

Being Elliot Carver

Or how to run a cable TV network in your living room



Phil Pemberton

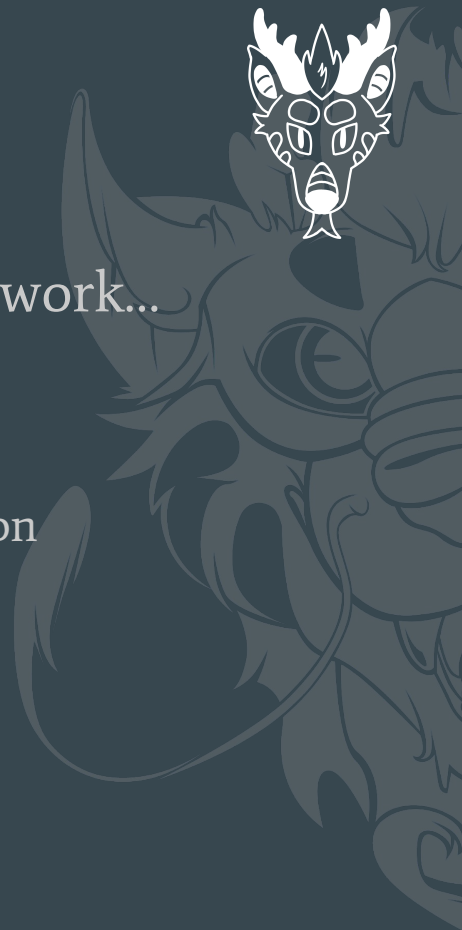
EMF, May 2024

www.philpem.me.uk / philpem@philpem.me.uk



A bit about me

- Software engineer, embedded systems
- Hobbyist maker - electronics, radio, firmware, metalwork...
- Licensed amateur radio operator (73's de M0OFX))
- Retro tech enthusiast and reverse-engineer
 - HackTV, NABU PC cable modem, Datatrak radio navigation
- Not a James Bond villain in disguise.



**YOU ARE ENTERING
THE ANALOG TV SECTOR**

DVB & MPEG IST VERBOTEN!

ENTSPANNEN UND FERNSEHEN



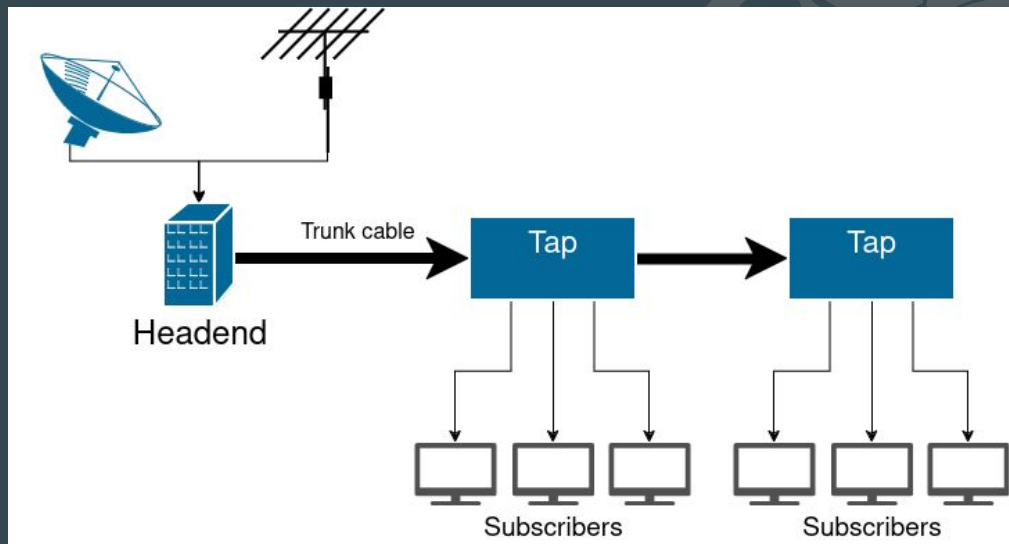
What is cable TV?

