ADVANCED TMS

Research with PowerMAG
Products and Application Booklet
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**TMS IN GENERAL**

TMS (Transcranial Magnetic Stimulation) is a technique where neuronal activity can be influenced by non-invasively stimulating the cortex through the intact skull bone. The stimulation is caused by short magnetic pulses that induce a current flow in cortical brain areas. Thus brain activity may be triggered or modulated without surgery or externally applied electrodes. TMS is a non-invasive method with several benefits:

- No skin preparation is needed
- The magnetic field is able to penetrate high resistance structures, such as the skull, without attenuation
- TMS is almost completely pain free as currents do not have to pass through the skin

Depending on the stimulation protocol, neuronal functionalities can be inhibited or facilitated for a defined period of time. In addition, repetitive TMS, also known as rTMS, may produce longer-lasting effects.

Overactive or underactive areas of the brain can be observed and then focally modulated with TMS e.g. using functional imaging, such as fMRI and PET. This makes TMS an excellent therapeutic treatment option for psychiatric and neurological disorders.

Furthermore, TMS also contributes to research in neuroscience by demonstrating the involvement of brain regions in various cognitive tasks or mental processes.
WHY MAG & MORE:

- Full external controllability
- Decentral mini coils
- Reproducibility
- Various Coils
- Stable output power
- Optimized coil design
- Precise timing
- Integration
- Various Coils
- Safety Borders
- Usability
- Various protocols
- Optimized pulse length
- Electrical shielding
- High frequency TMS
- Half- and full wave
- Online EEG feasible
- High speed stimulation
- Current direction invertible
- No mains noise

Legend:
- TMs
- High
- Usability
- Online EEG feasible
- Short pulse length
- Half- and full wave
- High speed stimulation
- Accurate stimulation
- Short pulse length
- Full external controllability
- Power
- Usability
- Optimal
- Short pulse length
- Half- and full wave
- High speed stimulation
- Electrical shielding
The use of TMS in research requires an individual and precise positioning of the TMS coil at the selected brain region. MR-based neuro-navigation systems can visualize the electromagnetic hot-spot of the coil in real-time at an individual, anatomical MR-data record. This enables the user to stimulate the target with great precision and makes reproducibility of the TMS set-up much easier. Additionally, navigated TMS allows the researcher to protocol and map his or her work for studies and papers. Color coded fMRI data showing active regions of the brain is another helpful tool to find the right target areas.

**Major Considerations and Solutions:**

- **Precise coil navigation**
  - Wireless IR-tracking system with great accuracy and high resolution.
  - Integrated navigation points on the stimulation coils.
  - Ability to integrate (future) coil geometries.

- **Intuitive operability**
  - Implementation of intelligent algorithms (fully automated brain segmentation, surface reconstruction, "brain peeling").

- **Handling of data formats for 3D reconstruction**
  - DICOM capable.
  - Proprietary data formats for most of the current MR scanner manufacturers.

- **Reproducibility and data export for statistical analysis**
  - Store and recall stimulation points and coil positions in 6D.
  - Record EEG electrode positions.

- **Data import and interfaces**
  - Interfaces to BrainVoyager for importing and overlaying functional data onto the anatomical reconstruction of the brain.
  - Import of structural and functional MRT analysis (fMRI, DTI, EEG/MEG).

**Why Mag & More:**

- Full external controllability
- Accuracy
- Precise timing
- Reproducibility
- Usability
- Integrated navigation points
- Integration
- Various protocols

**Related Products for Navigated TMS:**

- **Stimulators:**
  - PowerMAG EEG
  - PowerMAG QPS

- **Coils:**
  - PMD70
  - PMD45-EEG
  - PMD45-fMRI
  - PMD25-decentral

- **Accessories:**
  - control splitter box
  - TMS-field probe
  - Neuronavigation

- **Service:**
  - Training
  - Integration
OVERVIEW:

Clinical TMS research is conducted to evaluate the safety and effectiveness of TMS by investigating its effects on human beings. Transcranial Magnetic Stimulation is a great way to selectively modulate targeted areas of the brain (facilitating or inhibiting) in order to treat neurological and psychiatric diseases. In contrast to pharmaceuticals, TMS is a non-systemic way of treatment which means that TMS does not circulate in the blood stream throughout the body and does not have body wide systemic side effects.

By delivering its therapeutic effects directly to the brain this non-invasive and almost side-effect free technique appears to have a great future in treatment of various neurological and psychiatric indications.

