16-channel current sink/source for neuromuscular stimulation

General description

The integrated circuit MS1033 is a 16-channel current sink/source for neuromuscular stimulation. It can be operated in monopolar or bipolar configuration. Monophasic or biphasic and anodic or cathodic modes are supported. The MS1033 can be configured to deliver a DC current instead of pulsed sequence, and in endless mode the stimulation sequence is repeated continuously. The MS1033 supports applications in which the stimulation current must follow a ramp function. The set of programmable parameters allow operation with a minimum intervention from a microcontroller. Stimulation can be started either via the SPI interface or via a trigger input. Multiple MS1033 can be operated synchronously if they are clocked by a common external clock. The stimulation voltage and the common electrode voltage are usually supplied externally, which offers great freedom of operation. For applications with low power consumption, the stimulation voltage and the common electrode voltage can be supplied by internal DC/DC converters (charge pumps). The stimulation voltage can be programmed between 10V and 22V in four levels. A possible bad connection at the electrode-tissue interface can be detected with the built-in impedance check. The impedance check is performed without interrupting the stimulation sequence. Programming from the microcontroller is done via an SPI interface.

Application

- Neuromuscular electrical stimulation

Typical application

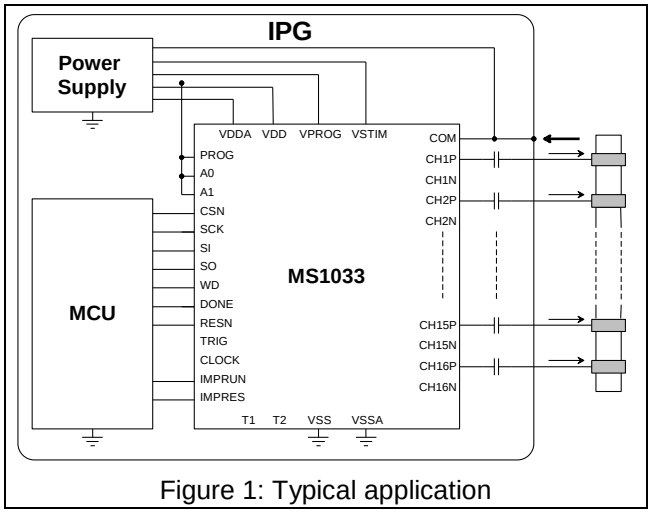

Figure 1: Typical application

Features

- 16-channel current sink/source
- Monopolar or bipolar channel connectivity
- Monophasic or biphasic current generation
- Anodic or cathodic pulse generation
- Charge balanced with/without slow reversal
- Each channel can be enabled or disabled
- Channel grouping if a higher current per channel is required (2, 4, 8, 16)
- Current value individually programmable from 10µA to 2.55mA with a resolution of 10µA
- Programmable pulse timing per channel
- Programmable pulse sequence per channel
- Programmable ramp-up/ramp-down mode
- Endless mode (pulse sequence is repeated continuously)
- DC mode, which outputs a constant current
- Trigger input to start and immediately stop stimulation
- MRI safe mode
- Internal 100kHz oscillator or external 100kHz clock
- Synchronous operation of multiple MS1033
- Impedance check during stimulation sequence
- 10MHz SPI slave interface
- Typical operating voltage 3V
- Stimulation voltage max. 22V
- Flexible common electrode voltage range depending on the application
- Integrated charge pump for low power applications. Output voltage of the charge pump programmable between 10V and 22V (four levels)
- Ambient temperature operating range 0 to 50°C
- Delivery form QFN56 (7x7). Other delivery forms such as die or flip-chip can be considered.

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Pulse modes

The MS1033 supports different pulse modes: monophasic (a), biphasic (b) or biphasic with slow reversal (c).

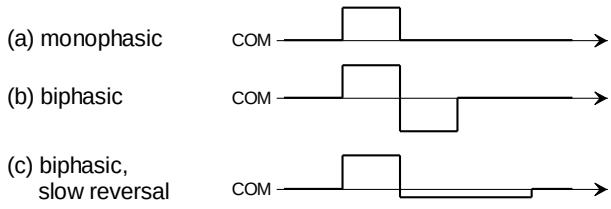

Figure 2: Pulse modes

Pulse specification

A pulse is specified by the amplitude of the current source (AMP), the phase width (PH) and the interphase gap (DZ0). Monophasic, biphasic and biphasic with slow reversal are supported.