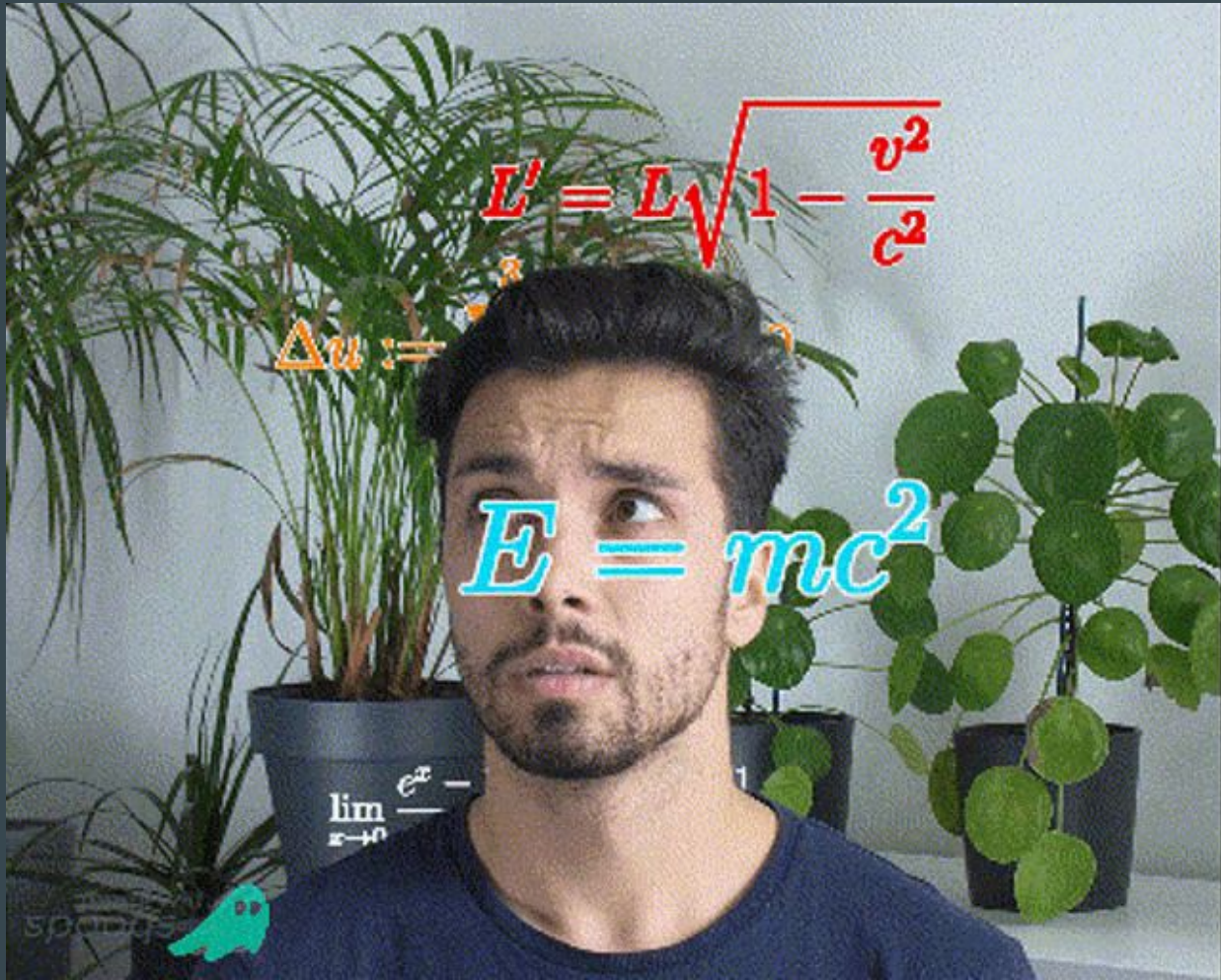
- Started as radio and TV relay services: Community Antenna TV or Rediffusion
 - Poor signal an issue in valleys around hills and mountains
 - Fix: Put the antenna on a hill, amplify the received signal, retransmit it over cable
- Happy coincidence: reduced cost of entry for new services
 - RF: New transmitter + licenses (£millions) vs. ~£1000 for another modulator
- Scalable infrastructure
 - ~500 MHz bandwidth, 8 MHz/channel => space for 60 channels! Telephone! Data!
- Led to an explosion in local and large-scale programming
 - Coverage of local news and events (e.g. Swindon Cable's "Swindon Channel")
 - HBO, Nickelodeon, TNT, MTV, ... with their own in-house productions
 - Many well-known "classic" shows are from the "Golden Age of Cable"
 - ER, Seinfeld, X-Files, Quantum Leap, The Sopranos, Breaking Bad, Game of Thrones ...



A typical commercial setup

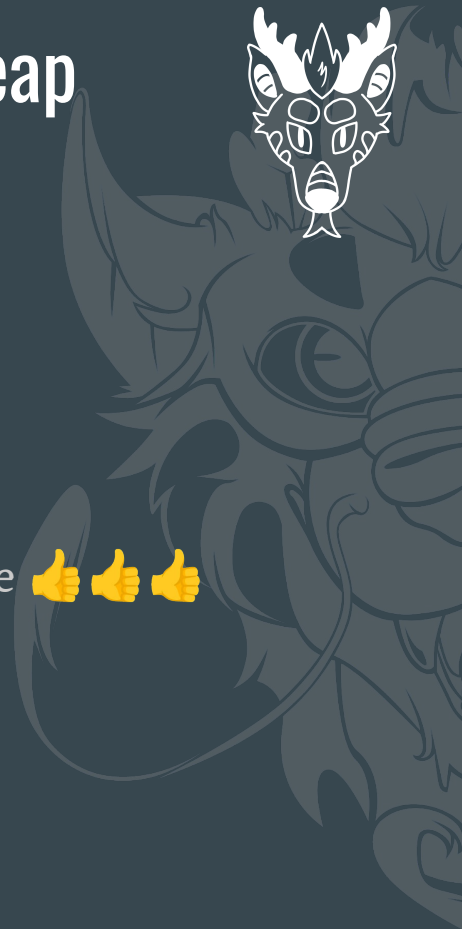
- Headend receives satellite/antenna signals, retransmits them
Adds locally-generated signals e.g. control data, local channels, DOCSIS
- Trunk cable (~13-25mm dia. ultra-low-loss co-ax) carries signals between Taps
- Taps tap off a fixed amount of the signal for subscribers (RF splitter)
- Amplifiers boost the trunk signal to cover longer distances
- Node: street cabinet with Fibre RX, Amplifiers and other H/W
- Improvements over time
1980s: fibre-optic trunks
1990s: DAVIC/DOCSIS internet





Minimum viable product: getting started for cheap

- Video source (DVD, Raspberry Pi, Laserdisc, VHS)
- Modulator
- Cables
 - Type-F threaded for RF connections.
(Get an F-connector wrench to save your fingers.)
 - PPC Compression-type F-connectors and WF100 cable 🙌🙌🙌
Starter kit ~£20 (ebay)
 - Composite video usually BNC or RCA/Phono.
(R-Pi will need TRRS and/or TRS adapters)
- TV with analog RF (antenna) input



No analog RF input on the TV?



