

**BI-DIRECTIONAL HIGH CURRENT
MEASUREMENT SYSTEM**

Model LKAT

Manual Item No. 043269

Rev. F

**Installation, Operation
and Service Instructions**

LEM DynAmp, INC.

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LEM DynAmp Inc. WARRANTY

Items and components manufactured by Seller for permanent installation are warranted for two (2) years from the date of shipment.

Items and components manufactured by Seller for portable and temporary use in more than one location are warranted to be free from defects in material and workmanship for a period of eighteen (18) months from the date of shipment.

Items and components not manufactured and resold by Seller are warranted by their manufacturer.

Warranty repair shall be, at LEM's option, in the form of repair or replacement of the defective items or components. Concerning warranty repairs, LEM will be responsible for LEM provided time, material and transportation costs (shipping or travel). Actual method of warranty repair / correction will be determined by LEM at LEM's sole option. Such warranty repair shall constitute a fulfillment of all LEM DynAmp Inc. liabilities in respect to said items and components. In no event shall LEM DynAmp Inc. be liable for consequential damages.

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Hazard Warning!



GENERAL

All installation, maintenance and service must be performed by qualified technicians who are familiar with the warnings and instructions of this manual.

The enclosure cover must remain closed at all times during operation to ensure safety of personnel. The cover may be opened using a screwdriver; however, only authorized personnel or technicians should be allowed to open and service the unit.

Use of the equipment in a manner not specified by the manufacturer can impair the protection provided within.

LEM does not assume liability for the customer's failure to comply with the rules and requirements provided in this manual.



HAZARDOUS VOLTAGE

The measuring head is designed to be installed on high voltage bus bars. All interconnection cables must be safely routed away from bus bars and high voltages. **Do not** allow any interconnection cable to contact bus bars or high voltages. Ignoring the installation precautions and warnings can result in severe personal injury or equipment damage.

To avoid the risk of electrical shock or fire, the safety instructions and guidelines in this manual must be followed. The electrical specifications must not be exceeded and the unit must be installed according to directions provided.



INSTALLATION

This equipment is intended for indoor use only. It should be mounted in a well-ventilated area, away from high heat, dust, and corrosive atmosphere. The ambient temperature must not exceed 80°C for the measuring head and 50°C for the electronics.

For mounting considerations that fall outside the recommended specifications provided in this manual, the factory should be contacted for approval.

This unit is rated for installation category III and pollution degree 2.

Symbol Identification:

General definitions of safety symbols used on equipment and manual.



Caution/Warning: Refer to accompanying documents for instructions.

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REVISION PAGE

<u>Page</u>	<u>Change</u>	<u>Reason For Revision</u>	<u>Date</u>
all	Rev NEW		04/00
all	A	Table 4-1 & 4-2, Delete Mounting Clamp, Fabrication drawings, add Calibration Section	11/00
7,8	B	Revised Specifications; added Response Time, di/dt Accurately Followed, and Figure 3-1	03/01
16, 17	C	Changed power supply tolerance to $\pm 0.5v$. Changed acceptable differences to A1 vs. A2 and B1 vs. B2.	06/02
3, 7, 8	D	Section 2-2 paragraph 3 deleted term "molded-on", changed Section III Table 3-1 Temperature sensitivity for custom cable lengths/added Note 1.	02/03
25, 27	E	Added "Remove tape seal from switch SW1, if necessary"	06/03
10,13-17, 24, 30	F	Updated Installation Section pages / Tables 4-1 & 4-2, removed Table 4-3, updated 5-6 "Troubleshooting AD fault and Spare Parts List 6-1	01/04

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Section I

SAFETY

1-1. OVERVIEW

The measuring head is designed to be installed on high voltage bus bars. All interconnection cables must be safely routed away from bus bars and high voltages. Do not allow any interconnection cable to contact bus bars or high voltages.

Ignoring the installation precautions and warnings can result in severe personal injury or equipment damage.

The following are general guidelines to be followed during installation, operation and service of the metering unit and measuring head.

- All installation, maintenance and service must be performed by qualified technicians who are familiar with the warnings and instructions of this manual.
- Always follow all local and plant safety procedures.
- The enclosure cover must remain closed at all times during operation to ensure safety of personnel. Only authorized personnel or technicians should be allowed to open and service the unit.
- Service must be performed by qualified technicians only. If use of an oscilloscope becomes necessary during servicing, either the scope must be floating and ungrounded, or differential probe(s) must be used. The metering unit is isolated from the mains via the power transformers. If a grounded scope is used, a hazardous condition is created since current will flow through the probe to ground.
- Units are not intrinsically safe. Do not place in explosive atmospheres.
- Use of the equipment in a manner not specified by the manufacturer can impair the protection provided within.
- Replace fuse with the same type and size as originally supplied with the unit. Failure to do so may result in intermittent operation and premature failure.
- LEM does not assume liability for the customer's failure to comply with the rules and requirements provided in this manual.

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Section II DESCRIPTION

2-1. OVERVIEW

The LEM DynAmp, Inc. LKAT system is designed to accurately measure AC or DC current flowing in a bus bar. Each system consists of a measuring head, a metering unit, and multi-conductor cables.

2-2. MEASURING HEAD

LKAT measuring heads contain an arrangement of Hall Effect sensor ICs and signal conditioning electronics. The tubular enclosure is constructed of flame retardant plastic materials. Insulation from the bus is provided by the homogeneous (sealed) construction of the head. In the event that the head enclosure components become cracked, the bonding fails, or the weather-tight seal is broken in any way, a replacement head must be substituted. The measuring head is not designed to be repaired.

LKAT measuring heads are mounted on the bus bar using fiberglass channels and spring-loaded clamps. All mounting hardware is supplied with each system. The mounting clamps are factory installed on the measuring head. The spring-loaded plungers are adjusted to bus dimension specified with each order. When properly installed, the mounting hardware maintains the position of the head in the event of temperature fluctuation and / or bus vibration.

An interconnection cable assembly is integral to each half of the measuring head. The standard length is 33 feet (10 meters). Heads with extra-long interconnection cables are also available - consult the factory for details. The head cable assemblies are terminated with keyed connectors to ensure correct hookup. The interconnection cables from the head are identified as "A" and "B". Connecting head cable "A" to metering unit "B" will not result in damage to the head or electronics, but may degrade the calibration accuracy of the system.

