



DynAmp

MODEL LKB-45 & LKB-60
BI-DIRECTIONAL CURRENT METERING SYSTEMS

Installation, Operation and Service Instructions

Manual Item No. 041706

Rev. K



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DynAmp, LLC 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.

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This manual includes detailed drawings, installation, operation, service and maintenance. Users should evaluate the information in the manual and their particular application. DynAmp assumes no liability for any incidental, indirect, or consequential damages arising from the use of this documentation.

While all information presented is believed to be reliable and in accordance with accepted engineering practices, DynAmp makes no warranties as to the completeness of the information.

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The LKB Series 6 Channel includes the LKB-45 and LKB-60 Metering Units. These Metering Units conform to the latest European directives and standards concerning safety and electromagnetic compatibility.

Application of Council Directive(s):

73/23/EEC, 89/336/EEC and 93/68/EEC.

Standards to which conformity is declared:

EN50081-2 utilizing method EN55011: Radiated and Conducted Emissions for Heavy Industrial Environments, Class A.

EN50082-2: Radiated and Conducted Immunity Tests for Heavy Industrial Environments.

Safety Standards:

EN 61010-1: Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use.



Note

According to EN 50082, the manufacturer must state the degradation of performance level acceptable during immunity tests. Unless otherwise noted in the manual or data sheet, DynAmp limits degradation during immunity tests for this equipment to < 0.5% FS for A-criterion tests.

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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 door must remain closed at all times during operation to ensure safety of personnel. A set of keys are provided for locking the door. Only authorized personnel or technicians should be allowed to open and service the unit.

Disconnect power to the system before servicing or replacing fuses.

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

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



HAZARDOUS VOLTAGE

This equipment is designed to be connected to hazardous electric 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 55°C.

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.



The CE mark proves the compliance of the equipment with the requirements of the directives.

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DynAmp, LLC Customer Support

For further assistance, contact DynAmp Customer Support at:

Americas:

Telephone: +1 614.871.6900

Fax: +1 614.871.6910

8:00 AM to 5:00 PM USA Eastern Time

From first Sunday in November to second Sunday in March – 13:00 GMT to 22:00 GMT

From second Sunday in March to first Sunday in November – 12:00 GMT to 21:00 GMT

Europe:

Telephone: +41 22.706.1446

Fax: +41 22.706.1311

8:30 AM to 5:00 PM Central European Time

From last Sunday in October to last Sunday in March – 7:30 GMT to 16:00 GMT

From last Sunday in March to last Sunday in October – 6:30 GMT to 15:00 GMT

After Hours Critical Service Emergency:

Telephone: +1 614.871.6906

5:00 PM to 8:00 AM USA Eastern Time

From first Sunday in November to second Sunday in March – 22:00 GMT to 13:00 GMT

From second Sunday in March to first Sunday in November – 21:00 GMT to 12:00 GMT

Central e-mail:

help@dynamp.com

DynAmp web:

www.dynamp.com

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REVISION PAGE

<u>Page</u>	<u>Rev</u>	<u>Reason For Revision</u>	<u>Date</u>
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2,5	Rev A	Added fuse table, and RATED power specification	02/98
14,31	Rev B	Revised spare lamps, relay, and revised dwgs 108053, 108124, 108109.	07/98
all	Rev C	Warranty, Resistance chart error, Relay contacts, add Options drawing, Installation, Technical Bulletins List and updated drawings to current revisions.	12/02
25, 33	Rev D	Updated Accuracy Diagnostics & Spare Parts Section	03/02
iii, 7	Rev E	Updated Warranty and Installation paragraph	10/03
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	Rev H	Update Drawing List / ECO 3213	04/09
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1. SAFETY

This equipment is designed to be connected to hazardous electric voltages. Ignoring the installation precautions and warnings can result in severe personal injury or equipment damage. Also, the equipment is heavy and requires special handling procedures to ensure the safety of both personnel and equipment itself. The following are general guidelines that should be followed when installing, operation and servicing the Metering Unit and 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.
- Service must be performed by qualified technicians only. If use of an oscilloscope becomes necessary during servicing, the scope must be floating and not grounded. 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
- Do not place in the rain, or under water, or submerge any part of the Measuring Head or Metering Unit. The Measuring Heads are splash proof but are not waterproof.
- The surface on which the Measuring Head is mounted must be sound and capable of supporting the head. Fasteners used must be capable of supporting the weight of the head.
- **Make sure that the cables are disconnected from the head during installation.**
- The Measuring Heads are supplied with connector covers, which must be used whenever the head cables are disconnected from the head. The covers are necessary to prevent dust and water from entering the Measuring Heads. The covers also prevent fingers from contacting the connector pins during installation, which can carry hazardous voltages if the head is installed on a live bus.
- If the installation is to be made on a "live" bus, the Measuring Head cables must be disconnected from the head. A condition hazardous to the Measuring Head and any person handling un-insulated cable-lead terminals will result if metal parts of the head contact the bus, or sudden changes in the bus current occur. Personal protective gear should be worn when reconnecting cable back to Measuring Head. **Please refer to installation section for head storage on a live bus.**
- Measuring Head should be electrically isolated from the bus bars. A ¼" (6mm) minimum distance between the bus and window insulation should be maintained. This will insure electrical isolation of the head structure from the bus. The head itself is grounded via the cables to the Metering Unit. Refer to the "Installation Consideration" section of the manual for more details.
- An external circuit breaker or fuse with proper rating is required for branch circuit protection when wiring the main circuit to this Metering Unit. Each Metering Unit must have its own breaker. Use a wire and breaker or fuse (time-delay) sized adequately for the maximum burden of 20 VA/kA of measured current. The wire should have an insulation rating of 600Vac and 80°C minimum temperature rating.
- Replace fuses with correct type, size and value. All channel fuses are Type MDA time delay fuses 3AB style, 1/4" x 1-1/4" (6.3mm x 32mm). Refer to the servicing instructions or spare parts list for more information on replacement fuses. Do not

bypass the fuses or modify the electronics. Disconnect power to the System before replacing fuses. Failure to follow these instructions will result in intermittent operation and premature failure and will void the warranty.

- Metering Unit covers must be present or, when equipped, enclosure doors must remain closed at all times during operation to insure safety of personnel. A set of keys is provided for locking enclosure doors. Only authorized personnel or technicians should be permitted to open and service the unit.
- Bus current must be zero when taking resistance measurements.
- Use of the equipment in a manner not specified by the manufacturer can impair the protection provided within.

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

2. HANDLING AND STORAGE

DynAmp products are engineered and manufactured for use in industrial environments. However, they contain sensitive electronic and mechanical components which may be damaged and fail if not handled and stored properly. All products must be handled and stored with the same care as any precision measurement instrument. Severe bumps or jolts may damage internal parts and cause malfunction or premature failure. DynAmp products are designed and assembled with conformal coating, shock mounting, and environmental seals, when appropriate or when specified. However, this protection requires that the product must be properly installed and operational before the protection is fully functional. Therefore, adequate protection from humidity, shock, and temperature must be provided during handling and storage prior to installation.

The handling and storage of equipment must be sufficient to meet the storage temperature and humidity specifications of the product and to prevent any condensation or contact with water or any other liquid. The storage location and container or crate must provide adequate protection from precipitation (rain, snow, ice) and direct water contact. Adequate shelter must be provided to prevent the accumulation of precipitation (rain, snow, ice) and water which can lead to the deterioration or failure of shipping containers or crates and cause water ingress. Storage in coastal or industrial areas subject to salt-laden or corrosive air or areas of wind-driven sand or other abrasive dust must be adequate to prevent the deterioration or failure of shipping containers or crates and cause ingress. Frequent inspection of storage areas and storage containers or crates is required to ensure proper storage conditions are being maintained.

If the shipping container or crate is opened and/or the equipment is removed for inspection prior to installation, the equipment must be repackaged in the original undamaged container or crate in the same manner as it was shipped to prevent environmental damage or placed in a storage location that meets the required environmental and storage conditions.

General product storage temperature and humidity requirements:

Storage Temperature: -40 to 70°C
 -40 to 158°F

Storage Humidity: 85%, non-condensing

DynAmp, LLC does not assume liability for the customer's failure to comply with handling and storage requirements.

For further assistance, contact DynAmp customer support.

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3. DESCRIPTION

3.1 OVERVIEW

The DynAmp LKB Series 6 Channel are systems for accurately measuring bi-directional currents in a bus. The Models in this series are: LKB-45 and LKB-60. Each model consists of a two-piece Measuring Head, a Metering Unit, and two multi-conductor cables.

3.2 MEASURING HEAD

A magnetic core encircles the bus passing through the center of the Measuring Head. Magnetic null detectors are mounted in air gaps in the core. Each null detector is flanked by coils located on the magnetic core.

The Measuring Heads are constructed of cast aluminum with a tough powder coating finish, insulation from the bus being provided by a layer of high-grade polymer. The head halves are easily joined around the bus by use of 8 bolts.

