Access Networks Solutions

Introduction to S-CDMA

Why S-CDMA?

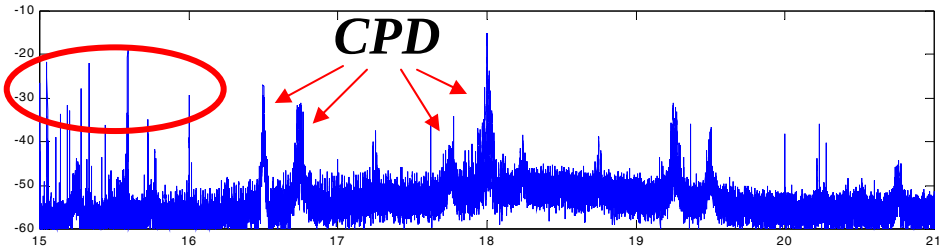
- **Upstream is a looming bottleneck**
  - Traffic growth
  - Competitive environment
  - Highly bandlimited
- **Imperative that the bandwidth be fully exploited**
  - Unused spectrum represents 25-40% of band
  - Unused Spectrum = Unused Capacity
- **DOCSIS tools for optimal upstream use**
  - Optimize Mbps: Modulation Profiles (64-QAM @ 5.12 Msps)
  - Optimize Channel: Pre-Equalization
  - Optimize Spectral Usage: S-CDMA
- **S-CDMA is standardized, mature, powerful – cost effective new capacity**

Upstream Impairment Catalogue

- Narrowband Interference
  - Radio signal ingress
  - Common path distortion (CPD)
- **Burst/Impulse Noise**
  - **1 us – 100 ms duration**
  - **Strongest < 20 MHz**
  - **Combined with ingress < 20 MHz**
  - ***S-CDMA is uniquely capable against impulse noise***
  - ***….and thus also against combined impulse plus ingress***
- Other
  - Frequency Response Distortion
  - Noise Floor

