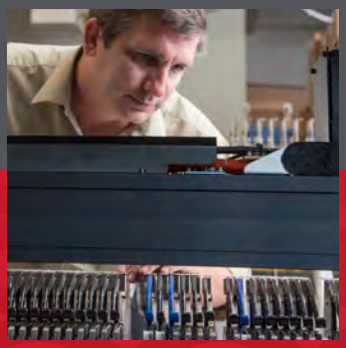
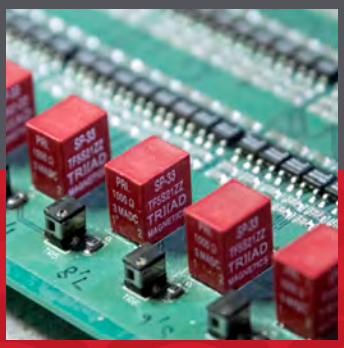
Tucker-Davis Technologies





Product Catalog 2018

Neuroscience Research Systems & Accessories

We develop and build the world's most advanced systems for neurophysiology research.

TDT's System 3 product family has expanded steadily with over 30 years of innovation. Our portfolio now includes everything from electrodes to specialized powerful processors and the software to run them. Informed by a close relationship with our customers, what we do is vision fulfillment—an informed vision about the tools that work best for our customers, fulfilled by a company that understands what is needed to deliver reliable results.

Contents

"We make tools for people who study the brain."

—Tim Tucker, President TDT

After 30 years of innovation, you might think we would be slowing down, but nothing could be further from the truth. In recent years, we have brought to market the most powerful hardware and software products in our industry. In 2014, we redefined the traditional biological amplifier and began shipping the PZ5 line of powerful NeuroDigitizers. Soon after, our Synapse software and its associated technologies hit the nail on the head with point-and-click operation and complete user control. Our newest, fastest processors and fully synchronous cluster technology offer systems capable of recording and processing thousands of channels of neural data in real-time. Most recently we have been working to bring the power of Synapse to the next generation of neuroscientists. Synapse Lite and the versatile Lab Rat Interface let anyone perform multichannel neuroscience experiments more cost effectively than ever before.

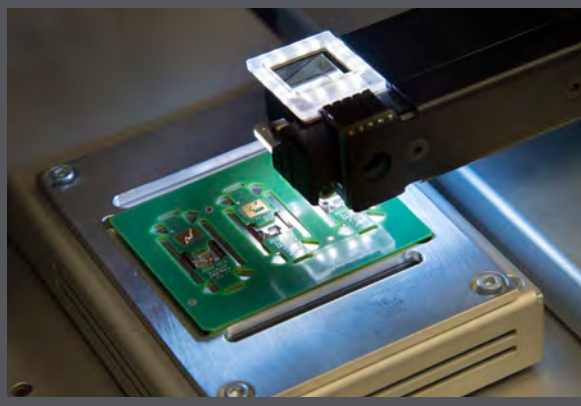
Tim Tucker

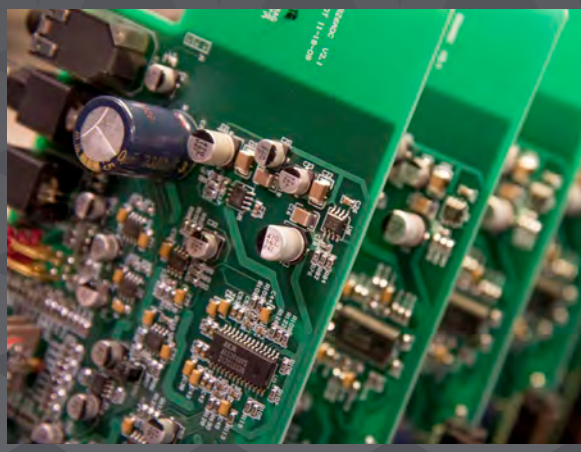
Built from the ground up.

At TDT, we recognize the benefits of promoting close ties between every department of our company.

Our goal is to supply you with the highest quality and most up-to-date technology available at an affordable price. We believe we can best meet this goal when all areas of our business work together in a cooperative and collaborative environment.

This belief is exemplified by the integrated nature of our facility, which brings together our team of scientists, on-site laboratory, engineering staff, and manufacturing floor all under one roof.





In-House = An Integrated Approach

In-House R&D=

From R&D:

VICTOR RUSH PHD, *has worked at TDT for over 17 years and is currently our Director of Technical Sales. His early life as an Academic nomad provided him with the skills to understand complex research environments and their requirements. With a PhD in Ecology and Evolution from UC Santa Barbara, Victor worked as a researcher at the University of Victoria BC and the University of Kentucky. Dr. Rush was headed for a career in academia before TDT offered him the deal of a lifetime: helping scientists around the world with the technical aspects of their work.*

NAFI YASAR PHD, MBA *earned his PhD in Bioengineering from Rice University and has experience working in both commercial and academic settings. Prior to joining TDT he worked in Michael Beauchamp's lab at the University of Texas studying integration of vision, audition, and somatosensation in human cortex. He joined TDT in 2010, first working in technical support for two years before moving to sales. Nafi's favorite part of the job is working on site with customers to help develop their exciting new research projects. In his spare time Nafi enjoys working on electronics projects and practicing Brazilian Jiu Jitsu.*

Informed Innovation

In keeping with our commitment to innovative product development, TDT has built a Research and Development Department with a full-time staff of scientists and engineers focused exclusively on inventing new devices and methods for bioscience research. Their mission is to identify target products, design and fabricate prototypes, evaluate these in real-world situations, and use the results to inform commercial product design. Our imaginative team of R&D engineers is currently focused on improving and expanding current hardware and software products. These efforts are geared toward improving performance, simplifying use, and supporting higher channel count recordings, including streaming many channels direct to data storage.

Building on success with recent innovations, they are also continuing to develop novel headstage designs and connectors and higher channel count electrodes. Whole system integration, including integrated vision processing, is another area that has seen recent advancements, leading to several new products, and will continue to be an area for further development.

In-House Engineering =

From Engineering:

DANIEL SHEPHERD *is working in his fifteenth year at TDT as an electrical engineer. He obtained his B.S in Electrical Engineering at the University of Florida and is an avid Gator fan. Before working at TDT he developed a keen understanding of digital and FPGA design and currently oversees the final stages of the engineering development process. Daniel enjoys the experience of taking an idea and seeing it through to fruition while being a major component of its realization.*

STEPHEN BELL, *in his seven years at TDT, Stephen continues to broaden the skill set he brings to developing new products. Having obtained a B.S. in Electrical Engineering from the University of Florida, he is involved in nearly every level of design, including circuit, mechanical, firmware, software, and FPGA design. Stephen enjoys working with new technologies and integrating them into our products.*

Elegant Design

The principal task of engineering is to turn ideas into products. We have some of the best engineers in the business and they design with quality and performance in mind. However, having our production facility and research lab 'in house' allows them to design for usability and ease-of-manufacturing as well, ensuring you get a high quality product that is both user friendly and cost effective.

Our R&D team plays a critical role in the engineering process, providing valuable information concerning the feasibility and usability of new features before they are implemented. As new products are designed and tested, our scientists put our equipment to use, just as it would be utilized in a research laboratory.

With our manufacturing department just steps away from the offices of our design engineers, we're able to streamline the entire product development process, from concept to delivery. With immediate feedback from production staff, the reaction time for product improvements and upgrades is very fast. When the design cycle is minimized, the cost of each new product roll-out is significantly reduced.

In-House Manufacturing =

From Manufacturing:

JAMES LUNDY *has worked for TDT for 17 years, advancing from technician and surface mount technology operator to his current position as production manager. Prior to joining TDT, James served for four years in the 82nd Airborne Army Division reaching the rank of sergeant. He then obtained his degree in Electrical Engineering Technologies from ITT Technical Institute. He enjoys working with cutting-edge technology and the state-of the art tools available in TDT's production and engineering department.*

Affordable Quality

Our commitment to affordable quality continues when the manufacturing process begins. We use the most modern production methods and put our products through a series of rigorous tests before shipping them to your lab. At TDT, delivering a product means taking it from concept to production. Each phase, including development, testing, board layout, component assembly and systems integration, is performed by highly trained and dedicated TDT team members. This eliminates the unreliability and increased turn-around time introduced by outsourcing parts of the process to contract engineering or manufacturing firms.

We believe the best solution is the one that is designed for the task at hand from the beginning. We don't build our systems around off-the-shelf boards; we build complete systems from the ground up. It is the only way we know to deliver the reliability, affordability, and performance you deserve.

5 YEAR WARRANTY

Five Year Warranty
Any defects in materials or workmanship are promptly repaired or replaced.

Custom hardware carries a one-year warranty on parts and labor. All headstages, the ES1 and the EC1 carry a two year warranty.

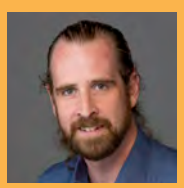
"Customer support has been excellent, especially considering the physical distance between Australia and the US. Equipment faults, although rare, have been fixed with little or no down time."

— Dr Antonio Paolini, La Trobe University.

In-House Customer Support=

From Customer Support:

MARK HANUS MSE *has assisted customers in experimental design development, troubleshooting, and training for over 10 years at TDT, advancing from applications engineer to his current role. He came to TDT with a Master's degree in Biomedical Engineering from the University of Michigan and work experience in two Northwestern University labs where he designed and maintained systems for primate behavioral studies using TDT equipment.*



CHRIS WALTERS *brings a diverse professional background to his work at TDT. He has worked as a software developer, hardware and software troubleshooter, and a production engineer at technology firms in Massachusetts and Florida. He graduated from Eastern Nazarene College and is currently pursuing a second degree in Electrical Engineering.*

Knowledgeable Assistance

Our Technical Support Engineers and Application Specialists have advanced degrees in Biomedical Engineering from topflight schools and many have research experience in neuroscience and physiology. This real-world experience means that the people who work with you not only have an intimate knowledge of our equipment, but also understand your needs and your research. Each support team member has access to a wide variety of hardware, software, and test equipment and when necessary, they'll replicate your set-up to provide you with practical solutions.

This real world experience means that the people who work with you not only have an intimate knowledge of our equipment, but also understand your needs and your research.

We know our products and we know your work. It is our goal to have the best customer support in the business.

Real-Time Technical Support

Our qualified and experienced support engineers are dedicated to only one job: to ensure that you get the help you need—when you need it. Now using GoToAssist® remote-support technology.

Online Tools for After-Hours Help

Searchable database of technical notes, online help files, and downloadable software updates.

Synapse and System 3:

A Complete Solution

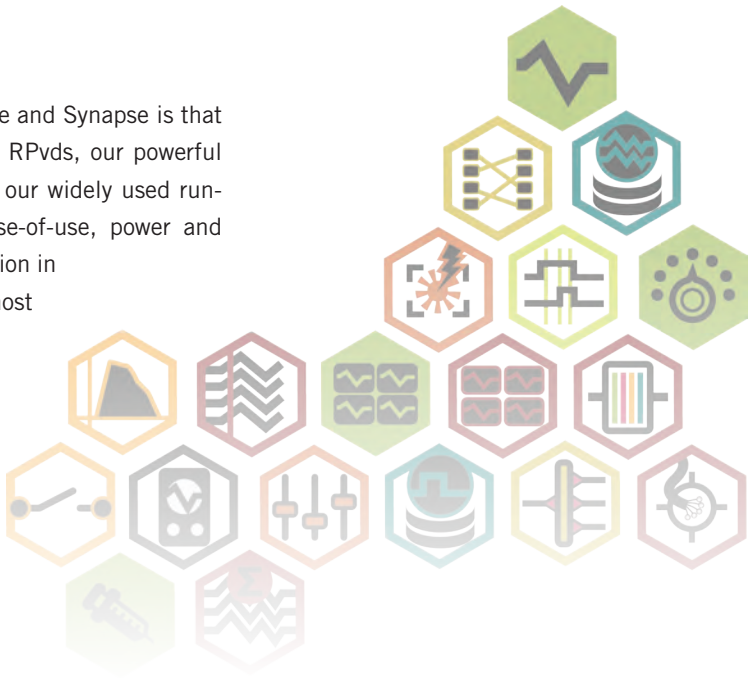
How We Got Here:

As a fully vertical company with 30 years of innovation experience, TDT offers the most capable and comprehensive line of products for neuro-physiology research. Building on the time-proven architecture of our DSP-based signal processors and optically isolated amplifiers, we have steadily increased the depth and breadth of our product offerings.

Our systems can handle the most demanding experimental paradigms with features and capabilities unmatched in our industry. Whether you are recording from 4 channels or 4,000 channels, we have a cost effective and powerful system to meet your needs.

Synapse Brings it All Together:

No great hardware realizes its full potential without great software and Synapse is that great software. Synapse is built on the strong underpinnings of RPvds, our powerful DSP configuration language, and the best elements of OpenEx, our widely used run-time application. Perfectly hitting the sweet-spot between ease-of-use, power and flexibility, Synapse offers complete experiment design and execution in an intuitive point-and-click environment. Synapse is simply the most capable and powerful software we have ever produced.



Synapse

Innovation
with Continuity

RP2: 1991

RZ2: 2016

...30 Years in the Past and 30 Years Into the Future...

Our first DSP-based product was the RP2 Real-time Processor. This first of its kind device had a single 150 megaflop processor and a Real-time Operating System (RPOS) that could be configured using a graphic design tool called RP Visual Design Studio (RPvds). Years later, our DSP products have grown exponentially more powerful, with up to 32 multi-core processors and nearly a teraflop of processing power. Our products include optimized architectures and extensive I/O capabilities not thought of in 1991; but, they all still run RPOS. Circuits and software built for the first RP2 will run seamlessly on our latest and greatest RZ processors.

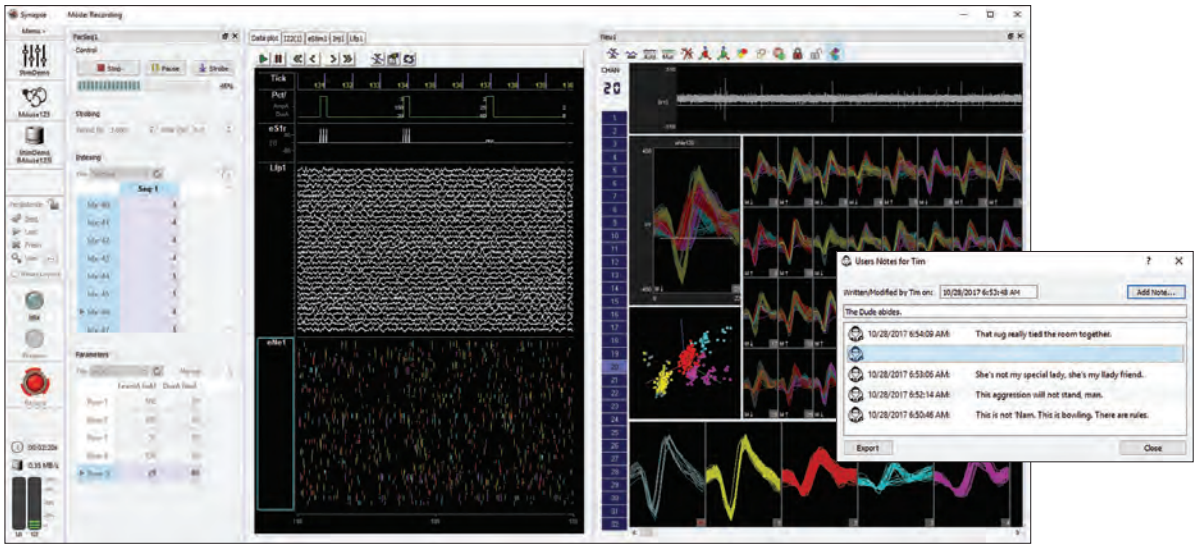
Continuity into the Future:

TDT offers the most complete line of cost effective systems for neurophysiology research. From our student focused Lab Rat all-in-one devices to our very-high channel count cluster systems, all of our systems are unified in their operation and they all run Synapse. This means experiments you build for your very first system will continue to work smoothly as your needs grow in the future.

Synapse training videos are available at:
www.tdt.com/synapse-video-training.html

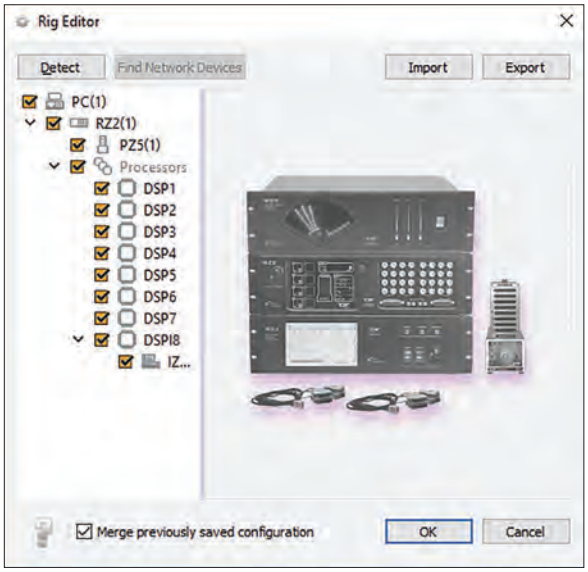
Software:

The Synapse Difference



Complete Neurophysiology Software Solution

Experience the power and flexibility of TDT's proven multi-DSP hardware platform easier than ever before. Synapse is TDT's ultimate in experiment control software to design, manage and collect data from your neurophysiology experiments. In Synapse, going from a new idea to collecting data takes just a few mouse clicks!



Automatic Hardware Detection and Resource Allocation

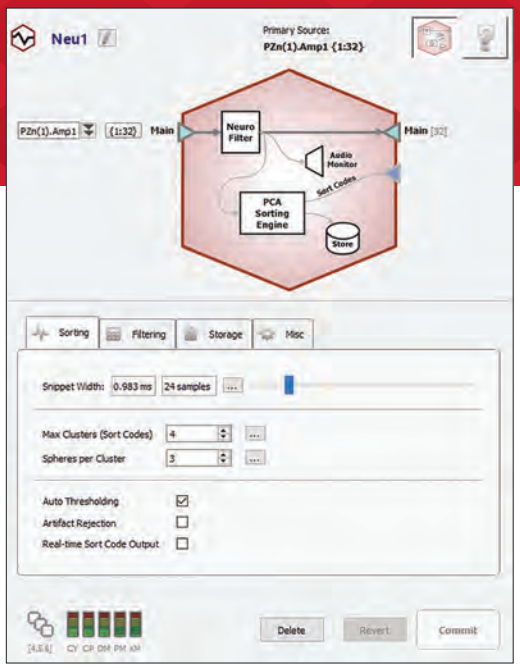
Synapse offers the highest level of setup and task automation for experiment design, execution and management.