The LKB Bi-Directional Current Metering Systems uses the LKP Measuring Heads. This manual may use either the LKB or the LKP model name for the Measuring Heads.

The LKP-60 Measuring Head is provided with mounting feet as standard equipment. The mounting feet facilitate the mounting of the heads vertically on the floor or on a platform. The LKP-45 head can be provided with mounting feet or with a bus bar mounting kit; both are optional.

3.3 METERING UNIT

The Metering Unit is housed in a standard NEMA type enclosure. In addition to the electronic circuitry (mounted on the internal heatsink), the Metering Unit contains terminals for all external connections. The Metering Unit requires 120/240 Vac, 50 or 60 Hz power. Burden on the supply circuit will not exceed 1500 VA. A thermo-magnetic circuit breaker is mounted on the inside of the enclosure and serves as the power on-off control. The Metering Unit should be located indoors where the ambient air temperature is within -20°C to +55°C at all times.

3.4 CABLE

Standard 33-foot (10 meter) interconnecting cables are supplied with each system (longer cable lengths are available - consult the factory for details). Each of the individual conductors is tagged with a numbered label corresponding to a terminal block connection, providing an easy hookup to the Metering Unit. Keyed connectors are provided on the Measuring Head side of the cables to ensure correct hookup.

3.5 ELECTRICAL

Five outputs are provided by the system:

1. A standard voltage output of 10 mV/kA, at TB1-3 and TB1-4.
2. An optional secondary voltage output, at TB1-1 and TB1-2.
3. A current output of 1 A_{dc} per 5 kA of bus current, at TB1-8 and TB1-9. The current output is available by removing a jumper connected across the TB1 terminals (do not remove the jumper while the system is energized). Maximum allowable voltage drop across the terminals is 5 V_{dc} at maximum bus current.
4. A normally-open (N.O.) contact for the Metering Unit over-temperature alarm, rated at 125 V_{ac}, 6 A, at TB1-60 and TB1-61.
5. A normally closed relay contact for ALARM STATUS output at TB1-62 through TB1-64.

NOTE
TS (Terminal Strip) and TB (Terminal Board) are used interchangeably throughout the manual and drawings.

4. SPECIFICATIONS

**TABLE 4.1
LKB SERIES 6 CHANNEL SPECIFICATIONS**

MODEL	MAX. FULL-SCALE RANGE*	MEASURING HEAD WEIGHT	METERING UNIT WEIGHT
LKB-45	45 kA	172 lb. (78 kg)	300 lb. (136 kg)
LKB-60	60 kA	297 lb. (135 kg)	300 lb. (136 kg)

Ambient Temperature Range of Measuring Head	-20°C to 55°C
Ambient Temperature Range of Metering Unit Location	-20°C to 55°C
Humidity (head and Metering Unit)	85% maximum
AC Line Voltage at 50 or 60 Hz $\pm 5\text{Hz}^{**}$	120/240 Vac +10%, -15%
Burden on ac Line (maximum)	20 VA/kA (1500VA maximum)
Maximum Allowable Burden of Output Circuit	5 volts
Linearity Error♦	$\pm 0.03\%$ of full scale from 5% to 100% of bus current.
Repeatability Error Limits♦	$\pm 0.02\%$ of full scale plus zero error. ♦♦
Temperature Sensitivity	$\pm 0.002\%/V @ 120V \text{ ac}$
Line Voltage Sensitivity	$\pm 0.001\%/V @ 120V \text{ ac}$ $\pm 0.0005\%/V @ 240V \text{ ac}$
Measuring Head To Bus Isolation♦♦♦	6kVac for 1 minute with 25mm air gap. See notes below.
Installation Category	III
Pollution Degree	2

- * Contingent upon DynAmp, LLC computer analysis of bus system.
- ** The LKB systems are factory-set for the correct voltage (120/240 Vac) and frequency (50/60 Hz) per customer order.
- ♦ When tested at 120 Vac, less than 1 V burden, 24°C ambient.
- ♦♦ Typical zero primary current errors (bus equiv.) for each model are shown in table 4.2.
- ♦♦♦ With bus passing through window insulation at 90° to the head.

**TABLE 4.2
LKB SERIES 6 CHANNEL SPECIFICATIONS, CONTINUED**

OUTPUTS	
Current output:	1 A/5 kA, $\pm 0.1\%$ full scale
Voltage output, ALL	10mV per kA of bus current, $\pm 0.1\%$ full scale

PHYSICAL	
Overall Dimensions, in. (mm):	
LKB Metering Unit (all)	42(1067) H x 30 (763) W x 10 (254) D
LKB-45 Measuring Head	30.4 (772) H x 33.4 (839) W x 6.4 (170) D
LKB-60 Measuring Head	35.6 (905) H x 39.7 (1008) W x 9.8 (250) D
Aperture Dimensions in. (mm):	
LKB-45 Measuring Head	20.8 (530) H x 20.8 (530) W
LKB-60 Measuring Head	23.4 (595) H x 23.4 (595) W

NOTE
The Measuring Head window insulation rating is directly proportional to the clearance of the head to the bus. For instance, a bus in direct contact with the window insulation of the head will have an insulation rating of 6kV. A clearance of 1" increases the window insulation rating to 12 kV. Thus, the greater the distance through the air between the bus and the head, the greater the insulation rating will be.

**TABLE 4.2
TYPICAL ERROR AT ZERO BUS CURRENT***

Models	Max. Core Set
LKB-45	± 6.75 amperes
LKB-60	± 9 amperes

**TABLE 4.3
LKB SERIES FUSE CHART**

Manufacturer & Type	Rating	Where Used
BUSS, MDA4	250V, 4A, Slo-Blo	Terminals, TB2 -11, TB2-18, TB2-22, and TB2-27
BUSS, MDA4	250V, 4A, Slo-Blo	Channel Amplifier PC Boards
BUSS, MDA15	250V, 15A, Slo-Blo	$\pm 15V$ Power Supply PC Board

* See section concerning magnetic effects of external buses.

5. INSTALLATION

5.1 HANDLING PRECAUTIONS

Even though the LKB Series systems are large and rugged, they should be handled with the same care as any precision measuring instrument. Larger Measuring Heads are quite heavy, and adequate handling equipment must be available. Severe jolts or bumps to the head or Metering Unit may cause movement of internal parts, and possibly a malfunction. It also advisable to avoid supporting the head-halves by the windows insulation. The window insulation is tough, but brittle. **Personnel involved in the installation should be experienced with equipment of similar size and weight. They should also 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 DynAmp, LLC immediately.

5.2 MAGNETIC CONSIDERATIONS: MEASURING HEAD

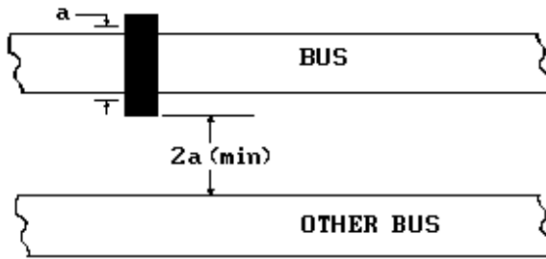
The LKB metering systems are designed and built for accuracy, stability, and reliability. However, these factors may be adversely affected by the arbitrary location of the Measuring Head without regard for magnetic fields. Secondary magnetic fields emanating from angled sections of the bus being monitored or from other nearby buses may cause overheating. Currents from other buses produce magnetic fields, which can sometimes cause zero offsets and errors at low current levels. To guard against these problems, you can have a computer analysis of your bus system made, or you can follow the guidelines presented in this section.

FREE BUS ANALYSIS

The general guidelines below should be applied only when a detailed analysis of your bus system is not available. DynAmp, LLC 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 is ordered. In this way you are assured that your LKB system will function properly.

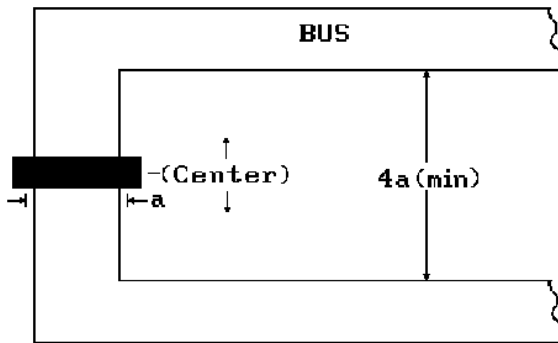
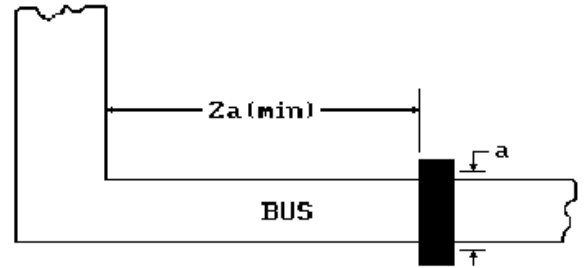
Whenever possible, the head should be installed on the longest straight run of the bus that is available in an area free of other bus structures. General guidelines requiring consideration when installing a Measuring Head are shown in figure 5.1 (guidelines illustrated are to be considered as the minimum required distances). If the proposed head location can be physically described by more than one of the diagrams (figure 5.1), a bus analysis should be performed. For the guidelines of figure 5.1 to apply, the **bus** height-to-width ratio should equal the **head aperture** height-to-width ratio, within $\pm 10\%$. This ratio does not affect the accuracy of the measurement, but it does affect the loading of different sections of the Measuring Head.

a = maximum aperture dimension



The head should be a minimum distance of $2a$ from another bus carrying equal or less current. If the other bus carries higher current, the distance should be greater, e.g., $3a$.

