2014 ARRL Convention
San Diego

Recent Advances
in Digital-ATV

by

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Digital-ATV

The Presentation Author….

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Digital-ATV

Digital-ATV technology allows Video Quality to exceed analog-ATV

Comparison of analog video and an DATV video using the same antennas with weak sigs
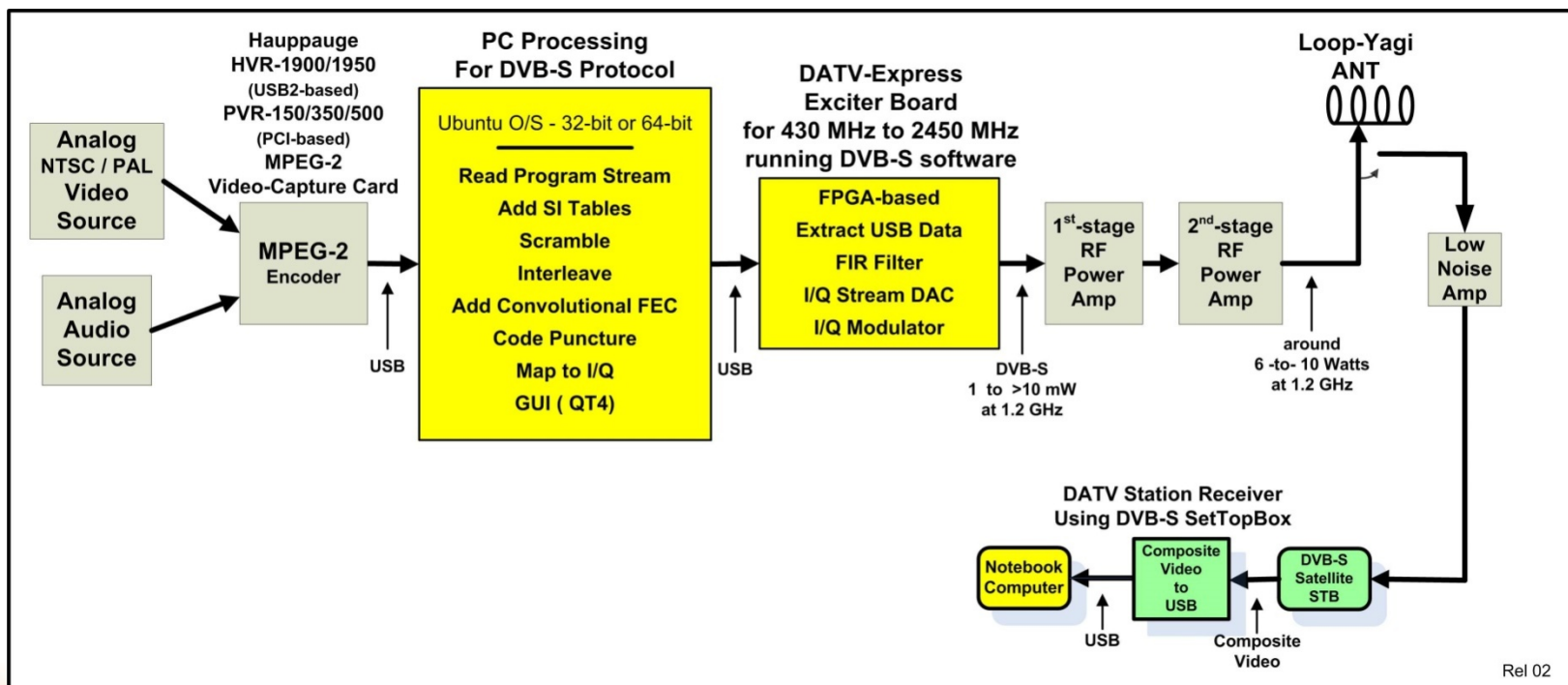
Digital-ATV

Status of Digital-ATV Today

- DATV Video Quality can exceed analog ATV

- Very few hams transmit DATV in USA today

- European DATV is very active and growing

- Australia/New Zealand have lots of DATV activity

- Currently Digital-ATV transmitters are expensive

- US $900 up for MPEG/DVB-S Encoder/Transmitters

- DATV Transmitter is cost barrier for most in USA

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Block Diagram of DATV Station

Typical System Block Diagram for DVB-S DATV Station

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Different Protocols used for DATV

- DVB-S (satellite based)

- DVB-S2 (satellite for HDTV)

- DVB-T (terrestrial reception)

- ATSC (commercial terrestrial reception in US)

- ITU-T_J.83-Annex B (US Canada cableTV)

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DVB-S Protocol used for DATV

• DVB-S is used for commercial satellite downlinks

• DVB-S was designed for commercial SD-DTV

• Protocol allows only QPSK Digital modulation

• Protocol typically calls for MPEG-2 encoding

• RF bandwidth is variable = 1.33 x Symbol-Rate

• very widely used by hams

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DVB-S2 Protocol used for DATV

- DVB-S2 used for commercial satellite downlinks
- DVB-S2 was designed for commercial HD-DTV
- Protocol allows following digital modulations:
  - **QPSK (2-bits/symbol)**
  - **8PSK (3-bits/symbol)**
  - **16APSK (4-bits/symbol)**
  - **32APSK (5-bits/symbol)**

