# Will LMR Interfere with Television Receivers?

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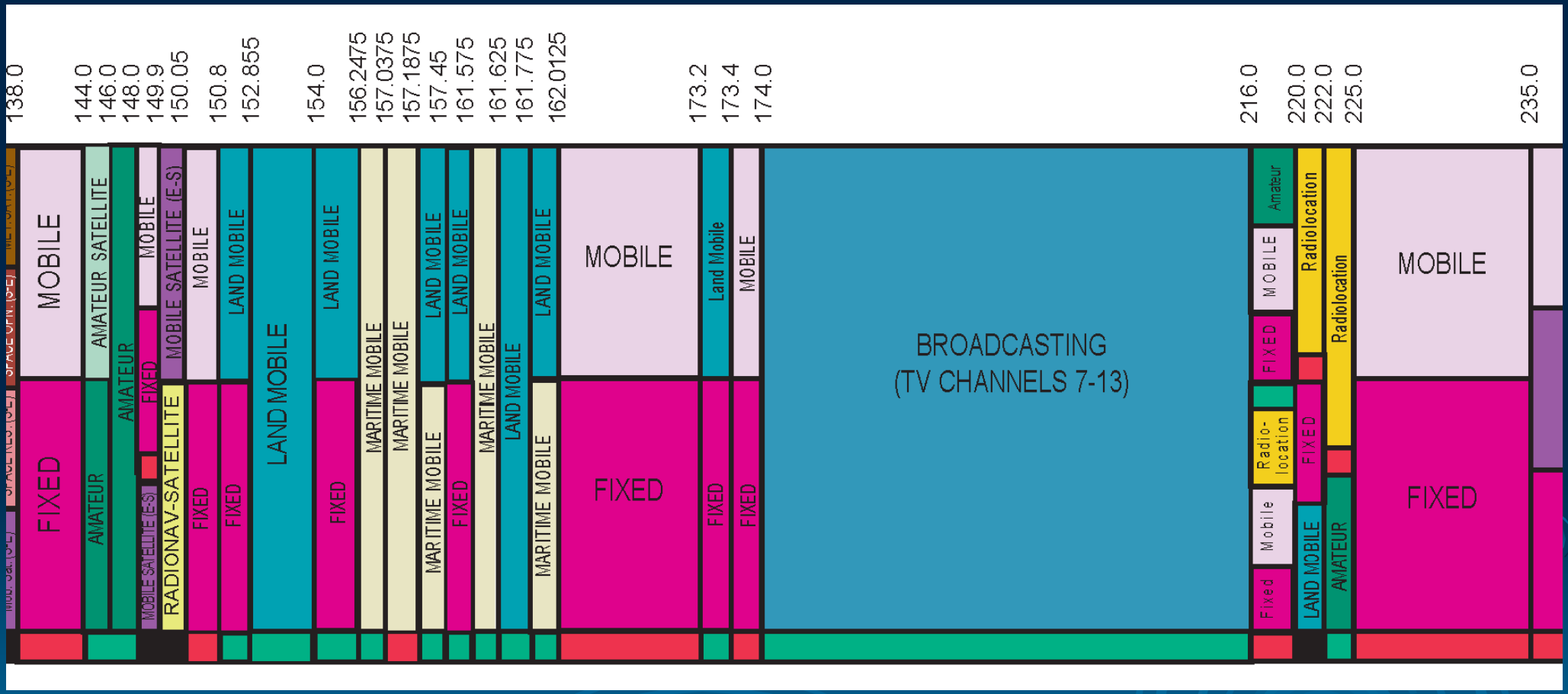
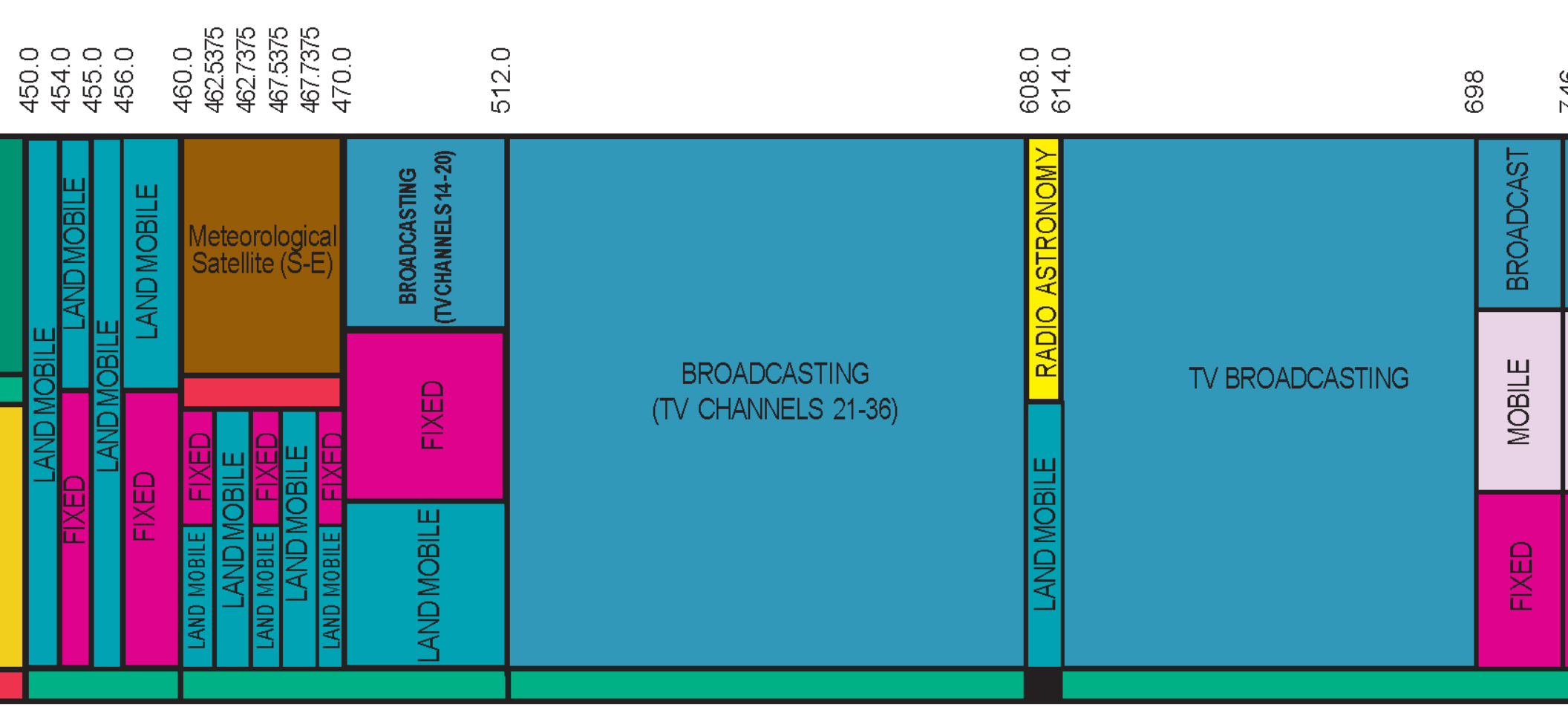
# Will LMR Interfere with Television Receivers?