MAJOR CONSIDERATIONS AND SOLUTIONS:

- **Individually set all stimulation parameters**
  Customize the TMS equipment to fit your needs.
  Free configurable stimulation protocols.
  Capable of advanced TMS protocols such as Theta-Burst or Quattro-Burst.

- **Future proof equipment**
  Upgradable technology in order to follow future TMS developments.

- **Precise coil navigation**
  Wireless IR-tracking system with great accuracy and high resolution.
  Integrated navigation points on the stimulation coils.
  Ability to integrate (future) coil geometries.

- **Reproducibility and data export for statistical analysis**
  Store and recall stimulation points and coil positions in 6D.
  Record EEG electrode positions.

WHY MAG & MORE:

- Full external controllability
- Safety borders
- Precise timing
- Reproducibility
- Usability
- Integrated navigation points
- Integration
- Various protocols

RELATED PRODUCTS FOR STIMULATION IN CLINICAL RESEARCH:

- **Stimulators:**
  » PowerMAG LAB
  » PowerMAG QPS

- **Coils:**
  » PMD70-pCool
  » PMD70-pCool SHAM

- **Accessories:**
  » PC Interface
  » TMS-field probe
  » Neuronavigation

- **Service:**
  » Training
  » Integration
OVERVIEW:

Using TMS in conjunction with other techniques allows for a more complete understanding of the human brain. TMS can be combined with various neuroimaging and neurophysiological technologies as EEG, MEG, EMG, PET, fMRI, NIRS or DTI. The combination of TMS with other techniques can show neuronal interactions and connectivity between different brain areas.

Because TMS cannot directly reach subcortical structures, combining TMS with neuroimaging methods can bring additional insights into the modulation of deeper brain structures which are indirectly induced by TMS.

MAJOR CONSIDERATIONS AND SOLUTIONS:

Safe operation of the stimulator in various combinations
Patented safety concept with safety restrictions on stimulation intensities and frequencies.
Integrated, independent safety channels and pneumatic safety switches.

Easy integration with existing laboratory equipment
Free control of stimulation parameters (USB, analogue & digital interface, triggers in/out).

Reliable results and reliable timing
Emitting TMS pulses with high pulse precision and stable timing.

Reproducible results with different protocols
Stable output power through all stimulation patterns (single-pulse, rTMS, Trains, Theta-burst, OPS).

Avoid electrical disturbances and electrical induction
Extremely high standards in the design and production with our quality seal “Made in Germany”.
Advanced recharging technology to avoid disturbing e.g. the EEG signal and allow high frequency TMS.
Special signal shielding.

WHY MAG & MORE:

- Full external controllability
- Safety borders
- Precise timing
- Reproducibility
- Electrical shielding
- Integrated navigation points
- Integration
- Various protocols

RELATED PRODUCTS FOR MULTI-MODAL STIMULATION:

Stimulators:
» PowerMAG EEG
» PowerMAG OPS

Coils:
» PMD70
» PMD45-EEG
» PMD45-fMRI
» PMD25-deentral

Accessories:
» Control splitter box
» TMS-field probe
» Neuronavigation

Service:
» Integration
OVERVIEW:

Multi-side TMS describes the use of multiple independently controlled stimulation coils which all are stimulating one subject. It is used for the investigation of functional connectivity within complex interconnected networks. By varying the timing and location of each coil, the temporal and spatial relationships between brain regions can be investigated. The operator can e.g. stimulate multiple locations with or without time delay between the stimulation pulses.

It is for instance possible to suppress one hemisphere while activating the other stimulation side. Another approach is to combine a “virtual lesion” which is evoked by applying rTMS on one or more brain area(s) and using single-pulse stimulation on another area. Up to 4 selected brain regions can be stimulated with different patterns and intensities at the same time while using highly focal coils.

MAJOR CONSIDERATIONS AND SOLUTIONS:

Safe and flexible operation of up to 4 stimulators
Patented safety concept with safety restrictions on stimulation intensities and frequencies.
Set and control the stimulation parameters freely through different options (USB, analogue & digital interface, triggers in/out, front panel).

Coil sizes and abilities
Variety of stimulation coils – different sizes and housings.
Application-oriented coil geometries for specific applications.

Precision of stimulation coils
Extraordinary temporal and spatial resolution through continuous development.

Reproducible results with different protocols
Stable output power through all stimulation patterns (single-pulse, rTMS, Trains, Theta-burst, QPS).

Stimulation of two spatially close brain areas at the same time
Decentral mini-coils enable the stimulation of areas that are only 2-3cm apart.