- Protocol typically calls for MPEG-4 encoding
- RF bandwidth is variable = 1.2 x Symbol-Rate
- There are licensing issues for ham radio usage

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DVB-T Protocol used for DATV

- DVB-T is used for EU commercial TV reception
- DVB-T was designed for commercial SD-DTV
- COFDM protocol allows these digital modulations:
  - **QPSK (2-bits/symbol)**
  - **QAM-16 (4-bits/symbol)**
  - **QAM-64 (6-bits/symbol)**

- Protocol typically calls for MPEG-2 encoding
- RF bandwidth can be 2, 3, 4, 6, 7, or 8 MHz
- increasing usage by hams (repeater downlink)

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ATSC Protocol used for DATV

- ATSC is used for US commercial TV reception
- ATSC was designed for commercial HD-DTV
- Protocol allows only one digital modulation:
  - **8-VSB (3-bits/symbol)**

- Protocol typically calls for MPEG-2 video encoding and Dolby (AC3) sound encoding
- RF bandwidth fixed at 8 MHz
- Dolby licensing issues for ham radio usage
- no current active ham experiments

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ITU-T_J.83-Annex B Protocol used for DATV

- ITU-T_J.83-B is used for US/Canada cableTV
- CableTV is designed strong signals / low noise
- "QAM" Protocol allows these digital modulations:
  - QAM-64 (6-bits/symbol)
  - QAM-256 (8-bits/symbol)

- Protocol typically calls for MPEG-2 encoding
- Hams liked using MPEG-4 for HDTV
- RF bandwidth typically 6 MHz (TV channels)
- Most ham usage for DATV has been abandoned

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RF Exciters for ham DATV

- **SR-Systems – MiniMod exciter + MPEG-2 encoder**
  - DVB-S , DVB-T – about $875 as received in USA
  - DVB-S2 and ATSC – costs additional…also H.264 encoder was $900 additional

- **BATC - DigiLite exciter + Hauppauge encoder + PC**
  - DVB-S – SMT kit form (blank PCB and programmed PIC available from BATC)

- **BATC - DTX1 exciter with MPEG-2 encoder**
  - DVB-S – about $782 + shipping + currency fee as received in USA

- **DATV-Express – exciter + Hauppauge encoder + PC**
  - DVB-S – $300 + Hauppauge encoder + shipping
  - DVB-T – (extra bonus 2 MHz bandwidth) $300 + Hauppauge encoder + shipping

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RF Exciters for ham DATV – cont'd

- HiDes – exciter with MPEG-2 encoder + PC
    - DVB-T – model UT100B about $275 + shipping on e-bay
    - DVB-T – model HV200E standalone (with MPEG-2 and H.264) $658 on e-bay

- Drake - exciter with MPEG-2 and H.264 encoder
    - ITU-T_J.83-B – model DSE-24 was $1750 + shipping (clearance price available)

- Thor - exciter with MPEG-2 and H.264 encoder
    - ITU-T_J.83-B – HDMI QAM IP Modulator - $1950 + shipping

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DATV Receivers - now Low Symbol Rates are roadblocks

DVB-S (QPSK) with H.264					
Symbol-Rate	H.264 Video	Audio	Resolution	(Video Capture) Frames per Sec	FEC
250 KS/sec	300 Kbps	32 Kbps (MPEG1)	352x288 (SD)	18 or 20 fps	7/8
125 KS/sec	110 Kbps	32 Kbps (MPEG1)	320x240 (SD)	12 or 15 fps	7/8
400 KS/sec (HD test-1)	360 Kbps	192 Kbps (AC3)	1920x1080 (HD)	3 fps??	7/8
125 KS/sec (HD test-2)	110 Kbps	32 Kbps (MPEG1)	1920x1080 (HD)	1 fps	7/8

- Recent Low Symbol Rate testing results by Jean Pierre Courjaud F6DZP
- Commercial Receivers are now the research target for "low SR efforts"

Digital-ATV

Goals of the DATV-Express Project

- Significantly reduce price of Digital-ATV transmitters

- Provide Plug-and-Play hardware board to minimize home construction.

