phase tracker

LM7000 CONTINUOUS LEVEL MONITOR

COMMISSIONING AND INSTALLATION MANUAL

genuine BINDICATOR®

CPT280063 Rev. D

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Section A – Installation and Startup

A1 How to use this manual

This manual provides information on the installation, commissioning and troubleshooting of the LM7000 Continuous Level Monitor. Section A describes the installation and alignment using the keypad and LCD display on the main controller. Section B describes how to commission the LM7000 using a PC and the PCBUS diagnostic software supplied with each unit.

A1.1 Installation & startup guide

Bindicator measurement technology is inherently immune to the numerous factors which stymie alternative technologies; it's good to know that if a difficulty is encountered it generally means that something needs setting up or correcting rather than it being a case of "that's as good as it gets". Our experience indicates that a thorough approach to the installation and startup is the crucial factor in the startup process. The startup isn't complete until the customer considers it to be proven out that the installation is providing the reliable level measurement which the technology is capable of. Startup success is defined by how rapidly this is achieved.

When an installation error or challenge occurs, the startup strategy can make the difference between resolving the issue in minutes vs. weeks or months. Here is an overview of the installation and startup procedure.

1. Assess the following site variables which determine whether the startup will be easy or challenging:

    - Size and complexity of the system, especially interfaces to Bindicator equipment.
    - Presence or absence of challenging factors in the application
    - Stringency of the performance requirements
    - Background, focus and availability of personnel involved in the startup
    - Work environment at the location where the startup work is being done
    - Availability of product and varying product levels in the vessel during the startup

2. **Obtain and connect a standard direct phone line (or equivalent) to the LM7000 internal telephone modem.** An extension on automated attendant phone systems will also work if all other factors are the same as a direct line. The connection should be fulltime until startup completion. This is the fastest and least expensive method of commissioning.

3. While factory on-site assistance should be planned for as a contingency on every installation, most installations do not require this. However, even in some installations where field service has been provided, fine tuning may be necessary after the service technician has left. Again, this can be done by modem.

4. Obtain proper wire, cables, connectors and connector installation tools. These may be obtained from Bindicator or elsewhere. If purchased elsewhere, be sure that the BNC connectors are compatible with the coax.

5. Retain all documentation and software together in a safe place, including manual(s), packing slips, floppy disks and any other documentation provided.

6. Select a person who will be co-ordinating the installation and startup. This should be someone with some hands-on instrumentation or control experience who will be directly involved with the equipment. This person should either do or manage all aspects of the installation and startup, although they may elect to use other personnel (such as contractors or our technicians) to do portions of it.

7. **Section A4.7 contains a list of common installation problems. Read this carefully before proceeding.**

8. Load the data into the software "place" corresponding to where that sensor has been hooked up.

9. Select and set a simple, basic display format that will temporarily be used during the startup. "Feet-Empty" (distance in feet from the sensor head to the product surface) is recommended.

10. Run the unit. Provide our factory with the phone number of the line to the unit. Use arrangements made in step #2 (& #3 if applicable) to make any needed settings or corrections until the unit is running well. For technical and modem support, call 800-778-9242. Verify proper operation to the extent required by the system owner. If comparison with another measuremnet process is utilized, be sure to account for errors that the comparison process introduces. For example, if a "weight on a tape" is utilized, the tape should touch the product as close to the sensor entry point as possible. Calculate the established Phase Tracker error as the difference between the two measurements, minus the margin for error of the "weight on a tape" minus the maximum possible height difference between the points where the sensor and the "weight on a tape" tape first contact the material.

11. Make any data or analog output connections. Set up or calibrate remote devices to match the verified Phase Tracker display reading.

12. Set the display format to the desire final format, including loading and enabling any strapping tables. If this introduces errors, correct the format settings or strapping table values.

13. If, under the chosen approach, progress is not satisfactory, factory technician startup assistance should be utilized. Startup assistance may be ordered using the customer's standard purchasing practices, and may also include training of their personnel if desired. Order from the Bindicator representative or call 800-778-9242.

