neurocare

Brainsight cTMS

Brainsight® cTMS

Usually, TMS devices routinely use conventional biphasic pulses for repetitive TMS treatment protocols and monophasic pulses for single-pulse stimulation during diagnostic. Novel technological refinements and developments are emerging, such as TMS devices with adjustable pulse shapes, among them controllable TMS (cTMS), and closed-loop TMS.

The Brainsight TMS device allows adjustment of the pulse width. It enables optimization, selectively targeting distinct neuronal populations, and quantification of the strength–duration and input–output (IO) behaviors and curves. Different pulse shapes, including the pulse duration can influence the balance between concurrently activated neural elements. For example, brief pulses, i.e., pulses with a short duration or width, may result in preferential motor than sensory stimulation in peripheral nerves. Studies demonstrated that the ratio of cortical motor to scalp sensory threshold is lower for brief pulses compared to longer stimuli. Further, cTMS pulses can be more power-efficient allowing the stimulation in shorter time and having lower power consumption.

In conjunction with neurocare's LOOP-IT system, it can also conduct closed-loop cTMS experiments.

- Alavi et al. 2022 Closed-loop and automatic tuning of pulse amplitude and width in EMG-guided controllable transcranial magnetic stimulation (cTMS)⋆
- Alavi et al. 2023 Closed-loop optimal and automatic tuning of pulse amplitude and width in EMG-guided controllable transcranial magnetic stimulation
- Zhiyong et al. 2021 Modular multilevel TMS device with wide output range and ultrabrief pulse capability for sound reduction

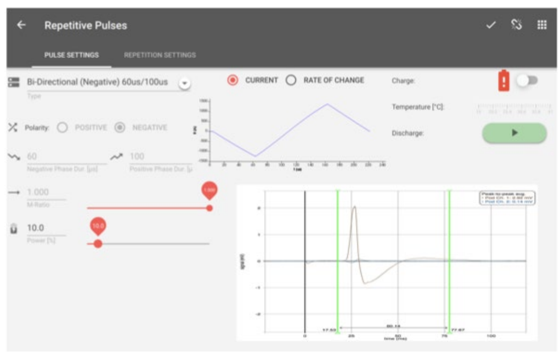
Features of cTMS

- First new TMS design in years
- Variable pulse shapes
- Integrated EMG
- Integrated output recording
- Multiple general purpose triggers (4 in, 4 out), switch in, TTL out
- External control via network
- Optional current reversal module (~1 msec switching time)

Thoughtful coil design

- Removable handles to suit every preference
- Different inductances to extend cTMS pulse range
- B-Field 3D mapped for use in E-field modelling research
- Integrated coil tracker mount
- More models to come (cooled coil, 50mm fig-8 etc.)

Modern intuitive user interface



- Large, capacitive touch screen
- Simple and advanced controls
- Predicted waveform displayed initially and actually measured output overlaid for confirmation of delivered pulse

Pulse Waveform Capabilities

- Directionality Control: Controls amplitude of the -ve phase relative to the +ve phase
- Variable pulse width up to 386 μSec (with optional high inductance coil)
- Monophasic, biphasic, polyphasic, staircase, asymmetric
- Repetition rates up to 1 kHz
- Unidirectional theta burst
- Charging power: 3x1500 Joules per second