- Provide open platform for future DATV development

- Help educate community about new technologies

- Get more DATV stations on-air

- Encourage wider audience to get ham licensed

- Byproduct can be Software Defined Transmitter from 70 – 2450 MHz ham bands with a B/W of up to 10 MHz
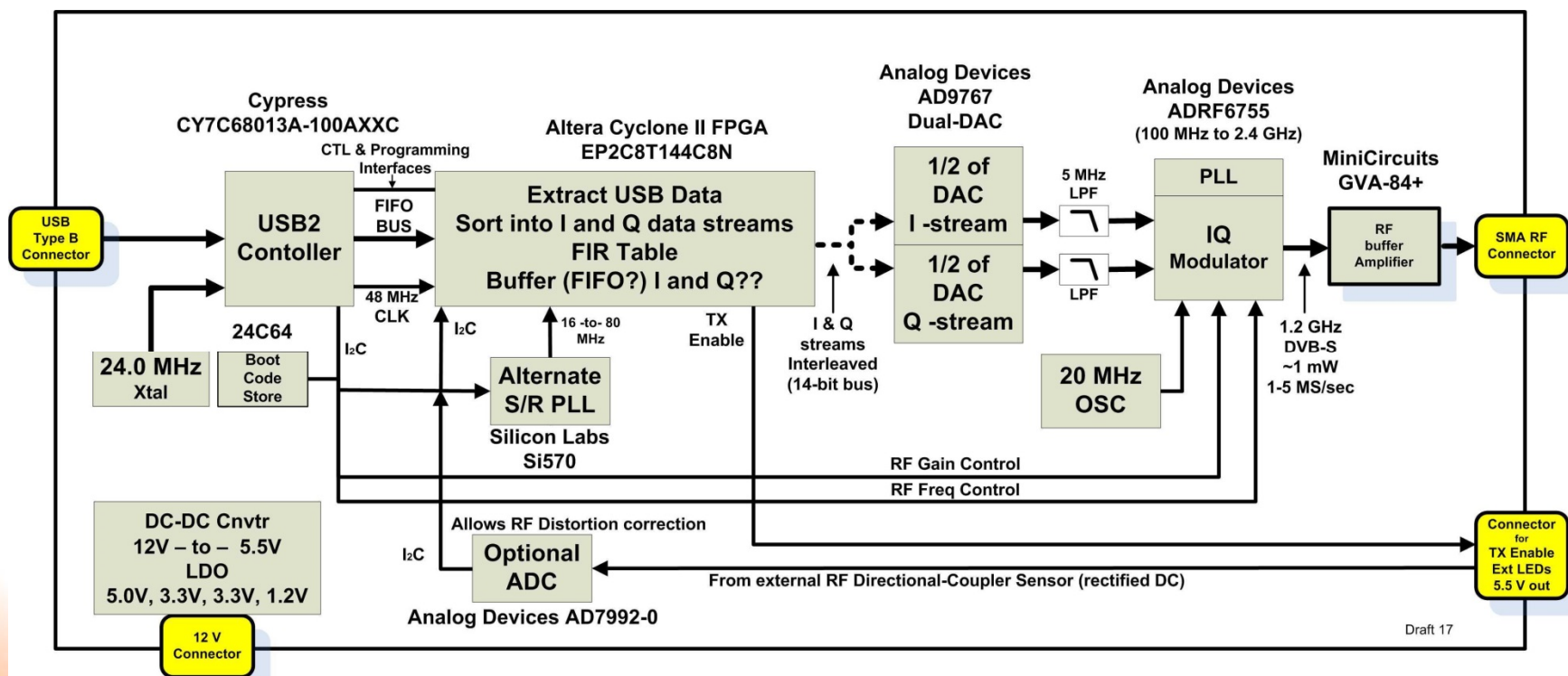
Digital-ATV

The DATV-Express Project Team

- Charles Brain   - G4GUO   Ferring, England

- Ken Konechy   - W6HHC   Orange, CA, USA

- Art Towslee   - WA8RMC   Columbus, OH, USA

- Tom Gould   - WB6P   Portland, OR, USA

DATV-Express

DATV-Express board internal block diagram

Block Diagram for DATV-Express Hardware Board

DATV-Express

## DATV-Express hardware board

DATV-Express

DATV-Express System Specs

- DVB-S protocol is tested and released
- All IQ modulations (QPSK modulation was tested)
- Frequency Range:

    70–2450 MHz   (Modulator chip specification)

- Symbol-Rate:
    - Adjustable: 1 to 5 MSymb/second
- Forward Error Correction is selectable
- RF output ~ 1-20 mW buffered (SMA connector)
- USB Video Capture card for NTSC or PAL
- Initially designed for one video stream
- PC Operating System – first Ubuntu-32/64-bit
    - ➤ then quadcore-ARM ODROID U3 w/ Libuntu

