MA-300 EMG System

User Guide

By Motion Lab Systems, Inc.

This manual was written by Motion Lab Systems using *ComponentOne Doc-To-Help.*™

Updated Monday, November 19, 2007

Trademarks

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Printed in the United States of America

Contents

Important Information

Warranty

Motion Lab systems, Inc., warrants that each MA-300 system, comprising of the Desk Top Unit and Back-Pack Unit will be free from defective materials and construction for twenty-four (24) months from the date of installation.

Motion Lab Systems, Inc., agrees to correct any of the above defects (parts and labor only) when the complete system is returned to the factory freight prepaid by the customer. Return authorization must be obtained from Motion Lab Systems before returning the system to the factory. The repaired system will be returned to the customer freight prepaid during the warranty period. Hardware Service Contracts are available to extend this warranty.

Under this warranty Motion Lab Systems may, at its option, repair or replace the defective system or system components.

This warranty will be invalid if, in the sole judgment of Motion Lab Systems, the system has been subjected to misuse, abuse, neglect, accident, improper installation or application, alteration or neglect in use, storage, transportation or handling.

The preamplifiers, cables and event switches supplied with the backpack and desktop unit are considered to be consumable items and are warranted to 30 days from initial use. These items are considered to have a limited life and should be replaced when necessary. Additional foot switches, pre-amplifiers and cables may be ordered directly from Motion Lab Systems or your EMG system distributor.

Intended Use

The Motion Lab Systems, Inc., MA-300 EMG system is designed for Clinical, Investigational and Research use and may be used in the treatment and diagnosis of humans.

All MA-300 systems have received US FDA 510(k) clearance (Sec. 890.1375) for use as a diagnostic electromyograph for medical purposes. A diagnostic electromyograph is defined by the US FDA as:

A diagnostic electromyograph is a device intended for medical purposes, such as to monitor and display the bioelectric signals produced by muscles, to stimulate peripheral nerves, and to monitor and display the electrical activity produced by nerves, for the diagnosis and prognosis of neuromuscular disease. [21CFR890.1375]

Year 2000 Compliance Statement

Motion Lab Systems, Inc. has reviewed the MA-300 EMG system for Year 2000 compliance. The MA-300 does not contain any software or hardware components that use dates. The MA-300 EMG system will continue to function correctly on and beyond the year 2000 and will not produce erroneous results as a result of changing centuries.

Mandatory Warnings

Read Manual Before Use

The MA-300 is an AC line powered device - make sure that you read this manual (User Manual) before operating the MA-300 EMG system or connecting the MA-300 system to any other device.

Warning – High Voltage Inside

CLASS I EQUIPMENT energized from an external power source.

TYPE BF protection from electrical shock.

Unauthorized personnel must not disassemble the MA-300 Desk Top Unit without taking the appropriate precautions to ensure safety.

Warning - Connect to a Grounded Outlet Only!

Safe and effective operation of this device requires a three wire AC power connection with an electrical ground (earth) connection.

SIP/SOP Connections

Accessory equipment connected to the analog and digital interfaces must be certified according to the respective IEC standards (i.e. IEC 950 for data processing equipment and IEC 601-1 for medical equipment). Furthermore all configurations shall comply with the system standard IEC 601-1-1.

Everybody who connects additional equipment to the signal input part or signal output part configures a medical system, and is therefore responsible that the system complies with the requirements of IEC 601-1-1. If in doubt, consult the technical services department or your local representative.

Fuse Replacement

The MA-300 Desk Top Unit uses 500mA/250V SLO-BLO fuses only.

In the event of a fuse requiring replacement you must replace the AC line fuses with 500mA/250V SLO-BLO fuses to maintain protection.

Maintenance

The MA-300 system is designed to be maintenance free and does not require any regular maintenance to ensure safe and effective operation.

Cleaning

The surfaces of the MA-300 system and preamplifiers may be cleaned and sterilized with a damp cloth and mild detergent or with isopropyl alcohol swabs. The MA-300 System is NOT SEALED. DO NOT IMMERSE IN WATER OR ANY OTHER SOLUTION. The MA-300 system is not designed for use in a sterile environment. DO NOT subject the MA-300 system to any sterilization procedure.

Anesthetic Environment

The MA-300 is not suitable for use in the presence of a FLAMMABLE ANAESTHETIC MIXTURE WITH AIR OR WITH OXYGEN OR WITH NITROUS OXIDE or in the presence of other explosive gases or vapors.

Use With HF Surgical Equipment

Connection of a patient to HF surgical equipment and to an electromyograph or evoked response equipment simultaneously may result in burns at the site of the electrical stimulator or biopotential input part electrodes and possible damage to the electrical stimulator or biological amplifiers.

Additional Documentation

Motion Lab Systems will make the following items available on request; circuit diagrams, component parts lists, descriptions and calibration instructions.

FCC Regulatory Information

Product Information

Product Name	Motion Lab Systems EMG System
Model Number	MA-300
FCC Rules	Tested To Comply With FCC Part 15, Class B
Operating Environment	For Home Or Office Use

FCC Compliance Statement

This equipment complies with Part 15 of the FCC Rules. Operation is subject to the following conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Information To The User

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference in a residential or office installation. This equipment generates, uses, and can radiate radio frequency energy and if not installed and operated in strict accordance with the manufacturer's instruction, may cause interference to radio communications. However, there is no guarantee that interference will not occur in a particular situation. Interference can be determined by turning the equipment off and on while monitoring radio or television reception. The user may be able to eliminate any interference by implementing one or more of the following measures:

- Reorient the affected device and/or its receiving antenna.
- Increase the distance between the affected device and the equipment.
- Plug the equipment and any peripheral equipment into a different branch circuit from that used by the affected device.
- If necessary, consult an experienced technician for additional suggestions.

Caution: Changes or modifications to the electronics or enclosure to this unit that are not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

International Standards

Canada

CSA C22.2 NO 601.1-M90 Medical Electrical Equipment - Part 1: General Requirements for Safety General Instruction No 1: Supplement 1; 1994 R(1997).

This digital apparatus does not exceed the Class B limits for radio noise emissions from digital apparatus set out in the Radio Interference Regulations of the Canadian Department of Communications.

Le present appareil numerique n'emet pas de bruits radioelectriques depassant les limites applicables aux appareils numeriques de la class B prescrites dans le Reglement sur le brouillage radioelectrique edicte par le ministere des Communications du Canada.

European Community

CENELEC EN 60601-1 - Medical Electrical Equipment Part 1:

IEC 60601-2-40 - Particular Requirements for Electromyographs and Evoked Response Equipment.

General Requirements for Safety Incorporates Corrigendum July 1994; Includes Amendments A1: 1993, A11: 1993, A12: 1993, A2: 1995 and A13:1996; IEC 601-1: 1988 + A1: 1991 + A2: 1995 +

CENELEC EN 60601-1-2 - Medical Electrical Equipment Part 1: General Requirements for Safety 2. Collateral Standard: Electromagnetic Compatibility - Requirements and Tests (IEC 601-1-2: 1993) - EMISSIONS

CENELEC EN 60601-1-2 - Medical Electrical Equipment Part 1: General Requirements for Safety 2. Collateral Standard: Electromagnetic Compatibility - Requirements and Tests (IEC 601-1-2: 1993) – IMMUNITY

EU Contact: Motion Lab Systems, Ltd. 22 Bulls Lane, Kings Sutton, Nr. Banbury, Oxfordshire OX17 3RB England.

Type of Equipment: EMG System.

Manufacturer: Electronic Manufacturing Co., 13440 Wright Circle, Tampa, FL 33626 USA. Telephone: +1 (813) 855-4068

Responsible Party: Motion Lab Systems, Inc., 15045 Old Hammond Hwy, Baton Rouge, LA 70816 USA. Telephone: +1 (225) 272-7364

http://www.motion-labs.com

United States of America

UL 2601-1 - UL Standard for Safety Medical Electrical equipment, Part 1: General Requirements for Safety Second Edition.

The MA-300 system and pre-amplifiers have received US FDA 510(k) clearance (Sec. 890.1375) for use as a diagnostic electromyograph for medical purposes in the USA - K974385, K000220.

CB Test Certificate

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)
COMMISSION ELECTROTECHNIQUE INTERNATIONALE (CEI)

Ref. Certif. No.
US/5657/UL

IEC SYSTEM FOR CONFORMITY TESTING AND CERTIFICATION OF ELECTRICAL EQUIPMENT (IECEE) CB SCHEME

SYSTEME CEI D'ESSAIS DE CONFORMITE ET DE CERTIFICATION DES EQUIPEMENTS ELECTRIQUES (IECEE) METHODE OC

CB TEST CERTIFICATE
CERTIFICAT D'ESSAI OC

Product *Produit*	Multi-Channel EMG System
Name and address of the applicant *Nom et adresse du demandeur*	Motion Lab Systems, Inc. 4326 Pine Park Drive Baton Rouge, LA 70809, USA
Name and address of the manufacturer *Nom et adresse du fabricant*	Motion Lab Systems, Inc. 4326 Pine Park Drive Baton Rouge, LA 70809, USA
Name and address of the factory *Nom et adresse de l'usine*	MDCO Inc., DBA Electronic Mfg. Co. 13340 Wright Circle Tampa, FL 33626, USA
Rating and principal characteristics *Valeurs nominales et caractéristiques principales*	Input: 100-240 V ac, 50-60 Hz, 40 VA
Trademark (if any) *Marque de fabrique (si elle existe)*	**Motion Lab Systems, Inc.**
Model / Type Ref. *Ref. de type*	MA-300
Additional information (if necessary) *Information complémentaire (si nécessaire)*	The CB Test Report comprises 7 Enclosures.
A sample of the product was tested and found to be in conformity with *Un échantillon de ce produit a été essayé et a été considéré conforme à la*	**PUBLICATION** **EDITION** **IEC 60601-1 (1988) Second Edition with Amendment No. 1 (1991) and No. 2 (1995).** Additionally evaluated to IEC 60601-2-40.
as shown in the Test Report Ref. No. which forms part of this Certificate *comme indiqué dans le Rapport d'essais numéro de référence qui constitue partie de ce Certificat*	00RT6519A-11092001

This CB Test Certificate is issued by the National Certification Body
Ce Certificat d'essai OC est établi par l'Organisme National de Certification

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Date:
Issued: 28 January 2002

Signature:
Jolanta M. Wroblewska

Issued 08-2000

Declaration of Conformity

Declaration of Conformity

Manufacturers Name:	Motion Lab Systems, Inc.
Manufacturers Address:	15045 Old Hammond Highway, Baton Rouge, LA 70816 USA

declares that the product:

Product Name:	Electromyography Device
Model Number:	MA-300

conforms to the following standards:

Safety: IEC 60601-1 (1988) Second Edition
With Amendment No 1 (1991) and No 2 (1995).
IEC 60601-2-40

EMC: Medical Device Directive
IEC 60601-1-2 : 1993
IEC 801-2 : 1991
IEC 801-3 : 1984
IEC 801-4 : 1998
IEC 1000-4-5 :1995
EN 6000-4-5 : 1995
EN 55011 : 1991 Group 1, Class B

The product is in conformity with the requirements of the Low-Voltage Directive (73/23/EEC) and the EMC Directive (89/336/EEC).

European Contact:
Motion Lab Systems, Ltd,
22 Bulls Lane, Kings Sutton, Banbury, Oxfordshire,
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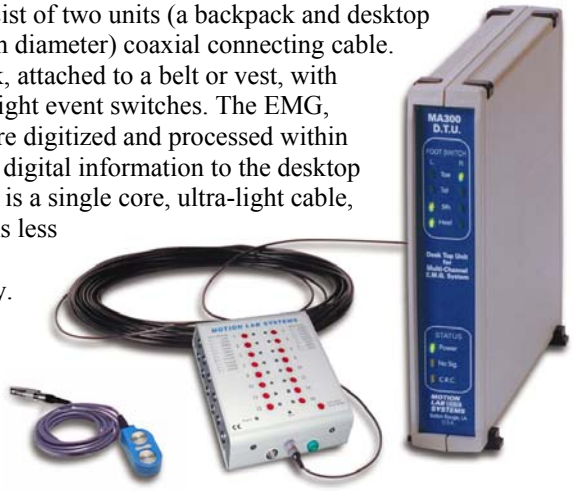
Edmund Cramp, President
Motion Lab Systems, Inc. Baton Rouge, USA
January 28, 2002

Introduction

Features

All MA-300 systems have received US FDA 510(k) clearance (Sec. 890.1375) for use as a diagnostic electromyograph for medical purposes.

Welcome to the User Guide for the Motion Lab Systems MA-300 Electromyography systems. These are a range of high quality EMG systems intended for use in the investigation of the physiological process involved in muscle contraction and can be used to record multiple channels of EMG data from human beings in a clinical environment - either as a stand-alone system, or with a motion capture or gait analysis system. These systems enable the user to observe the electromyographic signals that are produced when muscles contract, while maintaining the electrical isolation of the subject from any measuring or recording equipment that is attached to the system.



All MA-300 EMG systems consist of two units (a backpack and desktop unit) with a single thin (2.66 mm diameter) coaxial connecting cable. The subject carries the backpack, attached to a belt or vest, with EMG pre-amplifiers and up to eight event switches. The EMG, event switch and other signals are digitized and processed within the backpack and transmitted as digital information to the desktop unit over the coaxial cable. This is a single core, ultra-light cable, 18 to 35 metres long, that weighs less than 160 grams and does not encumber the subject in any way. The standard MA-300 system does not use radio or infrared telemetry and can be used in almost any environment without any of the restrictions of wireless telemetry systems.

The MA-300 is a small, lightweight and versatile system that avoids the problems of radio frequency interference inherent in traditional EMG radio telemetry systems. The ultra-light cable used does not restrict the subject in any way, unlike the cumbersome, multi-core cables required to transmit data in the traditional cabled EMG systems where a separate cable is used for each channel of information. By digitizing all signals at the subject, the MA-300 guarantees a clean signal without any degradation from the transmission of analog signals.

The backpack receives isolated low-level DC power from the desktop interface unit over the same cable that carries the EMG signal. This keeps the backpack unit lightweight, makes the system simple and reliable to use, and eliminates the need and expense of batteries. Since the system does not use radio frequencies there is no risk

of interference or interaction with other equipment. Sophisticated electronic circuits within both units enable the reliable supply of power to the subject backpack while simultaneously transmitting digital information over the same cable. In addition, electrical isolation of the subject is maintained at all times.

The **backpack** is attached to a belt or vest worn by the subject and supports a number of EMG pre-amplifiers, from six to sixteen, depending on the model. It also provides eight additional channels for event switches and an additional four low frequency channels for research use with goniometers, accelerometers, strain gauges etc. Each of the EMG channels has an adjustable gain switch that can be preset to any one of ten different values. This guarantees that your MA-300 EMG System has a precise gain setting at all times while allowing the user complete control of the output signal levels – an additional recessed test button at the bottom of the backpack allows the user to test each of the EMG channels by applying 8.8mV pk-pk sine wave at 78Hz to all of the EMG channels – this is equivalent to an 3.11mV RMS signal and can be used to automatically calculate the individual channel gain settings when using the Motion Lab Systems EMG Graphing or EMG Analysis software applications. An addition control on the back-pack allows the EMG signal bandwidth to limit the maximum EMG frequency that will be processed to avoid the possibility of recording signal aliasing errors.

