8-channel current sink/source for neuromuscular stimulation

General description

The integrated circuit MS1032 is an 8-channel programmable current sink/source for neuromuscular stimulation. The stimulation parameters (timing and amplitude) of each channel can be individually programmed. Monophasic (current flow only in one direction) or biphasic mode (current alternating) and anodic or cathodic mode are supported. The set of parameters allow operation with a minimum intervention from a microcontroller. The stimulation can be either started over the SPI interface or over trigger inputs (one trigger input per channel).

The MS1032 has a switch matrix with 16 outputs. The 8 current sink/source channels as well as 8 analog peripheral inputs can be assigned to any of the 16 outputs. This enables a very flexible operation and allows optimization of the stimulation process during the treatment. Each channel has an over-current and an under-current protection. The stimulation is immediately stopped if the current is not within limits. An additional shut-down input allows for immediate interruption of the stimulation sequence.

Programming from the microcontroller is done via an SPI interface.

Application

- Neuromuscular electrical stimulation

Typical application
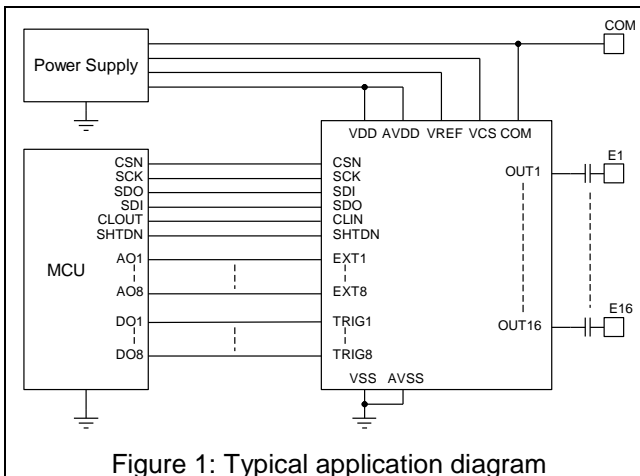

Figure 1: Typical application diagram

Features

- 8-channel current sink/source
- Monophasic or biphasic mode
- Anodic or cathodic generation
- Charge balanced with/without slow reversal (4:1)
- Each channel can be enabled or disabled
- Current value individually programmable from $10\mu A$ to 2.55mA with a resolution of $10\mu A$
- Programmable pulse timing per channel
- Programmable pulse sequence per channel
- Over-current and under-current protection
- Shut-down input to immediately stop stimulation
- 8 analog peripheral inputs
- Switch matrix between current sinks/sources, peripheral inputs, current sink/source reference and 16 output channels
- Internal (RC oscillator) or external 100kHz clock
- Internal or external 1.25V reference voltage
- 10 MHz SPI slave interface
- Operating voltage range 2.2 to 3.3V
- Current source voltage max. 18V
- Temperature operating range 10 to 50°C
- Full custom process (XH035)
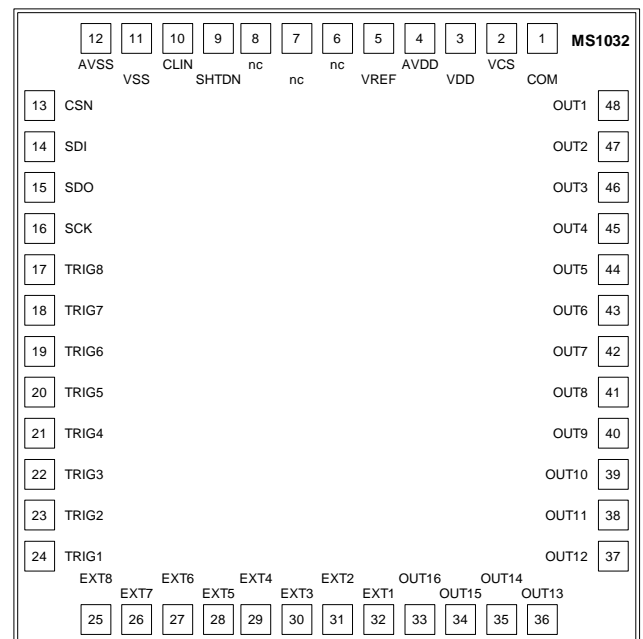- Various packaging options (die, flip-chip, packaged)

Pinout

Figure 2: Pinout (die)

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Page 1

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Pin description

Pin	Symbol	Description
1	COM	Current source reference (12V)
2	VCS	Current source supply (18V)
3	VDD	Positive digital supply voltage
4	AVDD	Positive analog supply voltage
5	VREF	1.25V reference voltage
9	SHTDN	Shut down
10	CLIN	100kHz clock input
11	VSS	Negative digital supply voltage
12	AVSS	Negative analog supply voltage
13	CSN	SPI chip select
14	SDI	SPI data input
15	SDO	SPI data output
16	SCK	SPI clock
17	TRIG8	Trigger input channel 8
..	..	..
24	TRIG1	Trigger input channel 1
25	EXT8	Peripheral analog input 8
..	..	..
32	EXT1	Peripheral analog input 1
33	OUT1	Stimulation output 1
..	..	..
48	OUT16	Stimulation output 16