DATV-Express

1st DVB-S Transmission on First prototype
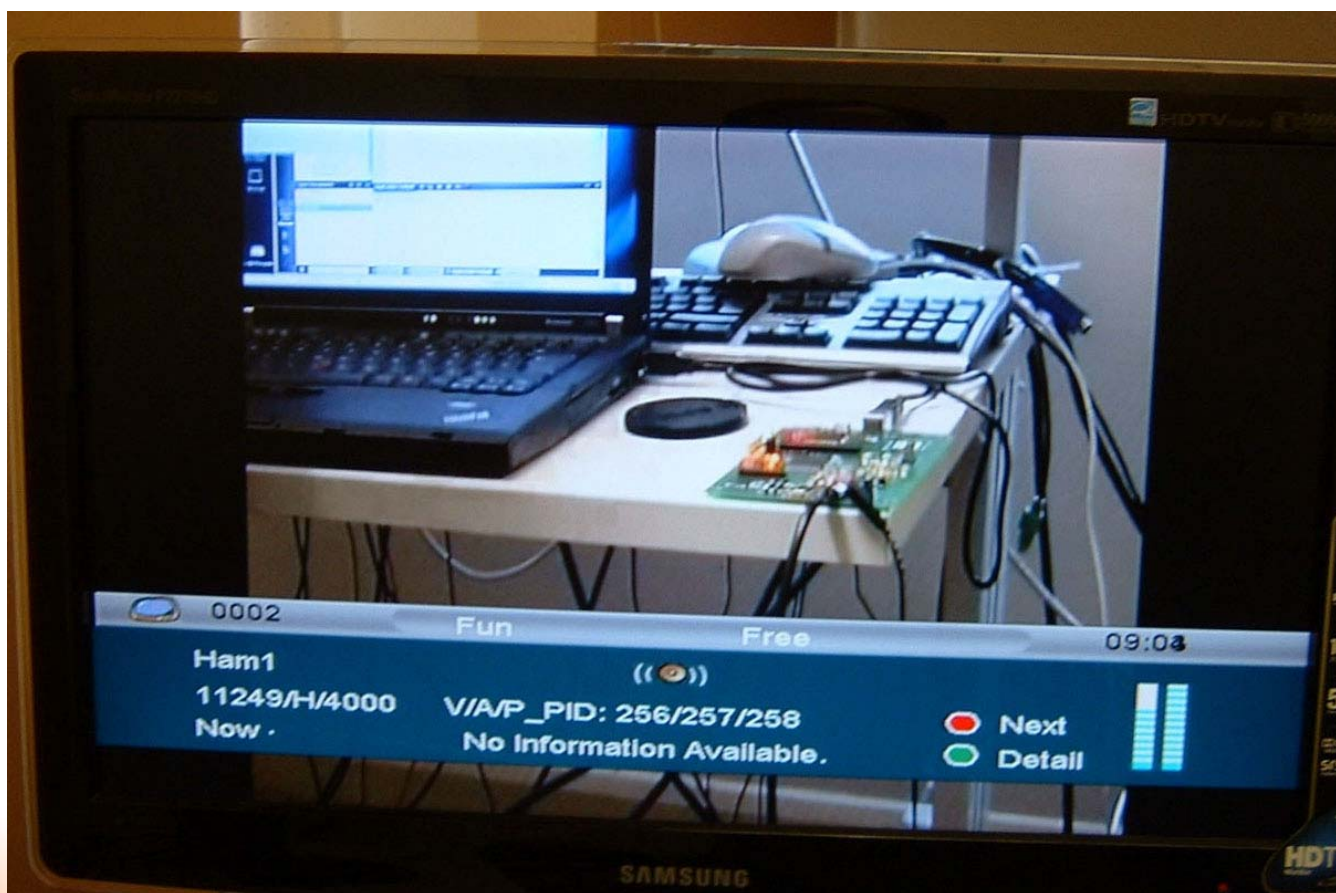
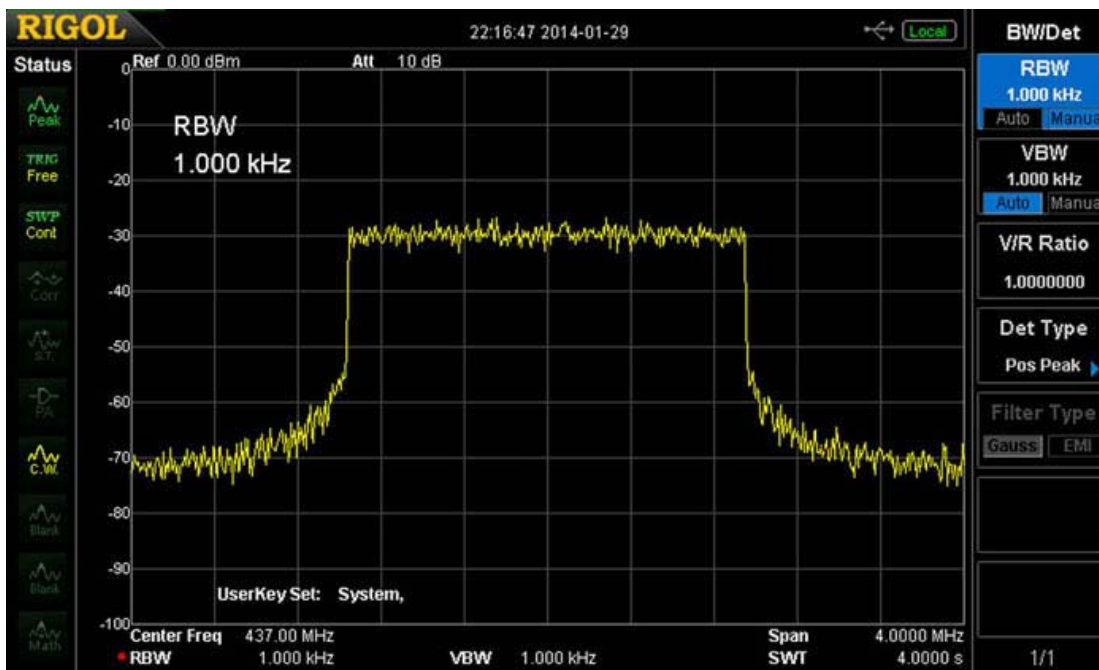# DATV-Express

