



Duplexing Methods for Ethernet Passive Optical Network Over Coax

- FDD or TDD?

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- It has been suggested that EPOC may use TDD as an option because:
 - **WiMax has TDD as an option**
 - **LTE supports TDD mode as an option**
 - **HiNOC uses TDD**
- Whether EPOC should adopt TDD should not be based on WiMax, LTE or HiNOC
 - **WiMax, LTE and HiNOC accept TDD for their own good reasons**
 - **Whether those reasons apply to EPOC is still a question**
- Considerations of duplexing methods for EPOC should be based on the intrinsic factors of EPOC
 - **Characteristics of coaxial cable; HFC out plants and EPON protocols**
- Let's first look into why wireless adapts TDD as an option

General Considerations of Duplexing Methods



- **Duplexing methods:**
 - Full duplex - Frequency Division Duplexing (FDD)
 - Half duplex - Time Division Duplexing (TDD)
- **Spectrum Considerations:**
 - For a given throughput FDD and TDD require similar amount of spectrum
 - Advantage of TDD: easier to find a single channel of unsigned frequency band
- **Transmission Delay:**
 - Transmission delay depends on frame lengths (applies to FDD & TDD); TDD introduces another factor - burst length
 - TDD introduces additional Duplexing Delay; duplexing delay affects delay sensitive services
 - Duplexing delay depends on both frames lengths and burst lengths
 - Duplexing delay in EPOC also depends on EPON scheduling protocol and DBA - more complicated than that of wireless and HiNOC
 - Large cable echo delay (3-7 us) results in longer OFDM symbol time (could 200us - 400us):
 - Larger OFDM frame size and larger TDD cycle

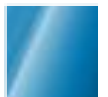


- **Channel reciprocity**
 - **A TDD channel receives from the same transmission channel, therefore only needs to measure the channel once**
 - **only needs one antenna**
 - **FDD receives and transmits in two channels; needs to do channel measurement twice**
 - **Transmission and receiving antennas may be different; especially if one is in a higher band and the other in a lower band. This creates a problem for antenna design especially for handsets**
 - **Channel reciprocity is another big advantage for wireless, but does not apply to EPOC**
- **Implementation considerations - complexity: For a given amount of throughput:**
 - **A TDD system needs two times the bandwidth than that of a FDD system for symmetrical services**
 - **Significantly increase system and CPE cost**
 - **Requires two times as many transmitters and receivers**

- **CPE transmit power: A TDD system needs more upstream transmission power to support two times total BW (than FDD)**
 - **A typical DOCSIS 3.0 cable modem transmits upstream at max power 57 dBmV in a 6.4 MHz channel for QAM64**
 - **The DS/US ratio can be changed but the CPE transmitter/amplifier must be sized for the total channel BW available.**
 - **There is an increase in transmission power due the increased channel BW.**
 - **$10 * \log (\text{Channel BW} / \text{Channel Width})$**
 - **For a 600 MHz channel this results in a 20dB increase in RF power to maintain the same power within a 6 MHz channel compared to currently deployed CPE's.**
 - **Compare with FDD, TDD transmission power increase by: $10 * \log((\text{US} + \text{DS}) / \text{US})$**
 - **For symmetric 3 Gb/s DS and 3 Gb/s US, TDD transmitter power increase by 3 dB**
 - **For asymmetric 5Gb/s DS and 1 Gb/s US, TDD transmitter power increase by 7.8 dB**
 - **This has a significant impact on the maximum power of the upstream CPE amplifier**



- **Advantages of TDD**
 - **Easier to find a single unassigned frequency band for transmission and reception**
 - A big advantage for wireless
 - Some advantage for coax
 - **Channel reciprocity**
 - A advantage for wireless
 - Does not apply for EPOC
 - **Dynamic upstream and downstream time assignment**
 - An advantage for wireless
 - Dynamic US/DS does not work with EPON protocol
- **Disadvantages of TDD**
 - **Introduces extra duplexing delay; affects delay sensitive services**
 - **Needs 2X bandwidth compare with that of FDD for the same amount of throughput**
 - **Implementation complexity**
 - **High power consumptions**





- For wireless the advantages of TDD are significant enough to have TDD as an option
- For EPOC, most of the TDD advantages may not apply
- On the other hand, the disadvantages of TDD for EPOC are significant
- Whether TDD works with EPON protocol is still a question
 - Additional duplexing delay may break the EPON protocol





Thanks