EC 7511 COMMUNICATION SYSTEMS LABORATORY

PROJECT REPORT

DIGITAL COMMUNICATION SYSTEM USING MATCHED FILTER RECEIVER

By:

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Introduction:

If a filter produces an output in such a way that it maximizes the ratio of output peak power to mean noise power in its frequency response, then that filter is called Matched filter.

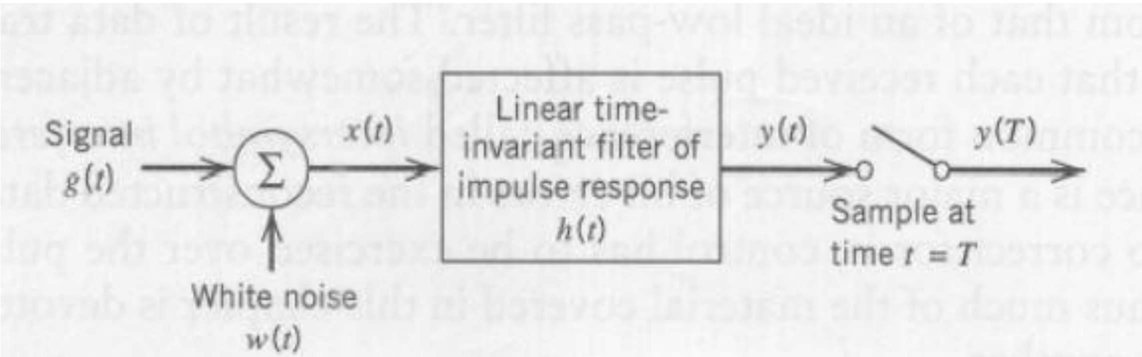
This is equivalent to convolving the unknown signal with a conjugated time-reversed version of the template. The matched filter is the optimal linear filter for maximizing the signal-to-noise ratio (SNR) in the presence of noise.

Principle:

A matched filter is obtained by correlating a known signal, or template, with an unknown signal to detect the presence of the template in the unknown signal.

So, the matched filter for a given signal x(t) has an impulse response h(t) which maximizes the correlation with the signal under search. It is deduced that $h(t)=x*(-t)$ corresponds to the matched filter.

Intersymbol interference is one type of noise added to a signal; using the matched filter eventually allows for detecting the signal buried in noise despite that interference.



The filter input x(t) consists of a pulse signal g(t) corrupted by additive channel noise w(t), as shown by,

$$\mathbf{x(t)=g(t)+w(t) \text{ ---[1]}}$$

where T is an arbitrary observation interval. The pulse signal g(t) may represent a binary symbol I or 0 in a digital communication system.