WHY MAG & MORE:

Full external controllability
Precise timing
Online EEG feasible
Current direction invertible
Decentral mini-coils
Integrated navigation points
Half- and full wave
Various protocols

RELATED PRODUCTS FOR MULTI-SIDE STIMULATION:

Stimulators:
» PowerMAG LAB
» PowerMAG EEG

Coils:
» PMD70
» PMD25-decentral

Accessories:
» PC Interface
» Control splitter box

Service:
» Coil tooling
» Rapid prototyping
OVERVIEW:

Event-related TMS depicts the combination of TMS together with a specific, cognitive task. Examples are stimulating the visual cortex while the subject is shown pictures, or stimulating Broca’s area while asking the subject to talk. As TMS is very focal and hence only influences very specific brain regions it is a very instrumental technique towards studying the brain’s inter-connections and functionalities while performing cognitive tasks.

For event-related TMS, the temporal relationship between a task with a reliable timing of the stimulation is crucial. The spatial resolution which is determined by the coil geometry is a second important factor which has to be considered.

The selection of the right stimulator and coil for event-related studies is essential for reliable results.

MAJOR CONSIDERATIONS AND SOLUTIONS:

Precise and reliable timing
Trigger in/out must be without jitter to ensure a proper, reproducible experiments.

Stimulation coils
Different geometries and sizes must be available. Customized coil development for innovative ideas.

Connection to existing lab equipment
Various interfaces to easily connect to devices which record VEP, AEP, MEP and other electrophysiological parameters. Different possibilities to control the stimulator with existing equipment.

Induction of mains noise into recording equipment and electrodes
Advanced shielding avoid interferences by mains noise and the stimulation pulse.

Reproducible stimulation
Integration into MR-based neuronavigation systems.

WHY MAG & MORE:

Full external controllability
Various Coils
Precise timing
Integrated navigation points
Electrical Shielding
Integration
Half- and full wave
High speed stimulation

RELATED PRODUCTS FOR EVENT-RELATED FAST TMS:

Stimulators:
» PowerMAG LAB
» PowerMAG EEG

Coils:
» PMD70
» PMD45-EEG
» PMD25-decentral

Accessories:
» Control splitter box
» TMS-field probe
» Neuronavigation

Service:
» Coil tooling
OVERVIEW:
Experimental brain research can benefit enormously from pain-free and non-invasive stimulation options. As such, TMS can induce a temporary functional disturbance in a focal area of the cortex. This lesional effect can be characterized by psychophysical measurements and lead to important conclusions about the functional relevance of the stimulated area of the cortex.

The high temporal resolution of electroencephalography (EEG) permits the direct derivation of brain activity triggered by TMS. In addition to the performance of TMS and EEG at separate times (offline method), the simultaneous use of TMS and EEG (online method) can provide an especially unique opportunity to investigate corticocortical connections.

» Interactive method: Analysis of TMS effects on functional networks during cognitive tasks.
» Inductive method: Evaluation of cortical reactivity and connectivity by measuring transcallosal evoked potentials (TEP).
» Rhythmic method: Monitoring of the influence of TMS stimulation on oscillatory brain activity to understand the causal relationships between cortical rhythm and perceptual, cognitive or motor processes.

MAJOR CONSIDERATIONS AND SOLUTIONS:

Induction of mains noise into electrodes and leads
Advanced shielding of stimulator to avoid interferences.

Precise and reliable timing
Trigger in/out must be without jitter.

Integration into existing EEG-labs
Various possibilities to control the stimulation with existing equipment.

Future proof equipment
Possibility to upgrade stimulation hard- and software in order to follow future TMS developments.

WHY MAG & MORE:

- Full external controllability
- Integrated navigation points
- Precise timing
- No mains noise
- Short pulse length
- Half- and full wave
- Current direction invertible
- High frequency TMS

RELATED PRODUCTS FOR EEG-TMS:

Stimulators:
» PowerMAG EEG
» PowerMAG OPS

Coils:
» PMD70
» PMD45-EEG
» PMD25-decentral

Accessories:
» Control splitter box
» TMS-field probe
» Neuronavigation

Service:
» Training
» Coil tooling

Why Mag & More:
Full external controllability
Integrated navigation points
Precise timing
No mains noise
Short pulse length
Half- and full wave
Current direction invertible
High frequency TMS
OVERVIEW:
A hot topic in today’s brain research is state-depending modulation of brain networks in real time by applying personalized TMS patterns. This real-time application allows you to investigate cortical excitability and induction of long lasting plasticity in network pathways with respect to the "right" timing with the "right" TMS stimuli.