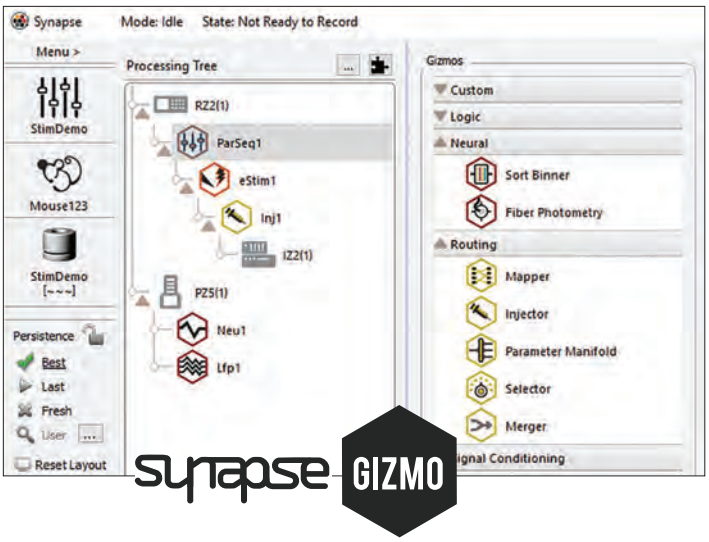
As you build your experiment, you won't have to think about the particulars of your hardware setup. If your hardware changes, Synapse will recognize it and reconfigure on the fly. With powerful built in optimization, Synapse will automatically balance the data processing load across all available hardware resources.

Easy Experiment Design

Synapse comes with preloaded experiment templates which provide a quick starting points for your next project.

Need to add some unique elements? Built-in gizmos provide easy building blocks to fine-tune data processing and collection. Synapse makes it easy to visualize and control data flow all the way through your experiment.





Turnkey Research Execution

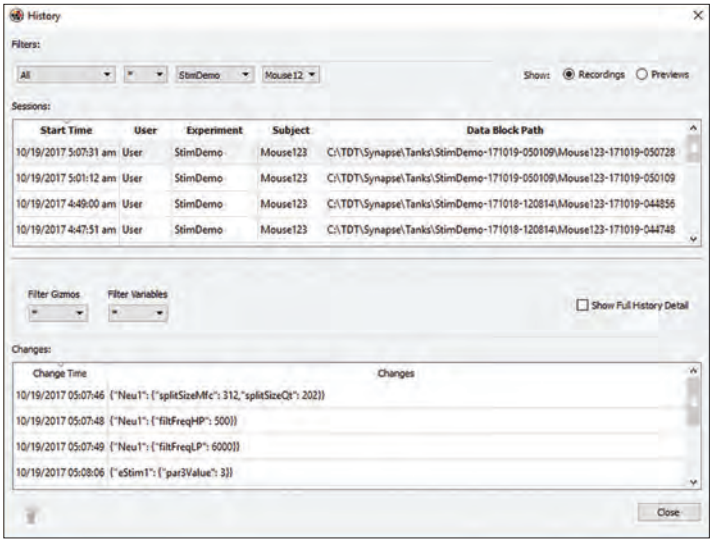
Synapse gizmos combine common processing tasks into simple drag-and-drop objects. Each gizmo allows you to configure settings during experiment design and control thresholds, filter settings and much more during runtime.

Gizmos can be chained together to form data processing chains as complex as you can imagine. Generate waveforms, manipulate parameters and design elegant closed-loop experiments without writing any custom software!

Comprehensive Lab Management

With its comprehensive relational database, Synapse tracks and logs modifications made during experiment runs and throughout the life of a project.

When running your experiment, you can use Synapse's runtime interfaces to change settings and visualize data as it's acquired. Acting as a laboratory notebook, Synapse allows you to see exactly who changed which parameters and when over time.



Software:

The Synapse Difference

Intuitive Drag-and-Drop Gizmos

Synapse encapsulates common research elements into easy-to-use building blocks called gizmos. Gizmos make it easy to create basic experiments quickly while still providing the flexibility to facilitate complex research paradigms. Chain multiple gizmos together to take step by step control of your data processing.

Gizmos are available for a variety of tasks, including reading input signals, filtering, online spike sorting, data storage, channel mapping and much more. Here are a few of the Gizmos our customers love to use...

LFP Processor
Filter and store multi-channel data from local field potentials (LFPs) and other slow neural waveforms. Used for: LFP, EEG, or ECoG recordings.

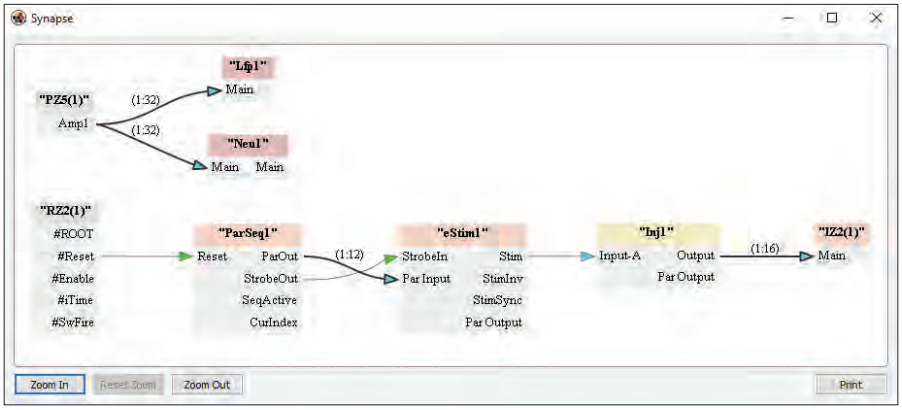
Tetrode Spike Sorting
Real-time filtering, cross-channel tetrode spike detection and classification in a fully customizable 2D feature projection. Used for: Awake behaving neurophysiology, acute and chronic extracellular recordings.

Fiber Photometry
Real-time control of up to four light drivers with acquisition and storage of demodulation results from a flexible demodulation "sensor x driver" matrix using up to two sensor inputs. Optionally store broadband raw signals and driver parameters.
Used for: Fiber photometry recordings.

Electrical Stimulation
Generate fully customizable monophasic and biphasic pulse trains for electrical or optical stimulation. Used for: Microstimulation, macrostimulation, optogenetics, stimulate-record protocols, closed-loop spike-triggered stimulation.

Mapper
Remap recording channels at runtime to match your electrode, headstage and adapter combination.

For more Gizmos, go online at www.tdt.com/Synapse/gizmos.html



Synapse API

Synapse API includes a rich framework to allow users to create custom applications that communicate directly with TDT hardware and software. User applications can be developed in Matlab, Python, C++ or any scripting language that can generate HTML requests. Perform tasks as easy as pulling data into Matlab for analysis, or as complex as automating the complete starting, stopping and runtime execution of your experiments. Synapse API makes it easy to read and change parameters (e.g. filter settings) during runtime and also provides a useful way to monitor the status of your ongoing experiments remotely.

Synapse

Core Features	Lite (LTE)	Essentials (ESS)	Suite (STE)
Hardware Support	LabRat Only	All System 3 Hardware	
Real-time Processing	Emulated	Real-time DSP Signal Processing	
Maximum Channels	64	*Unlimited	
Maximum Devices	Single	*Unlimited	

Included Software	Lite	Essentials	Suite
OpenScope		X	X
OpenBrowser		X	X
OpenBridge		X	X
OpenExplorer			X
OpenController			X
OpenSorter			X

**Maximum number of channels and devices are only limited by hardware purchased*

System Examples

Typical Neurophysiology Workstations

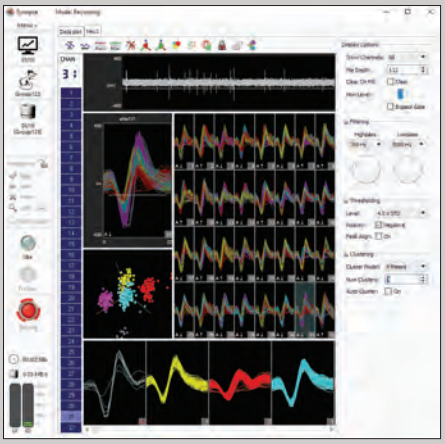
TDT's Neurophysiology Workstations each include a powerful real-time processor and one or more multichannel amplifiers. This combination delivers the low noise of an optically isolated, battery-powered amplifier and the flexibility of a user programmable real-time DSP. Every channel is simultaneously sampled and user-specific processing is performed *on the fly*. The Synapse software provides real-time control of an array of spike sorting techniques: PCA based cluster, Template matching and tetrode sorting. The real-time sorting system has near instantaneous control of spike triggered events.

Z-Series Basic 32-Channel Neurophysiology Workstation

This cost-conscious system is ideal for recording 32 channels of single units. It can do real-time spike sorting and data storage on all channels while streaming broadband data to the PC. You can also filter and record LFP's or other biological signals. The pre-installed stimulation control output allows for easy upgrade to include multi-channel stimulation. If you're doing stimulation you will want to add an extra DSP to your RZ5D.

The RZ5D also includes eight channels of purpose analog I/O and 24 bits of TTL I/O for interfacing the miscellaneous elements of I/O in your experiment.

Qty	Part #	Page #
1	RZ5D	35
1	PZ5-32	41
1	ZC32	49
1	PO5e	46
1	SynapseESS	18



The Synapse software provides real-time control of an array of spike sorting techniques: PCA-based clustering, template matching and tetrode sorting. The real-time sorting system has near-instantaneous control of spike-triggered events. The Synapse environment uses drag-and-drop access to gizmos, i.e. mini apps that control signal processing, such as filtering, data storage, control of digital I/O, and a real-time oscilloscope.

Powerful tools such as power band and RMS analysis are integrated into the RZ real-time processor. The user control side of the Synapse software has been developed to store all changes to settings while you run an experiment. Information about settings is stored on a per-subject level for easy system setup of chronic recordings. Our built-in notebook timestamps important information about the state of the subject.

Chronic Recording Neurophysiology Workstation

This system supports tethered recording from a freely moving animal. Using either a 32 or 64 channel commutator you can perform high channel count recordings with either analog or digital headstages. When using digital headstages and the ACO64 commutator, you can record up to 512 channels. For up to 64 channels we recommend using analog headstages for their superior recording performance.
The optional RV2 allows for real-time fully synchronized subject tracking, with user-specified tracking information being fed directly into the RZ2 processor for integration with neural data. The RV2 will also save a fully synchronized video for post analysis. Our ACO motorized commutator supports optogenetic stimulation via a dedicated center bore; this bore can also be using to pass fluids to the subject.

Qty	Part #	Page #
1	RZ2-8	33
1	RV2	48
1	VGAC Camera	48
1	PO5e	46
1	PZ5-0-4	41
1	ACO-32/64	59
3	ZD64	49
1	SynapseSTE	18

Tips from Victor:

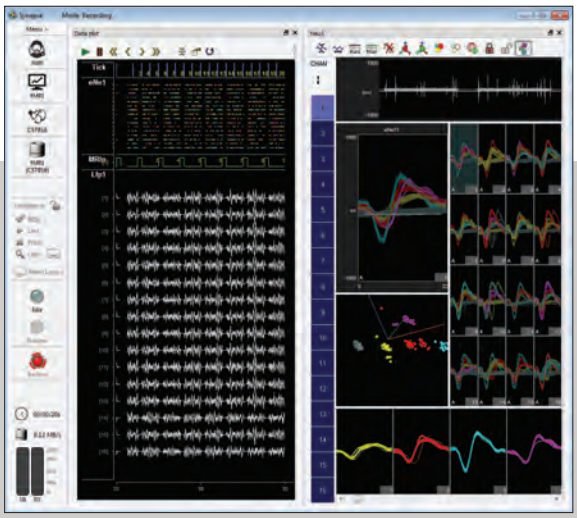
- Our Synapse software allows you to easily view and integrate the information from the video tracker with the electrophysiology.
- The PZ5 can be configured to accept digital or analog based headstages so that you can mix and match your recording configuration in your animal. Record 128 channels of spike data and 16 channels of EMG or EEG signals by mixing analog and digitizing headstages.
- Add some LEDs and use our Real-time Video tracker (RV2) to acquire and process in real-time the XY coordinate position of your animal and detect when the rodent moves into a particular region of the cage or maze. Use positional data to initiate electrical or optogenetic stimuli or even better, trigger based on a particular neuron firing when the subject is in one region of the cage or maze.

fMRI Compatible

Spikes + fMRI Neurophysiology Workstation

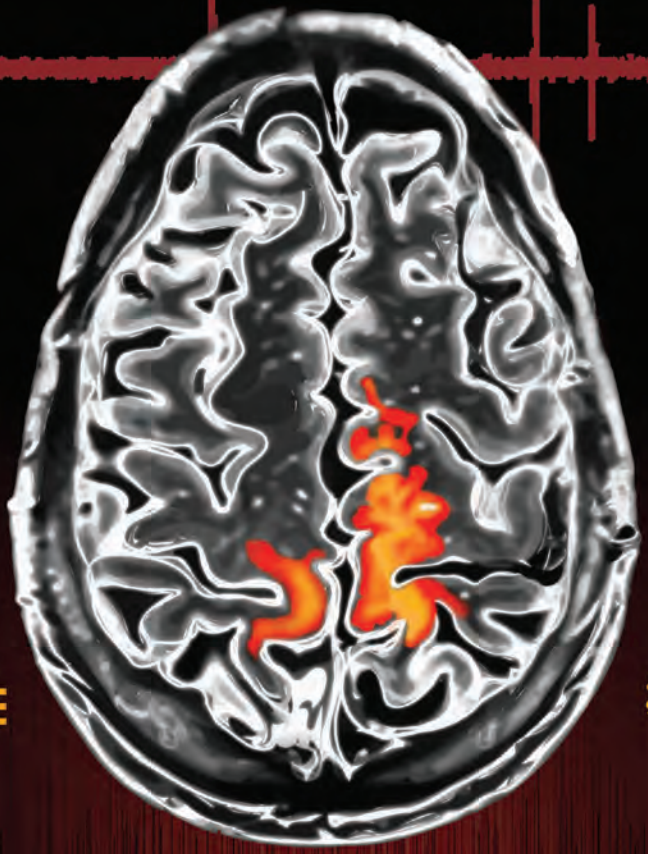
The combination of MRI compatible Headstages (LP16CH, LP32CH) and our PZ5 amplifier allows users to record single unit activity in an fMRI environment. The LP16CH-ZNF is designed with nickel-free Omnetics connectors and active electronics to provide an excellent signal in an fMRI coil. Cable lengths of up to 4 meters are possible with this active interface. The PZ5 amplifier's large input range ensures that during a scan the amplifier does not saturate; recovery of the signal begins immediately after the scan.

Qty	Part #	Page #
1	RZ2-8	33
1	PZ5-64	41
1	LP32CH-ZNF	51
1	WS8	48
1	SynapseESS	18



The SYNAPSE software provides easy to use Spike Sorting for real-time visualization of neural data and our artifact blocker removes the scan artifact so that the spike signals are not corrupted. Our PCA-based spike sorting algorithm makes it easy to cluster signals quickly and remove artifacts induced in the MRI environment. This system is designed for primate and rodent recordings and works in high Telsa environments such as those found with rodent fMRI.

SPIKES + fMRI



Capture precisely time-locked data

Analyze brain function in awake, behaving subjects

Record single-unit electrophysiology during fMRI neuroimaging

Correlate BOLD changes with underlying neural activity

TDT
TUCKER-DAVIS TECHNOLOGIES

Made Possible by the TDT PZ5 NeuroDigitizer

Fast developing into the most capable platform for neurophysiology research, TDT systems can now record single-unit electrophysiology simultaneously during fMRI imaging. Directly measure the correlation of individual neural activity with the hemodynamic response in the brains of awake, behaving subjects. Working closely with scientists in the field, TDT engineers helped enable this breakthrough by utilizing several unique features of the industry leading PZ5.

Key PZ5 design features:

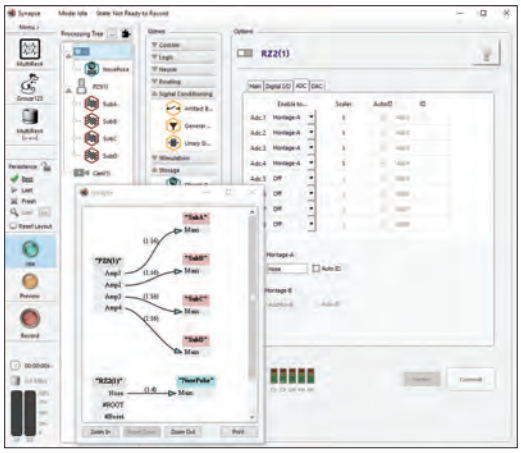
- Battery-powered & optically isolated amplifier
- Large input range (+/- 500 mV) prevents saturation
- Available in models ranging from 32 – 128 channels
- Connects via MRI patch panel with filters to reduce RF interference
- fMRI compatible (non-ferrous) TDT headstages minimize imaging artifacts

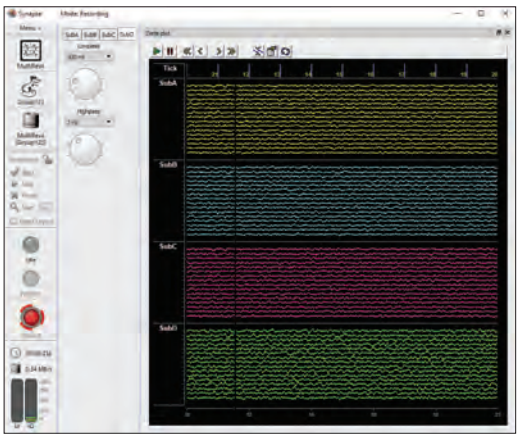
The modular and flexible nature of TDT System 3 Processors makes it easy to expand or completely change the functionality of your workstation—often with little or no additional equipment.