- Some TVs don't have an analog RF tuner (= cost savings)
 - They usually still have analog video in (SCART or RCA jacks)
- Monitors only accept analog composite and/or S-video or component
- Easy way: old VHS VCR (it only has to power on) or DVD recorder
- Nerdy way: Make your own! (~£20)
 - Philips FQ1216ME
 - 5V and I2C in, composite video out
 - Arduino or similar for control
- Congratulations, you just build a simple cable box!



Generating video

- Spare Raspberry Pi
 - Analog and HDMI on all models - config.txt allows a lot of configuration
 - Zero series and Pi 5 may need some soldering
 - 3B and earlier need a TRRS cable
- Spare PC
 - Usually only HDMI/DVI out: may need converters
 - More storage = better for big-dog playout
- Software
 - Lazy option: VLC/FFMPEG and a directory of videos
 - Comfy Channel
 - <https://github.com/mvarhola/comfy-channel/>
 - Handles scheduling of content, bumps (adverts) and “up next” screens

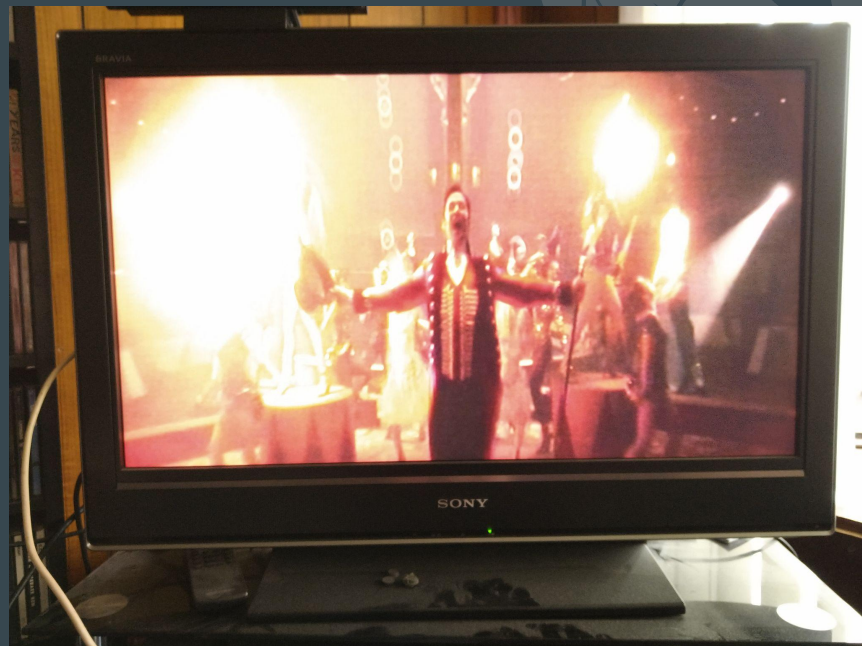
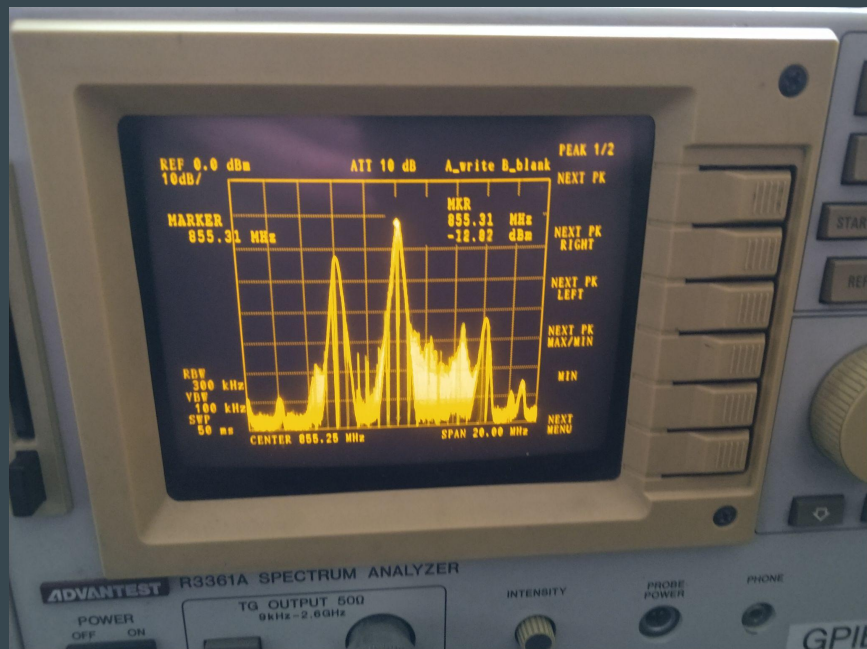


Modulation: from three wires to one

- HDM69 RF modulator (£35 ebay, less on Aliexpress)
- HDMI and Composite in
 - Set to HDMI with no signal -> colour bar test pattern
 - Stereo audio inputs but output is mono (no NICAM or A2 stereo)
- RF in-out loop-through: no need for a combiner
 - Has RF level and modulation adjustments for multi-channel setups
- Set for PAL-I, 8MHz, UHF C21-69
 - www.ukfree.tv will tell you which C-slots are free
- AM modulation (video): no VSB filter
 - Signal is 2x wider than standard on the negative end
 - Usually interferes with the lower audio carrier
 - FM “Capture effect” means TV locks onto the strongest
 - Space channels at least 16MHz apart



MVP: A-OK



Going from a channel to a network

- More channels! Just add more sources and modulators
 - RF splitters can be used in reverse as combiners
 - Some modulators can be looped through instead (no splitter needed)
- More outputs!
 - Amplified variable-gain splitter makes a usable low-cost launch amplifier
- Keep an eye on RF levels!
 - Channels should have reasonably consistent RF levels on the cable
 - Measure with channel-selective level meter
 - ~£50-100 (new RY-S110D, used Technetix TE-1250)
 - ~£300 (used Promax Prolink or TV Explorer)
 - Aim for ~75dBuV for a TV, or ~5-10dBmV for a cable box



Cool, what next?