Synchronizing the timing of the individual stimulation patterns with the actual state parameters is technically challenging. For following the dynamics in different brain states an online streaming EEG data acquisition equipment and a real-time capable TMS device is essential.

REAL TIME EEG TRIGGERED TMS

WHY MAG & MORE:
- Full external controllability
- Precise timing
- Integrated navigation points
- Half- and full wave high speed TMs
- Various coils
- Electrical Shielding
- Integration
- Control splitter box
- TMS-field probe
- Neuronavigation
- Training
- Integration

REAL TIME EEG TRIGGERED TMS

RELEVANT PRODUCTS FOR REAL TIME EEG TRIGGERED TMS:
- Stimulators:
  - PowerMAG EEG
  - PowerMAG OPS
- Coils:
  - PMD70
  - PMD45-EEG
  - PMD25-decentral
- Accessories:
  - Control splitter box
  - TMS-field probe
  - Neuronavigation
- Service:
  - Training
  - Integration

MAJOR CONSIDERATIONS AND SOLUTIONS:
Real-time capable equipment with reliable timing
Jitter free stimulation equipment.
Online streaming EEG data acquisition equipment.

No interference of mains noise
Shielded stimulator technology to avoid disturbances by mains noise.

Integration into existing lab setups
Free control of stimulator with existing equipment.

Future proof equipment
Upgradable technology in order to follow future TMS developments.

Computation
Calculation of next TMS stimulus based on last EEG signal

neurophysiological effect
parameters for brain modulation
EEG Monitoring of brain activity
parameters of current brain activity
Modulation of brain activity
OVERVIEW:

This innovative, new patterned repetitive transcranial magnetic stimulation protocol called quadri-pulse stimulation (QPS) can generate a broad range of motor cortical plasticity ranging from MEP suppression to MEP facilitation. In addition to evoking lasting cortical plasticity changes, QPS can also be used to evaluate priming effects: when used as a priming stimulation, which does not induce an LTP- or LTD-like phenomena itself, it can nevertheless change the threshold for LTP- or LTD-like plasticity caused by consecutive stimulations. Said effects enable the examination of metaplasticity theories in more details in humans. Other more clinical applications of QPS are being researched towards inducing symptomatic relief in patients with neurological or psychiatric disorders, such as Parkinson’s disease, depression, or intractable pain.

Our new technology platform enables for the first the combination of ultra-fast QPS and online TMS-EEG in one single device.

MAJOR CONSIDERATIONS AND SOLUTIONS:

Safe operation of the stimulator
Safety channel to immediately stop of the stimulation if necessary. Patented safety concept for setting safety borders of stimulation intensity and frequency.

Combination of QPS stimulation with EEG
Biphasic QPS pulses for minimization of stimulation artifact. Advanced shielding of stimulator and to avoid interferences by mains noise.

Comparison of various stimulation protocols
All-in-one stimulation equipment enables QPS, TBS and rTMS in one device.

Integration into existing research labs
Various possibilities to control the stimulation with existing equipment.

WHY MAG & MORE:

Safety boards
Optimized coil design
Precise timing
Customization
No mains noise
Integration
High frequency TMS

RELATED PRODUCTS FOR QPS STIMULATION:

Stimulators:
» PowerMAG QPS

Coils:
» PMD70
» PMD45-EEG

Accessories:
» Control splitter box
» TMS-field probe
» Neuronavigation

Service:
» Integration
OVERVIEW:

Translational and basic research are the major areas of TMS applications in animals. The use of animals has advantages in terms of subject homogeneity, disease models and available histology. Focuses such as TMS safety, neuronal connectivity, synaptic plasticity and cortical organization all have strong translational relevance.

Rats, mice, dogs, cats, rabbits and horses are the most commonly used animals for research with TMS. Stimulating small animals with TMS, sometimes even in conjunction with EEG, is challenging because of the animal’s size. This requires specific equipment, such as small dedicated TMS-coils with very focused magnetic fields.

MAJOR CONSIDERATIONS AND SOLUTIONS:

Size of the animals:
Decentral mini-coils enable a very focal stimulation in rodents.
Large range of stimulation coils – different sizes and housings.
Application-oriented coil geometries for specific animals.

No standardized experimental setup:
Customization of the setup – from cable length to coil mountings.
Free control of the stimulator.
Different stimulation parameters (pulse direction, pulse shape, protocols).

Simultaneous use with other equipment
Avoiding electrical disturbances and induction with special shielding.
Integrated safety concepts for safe operation in various combinations.
High frequency multimodal-TMS enabled with advanced recharging technology.