14. Enjoy and use accurate, reliable level information.

A2 Specifications

A2.1 Control unit

CAPACITY:	24 sensors.
POWER:	110/220 VAC, 50/60 Hz, 50 watts.
DISPLAY:	Front panel 16 character alphanumeric, 0.3 inch (7.6mm).
OUTPUTS:	4-20mA, self-powered, isolated/0 - 300 ohms.
	Form C relays, programmable HI, LO, and Equipment Alarm. 5A, 1/6HP, 250VAC. SERIAL RS232
SET UP:	Local keypad or PC using PCBUS Diagnostic Software.
HAZARDOUS AREAS:	Intrinsic safety module in-line with field wiring. Mounts in enclosure. Class 1 Group C & D, Class 2 Group G.
NETWORKING:	Up to 16 systems interconnected via RS485.
EXPANSION:	Allows expansion to 24 sensors using add-on expander, in groups of 4 (IS) or 8 (Ordinary locations).
TEMPERATURE:	Control unit -20° C to +50° C (-4° F to 122° F)
MEASURING RANGE:	1 TO 150 Ft (0.3 to 46m).
FIELD WIRING:	From control unit to sensor 400 ft (122m) max. (I.S.350 ft.)

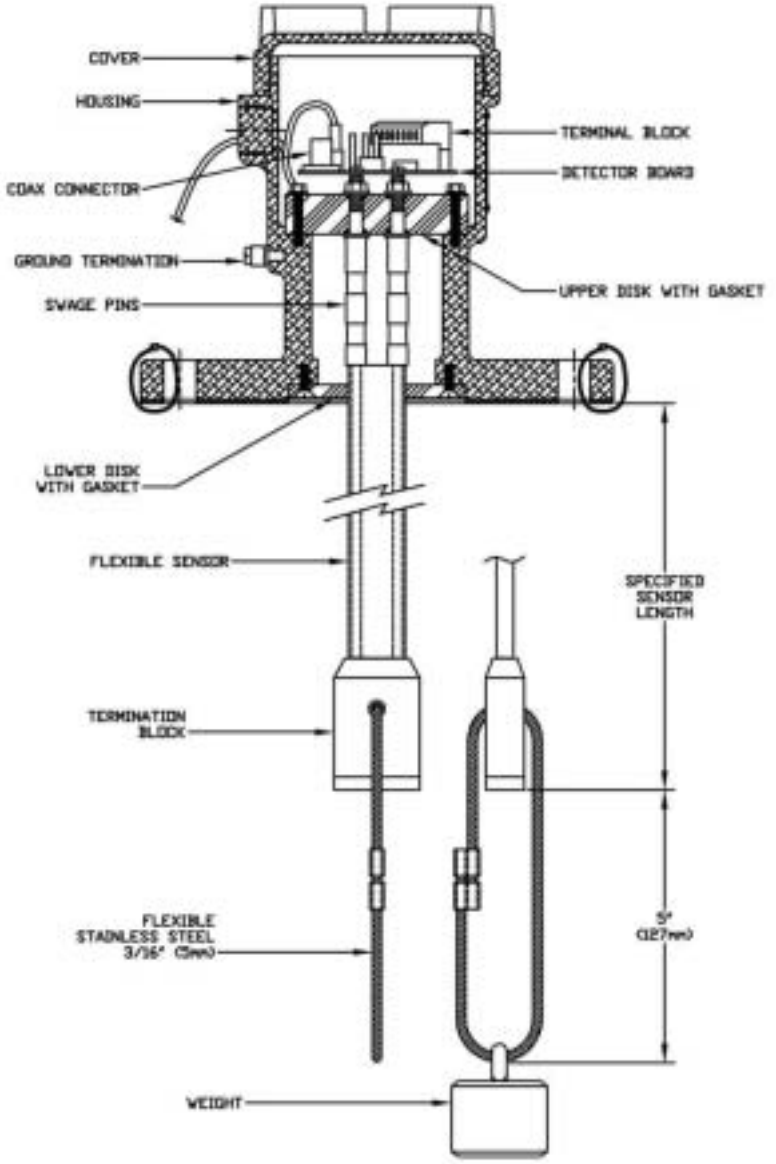
Note: Enclosure sizes shown in this manual are approximate. For exact dimensions, refer to the factory.

A2.2 Sensors

For detailed sensor specifications, refer to the following Drawings.

