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Please see FHC's microTargeting® products for FDA cleared, intraoperative versions.

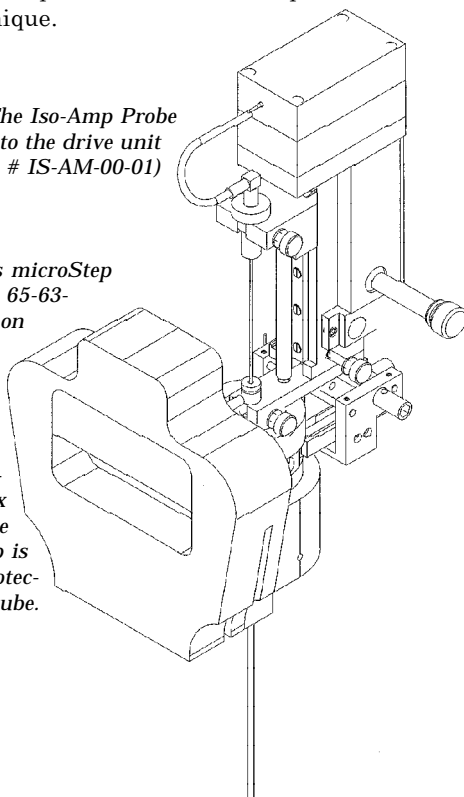
Intra-Operative Recording

- Amplifiers
- Micropositioners
- Microelectrodes
- Stimulators

For over 25 years, FHC, Inc. has been the leading supplier of microelectrodes and instrumentation to research investigators using extracellular recording techniques; so, as microelectrodes developed into a valuable neurosurgical tool, it was natural that FHC products would be adapted to the intra-operative technique.

Note: The Iso-Amp Probe is built into the drive unit (cat. # IS-AM-00-01)

FHC's microStep Drive and XY Table, 65-63-1, mounted on Radionics frame Adaptor. Also shown are Protective Tube, Insertion tube, and Guide Tube arrangement in max retracted position, the microelectrode tip is 1mm inside the protective tube.



Already we've customized our microelectrodes, micropositioners, amplifiers, and stimulators for surgical teams around the world; we've developed over 50 microelectrode configurations alone. Our micropositioners have been adapted to virtually all stereotactic frames.

We can draw on this experience to help you put together a system to meet your requirements whether it be a special microelectrode to fit your existing system, a micro-positioner adapted to your frame, electronic instrumentation to record or stimulate, or the entire system. All of our designs are computerized so they are available to match your needs rapidly, conveniently, and inexpensively.

Contact our application engineers; they can help make this exciting technique available to your team.

Information on individual components begins on the next page.

Microneurography Needles

FHC **Microneurography Electrodes** (also referred to as "needles") were developed to record single and multi-unit peripheral nerve activity in humans. They have been refined over the years by working in conjunction with the investigators who use them. The tip taper is dramatically shorter and broader than our standard microelectrodes; the convex shape facilitates a minimally painful penetration through the skin.

These tungsten electrodes can be provided with a variety of shank diameters and impedances to satisfy various recording requirements. A number of termination options are available to aid in the placement and support of the electrode in the nerve. FHC's UN series microelectrodes are typically provided with a 15mm square manipulating tab to aid in accurate placement. Alternatively an insulated floating termination can be provided to allow the electrode to move with the target tissue.

Our microneurography electrodes are available in an uninsulated configuration as well for use as a reference electrode.

Please refer to the guide for options and ordering information.

ORDERING INFORMATION

For Microneurography Needle prices please refer to page 4 of the price list. Though priced individually, our electrodes are packaged in quantities of 12.

TO SPECIFY FHC MICRONEUROGRAPHY NEEDLES:

CATALOG# **UN123456 (iin)**

Microneurography electrodes Specifications Customers Initials, if necessary

1 Configuration:
 A: Active Needles, box of 12 Insulated with selected tip impedance.
 N: Reference Needles, box of 12. No Insulation.
 P: Active and reference pairs, box containing 6 of each.
 X: Special / Specify

2,3 Electrode Length in millimeters
 35mm Standard if not specified see diagrams below for dimension definition.

