Four-Channel Differential AC Amplifier

1700

INSTRUCTION MANUAL

FOR

HIGH-GAIN DIFFERENTIAL

AMPLIFIER MODEL 1700

Serial #_____

Date_____

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Version 7.0
April, 2010

Contents

Each Differential AC Amplifier is delivered complete with:

Four 3' Cables
Rack Mount Hardware
Instructions & Maintenance Manual

NOTE

This instrument is not intended for clinical measurements using human subjects. A-M Systems does not assume responsibility for injury or damage due to the misuse of this instrument.

General Description

Instrument Features

The *Four-Channel Differential AC Amplifier Model 1700* is designed to amplify cellular neurophysiological signals in applications requiring high gain, high input impedance, low noise, high common-mode rejection, and powerline interference rejection. Typical applications include: extracellular nerve recordings using suction or hook electrodes; electromyographic (EMG) recordings from muscle using wire or needle electrodes; EEG, ERG and EKG recordings. **The instrument is not intended for clinical or operating room measurements using humans.**

The instrument consists of a high input impedance, low-noise differential input stage, followed by high-frequency, low-frequency, and notch filters. The gain settings are x100, x1000 or x10 000. It is also possible to connect a stimulator to each amplifier channel and stimulate through the recording electrodes. The *Model 1700* contains four identical and independent amplifier channels in a single instrument, useful for making extracellular recordings from several sources being monitored simultaneously.

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Controls and Connectors

INPUT: This 5-pin connector attaches the electrode cable to the amplifier channel. The pin and electrode cable wire designations can be found in the "Operating Instructions" section in this manual.

STIMULUS: This 5-pin connector allows for external signals to be applied to the electrode. For example, stimuli can be applied with a Model 2100 Isolated Pulse Stimulator.

MODE (STIM-REC): This switch sets the channel to Stimulus Mode or Record Mode. In Stimulus Mode, the **INPUT** connector is connected to the signal from the **STIMULUS** connector and the **OUTPUT** connector is disabled. In Record Mode, the **INPUT** connector is connected to the amplification circuits and the signal is available at the **OUTPUT** connector.

GAIN: This rotary switch sets the amplifier gain to x100, x1000, or x10 000.

LOW CUT-OFF: This rotary switch selects the cut-off frequency of the Low Frequency Filter for the amplifier channel. Signals below the cut-off frequerncy are reduced by a factor of 100 (40 dB) per decade decrease in the input signal frequency. The Low Frequency Filter may be used to reduce slow DC level variations in the signal being recorded (See Bode plot page 3).

HIGH CUT-OFF: This rotary switch selects the cut-off frequency of the High Frequency Filter for the amplifier channel. Signals above the cut-off frequency are reduced by a factor of 100 (40dB) per decade increase in the input signal frequency. This filter may be used to reduce high frequency noise above the frequency content of the signal being recorded.

NOTCH (IN-OUT): This switch allows the Notch Filter to be included (**IN**) in or excluded (**OUT**) from the signal processing circuitry on a per channel basis. When radiation from the power lines is present, it is picked up by recording electrodes creating unwanted interference in the recording signal. This interference can be reduced through proper grounding and shielding techniques. Occasionally it is impossible to reduce this interference sufficiently to record relatively noise-free signals. The Notch Filter can sufficiently reduce the interference. However, this filter causes some distortion in signals below 100 Hz. Use this filter when other noise reduction methods are inadequate.

OUTPUT: This BNC connector provides the output signal from the amplifier channel.

POWER: This switch turns on power to all four amplifier channels.

GND: This connector is attached to the circuit ground for all four amplifier channels. To obtain low-noise recordings, this terminal may be used to make a ground connection to the recording medium.