- We have our favourite movies and shows on TV and defeated choice paralysis!
- Now what?
 - VBI services: Teletext
 - Better sound: NICAM
 - Programme guide channel
 - Weather channel
 - Try to take over the world!



Teletext: data in the vertical blank

- This is analog only (doesn't work on HDMI) and requires a Raspberry Pi.
- Uses two software packages:
 - VBIT2: <https://github.com/peterkvt80/vbit2> (turns a directory of pages into a stream)
 - Raspi-Teletext: <https://github.com/ali1234/raspi-teletext> (puts the stream into the video)
- VBI insertion is done with the Pi's video output -> no HATs needed!
- Installation instructions on the VBIT2 Wiki
 - Just run one script to get started!
- Teletext page editors: <https://zxnet.co.uk/teletext/editor/> and <https://edit.tf/>
- Friendly community -
 - Facebook: <https://www.facebook.com/groups/TeletextGroup/>
 - Discord: <https://discord.gg/JfytfS3xmg>



Pre-EPG programme guides: Prevue Guide



- Problem: we don't know what's on
- No OSD - we're not even using a cable box
 - GI CFT2200 was one of the first with EPG ... but requires special headend hardware
- Solution: run Prevue Guide on an Amiga 1200 I just happen to have lying around... Genlock converts RGB to PAL
- If you don't have an Amiga: use UAE emulator or Prevue Simulator and a Raspberry Pi

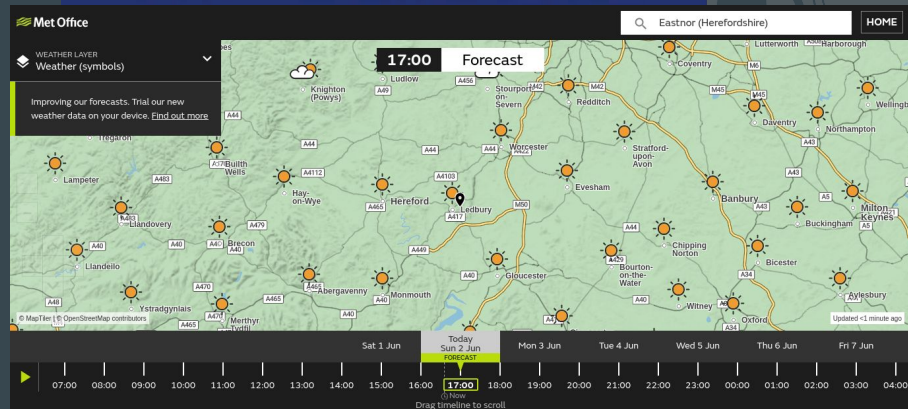
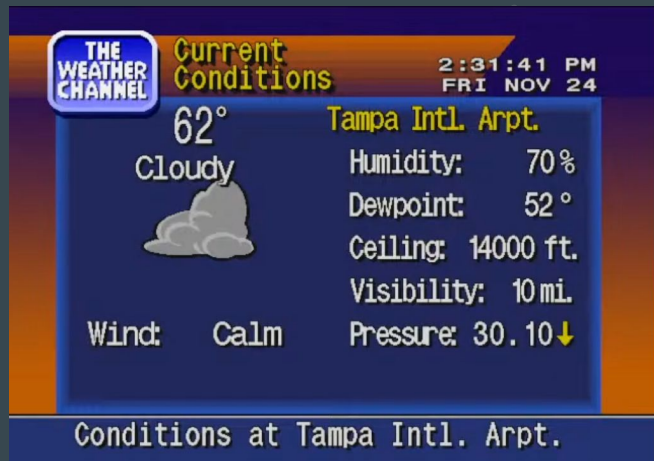
See:

- <https://prevueguide.com>
- <https://park-city.club/~frix/prevue/>

6:55:24	7:00 AM	7:30 AM	8:00 AM
57 GSPANZ	6:40 Allida Black Discusses her Book		
58 BRAVO	Paid Program	Paid Program	Rik Mayall Presents
59 A&E	Splendid Discovery		Voyages: Against the

Information services: Weather

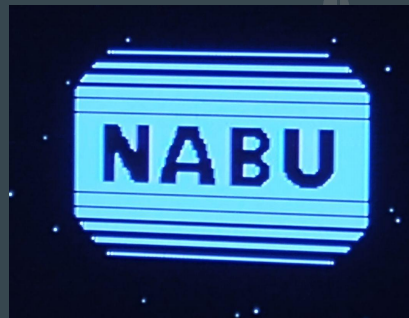
- *Why should I have to look out the window? I have a TV!*
- WeatherStar 4000 simulator (<https://www.taiganet.com/>) is cool ... but only works for US cities.
- UK option: Met Office
 - Load website into an iframe
 - Custom JS to switch between player, maps, forecast.
 - Custom CSS to tidy things up for TV
 - Bonus: the ad banner disappears auto-magically on small screens!