2-3. METERING UNIT

The metering unit is housed in a NEMA 4X enclosure. The enclosure cover must remain closed during normal operation. The enclosure is rated IP67, with the following characteristics:

- protection from electrical shock as hazardous voltages are inaccessible
- limited ingress of dust into the enclosure
- limited ingress of water into the enclosure via dripping, spray, jets, flooding, or temporary immersion.

The outside of the metering unit enclosure includes four receptacles for external connection to the measuring head, the metering unit outputs, and the input power. When properly mated with the associated cable assembly, these connectors are also rated IP67. External power for the metering unit is “universal input” type: 85 to 264Vac @ 47 to 440Hz, or 110 to 264Vdc. Wiring changes are **not required** for any supply voltage in this range. Burden on the supply circuit will not exceed 30VA.

The metering unit enclosure cover is made of clear polycarbonate. This allows the user to view a digital display showing measured bus current in kA. Also visible are LED status indicators. Illumination of the green indicates proper operation of the unit. Illumination of the red LED indicates a problem with the unit. For more information refer to Section V – THEORY OF OPERATION.

2-4. INTERCONNECTION CABLES

The LKAT system is supplied with two cable assemblies in addition to those connected to the measuring head.

The power input cable assembly is 33 feet (10m) in length. A keyed circular connector terminates one end. The other end is unterminated for connection to the power source by the user during installation.

The system output cable assembly is 100 feet (30m) in length. A keyed circular connector terminates one end. The cable is a 10-conductor type; however, at present only 5 of the 10 conductors are used. The unused conductors may be trimmed flush to cable jacket. The user connects this cable from the metering unit to the appropriate inputs during installation.

2-5. INDICATORS AND OUTPUTS

Visible outputs on the metering unit main pc board assembly:

- digital display of bus current in kA (indicates DC content only).
- operational status LEDs: green = OK, red = system problem.

Available via the metering unit output cable:

- 20mA current loop proportional to bus current. This output may be converted to a voltage output by adding a load resistor.
- normally open and normally closed relay contacts indicate operational status (same as green and red LEDs). For failsafe operation, the relay coil is energized when unit is functioning properly.

The current loop output may be factory-scaled in one of several ways.

**Table 2-1.
LKAT Current Output Scaling**

	DC		DC with reverse, or AC		
	Zero	+Full-scale	-Full-scale	Zero	+Full-scale
Bus Current	0kA	User specified	User specified	0kA	User specified
Signal Output	0mA	+20mA	+4mA	+12mA	+20mA
	+4mA	+20mA	-20mA	0mA	+20mA

Field calibration of LKAT Systems requires use of a reference current transducer with calibration accuracy of 0.1% full scale or better. Contact LEM DynAmp for calibration of the LKAT System. Refer to Section VI – MAINTENANCE AND SPARE PARTS for more information.

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Section III SPECIFICATIONS

**Table 3-1.
LKAT System Specifications**

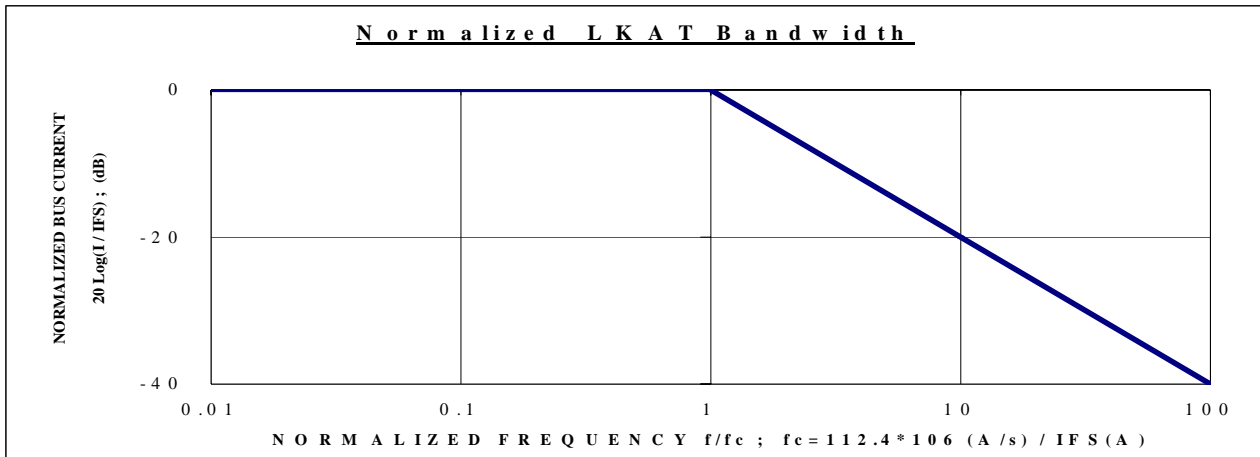
Full-Scale Measuring Range	5kA to 100kA
Ambient Temperature Range of Measuring Head (Operational)	-20°C to 80°C (-4°F to 176°F)
Ambient Temperature Range of Metering Unit Location (Operational)	-10°C to 50°C (14°F to 122°F)
Ambient Temperature Range of System (Storage)	-20°C to 65°C (-4°F to 150°F)
Humidity (head and metering unit)	85% maximum (non condensing)
Input Power	85 to 264Vac @ 47 to 440Hz, or 110 to 264Vdc.
Burden on ac Line (max)	30 VA
Maximum Allowable Burden of Output Circuit	10 volts
Linearity Error♦	±0.05% of full scale from 5% to 100% of bus current.
Repeatability Error Limits♦	±0.1% of full scale
Temperature Sensitivity (Note 1.)	±0.02%/°C
Line Voltage Sensitivity	±0.001%/V
Response Time (t _d)	≤ 50 μs
di/dt Accurately Followed	500 A/μs
Frequency Response	(refer to Figure 3-1)
Isolation: Bus to Output	6kVac for 1 minute
Isolation: Mains Supply to output	1kVac for 1 minute
Isolation: Mains Supply to chassis	2kVac for 1 minute
Isolation: Output to chassis	2kVac for 1 minute
Installation Category	III
Pollution Degree	2

♦ When tested at 120 Vac, less than 1 V burden, 24°C ambient.