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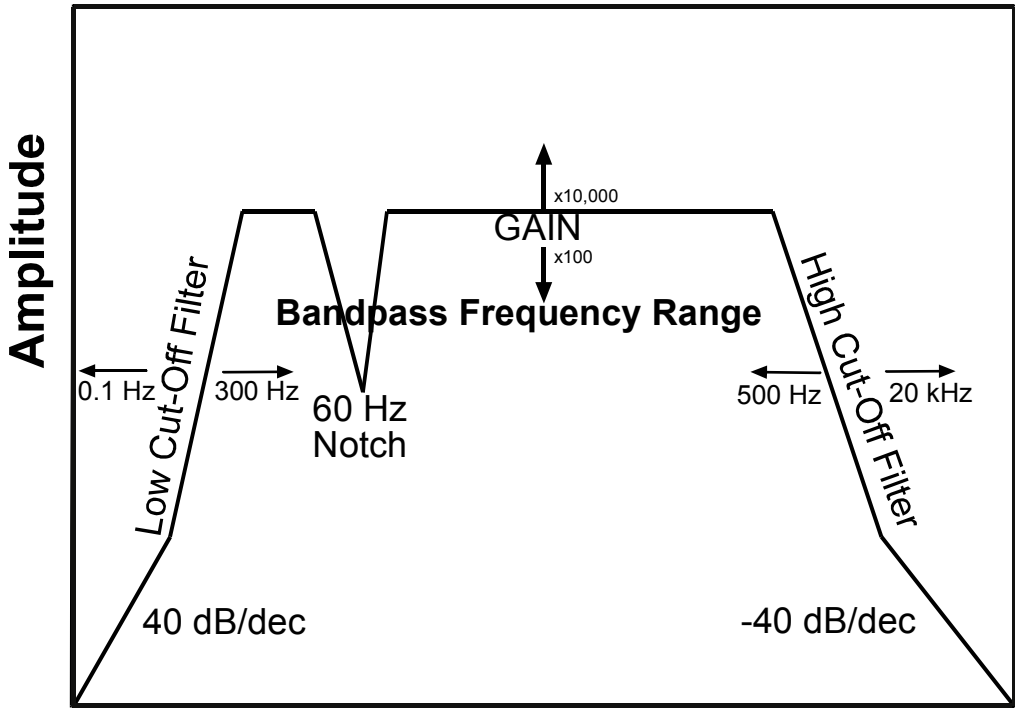

Bode Plot

An input frequency will be reduced in amplitude approximately one-half, when the input frequency equals the instrument panel Cut-Off Filter

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Operating Instructions

General Notes

Any amplifier channel not currently in use should have its **MODE** switch in the **STIM** position to protect the amplifier inputs. This grounds the inputs to the differential amplifier circuitry.

Set the **GAIN**, **LOW CUT-OFF** filter, **HIGH CUT-OFF** filter, and **NOTCH** filter according to the frequency content of the signal to be recorded.

While recording from biological preparations take care to keep all instrument cables as far away as possible from the recording situation. This will assist in maintaining proper grounding and shielding to insure a minimum of electrical interference.

Input cables are available to connect the amplifier to extracellular electrodes and/or stimulators. These cables will attach to either the **INPUT** or the **STIMULUS** connector. Additional cables can be ordered (catalog #692000, #701700). One end of each cable is left open to allow for maximum flexibility. The pin assignments for the connectors and the cables are as follows:

Pin	Wire	INPUT	STIMULUS
A	Black (Red before S/N 3683)	Active	+
B	White (Blue before S/N 3683)	Non-Active	-
H	Shield	Driven Shield	Ground
D		not used	not used
E		not used	not used

A driven shield is used with the **INPUT** connector to minimize the effect of capacitance on the cable, thus increasing common mode rejection. The shield is driven by a low impedance source with a differential signal voltage from the amplifier. **Note:** The shield should not be connected to ground, this would cause noise in the input signal.

The **STIMULUS** connector shield is connected to the system ground internally. Therefore, any ground referenced or isolated stimulator can be used with the **STIMULUS** connector.

Theory of Operation

Stimulus Mode

In Stimulus Mode, the **INPUT** connector is connected internally to the **STIMULUS** connector to apply the stimulation signal to the electrode. All amplification circuits are grounded in this mode, and the **OUTPUT** connector is disabled.

Record Mode

In Record Mode, the signal from the **INPUT** connector is coupled directly to the inputs of a high impedance, low noise differential amplifier stage consisting of two operational amplifiers with x10 gain. Direct coupling reduces the errors typically associated with capacity input coupling. The operational amplifiers are in non-inverting mode and their gain-setting networks connect through a common resistor to preserve high common-mode rejection.

