Adjacent Band Interference to Consumer Receivers

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Introduction

• The issue of adjacent-band interference to radio receivers has received recent attention
  – *In particular, adjacent band interference to GPS receivers*

• Leads to the question: How well do other types of radio receivers withstand adjacent band interference?

• The Aerospace Corporation tested a number of common consumer radio receivers against adjacent band interference signals
  – *Digital Television (Samsung LN52B530)*
  – *FM Radio (Sony STRDH100)*
  – 3 *types of GPS receivers*
    • Garmin Montana 650t, uBlox LEA-6A, Novatel OEM 628
Test Design

- All testing conducted in a controlled, laboratory environment
  - *Conductive or anechoic chamber - No external transmissions!*
- Continuous Wave (CW) signal transmitted at varying power and frequency offset from each device’s operating band
  - *Interference signal transmitted outside of device’s allocated band*
Start with CW tone in adjacent band

Desired Signal Band

Adjacent Band

Interference Signal (CW Tone)

Frequency (f)

Power

Interference to Desired Signal Power Ratio
Increase power …
• Failure criterion was total loss of track of all signals
• Used this criterion because signal-to-noise ratio degradation or similar metrics were not available from all devices tested
• Total loss of service enabled “apples to apples” comparison
Record the CW signal power (I) and frequency offset (Δf) at failure point; Compute (I/S)
Increase CW signal offset, repeat
Increase CW signal offset, repeat

Desired Signal Band

Adjacent Band

Frequency (f)

Power
Result is locus of (I/S) points where device failed
Power and Frequency Offset Considerations

• Interference to desired signal ratio (I/S) is used because desired signal powers vary widely by service
  – Simulated GPS signal power = -158 dBW (-128 dBm)
  – TV signal power = -51 dBm (77 dB stronger than GPS)
  – FM signal power = -67.5 dBm (60.5 dB stronger than GPS)

• Frequency offset is plotted as a percentage of desired band edge
  – Referenced from band edge to consider only adjacent band signals – avoid interference signals in desired band
  – Rationale for normalizing versus frequency
    • Filter “Quality Factor” (BW/f) also scales with frequency
    • Commonly used to describe filter roll-off
More resistance to interference

Greater frequency separation
Test Results – (I/S)

![Graph showing test results for various devices.](image)

- **uBlox GPS (Model: LEA-6A)**
- **Novatel GPS (Model: OEM628)**
- **Garmin GPS (Model: Montana 650t)**
- **Sony FM Radio (Model: STRDH100)**
- **Samsung Television (Model: LN52B530)**

**Interference to Signal Power Ratio for Device Failure (I/S) (dB)**

**Interference Signal Frequency Offset from Desired Signal Band Edge (Percentage)**
Test Results – (I/S)

- OmniSTAR Corrections MSS Downlink 1557.8 MHz (0.14%)
- OmniSTAR Corrections MSS Downlink 1540.0 MHz (1.28%)

Test Results – Alternative Power Metric – $I/(S+N)$
Summary and Conclusions

• Summary of test results
  – 3 different types of consumer receivers tested
  – All were susceptible to adjacent band interference

• Conclusions
  – Any radio receiver can eventually be overloaded by adjacent band signals of sufficient power
  – Compatibility assessments should consider relative signal powers of adjacent band services

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Notes on Novatel EOM 628 GPS Receiver

- Novatel OEM 628 is wide-band high precision GPS receiver
- Designed to receive differential correction signals from Geosynchronous satellites operating in the Mobile Satellite Service (MSS) band (1525-1560 MHz) below GPS L1
- As a result, some data points fell inside pass band of OEM 628 filter, even though they were outside of the GPS L1 band
  - *Novatel more susceptible to interference within 1% of band edge*
Desired Signal Below Thermal Noise: $N \gg S$
e.g. GPS

$B = \text{Receiver Bandwidth (MHz)}$

$No = \text{Noise Power Density (W/MHz)}$

$N = \text{Receiver Noise Power (W)} = B \times No$

\[
\left( \frac{1}{S+BNo} \right) = \left( \frac{1}{S+N} \right) \approx \left( \frac{1}{N} \right) \quad \text{for } N \gg S
\]
Desired Signal Above Thermal Noise: $S >> N$
e.g. TV and FM

Power

Desired Signal Band

Adjacent Band

B = Receiver Bandwidth (MHz)
No = Noise Power Density (W/MHz)
N = Receiver Noise Power (W) = $B \times No$

\[
\left( \frac{1}{S+BNo} \right) = \left( \frac{1}{S+N} \right) \approx \left( \frac{1}{S} \right) \quad \text{for } S >> N
\]