4 Shank Diameter:
 E: .005" / 125µm
 F: .008" / 200µm
 G: .010" / 250µm
 X: Special / Specify

5 Impedance:
 For Active needles only, reference needles have no impedance.
 A: 50k - 100k
 B: 300k - 500k
 C: 800k - 1.2M
 1: 1M +/-1M
 2: 2M +/-1M
 3: 3M +/-1M
 4: 4M +/-1M
 5: 5M +/-1M
 6: 6M +/-1M
 7: 7M +/-1M
 8: 8M +/-1M
 9: 9M +/-1M
 0: 10M +/-1M
 N: No Zap (high)
 R: Reference Needle
 X: Special / Specify
 M = Meg Ohm

6 Termination Options:
 Specials available upon request

R: Male pin and Tab
 Length 15 mm
 Color Coded Tab and .032"Ø male pin. Blue Tab: Reference Needle White Tab: Active Needle

S: Spiral Lead
 Length 15 mm
 30 ga Spiral Leads stretchable up to 20cm (8") Ends Stripped and Tinned the last 10mm

T: Spiral Lead, Male Pin
 Length 15 mm
 30 ga Spiral Leads Terminated with .032"Ø Male pins w/ color coded heat-shrink Red: Active, Black: Reference

U: Spiral Lead, Mini-Bananna Plug
 Length 15 mm
 30 ga Spiral Leads Terminated with Color Coded Mini Bananna Plugs Red: Active, Black: Reference

L: Floating termination, see diagram:
 38ga insulated copper lead, stripped and tinned
 Epoxy Cap
 X mm

D: No pin, Insulation not stripped
 E: No Pin, Insulation stripped 5mm
 G: No Pin, Insulation stripped 10mm
 H: No Pin, Insulation stripped 15mm
 J: No Pin, Insulation stripped 20mm
 X: Special (not listed)

Customers Initials and revision # only if necessary.
 ii: Initials of the customer for/by whom the electrode was designed
 n: Version or revision number

Other termination options are available, see: TO SPECIFY FHC METAL MICROELECTRODES for details.



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Intra-Operative Microelectrodes

FHC microelectrodes are used in intra-operative recording procedures around the world. Four standard configurations have been developed in response to particular needs. All can be provided in a variety of lengths, configurations, and tip impedances. We can use a variety of terminations and often add a stop at a precise distance from the tip.

Type 1 describes the lengthened version of the tungsten and stainless steel microelectrodes used in research for many years. Extremely straight, this configuration is insulated with many coats of a thermally cured epoxy. We also add a sheath of polyimide tubing to ensure a smooth fit through guide tubes. The result is a sturdy, safe, recording/stimulating microelectrode.

Type 2 microelectrodes are extended versions of classic glass insulated platinum/iridium microelectrodes. This type was used in many of the initial intra-operative recording procedures and is still favored in situations where maximum current delivery is required. The microelectrode is housed in a length of insulated stainless steel tubing to provide strength and straightness.

Type 3 Microelectrodes include an insulated outer stainless steel tube which can be used in a coaxial differential recording mode to minimize noise and artifacts. This version is available with tungsten, stainless steel or platinum/iridium microelectrodes.

Type 4 describes a macro- or semi-microelectrode bipolar configuration. Able to record multi-unit activity and deliver higher stimulating currents, this configuration has a sturdy, ground tip, stainless steel construction.

Types 5,6,7, and 8 are versions of configurations 1-4 which are provided with a stainless steel protective tube. This facilitates handling, sterilization, and insertion of the delicate microelectrodes. We often include a ground connection wire to provide electrical shielding.

Please note that any of the terminations and physical configurations shown in the examples below can be provided on any of the various types 1-4.