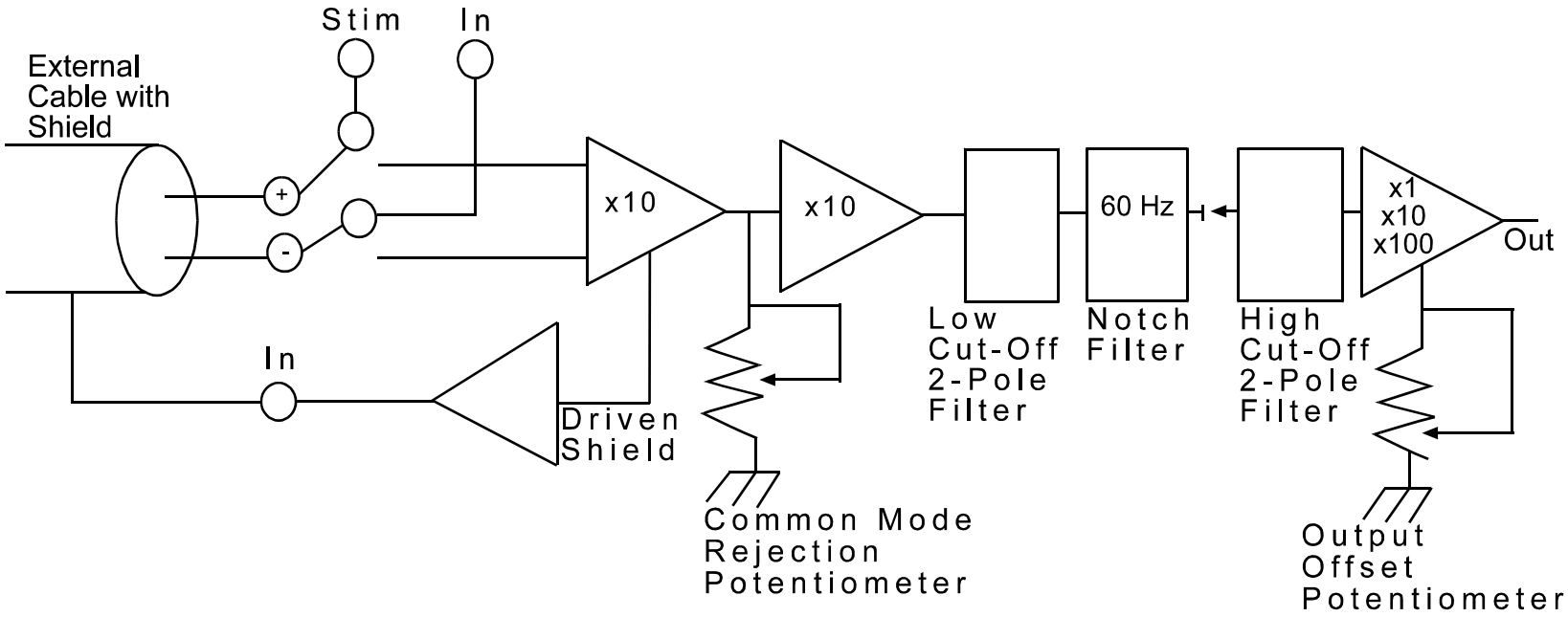
The common-mode voltage of the input signal at the inverting inputs of the operational amplifiers is measured, and is used to drive the electrode cable shield. This improves the common-mode rejection performance of the input amplifier stage. For this reason, the driven shield *should not* be grounded.

The output signals are then connected to a second differential operational amplifier circuit with a gain of x10. At this point, the differential electrode signal has been amplified by x100 and converted to a single-ended signal with respect to ground. An internal CMR potentiometer is trimmed at the factory to maximize the common-mode rejection.

The signal passes through a double-pole low-pass filter, which attenuates frequencies above the **HIGH CUT-OFF** switch setting. This stage provides no signal amplification.

If selected, the signal next passes through the Notch Filter. The Notch Filter is tuned to the power line frequency and consists of a twin-T network in a feedback loop with an operational amplifier. This stage does not amplify the signal.