Wild cards: the NABU PC and cable Adaptor

- NABU PCs and CATV Adaptors were found in a warehouse last year and sold on eBay
- Retrocomputing enthusiasts bought them
- Cable adaptor reverse-engineered this year
 - Jared Boone, Youtube: “The 40 year old cable modem” (RF)
 - Me: Github, packet engine MCU ROM dump, reverse-engineered schematic
- Work ongoing, but will soon be able to use a SDR + Gnuradio to generate NABU headend “wheel” carousel

Image credit: revspace.nl, CC-BY-SA



Embiggen the thing: Reviving old cable boxes



Making a cable network

- We've made "cable TV" a TV can tune into. What about a cable box?
- Boxes expect an "out of band" downlink from the headend
 - Need a headend controller (Addressable Controller) to generate this
- Messages the box needs:
 - Date and time (optional but recommended)
 - "Timer Reset" command: resets the Disconnect timer
 - "Enable" command: activates the box, if it's deactivated
 - System site code or password: set this to an arbitrary value and keep repeating it.
 - Used to prevent boxes from being moved between providers without authorisation
 - Input and output frequency maps (RF channel start, logical number, spacing)
 - Logical channel map and names (channel 1 is RF channel 31 aka "BBC1", 3 is 53 aka "ITV", etc)



General Instrument ACC-4000 Addressable Controller



- Manuals turned up on SegaRetro.org's "Sega Channel" page.
- I posted on VCFED in 2023 looking for the software and hardware.
- Someone had one to sell (in part)!
 - DEC ApplicationDEC 400xp server, 486DX4-100, Interactive Unix 3.2
 - Software was VERY old (version 6.3, last release was 12.0)
 - No support for CFT-2200 Smart boxes, but works OK with everything else
 - Seller sent Ghost images of the three hard drives and sold me the GI-specific hardware
 - And FedEx lost the hardware for two weeks...!

Overengineering, Jerrold style: the ANIC

- Lets the PC communicate with the headend equipment and cable boxes
- ANIC is an embedded 286 PC-AT
 - 1MB RAM (30 pin SIMMs), no VGA, serial port (not used)
 - Custom data interface built around a Xilinx FPGA
 - Data protocol is packetised, RS232 formatted, then Manchester biphase coded
- Talks to the PC over SCSI ... but the ANIC is the Initiator!
- PC or ANIC can organise the packet stream
 - Lists: same packet sent to a list of boxes. Used for background updates.
 - Punch: send a packet now. Used for instant changes (e.g. customer service calls -> Box Init/Refresh)
 - Poll: like a punch, but has return data. Used for opinion polling and system integrity checks.
 - “Box 555-1234, upload all unsent pay-per-view purchase records.”
 - “Scrambler 867-5309, what is your status?”



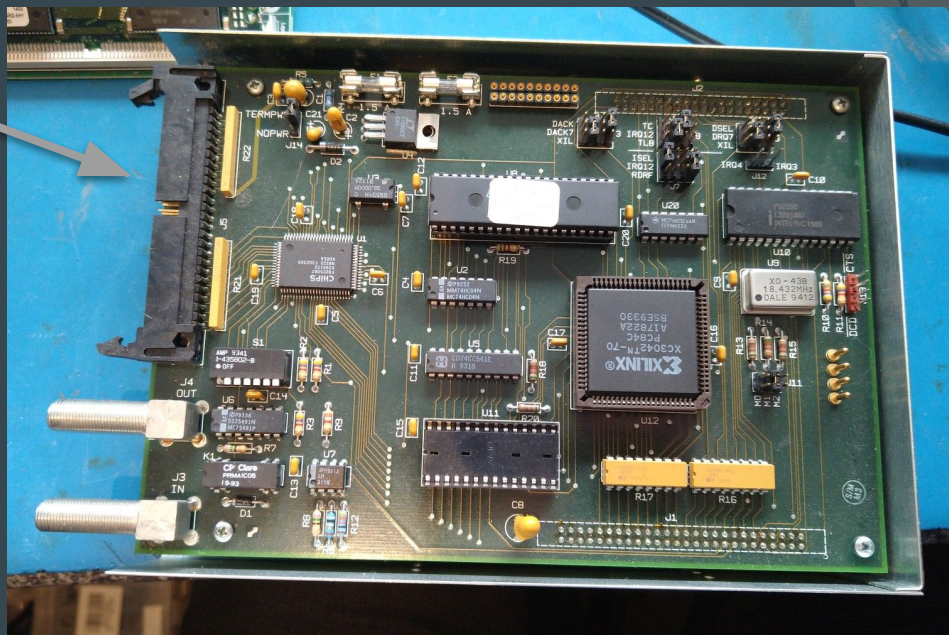
The ANIC in pictures



SCSI
(Molex 5V/12V
power
underneath)