Clean DVB-S 1.2 GHz spectrum
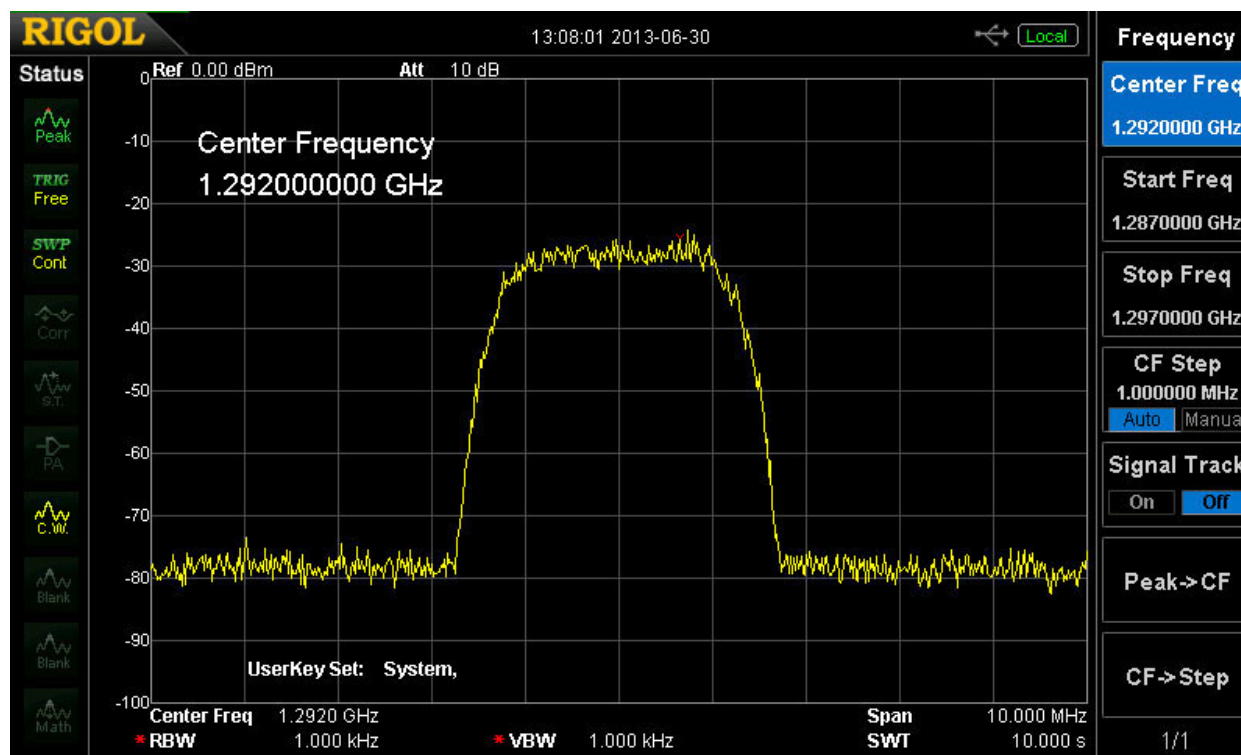
Barefoot board RF output – has 47 configurable levels of RF output

DATV-Express

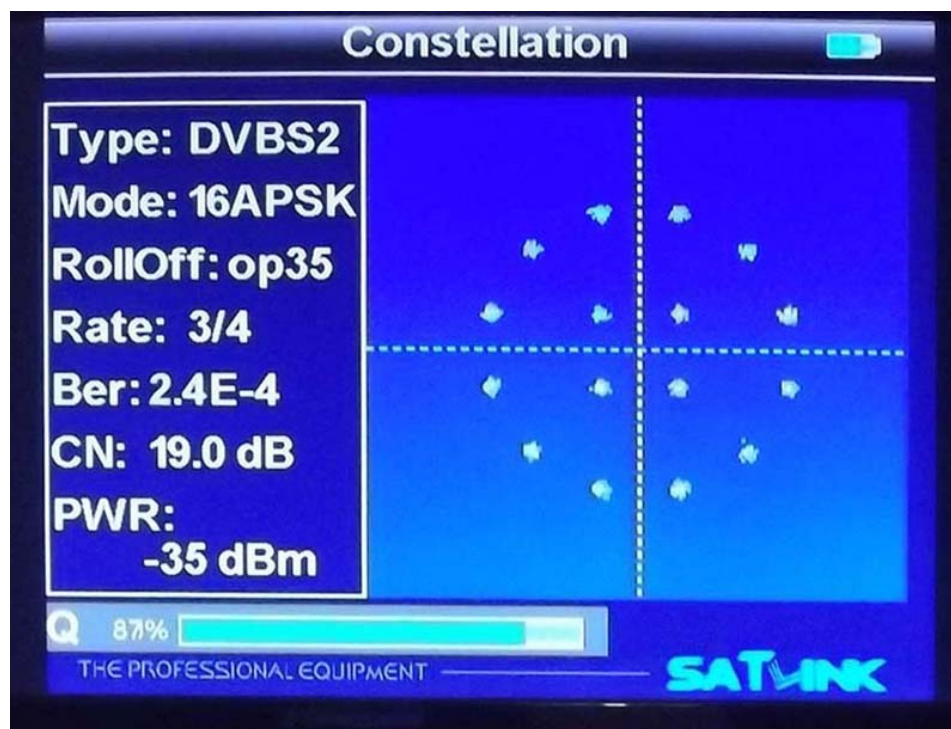## DATV-Express capable of other DATV protocols used by hams