The signal then passes through a double-pole high-pass filter, which attenuates frequencies below the **LOW CUT-OFF** switch setting. Also included in this stage is the final amplifier which provides x1, x10 or x100 gain to produce an output signal according to the total gain specified by the **GAIN** switch.



Block Diagram For High-Gain Differential AC Amplifier Model 1700

Calibration Procedures

The calibration interval for the *Model 1700* is the lesser of 1000 hours of operation or 6 months. Somewhat greater drift can be expected in the first 100 hours of operation as the semiconductors age. Adjustments should only be made after the instrument is fully warmed up (at least 15 minutes of operation).

The following equipment is required for these calibration procedures:

Digital multimeter with 0.1% accuracy
Oscilloscope with 30 MHz bandwidth
True RMS voltmeter with 4 MHz bandwidth
Function generator able to produce a sine wave up to 20kHz @ 1mV
Miscellaneous connectors and cables

WARNING: *The Model 1700 has dangerous voltages throughout the instrument, even with the* **POWER** *switch turned* **OFF**. Servicing the *Model 1700* should be done only by qualified service personnel. Use caution in handling any wires, connectors, or electrodes which may be directly or indirectly attached to the *Model 1700*. Disconnect power by unplugging the power cord from the receptacle.

NOTE: It is important to complete this entire procedure in sequence, changing only the instrument controls indicated. If any adjustment is made, all remaining adjustments must be made in order to ensure the published specifications will be met.

Initial Settings

Controls	Inputs / Observations	Adjust / Check
LOW CUT-OFF: 1 HZ **HIGH CUT-OFF: 20 KHZ** **GAIN: X10 000** **NOTCH: OUT** **MODE: STIM**		

Power Supply and Bias Voltages

Controls	Inputs / Observations	Adjust / Check
	Observe voltage at upper left of channel 1, wire marked +15 V	Check for +15 V ± 0.5 V
	Observe voltage at upper left of channel 1, wire marked -15 V	Check for -15 V ± 0.5 V

DC Offset

Controls	Inputs / Observations	Adjust / Check
	Observe voltage at **OUTPUT** with an oscilloscope	Adjust potentiometer R170 near top of channel for 0 V

Note: This section must be repeated for each channel.

Common Mode Rejection

Controls	Inputs / Observations	Adjust / Check
MODE: REC	Apply the positive output of a 60 Hz, 5 V p-p signal to both differential leads of **INPUT**	Adjust potentiometer R136 near bottom of channel for best possible null
	Observe voltage at **OUTPUT** with an oscilloscope	

Note: This section must be repeated for each channel. Use a 50 Hz, 5 V p-p signal if the line frequency is 50 Hz.

Driven Shield

Controls	Inputs / Observations	Adjust / Check
MODE: STIM	Apply the positive output of a 60 Hz, 5 V p-p signal to both differential leads of **INPUT**	Check for 60 Hz, 5 V p-p
	Observe voltage at middle pin (shield) of **INPUT** with an oscilloscope	

Note: This section must be repeated for each channel. Use a 50 Hz, 5 V p-p signal if the line frequency is 50 Hz.

Gain

Controls	Inputs / Observations	Adjust / Check
MODE: REC **GAIN: X100**	Apply a 60 Hz, 1 mV p-p wave to **INPUT**	Check for 100 mV, 60 Hz
	Observe voltage at **OUTPUT** with an oscilloscope	
GAIN: X1000		Check for 1.00 V, 60 Hz
GAIN: X10K		Check for 10.0 V, 60Hz

Note: This section must be repeated for each channel.

Notch Filter

Controls	Inputs / Observations	Adjust / Check
MODE: REC **NOTCH: IN** **GAIN: X100**	Apply a 60 Hz, 77 mV sine wave to **INPUT** Observe voltage at **OUTPUT** with a true RMS volt meter	Check for at least 25 dB less than applied signal

Note: This section must be repeated for each channel. Use a 50 Hz, 77mV signal if the line frequency is 50 Hz.

