.4
	2 / 3	4.9	5.7	8.4
	3 / 4	5.9	6.8	10.7
	5 / 6	6.9	8.0	13.1
	7 / 8	7.7	8.7	16.3
16-QAM	1 / 2	8.8	9.6	11.2
	2 / 3	11.1	11.6	14.2
	3 / 4	12.5	13.0	16.7
	5 / 6	13.5	14.4	19.3
	7 / 8	13.9	15.0	22.8
64-QAM	1 / 2	14.4	14.7	16.0
	2 / 3	16.5	17.1	19.3
	3 / 4	18.0	18.6	21.7
	5 / 6	19.3	20.0	25.3
	7 / 8	20.1	21.0	27.9

New Net Data Rate (Mbps)

Modulation	Code Rate	Guard 1/4	Guard 1/8	Guard 1/16	Guard 1/32
QPSK	1 / 2	3.73	4.15	4.39	4.52
	2 / 3	4.97	5.53	5.85	6.03
	3 / 4	5.60	6.22	6.59	6.79
	5 / 6	6.22	6.91	7.32	7.54
	7 / 8	6.53	7.26	7.68	7.92
16-QAM	1 / 2	7.46	8.29	8.78	9.05
	2 / 3	9.95	11.05	11.71	12.06
	3 / 4	11.20	12.44	13.17	13.57
	5 / 6	12.44	13.82	14.63	15.08
	7 / 8	13.06	14.51	15.37	15.83
64-QAM	1 / 2	11.20	12.44	13.17	13.57
	2 / 3	14.92	16.59	17.56	18.10
	3 / 4	16.80	18.66	19.76	20.36
	5 / 6	18.66	20.73	21.96	22.62
	7 / 8	19.59	21.77	23.05	23.75

DVB-T Signal

After Amplification
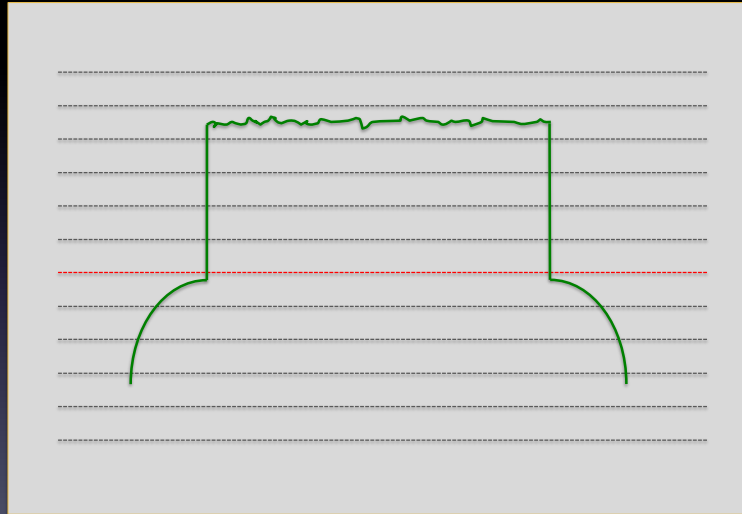
Amplification Settings

We want 30+ dB to the noise shoulder

So we attenuate modulator output by 15 dB *

Amplifier output

Low	25 dBm	300 mw
Medium	30 dBm	1 watt
High	35 dBm	3 watts

Modulator Calibration

MER in dB

36.0	
35.0	
34.0	
33.0	
32.0	
31.0	
30.0	
29.0	

5 4 3 2 1 0 -1 -2 -3 -4 -5 -6 -7 -8 -9 -10 -11 -12 -13 -14 -15 -16 -17 -18 -19 -20
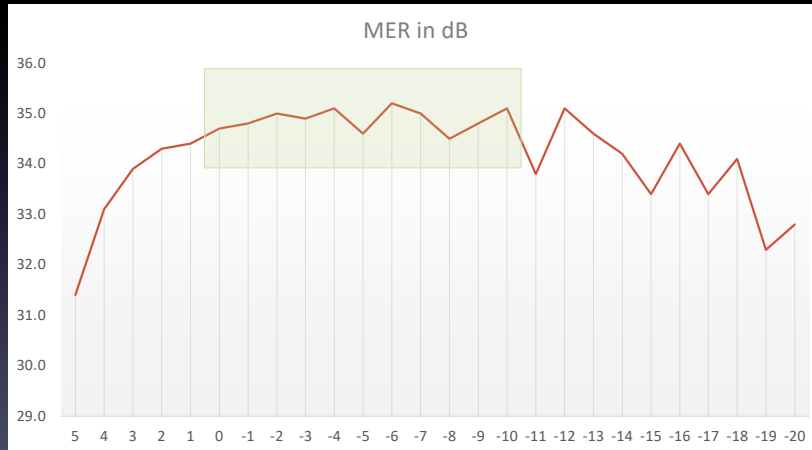
ATSC vs DVB-T

Only one   carrier & pilot

modulation (8ASK, 3 bits/symbol)

coding rate (2/3)

standard bit rate (19.4 Mbps)

