

**Department of Electrical Engineering, IIT Madras**  
**EE 5151: Communication Techniques**

Sep. 2019

**Tutorial #3**

KG / IITM

1. A 10ppm clock error exists in the incoming signal to the receiver, which in turn has a 5ppm clock error. If the nominal bit-rate is 1Mbps, how much time elapses between (bit-level) slips? If this slip rate must not be greater than  $10^{-3}$  slips/sec, what must be the new spec. on the total clock error?
  
2. In a system using elastic buffer with 2-frame memory, one frame slip occurs every 42 minutes in a system with a frame rate 150 frames/sec.
  - a) What is the ppm (parts per million) of the crystal used in the receiver?
  - b) Now, in order to have only one (frame) slip every 24 hours, what should the ppm be?
  
3. In a certain digital multiplexer, 2 input streams arrive at 20Mbps rate with clock of  $\pm 10$  ppm each, and another 4 input streams arrive with 10Mbps rate and with clock of  $\pm 15$  ppm each. If a 32-bit frame header and a 16-bit CRC are added to every  $L$ sec frame assembled by this multiplexer along with appropriate stuff-bits (and indicators), answer the following:
  - (a) If  $L=2$ secs, make a rough sketch of the assembled frame, indicating the various important fields. What is the output bit-rate in Mbps (Mega Bits per Second)?
  - (b) In the interest of error-detection, it is advisable to reduce the frame length (duration). For what least choice of  $L$  (you may express in secs) will the output bit-rate not exceed 80.001 Mbps?
  
4. In a certain digital multiplexer, there are 3 input streams arriving with the following specifications: a 1Mbps stream with clock of  $\pm 5$  ppm, a 4Mbps stream with  $\pm 3$  ppm, and finally, a 10Mbps stream with clock of  $\pm 2$  ppm. If a 4-bit frame header and a 6-bit CRC are added to every  $L$ sec frame assembled by this multiplexer along with appropriate stuff-bits (and indicators), answer the following:
  - (a) If  $L=50$ msec, what is the output bit-rate in Mbps (Mega bits per second)?
  - (b) For what least choice of  $L$  (you may express in msec) will the overhead decrease by 10%?