A single green power light on the front of the backpack indicates that the unit is receiving DC power from the desktop unit, while individual blue lights next to each of the EMG channel gain controls alert the user to any potential signal overload on any of the individual EMG channels. The coaxial connector to the desktop interface cable is on the left side of the bottom of the unit while a green indifferent (or ground reference) connector is located on the bottom right side. This standard "TouchProof" DIN 42-802 connector can be used to connect a reference electrode to the system.

The **desktop interface unit** contains the isolated electrical interface to the subject unit. It supplies isolated, low-level, DC power to the backpack unit and converts the digitized EMG signals to analog signals suitable for connection to any data collection system. Front panel status lights show the DC power status and provide fault detection (No Signal) plus an indication of signal quality (the CRC light). Activity indicators for each of the eight event switches provide easy individual switch monitoring and testing if event switches are used with the system. Note that many software analysis packages can automatically determine gait events and if you are using one of these systems with your MA-300 then you may not need the event switches. Many data capture systems also provide facilities to directly monitor the EMG and other analog signals.

Your MA-300 system will produce high quality raw EMG signals under clinical conditions without requiring any complicated set up or training period - if you can find the muscle, then the MA-300 will provide the signal. The system has been designed to be reliable and easy to use

under all circumstances and is supplied with EMG pre-amplifiers, event switches, vests for both adults and small children and all the cables needed to connect to any motion capture system or ADC system to start recording EMG and event data.

The easy upgrade path for the six and ten channel systems ensures that the system can by purchased by any user with the confidence that additional capabilities can be added as the needs increase.

Analog signal connection and installation information can be found at the end of this manual. Please contact technical support at Motion Lab Systems if you have any questions concerning the installation or signals provided by your MA-300 system.

Specifications

The MA-300 system is available with different numbers of EMG channels:

- **MA-300-6** has six (6) EMG channels; eight (8) event switches and four research channels. This unit may be upgraded to a ten or sixteen channel system.
- **MA-300-10** has ten (10) EMG channels; eight (8) event switches and four research channels. This unit may be upgraded to a sixteen-channel system.
- **MA-300-16** has sixteen (16) EMG channels; eight (8) event switches and four research channels.

All MA-300 systems consist of a Subject Back-Pack Unit (BPU), a Desk-Top Unit (DTU) and interconnecting coaxial cable with various accessories such as the EMG pre-amplifiers and event switches. This specification covers the two main electronic packages: the Subject Back-Pack Unit and the Desk-Top Unit. Electrical parameters are defined between the six pin input connectors of the Subject Unit and the 25 pin signal connector on the rear of the Desk-Top Unit.

MA-300 systems are available with two different input connector types for the EMG and research channels – these can be either 4-pin BINDER or LEMO connectors. All MA-300 system use the same connector type for the event channels, a 5-pin LEMO connector.

Each of the EMG channels have identical signal processing facilities. Unless otherwise stated, these specifications apply across all EMG channels. There are two (2) event switch input connectors, each with four (4) binary switch inputs. The event switch specifications apply to each of the eight (8) total binary input channels that are available as a pair of encoded analog channels at the MA-300 output connector. All MA-300 systems include four (4) research channel inputs that accept low data rate signals with a bandwidth of DC to 120Hz.

Each version of the MA-300 (six, ten and sixteen channel) can accommodate an optional internal band-pass filter assembly that provides a variable high-pass filtering as well as a pre-set low-pass filter for each EMG channel. These can be set to ensure that the EMG signals produced by the MA-300 do not exceed the capabilities of the users external analog system data collection system. This optional filter is in addition to the built-in, user selectable, low-pass filter in the MA-300 backpack. Full details of the optional band-pass filter can be found at the end of this manual - the quoted specifications for the MA-300 system assume that the optional band-pass filter has not been fitted. Motion Lab Systems reserves the right to alter or amend specifications without notice.

Performance Conditions

The following electrical specifications are valid for the MA-300 electronic units after a 15-minute warm-up and at an ambient temperature of 20°C to 30°C. All MA-300 systems are tested to meet specifications before shipment.

MA-300 Characteristics

The characteristics of the MA-300 are grouped into EMG, Low Speed (Research channels), Event Switch, Power Line, Environmental, and Physical. Unless otherwise noted, it is assumed that the system is set up for the default conditions with a DC to 2000 Hz system bandwidth and preamplifiers that include a 10Hz high pass filter. It is further assumed that the EMG mid-band test frequency is a 200 Hz sine wave.

Overview of System Specifications

Number of EMG channels	6, 10 or 16 depending on model selected.
Number of event channels	8 binary (on/off) event channels.
Number of Research channels	4 channels, DC to 120Hz.
EMG signal output level	±5 Volts Full Scale.
Built in Low Pass Filter	10 pole, Bessel, -3dB at 350, 500, 750, 1000, 1250, 1500, 1750 and 2000 Hz.
Signal connection	18 metres using standard RG-174 coaxial cable (2.66mm diameter, total weight 160 gm). Cable length can be up to 35 metres.
Electrical Isolation	1500 V DC Applied part
EMG pre-amplifier input noise	Less than 2 μV RMS nominal, C.M.R.R. >100 dB at 40 Hz.
AC input rating	100-240 Volts, 50VA, 50/60 Hz

All MA-300 signal outputs are electrostatic discharge protected, in addition, all Motion Lab Systems EMG pre-amplifiers supplied with the MA-300 are ESD and RFI protected.

Subject Back-Pack Characteristics

EMG Inputs

Input Impedance	31 KΩ	At the backpack input connectors.
Input max Level	500 mV	Peak to Peak
Backpack Bandwidth	DC to 2,000 Hz	-3 dB at 2kHz.
Unit Gain Range	10 to 500	(± 5%) ten (10) switch settings.
Signal to Noise Ratio	>50 dB	(At full scale output)
Crosstalk	>50 dB	Adjacent EMG channels

Low Speed (Research) Inputs

Input Impedance	31 KΩ	At the backpack input connectors.
Input max Level	2.5 Volt	Peak to Peak
Signal to Noise Ratio	>40 dB	(At full scale output)
Crosstalk	>40 dB	Inter channel crosstalk.
DC Power available	9 Volts at 10 mA	Isolated DC power.

The MA-300 backpack generates an internal test signal that is a 78Hz sine wave of 8.8mV peak to peak applied to the backpack inputs. This is equivalent to a peak to peak signal level of 440uV at the input of a standard (x20 gain) preamplifier.

Desk-Top Unit Characteristics

EMG Outputs

Output Impedance	100 ohms, 10%	±5 Volts max at 10 mA.
Desk Top Unit Gain	2 (± 5%)	±5 Volts full scale output.
Over Voltage Protection	±5.2 Volts	Zener clamped.

EMG Subject Isolated Interface

Hi Pot Test	1500 V DC	for 10 seconds (<1 mA)

EMG Pre-amplifier Characteristics

The Surface EMG pre-amplifiers supplied with the MA-300 are single, miniature, modular, surface-mount pre-amplifiers with a built-in instrumentation amplifier using a dual differential input configuration, full static (ESD) and muscle stimulator protection and includes a Radio Frequency Interference (RFI) filter. A single shielded high flex miniature cable connects to a either a 4-pin BINDER or LEMO connector.

Input Impedance	>100,000 MΩ.
Input Configuration	Dual Differential
Input Protection	± 40V DC.
Equivalent Input Noise	less than 2μV RMS nominal.
C.M.R.R.	>100 dB min at 40 Hz.
Bandwidth (-3 dB)	10Hz to 2,000 Hz.
Standard Gain	20 (± 2%).
Body size	38 mm x 19 mm x 9 mm.
Weight	20 grams.
Connector	4-pin BINDER or LEMO connector

Event Switch Characteristics

Input Impedance	10 KΩ 3% Pulled to 5 Volt DC
Logic Threshold	2 to 3 Volts DC
Delay (ON or OFF)	< 1.5 msec
Pressure to "close"	Less than 150 gm
Analog Outputs	0 to 4.688 Volts Full Scale
Analog Impedance	100 ohms 5 mA maximum
Analog Encoding	Weighted binary 1, 2, 4, 8
Analog Accuracy	0.6% of Full Scale10 mV DC absolute.
Connector	5-pin LEMO.

AC Power Supply Characteristics

Connector	3 pin IEC 622 style
Line Volts	Auto selected - working range 100 - 240 Volts AC.
Line Frequency	50/60 Hz.
User Replaceable Fuses	Dual 500 milliamp, slo-blow 20 mm fuses.
Wattage	40 VA
Safety Compliance	The AC power supply (Condor GSM28-12) is certified to be in compliance with the applicable requirements of UL-2601-1 First Edition, CSA 22.2 No. 601.1 and IEC601-1 1988 Amend. 2. The unit is in conformity with the applicable requirements of EN60950 following the provisions of the Low Voltage Directive 73/23/EEC.

Environmental Characteristics

Operating Temperature	20°C to 40°C
Storage Temperature	-15°C to 55°C
Relative Humidity	Maximum 90%, no condensation.
Shock (two hits)	30 G max each axis

Physical Characteristics

Subject Unit dimensions	135 x 105 x 42 mm. 5.2 x 4.2 x 1.6 inch (DxWxH)
Subject Unit Weight	0.4 Kg (14 Ounces)
Interface Unit dimensions	318 x 75 x 290 mm. 12.5 x 3.0 x 11.5 inch (DxWxH)
Interface Unit Weight	4.3 Kg (9.5 lb.)

The desk top unit enclosure is made from injection molded glass-reinforced polycarbonate and is rated V-O in the UL flammability test.

System Connections

All MA-300 systems consist of two units, a desk-top interface unit and subject backpack with its associated EMG pre-amplifiers and event switches. In use, the subject backpack is attached to a belt or vest on the subject via a Velcro® pad on the rear of the belt. The interface and the backpack are connected via a thin, lightweight cable with a special locking coaxial connector at both ends that powers the subject unit and carries the EMG signals back to the interface unit.

The connection to the backpack is at the bottom of the unit so that the cable can trail behind the subject, allowing them a large amount of freedom to walk or otherwise move around the testing area. The connection between the backpack and the computer interface uses a lightweight, single core, coaxial cable that plugs into the bottom of the backpack and couples to the desktop interface via a connector at the top of the back of the desk-top interface unit.

The backpack can be connected or disconnected from the interface unit at any time - subject safety is assured by electrical isolation of the backpack from the desk-top interface (see specifications for details). Please note that it is not necessary to turn the desktop interface unit off before connecting or disconnecting the backpack.

The desktop interface unit can be powered by any common AC line voltage in the range of 100 Volts AC through to 240 Volts AC. When AC power is applied to the unit, it will automatically detect the AC power voltage and configure itself for the correct range. There are no settings to worry about - this auto-configuration will occur each time the MA-300 system is connected to the AC power. As a result it is not necessary open the interface unit to select the correct power voltage.

Electrical Safety

Each MA-300 system is tested before it leaves the factory to ensure that the backpack interface provides the specified DC electrical isolation. The system meets all U.S.A., electrical safety standards for patient connected equipment, including leakage and is tested to meet UL 2601-1 - UL Standard for Safety Medical Electrical equipment, Part 1: General Requirements for Safety Second Edition. The maximum voltage supplied to the backpack, carried by the subject, is 9 volts DC via the isolated interface. All power supplied to the EMG pre-amplifiers and event switches is current limited. The system power supply is a U.L. and C.S.A. approved power supply with CE marking and uses U.L. approved wiring and components for all internal power supply connections.

It is not necessary to switch the MA-300 off when connecting or disconnecting the subject backpack. All signal output lines are protected against electrostatic discharge and radio frequency interference. The MA-300 system is tested to meet the FCC radio frequency emission regulations, Part 15 Subpart J, Class B - suitable for Home or Office use. For complete information please refer to the section on *International Standards Compliance* at the beginning of this manual.

Maintenance

Under normal use the MA-300 system does not require any internal adjustments. The cover should only be removed by qualified personnel to ensure that the electrical isolation and radio frequency shielding is maintained. There are no user-serviceable components inside MA-300 systems. All day-to-day set-up functions can be performed without disassembling either the backpack unit or desktop interface unit.

Cleaning

This may be performed as necessary. After disconnecting the MA-300 from the AC power cord, you may clean the exterior of the MA-300 with a damp cloth using a mixture of soap and water or isopropyl alcohol swabs. Wipe the system dry before connecting the AC power cord. Do not immerse in water or any other cleaning solution.

Preventative Maintenance

The MA-300 system does not require any routine preventative maintenance to ensure its performance. System performance may be checked using a Whisper EMG Test Set and Simulator available from Motion Lab Systems.

Preventative Inspection

Routine preventative inspection maintenance may be performed once a week or as necessary depending on system usage. All EMG pre-amplifiers should be connected to the backpack and tested. A simple test can be performed by applying each EMG pre-amplifier to the surface of a muscle and observing a muscle contraction. The coaxial cable connecting the subject backpack to the desktop unit should be checked for any cuts or other damage and replaced if necessary.

System Performance

Users may choose to perform a complete system specification test on the MA-300 system at intervals appropriate for their environment. System specification tests may be easily performed using biomedical signal generators such as the Whisper EMG Test Set and Simulator (Roessingh Research and Development), the Model 220 Biomedical Function Generator (Medi Cal Instruments), or any similar equipment setup.

Setting up the MA-300 system

Getting started

Before you use the MA-300 system to collect data, you probably will want to set up the interface unit to provide the correct frequency bandwidth of EMG signals that you need for your experiment. This may be determined by the system that you are using to collect or record the EMG data and may depend on your experimental protocol. The only setting that you may need to change is the anti-alias bandwidth - this is controlled by a small rotary switch at the lower left side of the backpack unit and is normally set up when the system is installed. This will only need adjustment if you change your analog sampling rate.

The instructions in this manual apply to all MA-300 systems using LEMO or BINDER connectors - regardless of the number of EMG channels in your system. Both the 6 and 10 channel MA-300 systems can be upgraded at any time to the full 16-channel system.

If you have purchased the optional MA-300 high pass filter, you can also set the high pass filter frequency via a rotary switch on the back of the desktop interface unit.

Individual EMG channel gains may be set at any time during system operation and the system gain will immediately change to reflect the new selection. You may wish to record any gain selection changes for use in subsequent data analysis.

Default system configuration

Without the optional high pass filter the MA-300 supplies raw EMG signals, each with a bandwidth that goes up to 2,000 Hz (-3 dB). The EMG signal output levels are set for a maximum of ±5 volts. Actual output voltages will depend on the level of the EMG input levels and the setting of the individual EMG channel gains.

The two analog event switch outputs will, by default, produce a signal between 0 and +4.688 Volts. This signal will have up to sixteen different levels depending on the combination of each of the four input switches closed at any instant.

Raw EMG output

Your MA-300 system can supply six to sixteen channels of raw EMG signals depending on the model that you have purchased. The bandwidth of these signals may be modified by the action of the built-in low pass filter and optional high pass filters described later. Good quality surface EMG can be obtained with the backpack filter switch set to 7 - resulting in a default bandwidth up 350 Hz.

The raw EMG signal is the normal, unprocessed electrical signal seen directly from the muscle. Raw EMG signals can have a high bandwidth and in certain circumstances frequency components over 1,000 Hz may be recorded. Some data recording or analysis systems cannot respond to frequencies this high and will produce an “alias” artifact signal when high frequency EMG signals are input to the data recording system.

When using the MA-300 you may wish to attenuate the higher frequencies so that you do not attempt to record higher frequency signals than your recording equipment can handle. Use one of the low pass filter settings of 350 Hz, 500 Hz, 750 Hz, 1000 Hz, 1250 Hz, 1500 Hz, or 2000 Hz to reduce the signal bandwidth to a more manageable range so that the MA-300 system does not present the recording system with any signal components above the Nyquist point. Your analog recording system should be set to sample data at least twice as fast as the highest frequency that the MA-300 can produce.