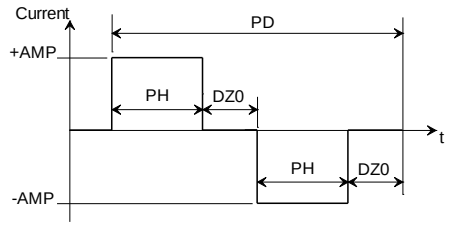

Figure 3: Pulse specification (biphasic mode)

Master pulse

N represents the number of consecutive pulses separated by the delay DZ1. X represents the number of successive sets of PSQ pulses each separated by the delay DZ2.

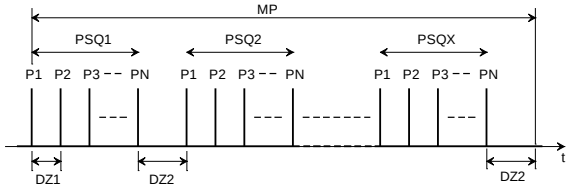

Figure 4: Pulse set

Master pulse sequence

The master pulse sequence consists of M master pulses, each separated by the delay DZ3. The pulse generation is completed when the specified number of pulse sets is finished. The start of the Master pulse sequence can be delayed by DEL.

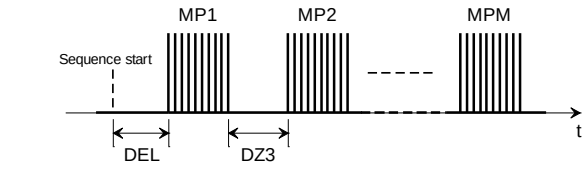

Figure 5: Master pulse sequence

Ramp mode

The amplitude of the stimulation current during the pulse sequences of a master pulse can be constant, rising, falling, rising and falling or falling and rising. The start and end amplitudes as well as the number of sequences (XE) at the end amplitude can be configured.

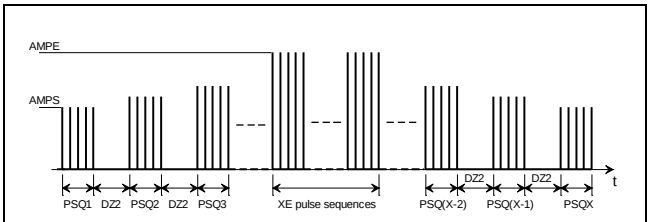

Figure 6: Master pulse ramp up/down

Endless Mode

The master pulse sequence can be repeated continuously. Optionally, a programmed ramp mode can be deactivated after the first master pulse sequence.

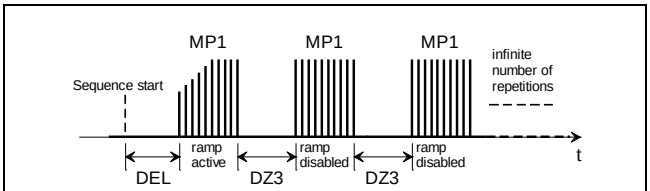

Figure 7: Endless mode, ramp mode disabled

Impedance check

The voltage Vimp at the electrode outputs is a measure of the impedance. The MS1033 measures the voltage during a regular stimulation pulse and compares it with programmable limits.

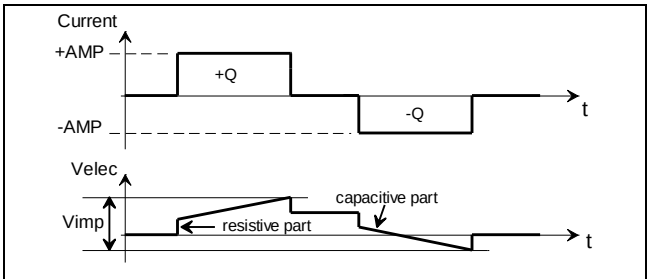

Figure 8: Vimp in biphasic mode

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