Multi-Subject Neurophysiology Workstation

TDT's multi-subject system configuration is well suited for experiments that require recording from multiple animals simultaneously. The PZ5 amplifier makes this possible by electrically isolating each bank so the recordings for each animal are kept separate. Synapse makes it easy to process all signals identically or split the data stream to process and store the data from each animal differently.

Qty	Part #	Page #
1	RZ2	33
1	RS4	47
2	PZ5-128	41
1	ZC32	49
1	PO5e	46
1	ACO-32	59
1	SynapseSTE	18





CUSTOMER PROFILE – MULTI SUBJECT RECORDING SYSTEM

Biogen Idec is a leader in the development of therapies for neurological and neurodegenerative diseases including multiple sclerosis and spinal muscular atrophy. Biogen scientists use in-vivo electrophysiology in combination with other techniques to develop and test potentially transformative new medicines. As such, they need neurophysiology equipment capable of recording biological signals from multiple subjects.

"At Biogen, we use a TDT system with a PZ5 amplifier to record from several animals at once. We are interested in multiple biological signals and are thrilled that we don't need special headstages or separate amplifiers to acquire EEG and EMG simultaneously. The TDT recording software allows us to record each animal into a separate, unique record for easy offline analysis saving us time and money. And the TDT support team is constantly there to help when we need them!"

—Brian Harvey, MS
Senior Associate Scientist, Biogen Idec

Complete Entry Level System

LR10 - Lab Rat

The Lab Rat is TDT's all-in-one, entry-level solution for conducting neurophysiology experiments. Lab Rat connects via USB and incorporates design elements found in our more advanced System 3 products. Lab Rat works seamlessly with Synapse Lite and Corpus (DSP emulator software) to offer a comprehensive, cost-effective solution unmatched in the industry.

The system includes

LR10	Lab Rat Interface
SB4	Touch-proof Connector Breakout for Surface Electrodes
AC16LR	16 Channel High Impedance Headstage
SynapseLTE	Page 18

LAB RAT

Lab Rat is a complete, economical acquisition system that includes everything you need to start running neurophysiology experiments.

Key features:

- 16 channels of neural recording
- 1 Intan-based digital input
- 16 bits of digital I/O
- 2 general A/D channels
- 2 general D/A channels
- Monitor speaker
- USB 3.0 connection
- Synapse Lite software

Synapse

CORPUS

It all starts with powerful software. Synapse Lite includes much of the amazing functionality found in the full versions of Synapse, while Corpus faithfully emulates hardware DSP processing on your PC. Use the flexible gizmos within Synapse to deliver fully synchronized stimuli and even design closed-loop experiments with a delay as low as 50ms!

High Channel Count Systems

High Count Channel Neurophysiology Workstation

A number of key technologies allow TDT systems to record from literally thousands of channels with unmatched fidelity and synchronicity. It starts with the WS8 high performance workstation connected to the RZ2-8 signal processor. The RZ2 is equipped with the QZDSP quad core DSP cards. These ultra-fast processors provide an amazing 800 GigaFlops of computing power supporting real-time single unit processing across all neural recording channels. Up front, the PZ5M-512 biological amplifier provides the industry's best recording fidelity, with multiple levels of electrical isolation and optional battery powered operation.

These 512 channels building blocks are then connected laterally using the PO5c interface card. This special version of our interface card supports TDT 'Cluster' configurations allowing full hardware and software integration and synchronization across all nodes. This Cluster technology is fully supported by Synapse allowing seamless software and hardware integration across a system recording from thousands of channels.

Qty	Part#	Page #	Qty	Part#	Page #
2	RZ2-8	33	16	ZC64 (typical)	49
2	PO5c	46	2	WS8	45
1	RS4-4	47	2	SynapseSTE	18
2	PZ5M-512	42			

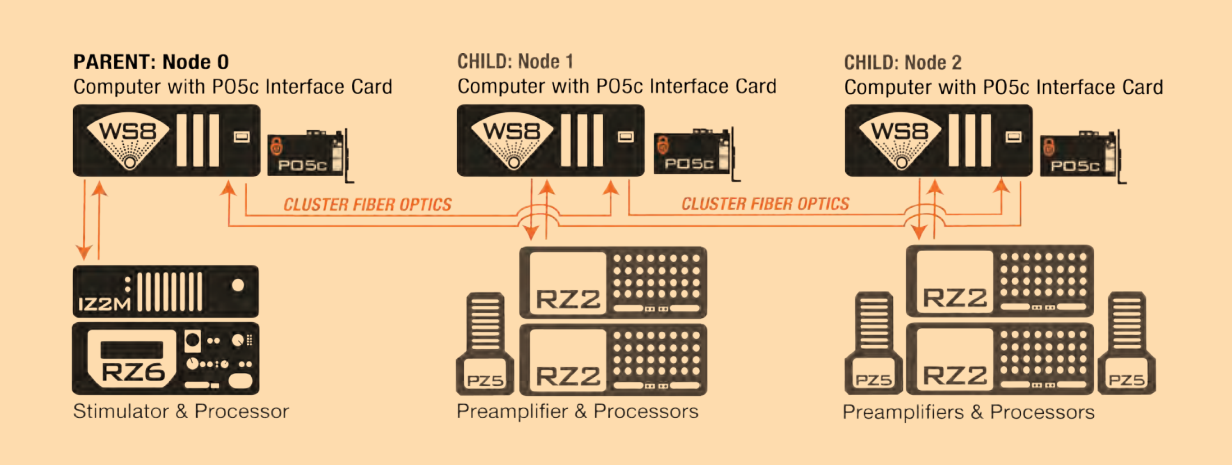
CUSTOMER PROFILE

At the **DEPARTMENT OF NEUROSCIENCES, UNIVERSITÉ DE MONTRÉAL**, *Prof. Numa Dancause and his laboratory investigate how primary and premotor cortices control movements and how these brain regions interact with each other. They also study the reorganization of these critical areas following injury (e.g. stroke recovery) and develop methods to manipulate neural plasticity in order to maximize recovery. To accomplish all of this, they use a range of animal models and electrophysiological techniques which requires neurophysiology equipment that is flexible, scalable and capable of recording many channels from multiple brain regions (often across hemispheres) simultaneously.*

"We started using TDT equipment to record and stimulate from just a few channels (16-32). The great scalability of the TDT system allowed us to easily expand the number of electrodes we could implant to nearly 400 channels. Limited only by funding, we now can selectively record from up to 256 of these channels by combining multiple TDT amplifiers and processors with a single computer. The TDT technical support team has been outstanding. They helped us on numerous occasions to program the stimulation and recording experiments as well as tightly integrate our behavioral tasks so that everything is controlled by the TDT system.

—Prof. Numa Dancause
Associate Professor

TDT's unmatched platform allows for a virtually unlimited number of channels to be recorded simultaneously; with customers currently recording more than a thousand channels, TDT is uniquely ready to meet the challenges of future research that will require exponentially larger amounts of data.



Synapse Cluster

Streamline experiments by dividing complex tasks including spike sorting and stimulus control across multiple workstations, screens and users.

Using a Synapse Cluster, you can divide real-time experimental tasks across multiple PCs and users. For example, dedicate one lab member and screen to sort one block of channels (1-512) while another team member simultaneously works at another station on additional channels (513-1024). Or, separate recording tasks and stimulus control amongst your team members at different physical workstations.

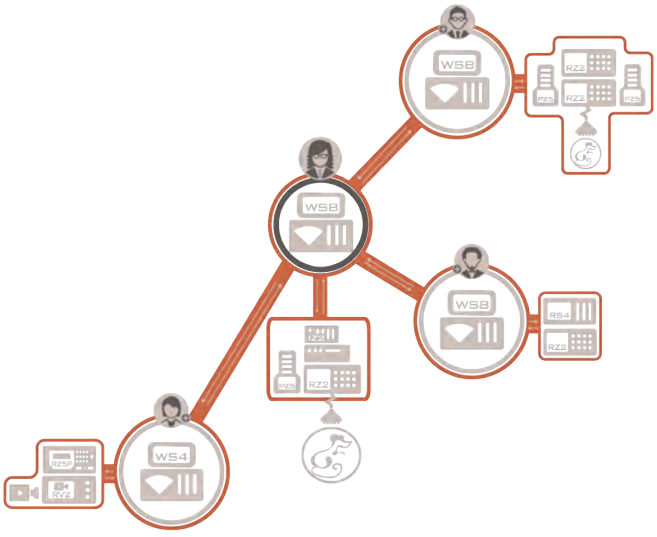
All devices connected in your Synapse Cluster are time-locked to a single master clock, eliminating the need for post processing synchronization.

Don't settle for a system that requires complicated post-processing to synchronize or realign your data!

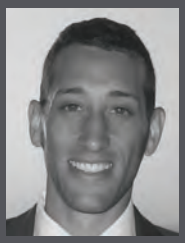
"One of the most exciting but challenging applications of high channel recordings is utilizing that data for real-time applications, such as brain machine interfaces or epileptic seizure detection. TDT's parallel multi-DSP architecture is uniquely capable of processing this high-bandwidth data on a millisecond scale and in a linearly scalable way to expand as you need it."

—Nafi Yasar, Ph.D., M.B.A.

Synapse Cluster allows you to add additional workstations to record and process even more neural channels in real-time. Easily scale to 2,000 channels and beyond while retaining the full power and flexibility of TDT's real-time signal processing.



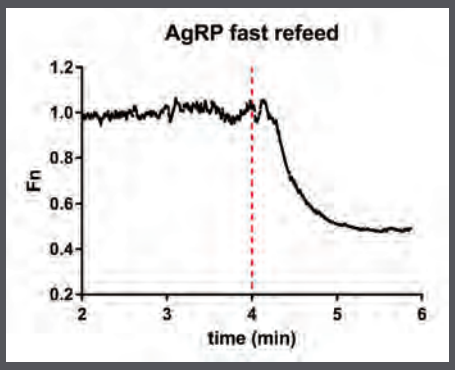
CUSTOMER PROFILE - FIBER PHOTOMETRY



Dr. Michael Krashes is an NIH scientist who investigates how the brain integrates information from peripheral senses, hormones, and past experiences to regulate hunger and feeding behavior. His lab employs novel genetic tools and techniques to dissect feeding circuits with the hopes understanding the behaviors that drive humans to obtain food and ultimately how these behaviors can be manipulated to battle human eating afflictions. To achieve his goals, Dr. Krashes wanted a flexible electrophysiology system that can implement fiber photometry experiments.

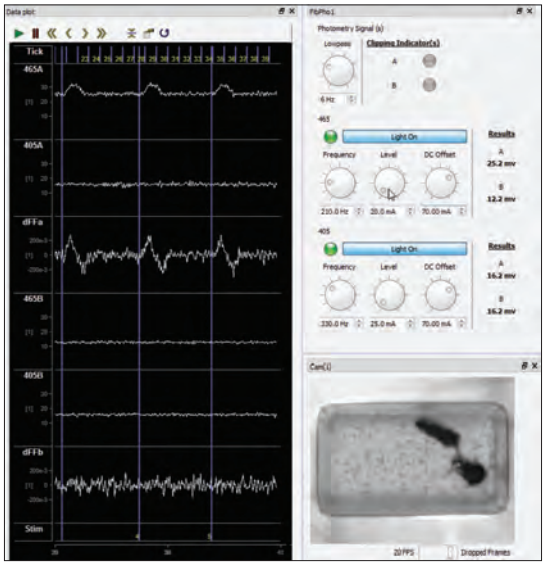
"We study hunger and feeding, and greatly appreciate how easy it is to setup complex behavioral fiber photometry experiments with the TDT RZ5P Processor. After surgery, setting up a fiber photometry recording with multiple light sources literally takes minutes, and I can easily connect to and control the behavioral devices I need."

—Michael Krashes, Ph.D.
Acting Section Chief,
Section on Motivational Processes Underlying Appetite
National Institute of Diabetes and Digestive and Kidney Diseases



What is Fiber Photometry?

Fiber Photometry is a method for measuring brain activity using calcium-sensitive fluorescent proteins. Due to its low cost and much simpler surgery and data analysis compared to electrophysiology, it is quickly becoming one of the most popular choices for measuring neural responses from behaving animals. TDT is contributing to the growth of this novel method by providing hardware & software for fiber photometry lab experiments that can do everything in half-a-dozen mouse clicks or less.

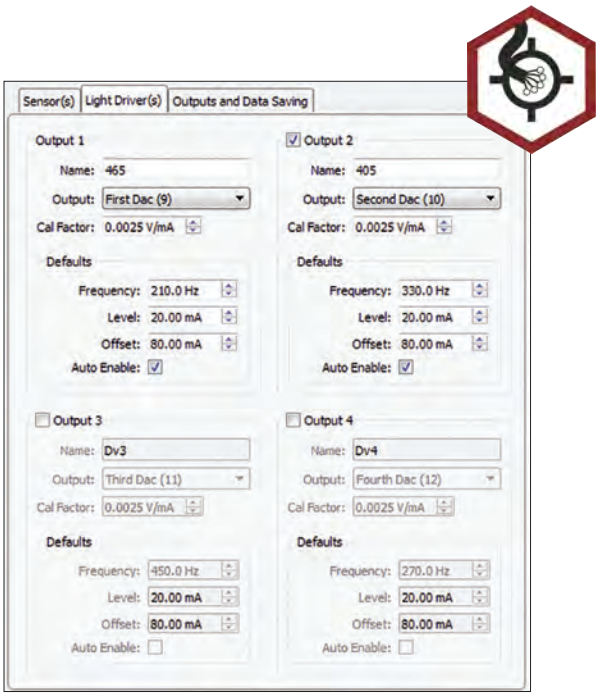


Fiber Photometry System

Fiber Photometry

The RZ5P Processor is TDT's all-in-one, turn-key system for fiber photometry. Easily control excitation sources and acquire photosensor responses in several brain areas of one or more freely behaving subjects. Using the dedicated fiber photometry Synapse gizmo, you can be setup in less than a minute and start creating dynamic experiments for animal's behavior or physiological response. With the Synapse Software handling your digital signal processor (DSP) details, like assigning tasks to the DSP and distributing tasks evenly, you only need to worry about higher level functions like organizing multiple experiments across numerous subjects and various lab members. The RZ5P can send up to four light signals (such as GCamP excitation, RCamP excitation, Autofluorescence and closed-loop optogenetic stimulation) down a single fiber and record the individual responses from up to two photosensors with exceptional signal-to-noise and signal isolation.

Qty	Part#	Page #
1	RZ5P	35
1	P05e	46



The new UZ3 connects the fiber optics from the RZ processor to a high speed USB 3.0 interface enabling laptop use. See more on page 46 .

System Examples

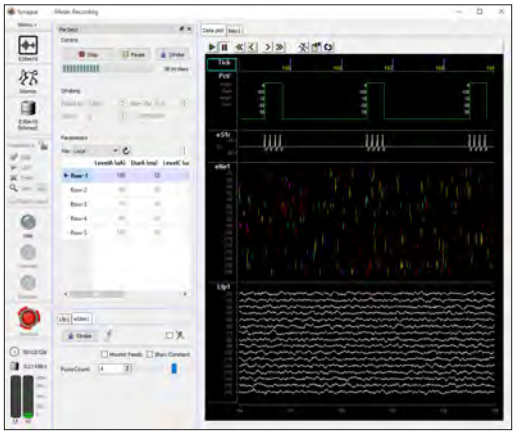
Electrical Stimulation and EEG Workstations

TDT systems have been used to record an almost endless variety of bioelectric potentials including single unit activity, local field potentials (LFP), electroencephalograms (EEG), electrocorticograms (ECoG), electromyograms (EMG) and more. The PZ5 NeuroDigitizer makes it easy to record multiple signal types on a single amplifier. TDT systems are also every bit as flexible in generating stimuli; evoke responses with time-locked auditory, visual, electrical, optogenetic and other stimuli. Our Synapse software makes it easy to create closed-loop experiments and compare multiple biological signal types.

Electric Stimulation

This TDT system includes everything needed for closed-loop electrical stimulation experiments. Record up to 32 channels of single unit, LFP or EEG signals on the versatile PZ5 amplifier. The RZ5D processes all signals in real-time enabling you to design triggers off of neural firing patterns, behavioral inputs or any combination thereof. Use those custom triggers to deliver precisely timed electrical stimuli via the IZ2 stimulator. Synapse makes it easy to design stimulation pulse trains and tie the whole closed-loop experiment together.

