# CSI040

## 16-Channel High Voltage Programmable Current Sink/Source

CSI040 NeuroStim ASSP Datasheet Rev 1.0

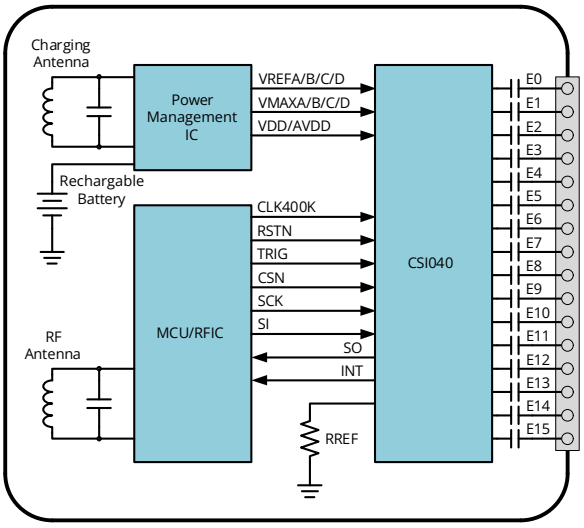
Cirtec MEDICAL

## FEATURES

- 16 Output Channels per IC
- Independent 7 Bit DAC Programmability
- SPI Programmable Output Current Range
- High Output Current [up to 25.4 mA]
- High Output Voltage [up to 18 V]
- Normal mode – DC mode – FAST mode
- Real-time continuous electrode impedance measurement
- Programmable Pulse Widths/Frequencies
- Amplitude Ramp-Up/Down
- Integrated Charge Balancing
- Low Voltage SPI Interface [2.5 V]
- Low Overhead Power [< 10 mW]
- Ultra-Low Standby Power [< 25 µW]
- SPI Writable Trigger Register to synchronize channels & multiple ICs
- *Most flexible stimulation ASIC on the market*

## APPLICATIONS

- Neurostimulation/Neuromodulation
- Implantable Pulse Generator/IPG
- MEMs and Sensor Applications
- Battery Powered Applications




## GENERAL DESCRIPTION

The CSI040 is a highly programmable current sink/source ASIC that features 16 independent, current 7-bit-programmable outputs with 25.4 mA full-scale source or sink capability. Four 18 V supply voltages (VMAXA/B/C/D) allow for up to 25.4 mA output currents into 300Ω loads. The CSI040 stimulation pulse timing is fully programmable via an SPI bus and programmable parameters include sink/source pulse widths, pulse frequencies, stimulation on/off times, stimulation current amplitudes and amplitude ramping. Internal timing generators in the CSI040 use programmed parameters to create therapy profiles with minimal intervention by a host processor. Stimulation charge balancing is accomplished using a charge redistribution source/sink pulse with a programmable current ratio. A FASTStim mode allows stimulation rates up to 50 kHz. A DCStim mode allows for DC stimulation with which the user can generate virtually any stimulation waveform. Finally the ASIC is capable of real-time measurement of the impedance between any of its channels at a rate of up to 40 kHz.

# ASIC DESIGN

## STIM Channel

As shown in Figure 2, the CSI040 includes 16 identical, independently programmable current stimulation channels. Each stim channel provides stimulation and discharge current pulses to its electrode output. The parameters for each channel are set by an MCU through the SPI interface. The STIM Profile Generator generates the control signals to the STIM Channel based on the programmed parameter values for each channel. Each stimulation channel includes a 7-bit current DAC to set the amplitude of the stimulation pulse, current sink and source circuits that amplify the DAC currents to the output and output switches to enable the sink or source current. The Current sink block sinks current from the electrode output to ASIC ground, and the Current Source block sources current from the VMAXx supply to the electrode output. Each stimulation channel includes a programmable Discharge Resistor to bleed residual charge from the electrode outputs to the VREFx supply. There are four VMAXx/VREFx high voltage domains, each domain includes four STIM channels as follows:

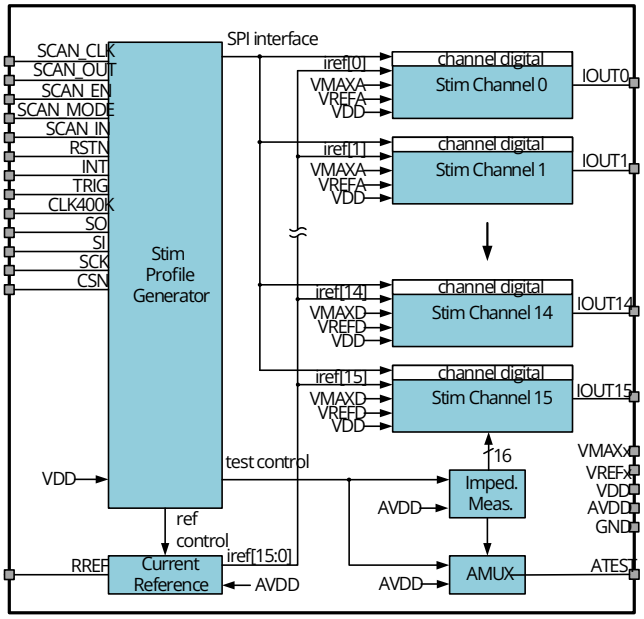



Figure 2: ASIC Architecture

| | | |
|---|---|---|
| channels 0 - 3 | - | VMAXA/VREFA |
| channels 4 - 7 | - | VMAXB/VREFB |
| channels 8 - 11 | - | VMAXC/VREFC |
| channels 12 - 15 | - | VMAXD/VREFD |

## Current DAC

The Current DAC (See Figure 3) operates on the AVDD supply and produces a current proportional to its 7-bit input (idac[6:0]). The Current DAC output is applied to both the Current Sink and Current Source blocks where it is amplified based on the range[1:0], ratio[1:0] and pol inputs. Its full-scale range is 127 µA, with a step size of 1 uA. The Current DAC has 4-bit, bipolar trim (itrim[3:0]). The trim bits are programmed using the trim register for each respective channel. Characteristics of this trim are as follows:

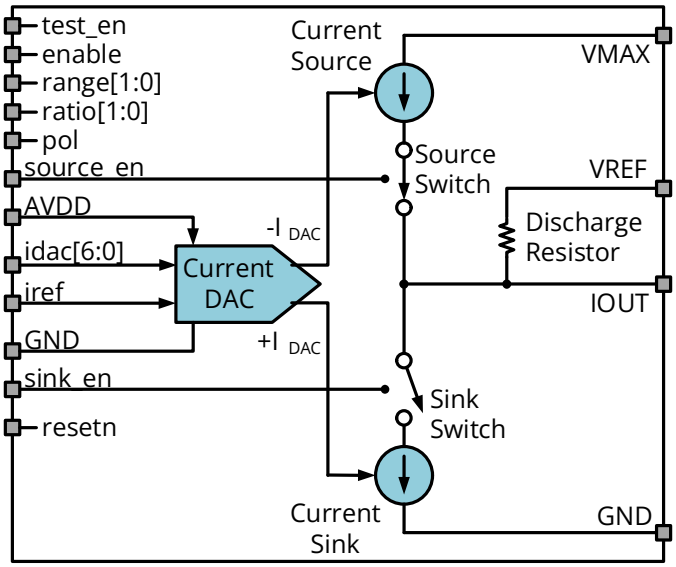



Figure 3: STIM Channel Circuit

| | | |
|---|---|---|
| trim range | - | -4.0% - 3.5% |
| trim resolution | - | 0.5 % / LSB |
| min trim (-4.0%) | - | itrim[3:0] = 0000b |
| nominal trim | - | itrim[3:0] = 1000b |
| max trim (+3.5%) | - | itrim[3:0] = 1111b |