- What caused us to ask this question?
- If yes, how serious is the problem?
- Does it make a difference if the TV receiver is Analog or Digital?
- Will interference be an issue for “my” system?

# LMR / TV Interference? Interleaved Spectrum

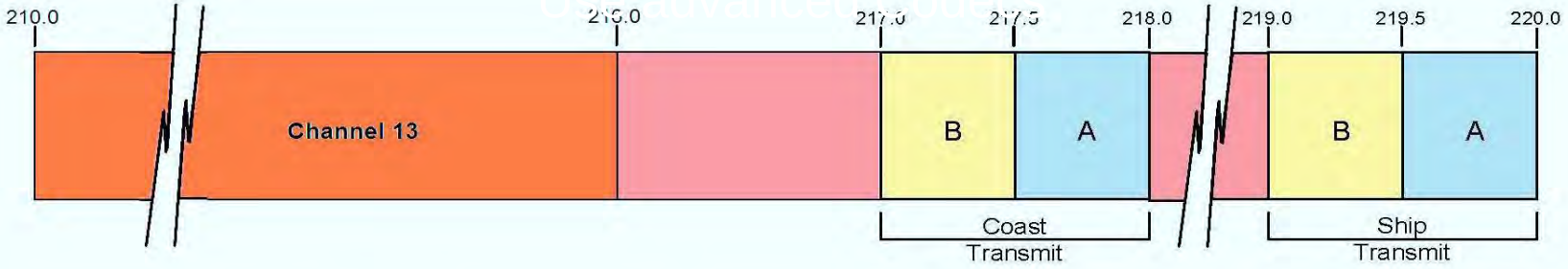


# LMR / TV Interference?
# Interleaved Spectrum



# LMR / TV Interference? Interleaved Spectrum

## Automated Maritime Telecommunications System (AMTS) Band Plan




| Channel Block | Frequency Bands (MHz) | Bandwidth |
|---|---|---|
| A | 217.5 – 218.0 / 219.5 – 220.0 | 1 MHz |
| B | 217.0 – 217.5 / 219.0 – 219.5 | 1 MHz |

# Background Information

- Automated Maritime Telecommunications System (AMTS) Spectrum.
  - Originally proposed in 1981
  - Purpose to expand private maritime communication
- NTSC: Analog television system used in most of North America.
  - Standards first adopted in 1941 and modified later
- ATSC: Digital television system that replaced the NTSC system North America.

# Background Information

- The Eckert Report (1982) characterizes the performance of typical analog NTSC TV receivers of current manufacture.
- Addresses adjacent channel sideband energy degradation of the analog TV receiver threshold in terms of desired and undesired signal powers.

# LMR / TV Interference? Why the Question?

- The FCC 217, 219 MHz AMTS Spectrum rules.
- The geography licensed AMTS operator must mitigate harmful LMR interference into channel 13 & 10 TV receivers when such interference occurs due to operating in the AMTS spectrum.
- The AMTS/LMR operator must predict the quantity and level of interference when filing with the FCC to operate a LMR system.