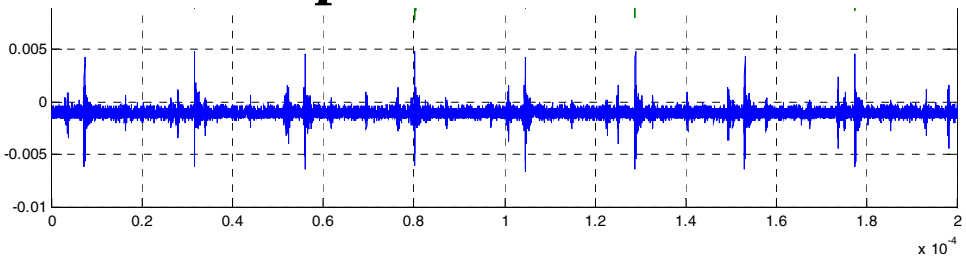
Narrowband Interference

Ingress



Frequency ⟶

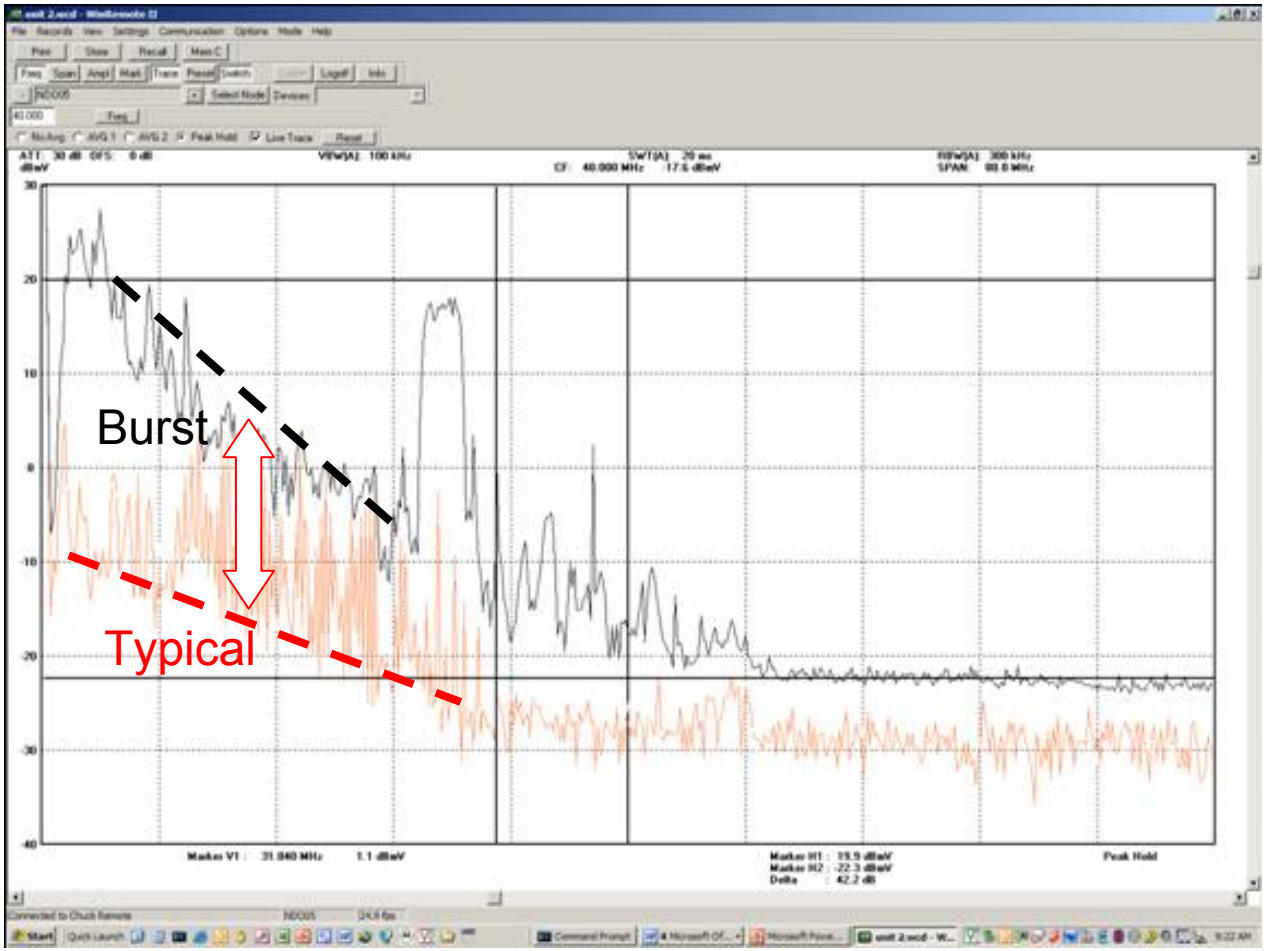
Impulsive Events



