Computer Networks Assignment #2 Zhang Zhexian (0545080) zhangzhexian@outlook.com

1. [Chapter 2 Hands-on 1] Find and summarize the network-related modules in www.opencores.org into a table. In the table, compare their protocol layer, purpose, programming language, and key implemented algorithms or mechanisms.

Module Name	Protocol Layer	Purpose	Programming Language	Key Implemented Algorithms or Mechanisms
10/100M Ethernet-FIFO convertor	Link	Communication controller, data queuing	Verilog	TxModule.v RxModule.v and common.v
100 MB/s Ethernet MAC Layer Switch	Link	The switch receives 100 MB/s data rate from 6 channels and direct each frame received to its destination port.	Verilog	1. Simultaneously Read / Write frames memory - to improve latency 2. Digital serialize / De - Serialize and digital routing core
Manchester Decoder for Wireless	Link	This core decodes incoming Manchester encoded data	VHDL	ASK A315 transmitter/receiver pair; Manchester encoding
Physical Coding Sublayer (PCS)	Physical	FPGA proven verilog implementation of IEEE 802.3-2008 Clause 36 - Physical Coding Sublayer (PCS)	Verilog	Verilog implementation of IEEE 802.3-2008 Clause 36 - Physical Coding Sublayer (PCS) type 1000BASE-X (1000baseLX and/or 1000baseSX)
UDP / IP Stack	Transport	Allows full control of UDP src & dst ports on TX. Provides access to UDP src & dst ports on RX (user filtering)	VHDL	Implements UDP, IPv4, ARP protocols
16550 UART core	Transport	A UART that is compatible with the industry standard 16550D	VHDL	Includes wrappers for the Wishbone and AMBA APB busses
Wishbone SD Card Controller	Transport	MMC/SD communication controller designed to be used in a System-on-Chip	Verilog	32-bit Wishbone interface & DMA engine for data transfers

2. [Chapter 2 Written 2] Compare the number of required frequencies and the size of bandwidth to represent the following signals: (a) periodic analog, (b) aperiodic analog, (c) periodic digital, and (d) aperiodic digital.

Signal Type	Number of required frequencies	Size of bandwidth
Periodic analog	1	Discrete
Aperiodic analog	Infinite	Continuous
Periodic digital	Infinite	Discrete

Aperiodic digital	Infinite	Continuous

3. [Chapter 2 Written 7] Among unipolar NRZ-L, Polar NRZ-L, NRZ-I, and RZ, Manchester, differential Manchester, AMI, and MLT-3, which schemes have no issues on synchronization, baseline wandering, and DC components, respectively?

   Having no issues on

   - synchronization: RZ, Manchester, differential Manchester, AMI (with bit stuffing)
   - baseline wandering: RZ, Manchester, differential Manchester
   - DC components: Polar NRZ-L, NRZ-I, RZ, Manchester, differential Manchester, AMI, MLT-3

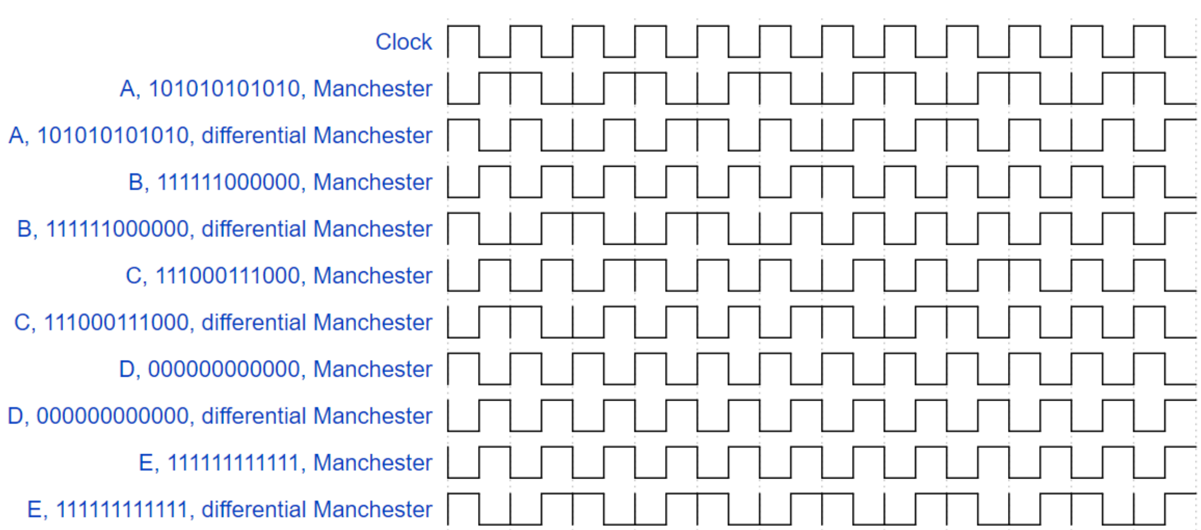
4. [Chapter 2 Written 9] Draw the waveforms using the schemes of Manchester and differential Manchester for the following data streams. Calculate the value of sdr (signal-to-data ratio) and the average baud rate.
   a. 101010101010 b. 111111000000 c. 111000111000 d. 000000000000 e. 111111111111