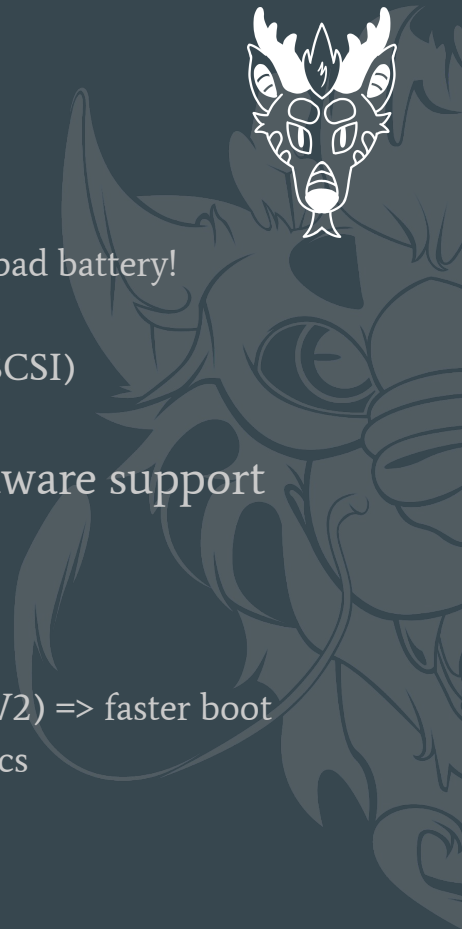
Data Out

Data In



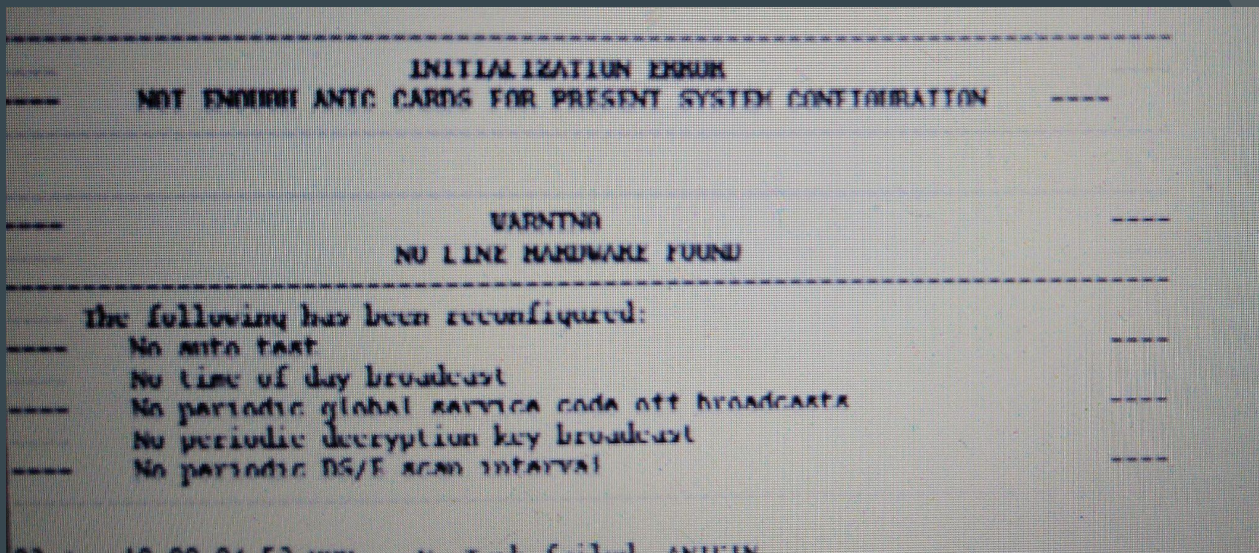
Building a new Addressable Controller

- K6-II/400 PC rescued from garage and kitted out
 - New Dallas clock module battery (Dremel hack) -> PC wouldn't boot with bad battery!
 - Western Digital PVGA1024 WD90C30 graphics card
 - Adaptec AHA-1540 ISA SCSI for main disks (3x 500MB, emulated by BlueSCSI)
 - Buslogic SCSI controller for the ANIC
- Upgraded Interactive Unix to v4.1.1 (last release) for better hardware support
 - Disabled drivers for removed hardware (port concentrator and APC UPS)
 - Fixed issues with crontabs not running (and other brokenness)
- Upgraded the hardware
 - Adaptec AHA-2940UW SCSI controller for boot disks (3 off, on BlueSCSI V2) => faster boot
 - Trident TVGA8900C graphics => non-interlaced 1024x768 16-colour graphics
 - Brainboxes quad RS232-POS serial port card (terminals and Wirelink)
 - Intel PRO/100 Ethernet card (3C509B had issues on IUNIX)



A small problem

The ANIC had been damaged by a leaking Varta CMOS battery.
This broke the RAM address decoder...



It's alive!

After repairing the damaged ANIC:

ACORNUI LOGGER WINDOW

```

25-Jun-10 22:41:55 USP I Started PPV2
25-Jun-10 22:41:55 WLINK2 I Wire Link 2 - Software Revision Number V1.2
25-Jun-10 22:41:55 USP I Started SCR000
25-Jun-10 22:41:56 WLINK3 I 277 - W.L. 3 Restarting Because Of System Restart
25-Jun-10 22:41:56 WLINK1 I 277 - Wire Link Restarting Because Of System Restart
25-Jun-10 22:41:56 WLINK2 I 277 - W.L. 2 Restarting Because Of System Restart
25-Jun-10 22:41:56 MS0000R I Initialization Complete
25-Jun-10 22:42:30 USP I Started SCR000
25-Jun-10 22:42:30 USP I Started SCR001
25-Jun-10 22:42:30 USP I Started SCR002
25-Jun-10 22:42:30 USP I Started SCR003
25-Jun-10 22:42:34 SCR001 I Begin screen task initialization for screen # 1
25-Jun-10 22:42:34 SCR001 I partner screen task name = NEMAD1
25-Jun-10 22:42:37 SCR002 I Begin screen task initialization for screen # 2
25-Jun-10 22:42:37 SCR002 I partner screen task name = NEMAD2
25-Jun-10 22:42:40 SCR003 I Begin screen task initialization for screen # 3
25-Jun-10 22:42:40 SCR003 I partner screen task name = NEMAD3
25-Jun-10 22:46:20 PSL I Last recorded delete occurred too long ago for timed delete to be safe.
25-Jun-10 22:46:20 PSL E Please verify that system date / time is correct.
  
