

## NNC-ENS001

### Universal Electrical Neural Stimulation SoC

The NNC-ENS001 is a highly programmable stimulation SoC. It integrates a powerful ARM Cortex-M0 MCU with an integrated battery charger circuit, a power supply switcher, a high-voltage boost converter and 35 high-compliance stimulation drivers. There are 3 different stimulation driver architectures producing several kinds of stimulation waveforms with output current up to 67mA, thanks to the integrated MCU. The ENS001 chip generates multiple stimulation patterns to support various wearable and implantable electrical neural stimulation applications. Moreover, the system integrates various analog peripherals, providing high flexibility for product design.

### Applications

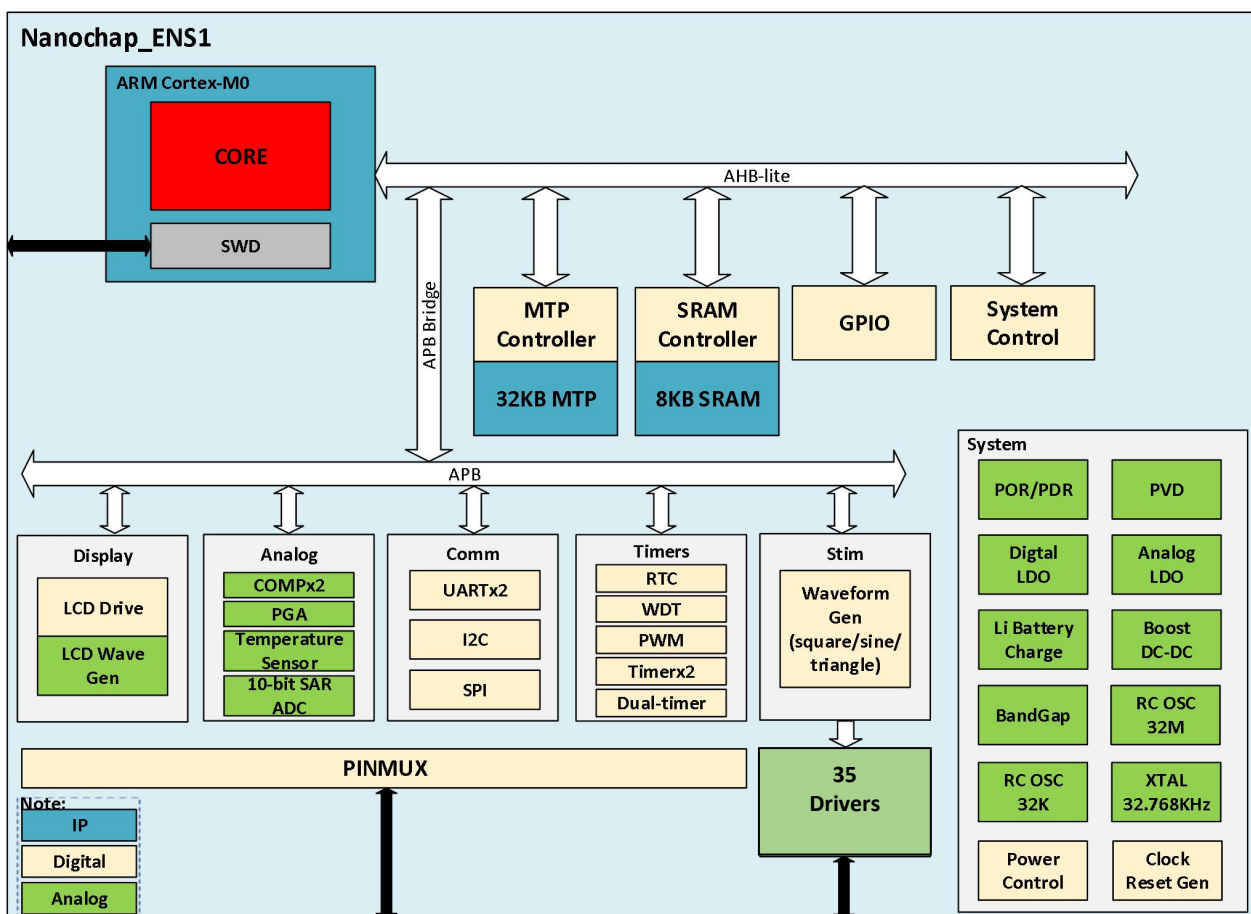
- Muscle Strengthening (EMS) and Weak Muscle Rehabilitation, TENS products
- Interferential Current Therapy (IFT)
- Deep Brain Stimulation (DBS)
- Spinal Cord Stimulation (SCS)
- Cochlear Implant