Qty	Part #	Page #
1	RZ5D	35
1	PZ5-32	41
1	IZ2H-16	43
1	LZ48M-250	43
1	ACO-32	59
1	PO5e	46
1	SynapseSTE	18

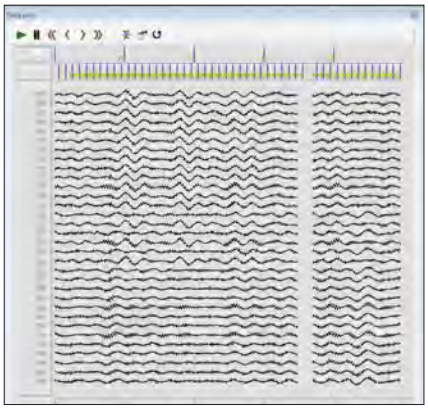


EEG, ECoG, and EMG Workstation

This system features 64 channels of data acquisition and is ideal for EEG, ECoG, and EMG recording. The optically isolated preamplifier features fully differential amplification and onboard impedance measurement. With our 28-bit analog-to-digital convertors, the system provides 116 dB of dynamic range and a 0.75uVrms noise floor. Synapse software provides the experimental control and design interface for sophisticated experiments. Synchronized stimulus generation can be accomplished using onboard analog output or by adding a high quality IZ2 stimulation module. (System also available with up to 128 channels)

Synapse features:

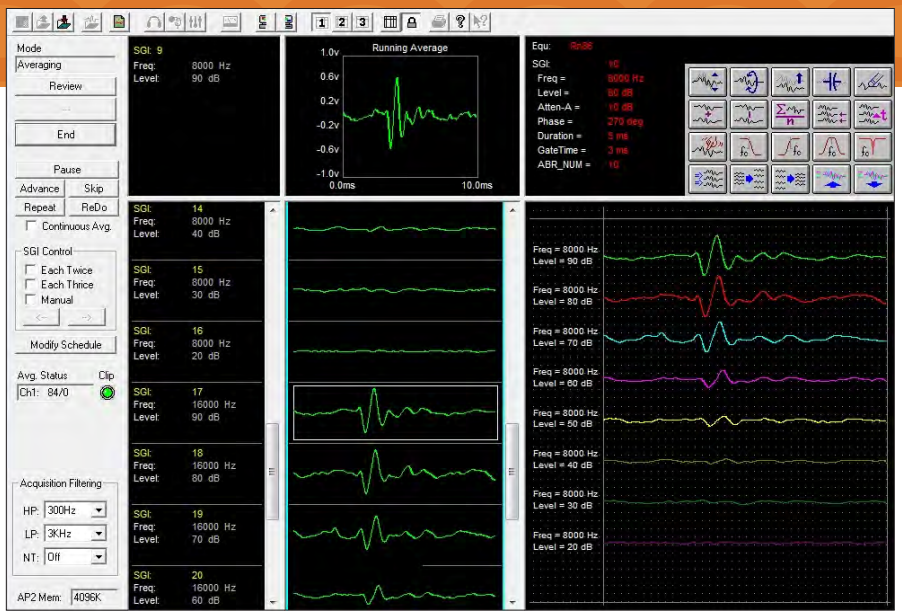
- Timestamped waveforms, stimulus parameters, and external events stored into a single data set
- Easy to configure multi-channel plots
- Built-in access to RPvdsEx for custom processing
- Specialized RPvdsEx signal averaging components for evoked potential recording
- Export data to popular formats



Qty	Part#	Page #
1	RZ2-2	33
1	PZ5-64	41
2	S-BOX	60
1	PO5e	46
1	SynapseSTE	18

Software

for Evoked Potentials



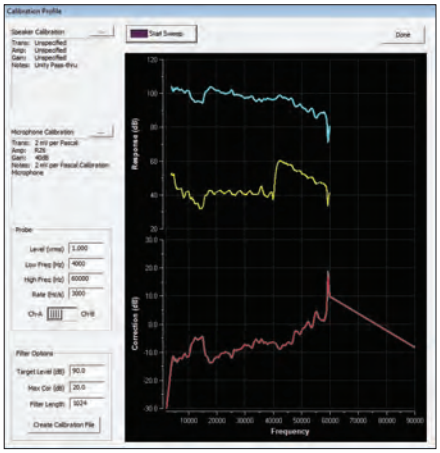
Instantly access different views as you record:

- Stimulus
- Raw A/D
- Frequency Domain
- EEG
- Running Average

BioSigRZ—ABR and DPOAE Software

BioSigRZ is an easy-to-use tool designed for rapid animal screening. It automates the process of presenting stimulus signals and acquiring response signal data. BioSigRZ works with the RZ6 Multi I/O processor and supports stimulus customization. BioSigRZ gives you control over the stimulus signal parameters used to generate stimuli that vary across successive presentations. Standard configuration files enable you to run ABR and DPOAE screening protocols out-of-the box with little or no software configuration beyond basic installation. Simply open BioSigRZ, load a standard configuration, specify a speaker (and microphone, for DPOAE) and begin signal acquisition. TDT provides calibration files for common speakers and microphones, so calibration is as easy as selecting the transducer or microphone from a list.

With the powerful BioSigRZ signal averaging software, you'll have control over timing of stimulus and recording windows, plus a built-in worksheet where you can edit data records and generate detailed, hard-copy reports even while acquiring data. An auto-cursoring function applies predefined cursor points to averaged waveforms and a comprehensive Cursor Edit window provides peak, latency, and waveform comparison overlay analysis. BioSigRZ also provides powerful data and record management tools, for instantly accessing up to 100 records, and dozens of built-in mathematical functions, for working with data. Includes SigGenRZ for custom stimulus generation.

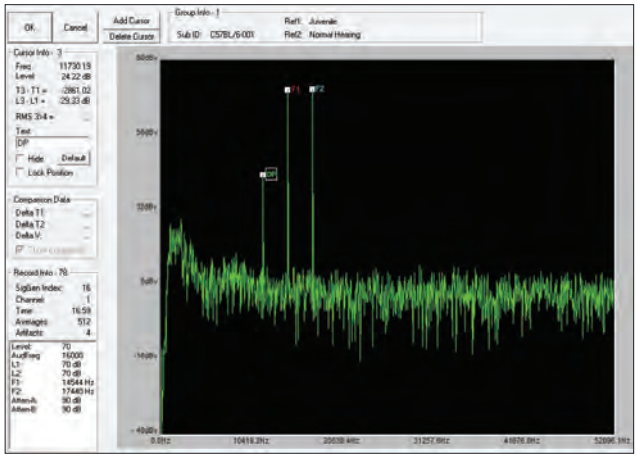


BioSigRZ features

- Modify signal presentation on-the-fly, adjusting frequency, level, phase and more
- Manually or automatically adjust how stimulus parameters vary across successive presentations
- Control and modify variables and the stimulus schedule
- Artifact rejection
- Peak, latency and comparison overlay analysis
- Auto-cursoring
- Dozens of built-in mathematical functions for manipulating data

Auditory Stimulation – ABR & DPOAE Workstation

This system combines our powerful low-noise, high bandwidth hardware with our easy to use BioSigRZ software for ABR and DPOAE recordings. Targeted for animal screening protocols, the system includes two channels of 24-bit Sigma-Delta DACs and supports a maximum sampling rate of 200 kHz. Displaying the real-time signal averaging as the signal is collected, the TDT ABR and DPOAE workstation quickly alerts you to any problems, and with a built-in module for fast and easy speaker calibration, the TDT system is ideal for rapid hearing screening and high-throughput data collection (such as rapid phenotyping). Support for TDT transducers is built into both the hardware and the software. A comprehensive set of calibration and experiment configuration files are also provided with the system, minimizing experiment set-up and streamlining daily operation.



Qty	Part#	Page #
1	RZ6-A-P1	37
1	RA4PA	52
1	RA4LI	52
1	PO5e	46

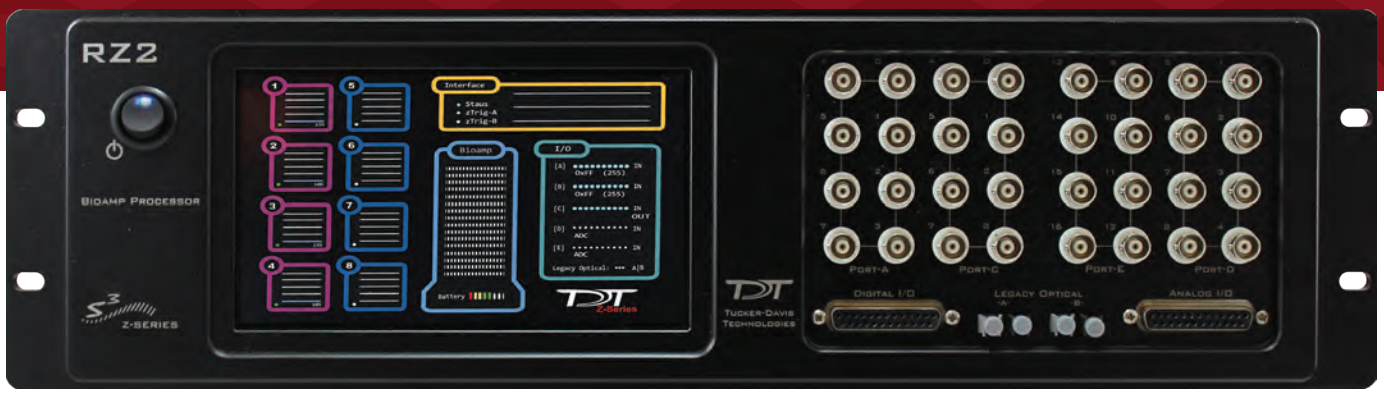
CUSTOMER PROFILE – ABR & DPOAE SYSTEM

Prof. Ram Ramachandran investigates the biological basis of hearing in noisy environments and how hearing impairment disrupts these mechanisms. His lab is primarily interested in how sounds are encoded in the brain and how different populations of neurons are involved in auditory perception. They use approaches that combine electrophysiology, behavior and quantitative analysis which requires a recording platform that can deliver complex auditory stimuli that are precisely time-locked with recorded neural signals and behavioral responses.

"The recording quality, configurability, and ease-of-use of the TDT ABR & DPOAE system has greatly benefited my research. Thanks to how easy the system is to use, I can quickly get my lab members trained and collecting the large amounts of high-quality data we need."

—Ramnarayan Ramachandran, Ph.D.
Assistant Professor
Department of Hearing and Speech Sciences, Psychology
Vanderbilt University

RZ2 BioAmp Processor



Designed for up to 512-channel data acquisition, the RZ2 Z-Series processors feature two, four or eight ultra fast digital signal processors networked on a novel bus architecture that speeds both onboard communication and memory access. Like all RZ devices, the RZ2 Supports the QZDSP Quad Core DSP cards to expand channel counts and processing capabilities. Simultaneous acquisition and real-time processing on up to 512 channels, at sampling rates up to ~50 kHz on 128 channels. High bandwidth data is streamed from a Z-Series PreAmp (pg 41) to the RZ2 over a fast fiber optic connection. Our innovative Optibit optical PC interface ensures fast and reliable data transfer from the RZ2 to the PC. The RZ2 also features 16 channels of analog I/O, 24 bits of digital I/O, two legacy optical inputs for Medusa PreAmps (pg 52), and an onboard LCD for system status display.

RZ2 Base Station Part Numbers:

RZ2-2	Two DSPs
RZ2-4	Four DSPs
RZ2-8	Eight DSPs
RZDSP	Additional DSPs
QZDSP	QuadCore DSPs

Technical Specifications:

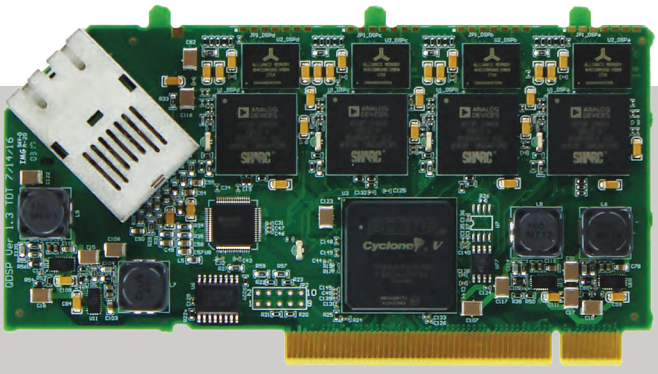
DSPs:	Any combination of up to 8 DSPs/QZDSPs
Standard DSPs:	400 MHz DSP, 2.4 GFLOPS peak, 64 MB RAM
Quad DSPs:	1600 MHz QuadCore, 10 GFLOPS peak, 256 MB RAM
UDP Port:	Ethernet connection to second computer for real-time data interface.
Max sampling rate:	~50 kHz
D/A:	8 channels, 16-bit PCM
A/D:	8 channels, 16-bit PCM
Digital I/O:	24 bits
Fiber optic ports (new):	one 256-channel input (~50 kHz maximum sample rate)
Fiber optic ports (legacy):	two 16-channel inputs (~25 kHz maximum sample rate)
Dimensions:	19 inches wide, 5.25 inches tall (3U), 12 inches deep

RZ2 Base Station (RZ2)
The RZ2 processes and filters acquired signals and can be used to control digital I/O and/or generate analog signals. Multiple RZ2s can be connected to form systems for greater than 256 channels.

Standard QZDSPs can be ordered to provide a computational boost or QZDSPs can be optionally configured with fiber optics to flexibly interface with any of TDT's powerful peripheral devices including the RS4, RV2, PZ5 and IZ2.

The QZDSP Quad Card from TDT combines four of the fastest Sharc processors with a high-density FPGA into a tightly integrated DSP card that mimics a multi-core processor architecture. The innovative multi-core QZDSP offers up to a 4x performance improvement over a classic TDT RZDSP device.

Control of the QZDSP is fully integrated into all levels of TDT's software. Directly program the quad core via RPVDS visual design studio or when using Synapse, the built-in compiler will automatically recognize the QZDSP architecture and optimize utilization for the experiment.



Just how powerful is the TDT RZ2 with QZDSP processors?

- **Intel Core i7 processor:**
  ~25 GFlops per core x 4 cores = ~100 GFlops
- **TDT RZ2 processor:**
  ~100 GFlops per RZQDSP x 8 cards = ~800 GFlops

TDT systems are compatible with a wide variety of electrode types, including stereotrodes and tetrodes, microwire arrays, metal microelectrodes, acute and chronic NeuroNexus probes, surface electrodes, multi-electrode caps, and needle electrodes.

PZ5- 32, 64, 128, 256, 512
The industry's first multi-modal amplifier. The Z-Series PreAmps digitize neural signals and are available in 32 to 512 channel models and supports sampling rates up to ~50 kHz. See pages 39-41.

RS4
TThe data streamer can add up to eight terabytes of solid state data storage and stream up to 1024 channels at full bandwidth. See page 41.

IZ2-32, 64, 128 and IZ2MH
The stimulator can deliver up to 3000 microamps into 128 channels under the control of the RZ processor for closed loop control of spike-triggered stimulation. See page 44.

RV2
A machine vision color camera and dedicated video processor and collection device for video capture and tracking. See page 48.

WS8
A High Performance Workstation Computer optimized for research and built to run your TDT equipment. For less demanding applications, choose the lower cost WS4. See page 45.

RZ5D BioAmp Processor

The RZ5D is the little brother to the R22 processor. The standard configuration supports connections to an IZ2 stimulator and a PZ5 amplifier. The RZ5D was specifically designed as a lower cost alternative for those working with fewer channels and/or have lower bandwidth needs. The RZ5D is perfect for closed-loop stimulation and acquisition experiments on up to 64 channels.

The RZ5D can be equipped with up to four DSP cards, QZDSP cards and optionally the UDP interface port.

RZ5D
Perfect cost-effective solution for lower channel count applications. Also supports QZDSP processors for even more power!

RZ5D BioAmp Part Number:
RZ5D Up to 4 DSP

Technical Specifications:

DSPs:	Any combination of up to 4 DSPs/QZDSPs
Standard DSPs:	400 MHz DSP, 2.4 GFLOPS peak, 64 MB RAM
Quad DSPs:	1600 MHz QuadCore, 10 GLOPS peak, 256 MB RAM
Max sampling rate:	~50 kHz
D/A:	4 channels 16-bit PCM
A/D:	4 channels 16-bit PCM
Digital I/O:	24 bits programmable
Fiber optic ports PZ5:	Up to 64 channel support, up to 50 KHz sample rate
Fiber optic ports (Stimulator):	Up to 64 channel support, up to 50 KHz sample rate
Dimensions:	19 inches wide, 5.25 inches tall (3U), 12 inches deep

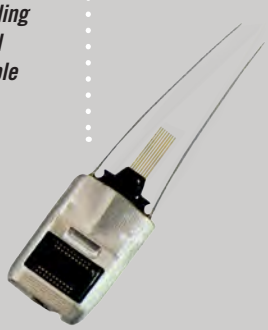
Interested in fiber photometry? Check out our RZ5P model processor purpose-built for fiber photometry experiments. See page 28 for details.

RECORD

PZ5-32
Multi-Modal Amplifier. The Z-Series PreAmps are used exclusively with the RZ base stations and digitize neural signals and support sampling rates up to ~50 kHz. Now available with Digital INTAN Boards. See page 39.

ZC32
ZIF-Clip® Analog Headstage are designed for zero insertion-force transition when connecting to electrodes or adapters. For a complete list of headstages and adapters, see page 49.

ZIF-Clip® Based Electrodes
Microwire arrays deliver excellent recording characteristics for chronic multi-channel neurophysiology applications. For available array configurations, see page 53.



STIMULATE

IZ2-32
Stimulator converts digital waveforms into analog waveforms delivering user defined stimuli through multichannel electrodes. See page 43.

S-BOX-32
Amplifier Input Splitter for routing low impedance biological signals to both a TDT acquisition system and a parallel recording system. See page 60.

RZ6 Multi I/O Processor

RZ6
Filter and play out high quality auditory signals in real-time.

Also supports QZDSP processors for even more power.

The RZ6 Multi-I/O processor from TDT is a high bandwidth device ideal for animal screening and auditory stimulation applications. It features high quality Sigma-Delta ADCs and DACs for wideband audio signals and delivers the functionality of several System 3 modules, all in a single easy-to-use, easy-to-connect device. Built on the ultra fast RZ platform, the RZ6 combines a multi-DSP architecture with superior onboard analog input/output capabilities to deliver exceptional processing power, fast data transfer, and a realizable sample rate of ~200 kHz.

The RZ6 can be equipped with up to 4 high performance DSPs to support complex stimulus control, high frequency applications, and real-time normalization for speakers and microphones. The all-in-one form factor incorporates two-channel headphone and electrostatic speaker drivers, two channels of programmable and manual attenuation, XLR and audio jack microphone inputs, a monitor speaker, and digital I/O. This minimizes the need for peripheral devices and simplifies connections. Plug your speakers or microphone directly into the RZ6. You'll never need more than four cables, two in and two out, for any application.

The RZ6-A-P1 is a 3 DSP version of the RZ6 that includes all of the onboard I/O capabilities of the basic RZ6 and adds a fiber optic input port for direct connection of an optically isolated, battery powered RA4PA Medusa PreAmp (pg 52). This version is well-suited for ABR screening, evoked potential research, or low channel count, single unit neurophysiology.

For multi-channel neurophysiology and higher channel count EEG, consider the RZ5D (pg 35) or RZ2 (pg 33) base stations.

