

## Bluetooth System Simulation

Maurice L. Schiff, Ph.D., Chief Scientist, ELANIX, Inc.

### Introduction

Bluetooth is a wireless system designed for short range connections of computing and telecommunication devices, much like the IrDA devices in common use today.

One advantage of Bluetooth over IrDA is that the former does not need line of sight and can transmit through walls, etc.

In this application note we will describe the basic nature of the Bluetooth signal and demonstrate a corresponding SystemView simulation file.

### Bluetooth System Specification

**Table 1** provides the basic specifications of the Bluetooth system. Bluetooth combines FM modulation and frequency hopping (FH).

Specification	Value
Frequency band	2.45 GHz ISM band
FH hopping channels	23 or 79 depending on country
FH hop rate	1600 hops/s
FH channel spacing	1 MHz
Duplex method	TDD
Duplex format	625 usec (1/1600 sec.) on and off
Modulation Format	GFSK
GFSK BT	.5
Modulation data rate	1 MBps
Modulation index	.28 ó μ ó .35

Table 1. Bluetooth system specification

### Bluetooth System Simulation

**Figure 1** is the block diagram of the simulation (Bluetooth.svu). This simulation represents one concept.

Alternative approaches are possible. The elements of the simulation are detailed below.

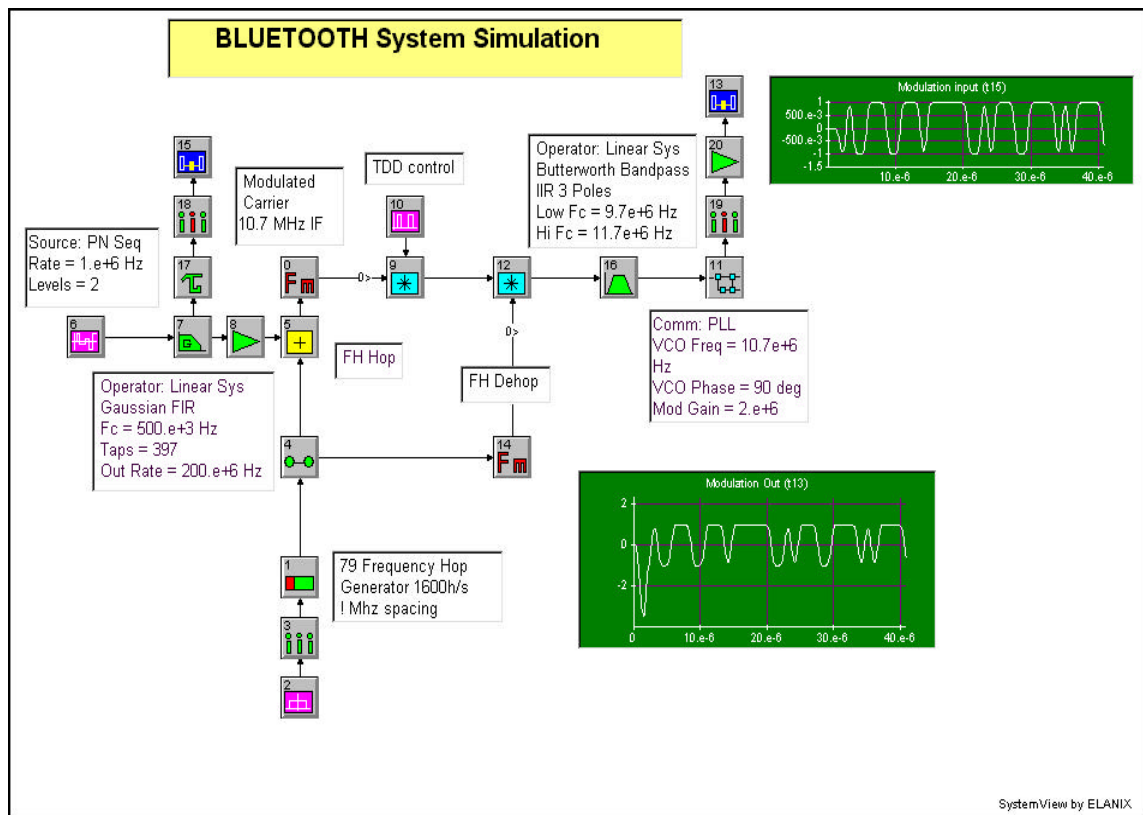


Figure 1. Bluetooth system simulation

**FH frequency command generation:** Tokens 1, 2, 3 and 4 generate the FH frequency commands. Token 2 is a uniform random number generator set over the range 0 to 79e6 (79 frequencies @ 1 MHz spacing). This token is then sampled at the hop rate, 1600 hops/s. Taking the integer part generates the hop frequency commands.