Testing DVB-T (2K mode) protocol at 2 MHz bandwidth on 437 MHz (using 4096-point iFFT math - with NO alias spurs)
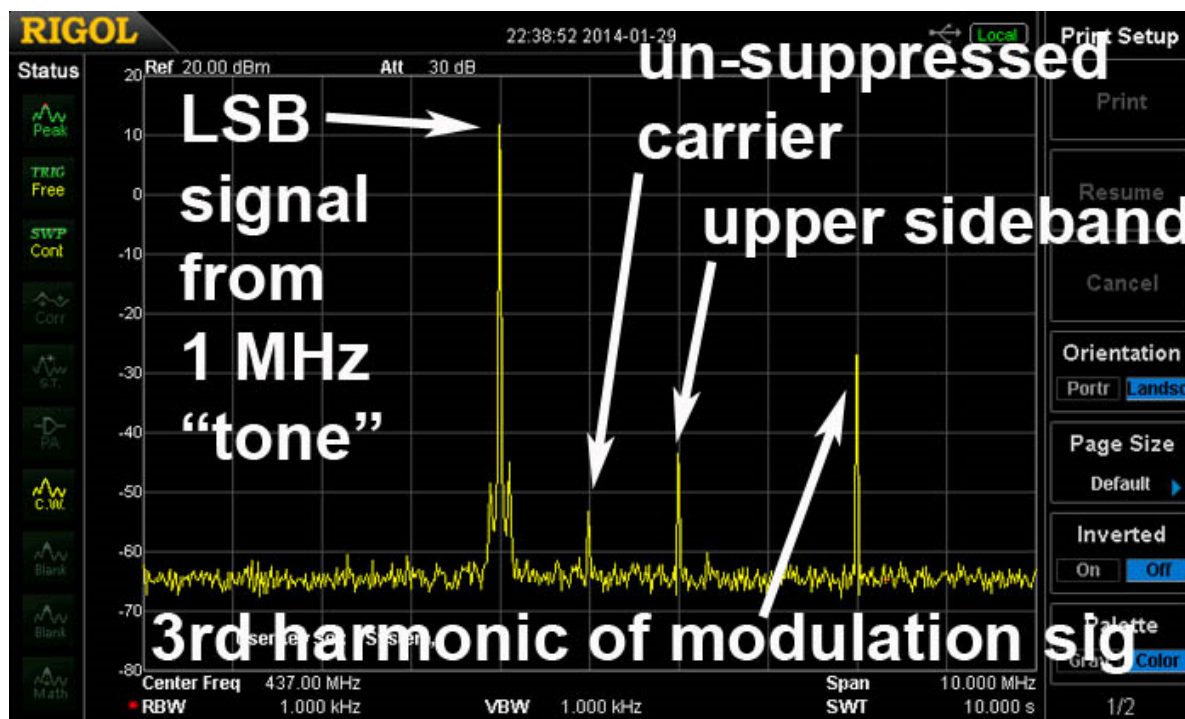
DATV-Express