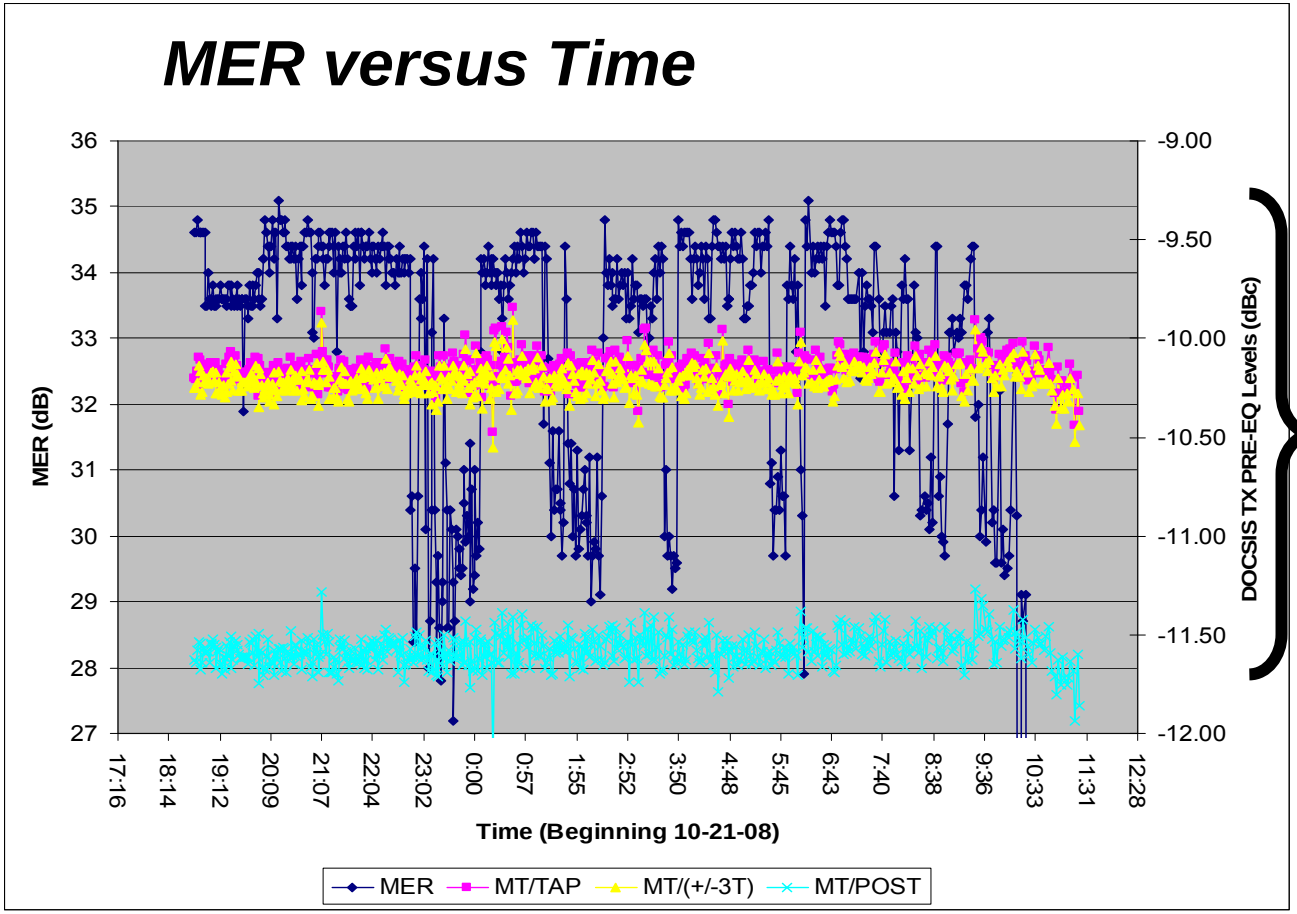
Time ⟶

Impulse Noise – Spectrum

Impulse Noise – Typical < 20 MHz Signature and Burst