# LMR / TV Interference?
## Why the Question? - AMTS

- An engineering study must be prepared.
  - Will AMTS LMR into TV interference occur?
  - How many Channel 10 & 13 subscribers may be harmed?
- Broadcaster(s) must be notified of intended LMR operation and possible harmful interference.
- FCC application to operate AMTS LMR must include:
  - Engineering study
  - Mitigation commitment and a mitigation plan

# LMR / TV Interference?
## Why the Question?

- FCC rules based on:
  - Analog AMTS LMR into Analog Ch 10/13 TV based on the Eckert Report published in 1982
- The reality is:
  - *Analog / Digital LMR into Analog Ch 10/13 TV*
  - Analog / Digital LMR into Digital TV (DTV)

# LMR / TV Interference?
## Why the Question?

- Why Analog Channels 10 & 13?
  - 217/219 AMTS MHz are adjacent channel to Channel 13 and thus we have a potential side band energy issue.
  - A DTV receiver tuned to Channel 10 is subject to harmonic mixing with 216-222 MHz signals which create an unwanted TV inter-modulation product in channel 10. In TV land this is known and the N+4 problem

# LMR / TV Interference?

## Does it make a difference if the TV receiver is Analog or Digital?

- Yes, but – Off the air analog TV reception is dead with the exception of translated signals
- Digital TV receivers behave differently than analog receivers:
  - Minimal RF filtering and a wide band AGC circuit (~1.4 dB/MHz)
  - All filtering is done with IF DSP and an IF AGC

# LMR / TV Interference?

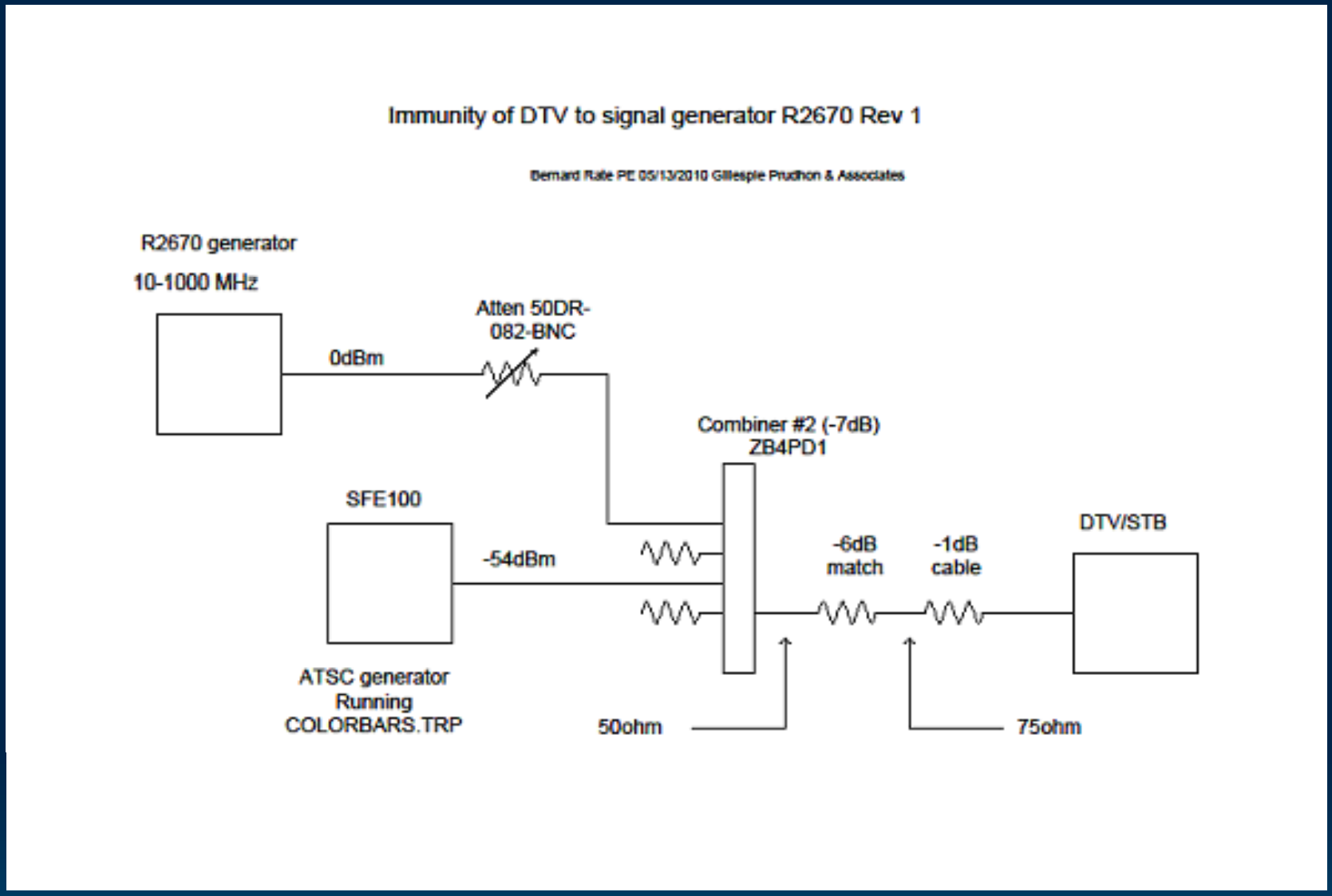
## Does it make a difference if the TV receiver is Analog or Digital?

- At what levels is a DVT receiver degraded?
- What is the threshold for when a mitigation plan is necessary?
- What must be filed with the FCC?
- Other considerations such as:
  - Incumbent fixed station licensees
  - SASPUR
  - Geographical boundaries

# DTV Receiver Immunity to AMTS LMR Signals

The following test data and results were prepared for Avista Corporation.

The test results are proprietary and are not included in shared copies of this presentation.




