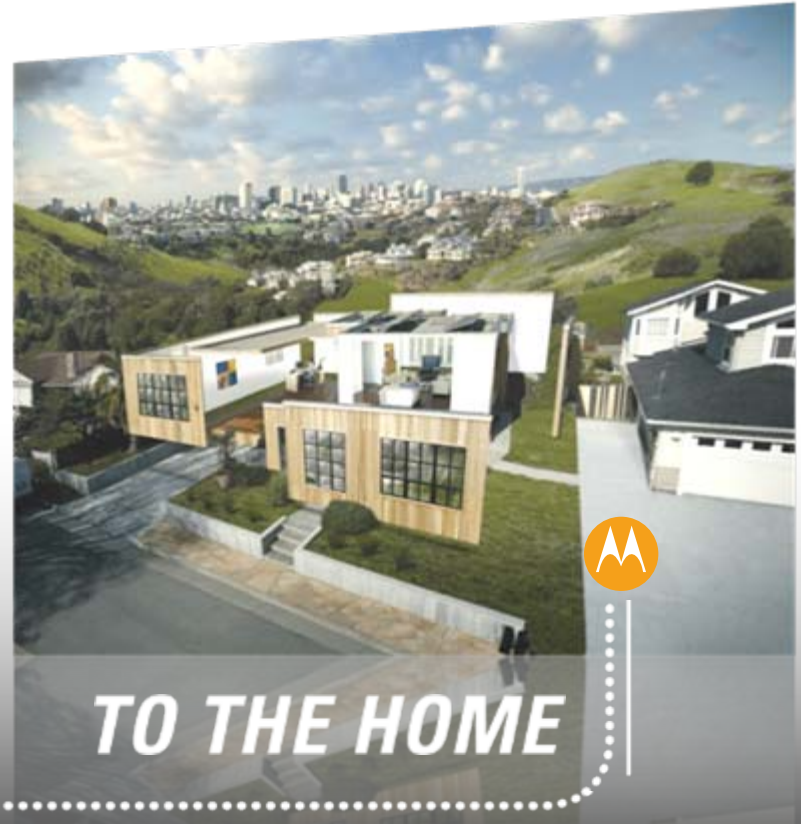




Access Networks Solutions

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**

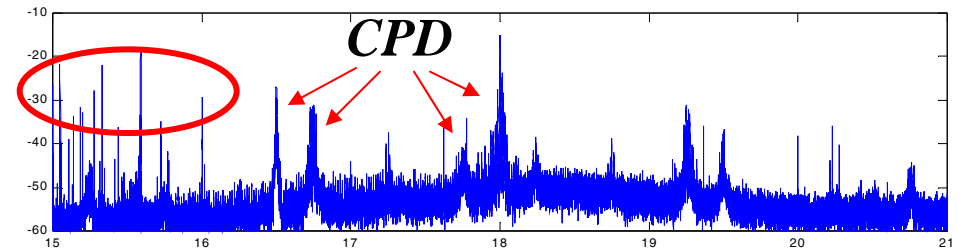
Upstream Impairment Catalogue



