OFDM Subcarrier Nulling in Downstream P802.3bn

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In-band Spectrum Nulling Purpose

1. To prevent egress interference to wireless service (LTE, mobile radio, radio navigation, GPS, etc.).
2. To mitigate ingress interference.
3. To share the spectrum with Analog Video channels.
4. To share the spectrum with SC-QAM channels.
5. To work around fixed legacy plant pilots.

Issues

- For every signals inserted within the 192 MHz OFDM block by subcarriers nulling, we need to:
  - Consider interference from OFDM to the signal.
  - Consider interference from signal to the OFDM (if signal is not orthogonal).
  - Add guard-band subcarriers and adjust bit loading of subcarriers adjacent to nulled bandwidth.

Goals

- Maximize throughput of EPoC by:
  - Maximizing OFDM spectrum continuity (no “swiss cheese” OFDM spectrum block).
  - Avoiding inserting signals that have a higher power spectral density than the OFDM signal.
  - Avoiding inserting signals that are not random and do not have a uniform power spectral density. Such signals may affect algorithms in receiver.
  - Selecting the right level of nulled power as it impact the OFDM symbol shaping, CP length extension and guard band subcarriers.
- Minimize degradation of OFDM and in-band signal.

Case 1: Egress Interference

- Nulling bandwidth is on case by case basis, BW is adjusted manually by the operator.
- The system management has no feedback mechanism to auto-adjust the nulled BW.
- Nulled power spectral density is on case by case basis.

Case 2: Ingress Interference

- Nulling bandwidth is on case by case basis.
- The system management can poll CNU MER to:
  - Adjust bit loading of degraded subcarriers (weak interference).
  - Null subcarriers (strong interference).

Case 3: In-band Analog Video

- Nulling bandwidth: 6 or 8 MHz
- Signal power: +6 dBc relative to OFDM (in 6 or 8 MHz BW)
- Minimum operational C/N at system outlet (IEC 60728-1-2)
  - NTSC: 42 dB in 4.0 MHz
  - PAL B/G: 43 dB in 4.75 MHz
- It is possible to null subcarriers for an in-band analog video but we should avoid it here. Analog video power is higher than OFDM and is not noise like (concentrated at few discrete frequencies).

Case 4: In-band SC-QAM

- Nulling bandwidth: 6 or 8 MHz
- Signal power: 0 dBc relative to OFDM (in 6 or 8 MHz BW)
- DVB-C 256-QAM minimum C/N at outlet (include recommended 6 dB margin in IEC 60728-1-2)
  - 6 MHz SC-QAM: 37 dB in 5.36 MHz
  - 8 MHz SC-QAM: 37 dB in 6.94 MHz
- An integrated noise power of -49 dBc in 6 or 8 MHz nulled BW will reduce the C/N by 0.25 dB and hence the margin by the same amount for either DVB-C or J.83 Annex B.

Case 5: In-band pilot

- Nulling bandwidth: small? (for discrete pilots)
- Signal power: ?
- Signal to noise requirements: ?
- Is the discrete pilot orthogonal to OFDM subcarriers?

Recommendations

- Avoid inserting Analog Video channel in-band of a OFDM spectrum block.
- If SC-QAM channel(s) needs to be in-band of a OFDM block, integrated power in 6 or 8 MHz of nulled BW should be at least -49 dBc. If possible, SC-QAM channels should be contiguous.
- The system management (outside the scope of the standard) need to poll the MER of all CNUs and adjust bit-loading according to the average channel conditions.