Address Event Representation Router

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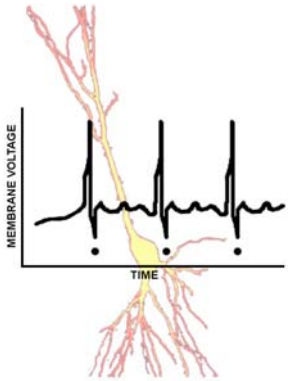
Background

Nearly all neurons in the brains of animals form communication networks using voltage spikes. Researchers model these biological, electrical networks on neuromorphic VLSI chips in an effort to match the computational power of the brain. While it is easy to place the tens of thousands of neuron equivalent circuits onto a chip, the millions of interconnections between these neurons are impractical to fabricate in silicon. A "virtual wiring" scheme called **address-event representation** (AER) has been introduced to transmit the digital identities (addresses) of spiking neurons, nearly mimicking the connectivity of neurons in real time. This asynchronous protocol uses time-division multiplexing of address events.

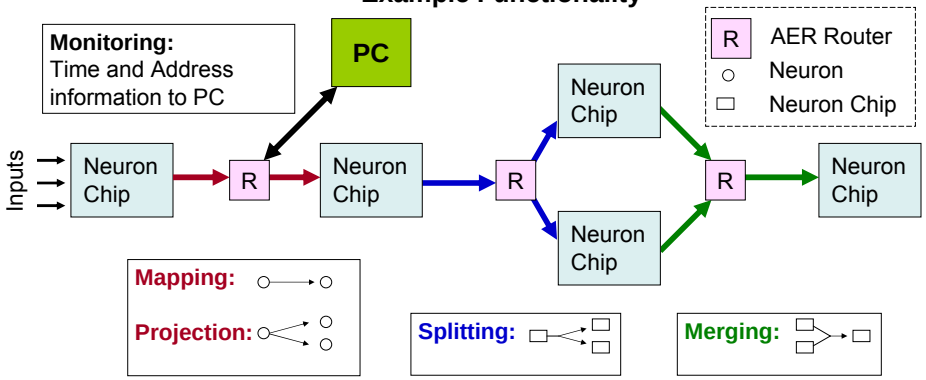


Project Description

The goal of the project is to design and build an AER router that can monitor ongoing spike activity at the output of neuron chips, pass events to other chips with or without remapping, and implement complex connectivity patterns between chips. This router is online reconfigurable (via USB 2.0) for simulating the rewiring process seen in neural systems that are in development.

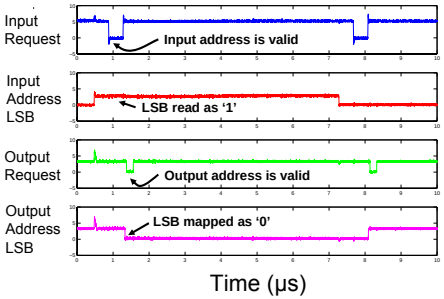
A Silicon Laboratories™ C8051340 Development Kit board is used as the core processor for this project. It has five 8-bit ports: two acting as inputs, two acting as outputs, and the fifth for handshaking procedures. Not all ports are used in every function.

Example Functionality

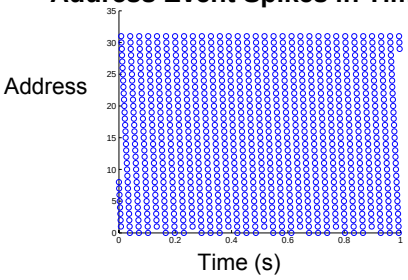


Results

Mapping Mode Voltage Waveforms



Address Event Spikes in Time



Spikes generated by a decrementing binary counter

The upper plot shows a sequence of two asynchronous AE transfers with the router in mapping mode. As depicted, an input address with 1 in the LSB can be mapped to an output address with 0 in the LSB.

When monitoring, event addresses and timestamps accurate to 21ns are stored in on-chip RAM that can be configured to hold as many as 660 events. When this buffer is full, the router transmits these events over USB to the computer, where MATLAB™ can produce a raster plot of AEs versus time (lower plot). As these events are transmitted, input spikes cannot be captured and gaps proportional to the buffer size can appear in monitored data.

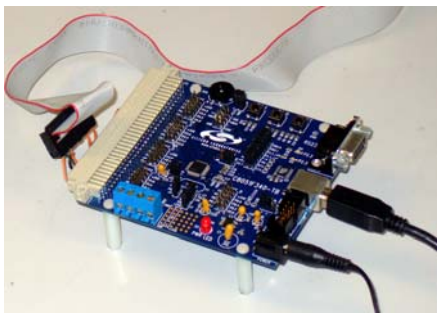
The device can take up to 4µs to service an input request in mapping mode while simultaneously monitoring input AEs. This accounts for a transfer speed over USB that is approximately 150k events/second.

Interface

A graphical user interface (GUI) is implemented in MATLAB™ to control data collection from the router. The GUI makes it possible to monitor input address events, load lookup tables into the device from Microsoft™ Excel, and change single values in the lookup table. The GUI interacts with a Mex-file (C code that can be executed from MATLAB™) that makes use of functions found in the Silicon Laboratories™ USBXpress library to transmit data between the device and the computer.

Outcome

The AER Routing tool that was developed will be beneficial for projects in the CSSL lab for testing AER neuron chips.



Acknowledgements

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