Calibration and EMG output levels

The MA-300 EMG system has a wide dynamic range with individual gain controls for each EMG channel using a ten position rotary switch. Therefore, the effective system gain is always fixed to discrete value and the EMG output of the MA-300 system is always calibrated so long as the individual channel gain selections are known. As a result, the EMG output levels from the MA-300 can be directly related to the detected EMG level at the pre-amplifier inputs.

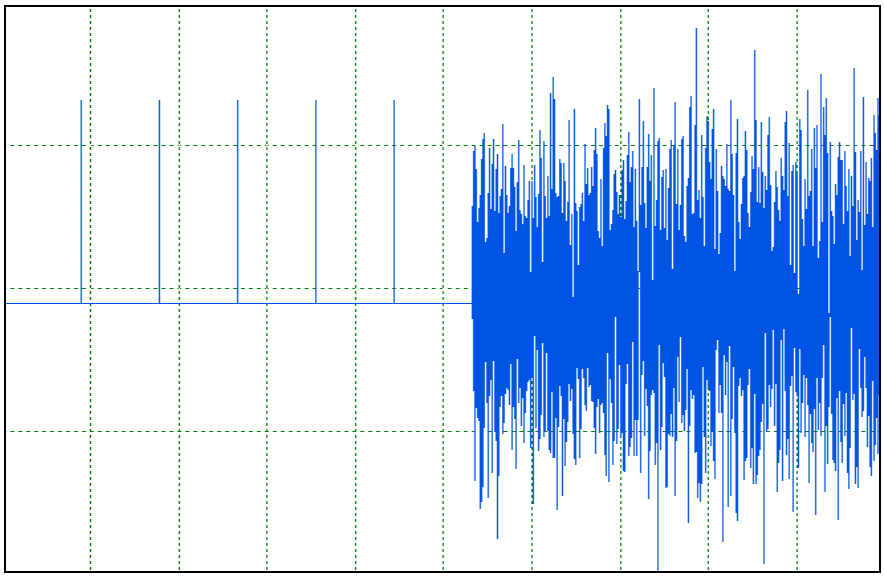


Figure 1 - Five calibration pulse precede the start of the calibrated Whisper EMG signal

The gain figures shown below are accurate within 5% of the stated value for the system bandwidth as determined by the internal low pass filter and the optional band

pass filter. Exact gain measurements may be made using the Whisper EMG Test Set or other laboratory calibration equipment.

Back Pack Gain Switch	System Gain	Maximum Input Level
0	350	±14.0 mV
1	2000	±2.50 mV
2	4000	±1.25 mV
3	5700	±875 µV
4	8000	±625 µV
5	9500	±525 µV
6	11500	±435 µV
7	13200	±375 µV
8	16600	±300 µV
9	18000	±275 µV

Switch settings 2 through 5 are appropriate for most EMG signals.

The system gain figures shown above include the EMG pre-amplifier gain - normally 20 if using an MA-311. Thus with Back Pack Gain Switch setting 2 (gain of 4,000), the EMG channels, when connected to an MLS EMG pre-amplifier, accept any signal with a bandwidth of 20 to 2,000 Hz that has an input range of ± 1.25 millivolts or 2.5mV peak to peak. This produces a full-scale output of ± 5.00 volts (10 volts peak to peak) with a minimum resolution of 0.15 µV at the EMG pre-amplifier signal inputs (2.5mV / 214).

The MA-300 system gain on each of the four research channels is x2. The research channels accept any analog signal with a bandwidth of DC to 120 Hz and a range of ±2.5 volts. This will produce a full-scale output of ±5 volts with a minimum resolution of 2.44 mV at the desktop output for each research channel (indicated on the output cable as Low A through Low D signals).

A small amount of isolated DC power is available for interface purposes at the research input connector. This power is drawn directly from the backpack power supply and care must be taken to avoid excessive current drain when constructing any external interface circuitry. Any external circuitry using this isolated DC power should provide its own regulation and AC decoupling. Care must be taken to avoid RF radiation and EMI pickup with any external circuitry connected to the MA-300. Please contact technical support at Motion Lab Systems if you are in any doubt about connecting external interface circuitry to your MA-300 system.

Working with C3D files

Many MA-300 systems are used with motion capture systems that use C3D files to store the recorded EMG information together with force data and 3D trajectory information. The analog data within C3D files can be calibrated by storing an analog scale parameter for each analog channel. This scale factor is usually calculated to scale the data to report either the data in terms of "volts applied to the ADC inputs" or, the data values actually measured by the device. The following discussion assumes that the reader is familiar with C3D files – a detailed discussion of the factors affecting C3D scale factors and a detailed explanation of the calculation of these scales can be found on the C3D web site at http://www.c3d.org.

Default C3D scale factors

It is recommended that all EMG signals in a C3D file are scaled in terms of "Volts applied to the ADC inputs" – normally this will have a range of ± 5 Volts.

The magnitude of the recorded EMG signal is affected by the ADC hardware as well as the individual EMG channel gain switch settings. Since the user can change the individual gain settings for each channel, it is normal to select C3D scale factors that simply scale the MA-300 system output in terms of volts produced by the MA-300 system and allow another application to scale the results to take into account the individual EMG channel gains. The is the recommended C3D scaling method and is required if the data is to be processed using either the ***EMG Analysis*** or ***EMG Graphing*** applications available from Motion Lab Systems.

Assuming an ANALOG:GEN_SCALE factor of 1.00 and an output signal range of ±5 from the MA-300, the ANALOG:SCALE factors for each EMG channel are:

12-bit ADC	ANALOG:SCALE = 0.002441406
16-bit ADC	ANALOG:SCALE = 0.000152588

These values will produce a C3D file with all EMG data scaled to ±5 Volts – this is the recommended method of scaling EMG data and is required if the EMG data is to be analyzed using any Motion Lab Systems software application. These applications contain functions that provide methods of scaling the reported data with respect to the individual EMG channel gains.

If you scale the EMG channels in volts using either of the above parameter values, we recommend that you modify the ANALOG:UNITS parameter to "V" to indicate correct scaling values.

Complete information on the C3D file format, with worked details of analog scale calculations, and a full manual, is available on the Internet at http://www.c3d.org.

Individual C3D scale factors

Alternative, the EMG data can be recorded and viewed with the data calibrated in microvolts (μV) at the skin surface by entering individual scale factors for each analog channel. The value of these individual channel scale factors (called ANALOG:SCALE parameters) can usually be determined from to your data collection system documentation or calculated from the following formula:

$$SCALE = \frac{BIT / GEN\_SCALE}{GAIN}$$

The GEN_SCALE value is normally chosen when the analog data collection system is installed. The value of GEN_SCALE is normally preset and affects all ANALOG:SCALE calculations - it should not be changed without careful consideration of the effects on any other analog signals recorded in the C3D file. The BIT value represents the value of 1-bit in Volts and is determined by the characteristics of the ADC collection system. It can be calculated from the following formula:

$$BIT = \frac{range / gain}{resolution}$$

where *range* is the ADC input range in Volts, *gain* is any ADC gain factor that is applied to the channel, and *resolution* is the bit resolution of the ADC (i.e. 4096 for a 12-bit ADC or 65536 for a 16-bit ADC). Note that the range value is the full ADC measurement range - this will have a value of 20 for most common ± 10-volt ADC systems.

An Excel spreadsheet that calculates all analog C3D scale factors is available from Motion Lab Systems.

A table of ANALOG:SCALE parameters is given here to scale the C3D file output in microvolts at skin surface for GEN_SCALE values of both 0.0048828 and 1.000. Both these ANALOG:GEN_SCALE values are commonly used with 12-bit ADC data collection systems that sample data with a ± 10 Volt range.

Note that setting the GEN_SCALE value to 1.00 will result in very small individual ANALOG:SCALE values that are very small if the users attempts to scale the output results in terms of microvolts at skin surface. Some software applications may have problems with interpreting very small ANALOG:SCALE values. The following values assume that the ADC range is ± 5 Volts (a ± 10 Volts ADC with a gain of x2), and the ADC resolution is 12-bits:

Gain Switch	ANALOG:SCALE value if GEN_SCALE is 1.000	ANALOG:SCALE value if GEN_SCALE is 0.0048828
0	0.0000070358	0.0014409259
1	0.0000012624	0.0002585322
2	0.0000006226	0.0001275188
3	0.0000004432	0.0000907773
4	0.0000003172	0.0000649690
5	0.0000002631	0.0000538911
6	0.0000002193	0.0000449157
7	0.0000001912	0.0000391482
8	0.0000001477	0.0000302591
9	0.0000001349	0.0000276183

If you enter the appropriate parameter value for the ANALOG:SCALE then we recommend that you also modify the ANALOG:UNITS parameter to “uV” to indicate the new scaling values. Complete information on the C3D file format is available on the Internet at http://www.c3d.org.

Selecting the EMG frequency bandwidth

An optional high pass filter is available to limit the low end of the signal bandwidth if needed.

The default maximum EMG signal bandwidth of the MA-300 system is 2,000 Hz. Sometimes this may be higher than your data collection or data recording equipment requires or it may just be higher than you require for a particular experimental protocol. The MA-300 system provides a way to adjust the signal bandwidth by filtering the higher frequency components of the EMG signals – thus reducing the bandwidth of the raw EMG signal to a range that is suitable for your recording system or protocol and eliminating signal aliasing.

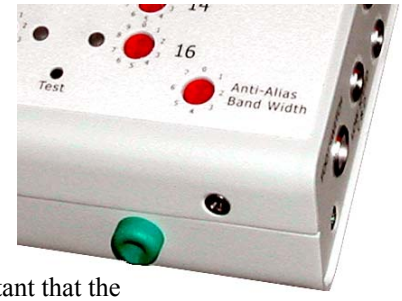
Unlike almost every other multi channel EMG system, the MA-300 includes a high quality, Bessel, variable anti-alias filter that can be preset by the user to control the bandwidth of the data signals from the system. A Bessel filter is a variety of linear filter with a maximally flat group delay (linear phase response) with an almost constant group delay across the entire EMG signal bandwidth, thus preserving the wave shape of filtered EMG signals without introducing spurious signals that may affect the EMG frequency spectrum.

This filter allows the user to limit the higher frequency content of the EMG signal to ensure that the analog recording system is not presented with ‘out-of-band’ signals that could cause unwanted artifact in the recorded EMG signals when the analog sampling rate is not high enough. According to the Nyquist sampling theorem the analog sampling rate should be at least twice the maximum frequency component of the signal of interest – in this case the EMG signals**.** In other words, the maximum

frequency of the EMG signal should be less than or equal to half of the ADC system sampling rate to avoid the introduction of aliasing artifact into the EMG signals that you wish to record.

The MA-300 Anti-Alias Filter

All EMG signals from the backpack are low pass filtered before being transmitted to the desktop unit. This restricts the highest frequencies available from your MA-300 to levels set by the low pass filter within the backpack. This anti-alias filter will pass all frequencies lower than the value selected and attenuate all analog signal components higher than the chosen value.



The anti-alias filter provides seven different settings at 350, 500, 750, 1000, 1250, 1500, and 2000 Hz and is controlled by a rotary switch on the backpack unit.

The inclusion of high quality Bessel anti-alias filters for each EMG channel in the MA-300 systems allows raw signals to be recorded at the full bandwidth of your analog recording system. As a result, it is most important that the data collection system analog sample rate is set to a suitable frequency taking into account the bandwidth of all the signals.

In order to avoid aliasing errors in the sampled EMG signal it is essential to filter raw EMG signals before recording or sampling them to remove all signal components above half the system sampling frequency. For example, if you are sampling an EMG signal at 700 samples per second then you should select the 350 Hz low pass filter. However, if your clinical protocol requires EMG signals up to 800Hz (for instance if you are involved in fine-wire recording for research purposes) then you should select filter setting 4 (1000Hz) and sample the signal at a minimum of 2000 s/s to ensure adequate signal quality and avoid the possibility of aliasing artifacts.

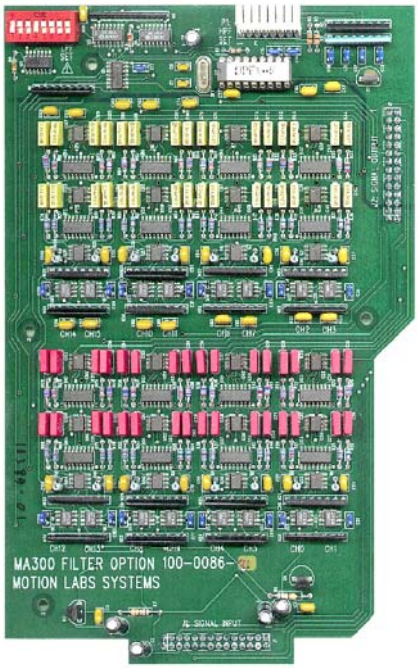
Filter Switch	EMG Bandwidth	Minimum Sample Rate
0	2000 Hz.	4000 s/s
1	1750 Hz.	3500 s/s
2	1500 Hz.	3000 s/s
3	1250 Hz.	1500 s/s
4	1000 Hz.	2000 s/s
5	750 Hz.	1500 s/s
6	500 Hz.	1000 s/s
7	350 Hz.	700 s/s

By filtering the EMG signal in this way, before the signal is sampled by your motion capture or data collection system, you will avoid the problem of "signal aliasing" that occurs when a signal changes faster than it can be recorded or analyzed. Signal aliasing can introduce false signals into the sampled EMG that interferes and distorts the original EMG signal. It is impossible to filter an EMG signal to remove aliasing artifact after the signal has been recorded.

The internal Anti-Alias filter is reset whenever the switch is changed – this may introduce a momentary spike into each analog channel so is important that the anti-

alias switch is only changed prior to recording EMG signals. Changing the anti-alias filter switch after starting to record an EMG trial is not recommended.

Band-Pass filter option



In addition to the built-in Low Pass Filter, the MA-300 offers an optional high quality Band Pass Filter that allows the user to dynamically set the High Pass filter frequency (thus removing most typical motion artifact signals) and preset a Low Pass frequency to ensure that the MA300 never produces analog signals with a higher frequency content than your data collection system can sample or record.

The optional Band Pass filter is installed in the EMG signal path, inside the MA-300 desktop unit, and is powered by the internal MA-300 power supply to eliminate the possibility of introducing ground loops or external interference into the EMG signal. Although the installation is usually done at the factory, prior to system sale, instructions are included at the end of this manual to allow users to add this useful feature to their system after the initial purchase.

If your system does not have a rotary switch at the top of the rear panel of the MA-300 desktop unit then you do not have this option.

The primary function of the Band Pass filter is to restrict the lowest frequencies that the MA-300 interface unit can output to your data collection or data measurement system. The high pass filter will, as its name suggests, pass all frequencies higher than a certain value. You may select this value to 20, 40, 60, 80, 100, or 120 Hz. — a common setting is 40 Hz for surface EMG recordings. The principal function of this filter is to reduce the amount of the low frequency artifact (or noise) component of the EMG signal. This tends to produce EMG signals with a flat baseline that may be easier to analyze in many gait protocols. The optional high pass filter is set via a rotary switch at the rear of the Desk Top Unit.