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 must be a minimum of $4a$, 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 minimum distance of $4a$ from the joining point.

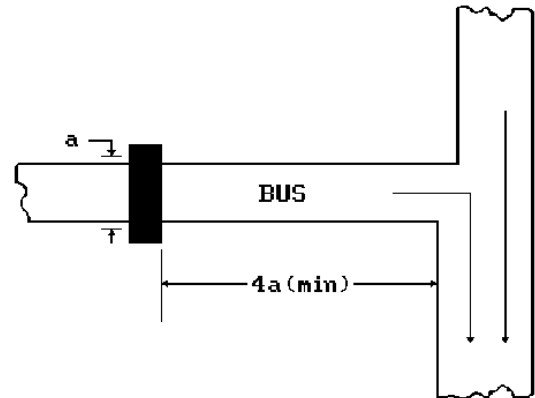


Figure 5.1 General Guidelines for Locating Measuring Heads

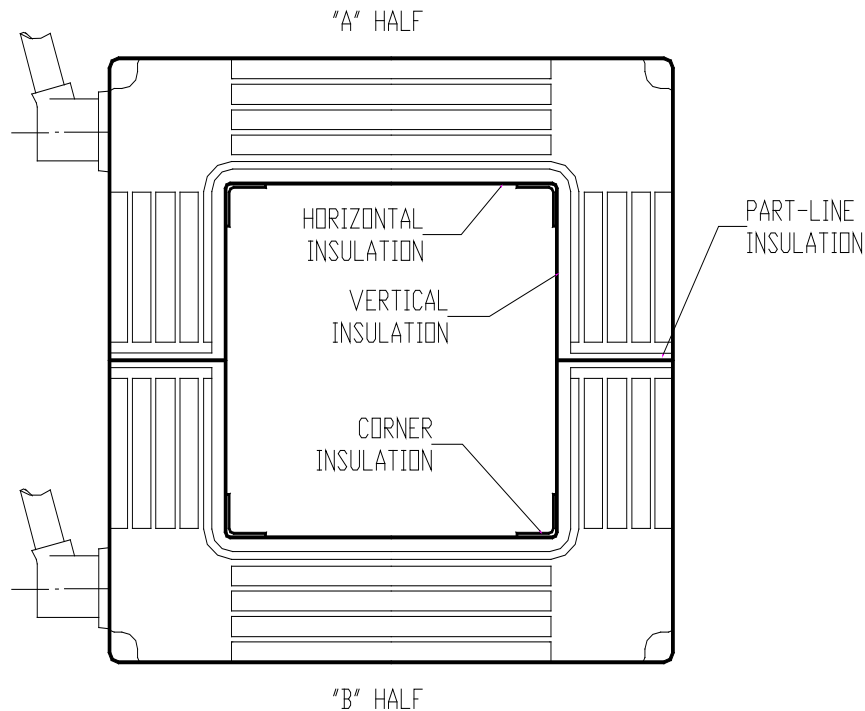
5.3 HEAD INSTALLATION

Before actually installing the Measuring Head on the bus, the head may be checked for proper operation first, if desired. This is accomplished by connecting the entire system as explained in this section, and then performing the head checkout procedure described in the "Magnetic Centering" section with the head removed from the bus. After the procedure is complete, the head should be mounted according to the instructions in this section.

Check the mating faces of the Measuring Head. Make absolutely certain that the serial numbers of both halves of the head match, otherwise you may cause misalignment and unit failure. Use only a small brush or cloth to remove any dirt particles from the head part-line insulation, multi-conductor connector, and latch areas.

NOTE

When installing the Measuring Head, protect the window insulation from impact, and do not let the weight of the Measuring Head rest upon the window insulation as it can be easily damaged. Also, the interconnecting cable is of top quality, but it is not armored. Protect it from abrasion and sharp edges.



**Figure 5.2 Window Insulation Description
Typical For LKB Series Heads.**

CAUTION: The part-line insulation pieces (located on the mating surfaces of the head) are brittle and can be easily damaged if one is not careful during installation. Mount the Bottom half of the head on the floor or platform and secure it in place temporarily. An arrow indicates the direction that conventional bus current must flow through the aperture (+ to -). Place the upper half of the Measuring Head over the bus. Connect the bottom half of the head to the top half using the M8 bolts (provided). Tighten the bolts until snug. Do not over-tighten. Since the bolts are stainless steel, it is recommended to lubricate the bolts before installation to prevent them from sticking or seizing. A dry “Moly” type lubricant is recommended. Also, make sure that the serial number on the top half of the Measuring Head matches the serial number of the lower half, and that the halves go together squarely and evenly without forcing, twisting, or cocking. If for some reason the head halves do not press tightly together, do not try to force the heads closer together as it might lead to damage. Check for obstacles preventing the head from mating properly. Mounting the

head backward will not damage the equipment, however, the meter will read zero. After final positioning of the head, secure the mounting feet permanently to the floor or platform.

NOTE

The head must be installed with current arrows in the same direction as conventional current flow in the bus. No damage will occur if the head is reversed, but the system will produce an output with polarity opposite to what is expected.

5.4 INSTALLATION CONSIDERATIONS

In general, the head can be installed vertically, horizontally, or in any intermediate orientation. The Measuring Head is equipped with several mounting holes that can be used to bolt the head to a wall or support frame around the bus. Alternatively, optional mounting feet can be purchased that can simplify mounting the head to a platform or wall. Also available, are bus bar mounting kits that allow the LKB-15 or LKB-30 heads to be mounted directly onto a bus bar. These kits eliminate the need to assemble any additional mounting platforms or brackets. The prime considerations in all mounting cases are as follows:

Read and follow the following considerations before mounting the head. These detailed in Technical Bulletin No. 9907 titled “LKP & LKB Sensor Mounting Guidelines and Restrictions.”

- A.) Choose a mounting location where the ambient air temperature does not exceed 55°C. The standard head is designed for indoor use only and should be kept away from high heat and corrosive atmospheres. Protect the head from direct sunlight which causes the head temperature to rise, thus limiting the upper operating range in some applications. If the head is to be installed in a harsh environment, please discuss protective measures with the factory.
- B.) The head must be protected from water. The LKP and LKB sensor head designs rated 15 kA and higher are tested to meet IP 64 when manufactured, indicating protection from splashing water from any direction. However, this rating is not a blanket approval for simply installing it outdoors without additional water protection. The Measuring Heads are splash proof but are not waterproof. Classification IP64 acknowledges that some water may penetrate the seal. Water that invades the sensor is likely to cause long-term destruction. Consequently, it is necessary to provide some rain and snow protective covering if the equipment is to be mounted outdoors or in the vicinity of a sprinkler system.
- C.) To minimize distortion of the magnetic field as seen by the head, temporary and final support members should be nonmagnetic (for example, aluminum beams, struts or stranded cables, or wood, fiberglass, or Phenolic where appropriate). It is recommended to keep large structural magnetic materials at least 2 meters distant from the Measuring Head. For additional details, refer to Technical bulletin No. 987 titled “Ferromagnetic Materials Near LKP or LKB Current Sensors.”
- D.) The head is designed to be supported from the bottom. The top half should be attached to an anti-tipping brace. **Never suspend the head by the top half alone.** If the heads are to be mounted in a position other than vertical, each half of the head should be independently supported. Additional drilling of the head is NOT authorized, as damage may result.