But it's cheaper! *

* Well, the set-top boxes are cheaper …

Modulator Settings

There are several technical settings

These must be set using a PC and USB cable

The PC driver & software must be installed first

Transmission Configuration
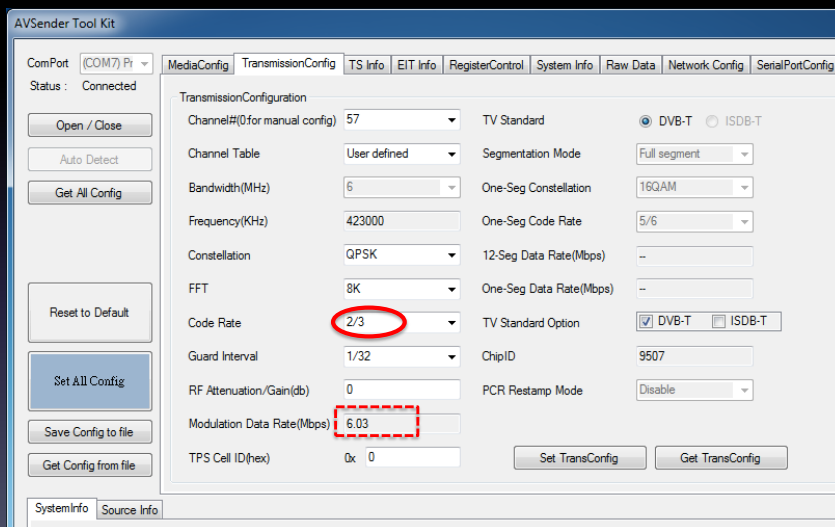
Media Configuration
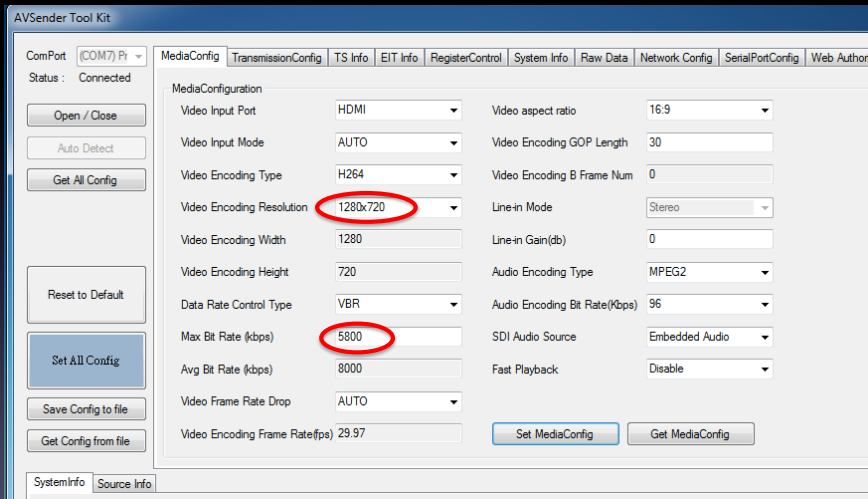
Transport Stream Info

Modulator Attenuation

Video Source Info

Can We See the Numbers?

Using the Hi-Des receiver as a test tool

Using a commercial DVB-T test tool

Green Button Screen

Demod FW Version:			
Demod Tuner ID:			
Frequency:	423000	Transmission Mode:	8K
Bandwidth:	6M	Frequency Offset:	0
TPS Lock:	Yes	Signal Quality:	100
MPEG2 Lock:	Yes	Signal Strength:	100
RSD Abort Count:	0	Signal Strength dBm:	-11
Post VTB BER:	0.00e+00	SNR:	22
Constellation:	QPSK	RSSI:	113
High Code Rate:	2/3		
Guard Interval:	1/32		

: Channel   : Page   EXIT : Exit

READ   DEMOD   Reg: 0 x   __ __ __ __   Val: 0 x   __ __

: R/W   : D/T   : Reg   : Val   OK : Run
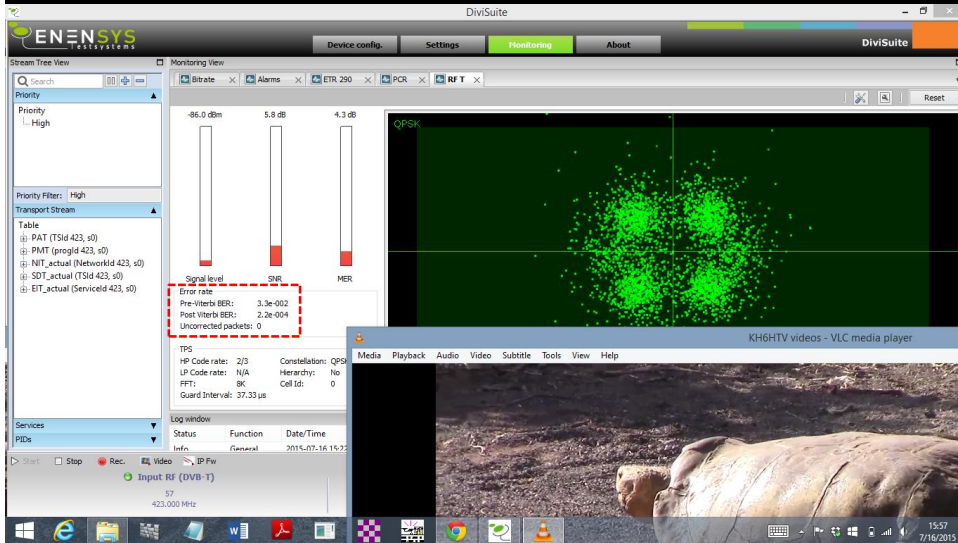
Good: Without Preamp

Better: With Preamp

Really Bad Signals

Thanks

KH6HTV   Jim Andrews

NØYE   Don Nelson

KØLRS   Mark Huff

KIØHG   Dave Sharpe

©2017 KØDVB