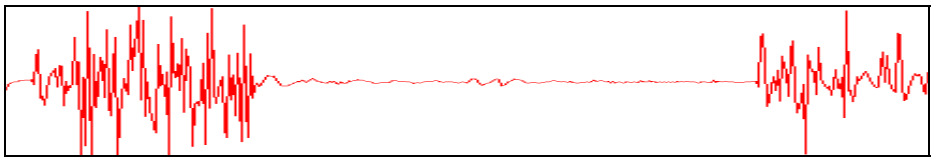


Figure 2 - Unfiltered EMG (20-800Hz) with significant low frequency artifact signals

All MA300 systems can be upgraded to include the filter by purchasing the optional filter assembly.

The optional high pass filter also contains an additional anti-aliasing filter that may be preset on installation to a range of frequencies from 300 to 2,000 Hz. This additional filter can be used to ensure that the output signal from the MA-300 system does not contain any signals that might cause aliasing errors. Setting this internal filter will override the backpack filter setting and ensure that the system cannot produce any signals higher than the internal value. This can be set when the system is installed and offers a wider range of filter points as well as a much steeper roll-off.

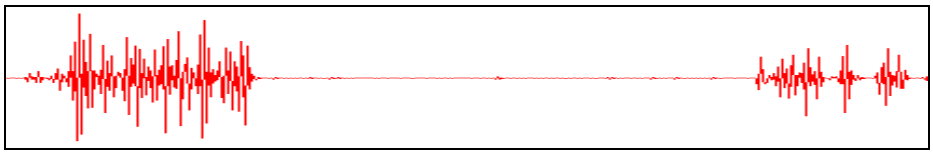


Figure 3 - Filtering the EMG signal (80-350Hz) to remove artifact produces cleaner data.

The effects of filtering the EMG signal are shown in *Figure 2* (unfiltered) and *Figure 3* (filtered). Both illustrations are the same signals from a fine wire recording of the Tibialis Anterior muscle.

The filter does not apply to the research channels that are available on the 16-channel system, nor does the filter apply to the event switch channels, which are processed separately.

The illustration shows the original sampled EMG data, recorded at 1600 samples per second. This means that the analog data can contain frequencies as high as 800 Hz. The result of filtering the original EMG signal with a digital band pass FIR filter set at 80 Hz to 350 Hz are shown in *Figure 3*. These illustrations were generated using Motion Lab Systems EMG Analysis software together with the C3Deditor analog filter. Demonstration copies of these software packages can be downloaded from the motion lab systems web site at http://www.motion-labs.com at any time.

It is important to note that applying a filter to the MA-300 signal path will filter all signals passing through the EMG channels in the MA-300.

If you intend to perform an electrical specifications test of the MA-300 system EMG channels with a device such as the Whisper EMG Test Set then we recommend that low-pass filter in the backpack and the high-pass and low-pass filters in the optional internal band-pass filter are set to their minimum effective settings (20Hz HP and 2kHz LP) and that data is sampled as fast as possible (at least 4,000 sample per second per channel) to reproduce the test signal as accurately as possible.

The four research channels

All MA-300 systems include an additional four channels that can be used for low frequency signals. These four channels have a bandwidth of DC to 120 Hz which makes them ideal for many research applications that require a DC frequency response such as EKG, Respiration, and O_2 consumption to list only a few of the possible applications. The low pass frequency response of these channels is fixed at 120 Hz. Any input signals above 120 Hz will be attenuated and will not appear at the output of the MA-300. Inputs to all four channels are through a pair of input connectors – one on each side of the backpack and must be within the range of ±2.5 Volts. A small amount of isolated DC power may be drawn from the subject backpack to power any external interface circuitry. Please contact Motion Lab Systems if you require a cable to interface to these channels.

Event switch signals

All MA-300 systems support the use of up to a total of eight (8) event switches to record gait events such as heel-strike and toe-off. The MA-300 event switch interface is designed to work with Force Sensitive Resistor event switches, our standard MA-153 event switch or any common switch device. All event switch inputs are fully "de-bounced" in the subject backpack.

The state of each of the eight (8) event switches (open or closed) is encoded in the MA-300 backpack and sent to the interface unit as digital signals in ensure signal integrity. On arrival at the MA-300 desktop interface unit the event switch output is transformed into two analog outputs that encode the state of four event switches each (left and right feet) as 16 discrete DC levels for each analog event signal output. Note that there is no requirement to use all eight (8) event switches. If your application only requires heel and toe contact information to define a gait cycle then

just use two (2) event switches and disconnect the unused event switches. The system will ignore the unused inputs, which will be treated as “open” switches.

By encoding four switches onto a single analog channel the user is only required to record or monitor a total of two analog channels to observe the state of all eight (8) event switches. Each of the two analog event switch output channels is at zero volts when all four of its event switches are open. When any one of the four (4) event switches closes, the appropriate analog event switch channel output voltage will increase by an amount determined by the closing switch. Each switch changes the output by a unique value.

This system works because each of the four (4) event switches (left or right side) adds a different DC voltage to its appropriate analog event switch output. When the Heel event switch closes a DC level of 2.500 volts will appear on the analog output for that channel (right or left). Closing the next event switch (generally the fifth metatarsal) will add 1.250 volts to this signal. Thus, the output channel will be at 3.750 volts; the other event switches (first metatarsal and toe) will add 0.625 and 0.313 volts respectively.

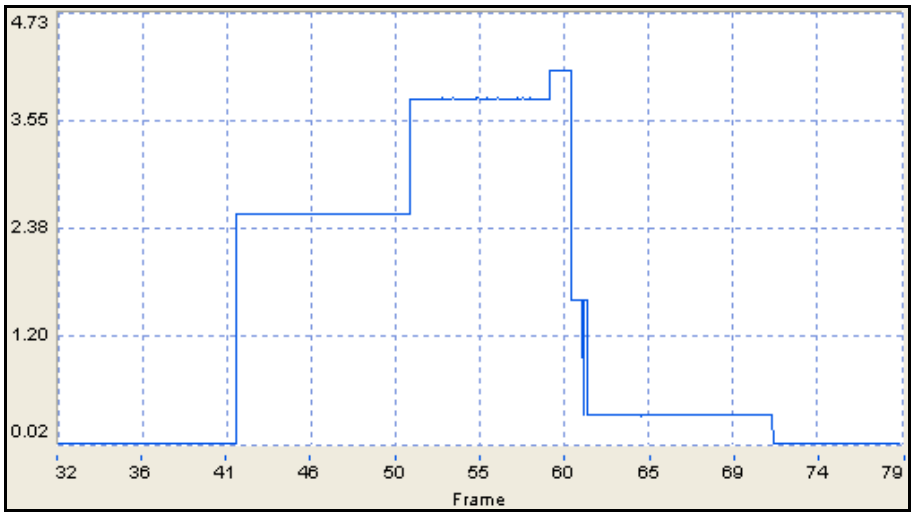


Figure 4 - A typical analog event switch signal indicating multiple switch closures.

By adding the four different voltages, each event switch channel can display the full range of 16 different event switch states. If all four switches are closed then a maximum voltage of 4.688 volts will be seen on the analog output. A table of all 16 combinations is shown in appendix A, at the end of this User Guide. Please contact Motion Lab Systems technical support if you need further explanation of this feature.

Event switch sensors

The ten (10) event switches supplied with the MA-300 (includes two spares) will turn on when a pressure of approximately 50-100 grams of pressure is applied. They can be tested by connecting them to the backpack (via the supplied cable) and pressing them between two fingers while watching the front panel indicator lights. Since the sensors are small, they require a little care in placing the sensors in the right position to record the appropriate event/floor contact. Usually a few practice sessions on a willing subject are all that is necessary to enable you to attach the sensors quickly and accurately.

Figure 5 - A standard Motion Lab Systems event switch.

The sensors each have a two-pin connector on a lead - this connector is designed to make a reliable electrical connection yet disconnect easily should any force be applied to the connection to avoid damage to the sensors. The connector should mate with a event switch cord (sold in packs of eight - Motion Lab Systems part number MA-136) that plug into the event switch cable from the subject backpack. The event switch cable plugs into the subject backpack and has a four-connector housing at one end that connects to the event switch cables. This housing should normally be taped to the subject's ankle so that the event switch cords and switches can be easily placed to provide the most reliable signals while interfering with the subjects gait as little as possible.

System Displays

Signal Displays

The MA-300 desktop unit provides eight individual green LEDs that display the status of each event switch connected to the system. These lights enable you to immediately check the functioning of any event switches that may be connected to the subject.

Besides event switch indicators at the top of the front panel, there are three system status indicators grouped together at the bottom of the front panel. These are two yellow LEDs that show possible fault conditions and a green LED that will always be illuminated when the system is turned on.

System Status

The two yellow LEDs are labeled “No Sig.” and “CRC”. The yellow “No Sig.” LED will illuminate when the desktop interface unit is not receiving a signal from the backpack. This would be quite normal if the pack-back were disconnected from the deck-top interface but would show an error condition if the LED comes on while the backpack is connected. A faulty coaxial interconnecting cable or an internal fault within a system component could cause such an error condition.

The yellow “CRC” LED will be illuminated when the internal digital error checking circuitry detects an error in the incoming signal. Small errors of one or two bits will be corrected by the circuitry within the interface unit and may cause the LED to flash briefly.

Event switch indicators

There are eight green event switch activity indicators at the top of the interface front panel. Each activity indicator lights when its associated event switch closes and, during normal gait (heel, 5th, 1st metatarsal and toe sequence), you will see the indicators light in a moving

bar from heel to toe. These lights also enable the user to test each event switch individually and quickly find and replace faulty event switches at any time.

Backpack indicators

There are only two indicators on the backpack. These are green PWR light that should always be on when the system is operating and an orange OVLD light that shows a possible input signal overload condition. The overload light will light whenever any of the EMG inputs is at its maximum operating level.

Fault Detection and Troubleshooting

The MA-300 systems are very reliable but if you experience any problems then the following hints may prove useful. Always return any faulty units to Motion Lab Systems or a qualified biomedical engineer for internal repairs.

Note that it is normal for all the indicator lights to flash ON briefly when AC power is first connected to the system or when the subject backpack is connected to the system or cable.

The Display Unit No Sig light is on.

There is no signal coming from the backpack. Check that the backpack is connected and the backpack DC OK light is on. If it is not ON then you probably have a broken coaxial cable — replace the cable with a spare and schedule the broken cable for repair as soon as possible.

None of the front panel lights are on.

Check the line cord and fuse — at a minimum the green POWER light should be on to show that AC power is applied to the unit and the DC Power Supply is operational. Note that there are no user adjustments inside the desktop interface unit. The internal power supply is auto-sensing and will select the correct AC voltage range - no user adjustment is required.

The CRC light is on.

Check that the backpack is connected to the system. If the backpack is connected and appears to be functioning then you may have an internal fault in the system. This light shows that one or more of signal channels is generating an error. Return the unit to your distributor or biomedical engineering department for service.

The OVLD light on the backpack is ON although the subject is inactive.

Turn down the channel gain - if the light does not extinguish then you may have a defective EMG pre-amplifier. Check the sampled EMG signals to decide which one is the overload channel. This will suggest the faulty pre-amplifier. Check that the pre-amplifier has been applied correctly — if you cannot see what the problem is then replace it with a spare and test it later.

The software package used to analyze the EMG signals from the MA-300 does not find the correct gait cycles.

Check that the analog event switch signals are assigned correctly so that the left side EMG signals are being analyzed with the event switches on the correct event. Read your EMG analysis software manuals to determine how the software determines gait cycles. Contact Motion Lab Systems technical support if you cannot resolve the problem.

The EMG signals recorded are very small although the

Check that your ADC sampling system gain is set correctly to match the input level expected by your ADC recording system. Typically when you have this problem you

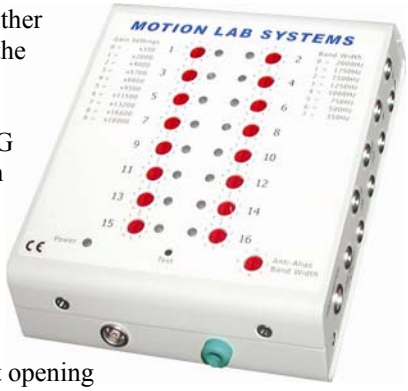
OVLD indicator on the backpack shows that a large signal is being recorded.	will find that the ADC sampling system has been set to respond to a ±10 Volts (i.e. 20 Volt range) signal. If in doubt, use an oscilloscope to confirm the MA-300 output levels. The correct analog signal range for the MA-300 signals is ±5 Volts for all EMG and event switch channels.
The system is functioning well but no EMG is recorded on any external device.	Check the connecting cable with an oscilloscope to ensure that the cable is correctly connected and that EMG signals are present at the input of the ADC sampling system.
Some EMG channels work but others do not have any EMG signals.	Check the analog signal connections from the back of the MA-300 desktop unit through to your measuring/recording system. 99% of all 'lost signal' complaints are due to problems with the analog signal cables and connectors.
The MA-300 system appears to be functioning but the EMG is recorded with very large amounts of noise and AC interference.	Check the connecting cable with a multi-meter to ensure that there are no broken connections. Check that the signal return (output pin #17) is connected correctly and that you are not using the Chassis Ground (output pin #25) as a signal ground. If you are seeing noisy signals try using a disposable electrode to provide a ground reference. Apply the electrode to the subjects skin surface and connect the electrode cable to the safety DIN connector adjacent to the coaxial cable connector on the subject backpack.
The systems appear to be functioning but the signals recorded are very large or very small compared to another EMG system such as the MA-100.	Check the settings of the gain switches for the channels that appear to have problems. Increase the gain for any low level signals by turning the gain switches clockwise, decrease the gain by turning counter clockwise.
Changing the backpack filter settings does not appear to affect the recorded EMG signal.	The filter-setting switch is read whenever power is applied to the backpack. If you change the switch with power applied to the backpack then you must disconnect and reconnect the backpack before the new filter settings will take effect.
The EMG signal recorded from the MA-300 is very noisy.	Use an oscilloscope to measure the signal present at the MA-300 analog output connector with the unit turned on and connected to the backpack but without any EMG pre-amplifiers connected to the backpack. The AC noise component of the output signal should be less than 10mV (a small DC offset may be present if the optional band-pass filter is not fitted). Signals greater than 10mV may indicate a grounding problem or a fault within the MA-300 EMG system. You may wish to contact Motion Lab Systems. Check that you are recording/sampling the EMG at a high enough sample rate.

Using the MA-300

Connections

Each MA-300 system consists of a backpack, carried by the subject using one of the belts or jackets supplied, and a desktop interface unit. These two units are connected by means of the lightweight coaxial cable supplied with the system. The backpack comes with several EMG pre-amplifiers (six, ten or sixteen - depending on the model in use), two (2) event switch connection cables, eight (8) event switches - plus two (2) spares - and a coaxial connecting cable together with adult and child jackets to support the backpack during use.

The subject backpack



The backpack has two rows of connectors on either side of the casing that provide connections for the EMG pre-amplifiers, research channels and the event switch cables. The event connectors are always 5-pin LEMO connectors, while the EMG and research connectors will vary depending on the options selected when the system was purchased – these can be either 4-pin LEMO or BINDER connectors.

There are no subject connections or user adjustments inside the backpack cover – all connections and controls are accessible without opening the backpack.

Each side of the backpack will have a number of EMG connectors – three, five or eight, depending on the system. In addition to the EMG channels, each side of the backpack has a connector for two research channels and four event switches. You should not connect any EMG pre-amplifiers to either of these inputs. The backpack has been designed to be easy to use and therefore quick to connect to the subject for gait and other kinematic studies while providing a strong mechanical protection for all the internal connections.