- Test bench setup using R2670 RF signal generator to create undesired (U) signals.

# Test Bench

LG DTV displaying color bars, with Rohde & Schwarz SFE100 generator on bench (center) and R2670 (left).

# Test Bench

The Rohde & Schwarz SFU generator (center) used for earlier tests including multipath.

# Definitions

D is the desired signal power (TV in our case)

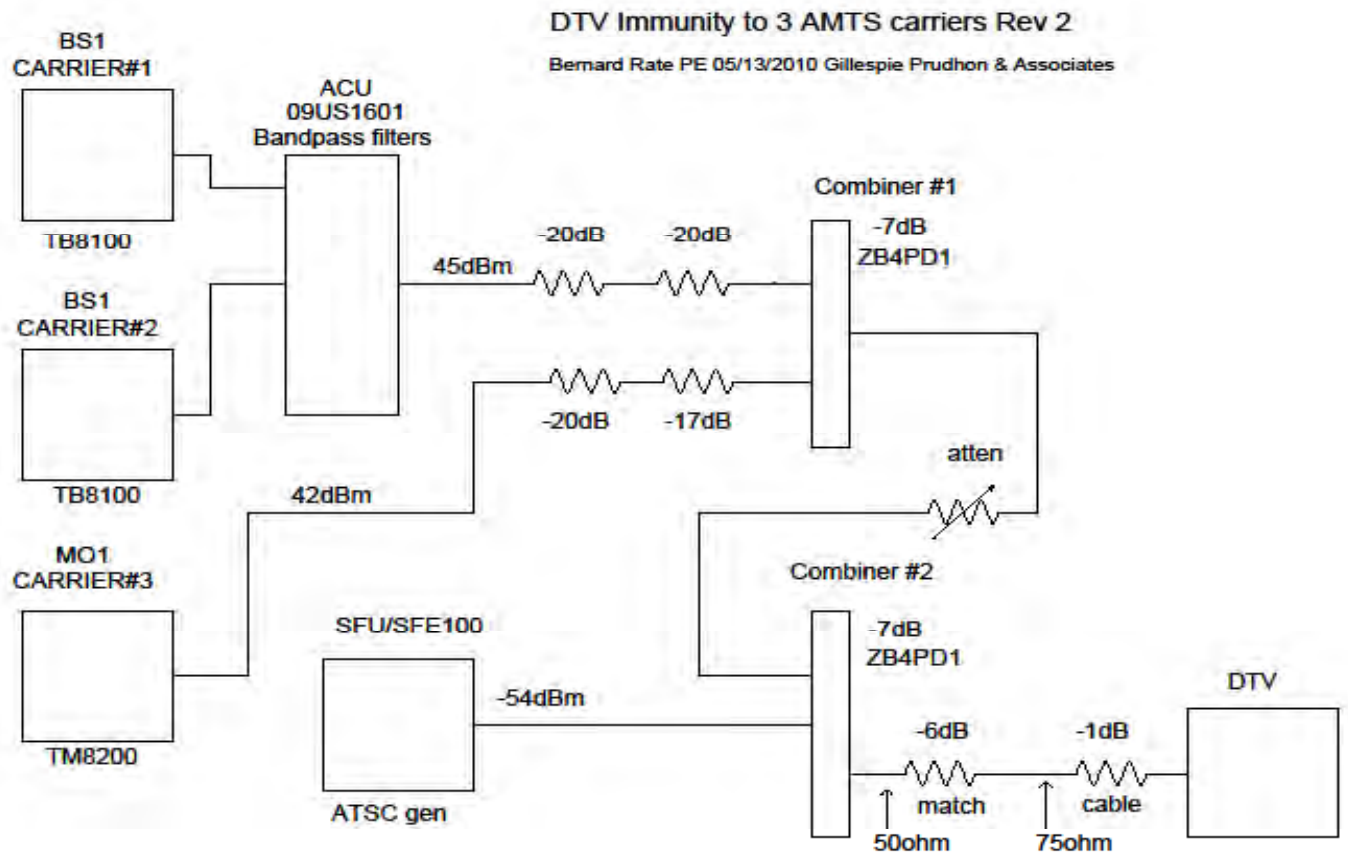
U is the undesired signal power (LMR in our case)

The ratio 10log(D/U) is:

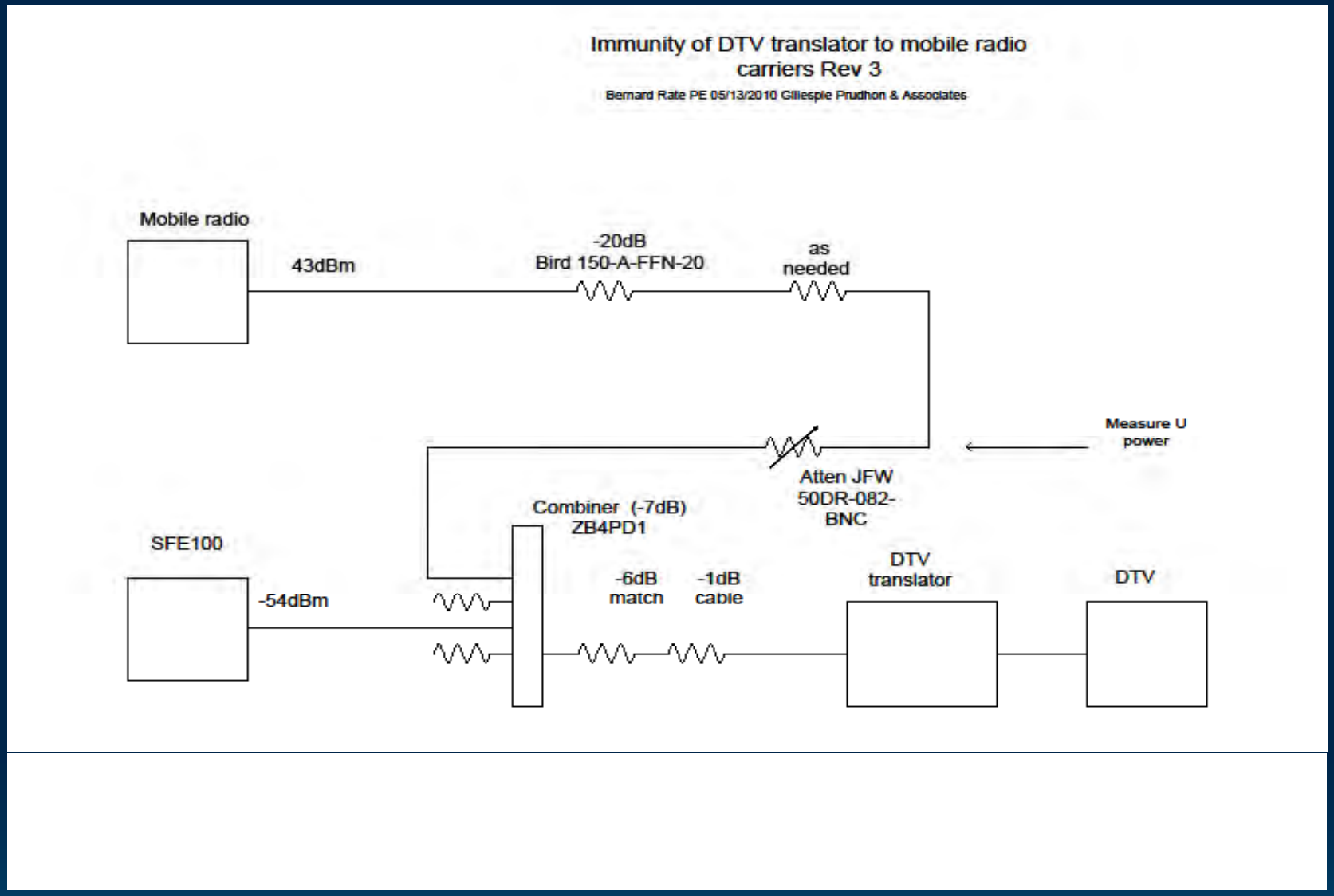
D (dBm) – U (dBm) = D/U (dB)

What D/U is sufficient to cause TV picture pixelation? (TOV)

We fixed D at -68 dBm and varied U



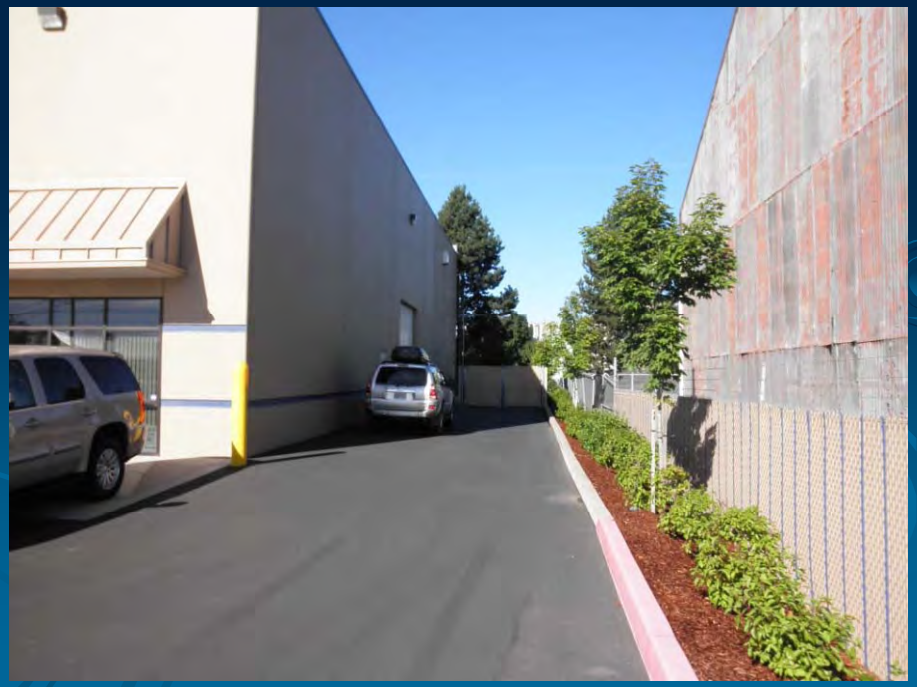

- Test bench setup for using up to 3 carriers with Multipath added to the D signal

