Comparison of Baseband Waveforms of GMSK and Binary 2REC Modulation

by
Lourens Van Der Jagt
Knowledge Implementations, Inc.
32 Conklin Road, Warwick, NY 10990
Voice (914) 986-3492
Fax (914) 986-6441
Email:kiilvdj@attmail.com

Commercial Introduction

The code listed in this document is executable using Wolfram Research's Mathematica. This code has been developed by Knowledge Implementations Inc. and is considered to be Proprietary property of Knowledge Implementations, Inc. KII makes no represententation regarding the suitability of this code for use in any analysis. This code is distributed as shareware if you find the code useful, we would appreciate the payment of a shareware fee of $50.00 to be sent to Knowledge Implementations, Inc. 32 Conklin Road, Warwick, NY 10990 (U.S. Federal Tax ID. 22-2579700), ATTN:Document IEEE p802.11-93/71 Shareware. This code will be posted in soft form on the California Microwave Bulletin Board and on MathSource at Wolfram Research, Inc..

Abstract

In order to narrow the transmit spectrum of a waveform carrying binary information at a raw transmit rate of 1 megabit per second to the extent necessary to meet the spectral mask requirements of FCC 15.247 a number of partial response techniques are possible. In this paper a specific comparison of two of these techniques is provided. In our previous submission, Document IEEE P802.11-93/32 we attempted to illustrate the differences and similarities between various modulation options when viewed in the frequency domain. In this submission we provide information regarding the time domain. The two techniques examined are .39 GMSK and 2REC. The purpose of this comparison is to draw attention to the difference in the waveforms that will appear at the output of the demodulator in the absence of channel impairments and noise. It is hoped that this comparison will help those evaluating modulation methods to begin developing a heuristic feeling for the impact of various decisions on receiver complexity, cost, post-detection processing options, clock recovery and ability to operate in the presence of channel impairments and noise.

Baseband Waveform Generation

The premodulation filter in a GMSK system distorts the basic transmit waveform in such a way as to stretch a pulse of unit duration into a longer pulse. The function defined in the following cell represents the baseband waveshape that is used in a GMSK system to represent a unit pulse. This function is general in that it takes two parameters defining the relationship between the bit period and the bandwidth of the premodulation filter.

In[18]:=

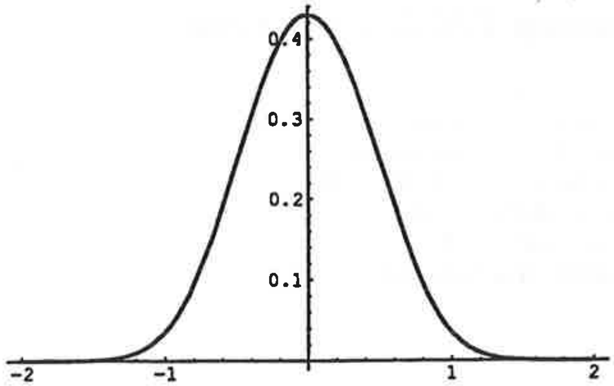
```
makegaussianp[bt_,bitperiod_]:=(kg=N[Sqrt[2/Log[2]] Pi];
     filterb=bt;
     width=-1 (Ceiling[1/(2 bt)]);
     duration=(-2 width)+1;
     p[t_]:=(Erf[-1 kg filterb (t-bitperiod/2)]+
             Erf[kg filterb (t+bitperiod/2)])/(bitperiod 4))
```

In[19]:=

```
makegaussianp[.39,1]
```

In[20]:=

```
Plot[p[t],{t,-2,2}]
```



Out[20]=

-Graphics-

A set of information streams that is intended to provide a set of information patterns that illustrates each possible bit pattern of length 3 is used to genenerate a set of baseband waveforms that illustrate the pattern dependent intersymbol interference that will exist in the baseband waveform. The information streams used for this are defined in the following cell.

```
Infostreams={{-1,-1,-1,-1,-1,-1,-1},{-1,-1,1,-1,-1,-1,-1},{-1,-1,-1,1,-1,-1,-
1},
{-1,-1,1,1,-1,-1,-1},{-1,-1,-1,-1,1,-1,-1},{-1,-1,1,-1,1,-1,-1},
{-1,-1,-1,1,1,-1,-1},{-1,-1,1,1,1,-1,-1}};
```

Out[21]=

```
{{-1, -1, -1, -1, -1, -1, -1}, {-1, -1, 1, -1, -1, -1, -1}, {-1, -1, -1, 1, -1, -1,
-1}, {-1, -1, 1, 1, -1, -1, -1}, {-1, -1, -1, -1, 1, -1, -1}, {-1, -1, 1, -1, 1, -1, -1}, {-1, -1, -1, 1, 1, -1,
-1}, {-1, -1, 1, 1, 1, -1, -1}}
```

Having established these information streams a plot is made of each of the streams. The vertical lines represent the center of the bit period. The cell that follows illustrates the GMSK case using the p[t] function defined above.