- **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

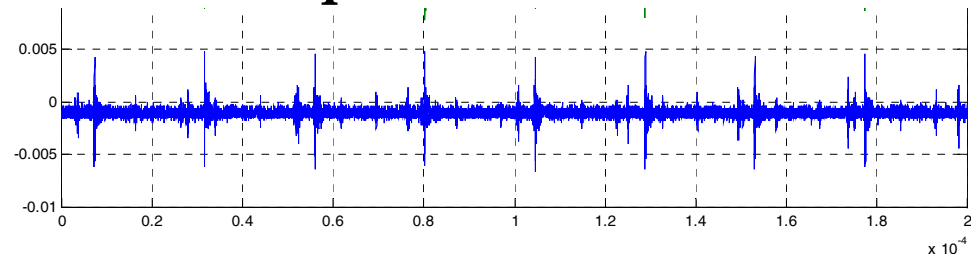
Narrowband Interference

Ingress



Frequency →

Impulsive Events

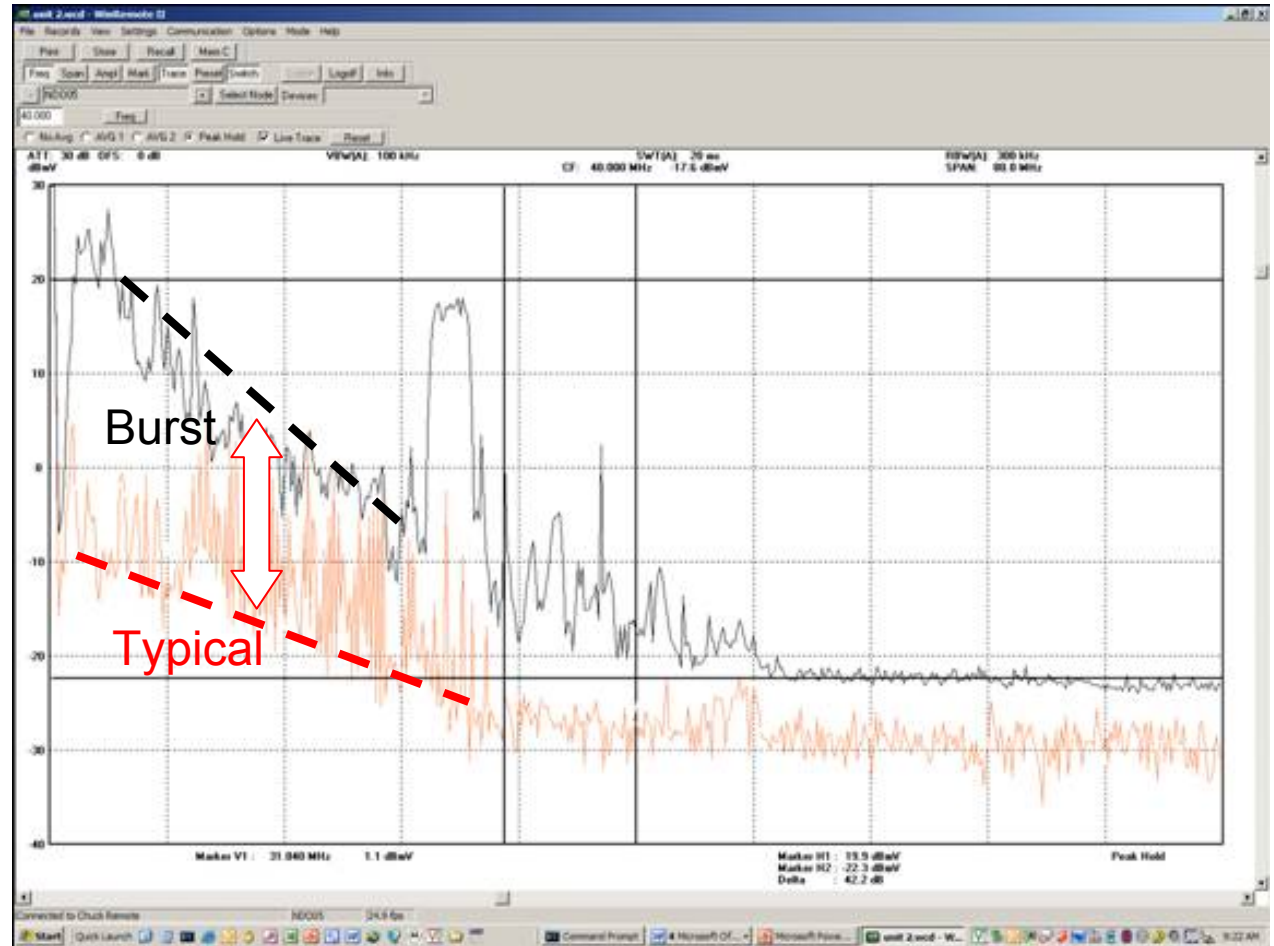


Time →