DATV-Express capable of other DATV protocols used by hams – cont'd

Testing constellation for 16APSK digital modulation for DVB-S2 protocol

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DATV-Express

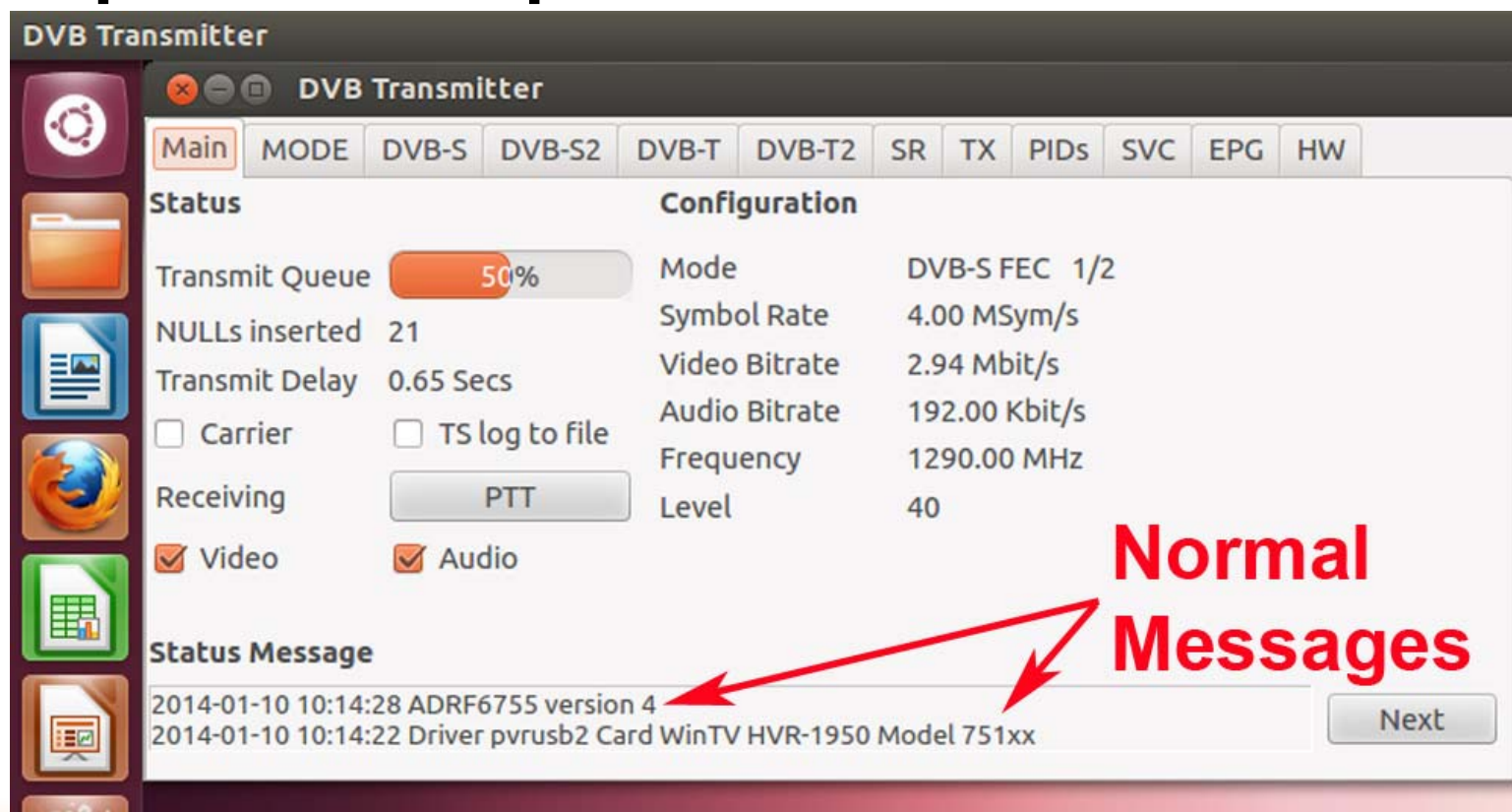## SDR allows Lower-Side-Band for example

Unsuppressed carrier is down 60 dB

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DATV-Express

## Simple DATV-Express User Interface

Software User Interface uses Qt4 (screen is configured for DVB-S Protocol)

DATV-Express

GNU Radio with DATV-Express

- Alex OZ9AEC has developed gnuradio "sink" module for DATV-Express – (see Github URL at end)
- Ron W6RZ has adapted gnuradio to run DVB-S2 32APSK
- W6RZ uses DATV-Express DVB-S2 code and tested with BladeRF & Novra S300V DVB-S2 STB at up to 10 MSym/s.
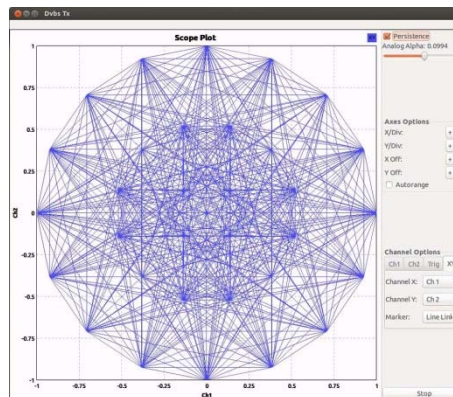
DATV-Express

Current Project Status on PC

- DATV-Express production board released in Feb 2014
  - ➢ Order at **www.DATV-Express.com** (PayPal)
  - ➢ Order at BATC Online Shop **https://BATC.org.uk/shop/**
- DVB-S completed and stable
- As extra bonus, have tested board to transmit DVB-T 2K mode, however cannot guarantee performance
- DVB-S2 tested, but there are licensing issues
- Next development phase to eliminate bulky PC

DATV-Express

Go More Portable than bulky PC or Notebook

- Reduce Micro-PC load by using more FPGA functions

- Maybe Raspberry PI ?

- or…RikoMagic MK802iv ?

- or…Hardkernel ODROID U3 ?