- E.) When mounted, the two head halves of the head should be in the same plane so no distortion of the part line will occur. No tension, twist, or excessive pressure should be applied to the part line.
- F.) The head should be electrically insulated from the bus. A 6mm (1/4") minimum distance between the bus and window insulation should be maintained in dry, clean air. More separation should be maintained if the bus voltage is greater than 1000 Volts or if the air quality is bad. This will insure electrical isolation of the head structure from the bus. **The aluminum head structure is grounded via the cables to the Metering Unit. Do not short between the head structure and the bus to prevent serious damage or injury.** For that reason, always disconnect the cables from the head prior to installation or maintenance. Touching both an energized bus bar and grounded Measuring Head may result in electrical shock.
- Most models interconnection cables have a GRN/YEL wire that is used for head grounding. To electrically float the head above ground potential, the GRN/YEL wire from each cable must be disconnected at the Metering Unit. Note that for safety reasons, the Metering Unit cabinet should be grounded at all times.
- G.) Do not loosen any of the bolts that hold the head casting sections together. Doing so, will compromise the seal between parts and allow water or contaminants to enter the head.
- H.) The head should be installed with current arrows in the same direction as conventional current flow in the bus. 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 an LKB system will produce an output with polarity opposite to what is expected.
- I.) CAUTION: The part-line insulation pieces (located on the mating surfaces of the head) contain sensitive electronic devices, are brittle, and can be easily damaged if one is not careful during installation.
- J.) Make sure that the serial number on the top half of the Measuring Head matches the serial number of the lower half, and that the halves go together squarely and evenly without forcing, twisting, or cocking.
- K.) Try to mount the head in an area free of other bus bars. This is not an essential requirement if a satisfactory magnetic centering can be achieved.
- L.) Final head position will be determined by the magnetic centering process, so the head support members should be temporary at first. If a bus analysis has not been performed, the head should be geometrically centered on the bus during the initial installation. If a bus analysis was performed, follow the recommendations for initial positioning, and also perform the centering process.
- M.) After final magnetic centering, the head must have adequate support.

Sudden changes or shutdown of bus current can induce high voltages in open coil circuits inside the Measuring Head. This is a risk of shock if someone is in contact with the connector pins during the event. There is a slight possibility of connector or coil damage if the Measuring Head is left un-operation (stored) for prolonged periods on a live bus with frequent fluctuations. The following precautionary measures must be taken to prevent damage and risk of shock.

Best option is to leave the cables connected between Metering Unit and Measuring Head. Even if the Metering Unit is not powered, it will shunt induced currents in the coil and

prevent high voltage from developing. If that is not feasible then use one of the following options:

- i. The Measuring Head cable leads from the channel feedback coils must be shorted together and isolated from all other cable leads and ground wire to prevent induced high voltages on the coil leads. Refer to the Head Resistance Chart and /or schematics for coil circuit wire numbers.

Warning : Keep all exposed head cable leads from touching the bus, ground, or any support structures.

- ii. Consult with DynAmp about using a shorting plug at each connector.

5.5 INSTALLATION PRECAUTIONS (LIVE BUS)

If the unit is to be installed on a live bus, the following precautionary measures must be taken before installing the Measuring Head:

- a. Connect the cables to the Measuring Head and then connect the other end to Metering Unit, or follow steps b and c.
- b. The Measuring Head cable leads from the channel feedback coils must be shorted together and isolated from all other cable leads and ground to prevent induced high voltages on the coil leads. (14, 15, 16, 17)
- c. Magnetic sensor leads must be isolated from ground and all other leads. This can best be accomplished by taping over the individual lead connections. (6, 7, 8, 9, 10, 11, 12, 13)

Always follow all local and plant safety procedures.

WARNING

If the installation is to be made on a "live" bus, the Measuring Head cables must be disconnected from the head. A condition hazardous to the Measuring Head and any person handling un-insulated cable-lead terminals will result if metal parts of the head contact the bus.

5.6 COMPLETING THE HEAD INSTALLATION

With the head temporarily installed and bus current off (or the head removed from the bus for verification prior to installation), complete the following steps.

1. Connect the interconnecting cable directly to the Measuring Head. Note that the connectors are keyed and can only be connected one way.
2. Before connecting the other end of the interconnecting cable to the Metering Unit, perform the ohmmeter tests in table 5.1. The tests are made from the open end of the cable, looking back towards the Measuring Head. Record these values for future reference.

NOTE

You cannot get good ohmmeter readings if the head is on a live bus. The coils pick up induced voltages from any rectifier ripple. The Hall plate resistance changes in a high magnetic field.

**TABLE 5.1
MEASURING HEAD RESISTANCE CHART
LKB-45 & LKB-60**

Measure Between Leads:	Desired Value (Ohms)	Circuit
CABLE TO "A" HALF OF HEAD		
24 & 29	22-24	Coil Circuit - Channel #1A
25 & 30	10.5-12	Coil Circuit - Channel #2
26 & 31	10.5-12	Coil Circuit - Channel #3
27 & 32	22-24	Coil Circuit - Channel #4A
21 & 19	3-4 k	Hall Current - Channel #1
21 & 19	3-4 k	Hall Current - Channel #2
22 & 20	3-4 k	Hall Current - Channel #3
11 & 12	200-450	Hall Signal - Channel #1
13 & 14	200-450	Hall Signal - Channel #2
15 & 16	200-450	Hall Signal - Channel #3
CABLE TO "B" HALF OF HEAD		
53 & 56	22-24	Coil Circuit - Channel #4B
52 & 58	10.5-12	Coil Circuit - Channel #5
49 & 55	10.5-12	Coil Circuit - Channel #6
48 & 54	22-24	Coil Circuit - Channel #1B
47 & 45	3-4 k	Hall Current - Channel #4
46 & 44	3-4 k	Hall Current - Channel #5
46 & 44	3-4 k	Hall Current - Channel #6
40 & 41	200-450	Hall Signal - Channel #4
36 & 37	200-450	Hall Signal - Channel #5
38 & 39	200-450	Hall Signal - Channel #6

NOTE: All resistances are measured by lifting cable leads at the Metering Unit and connecting ohmmeter between designated cable conductors. For Metering Units with two cables, each cable is measured separately when checking the hall plate supply resistances.

* These resistance readings are the room temperature values of the copper channel coils. Measured values can be 50% higher if head is hot and/or cable length is longer than 30 feet.

** Remove the protection relays (DPDT) from the relay sockets located on the main panel before making the resistance measurements.

5.7 METERING UNIT INSTALLATION

The location of the Metering Unit should be determined by the following factors:

- A. An indoor location where the ambient air temperature is within -20°C to $+55^{\circ}\text{C}$ at all times should be used.
- B. The location should be within reach of the head cable length to be routed.
- C. The location should be approximately 8 feet (2.5 meters) or more from high current bus bars. (Some installations have been made much closer to high current buses without difficulty, but the distance given is on the safe side.)
- D. Mount the Metering Unit on a wall, column, instrument panel, or other convenient location (refer to outline and mounting diagram in the back of the manual).
- E. The ventilation chimney through the Metering Unit requires 6 in. (150mm) free air space above and below the enclosure.

5.8 METERING UNIT WIRING

Terminate all conductors from the head as shown in the interconnection diagrams in the back of this manual. As an aid to wiring, each conductor is identified by a numbered sleeve (or imprinted numeral), which corresponds to the correct terminal destination. You should always use the wire numbers when making connections as wire colors may vary, or appear different under certain lighting conditions. If the wire ends get damaged and require re-stripping, use high quality wire strippers and set the strip length to 0.39" (10mm).

Install and connect the output-monitoring devices to the appropriate terminals at the Metering Unit. If current output is used, remove the factory-installed jumper between terminals TB1-8 and TB1-9 and connect the desired current output circuitry, using an adequate wire size. Make sure that the burden imposed by the wire is not excessive. The maximum burden permitted is 5V.

NOTE
If bus current is on, <u>bus ripple or sudden changes in bus current level</u> will induce significant voltages in the feedback coils. Therefore, the cables must be disconnected from the head while wiring them to the Metering Unit.

Complete the wiring job by connecting the external power lines to terminals TB2-5 (COMMON), TB2-7 (HOT), and TB2-3 (GROUND) in the Metering Unit.

Customer is responsible for supplying an external circuit breaker or fuse with proper rating as required by local codes for branch circuit protection when wiring the mains circuit to this Metering Unit. Each Metering Unit must have its own breaker. Use a wire and breaker or fuse (time delay) sized adequately for the maximum burden of 20 VA/kA of measured current. The wire should have an insulation rating of 600Vac and 80°C minimum temperature rating.

If an external transformer is being used to supply power to the Metering Unit, consider sizing the transformer to 20VA/kA minimum.

NOTE

With the LKB-45 or LKB-60 in operation, total or partial loss of forced air cooling inside the enclosure will elevate the temperature of the heat sink, causing the heat sink thermostats to close when the temperature rises above 93°C. These contacts are available at TB1-60 and TB1-61 for connection to the customer's alarm or annunciator.

5.9 INITIAL SYSTEM CHECKOUT

Recheck all wiring connections against the drawings to ensure proper installation. When they are satisfactory, turn on the system by first closing the external breaker or disconnect (if used), and then the Metering Unit circuit breaker. Close the Metering Unit door, and confirm that the amber POWER lamp is ON.