Our electrode specialists are ready to work with you to design a specific microelectrode for your intra-operative requirements. They will bring our years of experience to the design of the correct configuration for your recording equipment and stereotactic frame.

ORDERING INFORMATION

For Intra-Operative Microelectrode prices please refer to page 4 of the price list. Though priced individually, our microelectrodes are packaged in quantities of 12.

Please refer to FHC's microTargeting® electrode section for FDA cleared, intraoperative versions.

TO SPECIFY FHC INTRA-OPERATIVE ELECTRODES:

IO 123456 7 iin

Intra-Operative Electrode Base Electrode Factory Use Only Customer Initials and Version / Revision Number Configuration

In addition to the configuration style, it is necessary to determine the type of microelectrode to use, and any dimensional and termination requirements that you have. Please consult our Microelectrode Specialists to finalize an electrode design to best meet your needs. Once a design is finalized, we will assign initials and a revision number to complete the catalog number which completely specifies your microelectrode. A final price can then be quoted.

7 Configuration:
 1: Long (Tungsten or SS)
 2: Extended (P/ir)
 3: Micro-Concentric
 4: Macro-Concentric
 5: Long, with Protective Tube
 6: Extended, with Protective Tube
 7: Micro-Concentric with Protective Tube
 8: Macro-Concentric with Protective Tube
 X: Special / Specify

iin Customers Initials
 ii: Initials of customer for whom the matrix was designed
 n: Version or revision number

1 IO WGGSE 1AB1
 Dimensions: 100mm, 225mm +/- 0.5mm, 238mm, ~245mm, 8mm, ~2mm.
 Components: Tungsten Microelectrode, .011" ID PI x 135mm, 5 min. Epoxy together: .022" ID (M3-23) x 8mm, .028" ID (M3-27) x 8mm, .035" ID (M3-31) x 8mm, 17ga SS Tubing x 8mm, Male Pin M3-01.

2 IO PSEGSG 2KM1
 Dimensions: 10mm, 232mm, 245mm, 20mm.
 Components: Epoxy seal <.5mm dia, P/ir / Z=8-1.2 Meg Thin Glass Insulation (Smooth) O.D. Not to exceed OD of PI Tubing * Concentricity Critical, .55 ID x 215 POLYIMIDE (M3-23), 26ga SS TUBE.

3 IO WGGSE 3PB1
 Dimensions: 10mm, 200mm.
 Components: 23ga TW, grind end to expose outer conductor, Tungsten Microelectrode Z = 1.5 Meg, 26ga SS TUBE, Coax Connector (N1-15).

4 IO SVGXXE 4CB1
 Dimensions: .300Ø, .04mm, .22mm, 300mm, 10mm, 250Ø, .550Ø.
 Components: Outer Pole 24 ga SS Tube, 22mm, 22mm, SHRINK TUBING, 50mm x 36ga INSULATED Cu LEADS, Inner Pole SS, 250mm Ø, Male Pins with heat-shrink: Red = Inner Pole, Yellow = Outer Pole.

5 IO WGGSE 5PC1
 Dimensions: 228mm, 65mm, 33mm, 2mm, 1.2mm Ø, 31mm, 228mm.
 Components: 18.5ga SS Tubing, RETRACTED, EXTENDED, Round and Polish end of tube.

6 IO PSEGSG 6KM1
 Dimensions: 160mm, 245mm, 2mm.
 Components: Round and Polish end of tube, 20ga TW SS Tubing, 17ga SS Collar, Glue in place, 17ga SS Collar.

7 IO WGGSE 7PB1
 Dimensions: 200mm Typical, 40, 2, 5.
 Components: 19ga TW SS Tubing, 23ga TW, grind tip to expose, 17ga SS Collar with Heatshrink, Coax Connector (N1-15), Tungsten Microelectrode Z = 1.5 Meg, Ground.

8 IO SVGXXE 8CB1
 Dimensions: 50mm, 250mm, 2mm.
 Components: Round and Polish end of tube, 21 ga XTW SS Tube, K3-76-3A; March 9, 2001.