Impulse Noise – MER Perspective



> 8 dB Range

> QAM Order

MER

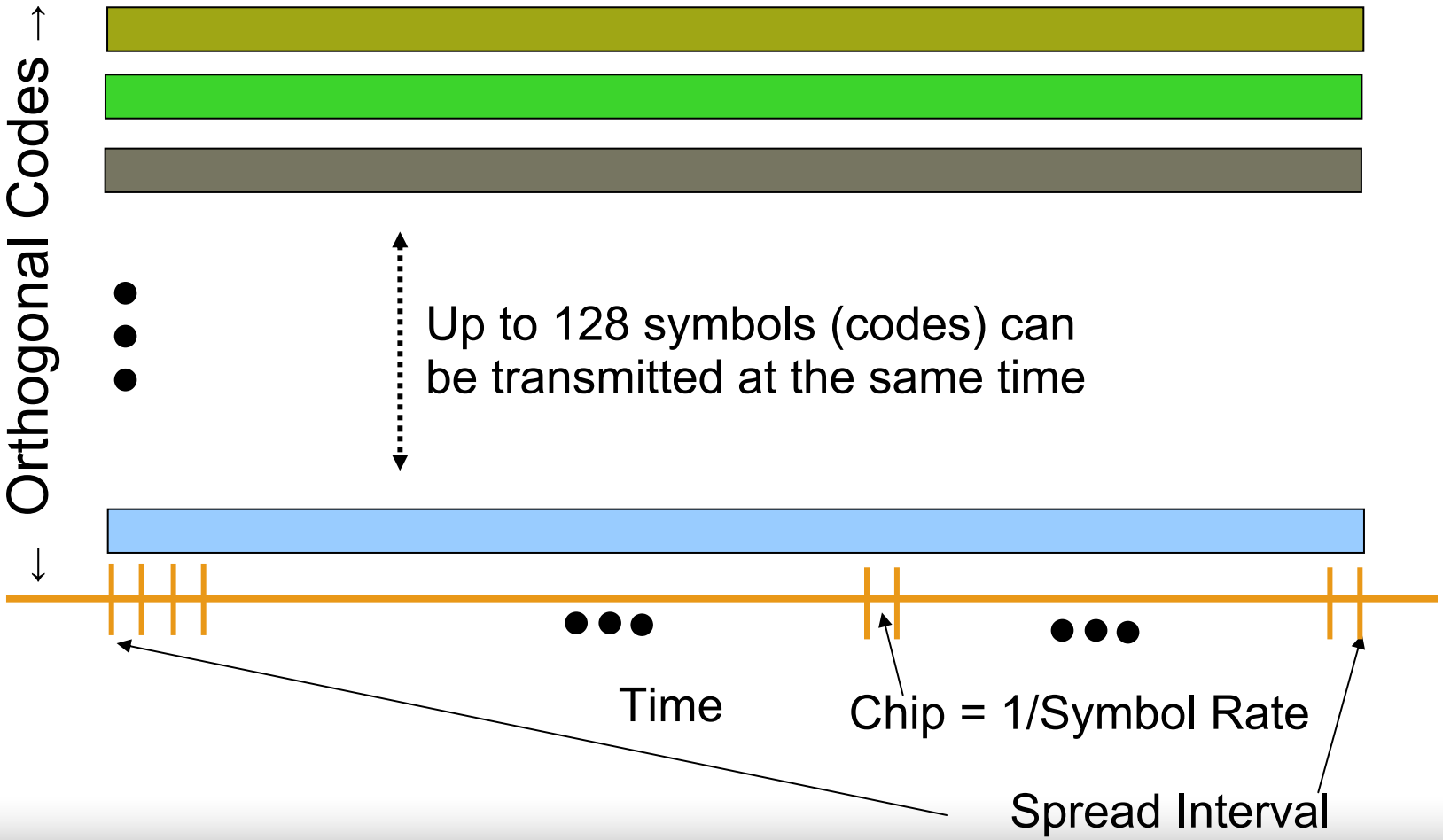
Equalizer Taps (Channel Freq Response)