```

Wire Link 1

```

06-25-10 22:41:56 I 277 - Wire Link Restarting Because Of System Restart
  
```

Wire Link 2

```

06-25-10 22:41:56 I 277 - W.L. 2 Restarting Because Of System Restart
  
```

Wire Link 3

```

06-25-10 22:41:56 I 277 - W.L. 3 Restarting Because Of System Restart
  
```

Enter operator name []

F6:Clear

SINGLE Single Converter Operations records found

Converter Type: 18 Hub code: 1 Converter ID: [redacted]
 Serial Num: C4E1446337B6 Account Num: 350170889753

Initialized: N	Responding:	Activate: V	Partition: 0
Conv Status: H	Tuning Type: S	Time Out: 384	Channel Map: 4
Amplifier:	Time Zone: 0	Phone Index:	Phone Exchg:
Credit:	RF Rtrn Lvl:	M/S Status:	M/S Code: 0
UHF Out Channel:	Output-Freq Map:	Aux 12V Opt:	
Install Date: 07/29/06	Emergency Alert:		

Volume Control: V	Last/Fav Channel: V	Time/TCP: V
Output Chan 3: V	PC Lock: V	PC Morality:
Data Test:	Purchases:	Remote Unit: V

SERVICES
 1 9 14

PF1: Exit PF2: Accept PF3: PF4: PF5: PF6: PF7: PF8: PF9: PF10: PF11: PF12: PF13: PF14: PF15: PF16: PF17: PF18: PF19: PF20: PF21: PF22: PF23: PF24: PF25: PF26: PF27: PF28: PF29: PF30: PF31: PF32: PF33: PF34: PF35: PF36: PF37: PF38: PF39: PF40: PF41: PF42: PF43: PF44: PF45: PF46: PF47: PF48: PF49: PF50: PF51: PF52: PF53: PF54: PF55: PF56: PF57: PF58: PF59: PF60: PF61: PF62: PF63: PF64: PF65: PF66: PF67: PF68: PF69: PF70: PF71: PF72: PF73: PF74: PF75: PF76: PF77: PF78: PF79: PF80: PF81: PF82: PF83: PF84: PF85: PF86: PF87: PF88: PF89: PF90: PF91: PF92: PF93: PF94: PF95: PF96: PF97: PF98: PF99: PF100: PF101: PF102: PF103: PF104: PF105: PF106: PF107: PF108: PF109: PF110: PF111: PF112: PF113: PF114: PF115: PF116: PF117: PF118: PF119: PF120: PF121: PF122: PF123: PF124: PF125: PF126: PF127: PF128: PF129: PF130: PF131: PF132: PF133: PF134: PF135: PF136: PF137: PF138: PF139: PF140: PF141: PF142: PF143: PF144: PF145: PF146: PF147: PF148: PF149: PF150: PF151: PF152: PF153: PF154: PF155: PF156: 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PF1013: PF1014: PF1015: PF1016: PF1017: PF1018: PF1019: PF1020: PF1021: PF1022: PF1023: PF1024: PF1025: PF1026: PF1027: PF1028: PF1029: PF1030: PF1031: PF1032: PF1033: PF1034: PF1035: PF1036: PF1037: PF1038: PF1039: PF1040: PF1041: PF1042: PF1043: PF1044: PF1045: PF1046: PF1047: PF1048: PF1049: PF1050: PF1051: PF1052: PF1053: PF1054: PF1055: PF1056: PF1057: PF1058: PF1059: PF1060: PF1061: PF1062: PF1063: PF1064: PF1065: PF1066: PF1067: PF1068: PF1069: PF1070: PF1071: PF1072: PF1073: PF1074: PF1075: PF1076: PF1077: PF1078: PF1079: PF1080: PF1081: PF1082: PF1083: PF1084: PF1085: PF1086: PF1087: PF1088: PF1089: PF1090: PF1091: PF1092: PF1093: PF1094: PF1095: PF1096: PF1097: PF1098: PF1099: PF1100: PF1101: PF1102: PF1103: PF1104: PF1105: PF1106: PF1107: PF1108: PF1109: PF1110: PF1111: PF1112: PF1113: PF1114: PF1115: PF1116: PF1117: PF1118: PF1119: PF1120: PF1121: PF1122: PF1123: PF1124: PF1125: PF1126: PF1127: PF1128: PF1129: PF1130: PF1131: PF1132: PF1133: PF1134: PF1135: PF1136: PF1137: 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PF1513:

Generating the out-of-band channel

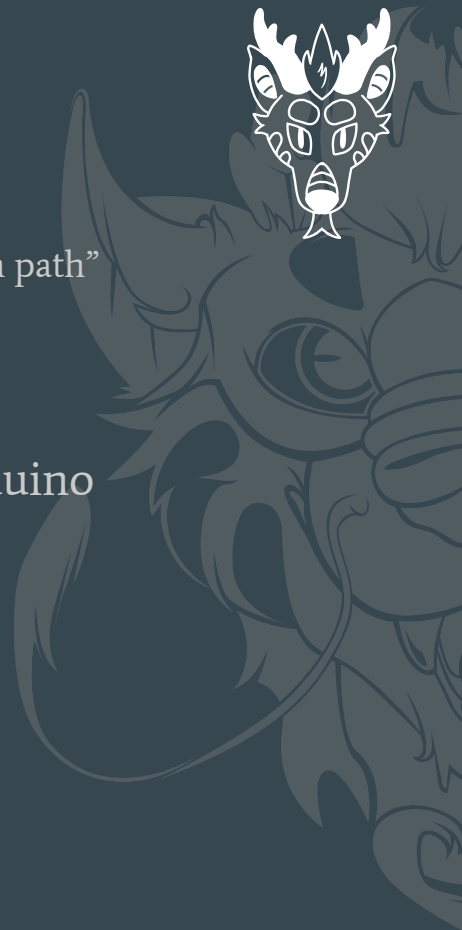


- Usually generated by a “Data Commander”
 - Generates OOB downlink at ~100MHz
 - Receives return channel at ~8-10MHz
 - *Can't find one for love nor money.*
- The RF modulation is just FM, though
- Can we just use an RF signal generator?
- Answer: Yes.
 - I used a Marconi 2022E in FM mode
 - Used a TV/SAT splitter to combine the RF-out with the modulated video signals.



