



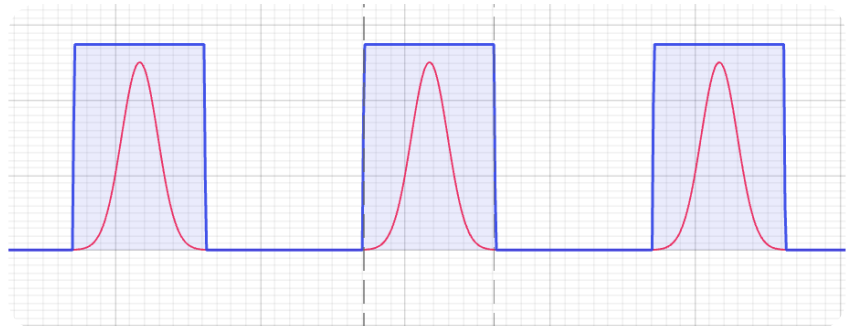
Moku Cloud Compile: Boxcar Averager

Getting started guide



Moku Cloud Compile (MCC) enables users to deploy custom code and tools directly to Moku devices. Liquid Instruments has produced a custom Boxcar Averager tool for use with MCC. This guide provides a step-by-step walk-through on how to quickly deploy and use this tool on Moku:Pro in a pre-compiled, bitstream format. The Boxcar Averager is also available on Moku:Lab and Moku:Go.

The Boxcar Averager is a tool for improving the signal-to-noise ratio (SNR) for measuring low-duty-cycle signals. By integrating the signal within narrow gates triggered by specific events, it effectively filters noise contributions between pulses. Averaging multiple gating events further enhances the SNR of the measurements.



Window alignment of Moku Boxcar Averager tool.

A full discussion of the development of the Boxcar Averager tool is available [here](#).

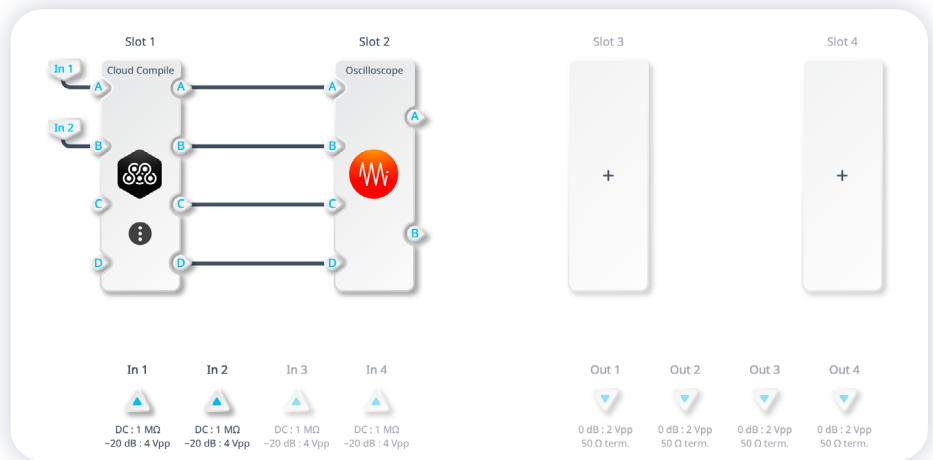
Moku:Pro Boxcar Averager tool specifications

Configurable trigger voltage: -20 V to +20 V
Configurable trigger delay: 0 to 210 μ s
Boxcar width: 0 to 210 μ s

Output or Align mode
Output gain: $1/(2^{16})$ to 2^{16}
Averager length: 1 to 65535 windows

Getting started

1. Download the Boxcar Averager tool [bitstream](#) and Control Register [spreadsheet](#).
2. Configure Moku:Pro in [Multi-instrument Mode \(MiM\)](#) with Moku Cloud Compile in Slot 1 and an [Oscilloscope](#) in Slot 2. Connect the input signal to be averaged to Input 1 and the trigger signal to Input 2.





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3. Upload the Boxcar Averager bitstream file.



4. Configure the settings:

a. Open the Control Register Values spreadsheet, select Moku:Pro, and input attenuation.

b. Enter the desired trigger level, trigger delay, averager length, and other parameters in "Your Input Parameters."

The screenshot shows a spreadsheet titled 'Control Register Values'. It has two main sections: 'Your Input Parameters' and 'Input Control Values'. The 'Your Input Parameters' table has columns for 'Boxcar Input Parameters', 'Input range limits', and 'Your Input Parameters'. The 'Input Control Values' table has columns for 'Register', 'MokuPro', 'Decimal (Unsigned)', 'Decimal (Signed)', 'Hexadecimal', and 'Binary'. A red arrow points from the 'Control0' row in the 'Input Control Values' table to the 'Control0' row in the 'Your Input Parameters' table.