### Features

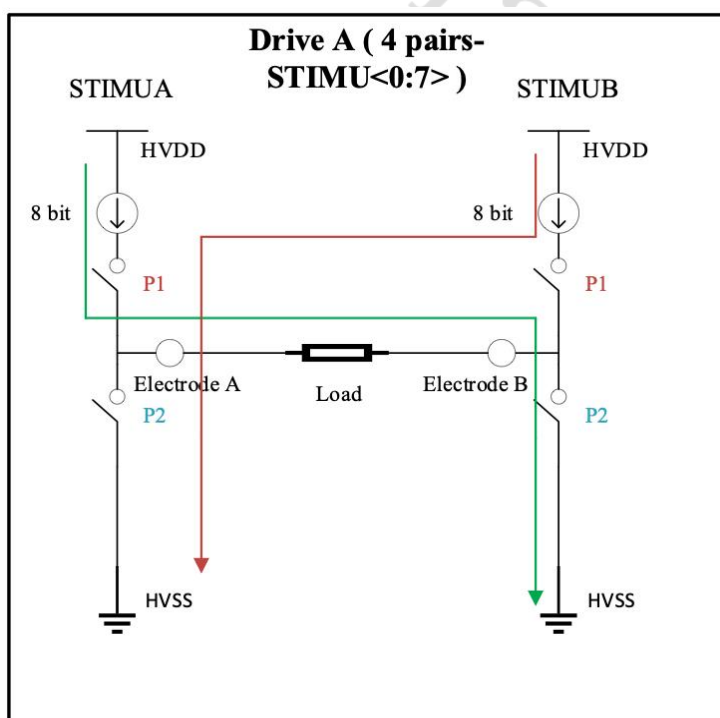
- Operating Voltage Range: 3 V to 5V
- Operating Temperature: -40°C to 85°C
- Low power mode: Sleep, Stop, Standby
- Integrated 10~60V High Voltage Boost Converter
- 4 Wide-Range Drivers (8 electrodes) (Max 60V)
  - Output current: 33uA~120 mA, with 255 steps
  - Output unit current: 33uA~264uA, 8 steps
  - 2us~infinity pulse width
  - Up to 250 kHz sinusoidal/triangle/square or arbitrary waveform
  - Can be used for TENS, IFT, EMS
- 8 Middle-Range Drivers (16 electrodes) (Max 60V)
  - Output current: 50uA~100 mA, with 255 steps
  - Output unit current: 50, 72 ~ 204 uA (8 steps)
  - 2us~infinity pulse width
  - Up to 250 kHz sinusoidal/triangle/square or arbitrary waveform