Precise coil positioning:
Integration into MR-based neuronavigation systems.

WHY MAG & MORE:

Full external controllability Various coils
Precise timing Customization
Online EEG feasible Half- and full wave
Current direction invertible Various protocols

RELATED PRODUCTS FOR ANIMAL STIMULATION:

Stimulators:
» PowerMAG LAB
» PowerMAG EEG

Coils:
» PMD70
» PMD45-EEG
» PMD25-decentral

Accessories:
» Control splitter box
» TMS-field probe

Service:
» Integration of custom-made coils
» Coil simulations
OVERVIEW:

In-vitro cell stimulation is utilized to research the physiological events in cortex cells on neuro-chip-systems. Findings in the field of in-vitro cell stimulation help improve current applications in neurodiagnostics and -rehabilitation.

The main advantage of neuro-chip-systems is that, due to their inter-neuronal connections, they represent nerve tissue much more comprehensively than single nerve fibers or preparations. These systems also highly suited towards analyzing defined chemical impacts on nerve cells (e.g. neuro-toxic impacts). Reproducible measurements can be conducted over extended periods of time while excluding many interference factors.

MAJOR CONSIDERATIONS AND SOLUTIONS:

**Ability to modulate the stimulus activity of neurons:**
Exact stimulation dosage and reproducibility.

**Definition of the geometric field parameters for the induced magnetic field:**
Selection of different coil forms and types.

**Research different pulse forms:**
Optimizing stimulus time and sequence (with or without switching the polarity).

**Improved stimulus effect for induced stimulation:**
Application of different pulse forms and patterns.

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**WHY MAG & MORE:**

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<thead>
<tr>
<th>Feature</th>
<th>Description</th>
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<tr>
<td>Full external controllability</td>
<td>Various coils</td>
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<td>POWER</td>
<td>Stable output power</td>
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<td>Customization</td>
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<td>Various protocols</td>
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**RELATED PRODUCTS FOR IN-VITRO CELL STIMULATION:**

**Stimulators:**
- PowerMAG LAB
- PowerMAG QPS

**Coils:**
- PMD70
- PMD25-decentral

**Accessories:**
- Control splitter box
- TMS-field probe

**Service:**
- Integration of custom-made coils
- Coil simulations
OVERVIEW:
Robotic TMS is a highly advanced technique and a unique tool to assure stimulation quality in terms of precision. The combination of a robot, MR-based neuronavigation and focal stimulation makes it possible to reproduce multiple sessions or ensure identical setups in e.g. multi-center studies.

Modern TMS robots are able to safely readjust to the subject’s head movement and ensure contact between the TMS coil and the subject’s head. Image guided TMS sessions can be planned in advance for fully automatic executions.

In addition to holding the stimulation coil reliably and accurately for target points, TMS robots are also capable of moving along pre-defined paths on the subject’s head. With this functionality it is possible to stimulate larger target areas with a focal stimulation coil.

MAJOR CONSIDERATIONS AND SOLUTIONS:

Safety:
Real time force control of the robotic arm.
TMS safety concept with safety restrictions on stimulation intensities and frequencies.
Dedicated workspace and limitation of the robotic arm’s movement range.

Accuracy and reproducibility:
Computer controlled coil positioning with multiple sensors
Store and recall individually set target points.

Performing complex TMS protocols
Integration of wireless real-time tracking systems.
TMS stimulator capable of running advanced protocols.

Compatible TMS equipment
Dedicated lightweight robotic coils with long and highly flexible cables.

WHY MAG & MORE:

- Full external controllability
- Various coils
- Precise Timing
- Customization
- Integration
- Half- and full wave
- Safety borders
- High frequency TMS

RELATED PRODUCTS FOR ROBOTIC TMS:

Stimulators:
» PowerMAG LAB

Coils:
» PMd70-pCool-robotic

Accessories:
» Control splitter box
» PC Interface

Service:
» Integration
WORLDWIDE
PowerMAG Research is available to over 1 billion people in more than 30 countries of the world.

QUALITY
Designed, engineered and manufactured in Germany.

EXPERIENCE
MAG & More has almost 20 years’ experience in development and manufacturing of high-end TMS devices.

FLEXIBLE
Rapid response to customer needs. MAG & More is privately owned and proud to listen to our customers.

SAFETY
Our medical products are developed and manufactured according to strict medical guidelines for therapy and research use.

CERTIFIED TRAINING PROGRAM
Become a certified TMS professional with our international TMS-Academy training program.

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