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MSK signal with Q&I engine on VSG6G1



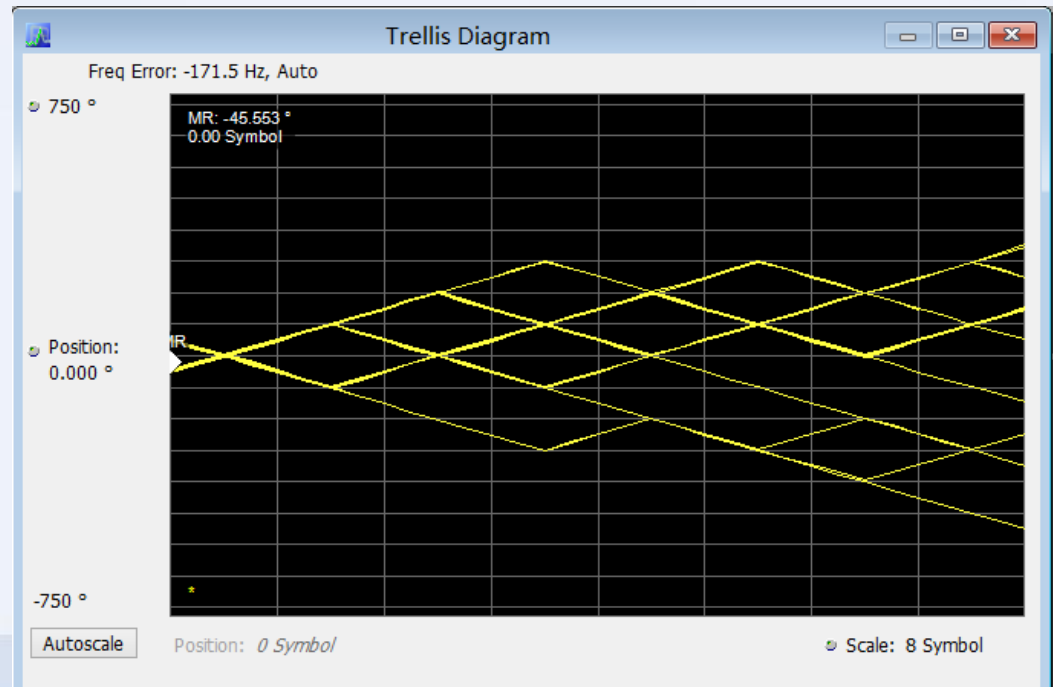
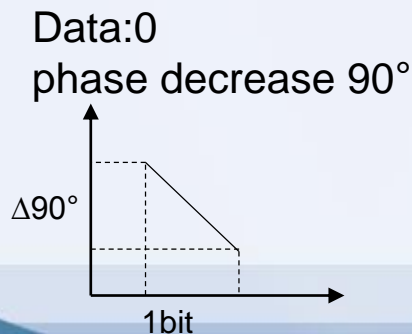
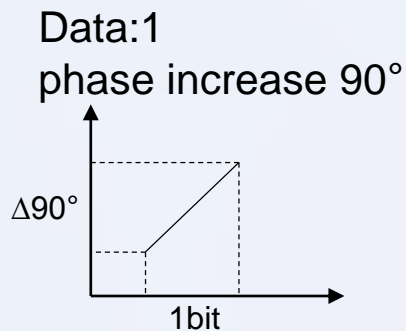


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minimum-shift keying (MSK) concept

minimum-shift keying (MSK) is a type of continuous-phase frequency-shift keying (CPFSK), the modulation index $m=0.5$, the carrier phase will be linearly changed by $+90^\circ/-90^\circ$ depending on the data is 1, or 0. so that total phase points will be $0^\circ, 90^\circ, 180^\circ, 360^\circ$.





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MSK I&Q pattern

MSK phase is only changed between 0,90,180,270 with two direction increase or decrease, so that I&Q pattern will be 8.