- Can be used for DBS, SCS
- 23 Channels Low-Range Drivers (24 electrodes) (Max 60V)
  - 8uA~2 mA output current, 255 steps of 8uA
  - 2us~infinity pulse width
  - Up to 250 kHz sinusoidal/triangle/square or arbitrary waveform
  - Can be used for Cochlear Implant
- Arbitrary waveform generation powered by the Cortex M0 and an intelligent driver controller.
- Support simultaneous stimulation
- ARM core
  - 32-bit ARM Cortex-M0 CPU
  - Frequency up to 32 MHz
- Memory
  - 32 kB MTP memory
  - 8 kB SRAM
- Digital Interface
  - 2 x I<sup>2</sup>C
  - 2 x UART, with hardware flow control
  - 2 x SPI interface
- Clock
  - 4~32 MHz RC oscillator
  - 32 kHz RC oscillator
  - 32.768 kHz crystal oscillator
- 24 GPIOs
- 96-bit unique ID
- LCD driver
  - COMx4, SEGx16
- Peripheral analog circuits
  - 12-bit ADC: 0 to VDD conversion range
  - Two low-power analog comparators
  - Temperature Sensor
  - PGA: programmable gain amplifier
  - Integrated battery charger
  - Low voltage detector (LVD)
  - Power-on/Power-down Reset (POR/PDR)
- Various timers
  - Real-Time Clock (RTC)
  - Watchdog Timer (WDT)
  - Pulse Width Modulation (PWM)
  - 32-bit Timer x2, SysTick timer
  - 32-bit or 16-bit dual-timer
- Package: QFN96\_10x10 or QFN64\_8x8 (less number of output drivers)

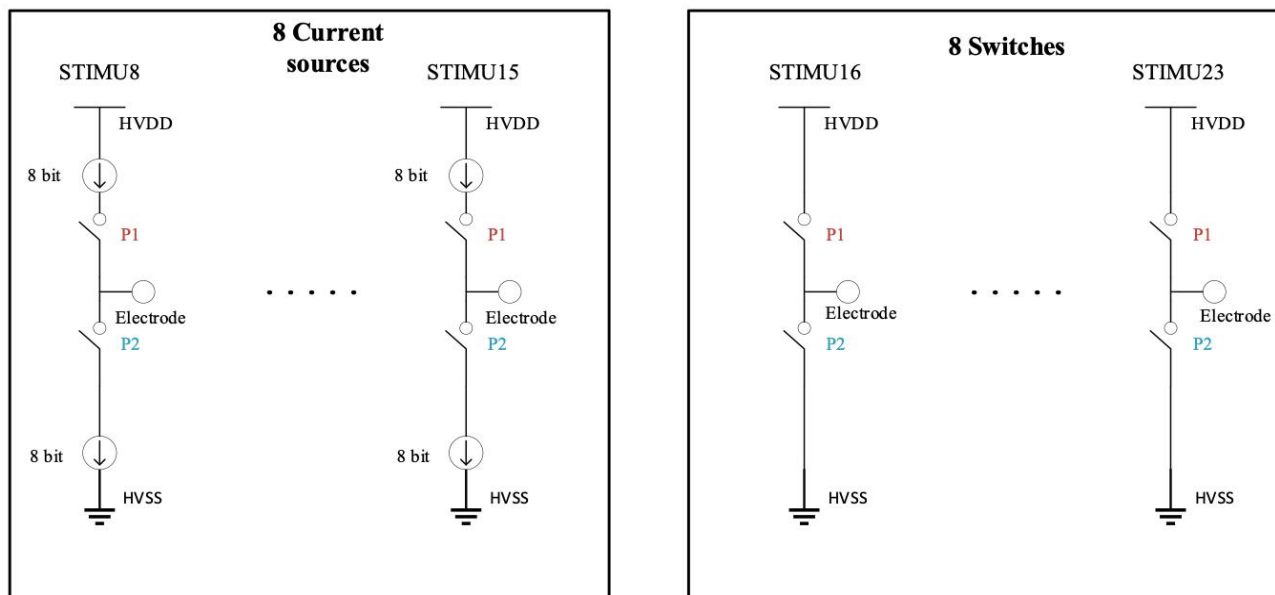
## Block diagram:



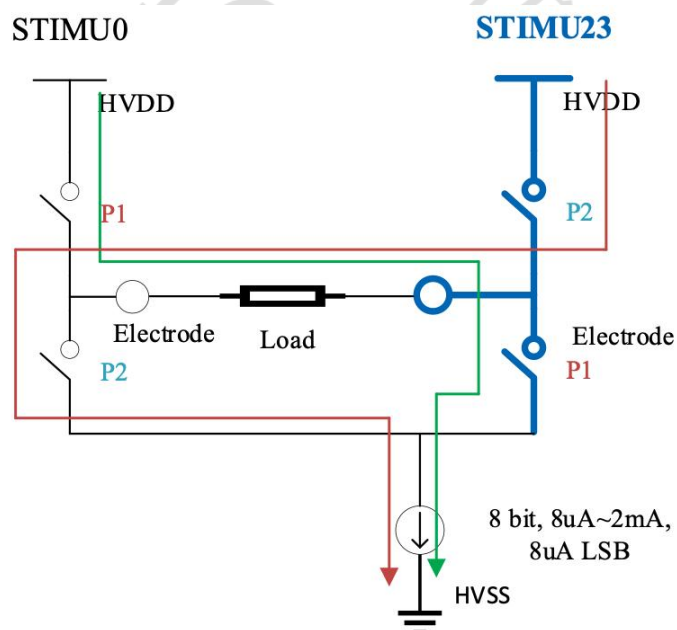
Wide-Range Drivers: up to 4 simultaneously active pairs



Mid-Range Drivers: up to 8 simultaneously active pairs



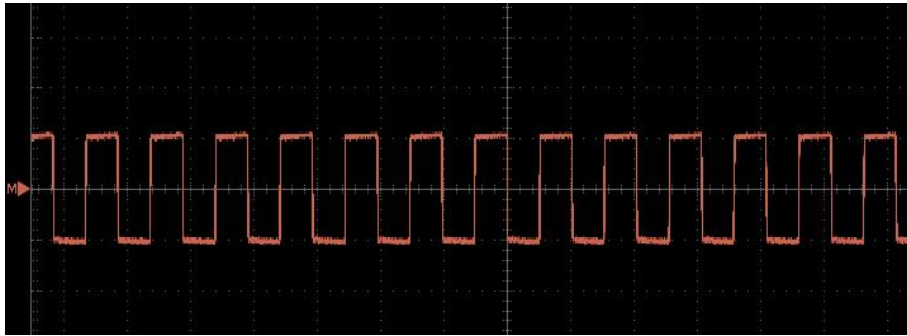
Low-Range Drivers: one active pair at a time



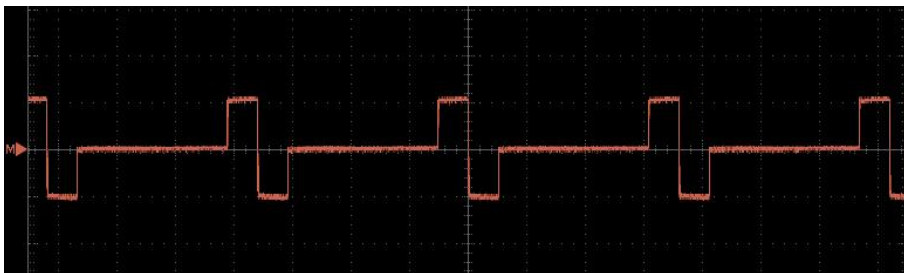
**Example waveforms:**

All 3 types of drivers can produce any current waveform. Below are some example waveforms:

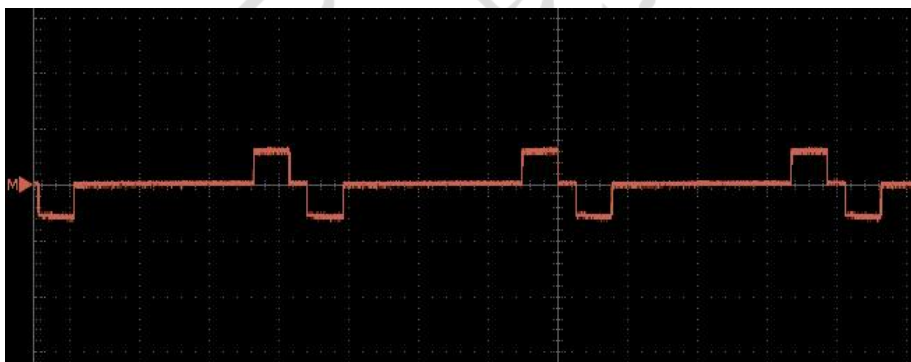
(1) Bidirectional continuous square wave①