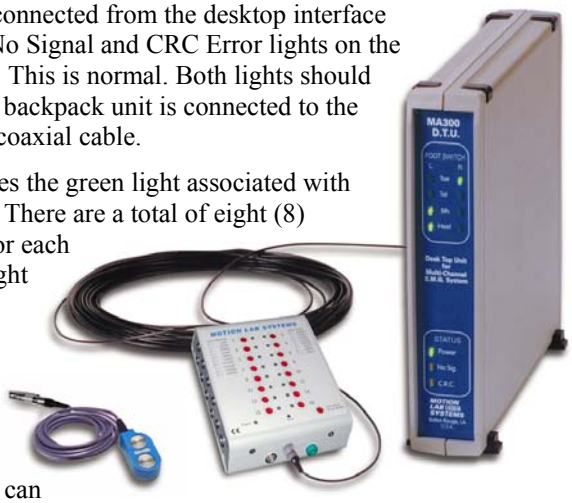
The subject backpack has a number of miniature LED indicators. The green POWER light should be on whenever the pack-pack is connected to the interface unit and shows that DC power is supplied to the system and the internal power supplies are functioning correctly. In addition to the power light, each EMG channel has a blue

LED indicator that will flash if the associated EMG signal is within five percent of an overload condition. Flashing occasionally during an experiment is normal for these lights as brief peaks of muscle activity occur during contractions.

In the center of the subject backpack are two rows of gain controls switches. These allow the user to vary the gain of the individual EMG channels to optimize the signal levels. Each control is a ten-position switch that changes the channel gain, allowing a wide range of signal input levels. Each control can be easily adjusted with a small flat-blade screwdriver.

The interface unit

When the coaxial cable is disconnected from the desktop interface unit, you will notice that the No Signal and CRC Error lights on the desktop interface unit are ON. This is normal. Both lights should be extinguished whenever the backpack unit is connected to the desktop interface unit via the coaxial cable.



Whenever a event switch closes the green light associated with that event switch will turn on. There are a total of eight (8) event switch indicators, one for each switch circuit, so that up to eight event switches may be individually monitored. They may be used to observe the operation and function of the event switches throughout the experiment. Note that although the system can monitor up to four switches on each event, few software packages require all four switches for gait analysis. If all you require is gait timing information then you may find that you only need the heel switch to provide basic gait cycle information.

The EMG pre-amplifiers

It's generally best to attach the backpack behind the subject using a jacket or belt. Additional belts and jackets may be ordered from Motion Lab Systems if required. It is generally recommended that the EMG pre-amplifiers are left connected to the subject backpack at all times as this speeds up the application of the pre-amplifiers to the subject. However this does require that you are organized and tidy up the EMG pre-amplifier cables up carefully after each session. Working carefully and preventing the cables from becoming tangled will prolong the life of all the cables and pre-amplifiers used with the system. Bead Markers are available from Motion Lab Systems and can be used to identify individual pre-amplifier leads. Each Bead Marker clips over the pre-amplifier cable and identifies the cable by color.

Once the backpack has been fixed to the subject you can attach the EMG pre-amplifiers to the subject. Note that there is no need to have the backpack connected to the coaxial cable from the interface at this stage. It can be connected at any point before the collection of data - you do not need to switch off the interface unit when

you connect or disconnect the backpack or attach the EMG pre-amplifiers to the subject.

Surface EMG

If the skin surface appears dirty or greasy then you will need to "prep" the surface with an alcohol soaked cleaning swab. When you have found (or land marked) the correct position for the pre-amplifier on the muscle you should tape the pre-amplifier in place using Micropore® or some similar hypoallergenic tape. The tape should be wrapped tightly, and if possible, completely around the limb that the pre-amplifier is fixed too. If the pre-amplifier and been applied properly then you should see two circles impressed into the skin when the pre-amplifier is removed at the end of the session. These marks will generally fade within 10 to 20 minutes. Subjects with particularly sensitive skin or freshly shaved areas may find that the marks last up to 24 hours.

It cannot be stressed too much that this is the most critical stage in the preparation of the subject if you are to obtain high quality EMG recordings. Surface pre-amplifiers will provide good signals from most of the muscles involved in gait if sufficient care is taken in preparing the subjects skin and applying the pre-amplifiers.

It is most important to make sure that the preamplifiers cannot move of the surface of the skin as the subject walks or moves. Almost all motion artifact problems with this type of EMG preamplifier can be traced to noise generated by the movement of the preamplifier on the surface of the skin during the recording.

Fine Wire EMG

EMG preamplifiers manufactured by Motion Lab Systems Inc., are fully protected from accidental static discharge and cannot be damaged by muscle stimulators.

If you are using fine-wire electrodes (sometimes called "needle electrodes") then the wire should be inserted into the muscle by a qualified therapist and the insertion needle removed. If you want to stimulate the muscle to check the electrode insertion then this may be done *either before or after* the wires are connected to the EMG pre-amplifier. The Motion Lab Systems pre-amplifiers contain protection circuitry that ensures that they cannot be damaged by muscle stimulation signals so you can easily stimulate a muscle once the wire electrode has been inserted and connected to the MLS preamplifier.

Commercial fine-wire electrodes are always supplied in sterile packaging and should be 'ready to use' however, if you are making your own fine-wire electrodes you may find that your need to remove the insulation from the ends of the wire that will contact the EMG pre-amplifier. This can be done either with a strip of abrasive paper or with a flame as the insulation will usually vaporize easily.

Packs of 10 'Ready-to-Use' sterile fine-wire electrodes are available from Motion Lab Systems with 30mm and 50mm cannulas.

After checking that there is no insulation on the end of the electrode wires, the two wires from the muscle should be connected to the two inputs on the pre-amplifier. The pre-amplifier housing can then be taped in place at a convenient location close to the insertion site. At this point it is recommended that the therapist check that the needle is placed correctly by either a manual muscle test or stimulating the muscle to evoke a physical response.

Note that Motion Lab Systems MA-316 (fine-wire) preamplifiers are supplied with both a set of special springs contacts as well as a set of thumbscrews so that you have a choice of attachment methods for discrete electrodes such as fine-wire or disposable gel electrodes.

Disposable gel electrodes are available from Motion Lab Systems in packs of three.

If desired, you may also use a disposable subject ground electrode connected to the backpack unit ground reference socket by the coaxial cable connection. This helps to maintain the pre-amplifier common mode rejection ratio or C.M.R.R. (i.e., it helps keep the noise and hum levels low). The backpack connection will accept most standard disposable monitoring electrodes with a IEC-60601 'touchproof' connector.

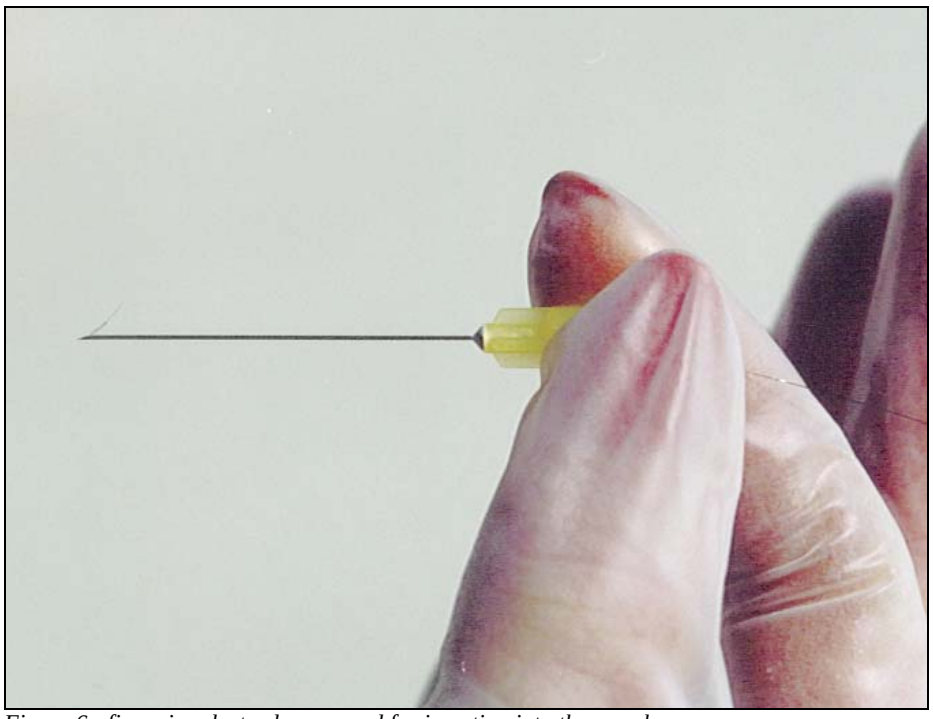


Figure 6 - fine-wire electrode prepared for insertion into the muscle.

The EMG pre-amplifiers supplied with the MA-300 should last a year or more in regular use. With care, especially in the removal of the pre-amplifier from the subject after the experiment, they can last longer. If the pre-amplifiers are abused by pulling them from the subject by their leads then their life will be considerably shortened. Replacement EMG pre-amplifiers are available through your local distributor, or directly from Motion Lab Systems Inc., (part number MA311). Please note that Motion Lab Systems provides only a thirty-day warranty on the pre-amplifiers and event switches and that this warranty does not cover normal wear and tear or abuse.

The event switches

The MA-300 is designed to record event contact with the floor. The sensors for this are small disks that are less than a millimeter thick. The MA-300 comes with a total of ten (10) 30 mm sensors. These sensors act as a switch when they are connected to the MA-300 and a pressure is applied. You can test them with a continuity tester in

the same way that you would a regular switch.

Figure 7 - A standard event switch.

Each switch has a thin connecting tail 100mm long that ends in a small, two-pin connector. The switches should be taped under the foot, using a hypoallergenic tape, such as Micropore®, so that the tail of the switch with its connector comes around the side of the foot and away from the contact area of the foot. The event sensor may then be connected to the backpack event switch cable via one of the eight individual event switch cords supplied with the system.

Note that both the event switches and their associated event switch cords (individual 2 pin connecting cables) are intended to be "disposable" items. Replacement event switches, connecting cables etc., are available through your local distributor, or directly from Motion Lab Systems Inc.

The coaxial cable

The 18 metre coaxial cable (Motion Lab Systems Part Number MA-133) that connects the backpack and the interface has been selected to encumber the subject as little as possible but it is not designed to last forever. Under normal operation it will eventually fail and should be replaced every year or so, depending on usage. Additional cables may be purchased from Motion Lab Systems if needed or the original cable may be returned for repair.

The coaxial cables supplied with the system use industry standard RG-174U coaxial cable. A standard cable is 18 metres long although this length is not critical and cables may be assembled with nonstandard lengths between 2 and 35 metres. Each cable uses identical coaxial LEMO connectors at each end.

Making an EMG recording

Getting started

Your MA-300 EMG system can be used to collect EMG signals in a variety of situations and as a result it is not practical or very useful to try to provide instructions at this point for the system under all conceivable circumstances. Therefore this chapter will describe the use of the system in a single setting — that of a Gait or Motion Analysis Laboratory. We assume that by this stage the MA-300 has been connected to a computer or other recording device and that the system has been tested to check that everything is working.

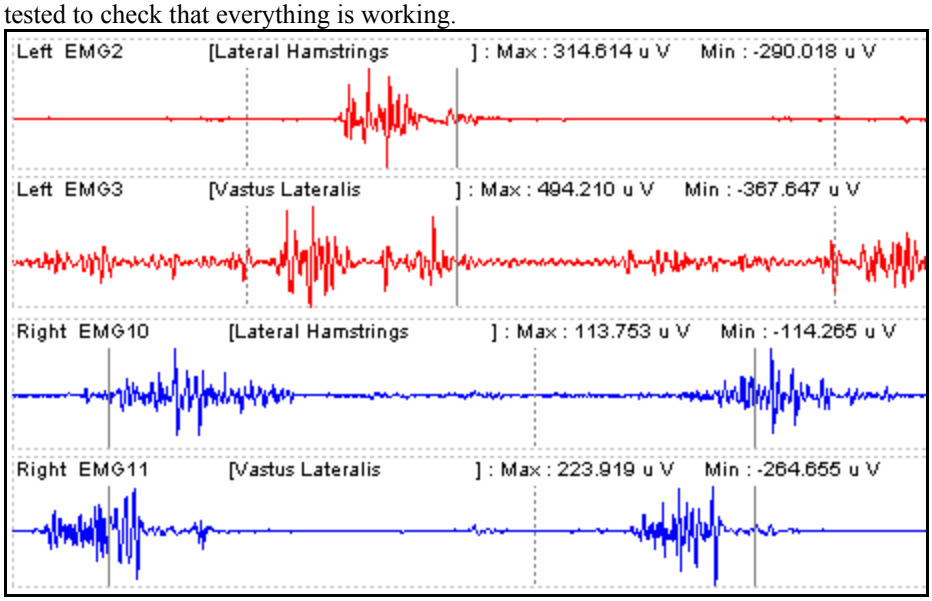


Figure 8 - Typical MA-300 raw EMG recordings from human gait

The usual procedure in Gait Testing is to have the subject walk, several times, in a straight line over a distance of four to seven meters (roughly 10-20 feet) while their movement is recorded for later viewing or processing. Information from force plates may also be collected simultaneously if the subject has a long enough stride length to be able to step on a force plate cleanly with a single foot.

Start the subject from the end of the walkway or data collection area and ask them to walk as they would normally - let the subject reach their normal walking speed before you start to record any data. Since they will be trailing the MA-300 coaxial cable behind them taping two colored arrows at either end of the walkway is often useful — these serve to show the subject which direction you would like them to turn

so that they do not catch the trailing cable as they return down the walkway. You can use green tape at the start line and red at the stop line - the subject will rarely notice the trailing cable at all and these arrows will help eliminate any unnecessary tangles.

If you are planning to record kinetic data from a force plate while you record EMG then you may find it convenient to place several different colored "start" lines at about six inch intervals to enable you to adjust the subjects starting position to obtain a good force plate strike with one foot. In this case you may have to walk the subject several times at the start of the test to decide the correct starting line so that they have a good chance of hitting the force plate cleanly with a single stride.

Subject Preparation

The preparation for EMG testing should always begin before the arrival of the subject. You will need to decide where to place pre-amplifiers and whether the study will be bilateral or unilateral. Using a single MA-300 you can study between six and sixteen individual muscles (depending on the model that your lab has purchased) and although the MA-300 subject backpack is marked on the assumption that you will record an equal number of muscles of each side this is not fixed in any way.

If you are also taking kinematic data with a Gait Analysis system then you will also need to prepare the marker sets (usually small retro-reflective balls) required. Always test your system (MA-300 and kinematic collection if used) before the subject arrives — any problems are much easier to diagnose and fix before the testing starts.