S-CDMA Overview

S-CDMA Basics

- **What**
  - **Synchronous Code Division Multiple Access (S-CDMA) is an upstream technology added in D2.0, and enhanced in D3.0**
- **Why**
  - **S-CDMA technology is particularly robust against impulse noise, a critical requirement at the low end (<20 MHz) of the band**
- **How**
  - **S-CDMA *stretches* QAM symbols out in time by 128 times**
  - **Symbols multiplied by (-1 or 1) via CDMA spreading "code"**
  - **Transmits all sets of stretched symbols in parallel**
  - ***Zero* theoretical interference among transmissions due to special code properties**
  - **No decrease in channel capacity**

S-CDMA Spread Symbol



DOCSIS 2.0 vs 3.0 S-CDMA

- **DOCSIS 2.0 S-CDMA**
  - **Full impulse immunity (Code spreading + FEC)**
  - **Ingress cancellation**
    - **A few narrowband interferers**
    - **Sufficient for majority of live deployments**

- **DOCSIS 3.0 S-CDMA**
  - **Selectable Active Codes: SAC Mode 2**
    - **Enhanced ingress cancellation**
  - **Maximum Scheduled Codes (MSC)**
    - **Trade SNR for throughput – fewer codes used, more power in each**

S-CDMA: Benefits and Capabilities

Key S-CDMA Benefits

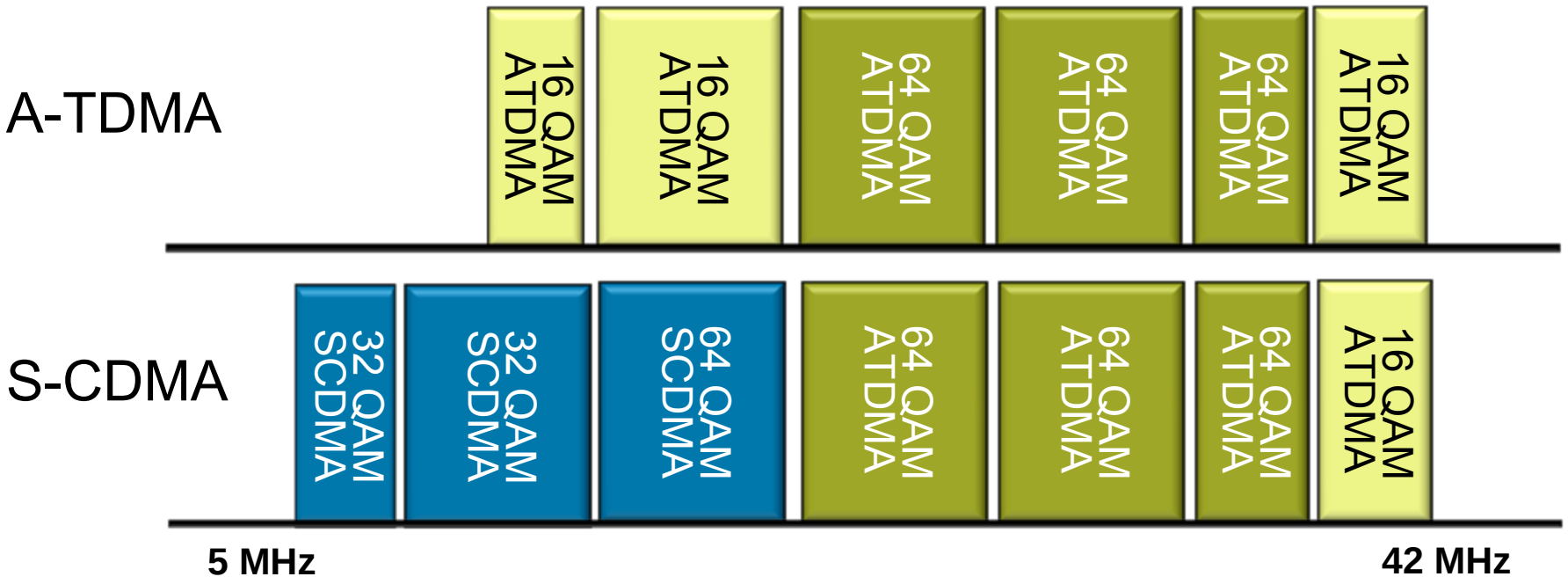
- **Impulse noise robustness for lower upstream band**
  - **Gain of symbol spreading >100x A-TDMA at same throughput**
  - **Improving A-TDMA robustness requires narrower channels**
    - **Decreases throughput**
    - **Still weaker than S-CDMA**

  ⇒ ***S-CDMA is strongly recommended below 20 MHz***

- **Combined ingress and impulse immunity**
  - **D3.0 S-CDMA & A-TDMA are comparable in *ingress-only***
  - **S-CDMA outperforms A-TDMA for combined ingress + impulse typically observed < 20 MHz (D2.0 or D3.0)**

- **Secondary Benefits**
  - **Increased efficiency of synchronous operation**
  - **Lower FEC overhead due to inherent impulse immunity**
  - **Max Scheduled Code feature – SNR vs throughput trade-off**

S-CDMA vs. A-TDMA Comparison



- **Recover unused and/or underutilized 5-20 MHz bandwidth**
  - **S-CDMA: 67 Mbps in lower channels (152 Mbps total)**
  - **A-TDMA: 30 Mbps in lower channels (115 Mbps total)**
- **S-CDMA throughput Advantages**
  - **Increase capacity up to ~50%**
  - **Ensure 100 Mbps upstream service capacity**
  - **Defer node splitting**

Est. Link Gain – S-CDMA vs A-TDMA

Frequency Band	2.56 Msps	5.12 Msps
5.0-9.0 MHz	< 6 dB	< 8 dB
9.0-15.0 MHz	< 4 dB	< 6 dB
15.0-20.0 MHz	< 2 dB	< 4 dB
20 MHz < fo	~Equiv	~Equiv

- **QAM Relationships:** 4-8 dB represents 1-2 orders of modulation
  - 16-QAM → 32-QAM (~3 dB) → 25% more throughput
  - 16-QAM → 64-QAM (~6 dB) → 50% more throughput
  - 32-QAM → 64-QAM (~3 dB) → 20% more throughput

S-CDMA Summary

- **The Situation Upstream**
  - Traffic continues to grow
  - New channels are being added
  - Spectrum remains limited
  - ⇒ *Maximize spectrum*
  - ⇒ *Optimize its use*

- **Congestion Relief**
  - S-CDMA: standardized 7+ years ago
  - Built for tough channels
  - Available, mature, improved, proven

- **S-CDMA is required to effectively operate high throughput channels at lower end of band**
  - Works where A-TDMA will not
  - Better throughput where A-TDMA supports a modest link

- **S-CDMA: Cost-Effective Upstream Capacity**

Access Networks Solutions

Thank You!

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