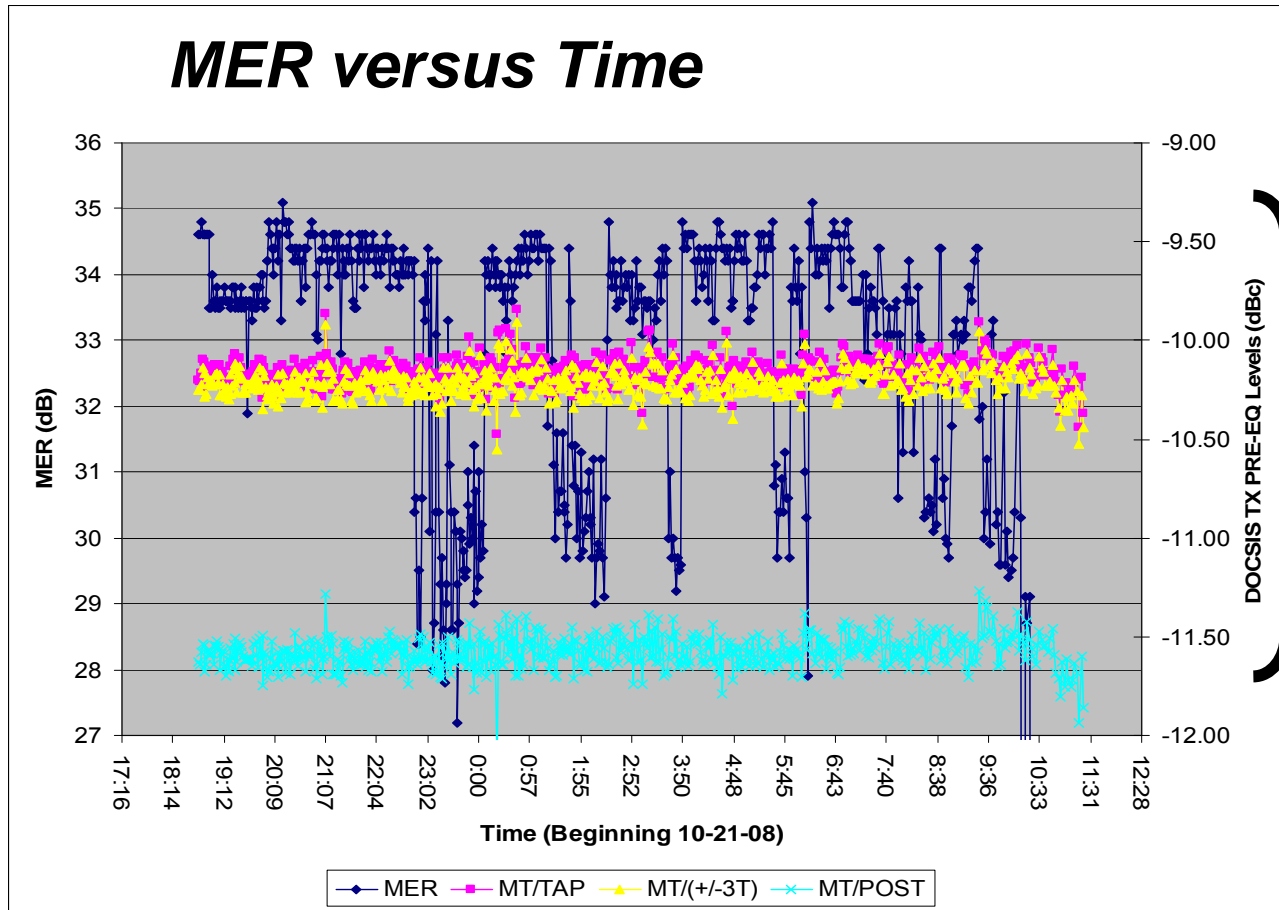
Impulse Noise – Spectrum



**Impulse Noise –
Typical < 20 MHz
Signature and
Burst**



Impulse Noise – MER Perspective



> 8 dB Range
> QAM Order



MER



Equalizer Taps (Channel Freq Response)