   The waveforms are drawn using the online tool Wavedrom (http://wavedrom.com/editor.html).

   The code:

```
{signal: [
  {name: 'Clock', wave: 'p...........'},
  {name: 'A, 101010101010, Manchester', wave: 'npnpnpnpnpnp'},
  {name: 'A, 101010101010, differential Manchester', wave: 'p.n.p.n.p.n.'},
  {name: 'B, 111111000000, Manchester', wave: 'nnnnnnpppppp'},
  {name: 'B, 111111000000, differential Manchester', wave: 'pnpnpnnnnnnn'},
  {name: 'C, 111000111000, Manchester', wave: 'nnnpppnnnppp'},
  {name: 'C, 111000111000, differential Manchester', wave: 'npnnnnpnpppp'},
  {name: 'D, 000000000000, Manchester', wave: 'p...........'},
  {name: 'D, 000000000000, differential Manchester', wave: 'nnnnnnnnnnnn'},
  {name: 'E, 111111111111, Manchester', wave: 'n...........'},
  {name: 'E, 111111111111, differential Manchester', wave: 'pnpnpnpnpnpn'},
]}
```

   The graph:



Signal-to-data ratio (SDR)：

SDR = 2 / 1 = 2

Average baud rate

S = c * N * SDR = ½ * N * 2 = N

5. [Chapter 2 Written 11] Given a data stream of a bit rate 1 Mbps, 2 Mbps, or 54 Mbps, calculate the baud rate using the modulation of BFSK, BASK, BPSK, QPSK, 16-PSK, 4-QAM, 16-QAM, and 64-QAM.

Signal rate S = N × 1/r

r = number of data elements that an analog signal can carry

N = data rate. S is the digital signal rate before modulation

Modulation	r [data capacity]	N [data rate/bit rate] (Mbps)	S [baud rate] (Mbps) = N × 1/r
BFSK	1	1	1
		2	2
		54	54
BASK	1	1	1
		2	2
		54	54
BPSK	1	1	1
		2	2
		54	54
QPSK	2	1	½
		2	1
		54	27
16-PSK	16	1	1/16
		2	1/8
		54	27/8
4-QAM	4	1	¼
		2	½
		54	27/2
16-QAM	16	1	1/16
		2	1/8
		54	27/8
64-QAM	64	1	1/64
		2	1/32
		54	32/27

6. [Chapter 2 Written 15] Compare the PN codes and the orthogonal codes used in CDMA. Why can we support more users with PN codes than with orthogonal codes?

Orthogonal codes are vectors with strictly zero pair-wise inner product, while the PN codes are statistical and have pair-wise autocorrelation close to 1 if closely correlated and pair-wise cross correlation close to 0 if uncorrelated.

While the number of orthogonal codes for a given signal is fixed, the number of PN codes is flexible and usually more than the number of orthogonal codes.

The PN codes use the spectrum more efficiently than the orthogonal codes, due to the low, but nonzero cross-correlation nature of the PN codes. In the high-traffic bursts of telephony and data communications, the PN codes are more efficient in allocating to more users.

7. [Chapter 2 Written 21] What are the criteria for two signals to be orthogonal to each other in OFDM?

   In OFDM, two signals that cross over at the point of zero amplitude are orthogonal to each other.

   As illustrated below, the signal waves meet and cross each other at the frequency-axis (zero amplitude), so they are orthogonal to each other.