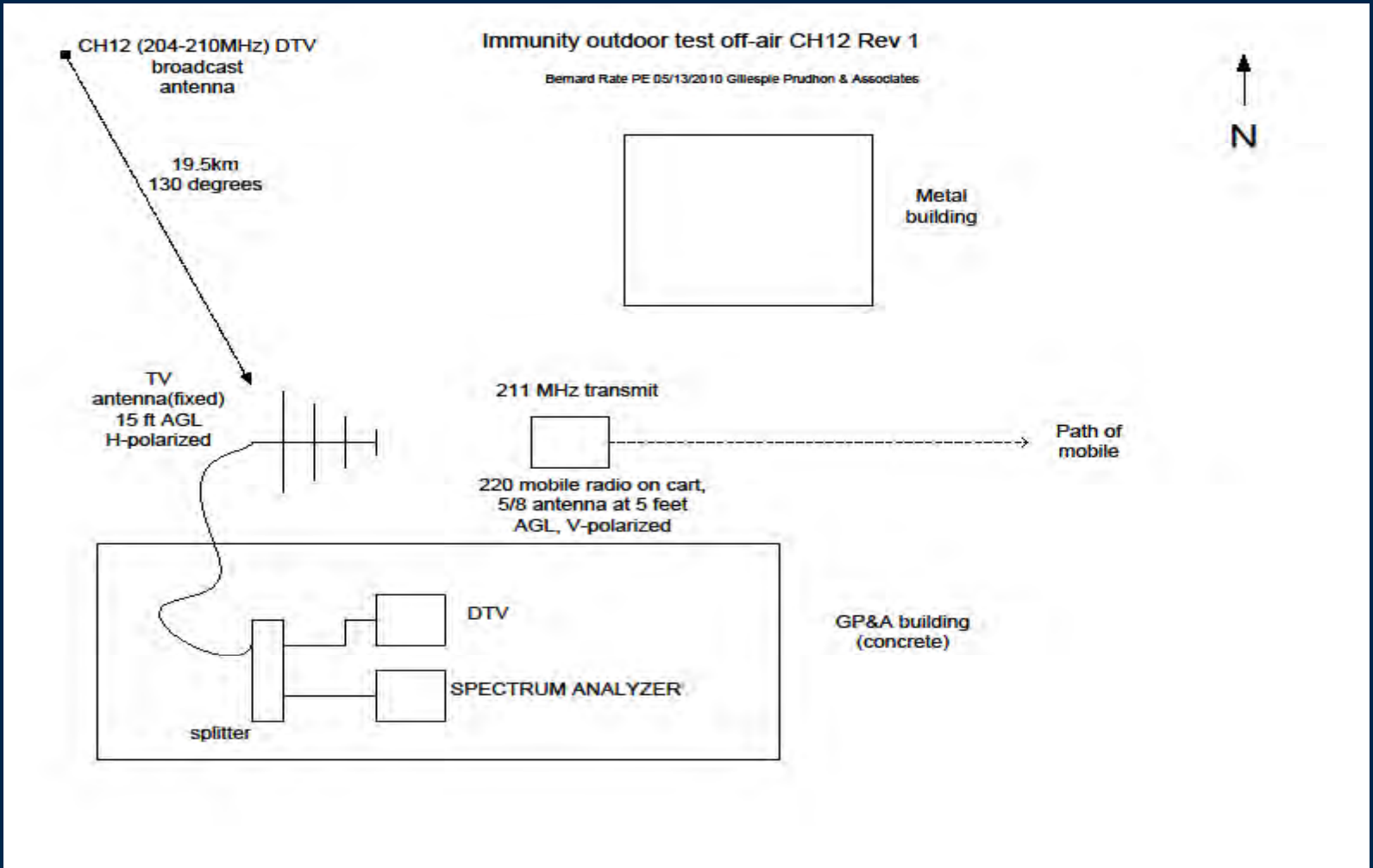



- Test bench setup for LARCAN translator

# Outdoor Test

- An outdoor UHF/VHF/FM horizontally polarized yagi antenna at 15 feet elevation was connected to a DTV inside the building.
- The DTV was tuned to CH12 (204 to 210MHz).
- A mobile radio transmitting at 211MHz was mounted on a cart with a vertical 5/8 antenna.
- The cart was rolled away from the TV antenna while transmitting, and the DTV was checked for loss of picture.






- CH12 off-air DTV signal measured with the spectrum analyzer showed multi-path degradation. This was the D signal of -66 dBm.
- The interfering source was a 20W mobile radio transmitting on 211.000 MHz (1 MHz above the CH12 upper edge) with mobile 5/8 vertically polarized antenna at 5 feet elevation. This provided the U signal.

# Acknowledgements

To Larry Sayer at Rohde & Schwarz for loaning us an SFU on short notice.

To Charlie Rhodes for his expert advice on DTV testing.

# LMR / TV Interference?
## Is it an issue for “my” system?

- If your system is 220 MHz AMTS and channel 13 is received in your area  = Yes
- If your system is VHF, 220, UHF or 700 MHz and adjacent channel (6-12 MHz) to TV receivers – Possibly
- If your LMR Transmitter(s) is/are close enough to a DTV receiver = Probably

# LMR / TV Interference?
## Is it an issue for “my” system?

- If you are a AMTS 217/219 operator you must mitigate the harmful interference.
- If your LMR equipment is the last transmitter to be added it may be your problem to resolve.
- Remember it is a RF power ratio problem more than it is a frequency separation issue.
- Is the DTV world aware of the problem?
  - A qualified yes.