The muscles that will be monitored during your study are dependent on the diagnosis of the subject and the extent of lower limb involvement. It is best if a decision about which muscles are going to be evaluated is made before the arrival of the subject — often this is done by, or in consultation, with the physician. You may find it useful to set up a muscle protocol to be monitored for each different diagnosis but use this as a guide only as each subject will be different. Some typical examples of diagnosis related protocols for a ten-channel MA-300 might be:

- **Spastic Diplegia** - Five muscles on each limb - Tibialis Anterior, Gastrocnemius, Rectus Femoris, Medial Hamstring and Adductors.
- **Myelomeningocele** - Either a bilateral study - five muscles on each limb (Rectus Femoris, Medial and Lateral Hamstring, Gluteus Medius, Gluteus Maximus) or for a unilateral study use all ten muscles eg. Tibialis Anterior, Gastrocnemius, Posterior Tibialis, Peroneal, Rectus Femoris, Medial and Lateral Hamstrings, Adductor, Gluteus Maximus and Gluteus Medius.
- **Hemiplegia and Head Trauma** - Tibialis Anterior, Gastrocnemius, Peroneal, Posterior Tibialis, Vastus Lateralis, Rectus Femoris, Medial Hamstrings, Adductors, Gluteus Maximus, Gluteus Medius

Each MA-300 EMG channel should normally be assigned to the subject's side and muscle on which the pre-amplifier will be placed. This information must be recorded as the pre-amplifiers are applied to the subject, as this information will be required for subsequent analysis of the recorded data. It is useful to keep a copy of this

information, with any relevant observations in the subject's chart to prevent any memory lapses later. See the sample data record sheet at the end of this manual for an example of a typical EMG information recording form. The use of Bead Markers on individual EMG pre-amplifiers greatly assists in the assignment of EMG pre-amplifiers to a specific muscle.

The preparation and application of the EMG pre-amplifiers will be different depending on the subject. Adult subjects usually only require an explanation of function of the pre-amplifier in recording their muscle activity while with young children allowing them to touch both the pre-amplifiers and event switches before placement on their body may be beneficial. This will allow them to learn that neither item will hurt them and may help gain their cooperation and assistance in the testing.

The Motion Lab Systems EMG pre-amplifiers contain circuitry to protect them from damage by static discharge however it is a good idea to avoid handling them unnecessarily. Most EMG pre-amplifier failures are due to mechanical damage that is not covered by the system warranty (e.g. cutting the pre-amplifier cables with scissors!).

Event Switch Application

If you are using the MA-300 with a motion capture system that can detect gait events automatically then you may not need to use event switches in most cases.

In normal feet the system is designed to use four event switches applied to the plantar aspect of the foot on the great toe, first and fifth metatarsal heads and the heel. Each event switch is a round mylar disk containing a pressure sensitive sensor connected to a small two pin socket on a short mylar extension. The event switches are available in two sizes, a large switch that works well for the heel and a smaller size that is usually used for the great toe and the metatarsal heads.

It is often easiest to put the event switches on first, before applying the EMG pre-amplifiers. This can be done with the subject reclined and the ankle supported by a small towel so that you have easy access to the entire foot. If you are using the event switches together with a motion capture system that uses markers then it is best to apply the event switches before the subject markers are placed if you intend to record both motion and EMG simultaneously. This allows for the event switches to be placed and the connecting wires attached so that they avoid the joint markers.

Plug each event switch cable into the appropriate event switch channel on the cable from the EMG subject backpack and test each event-switch as it is connected. Many EMG software analysis systems will require that each event switch be connected to the correct channel so it is important to make sure that the event switch applied to the great toe is connected to the right input (generally #1 on the event switch connector cable).

Note that while the descriptions below list the anticipated locations of all four event switches you will rarely need to use all eight event switches on every patient. Most clinical analysis packages require only the heel event switch (#4 below) to determine gait cycle timing — if the great toe switch is available then "toe-off" information can be calculated in addition to the basic gait cycle timing.

- #4 — Heel Switch - The heel event switch can be either medium or large depending on the size of the subject's foot. It should be placed in the center of the fat pad under the calcaneous. Special attention should be made to placement and method of attachment to the foot. The connector of the event switch should be brought around the medial aspect of the foot using two

pieces of two-inch wide tape. This allows for secure attachment of the event switch to the foot. Tape should cover the heel and continue up the side of the heel medially and laterally.

- #1 — Great Toe Switch - Place the switch in the center of the fat pad under the distal phalange. The connector and cable should be placed along the medial aspect of the toe and pointing in the direction of the first metatarsal before the switch is attached. Use one to one and a half inch hypoallergenic tape and place along the length of the event switch leaving extra tape at the large end. This places the circular portion of the event switch under the weight-bearing portion of the great toe. This is dependant upon the weight-bearing pattern of the subject. Subjects with extreme valgus may require the event switch to be placed more medially.

If your software analysis package does not require the first and fifth metatarsal event switches then there is no need to apply these event switches to the subjects feet — this can save valuable time during the initial subject preparation.

- #2 — First Metatarsal Switch - If used, this is usually a small event switch and is placed over the base of the first metatarsal head as palpated on the plantar aspect of the foot. The connector and cable should be directed towards the dorsum of the foot and pointed slightly posteriorly before the switch is attached. It is usually easiest to take 2 inch hypoallergenic tape and tape from the middle of the bottom of the foot around the side to the top of the foot.
- #3 — Fifth Metatarsal Switch - If used, the small sensor portion of the event switch should be placed just on top of the fifth metatarsal as palpated on the plantar aspect of the foot. The connector and cable should be directed towards the dorsum of the foot and pointed slightly posteriorly. Tape for the first and fifth metatarsals should be placed along the entire platar aspect of the foot and wrapped around to the dorsum of the foot both medially and laterally. This will have avoid damaging the event switches if the subject drags their foot during a walk.

The same procedure should be followed for each foot - note that the event switches can have either side placed next to the skin, they respond to pressure equally from either surface. All connectors and cables should be attached both to the dorsum of the foot and again to the distal and anterior aspect of the shank, remembering to leave some slack in the wire over the ankle joint to allow for movement.

Once the switches have been connected to the subject backpack, and thus to the interface unit, it is beneficial to check event switch placement by pressing the event switch on the bottom of the foot and watching the individual lights on the interface unit that represent the state of each event switch. The light for each event switch should be off when there is no pressure applied to the switch. The light should turn on when the event switch is pressed lightly and must also turn on when the subject stands on the appropriate limb. Testing of the event switches as they are applied, at the beginning of the test, will facilitate faster subject testing later.

You may find that carefully pulling a sock over the foot after fitting the event switches will protect the switches and cables without affecting the subject gait. This may prolong the life of the event switches by protecting them from rubbing and dragging directly on the floor.

Event switches can also be applied to the bottom of the subjects shoes - if the shoes (or orthoses) are being used in the testing you may get better results this way since event switches inside the shoe can be compressed between the sole and shoe and may always show as "on" although the foot is off the floor.

It is necessary to make certain that the point of application best represents the anatomical position it is documenting and that the shoes actually apply pressure on the ground at that point. The patterned shoe soles of many running shoes may make it difficult to place the event switch so that it fires consistently - if this is a problem you may want to dispense with the first and fifth metatarsal event switch and use only heel and toe switches to define the gait.

Points to Remember

- All the edges of the event switches should be covered with tape to prevent damage to the mylar sensor during the test. It may be convenient to allow the subject to wear a sock over the foot during the test to protect the event switches from damage.
- Leave some slack in the event switch cables where they cross the ankle joint to prevent the switch becoming disconnected during motion.
- Modify the marker placement instructions if the subject has foot deformities so that the event switches are placed on the weight bearing surfaces of the foot to define initial contact and terminal contact.

Cleaning the skin and the pre-amplifier

There is no need to abrade the skin surface to obtain good quality EMG recordings.

Each pre-amplifier should be cleaned with alcohol and allowed to dry before placement over the muscle belly. It is important that this is the last thing that you do before EMG pre-amplifier placement to eliminate any skin oils from either you or the subject. For young children getting them to help you clean the EMG pre-amplifier with a small alcohol prep may be helpful — participation in this prevents them becoming intimidated by the EMG pre-amplifiers and the application procedure.

The muscle belly should also be cleaned with alcohol before EMG pre-amplifier placement to the extent that the skin surface should be slightly red from rubbing the skin. This rids the skin of oils that increase impedance, producing artifact and poor recordings. Although shaving hair from the legs for EMG pre-amplifier placement is not necessary, it may be beneficial to help decrease the discomfort when the tape is being removed. It is strongly recommended that the skin surface is NOT abraded.

The use of electrode gel is not recommended and may contribute to poor EMG recordings

A simple cleaning is all that is required to obtain clean EMG signals - any abrasion of the skin surface can cause “weeping” that may short out the EMG pre-amplifier inputs. While this will not cause any damage to the MLS pre-amplifier it will usually produce poor, low quality EMG recordings.

Pre-amplifier placement

Once the muscles to be studied are identified, placement of the EMG pre-amplifiers may begin. Plug in each pre-amplifier as you go along to avoid any mixup of the pre-amplifier cables later. It is usually easiest to begin at the bottom of the leg and work your way up. Muscles such as the tibialis anterior and gastrocnemius are easy to put on when the subject is sitting. Anterior muscles such as the quadriceps group and the adductors follow — rolling the subject over onto their stomach may then be easiest if they are small and/or have difficulty standing to place the pre-amplifiers on the hamstrings, and glutei muscles.

Placement of pre-amplifiers can be determined by using The Anatomical Guide for the Electromyographer. Although this guide is for fine wire placement, it provides tests to determine action and descriptions of optimal placement and is very useful when first starting to use a clinical gait system.

It is necessary to get the subject to try to perform the action of the muscle to which is responsible. This will help in assuring accurate pre-amplifier placement, ensuring that the EMG pre-amplifiers are being placed over the muscle belly. The pre-amplifiers are generally secured by using 1-2" hypoallergenic tape over the pre-amplifier. A couple of short (4" strips of tape) should be used first to help maintain the pre-amplifier in place until it can be further secured by wrapping longer strips of tape around the limb to ensure that all of the stainless steel pre-amplifier contacts maintain a constant connection with the skin surface. This is usually best done after all the pre-amplifiers have been applied but under some circumstances (uncooperative subjects etc.) you may find it easier to tape up the pre-amplifiers as you go along.

After the EMG pre-amplifiers are all placed and taped initially it is necessary to secure them further as described above with either tape around the entire leg or an elastic belt around the leg. Even if a belt is used, you will still find that taping around both the bottom and top contact of the pre-amplifier helps ensure contact of the pre-amplifier once the subject starts walking and helps maintains the pre-amplifier position when the belt is applied.

Subject Testing

Once all of the EMG pre-amplifiers are secured, you will need to have the subject perform some trial walks. Have the subject walk around the room at their natural pace and record a test session that will allow you to evaluate and check your pre-amplifier positioning and the signal levels from each muscle. Check that each muscle is recording a good clear signal and adjust the gain levels for any EMG channel that appears to have either too large or too small a signal. Review this data before starting the full gait analysis or test session - correcting errors in pre-amplifier placement is much easier before the session starts than having to perform the entire session again later to correct a minor error.

Make sure you are certain that you are happy with the signals you see as the subject walks. Have the subject walk one trial and then view the data using either the optional software supplied with your MA-300 system or your Gait Analysis data collection system. This step is extremely important to ensure that good data is being collected before too many trials are done and the subject becomes tired.

Once you are certain that the data that you are recording is good, then continue with as many trials as deemed necessary. Usually you will want to try to record at least three or four gait cycles in each trial. For the EMG analysis it is not usually necessary that all these gait cycles occur within the area recorded by any video or kinematic analysis system that you may be using. If the subject is using orthosis you may need to take several runs of data both with, and without the orthosis. Don't forget to record which trials use orthosis and which trials do not — record any other conditions as they occur or video tape the entire session.

In general, three trials per condition are recommended but allow for the subject’s strength. After three trials are performed, pre-amplifiers can be moved to monitor more muscles bilaterally if you only have a six to ten channel MA-300 system.

When data collection has been completed, you should check that you are able to analyze at least one of the EMG datasets recorded before you start to remove the pre-amplifiers from the subject - pay particular attention to the event switch data since this is required to define the gait cycle and EMG activity cycles.

Connections

Signal Connections

Each MA-300 EMG system is supplied with an analog output cable. This is normally a 1.5m shielded multi-core cable with a female DB-25 connector on one end and free wires on the other end – the wire ends are terminated in gold pins suitable for connection to many common types of analog patch-panel. Longer cables are available on request, as are cables with BNC termination. Please contact Motion Lab Systems at the time of installation for a replacement analog interface cable if the cable supplied with your system is not suitable.

Important Warning

In order to maintain the electrical protections built into the MA-300, it is important that all accessory equipment connected to the analog and digital interfaces of the MA-300 is meets the required safety standards. Thus any accessory equipment must be certified according to the respective IEC standards (i.e. IEC 950 for data processing equipment and IEC 601-1 for medical equipment). Furthermore, all configurations shall comply with the system standard IEC 601-1-1.

This means that everybody who connects additional equipment to the signal input connectors (MA-300 backpack) or signal output connectors (DB-25 analog output connector or DB-9 digital output connector) is configuring a medical system, and is therefore responsible that the system complies with the requirements of IEC 601-1-1. If in doubt, you should consult your technical services department or your local representative.

The electrically isolated interface provided by the MA-300 desktop system isolates the DTU interface from the subject backpack and provides essential safety isolation between the MA-300 signal connections and the subject.

Male DB-25 connector

These are arranged to enable the user to connect quickly to the MA-300 system. Pin connections for the DB-25 analog signals (SIGNAL OUT connector) are listed by pin number. If you are using flat ribbon cable to connect to the MA-300 (not recommended) then please note that the connector pin number is NOT the same as the flat cable wire order. Pin #1 is at the top left hand side of the connector as viewed from the rear of the MA-300. All analog outputs are ±5 volts and include ESD protection.

The connections shown will vary depending on the number of channels that your system supports - unused channels will generally be at or close to ground potentials but must not be used as additional grounds as this may generate noise in the signal outputs.

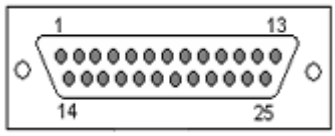


Figure 9 - Male DB-25 Analog Output connector

1 EMG channel 1 (All MA-300 systems)
2 EMG channel 2 (All MA-300 systems)
3 EMG channel 3 (All MA-300 systems)
4 EMG channel 4 (All MA-300 systems)
5 EMG channel 5 (All MA-300 systems)
6 EMG channel 6 (All MA-300 systems)
7 EMG channel 7 (MA-300-10 and MA-300-16 only)
8 EMG channel 8 (MA-300-10 and MA-300-16 only)
9 EMG channel 9 (MA-300-10 and MA-300-16 only)
10 EMG channel 10 (MA-300-10 and MA-300-16 only)
11 EMG channel 11 (MA-300-16 only)
12 EMG channel 12 (MA-300-16 only)
13 EMG channel 13 (MA-300-16 only)
14 EMG channel 14 (MA-300-16 only)
15 EMG channel 15 (MA-300-16 only)
16 EMG channel 16 (MA-300-16 only)
17 Analog Signal Return
18 Analog event switch - Left (0 to +4.688 volts)
19 Analog event switch - Right (0 to +4.688 volts)
20 Data parity (TTL High if Data is valid - normally not used)
21 Low speed channel A (DC-120 Hz channel)
22 Low speed channel B (DC-120 Hz channel)
23 Low speed channel C (DC-120 Hz channel)
24 Low speed channel D (DC-120 Hz channel)
25 Case (Chassis Ground - connect as appropriate)

These signals are generally self-explanatory, note that the data parity signal (pin 20) is not generally required and should not be connected to your data collection system. The case/chassis ground (AC line ground) is usually not connected unless you have ground loop problems – under these circumstances some careful investigation of the available ground sources may be required.

Female DB-9 connector

The MA-300 does not require any connection to the DISPLAY connector in order to function. This connector is provided for future options and system expansion.

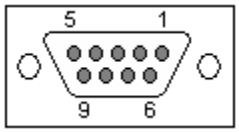


Figure 10 - Female DB-9 display connector

The 9-pin display connector on the rear of the MA-300 contains the following signals. This information is provided for technical service and support use only.

