

ULTRA-WIDEBAND PULSE GENERATING CIRCUIT AND METHOD THEREOF

Field of the Invention

[0001] The present invention generally relates pulse generating systems. In particular, the invention relates to a circuit for generating Ultra-WideBand (UWB) pulses.

Background of the Invention

[0002] Ultra-WideBand (UWB) communications has gain widespread interest in the recent years. UWB signals may be defined as any signals with a fractional bandwidth of greater than 20% of the centre frequency or a signal with bandwidth of greater or equal to 500MHz.

[0003] UWB wireless communications systems utilize the transmission of data in short pulses which are spread out over a wide swath spectrum. The wide bandwidth nature of UWB communication ensures high channel capacity and high resistance to noise and interference.

[0004] Furthermore, UWB communication systems can share frequencies that are used by other applications because the transmission duration is extremely short and the transmission power is very low. This results in extremely low probability of causing interference with other signals.

[0005] UWB pulse generators for generating of UWB signals are a key component to the UWB communication systems. However, present methods and systems tend to be expensive and overtly complicated.

[0006] At present there exists some methods of pulse generation that uses input waveform triggers that needs to be carefully shaped so as to drive the UWB generator to operate in a stable and unstable region. However, for such methods the input waveform needs to be very narrow and that would involve high costs implementing it digitally.

[0007] There are also other UWB generators that disadvantageously requires high trigger voltages in the order of a few -kV to induce transit time avalanche breakdown of a diode. While effective, this method disadvantageously unsuitable for low power applications.

[0008] Other possible methods involve the use of expensive high speed digital circuits and Analog-Digital Converters. They are used to generate large bandwidth UWB pulses that are also similarly unsuitable for low power applications.

[0009] It can thus be seen that there exists a need for a simple and low cost method for generating UWB pulses that can overcome or at least alleviate the disadvantages of the existing prior art.

Summary of the Invention

[0010] The present invention seeks an Ultra-Wideband pulse generating circuit.

[0011] Accordingly, in one aspect, the present embodiment provides, a circuit for generating an Ultra-WideBand (UWB) pulse comprising: an initial pulse shaping portion; a high gain-bandwidth product transistor coupled to the initial pulse shaping portion; a DC power supply for biasing the high gain-bandwidth product transistor;

a first differentiator, a second differentiator and

a third differentiator; wherein an input voltage waveform comprising at least one rising edge is input to the initial pulse shaping portion, causing the high gain-bandwidth product transistor to produce a fast falling edge corresponding to the at least one rising edge; and differentiating the fast falling edge by the first, second and third differentiators to generate a UWB pulse.

[0012] In another aspect, the present embodiment provides, a method for generating an Ultra-WideBand (UWB) pulse comprising the steps: providing a high gain-bandwidth product transistor; providing an input voltage waveform having at least one rising edge; generating a second voltage waveform having at least one fast falling edge by the high gain-bandwidth product transistor corresponding to the at least one rising edge; differentiating the second voltage waveform to produce a third voltage waveform having at least one sharp negative pulse; differentiating the third voltage waveform to produce a fourth voltage waveform having at least one enhanced negative pulse having a narrower pulse width than the at least one sharp negative pulse; and differentiating the fourth voltage waveform to produce a fifth voltage waveform having at least one UWB pulse.

Brief Description of the Drawings

[0013] A present embodiment of the present invention will now be more fully described, with reference to the drawings of which:

[0014] FIG. 1 illustrates a block diagram of an example of a system utilizing a UWB Pulse generator;

[0015] FIG. 2 illustrates a circuit diagram of a UWB pulse generator in accordance with the present embodiment;

[0016] FIG. 3A illustrates an input voltage waveform into the UWB pulse generator of FIG. 2;

[0017] FIG. 3B illustrates an output voltage waveform at a collector of a high gain-bandwidth product transistor of the UWB pulse generator of FIG. 2;

[0018] FIG. 3C illustrates an output voltage waveform after a first differentiation in the UWB pulse generator of FIG. 2;

[0019] FIG. 3D illustrates an output voltage waveform after a second differentiation in the UWB pulse generator of FIG. 2;

[0020] FIG. 3E illustrates an output voltage waveform of the UWB pulse generator of FIG. 2;

[0021] FIG. 4A illustrates a time domain output waveform of the output voltage of FIG. 3E; and

[0022] FIG. 4B illustrates a frequency domain output waveform of the output voltage of FIG. 3E.

Detailed description of the Drawings

[0023] A UWB pulse generator with a preferred embodiment is described. In the following description, details are provided to describe the preferred and the alternate embodiment. It shall be apparent to one skilled in the art, however that the invention may be practiced without such details. Some of the details may not be described at length so as not to obscure the invention.

[0024] The present embodiment proposes a simple and low costs circuit for a UWB pulse generator utilizing a high speed switch. The high speed switch in the present embodiment is a high gain-bandwidth product transistor. An example of such a transistor is a *High Performance Isolated Collector Silicon Bipolar Transistor* HBFP-0405 by Hewlett Packard having a high transition frequency (f_T) of 25 GHz.