DATV-Express

Raspberry PI

- Raspberry PI has singlecore-ARM at 700 MHz

- Raspberry PI typically uses Raspbian OS

- Originally designed for education market

- Raspberry PI is seriously under-powered for our app

- Raspbian source code repository is INCOMPLETE
     CAN NOT re-compile kernel

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RikoMagic MK802iv

- MK802iv has quadcore-ARM at 1.4 GHz

- PicUntu OS is light-weight Ubuntu

- MK802iv as option to create "smart TV's" for internet

- PicUntu source code repository is INCOMPLETE
    CAN NOT re-compile kernel

- Kernel does not use SMP to balance load on four cores

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RikoMagic MK802iv

DATV-Express

Hardkernel ODROID U3

- ODROID U3 has quadcore-ARM at 1.7 GHz
- Comes with Lubuntu 12.4 LTS (LDE Desktop)
- Single-board-computer designed for software developers
- Has very active software community for support
- Has complete source repository to re-compile kernel
- Charles G4GUO explains that once DATV-Express project is satisfied with release for ARM…it should work OK with almost any ARM product
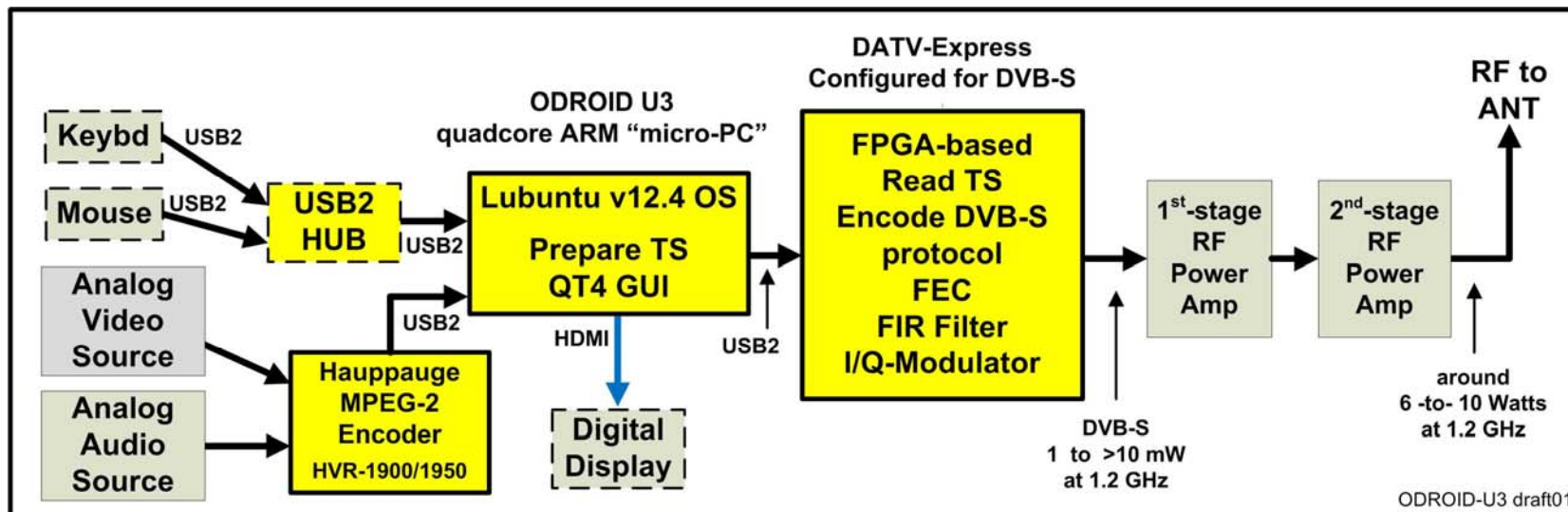
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Hardkernel ODROID U3 "micro-PC"

ODROID U3 is about the same size as Raspberry Pi

DATV-Express

Hardkernel ODROID U3

Planned System Block Diagram for DATV-Express DVB-S with ODROID U3

DATV-Express

Conclusion and Plans

- Ubuntu 32/64-bit Code for PC is finished

- We need volunteers to help with software

- G4GUO reports "have had a few genuine offers of help but the problem is that those with the time don't have the experience and those with the experience don't have time."

- Focus now is for replacing bulky PC with "ARM Micro-PC"

- Source files will be available

  (Software, FPGA coding, gerbers, etc.)

- Beginnings of source code repository at **https://github.com/G4GUO/datvexpress_gui.git**

Digital-ATV

- British ATV Club - Digital Forum
  - **www.BATC.org.UK/forum/**
- CQ-DATV online (free monthly) e-magazine (ePub format)
  - **www.CQ-DATV.mobi**
- OCARC library of newsletter DATV articles
  - **www.W6ZE.org/DATV/**
- TAPR Digital Communications Conference proceedings (free downloads)
  - **www.TAPR.org/pub_dcc.html**
- Yahoo Group for Digital ATV
  - **http://groups.yahoo.com/group/DigitalATV/**
- DATV-Express project website
  - **www.DATV-Express.com**
- DigiLite Project for DATV (derivative of the "Poor Man's DATV")
  - **www.G8AJN.tv/dlindex.html**
- Hardkernel (Korea) for ODROID model U3 ARM-based "micro-PC"
  - **www.hardkernel.com**
- HiDes (Taiwan) DVB-T D-ATV (Boards – and standalone)
  - **www.HiDes.com.tw/product_cg74469_eng.html**
- Alex OZ9AEC GNURADIO "sink" module for DATV-Express
  - **https://github.com/csete/gr-datvexpress**
- SR-Systems (Germany) D-ATV components(Boards)
  - **www.SR-systems.de** and **www.D-ATV.org**