Table 1: Pin description

Pulse modes

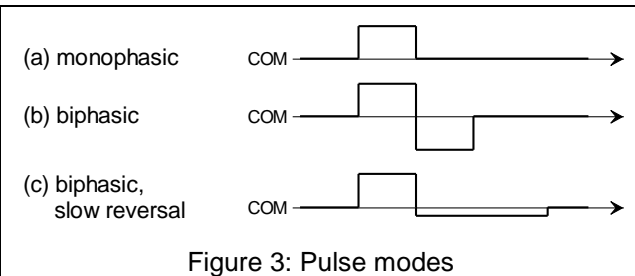The MS1032 supports different pulse modes: monophasic (a), biphasic (b) or biphasic with slow reversal (c).

Figure 3: Pulse modes

Pulse specification

A pulse is specified by the amplitude of the current source (AMP), the pulse width (PW) and the delay zone (D0).
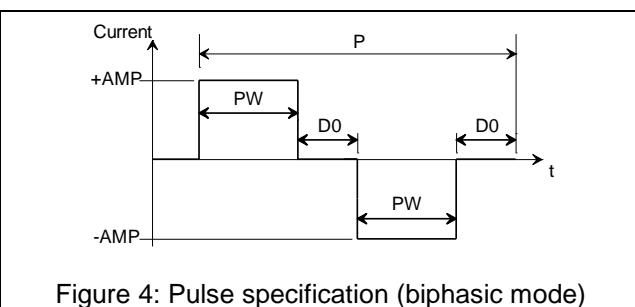

Figure 4: Pulse specification (biphasic mode)

Pulse set

N represents the number of consecutive pulses separated by the delay D1. X represents the number of successive sets of P pulses (=CP) each separated by the delay D2.
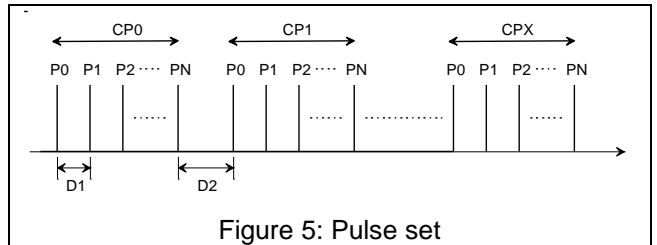

Figure 5: Pulse set

Master pulse sequence

The master pulse sequence consists of M pulse sets each separated by the delay D3. The pulse generation is completed when the specified number of pulse sets is finished.
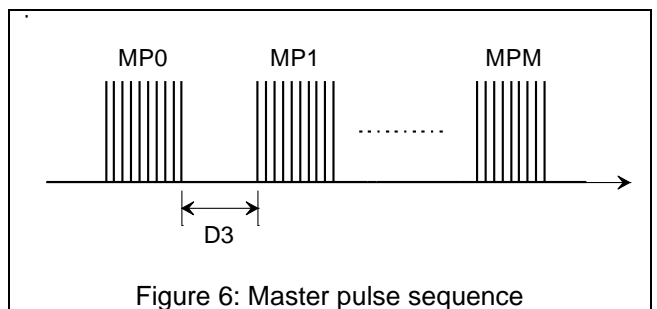

Figure 6: Master pulse sequence

Switch matrix

The switch matrix has 16 outputs. Each of the stimulation channels (CHn), the peripheral inputs (EXTn) and the current source/sink reference (COM) can be switched to any output channel.
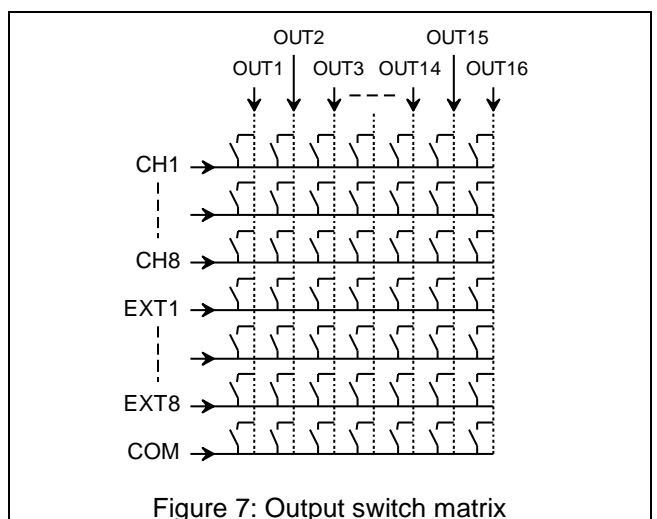

Figure 7: Output switch matrix

Page 2

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