**Table 3-1.
LKAT System Specifications, Continued**

OUTPUTS	
Current Output Proportional to full scale Bus Current	20mA ±0.75% full scale
Status Relay (Normally Open & Normally Closed Contacts)	Indicate proper operation or operational problem
Status LEDs	Green LED indicates proper operation Red Led indicates operational problem
Digital Display of Bus Current in kA units	3 ½ Digit Green LCD ±2% full scale
PHYSICAL	
Measuring Head Weight	2 to 8 lbs (1 to 4 kg)
Metering Unit Weight	10 lbs (4.5kg)
Head Interconnection Cables (2) - Standard Length	33 ft (10 m)
Head Interconnection Cables (2) - Custom Length (Note 1.)	Up to 164 ft (50 m)
Signal Output Cable (1)	100 ft (30 m)
Power Input Cable (1)	33 ft (10 m)
Environmental rating: Head, Metering Unit, and Interconnection Cables	IP67

Note 1.) For head interconnection cable lengths exceeding 20m the temperature sensitivity increases ±0.02% / °C per 10m additional cable length.



F.S. Bus Current (kA)	10	20	30	40	50	60	70	80	90	100
Corner Frequency (kHz)	11.24	5.620	3.747	2.810	2.248	1.873	1.606	1.405	1.249	1.124

**Figure 3-1.
LKAT Frequency Response**

Section IV INSTALLATION

4-1. HANDLING PRECAUTIONS

LKAT systems should be handled with the same care as any precision measuring instrument. Severe jolts or bumps to the head or metering unit may cause movement of internal parts, and possibly a malfunction. **Personnel involved in the installation should be familiar with the technical terms, warnings, and instructions in this manual, and all plant safety rules, and be able to follow these.**

The complete system should be inspected for shipping damage at the earliest opportunity. Visible damage must be reported to the carrier immediately. Concealed damage (not evident until the system is operated) must be reported to LEM DynAmp, Inc. immediately.

4-2. INSTALLATION CONSIDERATIONS

Read the following before mounting the head:

- 1.) The measuring head is designed to be installed on high voltage bus bars. All interconnection cables must be safely routed away from bus bars and high voltages. Do not allow any interconnection cable to contact bus bars or high voltages. Ignoring the installation precautions and warnings can result in severe personal injury or equipment damage.
- 2.) Always follow all local and plant safety procedures when the unit is to be installed on a live bus.
- 3.) Choose a mounting location for the head where the ambient air temperature does not exceed 80°C. The LKAT head may be located indoors or outdoors, but should be kept away from extreme heat and corrosive atmospheres. Do not install the head in direct sunlight, as excessive temperature rise could result in measurement error or damage to the head enclosure. If the head is to be installed in an especially harsh environment, please discuss protective measures with the factory.
- 4.) The head and metering unit are rated IP67; however, when installed, no part of the head should be submerged under water.
- 5.) If possible, keep magnetic materials, structural or otherwise, at least 1 meter (3ft) away from the measuring head.

- 6.) The head should be mounted in an area free of other bus bars. This is not an essential requirement if a satisfactory magnetic centering can be achieved.
- 7.) The head must be installed with proper polarity. An arrow indicates the direction that conventional bus current must flow through the aperture (+) to (-). No damage will occur if the head is reversed, but the system output will indicate current flow in the reverse direction.
- 8.) Measuring heads are shipped in matched halves. Make sure that the same serial number is on the both halves of the measuring head and the metering unit. The two halves should mate squarely and evenly without forcing or twisting.
- 9.) The measurement head is not grounded; however, the head cables should be disconnected from the metering unit prior to installation or maintenance to minimize the possibility of electrical shock. When properly connected, the power input cable will ground the LKAT Metering Unit panel. Refer to drawings at the end of this manual and connection detail on the side of the LKAT Metering Unit enclosure.
- 10.) When installing the sensor head, do not remove the seals from the exposed end of the sensor head tube. Doing so may allow water or contaminants to enter the head, and void IP rating and warranty.
- 11.) Measuring heads are shipped with mounting hardware installed and adjusted per order specifications. For permanent installation, the head halves may be semi-permanently bonded around the bus bar using silicone RTV sealant (adhesive). After the bond cures, the spring-loaded mounting screws (plungers) may require adjustment for appropriate position and spring force on the bus.

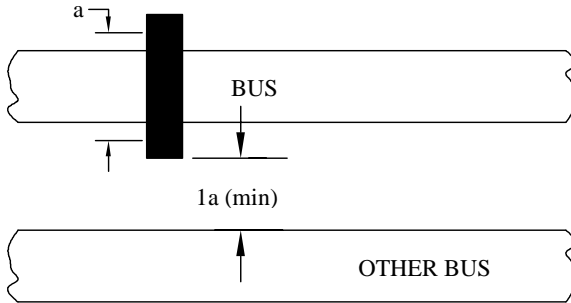
FREE BUS ANALYSIS

The general guidelines below should be applied only when a detailed analysis of the bus system is not available. LEM DynAmp, Inc. will perform one detailed computer analysis of the proposed location of the measuring heads within your bus system at no charge. Generally, this is done before or at the time the unit was ordered. In this way you are assured that your system will function properly.

Whenever possible, the head should be installed on the longest straight run of the bus that is available in an area free of other bus structures. The status LEDs and relay contacts indicate proper operation in a given head location.

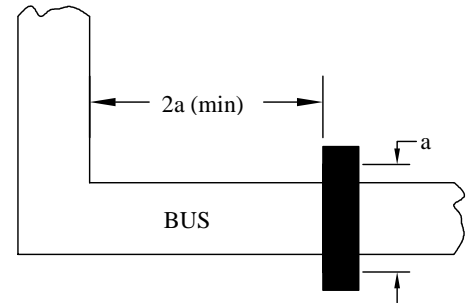
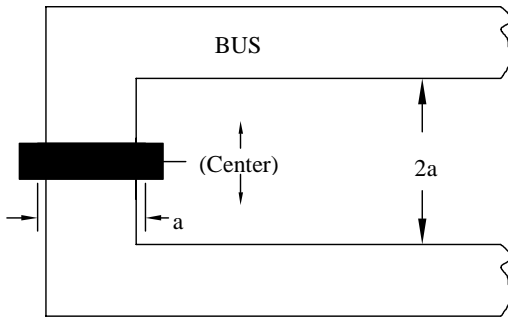
The following installation guidelines may reduce the amount of adjustment necessary to position the sensor head properly.

a = maximum aperture dimension



The head should be a minimum distance of $1a$ from another bus carrying equal or less current. If the other bus carries higher current, the distance should be greater, e.g., $2a$.

The head should be located a minimum distance of $2a$ from a 90° bend in the bus.



If the head is to be installed on a U-section of the bus, the distance between the parallel bus sections should be $2a$, and the head should be centered between them.

If the head is to be installed on a T-section of the bus, it should be located a distance of $2a$ from the joining point.