Specifications

Pulse type (positive PW, negative PW)		M-Ratio	10 Hz	25 Hz	50 Hz	100 Hz	200 Hz	400 Hz	800 Hz	1 kHz	Maximum Output	Maximum Freq. (Hz) at Max Output
Unidirectional Biphasic Train	45µs,145µs	.2	100	100	49	24	11	N/A	N/A	N/A	100	24
	60µs, 185µs	.22	100	82	40	19	9	N/A	N/A	N/A	100	20
	75µs, 22µs	.25	93	55	27	13	6	N/A	N/A	N/A	93	15
Unidirectional Biphasic Train (balanced pulse)	11µs, 54µs	.76	100	100	100	100	100	100	65	49	100	550
	20µs, 78µs	.139	100	100	100	100	91	43	19	14	100	184
	30µs, 105µs	.162	100	100	100	91	44	20	N/A	N/A	100	91
	40µs, 131µs	.182	100	100	100	54	26	12	N/A	N/A	100	55
	50µs, 158µs	.198	100	100	70	34	16	N/A	N/A	N/A	100	35
	60µs, 185µs	.2165	100	97	47	23	10	N/A	N/A	N/A	100	24
	70µs, 212µs	.2365	97	66	32	16	7	N/A	N/A	N/A	24	17
	80µs, 238µs	.2599	78	57	28	13	6	N/A	N/A	N/A	85	18
	86µs, 255µs	.2756	78	47	23	11	N/A	N/A	N/A	N/A	78	15
Bi-directional	Positive 60µs, 100µs	1	43	43	43	26	13	5	N/A	N/A	43	63
	Negative 60µs, 100µs	1	43	43	43	21	10	4	N/A	N/A	43	50

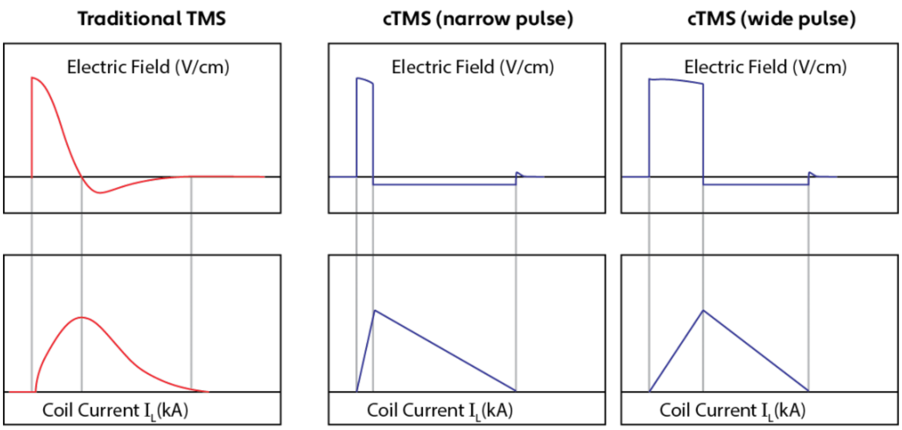
Details about cTMS

One of the strengths of cTMS is its ability to generate new types of TMS pulses. This additional flexibility requires that the traditional TMS nomenclature be augmented to be able to describe these new pulses. While cTMS offers new flexibility, it is not infinite flexibility, so a good understanding of the strengths and weaknesses will help you to take me most advantage of the device. This page will describe the typical parameters that describe the pulse and which ones are controllable and which ones are dependant on the first ones.

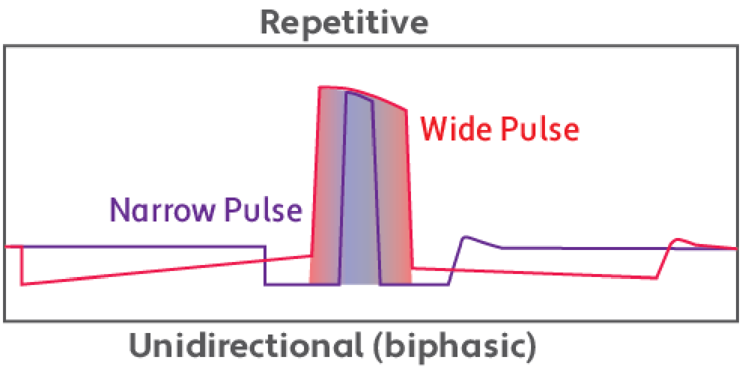
cTMS devices have been described in the scientific literature for several years. The design is based on the novel work by Dr. Angel Peterchev at Duke University (the first work was done while at Columbia University). Much of the nomenclature is introduced in his work and several relevant references are given at the bottom of this page.

