**Solutions to Chapter 2**

**Hands-On: (25 points each)**

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.

Answer:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Category | Language | Develop-ment status | chip | Layer  /Design/Spec. | License | Algorithm/Mechanism |
| Reed-Solomon  decoder | Arithmetic core | c/c++ | stable | FPGA proven | PHY/done | LGPL | a parameterized Reed Solomon decoder |
| Cyclic redundancy code (CRC) generator | Arithmetic core | VHDL | stable | ASIC proven | (MAC,Network)  /done/done | GPL | highly pipelined cyclic redundancy code (CRC) |
| cdma\_chip | Arithmetic core | VHDL | mature |  |  | LGPL |  |
| Baud generator | Communication controller | VHDL | stable | FPGA proven |  | GPL |  |
| 10/100M Ethernet-FIFO converter | Communication controller | Verilog | stable |  |  | LGPL |  |
| 10G Ethernet MAC | Communication controller | Verilog | alpha |  | MAC |  |  |
| Bluespec 802.11a  (OFDM baseband project) | Communication controller | Bluespec | stable |  |  | LGPL | a parameterized baseband hardware logic |
| Bluetooth baseband controller | Communication controller |  | alpha |  |  |  | Bluetooth baseband controller |
| Ethernet SMII | Communication controller | Verilog | beta |  | (MAC, PHY)  //done |  | Serial Media Independent Interface used between Ethernet MAC and PHY |
| IPv4 Ethernet packet creator and transmitter | Communication controller | VHDL | stable |  |  | GPL |  |
| UDP/IP core | Communication controller | VHDL | stable |  | TCP,IP | GPL | VHDL implementation of a UDP/IP core |
| Ultimate CRC | ECC core | VHDL | Stable | ASIC/  FPGA proven | (MAC,Network)  /done/done | GPL | a CRC generator/checker |
| Parallel CRC generator | Other | C/C++ | Stable |  | PHY//done | LGPL |  |

**Written: (10 points each)**

1. 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.

Answer:

Period analog signal: one discrete frequency

Aperiod analog signal: bandwidth-limited continuous spectrum

Period digital signal: infinite discrete frequencies

Aperiod digital signal: continuous spectrum , but bandwidth is unlimited.

1. 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?

Answer:

With self-synchronization problem: unipolar NRZ-L, polar NRZ-L, polar NRZ-I, AMI, MLT-3

With baseline problem: unipolar NRZ-L, polar NRZ-L, polar NRZ-I

With DC components problem: unipolar NRZ-L, polar NRZ-L, polar NRZ-I

Without self-synchronization problem: polar RZ, Manchester, differential Manchester

Without baseline wandering problem: Manchester, differential Manchester

Without or with very little DC components problem: polar RZ, Manchester, differential Manchester, AMI

We could summarize all of the above into the following table. X means it does not have this problem, while O means it has this problem.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Unipolar NRZ-L** | **Polar NRZ-L** | **Polar NRZ-I** | **Polar RZ** | **Manchester** | **Differential Manchester** | **AMI** | **MLT-3** |
| **Synchronization** | **O** | **O** | **O** | **X** | **X** | **X** | **O** | **O** |
| **Baseline wandering** | **O** | **O** | **O** | **X** | **X** | **X** | **O** | **O** |
| **DC component** | **O** | **O** | **O** | **X** | **X** | **X** | **X** | **O** |

1. 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.
   1. 101010101010
   2. 111111000000
   3. 111000111000
   4. 000000000000
   5. 111111111111

Answer:

Manchester, differential Manchester: sdr=2, average baud rate = bit rate

a: 101010101010

E:\workspace\yd.net_book\solutions\solutions_fig\sol_9_1a.wmf

b: 111111000000

E:\workspace\yd.net_book\solutions\solutions_fig\sol_9_1b.wmf

c: 111000111000

E:\workspace\yd.net_book\solutions\solutions_fig\sol_9c.wmf

d: 000000000000

E:\workspace\yd.net_book\solutions\solutions_fig\sol_9d.wmf

e: 111111111111

E:\workspace\yd.net_book\solutions\solutions_fig\sol_9e.wmf

1. 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 64QAM.

Answer:

While the modulation of BFSK, BASK, or BPSK is applied, the baud rate (signal rate, symbol rate) is equal to data rate (or bit rate). The unit of signal rate (symbol rate) is baud, or Bd. Therefore, baud rate is 1 MBd, 2 MBd, or 54 MBd, respectively.

The baud rate for QPSK is and one half of bit rate; hence, the baud rate of the given data stream is 500 kBd, 1 MBd, or 27 MBd, respectively, if the modulation QPSK is applied.

The baud rate for 16-PSK is and a quarter of bit rate; hence, the baud rate of the given data stream is 250 kBd, 500 kBd, or 13.5 MBd, respectively, if the modulation 16-PSK is applied.

The baud rate of 4-QAM, 16-QAM, or 64-QAM is (bit rate)/2, (bit rate)/4, or (bit rate)/6. Therefore, the baud rate of the given data stream using 4-QAM modulation is 500 kBd, 1 MBd, or 27 MBd, respectively.

The baud rate of the given data stream using 16-QAM modulation is 250 kBd, 500 kBd, or 13.5 MBd, respectively.

The baud rate of the given data stream using 64-QAM modulation is 166.67 kBd, 333.33 kBd, or 9 MBd, respectively.

1. Compare the PN codes and the orthogonal codes used in CDMA. Why can we support more users with PN codes than with orthogonal codes?

Answer:

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 crosscorrelation close to 0 if uncorrelated.

Asynchronous CDMA can allocate PN-code to active users flexibly without a strict limit on the number of users, while synchronous CDMA can only allocate their resources to a fixed number of simultaneous users, depending on the fixed number of orthogonal codes. In the high-traffic bursts of telephony and data communications, asynchronous CDMA is more efficient in allocating PN codes to more users.

1. What are the criteria for two signals to be orthogonal to each other in OFDM?

Answer:

Two signals that cross-over at the point of zero amplitude are orthogonal to each other.