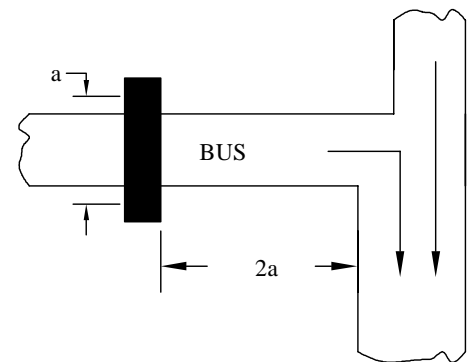


Figure 4-1.
General Guidelines for Locating Measuring Heads

4-3. FUNCTIONAL CHECK (Optional)

After unpacking the LKAT system (but prior to installation) conduct the following functional check of the system:

- 1.) Locate a convenient temporary power source for the LKAT system. This may or may not be in the location where the system will be installed. The power source must be in the range 85 to 264Vac @ 47 to 440Hz, or 110 to 264Vdc. The system draws a maximum of 30 volt-amperes.
- 2.) Refer to the drawing “Wiring Diagram, LKAT System” included at the end of this manual. Attach a suitable connector to the unterminated end of the input power cable assembly for connection to the power source to be used for this check.
- 3.) Connect the measuring head cables A & B to the metering unit.
- 4.) Connect the power input cable assembly to the metering unit and energize the unit.
- 5.) Observe the LEDs on the Main pc board assembly. If the LEDs light green, the system is functioning properly. If LED D6 (Accuracy Diagnostics “AD”) lights red, skip to “Troubleshooting an Accuracy Diagnostics Fault Indication” in the “Theory of Operation” section of this manual. If LED D5 (Trip 1) lights red, make measurements and complete the form “LKAT Diagnostic Measurements Form 1 – Zero Primary Current” and contact the factory.

4-4. HEAD INSTALLATION

Refer to “LKAT Diagnostic Measurements Form – Zero Primary Current”. Allow the system one hour to stabilize prior to making measurements. Make measurements and record data shown on the form. File the completed test form for future reference. It is OK to make these measurements away from location where the LKAT Plus system will be installed, but this should be noted on the form.

The head halves will be semi-permanently bonded together around the bus. The measuring head is comprised of two “L” shaped halves. Each half is identified with a serial number followed by an “A” or “B”. One interconnection cable exits from each corner box on each half. When the sensor head is installed on a horizontal bus, the corner boxes should be located beneath the bus. For vertical busses, the corner boxes may be located on either side of the bus, depending on mechanical and thermal considerations. The head should be mounted so conventional (+) to (-) current flows in the direction of the arrow on the sensor head.

The following tools and materials are required for installation:

Materials marked with an asterisk (*) are included with each LKAT System order.

34" (864mm) Releasable Cable Ties *
Silicone RTV adhesive / sealant *
1/8" (3mm) hex wrench *
Drill, drill bits, mounting hardware, screwdrivers, wrenches, etc.
Cable puller, cable ties, ladder, etc.

The following is the recommended sequence for installing the measuring head:

- 1.) Determine the position where the measuring head will be installed. Bus bar(s) should be free from grease and dust for the best adhesion of the LKAT fiberglass mounting channels to bus bar(s).
- 2.) Connect the head cable assemblies to the metering unit.
- 3.) Remove the backing from the adhesive foam strips on the fiberglass mounting channels. Position the mounting channels to the bus in the desired location.
- 4.) Squeeze a 1/4" (6.5mm) continuous bead of silicone RTV adhesive around the elbow and tube seam indicated by the yellow "HEAD SPLITS HERE" marker. Keep the Silicone RTV on the outside of the elbow cavity. There must be sufficient Silicone RTV adhesive to seal any gap between the sensor head halves.
- 5.) Position the two "L-shaped" head halves around the bus and the fiberglass channels. Mate the two halves, pressing them together until the tubes are firmly seated in the elbows.
- 6.) Install the releasable cable ties to hold the head halves together while the Silicone RTV cures. The cable ties may be removed after 24 hours.
- 7.) Route the interconnection cables away from the bus and other high voltages.
- 8.) Connect the power cable assembly to appropriate power source and LKAT metering unit.
- 9.) The Silicone RTV takes approximately 24 hours to cure. After Silicone RTV has cured, the plunger tension may be adjusted, if needed. Use the 1/8" hex wrench supplied with the system for this purpose.

4-5. SYSTEM CHECKOUT DURING INSTALLATION

Recheck all wiring connections against the drawings to ensure proper installation. After input power is applied to the system confirm that the green status LED is illuminated.

With the bus energized, the metering unit digital display should indicate the primary current (in kA units) within $\pm 2\%$. The current loop should produce an output signal of +20mA ($\pm 0.75\%$) at full-scale bus current.

Photocopy the appropriate *LKAT Diagnostic Measurements Form(s)* below. The form titled “Zero Primary Current” is for diagnostic measurements at zero bus current (with the sensor head on or off the bus). The form titled “Energized Primary Bus” is for diagnostic measurements with the sensor head installed on the bus with the bus energized. Follow the directions below to measure and record necessary information.

NOTE:

- These forms are intended to help keep accurate records of LKAT functional tests.
- This information may prove valuable in the event of a malfunction.
- These measurements do not constitute system calibration.
- Space is provided for the recording of three sets of readings.
- Voltages may vary slightly with temperature extremes.
- System performance will typically remain within nominal specifications when measured levels fall within the acceptable limits shown on the forms.
- Levels must be measured and recorded under test conditions shown on the forms.
- The metering unit cover must be open during system checkout, as all measurements are made inside metering unit on main pc board terminal blocks. The cover should remain firmly closed during normal operation.

