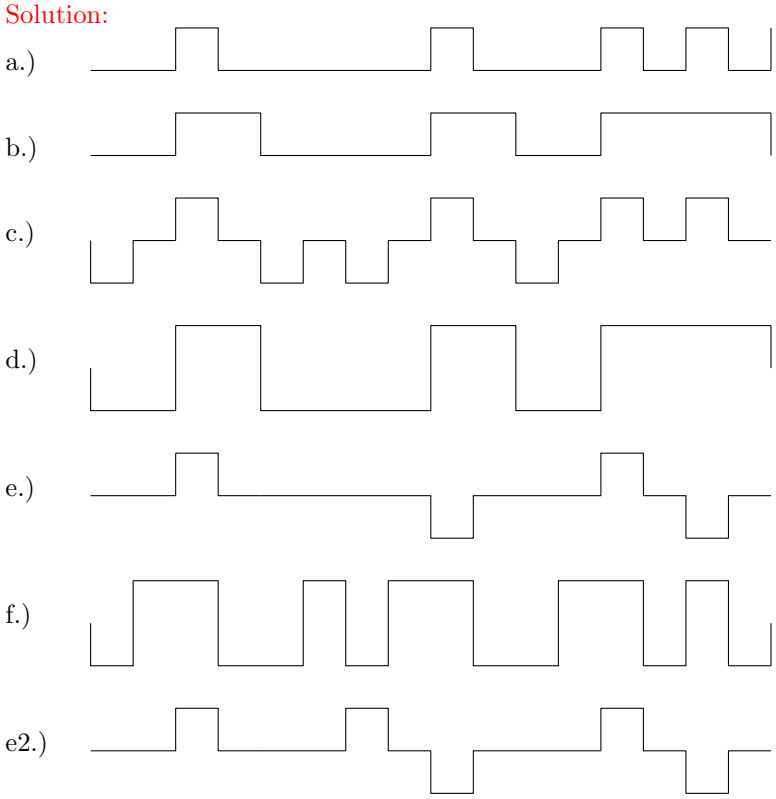
EE4440 HW#7 Solution

April 13, 2011

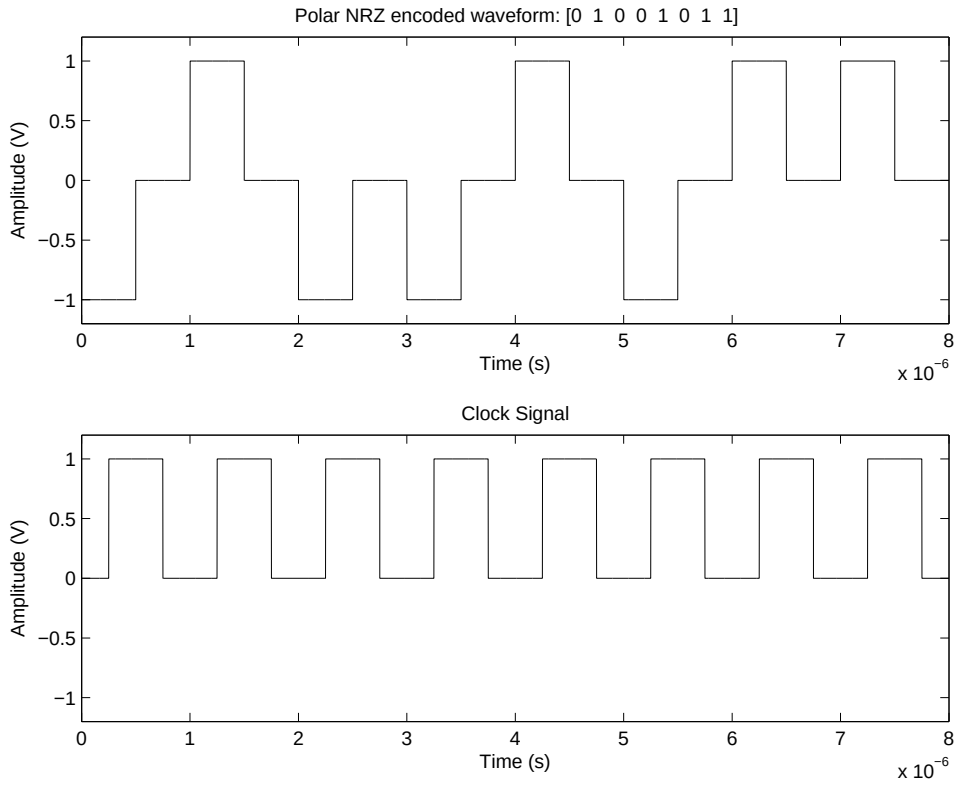
1. Draw the waveform for the binary sequence 0100 1011 using each of the following line codes:

   (a) Unipolar On-Off RZ
   (b) Unipolar On-Off NRZ
   (c) Polar RZ
   (d) Polar NRZ
   (e) Bipolar RZ
   (f) Manchester

   Solution:



2. Write a program in MATLAB that uses a bit time of $1\mu s$ to plot the waveform from Part c of Problem 1 as well as recovering and plotting the bit clock for the signal. Use a $\frac{1}{4}$bit time delay on the clock.
Solution:

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%John Davis Hw7 Problem 2 Soln 4/13/2011

function hw7problem2()
    bitstream=[0 1 0 0 1 0 1 1];

    obit=bitstream;

    bitstream=2*(bitstream-.5)

    Ts=1e-6/1000;
    Tb=1e-6;
    t=0:Ts:8*Tb;
    N=length(t);
    wave=zeros(1,length(t));
```

```
for n=1:length(bitstream)
    wave=wave+bitstream(n)*rect(t-(n-1)*Tb,Tb/2);
end

figure(1);
subplot(211);
plot(t,wave);
axis([0,t(end),-1.2, 1.2]);
title(['Polar NRZ encoded waveform: [' num2str(obit) ']']);
xlabel('Time (s)');
ylabel('Amplitude (V)');

subplot(212);
wave=[zeros(1,floor((N-1)/8/4)) wave];
wave=abs(wave(1:N));
plot(t,wave);
axis([0,t(end),-1.2, 1.2]);
title('Clock Signal');
xlabel('Time (s)');
ylabel('Amplitude (V)');

print -deps hw7problem2figure.eps

function x=rect(t,T)
    x=double(t>0 & t<T);
```

3. Re-draw the waveform of Part e of Problem 1 assuming that a bit error has occurred in bit 4. Assume that the bit error has resulted in a spurious, positive pulse.
   Solution: See solution to part 1, element 2e.

4. Find an application note or data sheet that describes a piece of hardware or software that performs Manchester encoding and decoding. Describe the method used for signal encoding, decoding, and clock recovery.
   Solution: Please see Atmel Application Note: Manchester Coding Basics, doc9164.pdf

5. If I want to stream audio data over a digital data link how much channel capacity is required for stereo 16 bit audio sampled at 44kHz? How does this rate compare to common rates for MP3 formatted audio files? If my channel bandwidth is 4kHz how much SNR must I have?
   Solution:The number of bits per second is found as follows

$$C = 2 \times \frac{16 bits}{sample} \times \frac{44000 samples}{second} = 1.408 M \frac{bits}{second}$$

   so the required SNR (in power dB) to achieve this capacity over a 4kHz

channel is:

$$SNR = 2^{\frac{1.408\times10^6}{4000}} - 1 = 9.17 \times 10^{105} = 1059dB$$

which is a LOT of power.

6. Look up 8b/10b encoding and explain what purposes (NOTE: purposes is plural!) it serves. How would you implement an 8b/10b encoder?
   Solution: See http://en.wikipedia.org/wiki/8B/10B. Amongst the purposes of this encoding is to balance the DC level of the code, as well as to provide enough transitions to enable reliable clock recovery.

7. Choose a product or technology that uses base band digital communications and find out what line code it uses. You may not choose RS-232 serial links or similar, or Ethernet because we talked about their line codes in class. What do they use? Examples you might look up include USB, Compact Discs, DVD, I^2C, etc.
   Solution: USB, for example uses a line code called NRZI.