They are:

Pattern 000, phase from $90^{\circ} \sim 0^{\circ}$

Pattern 001, phase from $180^{\circ} \sim 90^{\circ}$

Pattern 010, phase from $270^{\circ} \sim 180^{\circ}$

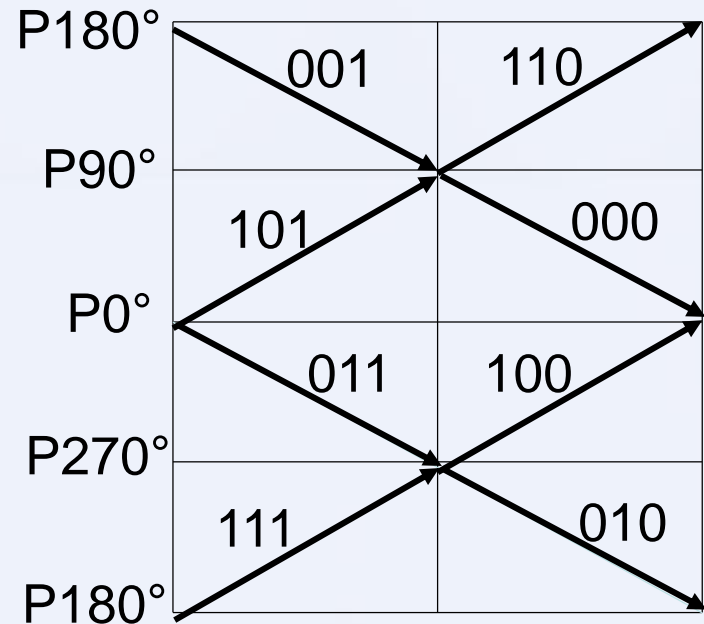
Pattern 011, phase from $0^{\circ} \sim 270^{\circ}$

Pattern 100, phase from $270^{\circ} \sim 0^{\circ}$

Pattern 101, phase from $0^{\circ} \sim 90^{\circ}$

Pattern 110, phase from $90^{\circ} \sim 180^{\circ}$

Pattern 111, phase from $180^{\circ} \sim 270^{\circ}$



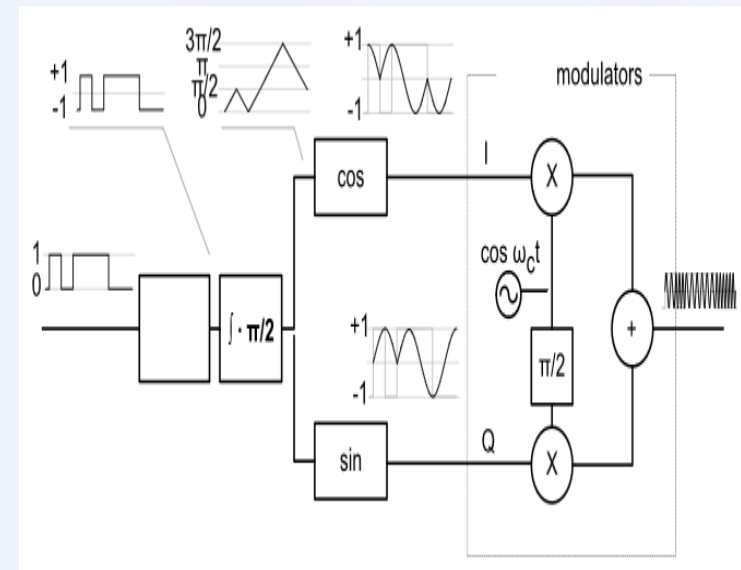


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MSK I&Q pattern Calculation 1

1. **Generate linear phase curve within one bit.**
2. **Input phase curve into COS to generate I data**
3. **Input phase curve into SIN to generate Q data**
4. **Convert I&Q data input DAC input data.**





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MSK I&Q pattern Calculation 2