[0025] Referring to FIG. 1, an example of an application using UWB, may be a communications system 30 where a UWB transmitter comprises a Pulse Position Modulator (PPM) 12 and a UWB pulse generator 50. Data is sent out frame by frame in the PPM 12 to the UWB pulse generator 50. The UWB pulse generator 50 then converts the data into UWB pulses to be transmitted.

[0026] A UWB receiver comprising a PPM demodulator 13 and a UWB pulse detector 14 is then used to receive transmitted UWB pulses and then demodulate the UWB signal to retrieve the data. The actual implementation of the PPM modulator and demodulator is well known in the art.

[0027] The present embodiment of a circuit for the UWB pulse generator in accordance with the present embodiment is shown in FIG. 2. Referring to FIG. 2, the circuit of the UWB pulse generator 50 comprises a high gain-bandwidth product transistor 60. For the generating of UWB pulses, an input voltage waveform 51 is used as input to the UWB pulse generator 50. The UWB pulse generator 50 utilizes the rapid turn-ON characteristics of the high gain-bandwidth product transistor 60 to generate an extremely fast falling edge signal for the initial generation of the UWB pulse.

[0028] The circuit further comprises a first capacitor (C1) 53 and a first resistor (R1) 54 coupled in series. The first capacitor (C1) 53 is further coupled to the

input voltage waveform 51. The first resistor (R1) 54 is further coupled to a base 61 of the high gain-bandwidth product transistor 60.

[0029] A second resistor (R2) 55 is also coupled to the base 61 of the high gain-bandwidth product transistor 60. The second resistor (R2) 55 is further coupled to a diode 57 which is further coupled to a collector 62 of the high gain-bandwidth product transistor 60. The diode 57 then serves to act as a voltage clamp to limit the voltage of the collector 62. A third resistor (R3) 56 couples the base 61 of the high gain-bandwidth product transistor 60 to ground. The first capacitor (C1) 53, the first resistor (R1) 54, the second resistor (R2) 55 and the third resistor (R3) 56 together form an initial pulse shaping portion. The initial pulse shaping portion of the circuit receive the input of the input voltage waveform 51, which comprises a substantially square wave. Referring to FIG. 3A, an example of an input voltage waveform 51 in accordance with the present embodiment is shown.

[0030] The circuit of the UWB pulse generator 50 further also comprises of a DC power supply 40 for the biasing of the high gain-bandwidth product transistor 60. An inductor (L1) 58 in series with a fourth resistor (R4) 59 is coupled to the collector 62 of the high gain-bandwidth product transistor 60. The inductor (L1) 58 serves to act as a RF choke to prevent signal leakage through the DC power supply 40.

[0031] The input voltage waveform 51 is first shaped by the initial pulse shaping portion. The rising edge of the input waveform is thus enhanced by the initial pulse shaping portion to have a faster rising edge. The rising edge of the input voltage waveform 51 causes the high gain-bandwidth product transistor 60 to switch ON rapidly. As the high gain-bandwidth product transistor 60 switches ON rapidly, voltage at the collector 62 drops off rapidly. Referring to FIG. 3B, this creates a

fast falling edge at the collector 62 corresponding to rising edge of the input voltage waveform 51.

[0032] The circuit of the UWB pulse generator 50 further also comprises of three differentiators in series. A first differentiator is coupled to the collector 62 of the high gain-bandwidth product transistor 60. The first differentiator is further coupled to the second differentiator. The second differentiator is coupled to the third differentiator.

[0033] The first differentiator comprises a second capacitor (C2) 71 having an input end coupled to the collector 62 of the high gain-bandwidth product transistor 60 and a output end coupled to ground via a fifth resistor (R5) 72. The second differentiator comprises a third capacitor (C3) 73 having an input end coupled to the output end of the second capacitor (C2) 71, and the output end coupled to ground via a sixth resistor 74. The third differentiator comprises a fourth capacitor (C4) 75 having a input end coupled to the output end of the third capacitor (C3) 73, and a output end coupled to ground via a load resistor (RL) 78.

[0034] The fast falling edge at the collector 62 thus undergoes three differentiations. Referring to FIG. 3C, the voltage waveform after a first differentiation is shown. The output at vc1 from the first differentiator is a sharp negative pulse.

[0035] This sharp negative pulse is input into the second differentiator producing an enhanced negative pulse having a smaller pulse width. Referring to FIG. 3D, the voltage waveform after a second differentiation at vc2 producing the enhanced negative pulse is shown.

[0036] This enhanced negative pulse having a smaller pulse width is then input into the third differentiator producing an UWB pulse. Referring to FIG. 3E, the voltage

waveform after a third differentiation at vc3 producing the UWB pulse is shown. The UWB pulse produced is output at the output end of the fourth capacitor (C4) 75.