RZ6 Part Numbers:

RZ6-A One DSP
RZ6-A-P1 Three DSP and one fiber optic input port
RZDSP Additional DSPs

Technical Specifications:

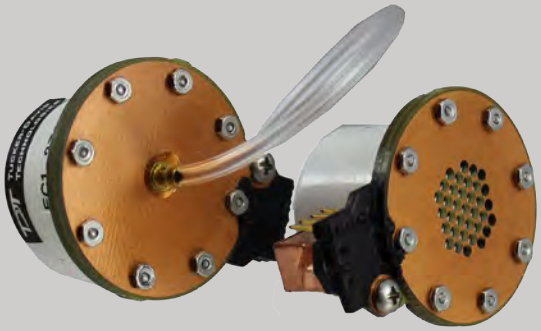
DSPs:	Any combination of up to 4 DSPs/QZDSPs
Standard DSPs:	400 MHz DSP, 2.4 GFLOPS peak, 64 MB RAM
Quad DSPs:	1600 MHz QuadCore, 10 GLOPS peak, 256 MB RAM
Memory:	64 MB SDRAM per DSP
Max sampling rate:	~200 kHz
D/A:	2 channels, 24-bit Sigma-Delta
S/N (typical):	115 dB (20 Hz - 80 kHz at 5 Vrms)
THD (typical):	-90 dB for 1 kHz output at 5 Vrms
Frequency response:	DC-Nyquist (~1/2 sample rate)
Sample delay:	31 samples
A/D:	2 channels, 24-bit Sigma-Delta
S/N (typical):	115 dB (20 Hz - 80 kHz at 5 Vrms)
THD (typical):	-90 dB for 1 kHz input at 5 Vrms
Frequency response:	DC-Nyquist (~1/2 sample rate)
Sample delay:	66 samples
Digital I/O:	24 bits programmable
Electrostatic Speaker Driver:	2 channels, frequency response of 4 kHz to ~90 kHz
Headphone Buffer:	2 channels, 1/8" stereo headphone jack or BNC
Microphone Amplifier:	2 channels, 1/4" stereo audio jack, BNC, or XLR interface
Programmable Attenuator:	2 channels, 0 to 60 dB attenuation in 20 dB steps
Manual Attenuator:	Single setting for both channels, 0 to 27 dB attenuation
ADC and Microphone Amplifier:	Single setting for both channels, 20 to 65 dB gain setting
Fiber optic ports (legacy PreAmp):	One 6-channel input (~25 kHz maximum sample rate) ***Available on RZ6-A-P1 only***
Dimensions:	19 inches wide, 5.25 inches tall (3U), 12 inches deep

RA4PA & RA4LI
Our Medusa offers four channels for researchers doing ABRs or low channel count neurophysiology recordings. TDT's low impedance headstages connect directly to our Medusa amplifiers via a standard 25-pin connector. *See page 52.*

MF1
Magnetic speakers offer high output and fidelity over a bandwidth from 1 kHz – 75 kHz. *See page 57.*

OR

ES1
These lightweight speakers deliver ultrasonic stimuli up to 90 kHz. *See page 58.*



Amplifiers

History in the Making

Since TDT developed its first digital biological amplifier in the mid 1990's, our battery-powered, optically isolated, direct digital designs have become an industry standard. The PZ5 Neuro-Digitizer expands upon the capabilities of our previous amplifiers to deliver the best neurological signal capture available today. Researchers can now record virtually any biological potential without signal clipping. The simultaneous capture of single unit (neuron) recordings, evoked potentials, EMG, and EEG on a single amplifier greatly simplify the process of neural recording.

The PZ5 builds on the best elements of prior TDT amplifier designs by extending the performance of the features most important in neurophysiology. Each channel of the PZ5 includes circuits to support a range of biologic signal types and custom TDT digitizing technology offers unmatched recording fidelity with low power consumption. Each 16 channel bank is electrically isolated allowing multi-subject recording as well as the ultimate flexibility in grounding and referencing. Best of all, everything is intuitively controlled by a touchscreen interface built right into the front of the amplifier.

The PZ5 connects via noise immune, high speed fiber optics and is 100% compatible with older PZ amplifier models. Upgrade to a PZ5 today to take advantage of all the design benefits!

"This product combines everything we know about amplifier design. It's been 30 years in the making and its capabilities and performance bear that out."

—Tim Tucker
Founder, Tucker-Davis Technologies

The PZ5M-512 is a 512 channel amplifier that meets the most stringent requirements for electrical safety in medical devices. It is built at our factory from over 25,000 discrete components.

TDT's PZ5 amplifiers combine exceptional performance and unprecedented versatility to deliver the absolute best signal capture available in our industry.

Available with 32 to 512 Channels

The Beauty is in the Details...

Huge input range with +/-500mV headroom. Capture every signal without clipping, from the smallest neural potentials to the largest artifacts.

Hybrid oversampling architecture yields a 120dB dynamic range and is completely immune to out-of-band interference (e.g. eye-trackers).

Full frequency spectrum records all the way to DC. Record the slowest waves and DC biopotentials without phase distortion.

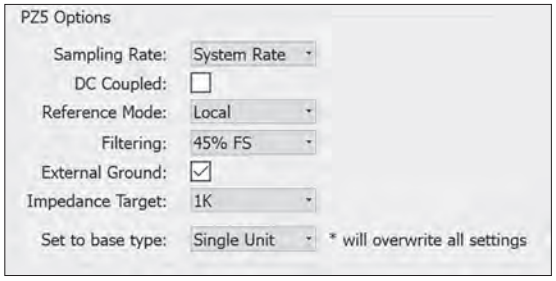
Universal amplifier input circuits support recording from any neural source using a number of referencing schemes including true differential.

Isolated bank architecture allows the creation of multiple logical amps within the PZ5. Record different biological signals (e.g. EEG, EMG, etc.) or even from different subjects with complete isolation.

Battery powered and optically isolated for complete recording isolation and noise immune, lossless data transmission.

Intuitive touch screen interface and imbedded controller allow for easy configuration, real-time signal monitoring and onscreen impedance checking.

Complete Synapse Integration allows you to configure and control the PZ5 uniquely for each experiment



Amplifiers

NOW AVAILABLE
DIGITAL BANK UPGRADES

PZ5 – Neurodigitizer

Designed for use with high impedance headstages, the Z-Series PZ5 amplifier features a fast fiber optic connection capable of simultaneously transferring up to 128 channels at full precision. This extended bandwidth supports sampling rates up to ~50 kHz and improves signal fidelity, spike discrimination, sorting, and analysis, used exclusively with Z-Series base station.

Analog Only:

PZ5-32	32 channels
PZ5-64	64 channels
PZ5-96	96 channels
PZ5-128	128 channels

Digital Only:

PZ5-0-2	2 digital inputs
PZ5-0-4	4 digital inputs

Analog and Digital:

PZ5-32-2	32 analog channels + 2 digital inputs
PZ5-32-4	32 analog channels + 4 digital inputs
PZ5-64-2	64 analog channels + 2 digital inputs
PZ5-64-4	64 analog channels + 4 digital inputs
PZ5-96-2	96 analog channels + 2 digital inputs

Specifications:

A/D:	Up to 128 channels, hybrid
A/D Sampling Rate:	Up to 48828.125 Hz (adjustable in steps of approximately 750, 1500, 3000, 6000, 12000, 25000, and 50000 Hz)
Maximum voltage in:	+/- 500 mV (+/- 5 mV for Intan boards)
S/N (typical):	Single Ended: 104 dB, Fs = 25 kHz, 300-7000 Hz Differential: 116 dB, Fs = 750 Hz, 0.4-300 Hz
Input Impedance:	1 GOhms (Analog)
Frequency Response:	DC coupled: 0 Hz – 0.45*Fs AC coupled: 0.4 Hz – 0.45*Fs Intan Boards: 0.1 Hz - 10 kHz
Battery:	8-10 hours to charge to 95% capacity, 14 hours to fully charge.
Battery life between charges per battery:	32 ch ~ 50 hrs 64 ch ~ 35 hrs 96 ch ~ 27 hrs 128 ch ~ 22 hrs
Indicator LEDs:	Analog: up to 128 status/clip warning analog, Digital: headstage channel count indicators
Input referred noise:	Single Ended: 3.0 µVrms, Fs = 25 kHz, 300-7000 Hz Differential: 0.75 µVrms, Fs = 750 Hz, 0.4-300 Hz

PZ5M – NeuroDigitizer

TDT's PZ5 combines exceptional performance and unprecedented versatility to deliver the absolute best neurological signal capture available today. This next generation, multi-modal neurodigitizer functions as the front end for TDT's popular RZ system, serving as a high performance option for new customers or a direct upgrade path for customers currently using earlier PZ amplifiers.

With both internal batteries and a mains power connection, the PZ5M form factor supplies continuous, clean electrical power with biomedical grade electrical isolation. Offered in 256 and 512 versions, the PZ5M is ideal for extended, high channel count experiments.

Easily connect multiple TDT RZ devices for higher channel counts. Both the PZ5 and PZ5M feature individually configurable banks for flexible experiment design. The rack-mountable PZ5M-512 can be used for simultaneous input of EEG, EMG, LFP and Single Unit signals.

Part Numbers:

PZ5M-256 256 channels
PZ5M-512 512 channels

Specifications:

A/D:	Up to 512 channels, hybrid
A/D Sampling Rate:	Up to 48828.125 Hz (adjustable in steps of approximately 750, 1500, 3000, 6000, 12000, 25000, and 50000 Hz)
Maximum voltage in:	+/- 500 mV
S/N (typical):	Single Ended: 104 dB, Fs = 25 kHz, 300-7000 Hz
Differential:	116 dB, Fs = 750 Hz, 0.4-300 Hz
Input Impedance:	1 GOhms
Frequency Response:	DC coupled: 0 Hz – 0.45*Fs AC coupled: 0.4 Hz – 0.45*Fs
Battery:	20 hours to fully charge - The device is battery operated and includes mains power connection, with full medical-grade isolation, for in-device battery charging.
Battery Life:	240 Wh 7.5 hours between charges (with every bank actively recording)
Indicator LEDs:	Up to 512 status/clip warning
Input referred noise:	Single Unit: 3.0 µVrms, 300-7000 Hz, 25 kHz Differential: 0.75 µVrms, 0.4-300 Hz, 750 Hz
Input referred noise:	The PZ5M is rack mountable in a standard 19" (482.6 mm) rack and is 2 U tall.

Stimulators

IZ2 – Microstimulation

The IZ2 Stimulator is used with any RZ real-time processor as part of a programmable microstimulator system that delivers user-defined stimuli through multichannel electrodes. The IZ2 converts digital waveforms into analog waveforms that can be output in either current or voltage mode.

A proven digital communication system optically isolates the electrical stimulator from the waveform generators to eliminate AC power surges and noise, ensuring superior safety and performance. Onboard PCM D/A converters ensure sample delays of only 4-5 samples and square edges on pulse stimulation waveforms. In addition, A/D converters present in the IZ2 provide stimulus measurement data which is sent back to the RZ2 for monitoring of a single bank of channels at any given time.

The IZ2 supports configurations of 32, 64, and 128 stimulus channels and is capable of delivering up to 300 µA of current simultaneously across up to 128 stimulating electrodes (impedances up to 50 kOhm). Power is supplied to the stimulator system through either the LZ48M-250 or LZ48M-500 Li-Poly battery packs.

IZ2 operation requires the RZDSP-I special DSP board (or QZDSP-OPT) installed in the RZ processor.

System Part Numbers:

IZ2-32	32 channels
IZ2-64	64 channels
IZ2-128	128 channels
LZ48M-250	Battery Pack
LZ48M-500	Battery Pack

Technical Specifications:

Stimulus output channels:	32 (IZ2-32), 64 (IZ2-64) or 128 (IZ2-128)
Sampling rate:	Up to ~ 50 kHz (RZ2, RZ5D), ~ 200 kHz (RZ6)
Stimulus output voltage:	+/- 12 V
Stimulus output current:	+/- 300 µA up to 50 kOhm load
DC offset current:	Less than 100nA
Battery Pack:	LZ48M-250: Up to 15 hours of continuous stim on 32 channels; LZ48M-500: Up to 30 hours of continuous stim on 32 channels.

IZ2H – Macrostimulation

The IZ2H Stimulator is a high current range version of the IZ2 that is available with sixteen stimulus channels. It can output up to 3mA per channel with the same low noise floor as the IZ2.

System Part Numbers:

IZ2H-16	16 channels
LZ48M-250	Battery Pack
LZ48M-500	Battery Pack

IZ2M – Medically Isolated Stimulation

Full medical grade isolation between the mains power and the electrode outputs ensures electrical isolation, and additional safety features ensure safe operation at all times. TDT's multichannel stimulator provides users with unparalleled control over stimulation properties. The RZ real-time processor control of the IZ2M allows for closed loop control with sub-millisecond precision. The signal processor on the RZ device allows user to control the waveform properties of each channel independently.

The electrical stimulator is optically isolated from the control system, providing fast processing of stimulation waveforms and ensuring subject isolation from power surges.

With up to 64 channels, the IZ2M can send monophasic and biphasic pulses as well as arbitrary waveforms. Modulate stimulus or create new waveforms based on neural activity or behavior. High quality signal convertors provide 80 dB of dynamic range from 300 nAmps to 3 mAmps.

System Part Numbers:

IZ2M-32 32 channels
IZ2MH-32 32 channels, high current
IZ2M-64 64 channels
IZ2MH-64 64 channels, high current

Technical Specifications:

Output Connector: DB26

Technical Specifications:

Stimulus output channels:	32 or 64 channels
Sampling rate:	Up to 48.828125 kHz
Stimulus output voltage:	+/- 12 V
Stimulus output current:	IZ2M: +/- 300 µA up to 40 kOhm load IZ2MH: +/- 3 mA up to 4 kOhm load
DC offset current:	< 100 nA on active channels and < 3 nA on open channels
Battery Pack:	Onboard, 240 Wh battery 20 hours to fully charge Battery charges whenever the Mains power is connected

Computers

WS – Desktop Workstation

The TDT WS computer workstations are rack-mountable and purpose-built for research applications, experiment control and data analysis. Optimize your research experience with a workstation built to run your TDT equipment. The WS is available in two configurations each with an optimized combination of processor, memory, and graphics.

The WS-8 is optimized for the most demanding applications, such as high-channel count neurophysiology, and includes premium peripherals. With Intel's flagship Core i7 processor, the WS-8 can rapidly process data at speeds up to 3.4 GHz. Using removable solid state hard drives, quickly access and save data via the front loading bays. With monitor support, the WS-8 features a state of the art GeForce video card with 4 GB video RAM and flexible networking configurations provided by 2 Gigabit Ethernet ports. Coupled with a 240 GB SSD hard drive, your workstation will quickly boot and load system software and experiments. TDT will install all PCI cards, software and drivers on the WS-8 before testing; and will test the entire workstation as a whole before shipping.

The WS-4 is targeted for less demanding applications, such as ABR and DPOAE testing with BioSigRZ software, while still tailored to the lab environment. Both form factors include two Gigabit Ethernet network ports for flexible integration to existing lab infrastructure or external device support.

Part Numbers:

WS4 WS-4 Desktop Workstation
WS8 WS-8 Desktop Workstation

Technical Specifications:

Specification	Default
CPU	WS-4: 3.4 GHz Intel® Core™ i5 (4 Cores). WS-8: 3.4 GHz Intel® Core™ i7 (8 Cores)
Memory	WS-4: 4 GB DDR3 SDRAM. WS-8: 8 GB DDR3 SDRAM
Video Card	WS-4: GeForce GT 730 with 2 GB GDDR3 RAM. WS-8: GeForce GTX 1050 Ti with 4 GB GDDR5 RAM
OS Hard Drive	240 GB Solid State Drive (SSD)
Data Storage	1 TB SSD removable hard drive (1 included)
Network	Two Gigabit Ethernet ports
TDT Interface	P05 card
Open Slot	PCIe x4, half-length
Operating System	64-bit Windows 7® Professional or Windows 10®
Software	TDT Drivers, Synapse, and other TDT software pre-installed as ordered

Interfaces

PCI – Interfaces

OPTIBIT INTERFACE: Our high-speed Optibit interfaces provide communication between your PC and zBus-based, hardware components. A PCI card mounts in your computer and connects to one or more Z-Bus devices with a built-in Optibit interface. These interfaces also provide automatic device identification, hardware initialization, and a single clock that phase-locks all devices in the system. Fiber optic interconnectivity eliminates communication errors caused by electromagnetic interference and allows lossless data transmission over longer distances.

Part Numbers:

F05 PO5/PO5e-to-zBus Interface module
P05 PCI Interface Card
P05e PCI Express Interface Card
P05c PCI Express Interface Card (for Synapse Cluster)

Technical Specifications:

Maximum cable length: 100 meters
Computer interface: PCI card/PCI Express x1
Transfer rates depend on system module accessed.

UZ3 – USB Interfaces

The UZ3 Interface supports connecting zBus devices to your PC via a standard USB 3 port. The UZ3 interface offers the same versatile optically isolated connection without the need for a PCI slot in your computer. While not quite as fast as our PCI based connections, the UZ3 offers a convenient reliable connection to laptops and other computer form factors where a PCI slot is not available.

Part Numbers:

UZ3 USB 3.0 Interface

Peripherals

RS4 – Data Streamer

The RS4 Data Streamer is a high performance data storage array designed to store broadband data streamed from the RZ2, our most powerful processor for high channel count data acquisition. Off-loading data streaming tasks from an RZ2 to the RS4 improves real-time performance and allows you to acquire high channel count continuous data over several days or weeks. The RS4 can be configured via an onboard touch screen interface. Access to the storage array can be provided through a network connection, direct connection to a PC, or data transfer to a USB storage device.

The RS4 allows streaming of up to 1024 16-bit channels at rates up to ~25 kHz and fewer channels at rates up to ~50 kHz. Streamed data is stored as individual channels and can be stored in different numeric formats (Short, Float, etc.). Stored data can be easily reincorporated into the Synapse data tank format for post processing. The RS4 uses fast and reliable solid state drives and is available with either 4 terabytes or 8 terabytes of storage and features 1 or 4 streaming ports.

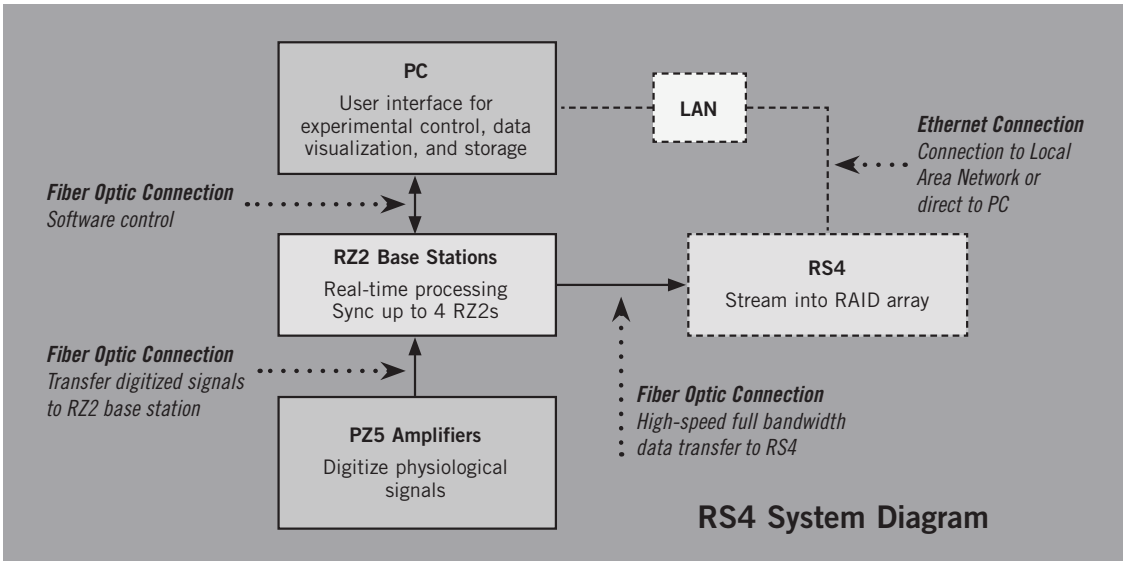
RS4 operation requires one RZDSP-S or QZDSP-OPT board installed on each RZ2 port connection.