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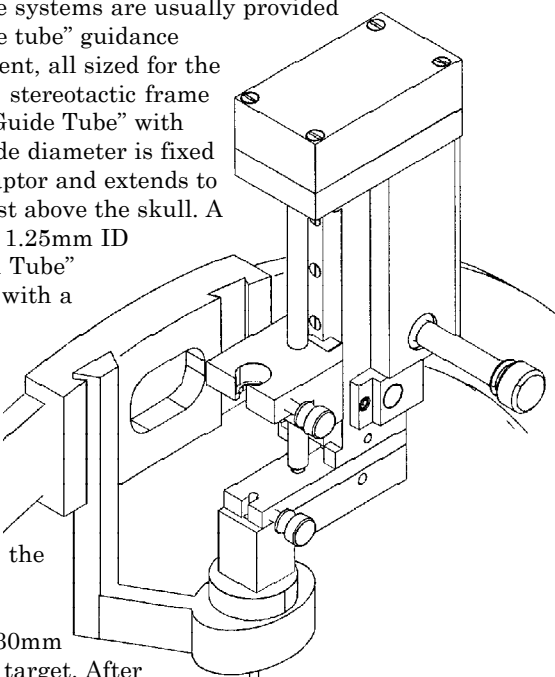
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Intra-Operative Micropositioners

FHC's microStep Drive System features 50mm travel in submicron increments. It is available in mounting configurations which can provide only axial motion, if changing X and Y coordinates is to be accomplished by adjusting the stereotactic frame, or with a XY table which allows repositioning of the microelectrode tracks over a 15mm diameter area.

FHC's system also includes electrode mounting adapters which assure precision location of the electrode tips. The system allows positioning of the lesion or deep brain stimulating electrode through the same guide tube using the microStep drive. As a result, errors in repositioning after recording are minimized.

FHC drive systems are usually provided in a "three tube" guidance arrangement, all sized for the particular stereotactic frame used. A "Guide Tube" with 2mm inside diameter is fixed in the adaptor and extends to a point just above the skull. A 2mm OD, 1.25mm ID "Insertion Tube" (provided with a stylet to prevent cutting tissue) is then pushed through the guide tube into the brain to a position typically 30mm above the target. After the stylet is removed, the microelectrode, inside a 1.2mm OD "Protective Tube", is positioned in the insertion tube. The length of the protective tube is such that it extends exactly to the end of the insertion tube. The tip of the microelectrode is typically 1mm inside the end of the tubes and can be advanced the 31mm to target and up to 15mm beyond.

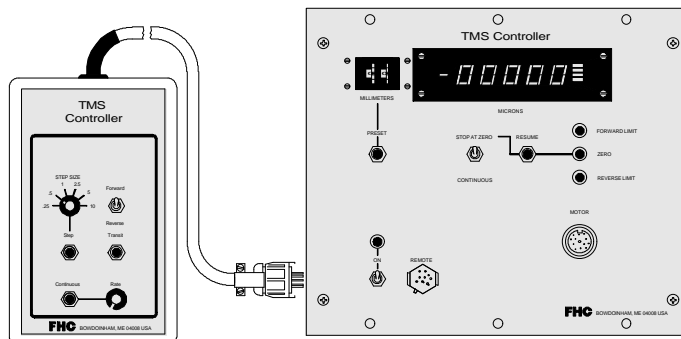


FHC's microStep Drive, 65-22-1, mounted on Leksell frame (axial motion only). Guide Tube (part of adaptor) is shown.

After recording, with the protective tube and microelectrode removed, a lesion electrode or DBS electrode with diameters <.125mm can be advanced through the insertion tube to the selected target depths using the microStep drive. If a larger (1.3 to 2.0mm) lesion electrode is required, the insertion tube is removed, and the lesion electrode is advanced through the guide tube to target.