**Table 4-1.
LKAT Diagnostic Measurements Form 1 – Zero Primary Current**

**LKAT Diagnostic Measurements Form
Zero Primary Current**

<p>Instructions:</p> <p>1.) Assure that head is off bus, or that bus is de-energized.</p> <p>2.) Measure and record the information below (make additional copies of this form as needed).</p>						
<p>TEST CONDITIONS:</p> <p>ZERO PRIMARY CURRENT (Head may or may not be installed on bus);</p> <p>LKAT SYSTEM must be ENERGIZED for AT LEAST ONE HOUR.</p>						
MEASURE	(+) DMM at	(-) DMM at	ACCEPTABLE RANGE	DATE ____/____/____	DATE ____/____/____	DATE ____/____/____
+5V supply	P4-1	P1-2	+5V (±0.5V)			
+15V supply	P4-3	P4-4	+15V (±0.5V)			
-15V supply	P4-4	P4-6	-15V (±0.5V)			
Input A1	P1-1	P1-2	0V (±5mV)			
Input A2	P1-3	P1-4	0V (±5mV)			
Input B1	P2-1	P2-2	0V (±5mV)			
Input B2	P2-3	P2-4	0V (±5mV)			

**Table 4-2.
LKAT Diagnostic Measurements Form 2 – Energized Primary Bus**

**LKAT Diagnostic Measurements Form
Energized Primary Bus**

<p>Instructions:</p> <p>1.) Assure that head is on bus and that bus is energized.</p> <p>2.) Measure and record the information below (make additional copies of this form as needed).</p>						
<p>TEST CONDITIONS:</p> <p>ENERGIZED PRIMARY BUS ;</p> <p>LKAT SYSTEM must be ENERGIZED for AT LEAST ONE HOUR.</p>						
MEASURE	(+) DMM at	(-) DMM at	ACCEPTABLE RANGE	DATE ___/___/___	DATE ___/___/___	DATE ___/___/___
+5V supply	P4-1	P1-2	+5V (±0.5V)			
+15V supply	P4-3	P4-4	+15V (±0.5V)			
-15V supply	P4-6	P4-6	-15V (±0.5V)			
Input A1	P1-1	P1-2	Within ±25mV of Input A2			
Input A2	P1-3	P1-4	Within ±25mV of Input A1			
Input B1	P2-1	P2-2	Within ±25mV of Input B2			
Input B2	P2-3	P2-4	Within ±25mV of Input B1			
Output Current Loop Burden Full-Scale	P3-1	B3-2	10.2V max			

4-6. METERING UNIT INSTALLATION

The location of the metering unit should be determined by the following factors:

- 1.) Ambient air temperature must stay in the range of -10°C to +50°C at all times.
- 2.) The location should not be exposed to direct sunlight.
- 3.) The location should be within reach of the head cables supplied with the system. Standard head cable length is 33 feet (10 meters). Extra long head may also be ordered for special applications.
- 4.) Route interconnection cables away from bus and other high voltages.

Refer to Metering Unit Outline & Mounting drawing at the end of this manual. Anchor the cabinet in the desired location after ensuring adequate cable reach.

Refer to the LKAT System Wiring Diagram. The output cable assembly consists of 22AWG twisted pair cable (5 pairs) with 10 position circular connector on one end, and stripped, tinned wires on the other end. One wire of each twisted pair is white. Only 5 of the 10 wires in the output cable are presently used. Connect the output cable assembly wires to the appropriate points in the process electronics system.

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Section V

THEORY OF OPERATION

5-1. GENERAL

The LKAT system uses open-loop, open-path (OLOP) technology to convert the magnetic field associated with a current carrying conductor into an isolated milliamperere current loop output. This output is scaled to be proportional to the primary conductor current. In addition, a local digital display of the primary bus current (in kiloamperes) is visible on the metering unit main pc board assembly.

The measurement head is a sealed unit and is not designed for repair in the field; however, a working knowledge of the LKAT system theory of operation is essential for timely and accurate diagnosis in the event of problems.

5-2. OLOP TECHNOLOGY

The term “open-loop” means that the magnetic circuit does not employ negative feedback to null the field produced by the primary conductor. The term “open-path” indicates that the sensor is an air-core design, without magnetic core material.

The LKAT system is a practical application of Ampere’s Law, which states: “the line integral of B (magnetic flux density) around any closed path is equal to $\mu_0 I$ (permeability times current)”. In practical terms, this means that integrating a closed path around a primary conductor will yield the net primary current.

This integration is implemented using a specific array of Hall Effect ICs. The LKAT system has effectively minimized errors typical with other open-loop sensors: zero drift, thermal drift, position sensitivity, and susceptibility to external magnetic fields. The absence of a magnetic core practically eliminates errors due to saturation, hysteresis, and core set (remanance) commonly associated with ferrite material.

A generalized block diagram of the LKAT system is shown below.