System Part Numbers:

RS4-1 Four terabyte (requires 1 RZDSP-S or QZDSP-OPT)
RS4-4 Eight terabyte (requires 4 RZDSP-S or QZDSP-OPT)
RZDSP-S RS4 Compatible DSP for the RZ2

Technical Specifications:

Processing cores:	4
Storage array size:	4 terabytes or 8 terabytes
Number of streaming ports:	1 or 4
Port speed:	12.5 MB/sec (per port)



RS4 System Diagram

RV2 – Video Capture & Tracking System

The system is comprised of a machine vision color camera and dedicated video processor and collection device. Video is streamed from the Gigabit camera to the RV2 collection device where it is processed and stored. Camera framing and control is precisely synchronized to the collection system allowing frame by frame correlation between video data and other recorded system signals.

A number of methods support robust subject tracking including red/green LEDs mounted on the ZIF-Clip headstage. Positional information is available in real-time and can be sent to an RZ device for storage. Image data is optionally stored on dedicated hard drives within the RV2.

The RV2 is recommended for use with TDT systems but can be used independently with a number of interface methods.

Part Numbers:

RV2	Video Processor
VGAC	Color Video Camera for RV2 Video Processor

CUSTOMER PROFILE

At the **UNIVERSITY OF PITTSBURGH SYSTEMS NEUROSCIENCE INSTITUTE**, *Dr. Robert S. Turner studies how the basal ganglia and cortex work together to control normal movement and how dysfunction in the basal ganglia-cortical network leads to disorders of movement like those seen in Parkinson's disease. The principal experimental approaches include multi-electrode single unit recording in awake non-human primates and manipulations of neural circuit activity by microinjection of pharmacologic agents. In a recent project, the Turner lab studied the neurophysiologic mechanisms that mediate the therapeutic effects of deep brain stimulation (DBS), an electrical stimulation therapy developed for the treatment of Parkinson's disease. They used TDT equipment to record from multiple neurons in the globus pallidus, a basal ganglia nucleus, while delivering high frequency DBS therapy in a monkey model of Parkinson's disease. DBS had little effect on the overall firing rate of pallidal neurons, contrary to standard theories of how DBS works. Instead, they observed that DBS-related reductions in symptoms were associated with reductions in the synchronized rhythmic firing of pallidal neurons.*

According to Dr. Turner, "unique features of the TDT system made it possible for us to record from multiple single neuron continuously during high frequency electrical stimulation." He added that "the ability to program the system's DSPs allowed us to subtract stimulation-related electrical artifacts automatically during data collection." A TDT RA16 Medusa system played an essential role in the DBS experiments described above. The Turner lab currently uses two 32-channel TDT RZ systems and ongoing work aims to improve the effectiveness of DBS therapy by exploring how variants of the standard DBS stimulation patterns alter rhythmic pallidal firing and change the parkinsonian symptoms.

Headstages

32 Channels

64 Channels

96 Channels

128 Channels

ZIF-CLIP

ZIF-Clip® Headstages

As electrode channel counts have increased, the limitations of conventional methods of connection have become clear. Typical connectors, using friction locked pins, have proven unreliable and difficult to use. TDT's solution to this seemingly insurmountable problem is the new ZIF-Clip headstage connector system—a miniature, low insertion-force set of connectors and headstages supporting up to 128 channel electrode arrays. The ZIF-Clip system features an innovative, hinged headstage design that ensures quick, easy headstage connection with almost no insertion force applied to the subject. Also available as passive headstages or with LEDs for motion tracking applications.

Self-aligning
ZIF-Clip headstages slide onto compatible probes via a single 1.5mm alignment post, automatically positioning the high-density connectors on the headstage and probe.

Auto-locking
The connector gently snaps closed around an implanted probe's PC board to firmly lock the headstage in place.

Low insertion force
The hinged design closes with a pinching motion, directing almost no force toward the subject.

Low impact
ZIF-Clip headstages are made of a lightweight aluminum and are designed to present a small footprint. A streamlined and low-profile mating connector provides for the subject's freedom of movement and allows stress-free headstage connection without anesthetizing the subject.

Maximum return on investment
This self-aligning design minimizes wear and tear on the pins so ZIF-Clip headstages last longer than traditional micro connector designs.

Made by TDT

This unique design is a TDT innovation and is implemented in the TDT tradition of in house manufacturing that ensures highly reliable quality, performance, and availability.

ZIF-Clip headstages are designed for Z-Series amplifiers; however, Z-Series to RA16PA headstage adapters are available on request.

Analog

Digital

Spring Wrapped

With LEDs for motion tracking applications.

Analog Part Numbers:

ZC16	16 channels
ZC32	32 channels
ZC64	64 channels
ZC96	96 channels
ZC128	128 channels

add **-P** for passive headstages
add **-LED** for LED headstages

Digital Part Numbers:

ZD32	32 channels
ZD64	64 channels
ZD96	96 channels
ZD128	128 channels
ZD-CBL	Digital Zif-Clip Headstage Cable

ZIF-Clip® is a TDT patented technology. Patent No. 7540752

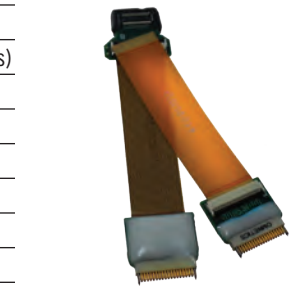
ZIF-Clip® Headstage Adaptors

A wide variety of adapters are available, allowing you to take advantage of ZIF-Clip technology when using common probes, including probes from NeuroNexus, Plexon, Gray Matter, and CyberKinetics.

ZCA-OMN

Compatible with ZIF-Clip®

Adapter for Headstage	Channels	Part No.	Preparations & Probe Connector	
Mill-Max Based Probes	32	**ZCA-MIL32**	Chronic	40-pin Mill-Max dual row header 0.050” pitch (1.27mm)
Mill-Max Based Probes	16	**ZCA-MIL16**	Chronic	18-pin Mill-Max dual row header 0.050” pitch (1.27mm)
NeuroNexus Acute Probes	64	**ZCA-NN64**	Acute	40-pin Samtec FOLC high density socket strip x 2 (1.27mm pins)
NeuroNexus Acute Probes	32	**ZCA-NN32**	Acute	40-pin Samtec FOLC high density socket strip (1.27mm pins)
NeuroNexus Acute Probes	16	**ZCA-DIP16**	Acute	18-pin female DIP socket header (0.5mm pins)
Plextrode® U-Probes	24	**ZCA-UP24**	Acute	36-pin female Omnetics dual row header (0.025” pins)
Plextrode® U-Probes	16	**ZCA-UP16**	Acute	10-pin female Omnetics single row header (0.050” pins) x 2
Omnetics Based Arrays	32	**ZCA-OMN32**	Chronic	36-pin female Omnetics Nano-pin dual row header
Omnetics Based Arrays	16	**ZCA-OMN16**	Chronic	18-pin female Omnetics Nano-pin dual row header
Utah Array Adapters	96	**ZCA-CK96**	Chronic	36-pin female micro socket header x 3 (1.27mm pins)
Electrode Interface Board	32	**ZCA-EIB32**		32-channel electrode interface board
Electrode Interface Board	128	**ZCA-EIB128**		128-channel electrode interface board
Flex Omnetics	64	**ZCA-FLEX-OMN**		ZIF-Clip Headstage to 64-Channel Flex Omnetics



ZCA64-FLEX-OMN

ZCA - DIP16 16 channel Samtec based probes (compatible with NeuroNexus probes)

ZCA-NN32, 64 channel version (ZCA-NN64) also available

ZIF-Clip® Headstage Holder

This 3/32” diameter, 3” length holder simplifies electrode insertion by securing your ZIF-Clip headstage firmly, enabling use with most micromanipulators. Each holder is designed for use with the specified ZIF-Clip headstage dimension.

Part Numbers:

Z-ROD32	16 or 32 channels (for ZC16/ZC32)
ZCD-ROD32	32 channels (for ZD32)
Z-ROD64	64 channels (ZC64/ZD64)
Z-ROD96	96 channels (ZC96)
Z-ROD128	128 channels (ZC128)

High Impedance Headstages

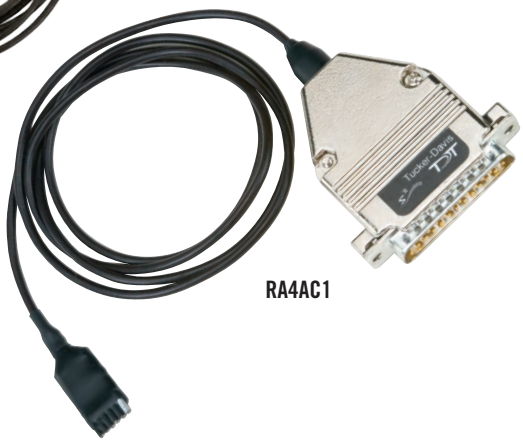
TDT's high impedance headstages are designed for extracellular neurophysiology using silicon electrodes, metal microelectrodes or microwire arrays. Each headstage offers excellent signal-to-noise (~5 uV rms noise floor) and connects directly to a Medusa preamplifier or PZ amplifier using a standard 25-pin (Medusa) or 26-pin (Z-Series) connector.

Number of Channels	Part #	Preparations	Gain	Input Connector	Mates with…
64	**NN64AC**	Acute	1x	2x 40-pin	2x Samtec MOLC header
32	**NN32AC**	Acute	1x	40-pin	Samtec MOLC header
16	**RA16AC**	Acute	1x	18-pin DIP	0.5 mm pins
16	**RA16AC4**	Acute	4x	18-pin DIP	0.5 mm pins
16	**RA16CH**	Chronic	1x	18-pin Nano	Omnetics Nano-Pin connector
16	**LP16CH**	Chronic	1x	18-pin Nano	Omnetics Nano-Pin connector
4	**RA4AC1**	Acute	1x	6-pin	0.76 mm pins
4	**RA4AC4**	Acute	4x	6-pin	0.76 mm pins
16	**LP16CH-ZNF**	Chronic	1x	18-pin Nano (NF)	Omnetics Nano-Pin connector
32	**LP32CH-ZNF**	Chronic	4x	36-pin Nano (NF)	Omnetics Nano-Pin connector

Z-Series and Medusa compatible versions of most headstages are available.

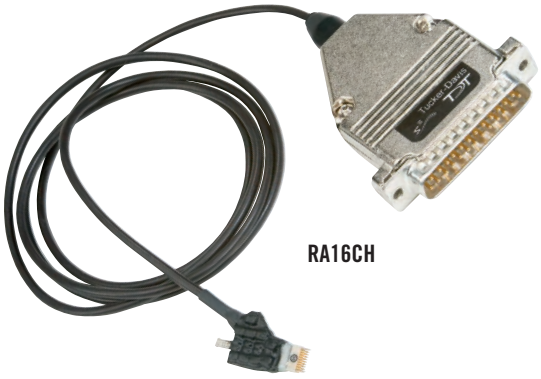
NN32AC

LP32CH-ZNF



RA4AC1

RA16AC



RA16CH

Acute Headstages

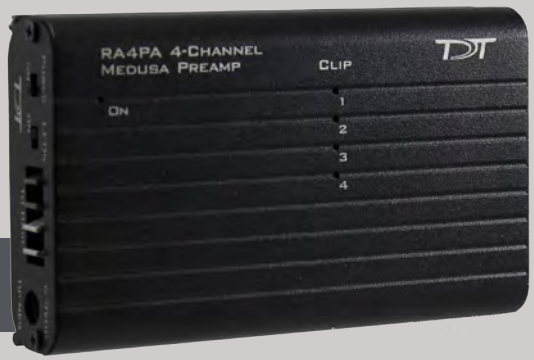
The 64, 32, and 16 channel headstage are designed for direct connection to acute NeuroNexus probes. The 4 and 16 channel headstages can also be used with metal microelectrodes (16 channel version via a 0.5 mm adaptor) and are available with unity or 4x gain.

Chronic Headstages

The 16 channel chronic headstage features a low-profile female Omnetics nano connector, and is compatible with TDT microwire arrays as well as NeuroNexus chronic electrodes. The headstage weighs 1.2 g and connects to the preamplifier over a custom cable designed to maximize freedom of movement. The headstage can be used to record from subjects as small as the rat or mouse.

Low Impedance Headstages

TDT's low impedance headstages are designed for evoked potentials, EMG, and EEG recordings using needle electrodes, surface electrodes and electrode caps. Headstages connect directly to the Medusa preamplifiers via a standard 25-pin connector.



Medusa PreAmps

PreAmps feature TDT's unique preamplifier design in a smaller, lower-count package. Signals are digitized at up to ~25 kHz on the preamplifier and sent over a fiber optic link to a DSP device such as the RZ2 or RZ6-A-P1 (pg 32) base station, where they are filtered and processed in real-time. A standard DB25 input connects the preamp directly to any of TDT's headstage designs (pgs 42-45).

Preamplifiers are available with either PCM or Sigma-Delta A/Ds. Typical applications use PCM A/Ds to acquire bioelectric signals with minimal delay. Choose Sigma-Delta A/Ds to record near high frequency electric or magnetic noise sources (e.g. eye-coils, wireless motion detectors, or touch screens).

Part Numbers:

RA4PA 4 Channels
RA16PA 16 Channels

Technical Specifications:

S/N (typical):	3 µVrms bandwidth 300 - 3000 Hz 6 µVrms bandwidth 30 -7500 Hz
A/D sampling rate:	~ 6, 12, or 25 kHz
Input impedance:	10^5 Ohms
Frequency response:	3 dB 2.2 Hz - 7.5 kHz
Battery:	four hours to charge
Battery life between charges:	20 - 30 hrs

RA4PA and RA16PA:

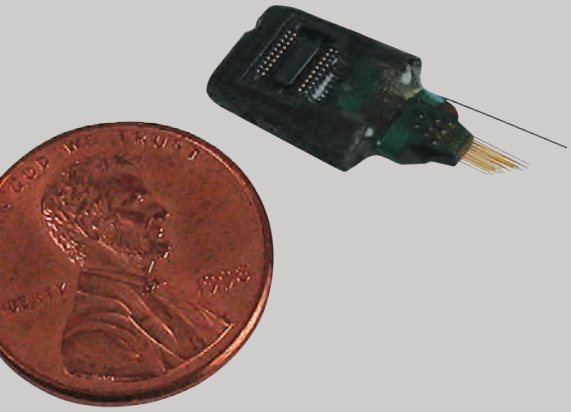
A/D:	4 or 16 channels, 16-bit PCM
Maximum voltage in:	+/- 4 mV
Lowpass filter:	7.5 kHz (3 dB corner, 1st order, 6 dB per octave)

Four-Channel Headstage

The four-channel low impedance headstage provides standard 1.5 mm touch-proof safety connectors for easy direct connection to electrodes. A built-in impedance tester can be used to test each channel and the reference with respect to ground.

Part Number: RA4LI

Microwire Arrays



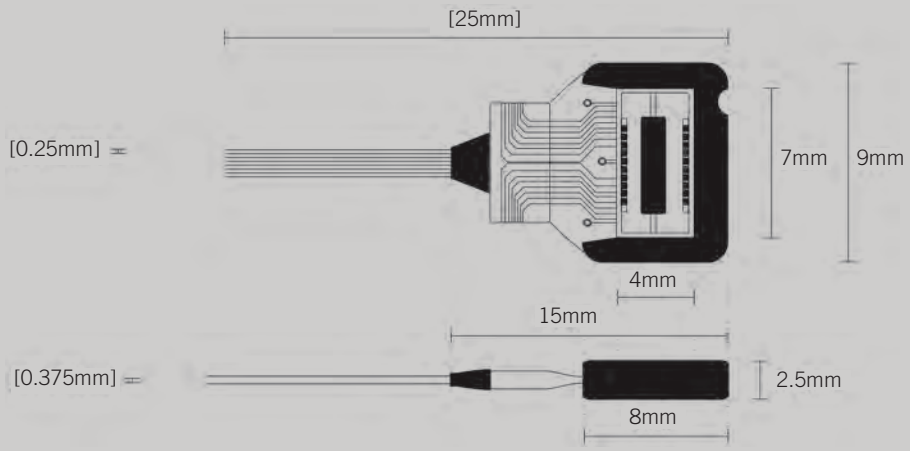
ZIF-Clip® Based Microwire Arrays

Features:

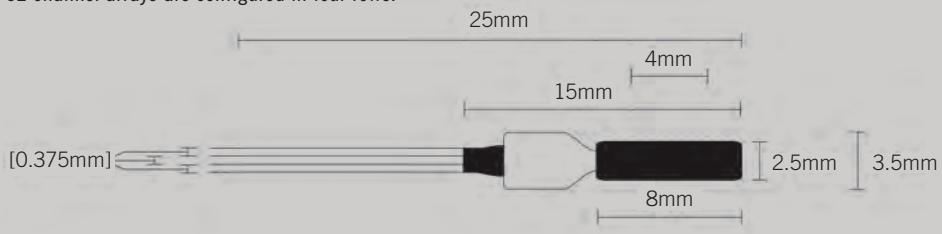
- Custom configurations for 16, 32, or 64 channels.
- Polyimide-insulated tungsten microwire for excellent recording characteristics and easy insertion.
- An optional epoxy “land” near the recording end of the array maintains electrode spacing.
- Laser cut manufacturing for custom array lengths. Each wire is individually cut to length, so you can specify an array profile that matches the geometry of your target tissue.
- Optional laser sharpened tips to minimize tissue damage during insertion.
- Lightweight design and small overall array size.
- Notched ZIF-Clip connector ensures correct insertion into the headstage.
- Optional 26 mm ribbon for flexible land-type applications. Available with separated or attached electrode sites.