High and Low Cut-Off Filters

Controls	Inputs / Observations	Adjust / Check
MODE: REC **GAIN: X100** **HIGH CUT-OFF: 20KHZ**	Apply a 20 kHz, 77 mV rms sine wave to **INPUT** Observe voltage at **OUTPUT** with a true RMS volt meter	Check for 3 dB less than applied signal
HIGH CUT-OFF: 10KHZ	Apply a 10 kHz, 77 mV rms sine wave to **INPUT**	Check for 3 dB less than applied signal
HIGH CUT-OFF: 5KHZ	Apply a 5 kHz, 77 mV rms sine wave to **INPUT**	Check for 3 dB less than applied signal
HIGH CUT-OFF: 1KHZ	Apply a 1 kHz, 77 mV rms sine wave to **INPUT**	Check for 3 dB less than applied signal
HIGH CUT-OFF: 500HZ	Apply a 500 Hz, 77 mV rms sine wave to **INPUT**	Check for 3 dB less than applied signal
LOW CUT-OFF:300HZ	Apply a 300 Hz, 77 mV rms sine wave to **INPUT**	Check for 3 dB less than applied signal
LOW CUT-OFF:100HZ	Apply a 100 Hz, 77 mV rms sine wave to **INPUT**	Check for 3 dB less than applied signal
LOW CUT-OFF:10HZ	Apply a 10 Hz, 77 mV rms sine wave to **INPUT**	Check for 3 dB less than applied signal
LOW CUT-OFF:1HZ	Apply a 8 Hz, 77 mV rms sine wave to **INPUT**	Check for 3 dB less than applied signal

Note: This section must be repeated for each channel.

Stimulus

Controls	Inputs / Observations	Adjust / Check
MODE: STIM	Apply a 60 Hz, 5 V p-p sine wave to **INPUT**	Check for a 60 Hz, 5 V p-p sine wave
	Observe signal at **STIMULUS**	

Note: This section must be repeated for each channel.

DC Output Verification

Controls	Inputs / Observations	Adjust / Check
MODE: STIM **GAIN: X10K**	Remove all previous connections	Check for 0 V
	Observe voltage at **OUTPUT** with an oscilloscope	Adjust potentiometer R170 if needed to obtain 0 V

Note: This section must be repeated for each channel.

Noise

Controls	Inputs / Observations	Adjust / Check
MODE: STIM **HIGH CUT-OFF: 20K**	Observe voltage at OUTPUT with an AC Voltmeter	Check for < 25 mV

Note: This section must be repeated for each channel.

Specifications

Note: all specifications measured at +25 ° C

Noise

Voltage, f_O = 10 Hz	40 nV/Hz$^{1/2}$, typical
Voltage, f_O = 100 Hz	15 nV/Hz$^{1/2}$, typical
Voltage, f_O = 1 Hz	8 nV/Hz$^{1/2}$, typical
Voltage, f_O = 10 kHz	6 nV/Hz$^{1/2}$, typical
Voltage, f_B = 10 Hz to 10 kHz	0.7 µV, rms, typical
Voltage, f_B = 0.1 Hz to 10 Hz	1.6 µV, p-p, typical
Current, f_B = 0.1 Hz to 10 Hz	15 fA, p-p, typical
Current, f_B = 0.1 Hz to 20 kHz	0.8 fA/ Hz$^{1/2}$, typical

Offset Voltage

Input offset voltage	± 0.3 mV, typical; ± 2 mV, maximum
Average drift	± 8 µ V/°C, typical; ± 15 µV/°C, maximum
Supply rejection	110 dB, typical

Bias Current

Initial bias current	± 3 pA, typical; ± 15 pA, maximum

Offset Current

Input offset current	± 3 pA, typical; ± 12 pA, maximum

Input Impedance

Input impedance

1 0 1 2 Ω || > 50 pF

Inter-channel Crosstalk

Inter-channel Crosstalk	90 dB @ 1 kHz

Voltage Range

x 100	.11 V_{AC} or .11 V_{DC} ± 5%
x 1000	.011 V_{AC} or .11 V_{DC} ± 5%
x 10000	.0011 V_{AC} or .11 V_{DC} ± 5%
Common-mode rejection (CMR)	75 dB