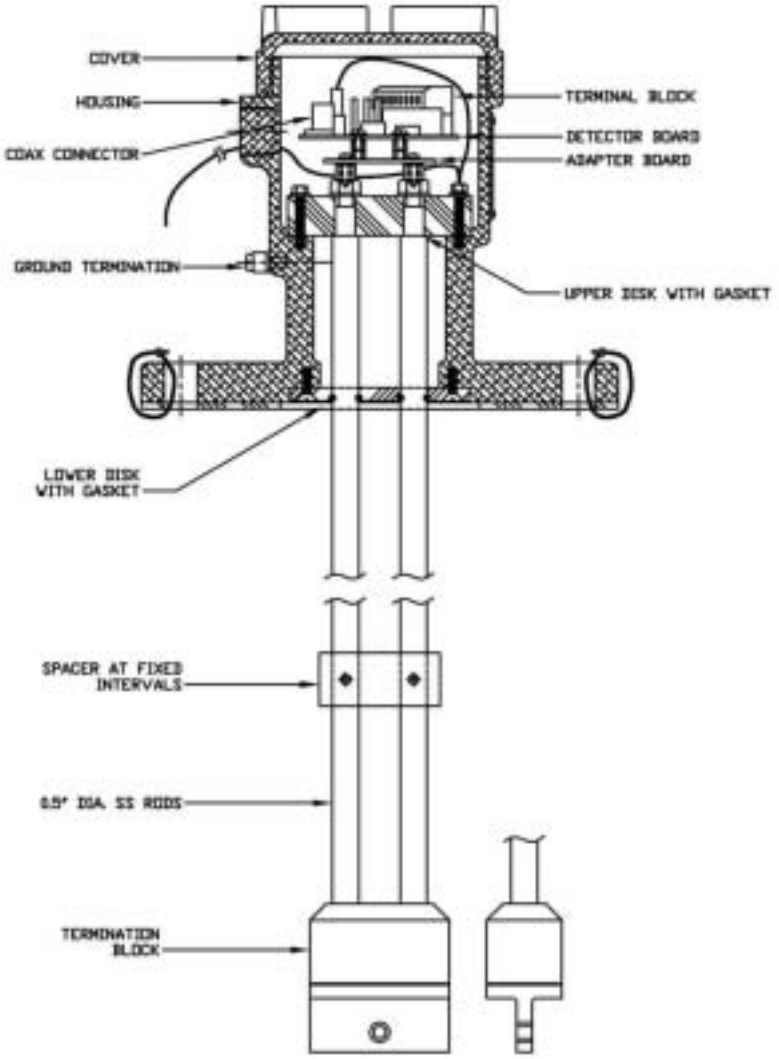
DWG #	PART #	TYPE	JACKET	APPLICATION	FIG
CPT201000 (REF:606405)	LM705	Flexible	Tefzel	Powders	2-1
CPT201200 (REF:606420)	LM720	Rigid	Bare SS Rod	Powders	2-2
CPT201377 (REF:606435)	LM735	Flexible	Tefzel	Liquid (Sanitary)	2-3
CPT201900 (REF:606490)	LM790	Flexible	Bare SS Cable	Powders (Hi-Temp)	2-4