Boxcar Input Parameters	Input range limits	Your Input Parameters
Trigger Level (V)	-0.2 - 0.2	0.01
Trigger Delay (ns)	0 - 209715	80000
Boxcar Gate Width (ns)	0 - 209715	90800
Averager Length (# of Boxcar Integrations for Average)	1 - 65535	5
Output / Align Mode (Enter "0" for Output or "A" for Align)	A or 0	a
Output Signal Gain Factor (1, 10, etc.)	1/(2*16) - 65536 (Typically <1)	0.00050

Register	MokuPro	Decimal (Unsigned)	Decimal (Signed)	Hexadecimal	Binary
Control0	299	299	299	0000 012B	0000 0000 0000 0000 0000 0001 0010 1011
Control1	25000	25,000	25,000	0000 61A8	0000 0000 0000 0000 0110 0001 1010 1000
Control2	28375	28,375	28,375	0000 6E07	0000 0000 0000 0000 0110 1100 1101 0111
Control3	5	5	5	0000 0005	0000 0000 0000 0000 0000 0000 0000 0101
Control4	2	2	2	0000 0002	0000 0000 0000 0000 0000 0000 0000 0010
Control5	33	33	33	0000 0021	0000 0000 0000 0000 0000 0000 0010 0001



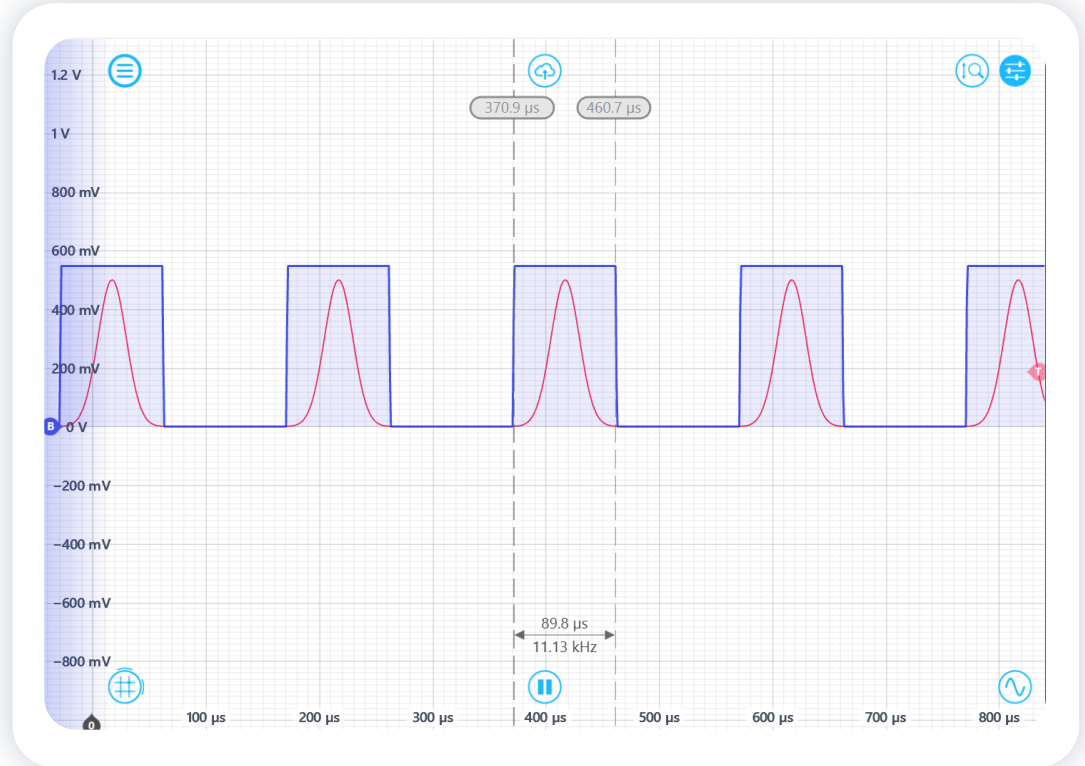
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c. Initially, configure Align Mode to “A” and align the window around the signal.

Output B of the Cloud Compile will show the gate (blue) relative to the input signal.



d. Adjust the trigger settings in the spreadsheet to align the gate with the input signal. The Oscilloscope cursors are useful to measure trigger delay and gate width.

e. Once the gate is aligned, change the mode to Output (O) and adjust the output Gain to avoid saturation. Divide the boxcar output by the calculated scale factor below the parameter table in the spreadsheet to get the boxcar average. **The Boxcar Averager is now running.**