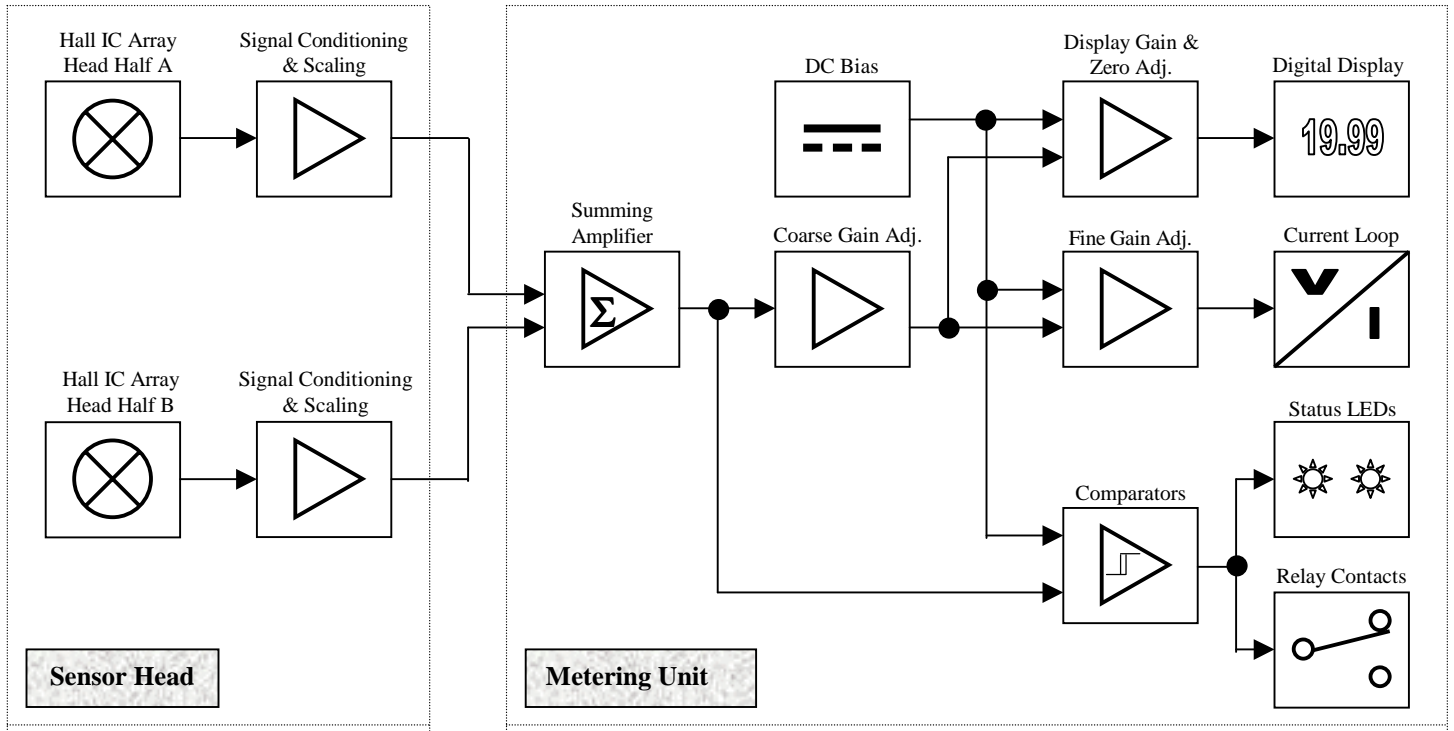


Figure 5-1.
Block Diagram of the LKAT System

5-3. SYSTEM FUNCTIONAL DESCRIPTION

The flux density associated with the primary current is sensed by arrays of Hall ICs in the sensor head. The outputs of these devices are scaled and filtered, then transmitted to the metering unit where these signals are summed, dc biased, and scaled. The coarse gain scaled signal drives separate amplifier circuits for the digital display and current loop output. The Accuracy Diagnostics status LEDs and relay contacts are driven by a signal input that compares the various Hall groups with voltage setpoints. When the Hall group signal exceeds the reference, the green LED will go out and the red LED will illuminate. The relay coil will de-energize under the same conditions.

The Accuracy Diagnostics status LEDs and / or status relay contacts may be used to monitor the following conditions:

- Head imbalance
- Power supply failure
- Head disconnected
- Sensor electronics failure
- Other circuit failures causing loss of measurement accuracy

Occurrence of one or more of the conditions above will trip the relay and change the LED indication from green to red. Refer to the section “Troubleshooting an Accuracy Diagnostics

Fault Indication” in this section for more information about determining the cause and eliminating a fault condition.

5-4. LKAT METERING UNIT

Refer to drawings in the back of this manual. The LKAT metering unit consists of a universal input power supply and main pc board mounted together on a steel U-chassis. Input, output, and power connections are made from outside the enclosure using panel-mount IP67 rated military-style connectors. All wiring harnesses within the metering unit are terminated using 5.08mm “Eurostyle” connectors with captive retention screws.

Input power connects to the power supply pc board assembly. The dc supply includes a slo-blo type fuse, in-rush and overcurrent protection, as well as MOV overvoltage clamping. The power supply provides outputs of $\pm 15\text{Vdc}$ and $+5\text{Vdc}$ required by the system electronics. These outputs connect to the main pc board assembly via a short wire harness.

Connections to the sensor head are made via the main pc board assembly. The u-chassis with power supply and main PC board is mounted on a sub-panel inside NEMA-4X enclosure. The enclosure cover must be securely closed and cable assemblies connected at all times during normal operation.

5-5. HEAD INTERCHANGEABILITY

Measuring heads of various sizes will operate properly when connected to the LKAT metering unit. However, the LKAT system is *factory calibrated as a system*. As a result, optimal measurement accuracy is achieved when the metering unit is connected to the head it was calibrated with, and installed on the size bus bar it was designed for.

5-6. CALIBRATION OPTIONS

The LEM DynAmp LKAT Current Measurement System is factory calibrated for accuracy of 0.75% of full-scale measured current (or better). The recommended calibration period for the LKAT System is two years.

There are several methods to verify LKAT calibration and adjust, if necessary. These include:

- Field Calibration (On Process Bus)
- Field Calibration (On Test Bus)
- Factory Calibration

For Field calibration (with the LKAT head installed on the process bus bar), a reference current measurement system is required. A 0.1% accurate current measurement system, such as the LEM DynAmp LKP or LKB, may be used as a reference. Due to their significantly larger size and mass, it may be difficult to install a comparably rated LKP or LKB measuring

head in close proximity to an LKAT sensor head. When several LKAT sensors of the same size and scaling are used in a rectifier or at the same location, the use of a factory-calibrated LKAT reference may be an acceptable means of verifying system accuracy. Acceptance of this approach typically depends on the accuracy requirements of the measurement application.

LKAT calibration may be performed on a test bus current that is less than the full-scale current of the LKAT System. It is advisable to use a test bus current of 50% (or more) of LKAT System rating. If necessary, LKAT Systems may be returned to the factory for calibration on a test bus at full-scale.

The LKAT current loop bias may be set according to the table below.

**Table 5-1.
SW2 Switch Setting (Output Bias)**

OUTPUT BIAS			SWITCH SETTINGS			
(-) Full-Scale	Zero	(+) Full-Scale	SW2-A	SW2-B	SW2-C	SW2-D
-20mA	0mA	+20mA	Closed	Closed	Open	Open
-12mA	+4mA	+20mA	Open	Open	Closed	Closed
+4mA	+12mA	+20mA	Open	Open	Closed	Open

IMPORTANT NOTE

LEM DynAmp, Inc. assumes no responsibility for the accuracy of LKAT Systems calibrated by any person other than a LEM DynAmp Technician.

5-7. CALIBRATION PROCEDURE

Calibration of the LKAT System may be summarized as follows:

Current Output

- a) Verify SW2 settings (change it required)
- b) Change SW2 settings, if required
- c) Remove tape seal from switch SW1, if necessary. Adjust coarse gain (SW1 & R52)
- d) Adjust zero (R60)
- e) Adjust fine gain (R52)
- f) Readjust zero (if required, R60)

Digital Panel Meter

- a) Adjust zero (R93)
- b) Adjust gain (R99)

The current loop output may be calibrated by using one of the following techniques:

- Null (best) Method
 - Comparison Method
- A. The Null method is shown in the figure “LKAT Calibration”. This requires the LKAT current output be loaded with a burden resistance to produce an output equivalent to the output of the reference system; i.e. 10mV/kA, or similar. The load resistance must have a temperature coefficient of 25ppm/°C or better, and adjustment resolution of 10 milli-ohms.
- B. The Comparison test circuit is connected exactly the same as the “Null Method” except the null meter is omitted. This method compares reading of two voltmeters:
- DMM1 measures and displays the LKAT output.
 - DMM2 measures and displays the Reference Current Meter output.