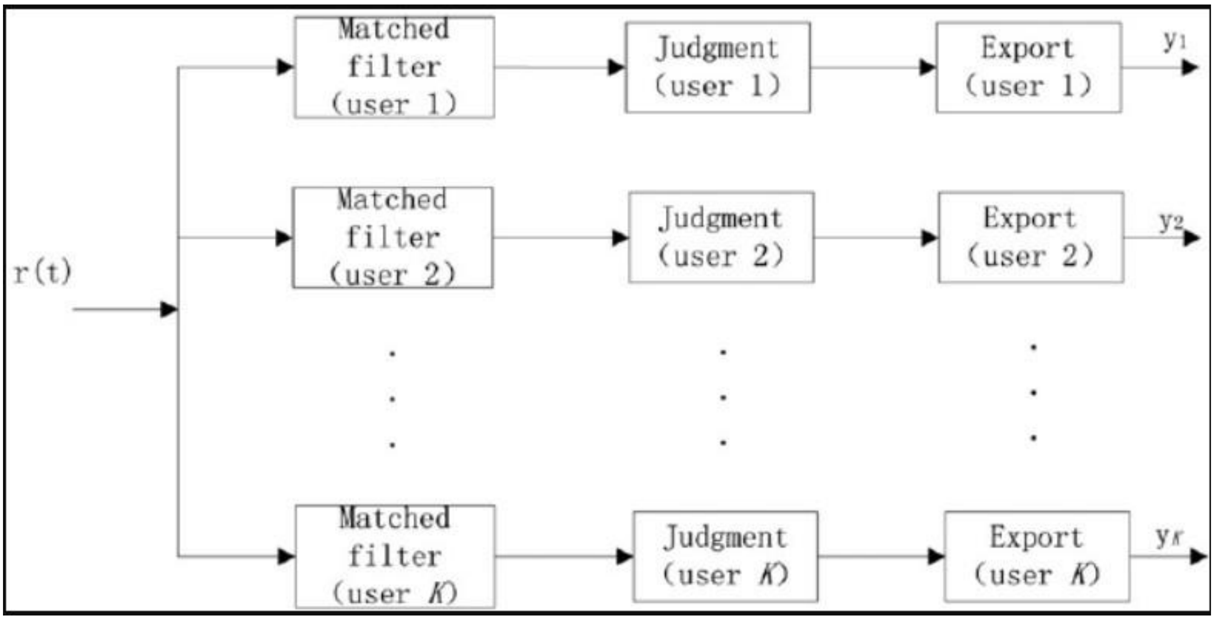
w(t) is the sample function of a white noise process of zero mean and power spectral density No/2.

Since the filter is linear, the resulting output y(t) may be expressed as,

$$\mathbf{y(t)=g_0(t) + n(t) \text{ ---[2]}}$$

Where $g_0(t)$ and n(t) are produced by the signal and noise components of the input x(t), respectively.

Block Diagram:



Where r(t) is the input & Y1,Y2…Yk are the outputs of the matched filter.

Applications:

- The matched filter is the optimal linear filter for maximizing the signal to noise ratio (SNR) in the presence of additive stochastic noise.
- Matched filters are commonly used in radar, in which a signal is sent out, and we measure the reflected signals, looking for something similar to what was sent out.
- Two-dimensional matched filters are commonly used in image processing, e.g., to improve SNR for X-ray pictures.