With the bus energized, the Metering Unit's output in use should accurately measure the bus current. However, it is now necessary to take a complete set of channel voltage readings. These readings serve two purposes. One; to verify that all channels are operating properly. Two; to aid in magnetic centering of the head. With the bus current operating at its highest operating level, take two sets of readings, the first set taken immediately (to verify no condition exists that may cause damage to the LKB Metering Unit), and the second set after a 24-hour period of time (to thermally stabilize the head). Proceed as follows:

- A.) The dc voltage range will usually be positive (e.g., 0 to +30 Vdc), but a given channel may measure from -30 V to +30 Vdc. (Refer to "D" below). Make certain the voltmeter being used is set to measure average dc volts in this range.
- B.) The measured bus and all other high current buses in the vicinity (or in the facility) should be operating at or near their highest levels. Note: All magnetic field sources will affect the channel voltage readings.
- C.) Make a photocopy of the table at the end of this section "Form for Recording Channel Voltage Measurements". The initial readings are made as instructed on the form, and are recorded in the individual blocks, which graphically show channel locations on the head.
- D.) Excluding the effects of external magnetic sources and assuming a full rated bus current, each channel is expected (by calculation) to measure approximately 18 V to 30 Vdc. In practice, channel readings should be more on the order of 10 V to 30 Vdc, but that may not be achievable. A channel failure will usually be indicated by either a full-negative (-50 V), full-off (0 V) or full-positive (+50 V) condition.

CAUTION

Avoid operating the unit for an extended time with any channel output over ± 30 V. This will permanently damage the system. For voltages over ± 30 V, consult the factory.

- E.) If any of the channel readings do indicate trouble, refer to Theory of Operations and Maintenance & Spare Parts sections and resolve the problem; then proceed with "Magnetic Centering".

5.10 MAGNETIC CENTERING

The distribution of load (i.e., heat), among the various channels will be optimized if the head is magnetically centered. This is a process of equalizing certain channel voltages by positioning the head on the bus bar. In essence, the channel voltages from opposite sides of the head are compared and the side having the lower voltage is moved toward the bus. Using Figure 5.3 as an example, the voltages of channels 1 and 3 are compared and the voltages of 2 and 4 compared. If the voltages are measured as shown, then the head is to be moved as indicated until the best balance at opposite sides is obtained. The final head position may yield voltages of 19 V at channels 1 and 3, and perhaps 13 V at channels 2 and 4.

The channel voltages depend on several factors, such as total bus current, bus shape, proximity to other bus bars, and channel coil resistance. In practice, it may prove impossible to obtain full equalized channel voltages because of a severe magnetic environment or lack of space for moving the head. In this case, the best position should be found; then all channels must be checked to see that all are within the limits of -30V to +30V. If these limits are exceeded, another location should be selected. If other locations are not available, consult the factory regarding forced air cooling of the overloaded channels, or replacing the system with a larger unit.

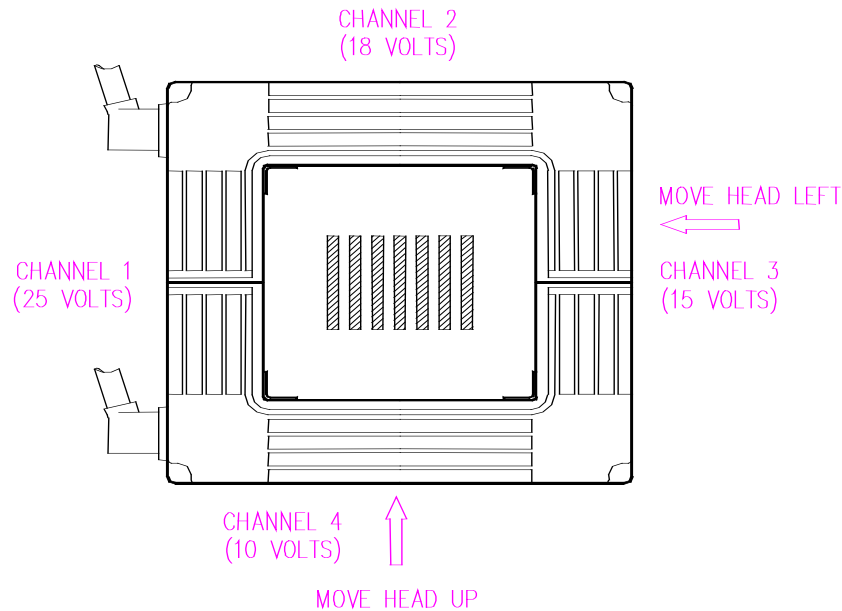


Figure 5.3 Magnetic Centering

CAUTION

If the head position must be changed it is important that it be kept in a vertical plane if possible. The head can be mounted in a tilted plane without loss of accuracy. However such mounting can impose stresses at the center joining points especially if one half is supported solely from the other half.

**TABLE 5.2
FORM FOR RECORDING CHANNEL VOLTAGE MEASUREMENTS**

LKB-45 & LKB-60

If the channel voltages are measured and recorded at least two hours after the LKB system is energized has been properly "centered" electrically, the information may prove valuable in the event of any future malfunction.

It is a good idea to take an additional set of readings at the hottest time of the year, especially if the equipment is exposed to outdoor temperatures; space is provided for the recording of three sets of readings.

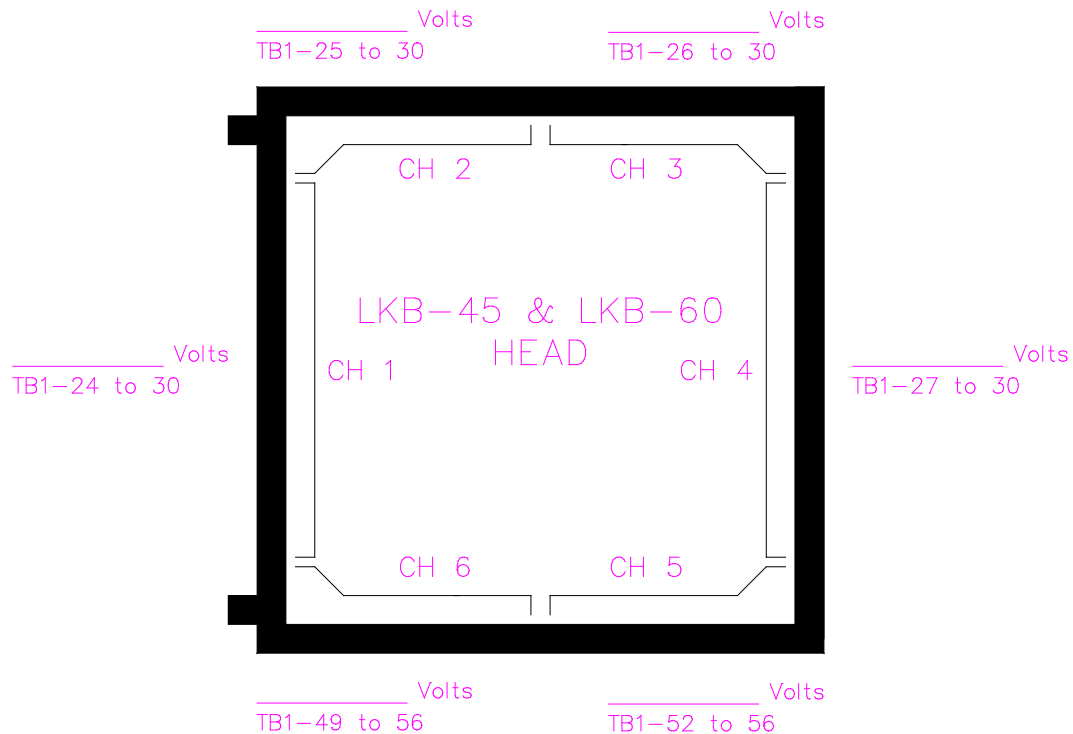
NOTE: Although the channel voltages may vary widely with temperature extremes, the accuracy will remain unaffected so long as each channel voltage falls within the limits of -30 V to +30 Vdc.

Channel voltages are measured between terminals at the Metering Unit terminal block with the LKB in service on an energized bus.

INSTRUCTIONS

1. Record the channel measurements for every channel (make additional copies of this form as needed).
2. Supply the information called for below.

CHANNEL VOLTAGES



Ambient Temperature: _____

Date: _____

<input type="checkbox"/> LOOP BURDEN (TB1-8 & 9)			
<input type="checkbox"/> LINE VOLTAGE: (TB2-5 & 7)			
<input type="checkbox"/> BUS CURRENT (kA):			

Serial Number of LKB-45 or LKB-60: _____

NOTE: The channel voltages should be between -30 and +30 Vdc.