A2.3 Sensor Drawings



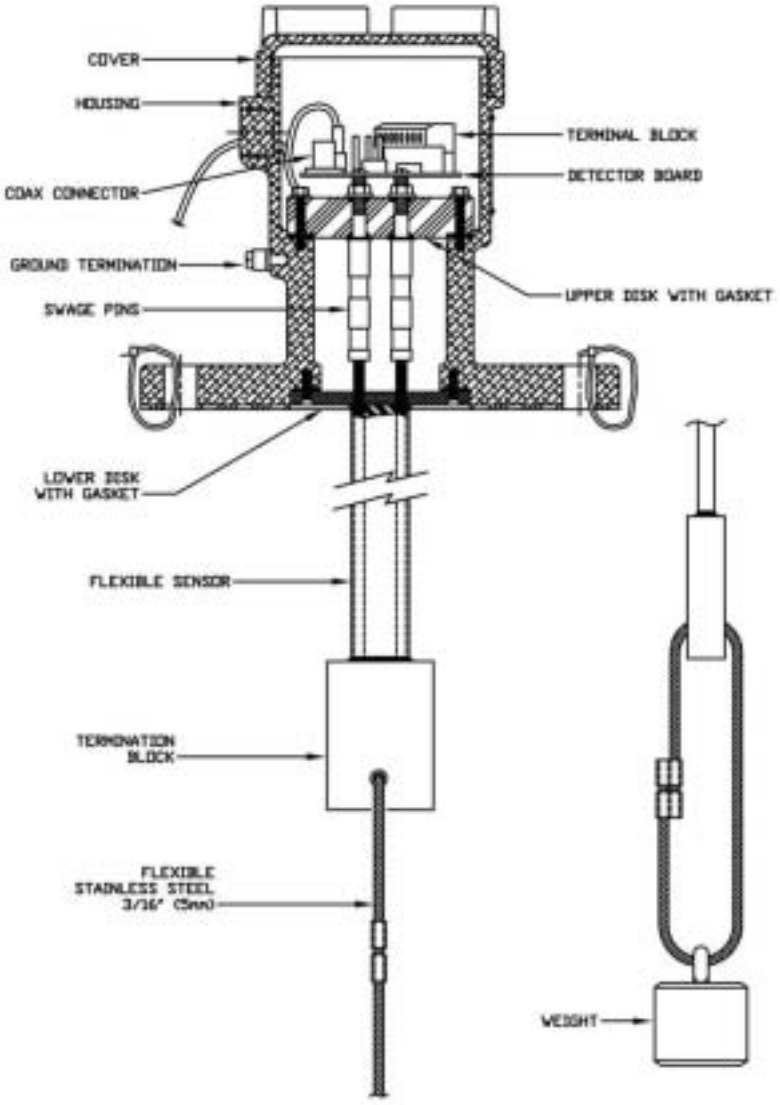
LM705 SENSOR
FIG. 2-1

SK30000



LM720 SENSOR

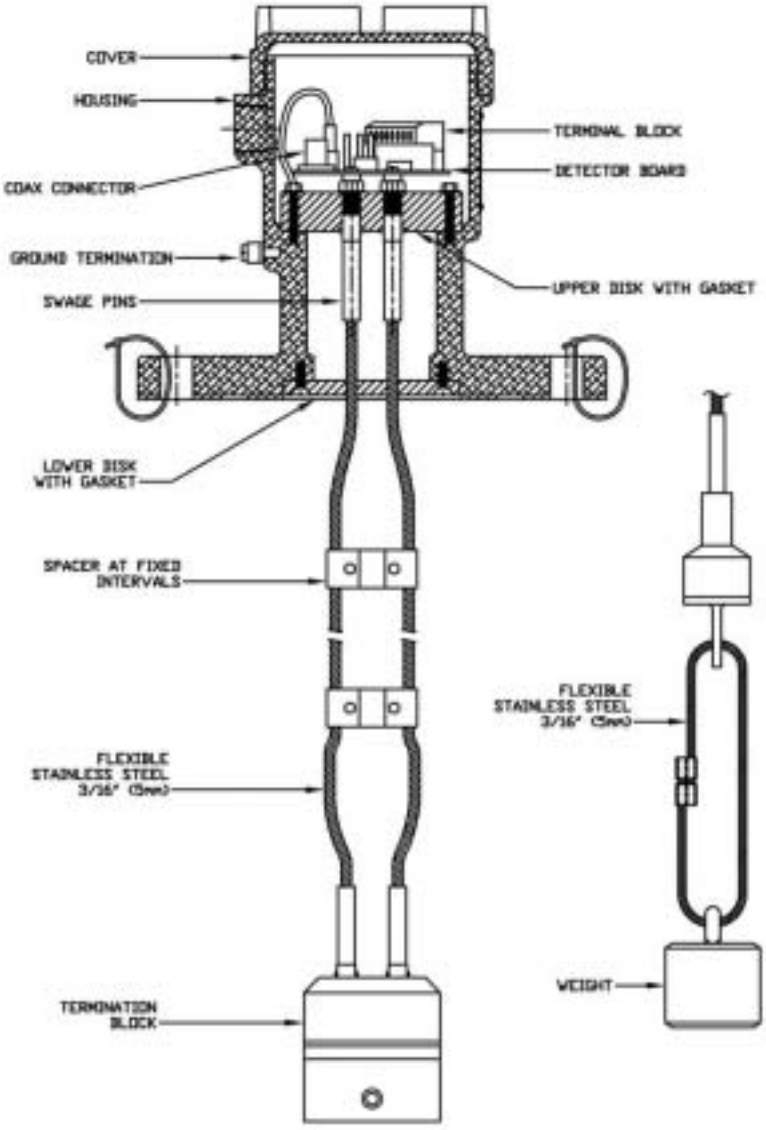
SK30000 FIG. 2-2



LM735 SENSOR

SK30001

FIG. 2-3



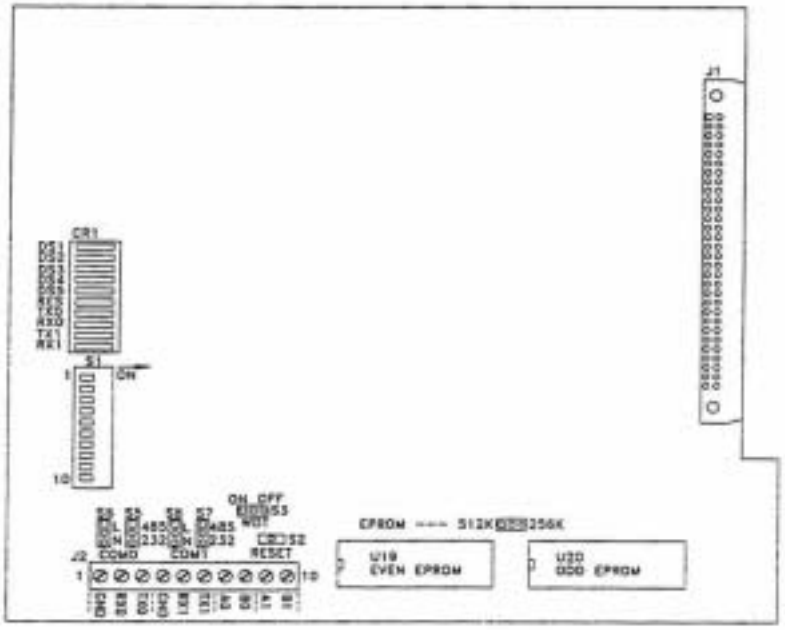
SK30001

LM790 SENSOR
FIG. 2-4

A3 Controller Modules

A3.1 CPU CPT210053 (REF:607001)

This module contains the processor, RAM, NVRAM and EPROM. It interconnects with the other modules via a 60 position ribbon cable. It is equipped with two serial data ports. These can be strapped for RS232 or RS485. It is located in the controller stack (Section A4, Fig 4-2 and Interconnection Diagram, Fig 13-1).