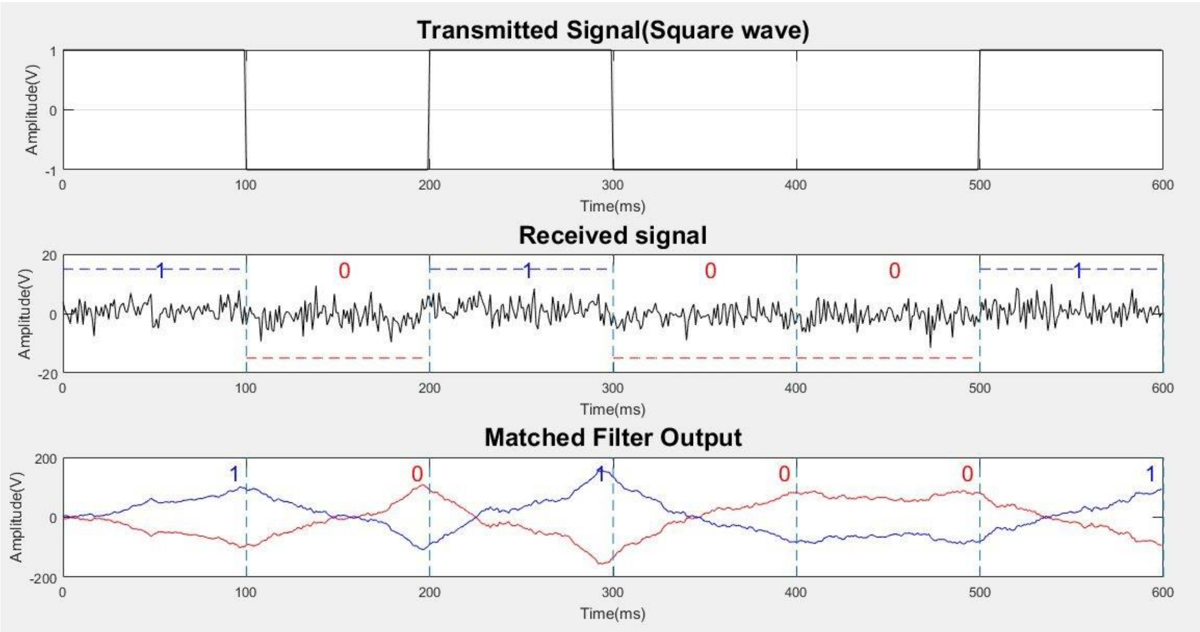
MATLAB Code:

```
%DIGITAL COMMUNICATION SYSTEM USING MATCHED FILTER
figure(1);
N = 100;
noise_amp = 3;
signal_set = 'bpsk2'; % either 'bpsk1', 'bpsk2', 'ask', or 'fsk'
bits = ['1', '0', '1', '0', '0', '1'];
if strcmp(signal_set, 'bpsk1')
signal1 = ones(1,N);
  signal0 = -signal1;
elseif strcmp(signal_set, 'bpsk2')
  signal1 = sqrt(2)*sin(2*pi*2*[0:N-1]/N);
  signal0 = -signal1;
elseif strcmp(signal_set,'fsk')
signal1 = sqrt(2)*sin(2*pi*2*[0:N-1]/N);
signal0 = sqrt(2)*sin(2*pi*3*[0:N-1]/N);
elseif strcmp(signal_set, 'ask');
signal1  =  ones(1,N);
signal0 = zeros(1,N);
else
perror(sprintf('Unknown signal set %s\n',signal_set));
end
color0='r';color1='b';
x = []; xcolor = [];
for n=1:length(bits)
x=[x eval(strcat('signal',bits(n)))];
xcolor = [xcolor eval(strcat('color',bits(n)))];
end
r = x + noise_amp*randn(1,length(x)); % Send signal through white noise channel
y1=filter(signal1(N:-1:1),1,r); % Run matched filters
y0=filter(signal0(N:-1:1),1,r);
subplot(3,1,1) % Graphics
t=[0:length(r)-1];
plot(t,x,'k');
xlabel('Time(ms)')
ylabel('Amplitude(V)')
h='Transmitted Signal'
title(h,'fontsize',18)
hold on
grid onsubplot(3,1,2)
t=[0:length(r)-1];
plot(t,r,'k');hold on
a = axis;
```