# LMR / TV Interference?
## Is it an issue for “my” system?

- Potential interference as defined by the FCC rules are pessimistic and not real.
- Actual interference can be calculated based on real signals arriving at a specific TV receiver.
- Possible interference cases can be anticipated but require system specific engineering
- Only your “Engineer Knows for Sure”

# LMR / TV Interference?

- Questions

# Digital Mobile Radio
# Is It Ready For Prime Time?

- Some pointed observations by a couple of very interested observers.

- Robin Smyth, PE – GP&A
- Dave Wand, PE – GP&A

# Digital Mobile Radio
# Is It Ready For Prime Time?

- The General Experience is varied
  - Where it works it's just fine, thank you.
  - Where it does not work there may be a good RF RSL but the audio output is non-existent.
- Why does perfectly good analog LMR coverage become unpredictably different when converted to digital LMR?

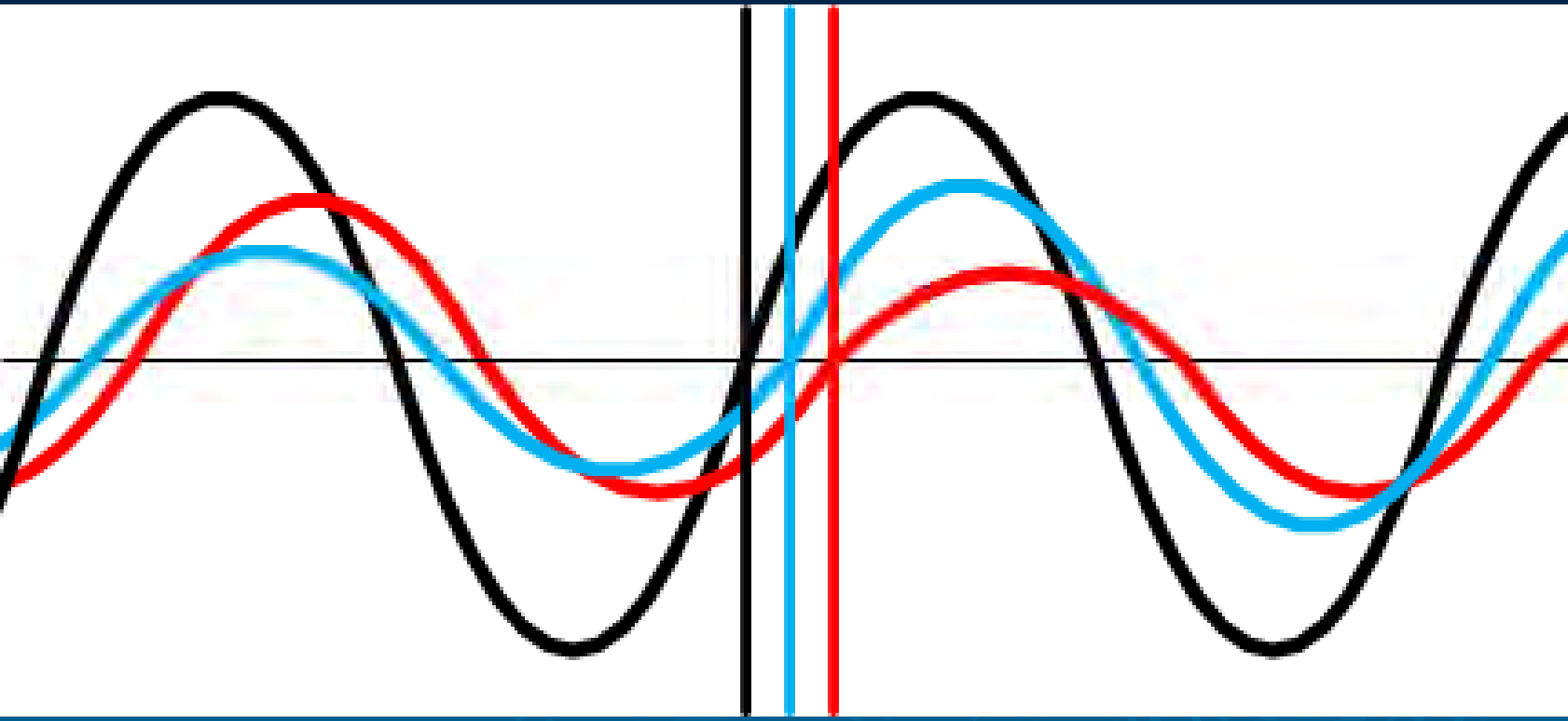
# Digital Mobile Radio
# Is It Ready For Prime Time?

- Short multi-path signals – Friend or Foe?
  - To an FM receiver nearly in phase (short multi-path) signals add to the received signal.
  - We count on diffracted and multi-path signals to fill holes in the direct LOS signal coverage.
  - We have coverage models and statistics to predict the time and location variability of multi-path signals.