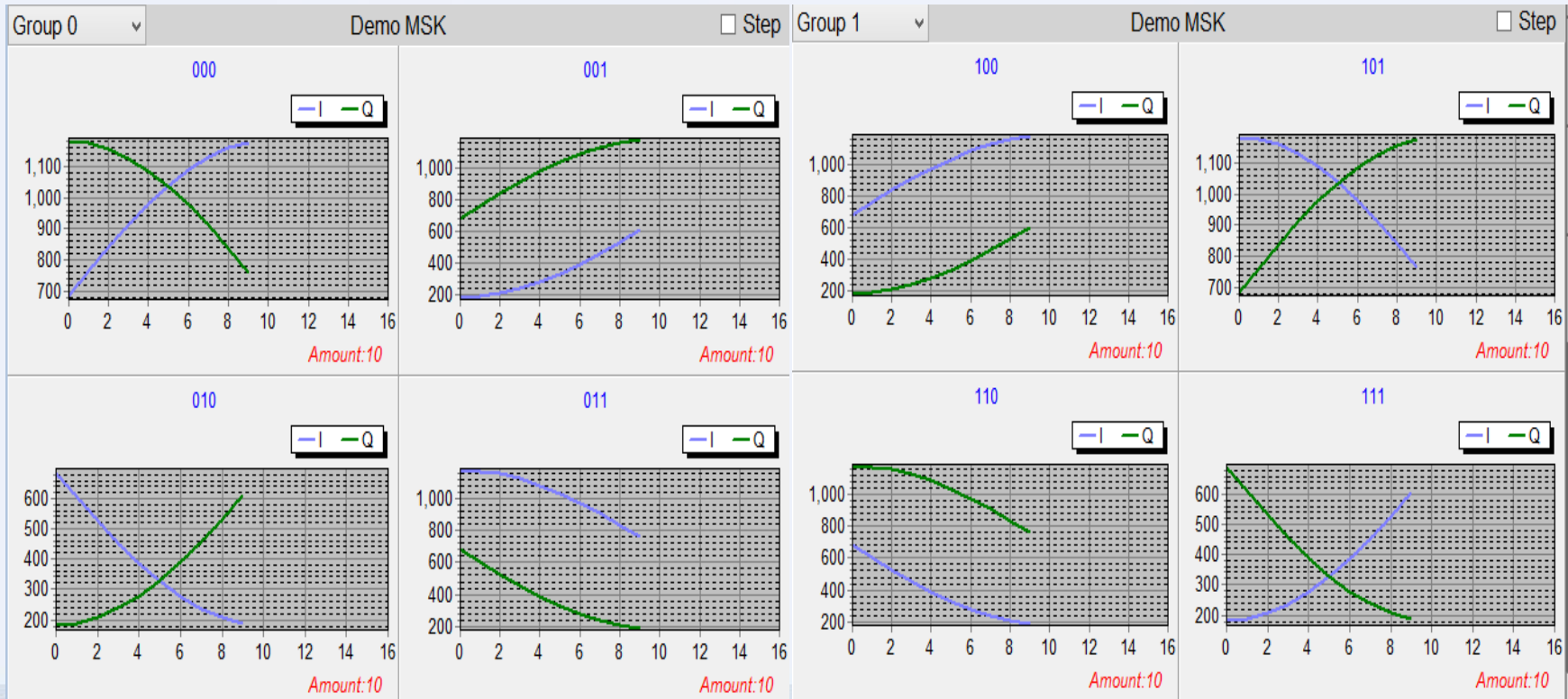
Following table is one example of calculation for Pattern 000 by Excel

Phase in Degree	90	81	72	63	54	45	36	27	18	9	0
Phase in Radian	1.57	1.413	1.256	1.099	0.942	0.785	0.628	0.471	0.314	0.157	0
I DATA from COS	0.0008	0.1571	0.3096	0.4545	0.5882	0.7074	0.8092	0.8911	0.9511	0.9877	1
Q DATA from SIN	1.0000	0.9876	0.9509	0.8908	0.8087	0.7068	0.5875	0.4538	0.3089	0.1564	0
I DATA on DA	683	762	838	910	977	1037	1088	1129	1159	1177	1183
Q DATA on DA	1183	1177	1158	1128	1087	1036	977	910	837	761	683



MSK I&Q pattern Calculation 3

Using Excel, it will be easy to generate 8 pieces of I&Q pattern





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MSK I&Q pattern length

The I&Q pattern length can be changed, it is the length of 10 at above example. The mini length of I&Q pattern for MSK will be 3, if it reduce to 1, the modulation will be changed into OQPSK.

When I&Q pattern length is small, the data rate will be fast, pattern resolution will be low.

When I&Q pattern length is large, the data rate will be slow, pattern resolution will be high. So that it need to trade off to select pattern length. Normally, pattern length can be 10.



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I&Q engine Data stream file 1

I&Q engine Data stream file have 4 section:

1. Binary Data input with FSK mode
2. S/P mode setting
3. Code converter setting
4. I&Q pattern data

For MSK setting, FSK mode must be 1, then input any data stream. It limit by 4K/pattern length.

S/P mode must be select 4,3

Code converter must be select 1

I&Q pattern must be 8 group, the pattern length can be changed.

The I&Q waveform will be generated based on input data steam.