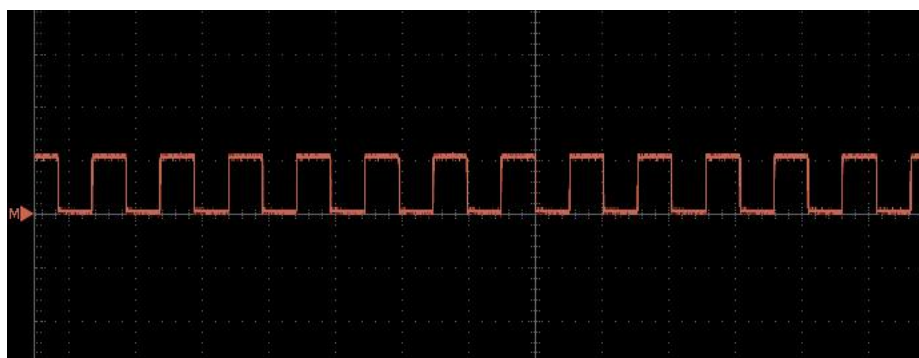
(2) Bidirectional continuous square wave②



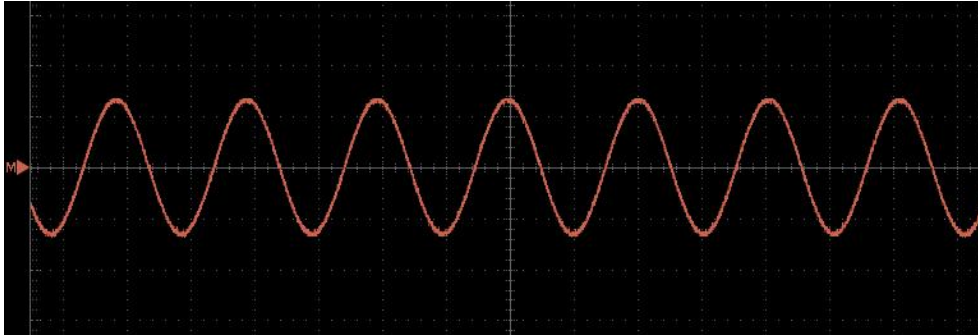
(3) Bidirectional continuous square wave③



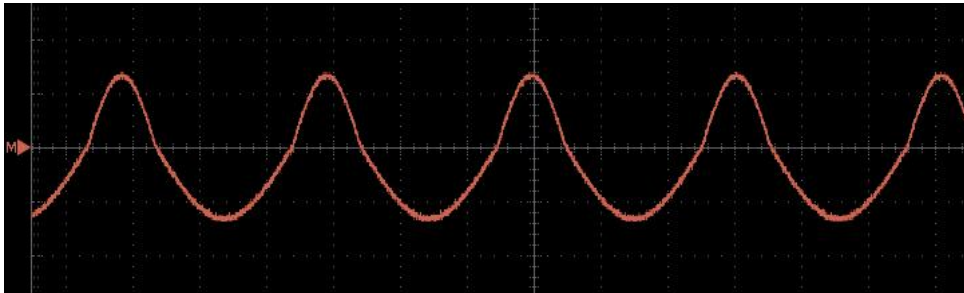
(4) Unidirectional continuous square wave