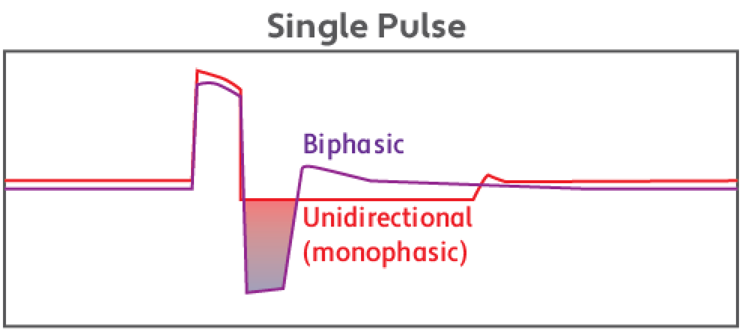
Before describing cTMS, a quick review of traditional TMS is a good place to start. Generally, TMS comes in two varieties: monophonic and bi-phasic (and some hybrid models that combine the two). Both types of TMS start with a capacitor (and charging circuitry to charge the capacitor) and a switch (to switch the capacitor connection from the charger to the coil to discharge the capacitor into the coil). In monophasic TMS, the capacitor sends is energy into the coil. Once discharged, the current in the coil is at its maximum. The laws of electromagnetism dictate that the rate of change of the coil current will generate the magnetic field. The return path for all that energy in the coil is fed through a diode and resistor, so some returns to the capacitor and the rest is dissipated through the resistor as heat. The pulse shape is fixed, and is a function of the capacitor, coil inductance and the resistor used to dissipate the energy. The advantages are a simple system with relatively few components and from a neurophysiological standpoint, a clean pulse in that there is a single rise and decay in the electric field produced by the pulse. The disadvantage is one of efficiency. It takes a long time (in TMS terms) to recharge the capacitor from the discharged state for a new pulse. For this reason, monophonic pulses are not suitable for most rTMS applications.

Biphasic TMS is a product of the desire to perform repetitive TMS. Instead of dumping the energy to the resistor, a more complex switch circuit recycles most of the energy in the coil back into the original capacitor. This occurs in a much shorter time than discharging through the resistor, and the capacitor needs a lot less new energy to fully recharge for the next pulse since it recycled a lot of the previous pulse. This allows for very rapid and sustained trains of pulses. The drawback is that the resulting waveform is not as straightforward as monophasic pulses.



cTMS overcomes these challenges by using a completely different approach. Our cTMS uses 2 capacitors and a sophisticated switching system to juggle the energy between the two capacitors (which is a lot faster than dumping energy through a resistor). In cTMS, we define two voltages, one for each capacitor and switch from one to the other (and back again) as need be with one capacitor handling the +ve phase and the other the -ve phase. This gives us a distinct new capability. While cTMS must obey the same laws of electromagnetism as traditional cTMS, we can be more creative in how we do this. For example, we can set the voltage to whatever we wish for either capacitor and define how long we connect that capacitor to the coil to control the width of a portion of the pulse. For example, by setting a low -ve voltage in one capacitor, a high +ve voltage in the other and going from one to the other and back again, we can generate a unidirectional (think monophasic) pulse.





cTMS introduces a new parameter called an M-ratio. This is a directionality control and describes the relative amplitudes of each phase of the pulse. It is the the ratio of the electric field amplitude of the -ve phase divided by the electric field amplitude of the +ve phase.

A balanced pulse is a pulse where the end voltages of the capacitors are at or slightly below the original voltages. Balanced pulses are desirable for repetitive cTMS as the time required to discharge a capacitor (that may have received a lot of residual energy) is long compared to the typical gap between pulses. This constraint can often be circumvented using a bit of creativity in defining pulses. For example, a bi-phasic pulse with an M-ration close to 1 is generally easier to balance. In cTMS, you can make the -ve phase at the start and end be shallow and long (rather than essentially equal to the +ve phase), so while it is technically a bi-phasic pulse, the effective electric field (from the neuron's perspective) will feel very monophasic.

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