Design Specifications and Ordering Information:

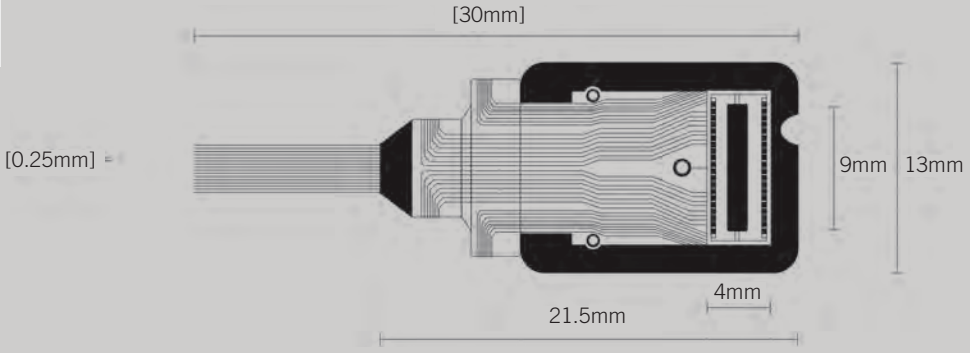
The standard ZIF2010 array consists of sixteen channels configured in two rows of eight electrodes each.



32 channel arrays are configured in four rows.



64 channel arrays are configured in eight rows. These arrays are accessed via a 64-channel ZIF-Clip connector.



ZIF-Clip® Aluminum Caps
Designed to protect the ZIF-Clip micro connector from potential damage in the absence of the ZIF-Clip headstage. The caps are made of high quality aluminum and feature a rubber O-ring for easy handling and grip.

Part Numbers:

Z-CAP32	Fits 16 or 32 channels headstages
Z-CAP64	Fits 64 channels headstages

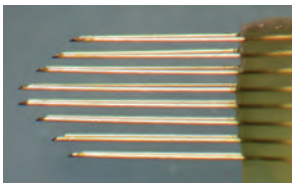
With over 20 years of experience in manufacturing hardware for scientific applications, TDT has the resources to reliably deliver the arrays you depend on for your research. Our manufacturing methods produce consistent, dependable, and affordable arrays while maintaining the flexibility to build custom arrays to your specifications. With TDT microwire arrays you can design your own electrodes without the time and labor intensive task of building arrays by hand.

Technical Specifications:

Metal:	Tungsten
Insulation:	Polyimide
Overall array size (standard array):	2.5mm x 9mm x variable; ~0.3 g (standard array); ~0.5 g (with G/R wires)
ZIF-Clip connector:	0.025 mil pitch; <2.5x9x8 mm

Options:

Specification	Default	Options
Electrode Type:	Standard	Flex Ribbon
Flex Ribbon Site Specification:	Attached	Separated
n Rows X n Electrodes:	2X8	Max channels per connector = 64
Wire Diameter:	50 µm	33 µm
Electrode Spacing:	250 µm	500 µm
Row Seperation:	375 µm	
Tip Angle:	Blunt Cut (0 degrees)	30, 45, 60 degrees
Tip Length:	2mm	0.5mm min to 10mm max
Ground and Reference Wires:	Differential	Differential, Single-Ended



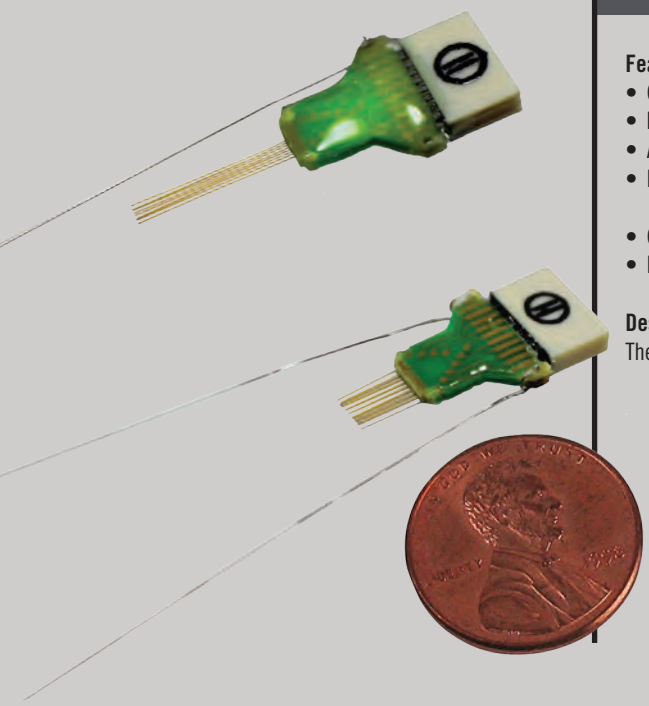
CUSTOMER LAB PROFILE

When Dr. Steven Laviolette first contacted TDT he had just moved to the **UNIVERSITY OF WESTERN ONTARIO IN LONDON** *and was setting up a new lab for his research on addictive behaviors in humans and animals. After contacting TDT and several other manufacturers, Dr. Laviolette quickly came to the conclusion that System 3's unique combination of flexibility, configurability, and elegant engineering was the best long term solution for his lab. Dr. Victor Rush helped Dr. Laviolette select a system configuration to meet the specific needs of his research, then went out to help him set up the lab. By the end of the first day they were able to record good, clean data.*

Dr. Laviolette, an avid user of our microwire arrays, has found that our professionally manufactured probes provide more consistency without sacrificing the ability to customize. Each of his arrays is custom configured to follow the contours of the nucleus he is targeting and uses a reference wire very close to the recording site which minimizes the biological noise of muscle activity in his recordings.

Dr. Laviolette has now expanded his research and lab to include awake, behaving experiments and video tracking and his use of standard condition paradigms along with protocols for looking at neural circuits has generated ground breaking papers on the neurobiology of addiction and the role of Dopamine and GABA in addictive behaviors. As his research evolves we continue to work with him to support the complex behavioral and neurophysiological paradigms necessary for his ongoing research.

Omnetics Based Microwire Arrays

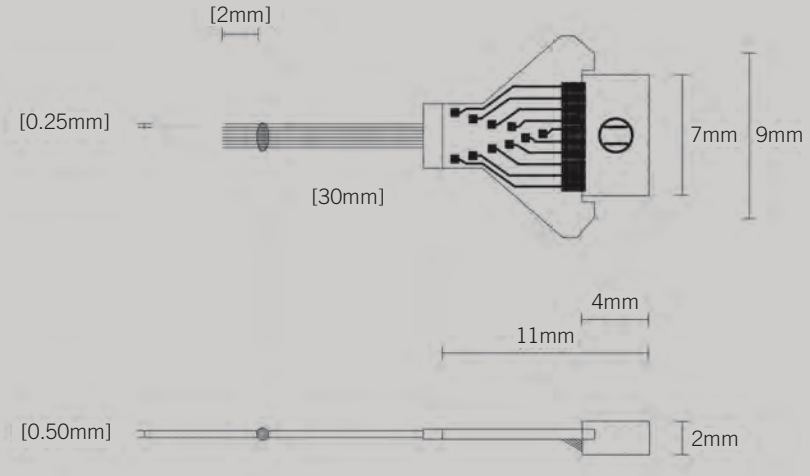


Features:

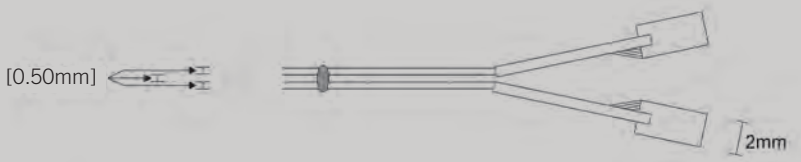
- Custom configurations up to 32 channels.
- Polyimide-insulated tungsten microwire for excellent recording characteristics and easy insertion.
- An optional epoxy “land” near the recording end of the array maintains electrode spacing.
- Laser cut manufacturing for custom array lengths. Each wire is individually cut to length, so you can specify an array profile that matches the geometry of your target tissue.
- Optional laser sharpened tips to minimize tissue damage during insertion.
- Lightweight design and small overall array size.

Design Specifications and Ordering Information:

The standard OMN1010 array consists of sixteen channels configured in two rows of eight electrodes each.



Arrays with more than two rows are constructed by stacking and bonding together standard two-row arrays. These are accessed via multiple 16-channel connectors and headstages.



2mm

Technical Specifications:

Specification	Default	Options
Metal:	Tungsten	
Insulation:	Polyimide	
n Rows X n Electrodes:	2X8	Max channels per connector = 16
Wire Diameter:	50 µm	33 µm
Electrode Spacing:	250 µm	175 µm, 350 µm, 500 µm
Row Seperation:	500 µm	1000 µm, 1500 µm, 2000 µm
Tip Angle:	Blunt Cut (0 degrees)	30, 45, 60 degrees
Tip Length:	2mm	0.5mm min to 4mm max
Land Specification:	None	5mm, 10mm, 15mm, 20mm, 25mm
Attached G/R Wires:	None	Ground, Reference
Overall array size:	2mm x 9mm x variable; ~0.3 g (standard array); ~0.5 g (w/shroud & G/R wires)	
Connectors:	Omnetics dual row 18-pin nano connector(s) (0.025 mil pitch; <2x7x4 mm)	

ZIF-Clip® Microdrive

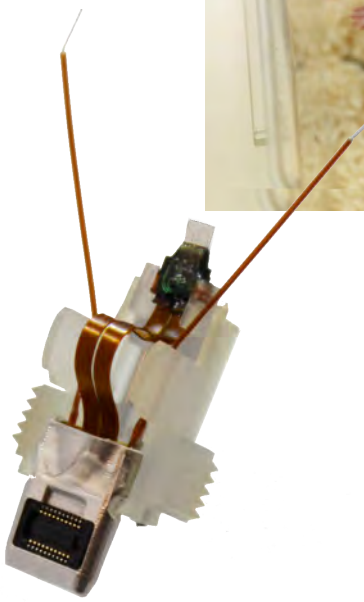
The precision and advantages of microdrives can now be combined with our easy to connect/disconnect TDT ZIF-Clip® headstages. The TDT Electrode Microdrive systems are available in custom configurations up to 32 channels. The TDT Microdrive allows high resolution movement of the electrode array via a set screw and guarantees a fixed and stable implantation.

The ability to move the electrodes post-surgery greatly extends the life of the implant. Moving the electrode can reverse the loss of single unit recordings and gives you the ability to correct position or even target new areas post-surgery.

Features:

- Sample more diverse groups of neurons using the high resolution movement of the electrodes
- Advance electrodes through up to 6.5mm of neural tissue
- Extremely lightweight, compact design arrives pre-assembled with electrode ready for implantation
- Protective cap secures electrode between recording sessions
- Two cleaning ports for saline and/or anti-biotic lavage
- Available in 16 and 32 channel versions for either central or lateral surgical approaches

Part Numbers:	**ZIF-Clip Microdrive**
zDrive-16C	16-Channel, Central Implantation
zDrive-16L	16-Channel, Lateral Implantation
zDrive-32C	32-Channel, Central Implantation
zDrive-32L	32-Channel, Lateral Implantation



The TDT ZIF-Clip® Microdrive was developed in collaboration with Scuola Internazionale Superiore di Studi Avanzati.

FB128 Neural Stimulator

The FB128 Neural Simulator is a tool for testing experimental paradigms during the design phase and debugging problems when they arise. The compact, battery operated device simulates neurological waveforms or sine waves that can be output directly to a ZIF-Clip® headstage. Neurological simulations consist of an LFP component and spike components. Eight unique spike waveform shapes are used depending on the mode. Up to 128 channels can be output (up to 96 unique).

Part Number:

FB128	Neural Stimulator

Transducers

Multi-Field Magnetic Speakers

TDT Magnetic Speakers offer high output and fidelity over a wide bandwidth (from 1 kHz - 80 kHz free field and 1 kHz - 75 kHz closed field). These broadband speakers have more power at lower frequencies than our electrostatic speakers, making them well-suited for laboratory species with lower frequency hearing. Their high output levels and broad bandwidth also make them excellent for noise exposure studies.

These 4 Ohm magnetic speakers are supplied with detachable tips, allowing them to be used in either free or closed field configurations. The free-field model delivers signals of up to 100 dB SPL with < 1% distortion over its entire bandwidth (+/- 4 V, 10 cm). The closed-field configuration incorporates an internal parabolic cone designed to maximize output and minimize distortion. Tapered tips are supplied for direct application or for use with tubing. 6" (mono) or 12" (stereo) 1/8" O.D. PVC tubing is provided. Speakers feature a rugged aluminum enclosure with a built-in, 8-32 threaded hole for use with standard laboratory mounting hardware and a variety of aluminum mount fittings for easier positioning in mono or stereo configurations.

TDT Magnetic Speakers can be driven directly from the RZ6 (pg 34) or using either TDT's SA1 or SA8 stereo amplifiers.

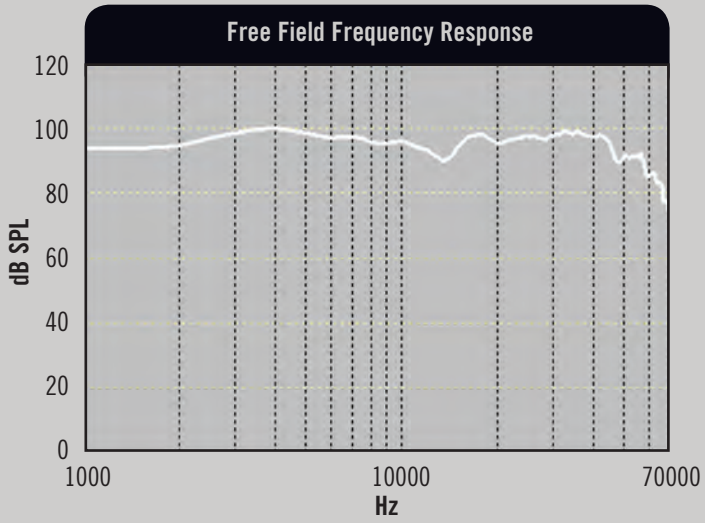
Part Numbers:

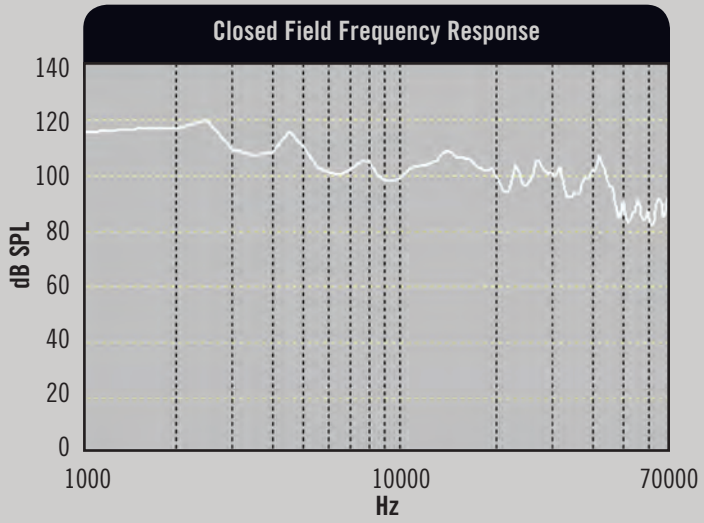
MF1-M Mono speaker
MF1-S Stereo speakers

Technical Specifications

Frequency response:	Free Field	+/- 13dB from 1 kHz to 80 kHz
	Closed Field	+/- 20dB from 1 kHz to 75 kHz
THD (typical):		<= 1% from 1 kHz to 50 kHz
Typical output:	Free Field	87 dB SPL at 10 cm
	Closed Field	100 dB SPL in 0.1 cc coupler
Weight:	Free Field	~216g
	Closed Field	~277g
Dimensions:	Free Field	2.6" outside diameter x 1.4" deep

Free field measurements typical at 10 cm using +/- 1 V input.
Closed field measurements typical for approx 0.1 cc ear tip coupler using +/- 1 V input.





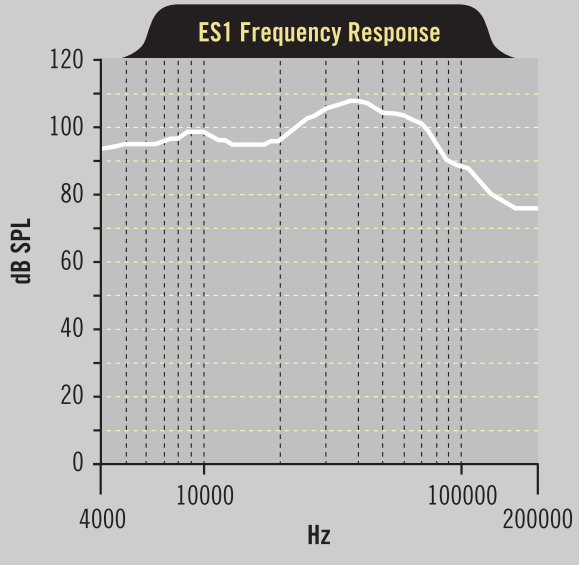
Electrostatic Speakers

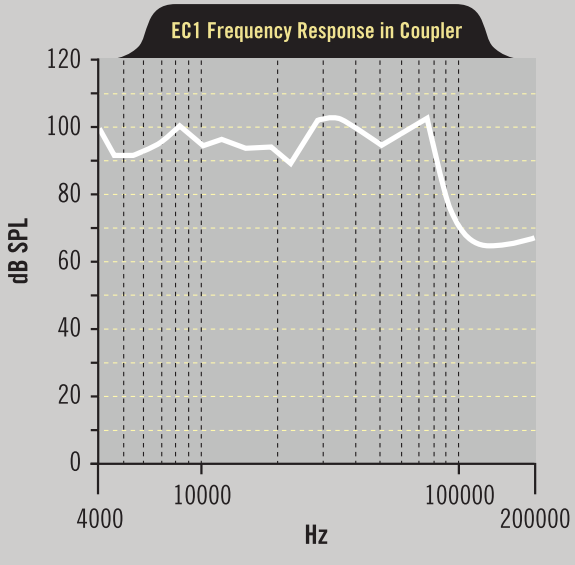
TDT Electrostatic Speakers are designed specifically for ultrasonic signal production. Our patented electrostatic design utilizes a thin, flexible membrane with an extremely low moving mass. Unlike conventional speakers, these speakers distribute the driving signal homogeneously over the surface of the membrane. These special features produce a small, lightweight speaker with an excellent ultrasonic response and low distortion. Available with or without a coupler, both models are easy to position and are particularly well suited for studies with small animals that have hearing in the ultrasonic range. The speakers can be driven by the RZ6 Multi I/O Processor or the ED1 Electrostatic Speaker Driver and are provided with a 6 m connection cable.