1 Chassis Ground
2 Buffered BD1
3 Buffered WE1
4 Buffered FC1
5 Signal Ground
6 Reserved
7 Analog Ground
8 Fused +12 Volt DC
9 Buffered SIG

MA-300 EMG Input Connector (Backpack)

Each MA-300 EMG input channel connects uses a four-pin LEMO or BINDER connector that supplied DC power to the EMG pre-amplifier electrode and receives the amplified EMG signal.

Figure 11 - LEMO connector

The power supplied to each EMG input connector is protected from any possible short-circuit overload via a 100 ohm resistor in each power rail which provides current limiting.

LEMO pin connections

1 EMG signal
2 - 5 Volt
3 +5 Volt
4 Analog Ground

Figure 12 - BINDER connector

BINDER pin connections

1 Analog Ground
2 +5 Volt
3 - 5 Volt
4 EMG signal

ESD protection is provided within the external, active EMG pre-amplifiers supplied with the MA-300 system. If you use non-MLS supplied devices with the MA-300 backpack then be aware that other manufacturers devices may not provide the desired level of EMI, EMC and ESD protection.

MA-300 Event Switch Connector (Backpack)

The event switch inputs use a larger 5-pin LEMO connector than the EMG inputs (see Figure 11). Each event switch input is pulled to +5V via a 10k ohm resistor; pressure on the event switch to the switch common pin pulls the input to ground to indicate switch closure.

Figure 13 - Event switch LEMO connector

EVENT connections

1 Switch #1 (Toe)
2 Switch #2 (1st)
3 Switch #3 (5th)
4 Switch #4 (Heel)
5 Switch Common

Each event switch input is filtered and deglitched to avoid problems with switch bounce and external interference. Connections to the event switch inputs can be made using the MA-335 event switch cable.

MA-300 Research Connector (Backpack)

The 'research' connector is next to the event connector on the MA-300 side panels. There are two connectors, one on each side of the backpack – each connector provides two additional, restricted bandwidth, analog channels together with access to isolated DC power.

LEMO connector research pin-out

1 Low Speed input A/C
2 Ground, 0 Volts.
3 +5 Volts DC at 10 mA.
4 Low Speed input B/D

Please contact technical support at Motion Lab Systems if you are in any doubt about connecting external interface circuitry to your MA-300 system.

BINDER connector research pin-out

1 Low Speed input B/D
2 +5 Volts DC at 10 mA.
3 Ground, 0 Volts.
4 Low Speed input A/C

Inputs to all four channels must be in the range of ±2.5 Volts maximum. A small amount of isolated DC power may be drawn from the subject backpack to power any external interface circuitry. This power is drawn directly from the backpack power

supply and care must be taken to avoid excessive current drain when constructing any external interface circuitry.

Default MA-300 configuration

Without an optional filter card installed, each MA-300 system will be set up to the following configuration when it is received:

EMG signal bandwidth	2,000 Hz (-3dB)
EMG input level	2.5 mV pk-pk at pre-amp inputs.
EMG signal level	±5 Volts (maximum)
Analog event switches	0 to 4.688 Volts in 16 discrete steps.

EMG signal filters

Unlike many EMG systems from other manufacturers, all MA-300 systems contain built-in Low Pass Filters in each EMG channel to enable you to filter the analog EMG signal before recording. The correct usage of these filters will enhance the quality of your recorded data by eliminating artifact caused when components of the incoming EMG signal exceed the ADC sampling limits. Even small amounts of high frequency noise, present in the ADC input signal, can cause significant amounts of artifact to appear in the sampled EMG recordings.

In addition, an optional band pass filter is also available that can provide high pass filtering to remove most forms of motion artifact if desired.

Low Pass Filter (all systems)

The MA-300 contains a variable ten-pole low pass Bessel filter controlled by a rotary switch on the subject backpack unit. This low pass filter applies to all of the EMG channels. The default bandwidth of the EMG channels of your MA-300 system is 20 Hz to 2,000 Hz making it suitable for most situations in EMG research and clinical use.

MA-300 Low Pass Filter settings.	Analog Sampling Frequency	
	50 Hz Video Frame Rate	60 Hz Video Frame Rate
350 Hz.	800 (x16)	960 (x16)
500 Hz.	1000 (x20)	1200 (x20)
750 Hz.	1600 (x32)	1500 (x25)
1000 Hz.	2000 (x40)	2400 (x40)
1250 Hz.	2500 (x50)	3000 (x50)
1500 Hz.	3000 (x60)	3000 (x50)
1750 Hz.	3500 (x70)	3600 (x60)
2000 Hz.	4000 (x80)	4200 (x70)

However, many data recording systems cannot record signals as high as 2,000 Hz and it is possible that your data collection system cannot record a signal with this bandwidth accurately. While it is unlikely that you will see significant EMG information at this high frequency using the surface EMG pre-amplifiers provided, it

is possible that you will encounter EMG signals that are higher than your data collection system can record if you are using fine-wire electrodes.

Your data collection system will sample the incoming EMG signals at a fixed rate. You need to know what this rate is to select the optimum MA-300 Low Pass Filter settings. You should select a Low Pass Filter setting that is no more than half the data collection system sample rate.

For example, if you are collecting data via an ADC synchronized to a 60-Hz video system and the ADC is sampling the EMG signal 25 times per video frame then you will have an actual analog data sample rate of 1500 samples per second. You should select a Low Pass Filter setting of 750Hz in this case:

$$\frac{60\ frames \times 25\ samples}{2} = 750\ Hz$$

Being conservative when selecting a Low Pass Filter setting is usually best since spurious "signal aliasing" can occur if the incoming EMG signal changes faster than the data collection system can record it. Selecting the optimum Low Pass Filter setting may involve adjusting your analog data collection rate since the two items are interrelated.

High Pass filter option

The MA-300 can be fitted with an optional high pass filter (part number MA300-F), which is controlled by a rotary switch on the back of the desktop unit.

Selecting a setting for the High Pass Filter is easier than selecting a Low Pass Filter setting since the principal function of the High Pass Filter is to remove unwanted low frequency artifact from the EMG signal before recording. Unless a High Pass Filter is installed, the default setting will be 20 Hz and thus all signals, whether they are EMG or not, above 20 Hz will be recorded. The recommended settings for gait analysis are between 40 Hz and 60 Hz.

In addition to the high pass filter, the optional MA-300-F filter card incorporates an additional low pass anti-aliasing filter that can be preset via an internal DIP switch to any of thirty different roll-off points from 100 Hz to 2,000 Hz listed in Appendix B.

This filter should be set depending on the maximum sampling or measuring rate of your analog recording or measuring system. Note that this optional filter allows the installer to limit the high-end bandwidth of the MA-300 system regardless of the setting of the subject backpack filter.

Appendix A

Analog event switch levels

Replacement event switch sensors are available from Motion Lab Systems, Inc., or from your local distributor.

The MA-300 is designed to use the event switch sensors supplied with the system. While you are free to use other types of switch sensors you should be aware that other switches or sensors may not give the same performance as those supplied by Motion Lab Systems, Inc. While every effort has been made to ensure that the MA-300 event switch sensors are reliable, they have a limited lifetime in normal experimental use.

Each set of four event switches (nominally 'left' and 'right') are encoded onto a single analog channel to allow all eight switch closures to be recorded using only two analog channels. By weighting each switch closure with a unique DC voltage, the results of switch closures can be arithmetically summed. The result is that each of the two analog event switch channels can have, at any given instant in time one of 16 unique DC values that indicates the state of all four switches. All sixteen possible values are listed in Table 1 where "Switch #1" refers to the connection marked with a red dot on the event switch connecting cable. The maximum DC output level of each channel is set to be a maximum of 4.688 volts when all four event switches are closed.

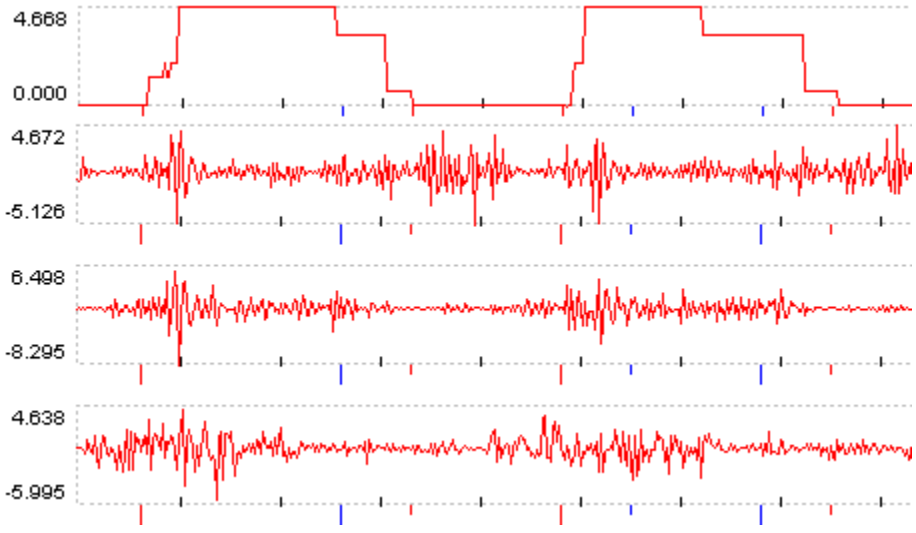


Figure 14 – MA-300 event switch and EMG signals in normal gait

When combined with EMG recordings the resulting event switch signals are quite easy to interpret enabling the analyst to easily determine the gait cycle phases of stance and swing.

While the discussion here is specific to clinical gait analysis, the event switch inputs are not limited to recording event switches and can be used for any switch recording needs, especially those that might require complete subject electrical isolation as the event switch signals have the same electrical isolation specifications as the EMG channels.

Default Analog Event Switch Output Voltages for the MA-300				
Switch #1 (Toe)	Switch #2 (1st)	Switch #3 (5th)	Switch #4 (Heel)	Output Volts
0.000	0.000	0.000	0.000	0.000
0.3125	0.000	0.000	0.000	0.313
0.000	0.625	0.000	0.000	0.625
0.3125	0.625	0.000	0.000	0.938
0.000	0.000	1.250	0.000	1.250
0.3125	0.000	1.250	0.000	1.563
0.000	0.625	1.250	0.000	1.875
0.3125	0.625	1.250	0.000	2.188
0.000	0.000	0.000	2.500	2.500
0.3125	0.000	0.000	2.500	2.813
0.000	0.625	0.000	2.500	3.125
0.3125	0.625	0.000	2.500	3.438
0.000	0.000	1.250	2.500	3.750
0.3125	0.000	1.250	2.500	4.063
0.000	0.625	1.250	2.500	4.375
0.3125	0.625	1.250	2.500	4.688

Table 1 - Analog event switch levels

Appendix B

Upgrading the MA-300

The MA-300 is a digital EMG system and has been designed to be completely self-contained system with an absolute minimum of user adjustments and settings. The only adjustment that is normally necessary is to set the low pass filter to match the sampling rate of your data collection system. Individual EMG channel gains may be adjusted for optimum recording levels.

The six and ten channel MA-300 systems can be upgraded to add additional channels by exchanging the system backpack or returning the backpack to Motion Lab Systems for modification and installation of additional EMG channels. Please contact Motion Lab Systems or your distributor if you are interested in upgrading your system to add additional EMG channels. All MA-300 systems may be fitted with an optional band-pass filter.

Only technically qualified personnel should attempt to repair or customize an MA-300 EMG system.

If you are in any doubt as to your ability to repair or modify the MA-300 EMG system, or one of its options, then you should return the unit to Motion Lab Systems, Inc, or their agents and request them to perform the required operations for you as the MA-300 is a patient connected device.

Service Contracts are available from Motion Lab Systems to provide full support of your MA-300 system. Please call us for current pricing and further information.

Upgrading to add additional EMG channels

Both the MA-300-6 (six channel system) and the MA-300-10 (ten channel system) can be upgraded to provide additional EMG channels. The MA-300-6 can be upgraded to either an MA-300-10 (10 EMG channels) or and MA-300-16 (16 EMG channels) while the MA-300-10 can be upgraded to an MA-300-16 (16 EMG channels).

The upgrade procedure is very simple. When you purchase the upgrade from Motion Lab Systems you will receive a replacement subject backpack and additional EMG pre-amplifier electrodes. Remove the EMG pre-amplifiers from the original subject backpack and plug them into the upgrade backpack. Plug the additional EMG pre-amplifiers that were supplied with the upgrade into the extra EMG channels. The new, upgrade, subject backpack may now be plugged into the coaxial interconnecting cable. The new upgraded MA-300-10 or MA-300-16 is now completely functional.

If the original installation anticipated that the system would be upgraded then you may find that your system already has the additional EMG channels already connected to your data acquisition system. If not you may need to connect and assign additional analog channels to record or sample the new EMG channels that have been added by the upgrade. Please contact Motion Lab Systems if you need a new analog connection cable or advice on connection the additional channels to your system. Once you are certain that the new system is completely functional you should return the original subject backpack to Motion Lab systems or your agent to complete the upgrade procedure.

Installing the MA-300-F Bandpass filter

You will need:

- MA-300-F filter installation kit.
- A small amount of Locktite® or similar thread locking material.
- Philips screwdriver, Open wrench and Hex allen wrench

Instructions

1. The filter card mounts inside the MA-300 Desk Top Unit (DTU). Turn the DTU AC line power off and disconnect the AC line cord from the rear of the DTU. Disconnect all other cables. These are the 25-way DB-25 analog signal cable, LEMO coaxial cable and 9-way DB-9 connector (if used).
2. Move the DTU to a clean work area and find a small container to store screws and other items that you remove from the unit as you open it - you will need these when you re-assemble the DTU.
3. While facing the front of the DTU, gently lay the unit over to the left side. All access to the inside of the DTU is from the right side of the unit.
4. Remove the two black plastic feet (on your right side) from the unit by pulling them straight up to expose the recessed securing screws. Note that the front and rear feet are slightly different - place the feet to one side - you will need them to reassemble the unit.
5. Remove the two similar black plastic screw covers (on your left side) from the top side of the cover by pulling them straight up to expose the recessed securing screws. Place the two covers (front and rear) to one side - you will need then to reassemble the unit.
6. Release all four securing screws using the Philips screwdriver and place them to one side - you will need then to reassemble the unit.
7. Remove the plastic cover by lifting straight up to reveal the metal box that contains the DTU electronics.
8. The internal metal cover is secured by fourteen (14) screws - remove all fourteen screws, placing them carefully to one side - you will need then to reassemble the unit. Each screw will have a small locking washer - try and keep the washers with the screws as it will save you time later when you replace the cover.

This completes the preparations for installation.

9. Lift off the metal cover to reveal the internal electronics board and AC line power supply in a separate shielded compartment. As you lift the cover from the DTU - note that there is a small lip on the metal cover that mates with the rear panel of the DTU.