FHC design engineers are available to apply our technology to your requirements. Solutions are available "off the shelf" to be adapted quickly and economically.

TMS Controller



ORDERING INFORMATION

Cat. # ST-MO-00 TMS Controller (for price see page 5 of price list)

The TMS Controller when used with the ST-DR-00 Drive Unit allows the investigator to position micro- and lesion electrodes in discrete sub-micron steps.

A hand held controller included with the TMS System can be used to advance or retract the microelectrode one step at a time, or at a continuous rate adjustable up to 25 microns per second. For rapid positioning, a transit switch moves the electrode at 0.6mm per second. All motion controls are push button activated so release immediately stops any electrode movement.

Two thumbwheel switches allow the operator to preset the target depth to a selected value, in millimeters. As the probe is advanced the display counts down, indicating the distance to the target. A toggle switch can be set to select whether the drive stops when the display gets to zero (ZERO LED lights) or continues through zero without stopping.

SPECIFICATIONS

TMS Controller:

Display: 5-decade display, pre-settable to target distance (mm) shows position to a resolution of 0.25 microns

Note: Display will blink when tool holder circuit is activated (ST-DR-00 required)

Power Requirements: 115/230V, switch selectable, 50-60Hz.

Dimensions: Control Module: 8 1/4" w x 7" h x 9" d (21 x 18 x 23cm), 9 lb. (4kg)

Hand Held Controller:

Mode: Continuous or step; forward or reverse

Step Length: Switch selectable; 0.25, 0.5, 1, 2, 5, 10 microns per step

Step Rate: To 25 microns/sec, continuously adjustable

Transit: 0.6 mm/sec

Dimensions: 5.7" w x 3.6" h x 1.2" d (14.5 x 9 x 3cm) with 2.5 meter cable standard

ORDERING INFORMATION

Cat. # 65-63-1¹ microStep Drive with XY table and Radionics adapter²
 Cat. # 65-73-1¹ microStep Drive with XY table and Leksell adapter²
 Cat. # 65-12-1¹ microStep Drive w/Radionics adapter²
 Cat. # 65-22-1¹ microStep Drive w/Leksell adapter²

For prices please refer to page 5 of the price list. Adaptors for other stereotactic frames are available.

¹ TMS Controller also required

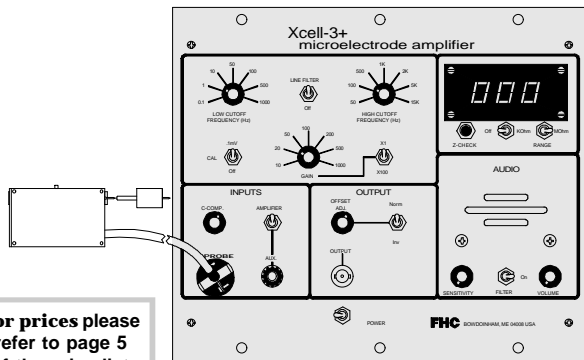
² Adaptors include insertion tube and stylet sized for correct target distance.



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Iso - Xcell 3+ Microelectrode Amplifier



For prices please refer to page 5 of the price list

ORDERING INFORMATION

- Cat. # IS-AM-00 Iso-Xcell 3+ Amplifier (shown above)
 Cat. # IS-AM-00-01 Iso-Xcell 3+ Amplifier w/Probe Integral with Drive Unit (see picture on Page 49)
 Cat. # IS-AM-04 4 Channel Iso-Xcell 3+ Amplifier

The **Iso-Xcell 3+ Amplifier** represents a new standard of low noise, amplification for intra-operative recording and microneurography. By mounting a high impedance, low noise, differential preamplifier near the microelectrode, external noise pickup is minimized.

For intra-operative recording, the probe is small enough to be mounted directly on the drive system to minimize cable length. For microneurography, the probe can be mounted within a few inches of the recording.