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6. THEORY OF OPERATION

6.1 GENERAL

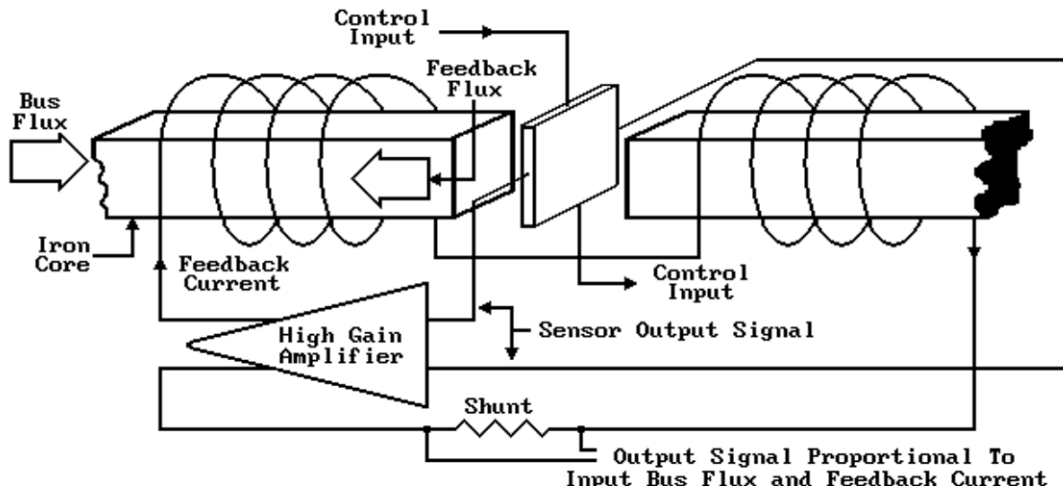


Figure 6.1 Magnetic Null Detector Diagram

A thorough knowledge of the LKB system theory of operation is essential for efficient troubleshooting. In figure 6.1, a portion of the Measuring Head is shown to illustrate the magnetic null principle used in all Series LKB current measuring equipment.

6.2 MAGNETIC SENSOR (NULL DETECTOR)

The magnetic sensor produces a voltage output proportional to the difference between the bus field and the feedback field. The sensor output is amplified and is returned to the magnetic circuit in the form of feedback current. This current is passed through 5000 turns to produce the feedback field.

The Measuring Head contains many magnetic sensors and feedback coils. Each set of sensors and the adjacent coils plus the associated amplifying section of the Metering Unit is termed a channel. Each channel responds nearly independently of the other channels to null the bus field in its own section of magnetic core. However, after passing through their respective coil groups, all channel currents are summed to produce the output current. This current, which is always in the ratio of 1 A to 5000 A of bus current, is passed through resistors or shunts to develop voltages for the meter and proportional outputs. The output current itself is also available at the output terminals, which are jumpered if not used.

6.3 SYSTEM DESCRIPTIONS

Effects of stray fields are nullified by joining a number of magnetic assemblies like the one just described in a closed path around the bus. Figure 6.2 shows four such assemblies (referred to as a 4-channel assembly). A 4-channel system is used here as an illustration to simplify the drawing and explanation.

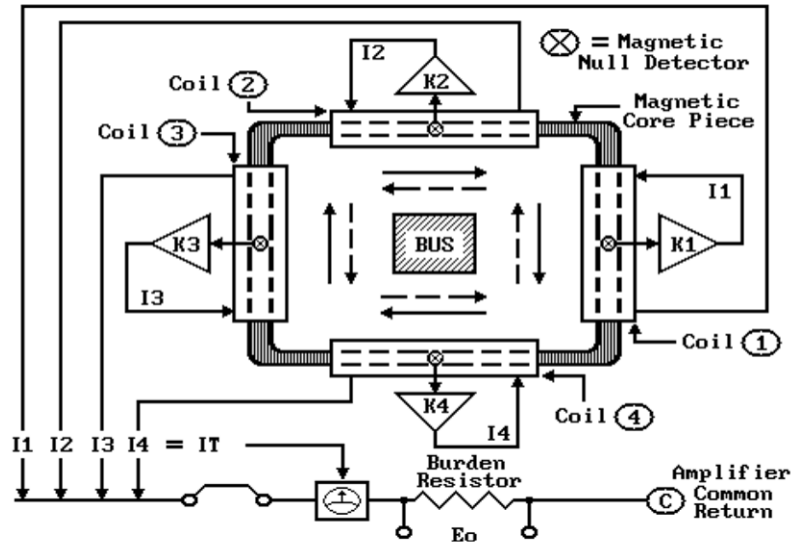


Figure 6.2 Functional Diagram of Four-Channel System

A magnetic null detector (sensor), high-gain current amplifier, and feedback coil are combined to form one channel, or current feedback loop. The function of each current loop (current I_1 , I_2 , I_3 , or I_4) is to maintain a state of zero flux in its related segment of the iron core. A burden shunt placed in series with the total current (I_t), develops an output voltage E_o , proportional to I_t . The common side of the shunt is returned to the four high-gain current amplifiers.

Since the bus current is directly proportional to the total current I_t by a ratio of 5000:1, the bus current can be measured accurately by summing the independent feedback currents ($I_t = I_1 + I_2 + I_3 + I_4$). Therefore, the bus current is equal to $5000I_t$. Moving the Measuring Head with respect to the bus will cause the values of the individual feedback currents to change but will not affect the total current nor the accuracy of the measurement.

6.4 CHANNEL AMPLIFIER

Refer to the system's schematics. Each channel amplifier is a high gain, bi-directional, direct-coupled, linear amplifier with high output capability. The input stage is an operational amplifier that receives signal inputs from its corresponding magnetic null detector in the Measuring Head. The amplifier output drives a pair of complementary transistors, Q7 and Q8, which serve as drivers and level translators to the output amplifiers, FETs Q4-Q6 and Q9-Q11. The output voltage level can approach the supply level of 50V with current output as required for a magnetic null in the Measuring Head. Since the output capability is high,

the output transistors, FETs Q4-Q6 (in upper right corner of schematic), might easily be destroyed if the channel were momentarily short-circuited.

However, a protective circuit is provided that limits the short circuit current to approximately 5A. This circuit is composed of 0.3-ohm output current sensing resistor R26 (between TP-9 and TP-10, near right side of board in schematic) and optical coupler U2, which are connected on the (+) side of the amplifier. At the 5A level, the optical coupler begins conducting, which pulls the base lead of driver Q7 toward common, thus limiting current through Q4 - Q6. On the (-) side of the circuit, R27 and U3 perform a similar function to limit current through Q9 - Q11 (lower right corner).

The FETs used in this amplifier are noted for their positive temperature coefficients, which permit parallel operation (currents through the parallel paths tend to equalize). In contrast, bipolar transistors have negative temperature coefficients, which make parallel operation difficult (initial unbalance becomes worse).

In the LKB-F amplifier, the inherent current sharing of the FETs determines current balance among the three parallel transistors (Q4, Q5 and Q6). However, if one of the three transistors approaches a 1.5 ampere conduction level, the forced-balance circuit becomes active. On Q4, for example, this circuit consists of resistors R16, R18 and R19 and transistor Q1. In operation, as the current through Q4 and 0.33-ohm resistor R19 approaches 1.5 A, transistor Q1 starts to conduct, which retards the increase in gate-to-source voltage at Q4, which in turn retards further increase in current through Q4. The parallel paths of Q5 and Q6 are forced to carry further increases in output requirements until, ideally, all three FETs carry equal drain currents. Thus current balance and, more important, heat dissipation among the three parallel paths are assured.

The 4.0A fuses F(+) and F(-), also designated as "F1" and "F2," are intended to protect printed-circuit foil paths in the event main transistors fail in a shorted mode.

Each channel is provided with a zeroing potentiometer, P1. This pot is used for compensation of its null-detector zero field offset and normal offset of the operational amplifier and associated circuits. It is set at the factory and normally needs no further attention.

For the condition of zero bus current, the main output transistors pass a small quiescent current. This current is factory adjusted to approximately 50-100mA by potentiometer P2. The quiescent current can be measured by the voltage drop across R26 or R27 (15mV at 50mA). The function of the quiescent current is to permit linear response to bus currents near zero. Without the quiescent current, a small bus current on the order of 100A would be required before any output current would flow.

Each channel amplifier is an integral assembly of power transistors and a PC card. All connections to a channel amplifier are made through a pair of 5-pin connectors on the card. Signal and output leads from the heads are routed to TB1 and distributed by cables to 5-pin connectors S1 through S6 on the amplifier PCBs.

6.5 POWER SUPPLY

The incoming line power is transformed by T1, located on the main panel to 34 Vac. The 34 Vac is rectified by bridge rectifier circuit FWB1 on the heat sink and filtered by capacitors C1 and C2 to produce the unregulated ± 50 Vdc, which is fed to the power supply board and then distributed to each of the channel amplifiers. Bridge rectifier FWB2 is used as freewheeling diodes. Zener diodes DZ9 and DZ10 are used to clamp the ± 50 Vdc power supply voltage to ± 62 Vdc.

The incoming line power is also transformed by T1, located on the power supply board to 17 Vac. The 17 Vac is rectified, filtered, and regulated by circuits on the power supply board to provide ± 15 Vdc. Except for the two power regulator integrated circuits, the components of the ± 15 Vdc power supply are all located on the power supply board

6.6 OUTPUT CIRCUIT

The six channel output currents exit from the signal converter via terminals TB1-24 & 48, 25, 26, 27 & 53, 52, and 49 corresponding to channels 1 through 6 respectively. After passing through their respective feedback coils in the Measuring Head, the channel currents return to the signal converter, where they are totalized at TB1-29, 30, 31, and 32 and TB1-54, 55, 56, and 58. From here, the total current (output current) is passed through shunts 1 and 2 (if furnished) and then to the system common.