10. Remove the large ribbon cable that runs from the base of the DTU and turns at ninety degrees to a connector just above the AC power supply. The MA-300-F option card will replace this signal cable.
11. Remove the cover from the HP filter switch opening at the rear of the DTU - this opening is directly above the LEMO interface connector.
12. Mount the rotary HP filter switch in the hole and route the switch wiring so that it runs underneath the top lip of the metal DTU case, towards the front of the DTU.
13. Secure the switch using the mounting hardware provided with the switch. Rotate the switch such that the switch knob aligns with the printed filter settings on the rear of the DTU.
14. Locate the two Phillips head mounting screws that are mid-line on the DTU main electronics board. One is just below the ribbon cable that connects the display card to the DTU main electronics card; the second screw is just above and to the left of the AC power supply compartment. These screws must be removed to allow the MA-300-F option card to be secured to the DTU main electronics card. Check their location using the mounting holes on the MA-300-F option card and remove both screws and locking washers. These two screws and washers will not be needed again and can be discarded.
15. Carefully insert the MA-300-F option filter card into the two sets of connectors on the DTU main electronics card. Note that the MA-300-F option connectors must align by pin numbers. Pin-1 on the filter card must mate with Pin-1 on the DTU main electronics card. Due to the differing number of pins on the two connectors this will result in the filter card appearing to have one set of connecting sockets that do not mate with any pins on the DTU main electronics card. This is correct.
16. When the filter card is inserted correctly, place the two spacers (supplied) in between the MA-300-F option card and the DTU main electronics board so that they align with the two mounting holes in the two printed circuit cards. Use a small amount of Locktite® on each of the two screws (supplied) and attach the MA-300-F option card to the DTU main electronics card using the spacers provided.

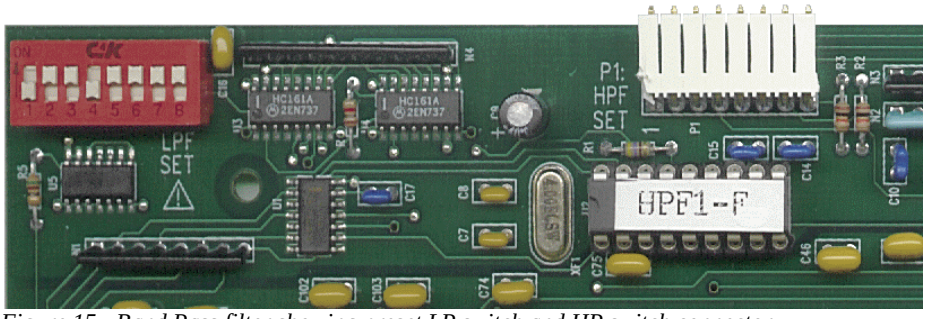


Figure 15 - Band Pass filter showing preset LP switch and HP switch connector.

17. Connect the filter switch cable to the MA-300-F option card. The 8-way connector is at the top of the MA-300-F option card and the wires from the switch will dress into the connector from below if the connector is aligned correctly.

This completes the functional installation of the MA-300-F option card.

18. Check that the DIP switch settings for the LP filter are set to the correct values. You may wish to change the default LP filter setting depending on your EMG data collection environment.

19. Replace the metal cover that you removed in step 9, taking care to make sure that the lip is fitted against the rear cover and that the screw holes all line up.
20. Secure the metal cover to the main DTU box using the fourteen screws and locking washers that were removed in step 8.
21. Replace the plastic cover and secure using the four Philips head screws that were removed in step 6.
22. Replace the two black plastic feet, taking care to make sure that the front and rear feet are pushed into the correct holes, as the two feet are not interchangeable. Replace both of the top screw covers making sure that the front and back covers fit into the right holes.

The upgraded MA-300 is now ready to use.

23. Reconnect the DTU to the AC power and test the system by applying EMG signals to each EMG channel in turn and confirming that the EMG signal appears on the recording or measuring device.

Filter Switch Settings

The optional MA-300-F band-pass filter implements a sophisticated pair of separate low-pass and high-pass filters on each EMG channel. The low-pass filter settings are preset when the system is installed and cannot be easily changed by the user. This feature enables the MA-300 to be configured (if desired) so that it always limits the high frequency component of the EMG signal to a value that can be handled by any external recording or measurement system. Each filter is implemented using a combination of analog and digital filters - all EMG channels are filtered at the same frequency.

The high-pass filter is user adjustable via a rotary switch at the rear of the MA-300 desktop unit and supports the following filter points:

MA-300-F High Pass Filter
25 Hz.
40 Hz.
60 Hz.
80 Hz.
100 Hz.
120 Hz.

The low-pass filter that is built into the MA-300-F should be set to a value that depends on the maximum sampling or measuring rate that you will be using with your analog recording or measuring system. The MA-300-F low-pass filter allows you to limit the high-end bandwidth of the MA-300 system regardless of the setting of the subject backpack filter switch. This is especially useful in situations where the MA-300 is used with a fixed clinical protocol that requires specific analog data sampling rates or where the installation engineer wishes to make sure that the EMG system cannot generate 'out-of-band' signals regardless of the users LP filter selection in the backpack.

The default filter frequency for the MA-300-F low-pass filter is -3 dB at 2,000 Hz as shown below. Many common gait labs will select a lower frequency such as 600Hz if they are sampling data at 1,200 samples per second (i.e. 20 samples per 60Hz video frame). Switches shown as "1 " are ON. The MA-300-F filter setting will then override any higher value selected using the backpack switch.

MA-300-F Low Pass Filter Settings			
Filter Selection	Minimum Sample Rate		DIP switch
2,000 Hz.	Default	4,000 s/sec.	0-1-1-0-1-1-1-1
1,800 Hz.		3,600 s/sec.	1-0-1-0-1-1-1-1
1,500 Hz.		3,000 s/sec.	1-1-0-0-1-1-1-1
1,400 Hz.		2,800 s/sec.	0-1-0-0-1-1-1-1
1,300 Hz.		2,600 s/sec.	1-0-0-0-1-1-1-1
1,250 Hz.		2,500 s/sec	0-0-0-0-1-1-1-1
1,200 Hz.		2,400 s/sec.	1-1-1-1-0-1-1-1
1,100 Hz.		2,200 s/sec.	0-1-1-1-0-1-1-1
1,050 Hz.		2,100 s/sec.	1-0-1-1-0-1-1-1
1,000 Hz.		2,000 s/sec.	0-0-1-1-0-1-1-1
950 Hz.		1,900 s/sec.	1-1-0-1-0-1-1-1
900 Hz.		1,800 s/sec	0-1-0-1-0-1-1-1
850 Hz.		1,700 s/sec	0-0-0-1-0-1-1-1
800 Hz.		1,600 s/sec.	1-1-1-0-0-1-1-1
750 Hz.		1,500 s/sec.	1-0-1-0-0-1-1-1
700 Hz.		1,400 s/sec.	1-1-0-0-0-1-1-1
650 Hz.		1,300 s/sec.	1-0-0-0-0-1-1-1
600 Hz.		1,200 s/sec.	1-1-1-1-1-0-1-1
550 Hz.		1,100 s/sec.	0-0-1-1-1-0-1-1
500 Hz.		1,000 s/sec.	0-0-0-1-1-0-1-1
450 Hz.		900 s/sec.	0-0-1-0-1-0-1-1
400 Hz.		800 s/sec.	0-1-1-1-0-0-1-1
350 Hz.		700 s/sec.	1-1-1-0-0-0-1-1
300 Hz.		600 s/sec.	0-1-1-1-1-1-0-1
250 Hz.		500 s/sec	0-0-0-0-1-1-0-1
200 Hz.		400 s/sec	1-0-1-1-1-0-0-1
175 Hz.		350 s/sec	1-0-1-1-0-0-0-1
150 Hz.		300 s/sec	1-1-0-1-1-1-1-0
125 Hz.		250 s/sec	0-0-0-0-1-0-1-0
100 Hz.		200 s/sec	0-0-0-1-1-1-0-0

Appendix C

Installation

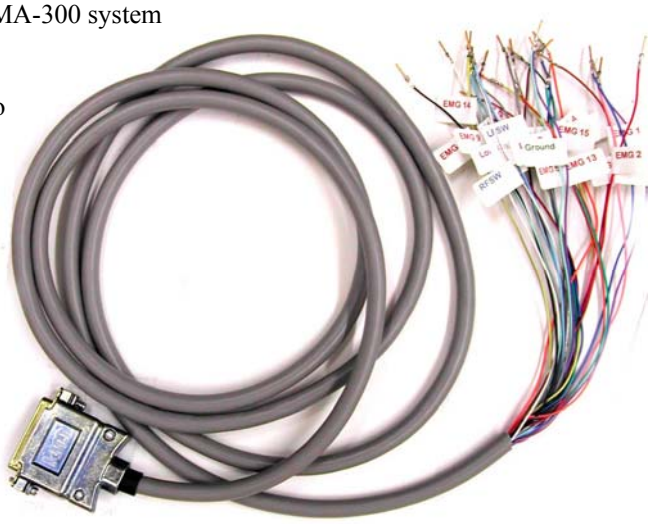
The MA-300 AC power supply will automatically select the correct AC line voltage – no adjustment is required.

The MA-300 uses a modern switching power supply that meets all international safety standards for medical equipment. It is also a "smart" power supply and will automatically set itself to the correct line voltage within any of the common ranges (100 to 240 Volts AC 50/60Hz) when the system is turned on. There is no need to open or adjust the MA-300 to select an AC line voltage.

Each MA-300 system is fully tested before shipment to the customer and end-user and, while we cannot guarantee that nothing will go wrong, we have found that virtually all initial problems with a new system are caused by faulty connections or miss-wiring the interface to the users analog data collection system. You can improve the chances of an easy installation by reading this appendix and carefully testing the system configuration before serious use of the MA-300 with subjects.

The MA-300 consists of two units (back-pack and desk-top unit) that are connected together by a lightweight RG-174/U coaxial cable. The standard system is designed to be completely self-contained and is very easy to setup and configure for use in any Gait, Biomechanics, or Motion Analysis Laboratory. It provides, electrically isolated, real time analog signals from EMG pre-amplifiers placed on a subjects skin surface, as well as other signals from optional event switches and other data channels.

In most circumstances MA-300 system installation consists of connecting the supplied analog interface cable to a Data Capture or Data Recording system. This cable has a female 25-pin connector on one end and 26 free-floating leads on the other end - details of the connector pin-out are provided in this manual. Each of the free-floating leads is labeled with an appropriate label indicating its function. This



would be a good point to stop and find the analog interface cable and examine it - you should find it packaged with a sheet of paper that provides some details of the pin to cable connections. An analog connection cable with individual BNC connectors is available on request.

The MA-300 also features a female 9-pin connector on the rear panel marked "Option" (or "Display on some models). This connector provides signals for future expansion of the MA-300 system. This connector supplies access to digital signals - it does not contain any analog signals and should not be connected directly to any analog data collection system.

The system installer should read the documentation that is provided with the data collection system that is to be used with the MA-300 before starting the installation. Since the MA-300 can be used with almost any data collection system it is difficult to provide precise and specific instructions on every installation situation. However the following issues are common to almost every situation:

MA-300 Outputs

All MA-300 outputs are static protected and voltage limited internally to no more than ± 5 volts. Each output is single-ended, using a common signal return point, and is driven by a current limited, low impedance source.

Signal Channels

The MA-300 system can support different numbers of signal channels that may contain specific data. It is not always possible to translate MA-300 channel numbering to use identical data collection channel numbers. Make sure that the system user knows what MA-300 channels are connected and which channels the data collection system uses to record or display EMG, Event Switch and Research Data.

Note that the standard analog signal cable is supplied with connections for all sixteen analog channels even when the system has only six or ten channels. If at all possible it is recommended that all sixteen channels are connected when the system is first installed as this will make any subsequent upgrades much easier if the user decides to add additional EMG channels.

Ground

Also known as "Signal Return" - it is vital that the MA-300 Ground is connected to the Analog ground (or signal return) of the users data collection system. Failure to connect the MA-300 Signal Return will result in crosstalk and noisy signals. Most initial data quality problems are caused by poor (or non-existent) ground connections.

Data Parity

This is a TTL level signal that indicates any problems with the digital data transmission. In most circumstances it can be ignored or connected to an unused analog channel. If connected to an analog channel it will have a level of between 4.75 to 4.95V when EMG and other signals are being transmitted without any errors. Do not connect this signal to any analog ground.

MA-300 Case

This is connected to the MA-300 case. It is an electrical ground for the metal case and should be connected to the chassis or safety ground of the data collection system. In many cases this can be connected to the analog signal ground. If problems are

occur with AC interference or excessive noise in the EMG signal then this connection can be moved to the Signal Return Ground (above), the AC line ground, the chassis ground of your data recording system or disconnected.

Shield

This is a connection to the shield of the signal cable supplied with your MA-300 system. It should be connected to the data collection system analog signal ground. Its function is to provide electrical shielding for the analog data signals in the MA-300 cable. This lead does not make any electrical connection to the MA-300. It is not a substitute for the Ground connection.

Configuration

If you are not familiar with the data measurement, or data collection system, that you are using then this is a good place to stop and read the manuals that were supplied with the data collection or recording system that you are planning to use.

Once the MA-300 analog cable has been connected to the your data collection system it is a good idea to start up the data collection system and setup the data collection parameters before applying power to the MA-300. In general there are two parameters that you will need to check - these are input signal level and sample rate.

Signal Level

All analog signals generated by the MA-300 are in the range of ± 5 volts so you need to set the analog data collection system to record data or accept input signals at this level. If you select a lower level (i.e. ± 2.5 volts) then the MA-300 signals may be clipped or distorted and will not be measured correctly. If you select too high a level (i.e. ± 10 volts) then the measured signals will be too small and you will loose some resolution or precision.

Sample Rate

The simple rule of thumb for setting the analog data collection sample rate is to always sample the data at twice the rate of the highest frequency present in the signal. Since the maximum bandwidth of the MA-300 system is 20 to 2,000 Hz this would require a very high sample rate (a minimum of 4,000 analog samples per second per channel) unless the signal is filtered to remove the higher frequency components. This is normally done by setting the low pass filter (inside the backpack) to a suitable value. Most of the signal power from surface EMG is lower than 350 Hz so setting the backpack filter to 350 Hz reduces the analog data recording requirements considerably. The system user will usually know what signal bandwidth is required.

It is a good idea to allow for some degree of over-sampling when you set the analog sample rate so if you were setting the backpack LP filter to 350Hz then a sample rate of between 700 and 1000 samples per second per channel would be appropriate.

Testing

Once the MA-300 system is connected you will need to make some test recordings or measurements to confirm that the system is (a) operational, and (b) working correctly with the your analog measurement system. So connect the system to the AC line using the power cable supplied and turn on the power:

a) If the MA-300 is operational then you should see a green Power Status light turn on. If the backpack is not connected to the desktop unit (or is not functioning correctly) then you will also see the amber No Signal (No.Sig) and CRC lights turn on. If the backpack is connected and functioning correctly then both of these lights will be off - disconnect the backpack and you will see them both turn on. When the backpack is connected you should also see a green light on the backpack indicating that power is reaching the backpack. This sequence of operations checks that all major systems within the MA-300 are functional.

b) Check that the system is working correctly by connecting a single EMG electrode to channel one and using it to make a test recording. Check that the EMG signal is recorded on the correct channel and not any other channels of the analog data measurement system. Check all the EMG channels in this way to verify the MA-300 EMG channels are connected to the correct analog channels on the users system. If you find any errors then correct them and restart the test from channel one.

If you are using event switch channels then connect the event switches to the backpack and check their operation using the green front panel lights that indicate event switch closure. Check that the correct DC levels are recorded by the users analog data collection system and that they are recorded on the correct channels - make sure that the left and right sides are connected and labeled correctly as getting these swapped can confuse any subsequent data analysis.

When connected correctly the MA-300 should provide many years of trouble-free service. Please contact Motion Lab Systems if you have any questions about either the installation information provided or the operation of the MA-300 system.

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