Part Numbers:
ES1 Free Field Electrostatic Speaker
EC1 Electrostatic Speaker – Coupler Model

Technical Specifications:

Frequency response:	ES1	+/-11 dB from 4 kHz to 110 kHz
	EC1	+/-9 dB from 4kHz to 110 kHz
Weight:	22g	
Dimensions:	3.8 cm outside diameter x 2.6 cm deep	
Typical output (9.9V peak input):	ES1	95 dB SPL at 10 cm, +/- 9.9V 5 kHz signal
	EC1	90 dB SPL, +/- 9.9V 5 kHz signal
Maximum output:	110 dB SPL at 10cm	
THD (ES1 typical):	< 3% at +/- 4 V input	





**Measurements were made in a 1 cm x 0.5 cm coupler with a 20 cm length of 3/32". 4 V peak input tones were tested and frequency response was measured with a calibrated pressure microphone.*

Commutators

Motorized Commutators

TDT's ACO is a compact, motorized commutator for simultaneous neural recording and optogenetic stimulation and is available in 32 and 64 channel models. The commutator actively tracks rotation on a headstage cable connected to a behaving subject and then spins the motor to compensate, eliminating turn-induced torque at the subject's end of the cable.

Built-in electrical shielding ensures an ultra-quiet environment for recording and lightweight cables and connectors minimize the torque caused by subject motion. Pushbuttons allow for optional manual control of the commutator motor, and an input BNC can be used to inhibit the motor during critical recording periods. A banana jack provides access to ground, so that users can connect the commutator ground to an external ground, such as a Faraday cage, to minimize noise.

Part Numbers:

ACO32	32 channels
ACO64	64 channels
FORJ	Fiber Optic Rotary Joint

Technical Specifications:

Channels:	**ACO32** Analog: up to 32 channels Digital: up to 256 channels **ACO64** Analog: up to 64 channels Digital: up to 512 channels
Signal/Noise:	120 dB (20 Hz to 25 kHz)
RPM (approx):	18
Digital Inputs:	1 Inhibit
Power Consumption:	ACO32 and ACO64 quiescent: 35 mA ACO32 rotating: 65 mA ACO64 rotating: 75 mA
Power Supply:	1500 mAh Li-ion Battery; 1000 cycles of charging
Charger:	6-9 V, 3A, center negative

Also Available:

Real-Time Processors

RX6	Multi Function Processor*
RX8	Multi I/O Processor*
RP2.1	Real-Time Processor*
RM1	Mini Real-Time Processors
RM2	Mobile Real-Time Processors

Software

ACTX	ActiveX Software
BioSigRP	AEP and OAE Software
BioSigRZ	ABR and DPOAE Software
OD1	Open Developer Suite
OE1	Open Explorer Software
OpenEx	OpenEx Software Suite
OS1	Open Sorter Software
RPvdsEx	Real-Time Processor Visual Design Studio
SykofizX	Psychophysics Software

zBUS Based Devices

ED1	Electrostatic Speaker Driver for the ES1/EC1 Speakers
FO5	zBus Interface Module
FLSYS	Flashlamp System
HB7	Headphone Buffer
HTI3	Headtracker Interface
MA3	Microphone Amplifier
MS2	Monitor Speaker
PA5	Programmable Attenuator
PM2R	Power Multiplexer
RA8GA	Adjustable Gain PreAmp (General-Purpose Digitizer)
SA1	Stereo Power Amp
SA8	Eight Channel Power Amplifier
SM5	Signal Mixer
ZB1PS	zBUS Device Chassis with Power Supply (UL Approved)

Other System 3 Devices

MZ60	MEA Interface
PP16	Patch Panel for RP Processors
PP24	Patch Panel for RX Processors
S-BOX	S-BOX Amplifier Input Splitter
LP16CH/LP32CH	Low Profile Chronic Headstages

Visit TDT.com for more information on these products.

**Note: all devices must be mounted in zBUS Device Chassis*

Other Products and Services:

TDT can help you complete your system. We offer a range of reseller items minimizing the number of places you'll have to shop when setting up your lab. Here is a short list of other products and services we offer.

NanoZ Impedance Tester
The nanoZ is used for testing multichannel electrodes, and has several electroplating modes for automated impedance matching, site activation, and site rejuvenation. It uses very low test currents for *in vitro* or *in vivo* testing, and can accurately measure the impedances of a 64-channel electrode in just 30 seconds.

Wireless Headstage and Receiver Interfaces
TDT provides the PZ5 preamplifier which interfaces extremely well with the Triangle BioSystems, Inc. (TBSI) wireless headstages and receiver. Record wirelessly from your subject and have the PZ5 digitize the data for input into an RZ base station.

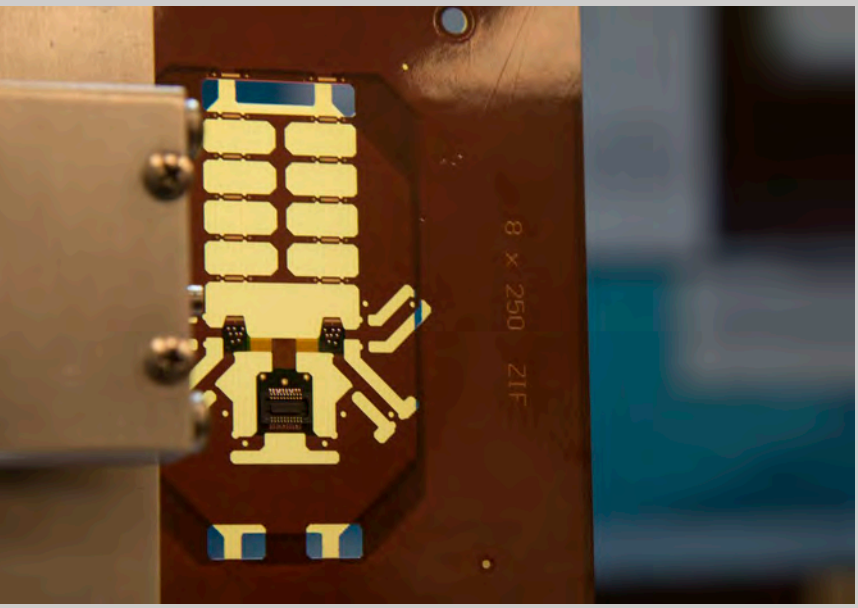
Needle and Surface Electrodes
We can complete your evoked response system with cup or needle electrodes.

Polhemus FASTRAK® and Ascension Flock of Birds® Motion Tracking Systems
These multi-axis tracking systems can be used to transduce the physical position of nearly any part of your subject. Either system can be connected directly to TDT hardware via the HTI3 tracker interface.

Etymotic Research,Inc. Speakers (Insert Earphones) and Microphones
Used for closed field or occluded ear canal auditory work and DPOAEs, we can help you get the best speaker/microphone system for your application.

PCB Piezotronics Calibration Microphones
PCB Piezotronics, Inc. offers high quality, cost effective free-field or pressure calibration systems for closed and open field audio work at up to 120 kHz.

BNC Wiring Kits and Table Top Racks
TDT provides BNC cables and relay racks tough enough to stand up to everyday use in the lab. Kits combine a variety of commonly used cable lengths and racks are available in several sizes to fit your system.



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System 3:

Headstages, Arrays & Adapters:

Software:

Our Customers:

NORTH AMERICA

Canada

Baycrest Centre for Geriatric Care
Baycrest Hospital
Cape Breton University
Capital Health Authority
Carleton University
Dalhousie University
Defence R&D Canada Atlantic
Defence R&D Canada Toronto
Defence and Civil Institute of Environmental Medicine
Electro-5 Inc.
Hospital Laval
Hydro-Quebec
Livingston International
Manitoba Institute of Child Health
McGill University
McGill University Health Centre
McMaster University
Memorial University of Newfoundland
Neurostream Technologies
Nipissing University
Queen's University at Kingston
Robarts Research Institute
Sommer Associates
The Hospital for Sick Children
The University of British Columbia
The University of Lethbridge
Unitron Hearing Ltd.
Universite de Montreal
Universite Laval
University of Western Ontario
University of Alberta
University of British Columbia
University of Calgary
University of Guelph
University of Manitoba
University of Ottawa
University of Prince Edward Island
University of Saskatchewan
University of Toronto
University of Toronto Erindale
University of Toronto Mississauga
University of Western Ontario
University of Windsor
York University

USA

Abratech Corporation
Adelphi University
Advanced Bionics
Advanced Information Engineering Services
Air Force Research Laboratory
Albany Medical Center
Albert Einstein College of Medicine
Alcatel-Lucent
Alcon Labs Limited
Apple
ARCON Corporation
Arizona State University
Army Research Lab
Articulation, Inc.
Arup Acoustics
AstraZeneca Pharmaceuticals LP
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Axon Human Technologies, Inc.
Baylor College of Medicine
Baylor University
Beltone Electronics
Beluga Software, Inc.
Beth Israel Medical Center
Bethel University
Binghamton University
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Biogen, Inc.
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Boys Town National Research Hospital
Brandeis University
Brigham Young University
Brookhaven National Laboratory
Brown University
California Institute of Technology
California State University Bakersfield
California State University Long Beach
Carnegie Mellon University
Case Western Reserve University
Central Institute for the Deaf
Children's Hospital and Health Center
Children's Hospital Boston
Children's National Medical Center
Christopher Newport University
Cincinnati Children's Hospital
City College of New York
City University of New York
CUNY, The Graduate Center
CUNY, Queens College
Cleveland Clinic Foundation
Coble Geophysical
Cochlear Americas
Cold Spring Harbor Laboratory
Colorado State University
Columbia University
Cornell University
Cornell University Weill Medical College
Cortech Solutions
Creighton University
Crimson Tech
CWE, Inc.
Cyterra Corporation
Dartmouth College
Dartmouth Medical School
DL Instruments, Inc.
Drexel University College of Medicine
Duke University
Duke University Marine Laboratory
Duke University Medical Center
DuPont Hospital for Children
East Bay Institute for Research and Education
East Carolina University
East Tennessee State University
Emory University
Engineering Design
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Fonar Corporation
Gallaudet University
General Monitors
Gentex Corporation
Geo Centers
Georgetown University
Georgia Institute of Technology
Georgia State University
GN ReSound
Gustavus Adolphus College
Harvard Medical School
Harvard University
Hawaii Institute of Marine Biology
Henry Ford Health System
Heuser Hearing Institute
Hospital for Sick Children
Hough Ear Institute
Howard Hughes Medical Institute
Howard Hughes Medical Institute, Janelia Farm
Howard Leight Industries
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Hui Jie International Trading, Inc.
Hunter College
Illinois College
Indiana University
Innovative Instruments, Inc.
Iowa State University
Ironwood Pharmaceuticals
IUPUI/Reiley Hospital
James Madison University
Jerry Pettis Memorial Veterans Med. Ctr.
John B. Pierce Laboratory
Johns Hopkins University School of Medicine
Kansas State University
Kenyon College
Kernel
Kresge Hearing Research
Lehigh University
Let Them Hear Foundation
Lexington School for the Deaf
Long Island University
Louisiana State University
Loyola University
LSU Health Sciences Center
Lucent Tech (Bell Labs)
Lucent Technologies; Agere Systems
Marine Biological Laboratory
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Massachusetts General Hospital
Massachusetts Institute of Technology
McLaughlin Research Institute
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Medical University of South Carolina
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Michigan State University
MicroTransponder, Inc.
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MIT
MIT Stata Center
Montclair State University
MOTE Marine Lab
Motorola Labs
Motorola, Inc.
MPI Research INC.
MRI Devices Corp.
Mt. Sinai School of Medicine
NanoNutrients
NASA Ames Research Center
Nathan Kline Institute
National Institute of Health
National Institute of Mental Health
National Institute of Standards and Technology
National Institute on Alcohol Abuse and Alcoholism
NIDCD
Naval Health Research Center
Naval Medical Center
Naval Research Laboratory
Naval Submarine Medical Research Laboratory
Neuralink
NeuroNexus Technologies
New York Medical College
New York University
New York University School of Medicine
Northeastern Ohio Universities Colleges of Medicine
Northeastern University
Northern Michigan University
Northwestern University
Northwestern University Music School
NOVA Navigation
Oak Ridge National Laboratory
Ohio State University
Ohio University
Old Dominion University
Optima Neuroscience
Oregon Health & Science University
Parke-Davis Pharmaceutical Research
Pepperdine University
Pfizer Inc.
Pomona College
Pratt & Whitney
Princeton University
Purdue University
Quiet Technologies
Radford University
Renovis, Inc.
Research Foundation for Mental Hygiene
Research Triangle Institute
Rhode Island Hospital Research
Rhythmia Medical Inc.
Rice Creek Medical
Rochester Institute of Technology
Rowland Institute at Harvard
Rutgers, State University of New Jersey
Saint Louis University
Salk Institute
San Diego State University
San Jose State University
Sandia National Laboratories
Sanofi-Aventis US
Skytek Corporation
Smith College
Smith-Kettlewell Eye Research Institute
Software House International
Sound ID
Sound Pharmaceuticals
South Carolina State University
Southern Illinois University
Space and Naval Warfare Systems Center
SSC Pacific
St. Joseph's Hospital - Phoenix
St. Jude Children's Research Hospital
St. Mary's College of Maryland
St. Norbert College
Stanford University
Starkey Hearing Research Center
Starkey Laboratories, Inc.
State University of New York at Buffalo
State University of New York at New Paltz
State University of New York at Plattsburgh
State University of New York at Stony Brook
State University of New York Research Foundation
Sytronics Incorporated
T.R.U.E. Research Foundation
Texas A&M University
Texas Tech University Health Sciences Center
The Children's Hospital of Philadelphia
The College of Wooster
The Dow Chemical Company
The John B. Pierce Laboratory
The Montreal Tinnitus Clinic
The Neurosciences Institute
The Pennsylvania State University
The Rockefeller University
The Scripps Research Institute
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The University of Memphis
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The University of South Dakota
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The University of Texas
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Toyota
Triangle Biosystems Inc.
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US Army Night Vision & ESD
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University of Colorado
University of Colorado at Boulder
University of Connecticut
University of Connecticut Health Center
University of Florida
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University of Illinois Urbana-Champaign
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University of Iowa Health Care
University of Iowa Hospital and Clinics
University of Kansas
University of Kansas Medical Center
University of Kentucky
University of Louisville
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University of Maryland
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University of Michigan
University of Michigan Medical School
University of Minnesota Duluth
University of Minnesota Minneapolis
University of Minnesota St. Paul
University of Mississippi
University of Mississippi Medical Center
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University of Nebraska
University of North Carolina
University of North Carolina Asheville
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University of North Carolina Greensboro
University of North Texas
University of Northern Colorado
University of Oklahoma
University of Oregon
University of Pennsylvania
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VA Medical Center - Iowa City
VA Medical Center - La Jolla
VA Medical Center - Nashville
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VA Medical Center - San Francisco
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Vanderbilt University
VAOPC Martinez
Veridian Engineering
Veridical Research & Design Corporation
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CUSTOMER LAB PROFILE

Dr. Antonio Paolini *and his colleagues in the* AUDITORY NEUROSCIENCE LABORATORY AT LA TROBE UNIVERSITY *are using TDT System 3 equipment to examine neural mechanisms underlying auditory information processing in the cochlear nucleus. In particular, they use multi-channel neurophysiological techniques and intracellular recordings to investigate the role of inhibition in neural timing and how this may play a role in frequency coding. The Auditory Neuroscience Laboratory incorporates the latest TDT hardware and software including multi-DSP modules, microwire electrodes, microstimulators and the OpenEx software suite.*

"The power of the TDT system is realized when conducting multi-channel recordings, especially with the five-DSP RX series of components. Stimulus delivery is also made easy through development of a custom front end within the OpenEx environment incorporating the flexible RPvds circuit design," remarks Dr. Paolini, "No additional programming outside the OpenEx environment is necessary." The ease of use and flexibility of the OpenEx Software was a deciding factor for Dr. Paolini. OpenEx allows him to change stimulus parameters on the fly and stores response waveforms along with all the appropriate Epoch information, maximizing the amount of data that can be recorded from a given cell.

Notes

Contact us:

If you're considering purchasing a TDT system, we encourage you to give us a call. You'll speak to a knowledgeable technical sales person who'll answer all your questions and might ask you some as well. Questions like which signals and subjects you work with, how many channels of I/O you need and what type of stimulus you plan to use. We'll use this information to determine the best TDT system for your application – a system that's been customized to include everything you'll need, and nothing you don't. And after you purchase your system, our full-time support staff will be there to help with any questions or problems you might have.

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TDT International Representatives:

Australia
Bioengenesis Technologies Pty Ltd
2 Research Avenue
La Trobe University R & D Park
Bundoora, VIC - 3083 Australia
Phone: 0402 246 247
E-mail: info@bioengenesis.com
Web: www.bioengenesis.com

China
ISEN Tech & Trading Co., Ltd.
Rm. 509, Bldg. A, Cyber Tower
No. 2 Zhongguancun South Ave.
Haidian District
Beijing, China 100086
Phone: 8610-51627071
Fax: 8610-51627073
E-mail: guozhk@isen.com.cn
E-mail: isenliu@public.bta.net.cn
Web: www.isen.com.cn

China
Global Biotech Inc.
RM 2526, Building A, No.500
Yunjin Road, Xuhui District
Shanghai 200000 P.R. China
Phone: 400-839-0899
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Web: www.glo-bio.com.cn

Italy
E.M.S. s.r.l.
via Giuseppe Ceneri 13
40138 Bologna – Italy
Phone: +39 051 398925
Fax: +39 051 342953
E-mail: sales@emsmedical.net
Web: www.emsmedical.net

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Korea
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RM 801, 74 Gangbuk
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United States & Canada
TDT Headquarters
11930 Research Circle
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Phone: +1 386-462-9622
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