The output current is accessible at TB1-8 and TB1-9. Remote devices (e.g., meters, recorders, etc.) can be substituted for the existing jumper across these terminals. The allowable voltage drop between TB1-8 & 9 is 5V at full-scale bus current. For example, the output current for a 50kA bus is 10A. For a 5V drop, the allowable external circuit resistance in this case is approximately 0.5 ohm. This value includes the remote device resistance and the resistance of its wiring, between TB1-8 & 9. Hence, large wire size will be helpful in minimizing voltage drops.

WARNING

The output current circuit must be continuous and must not be opened when the system is in operation. A hazardous voltage may occur at an open point

Five outputs are provided by the system:

- 1.) A standard voltage output of 10 mV/kA, at TB1-3 and TB1-4.
- 2.) An optional secondary voltage output, at TB1-1 and TB1-2.
- 3.) A current output of 1 Adc per 5 kA of bus current, at TB1-8 and TB1-9. The current output is available by removing a jumper connected across the TB1 terminals (do not remove the jumper while the system is energized). Maximum allowable voltage drop across the terminals is 5 Vdc at maximum bus current.
- 4.) A normally-open (N.O.) contact for the Metering Unit over-temperature alarm, rated at 120 Vac, 6 A, at TB1-60 and TB1-61.
- 5.) A normally closed relay contact for ALARM STATUS output at TB1-62 through TB1-64.

Burden resistors inserted in the series output circuit should be selected with care. The wattage rating should be at least two times higher than the calculated power dissipation. The burden resistor should have a low temperature coefficient (25 ppm or better).

The Metering Unit is supplied with a two-pole circuit breaker mounted inside the enclosure, on the main panel.

6.7 ACCURACY DIAGNOSTICS

“ACCURACY DIAGNOSTICS” (AD) is a system that assures the user that most internal circuits are operating properly and it is also a diagnostic tool. It is made up of a number of

circuits, monitoring conditions of many of the critical components, circuits and connections within the current monitoring system. The AD subsystem provides relay contacts for the user to connect to his remote warning indicator. The AD diagnostic light emitting diodes on each Metering Unit module indicate proper operation of associated circuits. On some larger systems a red warning light mounted on the enclosure door provides a simple visual warning (refer to wiring diagram for this feature).

The AD indicates the feedback circuits are functioning properly and the system's power supplies are within specifications. More specifically, this indicates the following conditions exist:

1. All channels have a core magnetic flux null:
 - a. All components in the circuits appear to be operating normally.
 - b. Input fields are of the expected polarity.
 - c. Input magnetic flux appears balanced by feedback flux.
2. Power supplies are operating within acceptable ranges.
 - a. Mains input power is on.
 - b. Hall plate sensor power supply output is correct.

The AD outputs indicate the present condition, having only a short time delay from an instantaneous condition. Although the AD does not monitor every possible error condition, it is an effective means of giving the user continual assurance of signal reliability.

- A. If the "Diagnostics Relay" is O.K. and the green LED indicators are all on: Continue operating normally.
- B. If the "Diagnostics Relay" indicates a warning and one or more green indicators are off:

This indicates there may be measurement errors. Consequently, the metering system should not be in full, automatic control of the rectifier. The AD relay contact output is not intended to be the only monitor protecting the power rectifiers. Primarily, it is expected that the customer wants to take immediate action to prevent unsafe operation. Unsafe operation could result if the metering system is in the rectifier control loop and it erroneously produces a significantly lower output than is true. This might cause the rectifier control circuit to inappropriately increase the power output, perhaps to overload levels for either the power supply or the process. So, if the metering system is in the control loop and the "Accuracy Diagnostics" indicates a potential problem, the following actions are recommended: FIRST- Lock out control actions that could drive the rectifier output higher and SECOND-alert the operator.

Basically, each module inside the Metering Unit has four channel LEDs and 2 power supply monitoring LEDs. The following is a description of their functionality:

- A. Line: This LED indicates whether the supply voltage to the Metering Unit falls within the specified limit of +10%, -15% of nominal. Significant changes from these values will cause this LED to turn off and trip the relay.
- B. Hall P.S.: This LED indicates whether the Hall plate supply voltage supply voltages fall with the specified operating limits. A failed Hall plate power supply or a line voltage out of specification will extinguish this LED and trip the relay.
- C. Channel LEDs: Each channel LED indicates the status of the corresponding channel to aid quick troubleshooting. An extinguished channel LED can be caused by the following:

- a. A blown channel fuse;
- b. a bad connection between the cable and the Metering Unit or cable and Measuring Head;
- c. a bad Hall device in the head;
- d. an open /or shorted coil in the head;
- e. a primary current that exceeds the dynamic measuring range of the Metering Unit;
- f. the primary current is too low to activate all channels properly;
- g. a strong external magnetic field causing a channel reversal.

Notes on items f and g above:

1. Under certain conditions, external magnetic fields can reverse one or more channels in the head. The accuracy indicators will show an error in those channels until the bus current level rises high enough to effectively turn on all channels (2-3Vdc is the minimum reliable channel voltage). This condition can cause false alarms. For more information on this, please refer to technical bulletin TEC9908, "Resolving External Magnetic Field Errors".
2. In some installations, when the channel voltages are balanced, the channel LEDs will remain on, even though the bus is turned down to zero. In this case, the accuracy diagnostics circuit is in an unstable condition and alarm faults, as indicated by the channel LEDs, should be ignored. Note that, in general, the Metering Unit's 0.1% accuracy is only guaranteed when the primary bus current is above 5% of the full scale rating of the unit.

A relay contact output is available to connect to a remote warning system. The relay is closed under normal operating conditions and opens when a fault condition occurs. The output connections are available via a connector located on the left side of the Metering Unit. The terminals are designated on the appropriate interconnection diagram. The terminals are used as follows:

Contact Terminals		Condition
TB1-62, 63	TB1-62, 64	
Open	Closed	Fault condition, zero bus current*, or Metering Unit turned off
Closed	Open	Normal operation

See notes above on zero bus current condition.

7. MAINTENANCE & SPARE PARTS

7.1 PERIODIC MAINTENANCE

As is true with any electronic circuitry, proper maintenance will prolong the service life. DynAmp, LLC recommends the following program be performed at the recommended interval to prevent or detect damage to the LKB system and to ensure continuing high-accuracy 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:
Keep organized, accurate recorded data (forms, etc.) from each Periodic Maintenance. This information may be invaluable in troubleshooting a malfunctioning LKB system.

7.2 ANNUAL MAINTENANCE

Perform the following steps at least once per year. If LKB system equipment is exposed to outdoor temperatures, DynAmp, LLC recommends these steps be performed during the hottest time of the year.

The following procedures should be performed at the recommended interval to prevent or detect damage to the LKB system and to ensure continuing high-accuracy performance. Use appropriate measures to correct any problems found.

- A. Repeat voltage measurements given in "Magnetic Centering" procedure to ensure that no significant change has occurred from the data recorded at startup. A large change in the amplifier output voltage of a given channel (compared to other channels) may indicate trouble in the channel. If all channels change proportionally, then that might indicate a change in the bus current. Remember that channel voltages will vary slightly depending on the ambient temperature of the head.
- B. Measure and record the Hall device dc power supply voltage.
- C. Visually inspect Measuring Head and interconnection cable for evidence of severe overheating, excessive corrosion, or possible leaks in the RTV rubber seal around the aperture. Record any suspect conditions.
- D. Visually inspect Metering Unit(s) for evidence of severe overheating, or excessive corrosion. Record any suspect conditions and take appropriate action.
- E. Clean the following items:
 - 1.) Cables and external surfaces of Measuring Head and Metering Unit: 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.
 - 2.) Metering Unit interior (should only be performed after disconnecting power to the Metering Unit): Dust and dirt can be removed by gently vacuum cleaning the unit. Be careful not damage the internal shunt. Solvents should never be used on any of the PC boards. The boards are coated with a protective conformal coating which can be stripped away by certain solvents.

- F. Check the electrolytic filter capacitors for seals that have been popped (degassed) or are leaking electrolytic fluid. Replace if necessary.
- G. If the unit is equipped with a cooling fan and filter, then the filter should be cleaned or replaced according to the manufacturer instructions.

CAUTION
To avoid the risk of shock and electrocution, always disconnect the AC power and head cables from the head before performing any cleaning or service operation on the Metering Unit.

Disconnect power to the system before servicing or replacing fuses.

7.3 CALIBRATION INTERVALS

DynAmp does not specify required intervals of calibration for its products.

The end user of the product is responsible for identifying the appropriate interval between calibrations. The intervals should be determined based on the following factors:

- Requirements of a Quality Management System
- Accuracy and permissible limits of errors
- Purpose and usage
- Experience with similar products
- Manufacturer's recommendations
- Stability of the product
- Past history
- Other characteristics of the product

Reference: "ISO/IEC 17025:2005, General requirements for the competence of testing and calibration laboratories" and Laboratory Accreditation Bureau "Guidance for Documenting and Implementing ISO/IEC 17025:2005 and Laboratory Guidance."