In[22]:=

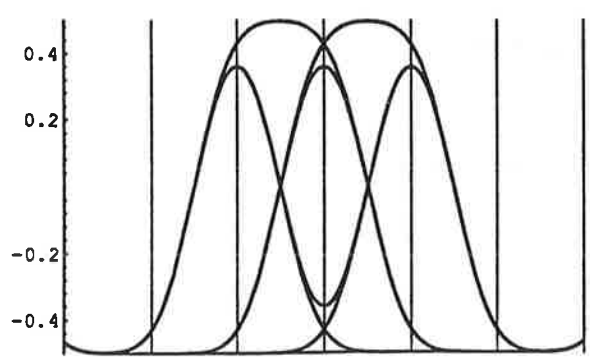
```
Do[temp[n]=Plot[Apply[Plus,{p[t-6],p[t-5],p[t-4],p[t-3],p[t-2],p[t-1],p[t]}
Infostreams[[n]]],

{t,0,6},PlotRange->{.5,-.5},GridLines->{{0,1,2,3,4,5,6},None},Axes->{False,True}
,AxesOrigin->{0,0}],
 {n,1,Length[Infostreams]}]
```

The following diagram is intended to simulate the eye pattern characteristic of this modulation choice.

In[25]:=

```
Show[temp[1],temp[2],temp[3],temp[4],temp[5],temp[6],temp[7]]
```



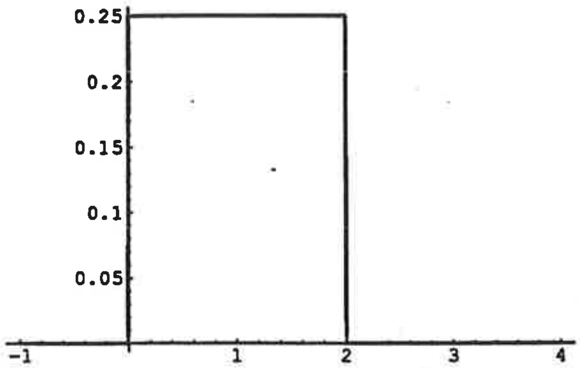
Having examined the waveforms that result from a choice of GMSK, the p[t] function is redefined to the square waveform, that is utilized in the 2REC modulation method defined earlier. This pulseshape is then run under the same conditions as above to illustrate the waveform that would appear at the output of the demodulator.

In[26]:=

```
Clear[p];
p[t_]:=0/;t<=0;
p[t_]:=.25/;0<t<=2;
p[t_]:=0/;t>2;
```

In[30]:=

```
Plot[p[t],{t,-1,4}]
```



Out[30]=

```
-Graphics-
```

In[31]:=

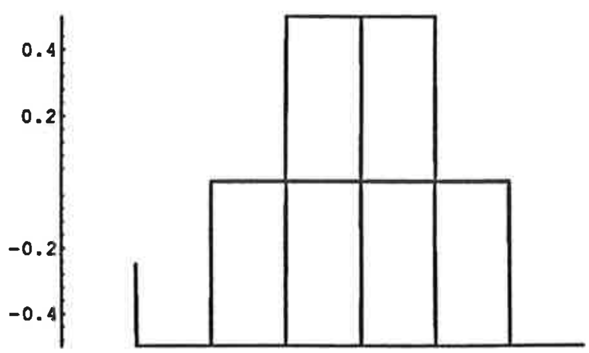
```
Do[temp[n]=Plot[Apply[Plus,{p[t-6],p[t-5],p[t-4],p[t-3],p[t-2],p[t-1],p[t]}
  Infostreams[[n]]],

{t,1,7},PlotRange->{.5,-.5},GridLines->{{0,1,2,3,4,5,6},None},Axes->{False,
True},AxesOrigin->{0,0}],
 {n,1,Length[Infostreams]}]
```

In this case the simulated eye diagram that would result appears in the following diagram.

In[36]:=

```
Show[temp[1],temp[2],temp[3],temp[4],temp[5],temp[6],temp[7],GridLines->{Fa
lse,False}]
```



Conclusion

The plots that appear above demonstrate the differences between GMSK and 2REC modulation as they will likely appear at the output of a demodulator. The GMSK waveform exhibits smooth rise and fall characteristics and amplitude variations that are data pattern dependent. The edges of the 2REC waveform are sharp and exhibit a trilevel amplitude characteristic. This time domain picture is consistent with the frequency domain observation that shows a wider main lobe in the case of the GMSK waveform and somewhat higher sidelobes in the 2REC waveform.