Sharp low and high cut-off filters and a line notch filter allow the investigator to reject signals outside the bandwidth of interest. The instrument also includes provision for:

- Impedance Check: A push of a button and the impedance (1000 Hz) of the microelectrode is displayed on a 3-digit readout.
- Microelectrode Disconnect: A switch electrically disconnects the microelectrode from the preamplifier input and connects it instead to a front panel connector (AUX), permitting the investigator to apply stimulation or lesion currents through the microelectrode.
- Audio Monitor: circuitry includes a noise filter, high gain, and adjustable frequency response.

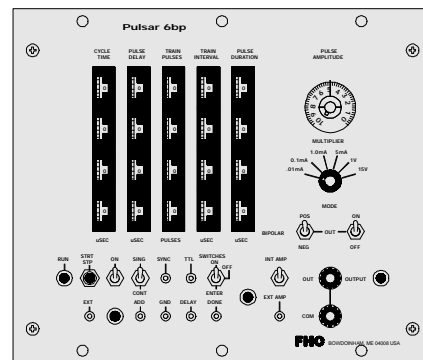
Isolation is provided by a separate isolation transformer which meets the current requirements of UL544 and is VDE certified to IEC 950 specifications. The isolated circuitry is coupled to the ground-referenced output stage through optical isolation amplifiers.

The Xcell 3+ is also available in a 4 channel configuration providing additional channels for EMG and/or evoked response recordings.

SPECIFICATIONS

- Input:** Differential, $>10^{12}$ Ohms Impedance
Frequency Response: .1 - 15KHz (-3db)
Isolation: Leakage current <100 microamps (per UL544), typically <10 microamps
Power Requirements: 115V/230V, switch selectable, 50-60Hz
Dimensions
Module: 7" h x 8.25" w x 9" d (18 x 21 x 23cm); 6.5 lbs. (3kg)
Probe: 1.90 x 1.2 x .62" (5 x 2.9 x 1.5cm) with 8' (2.5m) cable (other lengths optional)

Iso - Pulsar Stimulator



ORDERING INFORMATION

- Cat. # IS-PL-06 Isolated Bipolar Pulsar Stimulator

For prices please refer to page 5 of the price list

Bipolar waveforms are recommended for micro- and macro-stimulation to maximize current flow and minimize electrode tip degradation and electrolysis product build-up.

The **Iso-Pulsar Stimulator** has controls for CYCLE TIME, DELAY, NUMBER OF TRAIN PULSES, TRAIN INTERVAL, PULSE DURATION AND PULSE AMPLITUDE. Pulsars have SINGLE or CONTINUOUS (recycle) modes and feature a unique 3-position SYNCHRONOUS SWITCH which, when in the OFF position, disconnects the thumbwheel switches even while a program is running, so that new values set are not entered until the end of cycle after the ENTER position is activated. In the third ON position, thumbwheel switch value changes are immediately effected.

Digital values are set on 4-digit thumbwheel switches using the general form XXX10^P where XXX, the significant figures, are the first three digits and P, the exponent, is the fourth.

The isolated output features 6 constant current (0-10mA) or constant voltage (0-150V) ranges. It is optically coupled, powered by an isolated supply; no batteries are required. The output pulse can be specified as positive, negative, or symmetrical bipolar.

SPECIFICATIONS

- Cycle Time:** adjustable from 1uSec to 99,900Sec
Cycle Delay: adjustable from 1uSec to 99,900Sec
Train Pulses: adjustable from 1 to 999x10⁸ pulses
Train Interval: adjustable from 1uSec to 99,900Sec
Pulse Duration: adjustable from 1uSec to 99,900Sec
Output: optically isolated; constant current (1-10,000uA in 3 ranges) or constant voltage (.1-150V in 3 ranges), positive, negative, or bipolar pulse, switch selectable.
Power Requirements: 115/230V, switch selectable, 50-60Hz, 1A
Dimensions: 8 1/4" w x 7" h x 12" d (21 x 18 x 30cm). 8 lbs. (3.6kg)