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I&Q engine Data stream file 2

Following is example of I&Q data stream file

```
Binary_IN,1,000110111101010000011011110101001010101000101
S/P_mode,4,3
Code_converter,1
PatternI_000,683,762,838,910,977,1037,1088,1129,1159,1177
PatternQ_000,1183,1177,1158,1128,1087,1036,977,910,837,761
PatternI_001,183,189,208,238,279,330,390,456,529,605
PatternQ_001,684,762,838,911,977,1037,1088,1129,1159,1177
PatternI_010,682,604,527,455,388,329,278,237,207,189
PatternQ_010,183,189,208,238,279,330,390,457,529,606
PatternI_011,1183,1177,1158,1128,1087,1036,976,909,836,760
PatternQ_011,681,603,527,455,388,328,278,237,207,189
PatternI_100,682,760,836,909,976,1036,1087,1128,1158,1177
PatternQ_100,183,189,207,237,278,328,388,455,527,603
PatternI_101,1183,1177,1159,1129,1088,1037,977,910,838,762
PatternQ_101,683,761,837,910,977,1036,1087,1128,1158,1177
PatternI_110,683,605,529,456,390,330,279,238,208,189
PatternQ_110,1183,1177,1159,1129,1088,1037,977,911,838,762
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PatternQ_111,684,606,529,457,390,330,279,238,208,189
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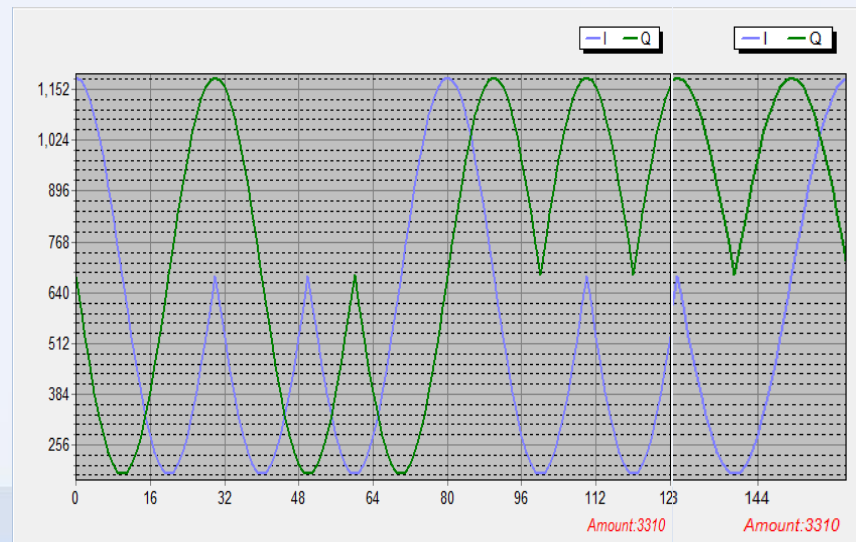
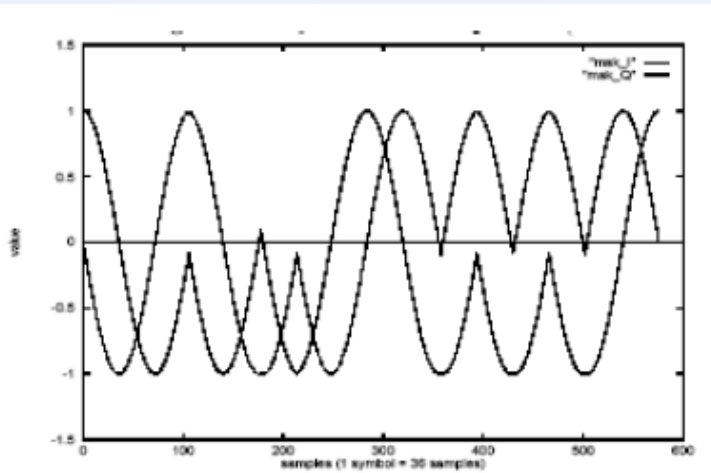


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MSK I&Q waveform example

The most of text book will be discussed with the MSK and shown the MSK I&Q real waveform, following is example, the right figure is from test book and left waveform is from TSG PC application, the input data will be 000110111010100. The both waveform are exactly same.





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MSK setting on the VSG6G1

The MSK modulation will be implemented by I&Q engine based on the I&Q pattern which you input into the I&Q stream file.

So that you only need to input stream data, the MSK signal will be generated at VSG6G1 output port.

You need to select carrier frequency and amplitude.

Another important parameter is data rate, you can change I&Q step count value to choose the right data rate.

The system clock is 72MHz. If you select I&Q step count is 72, and I&Q pattern length is 10, then the data rate will be $72\text{MHz}/(72*10)=100\text{KHz}$,

If you change I&Q step count =144, and I&Q pattern length is still 10, the data rate will be $72\text{MHz}/(144*10)=50\text{KHz}$,