Next steps

- Boxes can send data back using a “Starvue” module
 - Modulates data in FM on a 8-10MHz carrier: the “return channel” or “return path”
 - Need to build a receiver: nothing commercially-available goes this low
 - May be able to sniff the data off the Starvue module connector.
 - Only six out of eleven wires are used
- Reverse-engineer the headend and rebuild it on a Pi Pico or Arduino
 - Smaller, lower power
 - Lets other people build one and set up their own headend



Going further: reuse and recycle

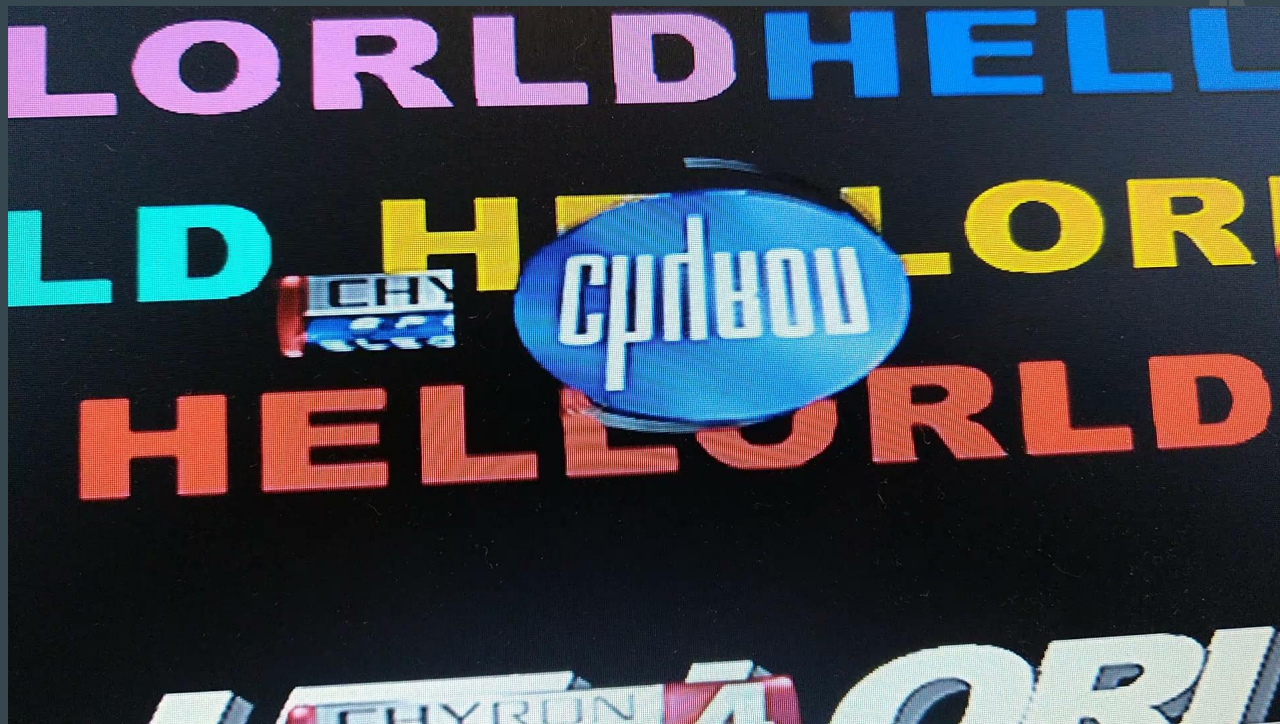


Fake news: Chyrons and crawlers

- A friend got an Aston Green and I wanted one. Nobody was selling one :(
- Found a Chyron Analog Lantern 64 card (pcCODI) on ebay US for £50
 - Turns out this is a PC-based character and graphics overlay card, similar to the Aston
 - Philips TriMedia processor, 64MB RAM, GPIO port, audio port
 - Digital Lantern is the same but has Digital SDI video in/out
- I put it in a PC.
 - Drivers, SDK and Lyric software were on Chyron's FTP site
 - SDK very easy to use: load graphics and fonts, send drawing commands (text).
 - Can use Chyron's Lyric software to set up 'pages' which can be loaded
- Now I can overlay news crawlers and sports scoreboards onto live video!



Chyron demo



Making life easier: matrix switch

- Matrix switch, aka Crosspoint switch.
- Any input to any output - or several.
- Wire everything into the Crosspoint, control it with software.
-> No need to re-wire!
- Makers: Comm-tec, Kramer, Extron
- Aim for something with Ethernet or RS232 control



What I'm doing next

- All-in-one headend
 - RP2040 controller, JSON interface
 - 88-122MHz FSK modulator = headend commands (OOB)
(AD9834 DDS + Si5351A LO + mixer)
 - 8-10MHz FSK demodulator = return path
(FSK receiver from broken cable box + Si5351A?)
- Video scrambling
 - Get this working - then add support to HackTV
- ... Cable TV at EMF 2026?



Q&A

- <https://www.philpem.me.uk/> (web)
- <https://digipres.club/@philpem> (fedi)
- philpem@philpem.me.uk
- DECT: 3699 (FOX9)
- Outside the Robot Arms for a little while