[0037] Referring to FIG. 4A, a time domain waveform of the UWB pulse produced by the UWB pulse generator 50 of the present embodiment is shown. Referring to FIG. 4B, a frequency domain waveform of the UWB pulse produced is shown.

[0038] The present UWB pulse generator 50 advantageously lowers the costs of generating UWB pulses. Furthermore, less power is also consumed by the UWB pulse generator 50. This is achieved by the high gain-bandwidth product transistor 60 being ON only when an input waveform is received.

[0039] In addition, the UWB pulse generated is dependent more on the characteristics of the high gain-bandwidth product transistor 60 and not on the width of the input waveform. This advantageously allows a wider variety of different input waveforms to be used.

[0040] The example of the present embodiment may further have the following values for the components:

C1=33 pF	R1=3.3 Ohm	R2=1300 Ohm
R3=270 Ohm	R4=1000 Ohm	L1=33 μ H
C2=3.6 pF	R5=50 Ohm	C3=1.8 pF R6=50 Ohm
C4=1 pF	RL=50 Ohm	

[0041] The present embodiment may further be described by way of a corresponding method. The method in accordance with the present embodiment then uses a high gain-bandwidth product transistor 60 for generating a second voltage waveform having a fast falling edge corresponding to an input of a first voltage waveform having a rising edge.

[0042] The method may further involve the shaping of the first voltage waveform causing the at least one rising edge to have a faster rising edge before input to the high gain-bandwidth product transistor 60.

[0043] The second voltage waveform then undergoes a first differentiation producing a third voltage waveform having a sharp negative pulse.

[0044] The third voltage waveform then undergoes a second differentiation producing a fourth voltage waveform having an enhanced negative pulse. The enhanced negative pulse has a narrower pulse width than that of the third voltage waveform.

[0045] The fourth voltage waveform then undergoes a third differentiation producing a fifth voltage waveform which resembles a first-derivative Gaussian monopulse which in effect is a UWB pulse.

[0046] It will be appreciated that various modifications and improvements can be made by a person skilled in the art without departing from the scope of the present invention.

Claims

1. A circuit for generating an Ultra-WideBand (UWB) pulse comprising:
 - an initial pulse shaping portion;
 - a high gain-bandwidth product transistor coupled to the initial pulse shaping portion;
 - a DC power supply for biasing the high gain-bandwidth product transistor;
 - a first differentiator,
 - a second differentiator and
 - a third differentiator;wherein an input voltage waveform comprising at least one rising edge is input to the initial pulse shaping portion, causing the high gain-bandwidth product transistor to produce a fast falling edge corresponding to the at least one rising edge; and differentiating the fast falling edge by the first, second and third differentiators to generate a UWB pulse.
2. The circuit according to claim 1, wherein the initial pulse shaping portion comprises:
 - a first capacitor;
 - a first resistor;
 - a second resistor; and
 - a third resistor;wherein the first capacitor is coupled to the first resistor, the first capacitor is further coupled to the input voltage waveform, the first resistor is further coupled to a base of the high gain-bandwidth product transistor;
the second resistor is coupled to the base of the high gain-bandwidth product transistor, the second resistor further coupled to a diode which is further coupled to a collector of the high gain-bandwidth product transistor, and

the third resistor couples the base of the high gain-bandwidth product transistor to ground.

3. The circuit according to claim 2, further comprising:

an inductor coupled to the DC power supply, the inductor further coupled to a fourth resistor which is coupled to the collector of the high gain-bandwidth product transistor, so that the inductor is operable as a RF choke to prevent signal leakage through the DC power supply.

4. The circuit according to claim 1, wherein the first differentiator differentiates the fast falling edge to produce a sharp negative pulse.

5. The circuit according to claim 4, wherein the second differentiator differentiates the sharp negative pulse to produce an enhanced negative pulse having a narrower pulse width than the sharp negative pulse.

6. The circuit according to claim 5, wherein the third differentiator differentiates the enhanced negative pulse to product a UWB pulse.

7. The circuit according to claim 1, wherein each of the first, second and third differentiator comprises a capacitor having an input end and an output end, and a resistor coupling the output end of the capacitor to ground.

8. A method for generating an Ultra-WideBand (UWB) pulse comprising the steps:

- a) providing a high gain-bandwidth product transistor;
- b) providing an input voltage waveform having at least one rising edge;

- c) generating a second voltage waveform having at least one fast falling edge by the high gain-bandwidth product transistor corresponding to the at least one rising edge;
 - d) differentiating the second voltage waveform to produce a third voltage waveform having at least one sharp negative pulse;
 - e) differentiating the third voltage waveform to produce a fourth voltage waveform having at least one enhanced negative pulse having a narrower pulse width than the at least one sharp negative pulse; and
 - f) differentiating the fourth voltage waveform to produce a fifth voltage waveform having at least one UWB pulse.
9. The method according to claim 8, further comprising step b1) before step c):
- b1) shaping the at least one rising edge of the input waveform producing a faster rising edge.