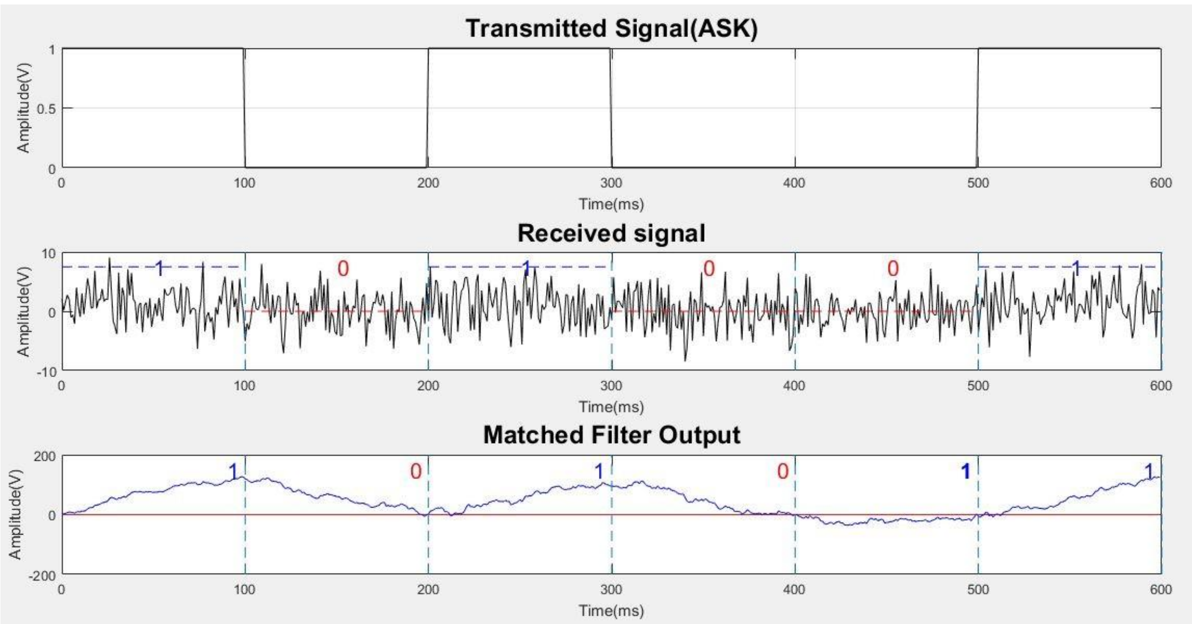
```
xp=x*(0.75*max(abs([a(3) a(4)])/max(x)));
for n=1:length(bits)
plot(t((n-1)*N+1:n*N),xp((n-1)*N+1:n*N),[xcolor(n) '--']);
xlabel('Time(ms)')
ylabel('Amplitude(V)')
h = text((n-1)*N+N/2,max(xp),bits(n));
set(h,'fontsize',16);
set(h,'color',xcolor(n));
end
for n=N*[1:length(bits)],h=line([n n],a(3:4));
   set(h,'linestyle','--');
end
h=title('Received signal');
set(h,'fontsize',18);
hold off
subplot(3,1,3)
plot(t,y0,color0,t,y1,color1)
xlabel('Time(ms)')
ylabel('Amplitude(V)')
a = axis;
for n=1:length(bits)
if y1(n*N)>= y0(n*N)
h = text(n*N-10,.75*a(4),'1');
set(h,'fontsize',16);set(h,'color',color1);
if bits(n) == '0'
set(h,'fontweight','bold');
end
else
h = text(n*N-10,.75*a(4),'0');
set(h,'fontsize',16);
set(h,'color',color0);
if bits(n) == '1'
set(h,'fontweight','bold');
end
end
end
for n=N*[1:length(bits)],h=line([n n],a(3:4));
   set(h,'linestyle','--');
end

h=title('Matched Filter Output');
set(h,'fontsize',18);
```

Outputs(From Matlab software):

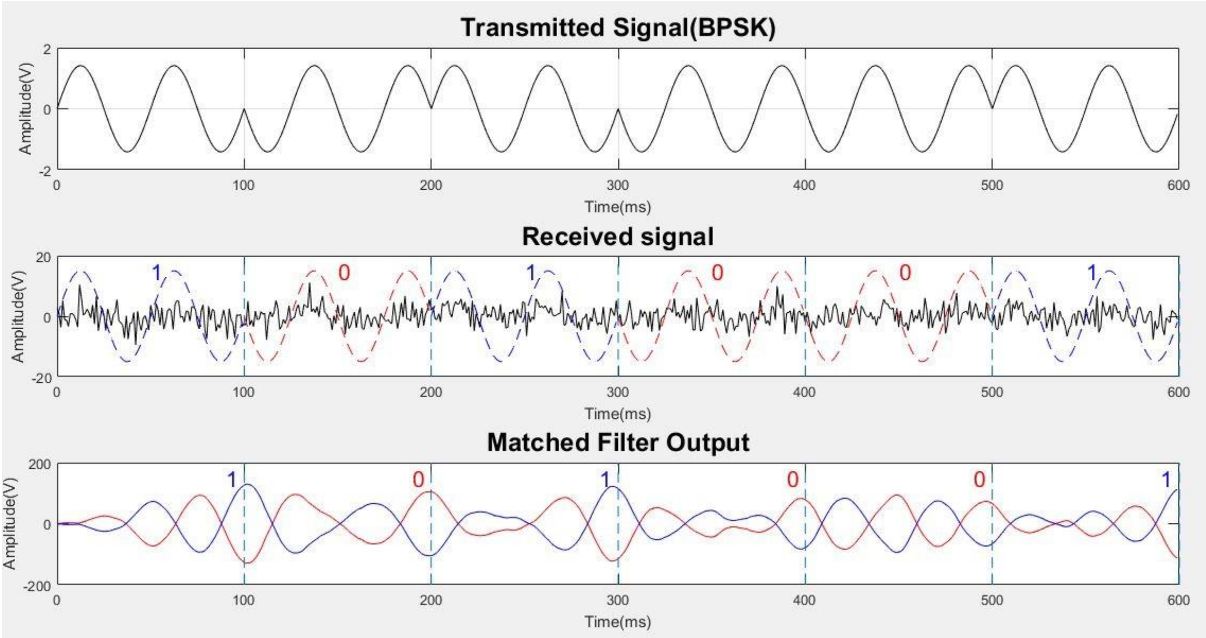
Input Square wave:



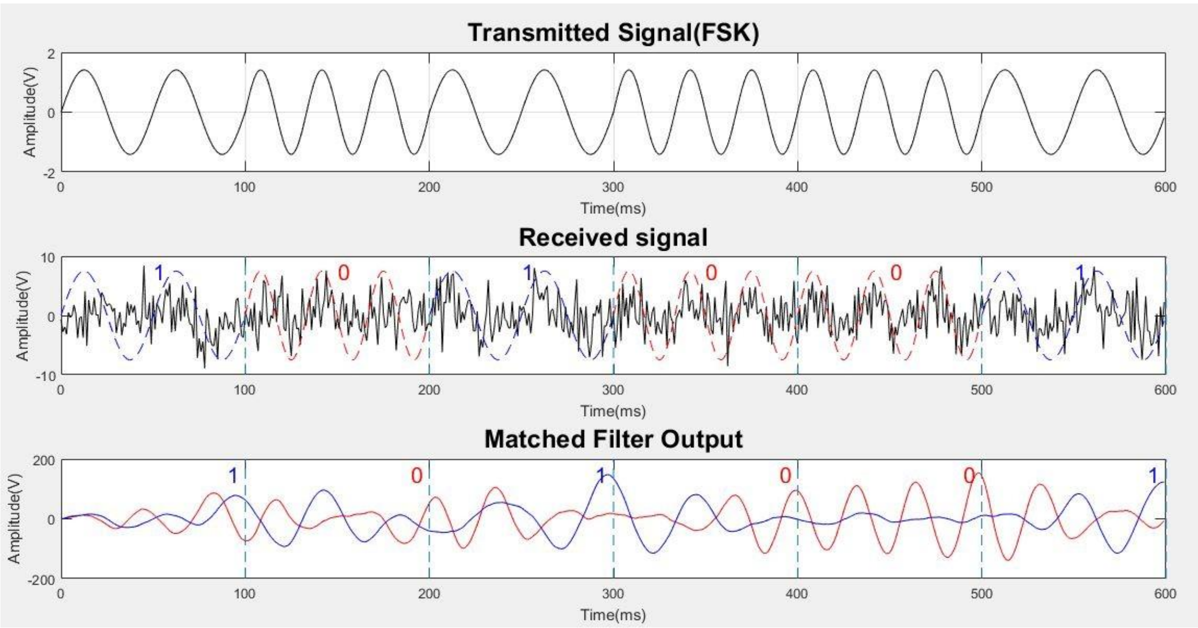
Input ASK(Amplitude shift keying) signal:



Input BPSK(Binary Phase shift keying) signal:



Input FSK(Frequency shift keying) signal:



Inference:

A simulation of digital communication system using a matched filter receiver is performed with the help of Matlab R2016a software and the outputs are observed.