**Data frequency command generation:** The 1 Mbps data source (token 6) is passed through a Gaussian LPF (token 7) set for a BT product of 0.5. The resulting output is passed through a Gain set to 140000 (token 8). This produces the desired FM modulation index of 0.28.

**GFSK Modulation:** The FH hop command signal is added to the data signal, and the composite drives the VCO modulator (token 0). Another method would be to separately FM modulate the data and the FH signal, and then mix the two. The VCO is set to a nominal frequency of 10.7 MHz. When mixed by the FH demodulation signal, all hops are collapsed to this IF frequency.

**TDD Control:** The TDD control is accomplished by blanking out the modulator. A square wave signal (token 10) is set to a 1.25 msec period. It is 'on' for 625 usec and then 'off' for 625 usec.

**FH Demodulation:** The FH hop commands are used to drive a VCO (token 14). The output of the VCO is mixed with the received FH signal. The difference frequency is at the 10.7 MHz IF, and the sum frequency is eliminated by the bandpass filter (token 16).

**If Processing:** After the FH dehop operation, the resulting signal is at 10.7 MHz. A 3 Pole Butterworth Bandpass IIR (token 16) with a band pass low Fc of 9.7e+6 Hz and a high Fc of 11.7e+6 Hz is used as the standard IF filter.

**PLL Demodulation:** We use a PLL (token 11) to directly demodulate the signal from the 10.7 MHz IF frequency. The PLL token has an internal LPF after the phase detector to eliminate the sum frequency from the loop. The cutoff frequency is set at 4 MHz which is wide enough to pass the desired signal. The modulation gain is set at 2e6. This gives the loop response time sufficient to demodulate the signal.

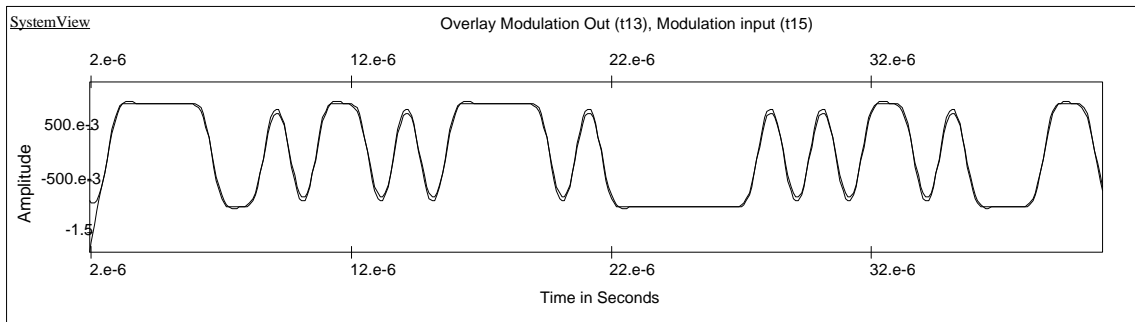


Figure 2. Overlay of input and output data signals

**Figure 2** shows the net result of the simulation. It is the overlay of the data input waveform with the recovered waveform output by the PLL demodulator. Note the near perfect agreement.

### Conclusion

This application note describes the basic modulation parameters of the Bluetooth wireless system and presents a SystemView simulation example which implements this specification.

For more information on SystemView simulation software please contact:

ELANIX, Inc.  
 5655 Lindero Canyon Road, Suite 721  
 Westlake Village CA 91362  
 Tel: (818) 597-1414  
 Fax: (818) 597-1427

Visit our web home page ([www.elanix.com](http://www.elanix.com)) to download an evaluation version of the software that can run this simulation as well as other user entered designs.