As a guideline, DynAmp recommends a 24-month interval of calibration for all permanently installed products and a 12-month interval of calibration for all products used in portable applications.

7.4 TROUBLESHOOTING

Trouble must initially be isolated to the power supply or to one or more signal processing channels. First consider these points:

1. Do not make or break any connection with the ac power on. Open the circuit breaker first. Refer to the system schematic.
2. If the bus is energized with ac or if it is subject to a rapid change in dc current, do not open the output circuit of any channel, as a high-induced voltage may be present. In this case, remove the head from the bus and use a test bus as described below.

3. When the Measuring Head is removed from the bus bar, a test bus can be arranged by winding a known number (N) of turns through the head, equally distributed on the four sides. A dc current passed through these turns will produce a "bus" current of $N \times I$ amperes. Alternately, test coils can be wound separately and placed around the head symmetrically and then connected in series. The latter method is used by DynAmp, LLC. for system calibration and testing. For difficult problems in troubleshooting, call DynAmp, LLC

7.5 TROUBLESHOOTING PROCEDURE (NORMAL OPERATION)

Inspect the circuit breaker on the LKB-F Metering Unit. If tripped, try resetting one time. If it trips again immediately, de-energize (circuit breaker off) and then disconnect the white plastic connector (P1 through P6) at the PC card of each of the six channel amplifiers. Reenergize, and if the circuit breaker does not trip, measure all power supply voltages, ± 50 and ± 15 Vdc with respect to common. If voltages are abnormal, replace faulty components in the power supply.

Using test point TP8 (GRY terminal on power supply) as the measurement reference point (refer to the channel amplifier board schematic), check the voltages at one of the white connectors. The voltages, beginning at pin 1 (near pointed end of connector) should be +50V, +15V, 0V, -15V and -50V, respectively. If these voltages are normal, open the circuit breaker and reconnect the connector (P1) at the channel 1 PC card. Close the circuit breaker; if the circuit breaker trips immediately, the trouble is in the channel 1 card. If the circuit breaker does not trip, the channel output voltage should be near zero if the bus current is off, or somewhere near the original channel voltage if the bus current is on. Measure the channel output voltage between test points TP8 (GRY) and TP9 (WHT) on the channel amplifier board. A full-scale output of +50V or -50V may indicate bad transistors; the transistors associated with the channel should be checked for shorts and opens and replaced if necessary. Each of the remaining channels should be similarly checked in turn, using the method just given for channel 1 and turning off the power before plugging in or unplugging any connector.

If all signal converter components of a suspect channel appear normal, the Measuring Head resistances should be checked using table 5.1. Bus current must be off, or the head must be removed from the bus, to make resistance measurements. Any serious deviation from normal resistance levels will necessitate replacement of faulty components in the head. (See instructions below.)

Since the LKB-F is a high gain, closed loop system, it is possible to have high-frequency oscillations caused by aging or partial breakdown of components. Oscillations may be hard to detect. A slight shift in output level with excessive heat dissipation in the output transistors usually indicates oscillation. If oscillation is suspected, it is best detected by observing the channel output voltages with an oscilloscope. All may show oscillation, but one channel will show more. Alternatively, each channel can be checked separately by connecting only one channel at a time as described above. An oscillating channel amplifier should be replaced (PC card and transistors), or all components should be individually checked and replaced as necessary. Subsequent oscillation in the same channel may mean a fault in the magnetic null detector.

7.6 SPARE PARTS ORDERS - ROUTINE OR EMERGENCY

Requests for spare parts should be directed to "Service" at DynAmp, LLC during normal hours. When contacting us, please present as much information as possible - the related equipment Model and Serial Numbers (available on the equipment tag); the required part name; its DynAmp, LLC item number (and other identifying or vendor number(s); and your time needs. An approved Purchase Order Number should be given with your order.

7.7 RECOMMENDED SPARE PARTS*

The following table lists the minimum recommended quantities* for spare parts for the LKB Series 6 Channel. As spares are used, replacements should be ordered. Since continuous operation of high-current measurement systems is usually critical, stocking spare parts should be given high priority.

The LKB Series 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 DynAmp service center for information on repairs.

**TABLE 7.1
SPARE PARTS LIST***

DESCRIPTION	ITEM NO.	QUAN
Metering Unit		
*Kit, Spare Parts, LKB-45	42786	1
*Kit, Spare Parts, LKB-60	42787	1
Spare Parts Kit includes Channel Amplifier, Power Supply, Regulators, Lamps, Fuses, and Fan as one package.		
Channel Amplifier PCB Assembly	43782	1
Power Supply PCB Assembly	41859	1
Voltage Regulator, +15V	41862	1
Voltage Regulator, -15V	41863	1
Lamp (amber LED), FAULT light	42121	1
Lamp (red LED), POWER ON light	42405	1
**Fuses, 4.0 A, 250V, MDA4 (5 per box)	12592	2 box
**Fuses, 15 A, 250V, MDA15 (5 per box)	26368	1 box
**Fuses, 0.75 A, 250V, MDA3/4 (5 per box)	41486	1 box
Fan, Axial	42242	1
Alarm / Status PCB Assembly	41785	1

* For one to five units, stock the quantities shown. For six or more units, a complete system (head, cable, and Metering Unit) should be kept on hand.

** All Fuses are Time lag MDA style (3AB) ¼" by 1 ¼" (6.3 mm x 32mm), 250 Volt

Disconnect power to the system before servicing or replacing fuses.

7.8 SERVICE ASSISTANCE

For further assistance, contact DynAmp Customer Support at:

Americas:

Telephone: +1 614.871.6900

Fax: +1 614.871.6910

8:00 AM to 5:00 PM USA Eastern Time

From first Sunday in November to second Sunday in March – 13:00 GMT to 22:00 GMT

From second Sunday in March to first Sunday in November – 12:00 GMT to 21:00 GMT

Europe:

Telephone: +41 22.706.1446

Fax: +41 22.706.1311

8:30 AM to 5:00 PM Central European Time

From last Sunday in October to last Sunday in March – 7:30 GMT to 16:00 GMT

From last Sunday in March to last Sunday in October – 6:30 GMT to 15:00 GMT

After Hours Critical Service Emergency:

Telephone: +1 614.871.6906

5:00 PM to 8:00 AM USA Eastern Time

From first Sunday in November to second Sunday in March – 22:00 GMT to 13:00 GMT

From second Sunday in March to first Sunday in November – 21:00 GMT to 12:00 GMT

Central e-mail:

help@dynamp.com

DynAmp web:

www.dynamp.com

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8. RELATED TECHNICAL BULLETINS

The following is a list of available technical bulletins that contain relevant information in regards to high current measurements and the use of LKB systems. The technical bulletins are available upon request from DynAmp, LLC. Always consult the factory for a list of the latest technical bulletins.

**TABLE 8.1
TECHNICAL BULLETINS LIST**

NUMBER	SUBJECT	TITLE / DESCRIPTION
9908	External Fields	Resolving External Magnetic Field Errors (replaces TEC727)
9907	LKP/ LKB	LKP and LKB Sensor Mounting Guidelines and Restrictions
9905	LKP/ LKB	Recommended Calibration Intervals for LKP or LKB High Current Systems
9904	Diagnostics	Self Diagnostics for DynAmp High Current Measurement systems (Accuracy Diagnostics)
987	LKP/ LKB	Ferromagnetic Materials near LKP or LKB High Current Measurement Systems
749	Bus Analysis	Computer Analysis of Measuring Head Locations In High Current Measurement systems
748	LKP/ LKB	Guidelines for locations of LKP or LKB High Current Systems Heads on Busses
747	kWH	Volt-hours times Ampere-Hours is NOT equal to Watt-hours
941	Bus Analysis	Data required for Bus Analysis of High Current Measurement Systems

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9. DRAWINGS

**TABLE 9.1
DRAWING LIST**

DRAWING TITLE	NUMBER
Interconnection Diagram: LKB-45	02B108165
Interconnection Diagram: LKB-60	02B109122
PCB Assembly: Channel Amplifier	26B108051
PCB Assembly: LKB 6 Channel Alarm/Status	26B108053
PCB Assembly: LKB Power Supply	26B108068
Schematic: Channel Amplifier PC Board	05B108050
Schematic: LKB 6 Channel Alarm/Status PC Board	05B108097
Schematic: LKB Power Supply PC Board	05B108069
Schematic: LKB-System LKB-45 & LKB-60	05B108109
Outline and Mounting: LKB-F 6 Channel Metering Unit	02C108164
Outline and Mounting: LKP-45 Measuring Head *	02C108100
Outline and Mounting: LKP-60 Measuring Head *	02C108101
Wiring Diagram: LKB-45/60	83B108124
Wiring Diagram: LKP-45 Measuring Head *	83B107967
Wiring Diagram: LKP-60 Measuring Head *	83B107968
Wiring Diagram: Optional Isolator and DPM	83B108373

* The LKB Systems use the LKP Measuring Heads.