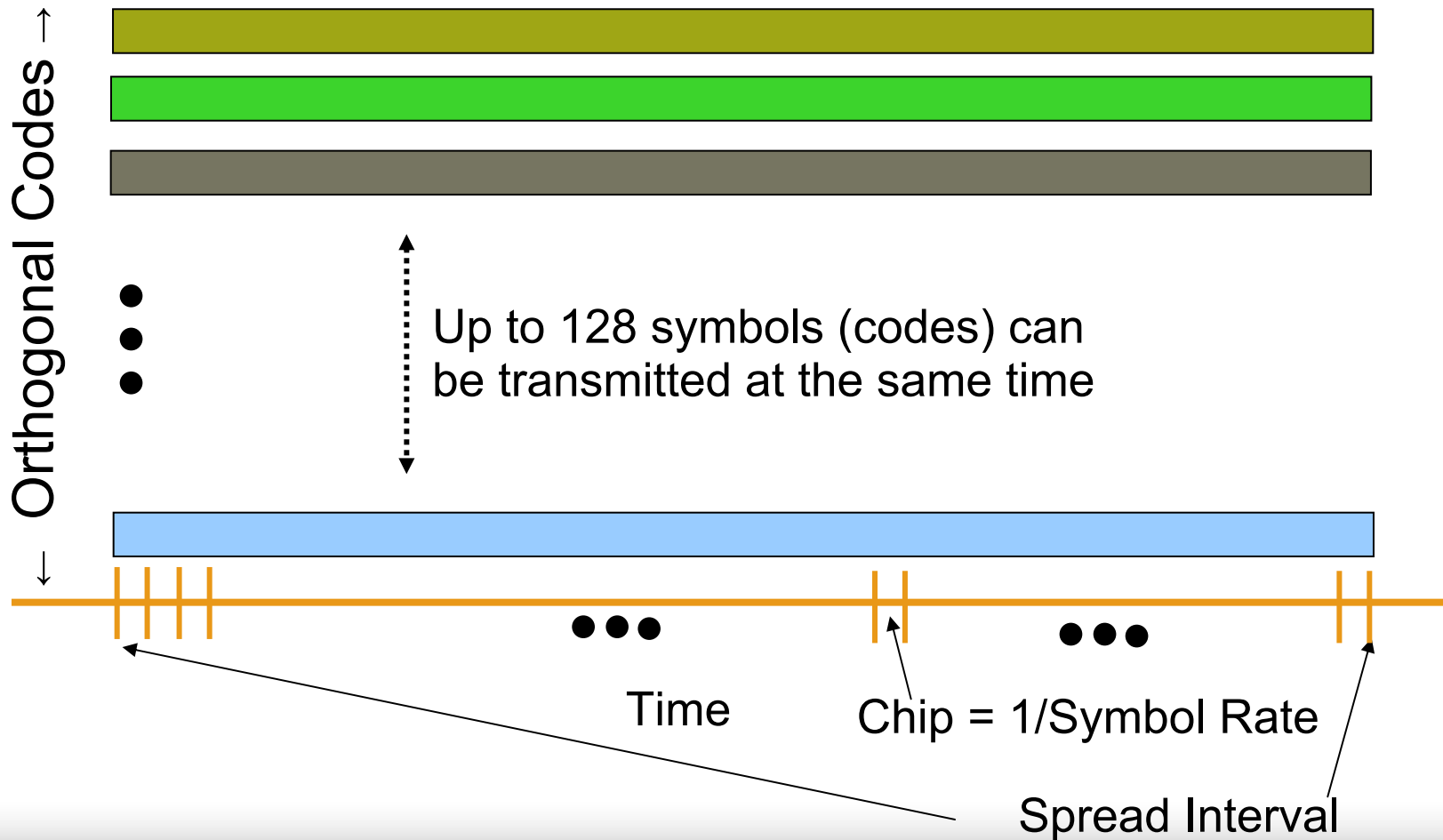


S-CDMA Overview



- **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 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



- **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



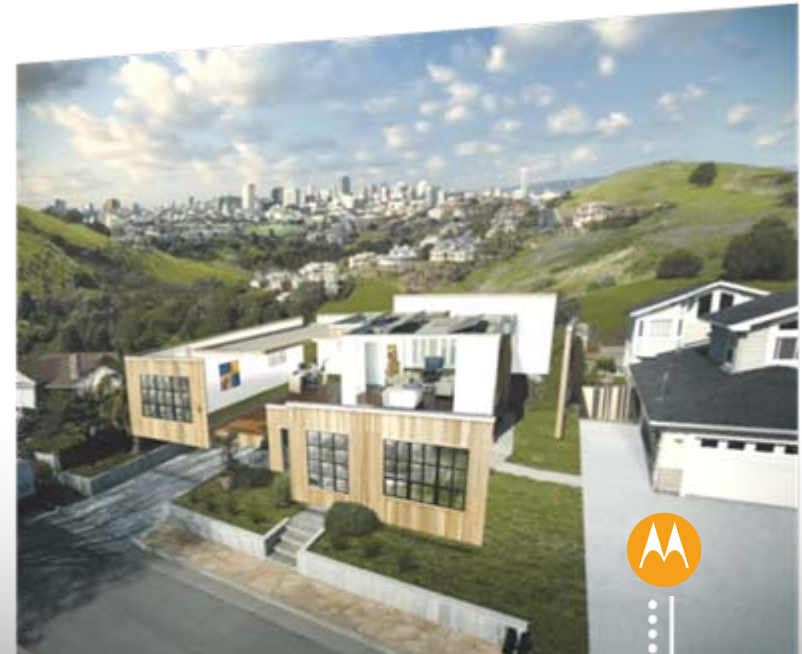
- **The Situation Upstream**
 - Traffic continues to grow
 - New channels are being added
 - Spectrum remains limited
 - ⇒ *Maximize spectrum*
 - ⇒ *Optimize its use*
- **Congestion Relief**
 - S-CDMA: standardized 7+ years ago
 - Built for tough channels
 - Available, mature, improved, proven
- **S-CDMA 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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TO THE HOME