CMR is internally adjustable

Slew Rate

Slew Rate	2 V/µs

Rated Output

Voltage Output	± 11 V

Current Output	5 mA
Output Resistance	> 5 Ω

Low Cut-Off Filter

Cut-off frequencies	0.1 Hz,1.0 Hz,10 Hz,100 Hz, 300 Hz
Cut-off rate	40 dB/decade

High Cut-Off Filter

Cut-off frequencies	500 Hz,1 kHz, 5 kHz, 10 kHz, 20 kHz
Cut-off rate	40 dB/decade

Notch Filter

Frequency	60 Hz or 50 Hz, factory preset
Line rejection	30 dB, typical

Power

AC Power source	110 V, 60 Hz or 230 V, 50 Hz, factory preset
Power usage	> 3 W

Operating Parameters

Temperature	20°C to 40°C
Humidity	20% to 75%

Physical Dimensions

Width	17 inches (43.2 cm)
Height	4.75 inches (12.1 cm)
Depth	11.25 inches (28.6 cm)
Weight	19 pounds

Warranty and Service

LIMITED WARRANTY

What does this warranty cover?

A-M Systems, LLC (hereinafter, "A-M Systems") warrants to the Purchaser that the Instrument, including cables, Headstage Probes and any other accessories shipped with the Instrument,(hereafter the "hardware") is free from defects in workmanship or material under normal use and service for the period of three (3) years. This warranty commences on the date of delivery of the hardware to the Purchaser.

What are the obligations of A-M Systems under this warranty?

During the warranty period, A-M Systems agrees to repair or replace, at its sole option, without charge to the Purchaser, any defective component part of the hardware. To obtain warranty service, the Purchaser must return the hardware to A-M Systems or an authorized A-M Systems distributor in an adequate shipping container. Any postage, shipping and insurance charges incurred in shipping the hardware to A-M Systems must be prepaid by the Purchaser and all risk for the hardware shall remain with purchaser until such time as A-M Systems takes receipt of the hardware. Upon receipt, A-M Systems will promptly repair or replace the defective unit, and then return the hardware (or its replacement) to the Purchaser, postage, shipping, and insurance prepaid. A-M Systems may use reconditioned or like new parts or units at its sole option, when repairing any hardware. Repaired products shall carry the same amount of outstanding warranty as from original purchase, or ninety (90) days which ever is greater. Any claim under the warranty must include a dated proof of purchase of the hardware covered by this warranty. In any event, A-M Systems liability for defective hardware is limited to repairing or replacing the hardware.

What is not covered by this warranty?

This warranty is contingent upon proper use and maintenance of the hardware by the Purchaser and does not cover batteries. Neglect, misuse whether intentional or otherwise, tampering with or altering the hardware, damage caused by accident, damage caused by unusual physical, electrical, chemical, or electromechanical stress, damage caused by failure of electrical power, or damage caused during transportation are not covered by this warranty.

What are the limits of liability for A-M Systems under this warranty?

A-M Systems shall not be liable for loss of data, lost profits or savings, or any special, incidental, consequential, indirect or other similar damages, whether arising from breach of contract, negligence, or other legal action, even if the company or its agent has been advised of the possibility of such damages, or for any claim brought against you by another party. THIS EQUIPMENT IS NOT INTENDED FOR CLINICAL MEASUREMENTS USING HUMAN SUBJECTS. A-M SYSTEMS DOES NOT ASSUME RESPONSIBILITY FOR INJURY OR DAMAGE DUE TO MISUSE OF THIS EQUIPMENT. Jurisdictions vary with regard to the enforceability of provisions excluding or limiting liability for incidental or consequential damages. Check the provision of your local jurisdiction to find out whether the above exclusion applies to you.

This warranty allocates risks of product failure between the Purchaser and A-M Systems. A-M Systems hardware pricing reflects this allocation of risk and the limitations of liability contained in this warranty. The agents, employees, distributors, and dealers of A-M Systems are not authorized to make modifications to this warranty, or additional warranties binding on the company. Accordingly, additional statements such as dealer advertising or presentations, whether oral or written, do not constitute warranties by A-M Systems and should not be relied upon. This warranty gives you specific legal rights. You may also have other rights which vary from one jurisdiction to another.

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Revision History

Rev	Date	Description
6	6/30/06	Initial Document Control release
7	4/28/10	DCR201200. New warranty info, and company name