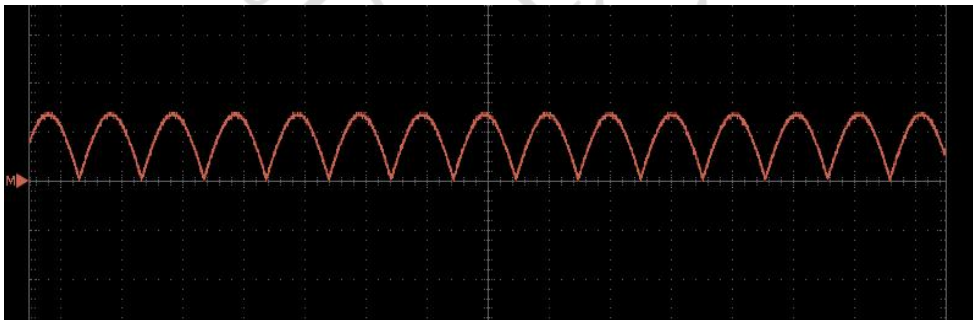
(5) Bidirectional continuous sine wave



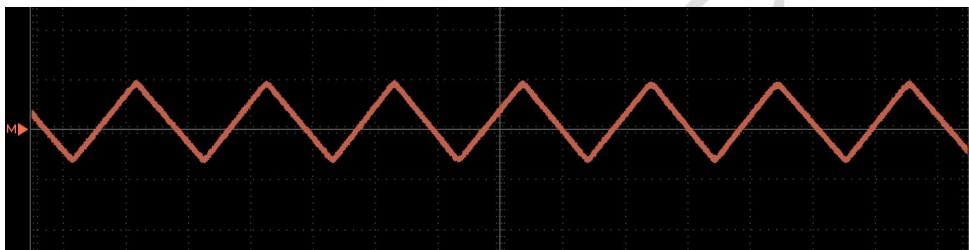
(6) Asymmetric sine wave



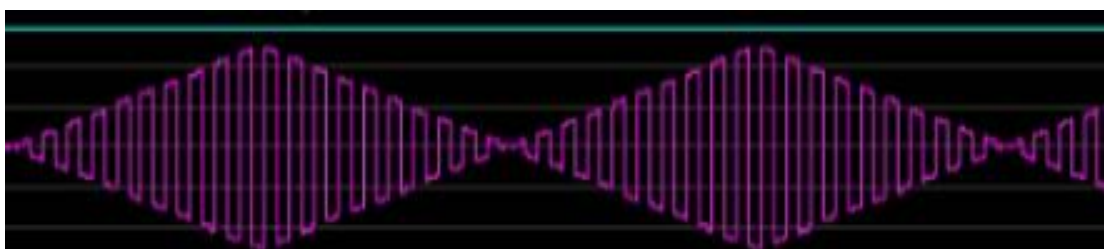
(7) Unidirectional sine wave



(8) triangular wave

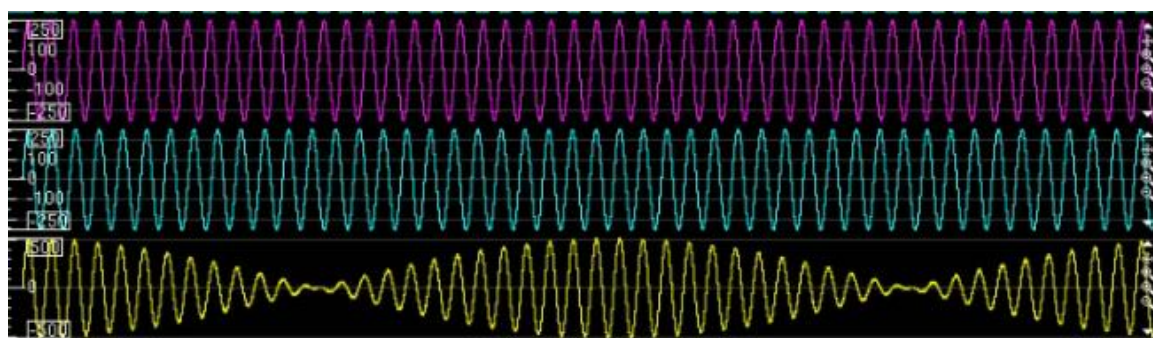


(9) Sawtooth current





(10) Interferential currents



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