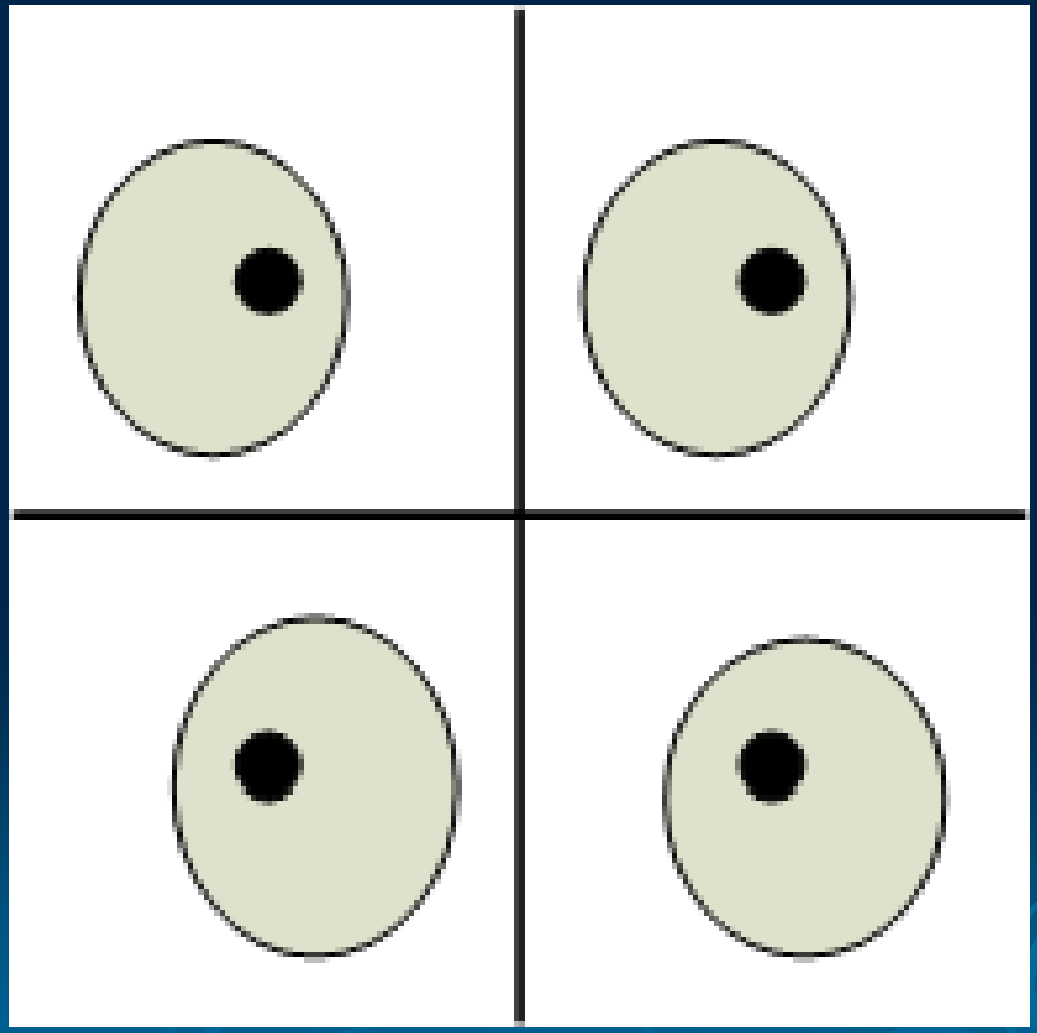
# Digital Mobile Radio
# Is It Ready For Prime Time?

- Short multi-path signals – Friend or Foe?
  - Similar magnitude multi-path signals produce jitter in the clock recovery circuit of a digital receiver.
  - Dissimilar magnitude/phase of the late arriving signal produce ambiguity in the constellation of bit positions in the digital decoder = Inter-symbol interference.

# Digital Mobile Radio
# Is It Ready For Prime Time?



# Digital Mobile Radio
# Is It Ready For Prime Time?



# Digital Mobile Radio
# Is It Ready For Prime Time?

- Clock Jitter & Inter-symbol Interference have been around since:
  - Coax digital carrier systems
  - T1 carrier systems
  - The dial up telephone modem
  - Digital microwave radio
  - WiFi and WiMax
  - And we expect digital mobile radio to be different?

# Digital Mobile Radio
# Is It Ready For Prime Time?

- What can we do about short multi-path signals?
  - Remove all discontinuities in wire line systems
  - Limit wireless systems to line of sight w/ no reflections or refractions = close base station spacing

# Digital Mobile Radio
# Is It Ready For Prime Time?

- What can we do about short multi-path signals?
  - Install countermeasures:
    - Antennas with high directivity
    - Space diversity antennas
    - Frequency diversity or hopping
    - Transversal equalizers – Amplitude, Phase/Time
    - Use special modulation techniques
    - Auto rate adjustment – Increase the inter-symbol spacing

# Digital Mobile Radio
# Is It Ready For Prime Time?

- Design coverage models that predict fixed multi-path (i.e. reflected and refracted) signals to each tile in a coverage model
- Develop new statistics for digital propagation to replace the current analog models used today.
- Use low elevation base station locations

# Digital Mobile Radio
# Is It Ready For Prime Time?

- Why is digital working for the Wireless Carrier industry?
  - Revenue driven utilization
  - Higher traffic volumes per base station
  - More spectrum
  - More resources (17 years into the digital game)
  - Use “all” of the counter measures
  - Use advanced Codecs
  - Initial digital field deployment was very painful

# Digital Mobile Radio
# Is It Ready For Prime Time?

- What is the future for Digital LMR
- P25 Digital, DMR3, pDMR, OpenSky, ???
- Once narrow banding is over will the manufacturers and the user community commit the resources to design and deploy the necessary suite of counter measures?

# Digital Mobile Radio
# Is It Ready For Prime Time?

- In controlled multi-path environments – A very qualified and bounded yes.
- In wide area uncontrolled multi-path environments - no!