MEBT 200Ω Chopper Waveform Generation

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Outline

• MEBT 200Ω Chopper Waveform Generation
  – System Design
    • General system requirements
    • Synchronization to beam bunches
    • Fine timing resolution
  – Arbitrary Waveform Generator (AWG)
  – LabVIEW Application
    • Waveform Generation and Manipulation
    • User Interface
  – 50Ω Kicker Additional Requirements
The chopper program module uses AWG to control 50Ω and 200Ω Kickers
System Requirements

- Delay with respect to synchronized trigger
  - Compensate for cable lengths
  - Compensate for kicker driver delay
  - Internal delay of Arbitrary Waveform Generator (AWG)
- Differential delay
  - Different characteristics of kicker switches
Chopper Waveform Generation

• Arbitrary Waveform Generator
  – Generates waveform for both helix structures
  – May contain more than one pattern
  – Synchronized to Beam/RF reference (1.3 GHz)
  – Trigger for oscilloscope
  – Up to ~4ms of beam chopping waveform

• Trigger Synchronization
  – Synchronization of control trigger pulse to 162.5 MHz beam reference

• LabVIEW Application
  – Generates beam pulse patterns for AWG running at 1.3 GHz
  – 38 ps time resolution
    • Delay on both the channels with respect to synchronized trigger
    • Relative delay between the two chopper waveforms
    • Independently adjusting rising and falling edges for each pulse
  – Inversion of the arbitrary waveforms for optical driver in 200Ω system
AWG Program Functional Diagram

Time Resolution ~38 ps

Delay

Common Delay

Delay Manipulation

Delay and Edge control

Anti Aliasing Filter

250 MHz

Decimation

1.3 GHz

DAC (AWG)

Trigger Synchronization

Clock 1.3 GHz

Trigger and DAC clock are synchronized to 1.3 GHz RF reference providing ps level jitter

Over-sampling

26 GHz

ANALOG FILTERING

Delay Manipulation

Delay and Edge control

Decimation

250 MHz

26 GHz

Time Resolution ~38 ps

Final time resolution is still dependent on oversampling period!
(with 26 GHz : 38 ps)

Processing in LabVIEW

Kicker Driver

162.5 MHz

Reconstruction in time domain

CSV input file

0s & 1s

Time Period ~6.15 ns

Time Period ~0.77 ns

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Signal theory and approach to fine time resolution (38 ps)

- Nyquist Bandwidth of the beam pattern is 81.25 MHz
- For a time resolution of <50 ps signal is oversampled at 26 GHz
- Resulting Nyquist Bandwidth is 13 GHz
- Signal manipulation can be done at a resolution of 36 ps (1/26GHz)
- The AWG is running at 1.3 GHz clock. The Nyquist Bandwidth of the signal should be < 650 MHz
- An anti aliasing filter at 250 MHz is used to eliminate higher frequencies.
- An analog anti aliasing filter reconstructs the waveform while limiting the bandwidth to 350 MHz
Arbitrary Waveform Generator

Model: WavePond DAx22000 with custom 1.3 GHz external clock input

WavePond® is a division of Chase Scientific

Specification of AWG:

- 2 Channels, 2.5 GSPS/ch
- 12-Bit D/A resolution
- 750 mVp-p 50Ω DC coupled outputs
- 8 MS/Ch memory size
- SFDR better than -50 dBc @ 825 MHz
- Full scale $T_{rise}/T_{fall} = 120$ ps (typ)
- 1.3 GHz external 50Ω clock input
- 2 Channels 3.3 V 50Ω TTL marker outputs
- All functions controlled through USB Mini-B connector
**Trigger Synchronization**

- Trigger signal from controls is not synchronized to Beam Bunches from the RFQ
- Trigger signal is synchronized to 162.5 MHz RF in the RFQ
- AWG’s trigger input is 50Ω DC coupled biased at 0.9V
Desired bunch selection pattern is uploaded via CSV format input text file

- "0" represents the beam bunch allowed to pass through
- "1" represents the beam bunch to be kicked out
- Each element is at a period of 6.15 ns (1/162.5 MHz)
LabVIEW User Interface: Oversampling

- Each value is oversampled at 26 GHz (38 ps)
  - Allows to adjust delays, rising and falling edges within 38 ps
LabVIEW User Interface: Independent Delay Adjustment

➢ Independent Ch1 and Ch2 delay adjustments
  • Time Resolution 38 ps
LabVIEW User Interface: Edges Adjustment

➢ Independent Rising and Falling edge delay/advance adjustments for each pulse
  • Time Resolution 38 ps
LabVIEW User Interface: Anti Alias Filtering

Filtering parameters adjustments
- Low Pass Filter
- Cutoff Frequency
- Order
Filtered waveform is decimated at 1.3 GHz (0.77 ns)
- AWG clock is 1.3 GHz
- Still the Time Resolution 38 ps!
➢ Decimated data is converted to AWG acceptable values and loaded
  • AWG starts playing the waveform when “Ext Trig Enable” is pressed
50 Ohm Kicker Additional Requirements

- Bipolar drive signal (No DC component)
- Linear Amp instead of comparators
- Will require higher frequency waveforms
Thank You...