For best results the two voltmeters should be synchronized so data from LKAT and reference are sampled. When properly calibrated, the readings of the two meters should be equal.

Energize the metering unit (120Vac 60Hz). Allow the head to burn-in for 2 hours at full scale (FS) or a percentage of FS.

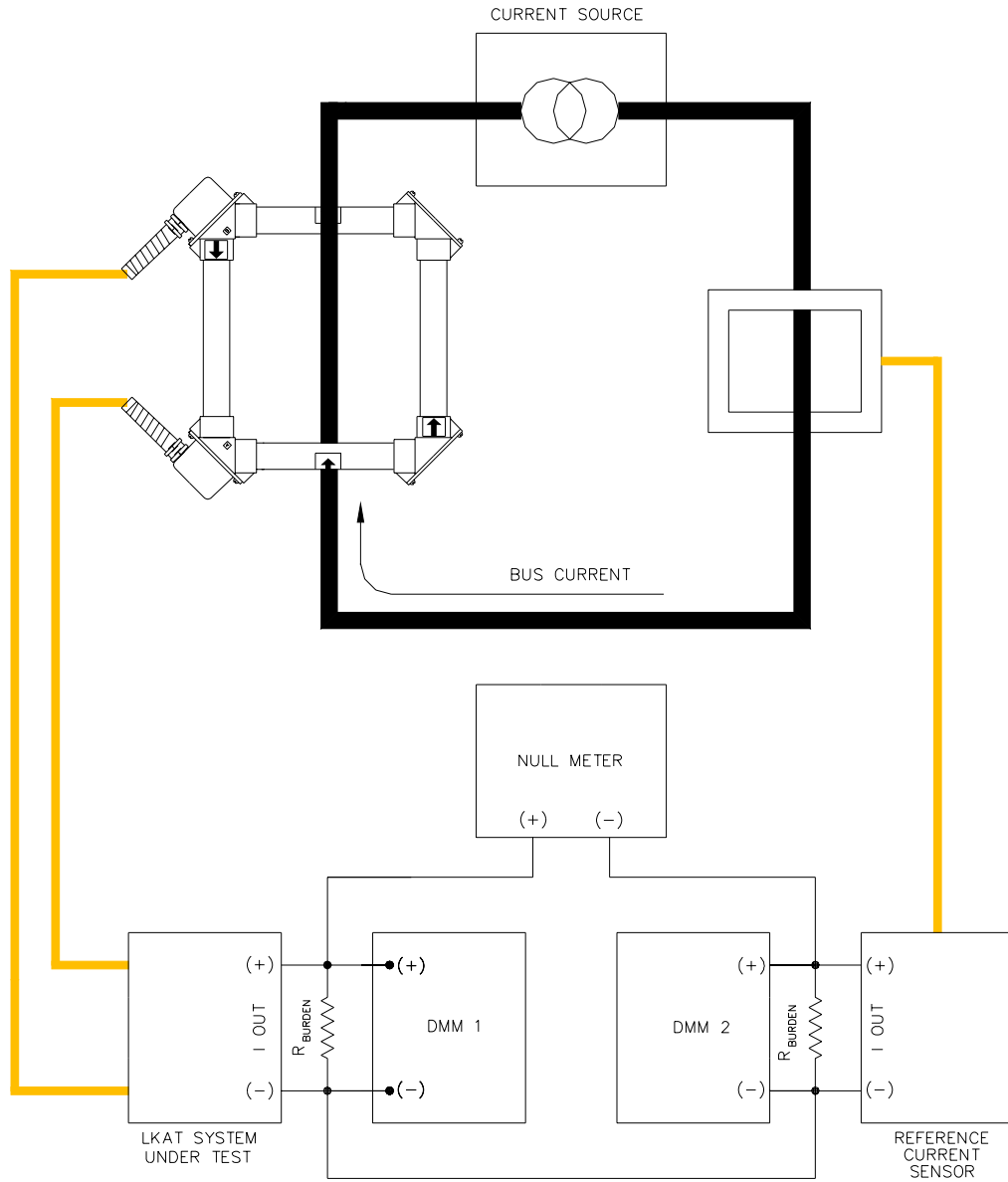


Figure 5-2.
LKAT Calibration-Test Circuit

Main PCB Output Bias:

Table 5-2. Main PCB SW2 Settings

OUTPUT BIAS			SWITCH SETTINGS			
(-) Full-Scale	Zero	(+) Full-Scale	SW2-A	SW2-B	SW2-C	SW2-D
-20mA	0mA	+20mA	Closed	Closed	Open	Open
-12mA	+4mA	+20mA	Open	Open	Closed	Closed
+4mA	+12mA	+20mA	Open	Open	Closed	Open

Set switches to desired output bias specified on Worksheet.

Adjust the Metering Unit Gain & Zero as follows:

1. Refer to Drawing 75A 108464, “Assy, LKAT Main PC Board” and refer to Figure 5-2, “LKAT Calibration”. Place the measuring head around an appropriately sized test bus.
2. Connect DMM across **R_{BURDEN}** in the LKAT current output loop.
3. Adjust Main PCB Output Gain Trimpot R52 full counter clockwise (CCW), then 5.5 turns clockwise (CW).
4. Remove tape seal from switch SW1, if necessary. Monitor the DMM display and adjust Main PCB SW1-1 through SW1-6 to produce a voltage as close to nominal output as possible. SW1 is configured to produce a binary weighted scale factor. SW1 positions 1 through 6 may be set to produce scale factors from 1X to 63X.

Table 5-3. Main PCB SW1 Settings

SW1-	Scale Factor
1	1X
2	2X
3	3X
4	4X
5	5X
6	6X

5. Adjust R52 for nominal output across **R_{BURDEN}** $\pm 0.25\%$.
6. Adjust DPM Gain trimpot R99 for nominal Main PCB DPM display reading.
7. De-energize the bus.
8. For -20mA / 0mA / $+20\text{mA}$ output bias: adjust Main PCB Output Zero trimpot R60 to produce a reading of 0.00mV ($\pm 2.0\text{mV}$) FS across **R_{BURDEN}**.
9. For -12mA / $+4\text{mA}$ / $+20\text{mA}$ output bias: adjust Main PCB Output Zero trimpot R60 to produce a reading of 20% +FS ($\pm 2.0\text{mV}$) across **R_{BURDEN}**.
10. For $+4\text{mA}$ / $+12\text{mA}$ / $+20\text{mA}$ output bias: adjust Main PCB Output Zero trimpot R60 to produce a reading of 60% +FS ($\pm 2.0\text{mV}$) across **R_{BURDEN}**.

11. Adjust Main PCB display zero trimpot R93, produce a reading of 000 (decimal point position varies).
12. Energize the test bus. Set current at Cal Point.
 - Comparison Method:

Adjust R52 for nominal output across $R_{\text{BURDEN}} \pm 0.25\%$ FS.
 - Null Method:

Adjust DPM Gain trimpot R99 for nominal Main PCB DPM display reading.
13. De-energize the test bus.
14. Check output across R_{BURDEN} . If necessary, readjust zero trimpots.
15. Repeat Gain / Zero adjustment until DUT is within tolerance.

Section VI

MAINTENANCE & SPARE PARTS

6-1. PERIODIC MAINTENANCE

As is true with any electronic system, proper maintenance will tend to prolong the service life. LEM DynAmp recommends the following program be performed at the recommended interval to prevent or detect damage to the LKAT system and to ensure reliable performance. Always use appropriate measures to correct any problems found. Following the suggested maintenance schedule may assist in early diagnosis of problem(s) to minimize repairs and down time.

IMPORTANT NOTE:

If the red status LED illuminates and / or the status relay coil deenergizes, a fault condition may exist in the LKAT electronics. When this occurs, the system may require immediate attention. Refer to “Troubleshooting Fault Indication”, in the “Theory of Operation” section of this manual.
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6-2. ANNUAL MAINTENANCE

The recommended calibration period for the LKAT System is one year. Refer to the “Calibration” section of this manual.

If possible, perform the steps described in section titled “SYSTEM CHECKOUT DURING TEMPORARY INSTALLATION” at least once per year to verify performance of the LKAT system. This may help to prevent or detect damage to the system and to ensure reliable performance. Use appropriate measures to correct any problems found. If LKAT system equipment is exposed to outdoor temperatures, LEM DynAmp recommends these steps be performed during the hottest time of the year.

In addition, the following steps should be performed once each year as part of annual maintenance:

- 1.) Visually inspect measuring head and interconnection cable for evidence of severe overheating, cracks, separation of bonded surfaces, or excessive corrosion. Record any suspect conditions.
- 2.) Inspect and adjust the tension of the mounting clamp plungers as needed.
- 3.) Inspect the condition of the pins and sockets on the cable assemblies and mating receptacles. Clean out any corrosion.

- 4.) Visually inspect metering unit and signal converter(s) for evidence of severe overheating, excessive corrosion, or condensation. Record any suspect conditions and take appropriate action.
- 5.) Clean as necessary; remove any oil or grease with a mild detergent or cleaner solvent. Do not use strong chemical solvents as they may damage the cables or erase the silk-screening from the metering unit.

CAUTION

To avoid the risk of shock and electrocution, always disconnect all cable assemblies before performing any cleaning or service operation on the metering unit.
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6-3. RECOMMENDED SPARE PARTS

The following table lists the minimum recommended quantities for spare parts for the LKAT system. As spares are used, replacements should be ordered. Since continuous operation of high-current measurement systems is often critical, stocking spare parts should be given high priority.

The cable assemblies for the LKAT system include circular connectors. If connector(s) are severed from the associated cable assembly, field installable replacement connectors may be purchased. Complete replacement cable assemblies may be purchased for the power input and output cables. Head cable connector(s) must be replaced by field installable type(s), or with a new head. Refer to Spare Parts List below.

The LKAT system measuring heads require special repair procedures and materials. However, the heads are very reliable and should require little or no repair over its service life. Please refer to the nearest authorized LEM service center for information on repairs.

**Table 6-1.
Spare Parts List**

DESCRIPTION	ITEM NO.	QUAN.
Fuses, 2A 250V Slo-Blo 5mm x 20mm (5 per box)	43054	1 box
PC Board Assembly, LKAT Power Supply	43027	1
Cable Assembly, LKAT Input Power 10m (33ft) one end terminated	43098	1
Cable Assembly, LKAT Output 30m (100ft) one end terminated	43100	2
Connector, Head Cable 9 Position Circular, solder cup	43265	2
Connector, Output Cable 10 Position Circular, solder cup	43267	1
Clamp Assembly, LKAT Mounting (includes 2 plungers)	43282	2
Plunger, LKAT mounting 1/4-28 x 1" body, 1/8" hex drive	43281	2
Head & Metering Unit Spare System (calibrated as system)	43114	1

6-5. SERVICE ASSISTANCE AND COMMUNICATION PROCEDURES

If operational problems arise which cannot be resolved by review of all related procedures given in this book, please contact "Service" at LEM DynAmp.

NORMAL BUSINESS HOURS: 8:00 am to 4:15 PM, USA EASTERN TIME ZONE, * Monday through Friday.

* **Greenwich Mean Time**, normal working hours Monday through Friday:
From last Sunday in October to last Sunday in April; 13:00Z to 21:15Z
From first Sunday in April to last Sunday in October; 12:00Z to 20:15Z

TELEPHONE 614-871-6900: Our automated answering service will accept your messages at all off-hours including weekends. Phone in and follow instructions for non-emergency service. We receive those messages at 8 am on the next normal workday. We will respond at the earliest time possible, within your time zone and normal workday.

FACSIMILE 614-871-6910: Automatic reception during all hours.

NOTE

If you are experiencing downtime or other circumstances that are truly critical during our off-hours (see above), and wish to telephone us, please telephone at 614-871-6900 and follow the instructions for EMERGENCY SERVICE. You will be contacted within 30 minutes. We cannot, however, guarantee that service assistance will be available at any given off-hour time.

When we are reached by phone, our first step will be to provide over-the-phone assistance, at no charge. If the problem cannot be resolved by telephone, we will arrange for service at your site or by shipment to LEM DynAmp, as you request. We will make every possible attempt to quickly support your emergency, on-site needs regardless of how contacted.

Section VII DRAWINGS

**Table 7-1.
Drawing List**

DRAWING TITLE	NUMBER
Wiring Diagram: LKAT System	83A108386
Wiring Assembly: LKAT Metering Unit Wiring Harnesses	83A108399
Assembly: LKAT Metering Unit	84B108400
Assembly: LKAT Main PCB	75A108464
Clamp: LKAT Mounting (Inside Half)	81A043271
Clamp: LKAT Mounting (Outside Half)	81A043272
Outline and Mounting: LKAT Sensor Head	02B108390
Outline and Mounting: LKAT Metering Unit	02B108389