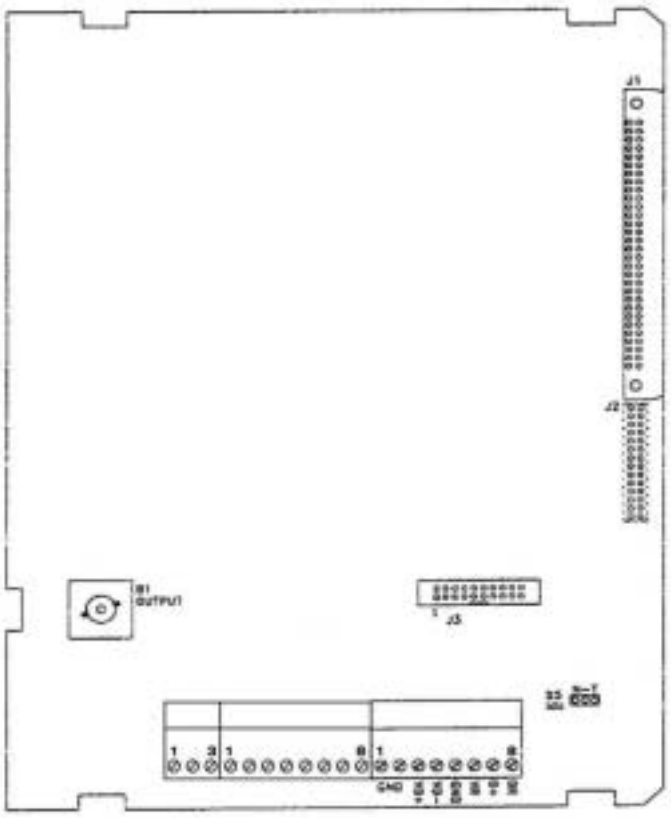


CPU BOARD LAYOUT

FIG 3-1

A3.2 DAS CPT210124 (REF:607022)

This module contains the AC, DC outputs and the sensor input circuits. It interconnects with the other modules via a 60 position ribbon cable. For single tank applications, it connects directly to the sensor via a coax and a three pair cable. For multi-tank applications, it connects to expander units via the coax and a 20 position ribbon cable. It is located in the controller stack (Section A4, Fig 4-2 and Interconnection Diagram, Fig 13-1).

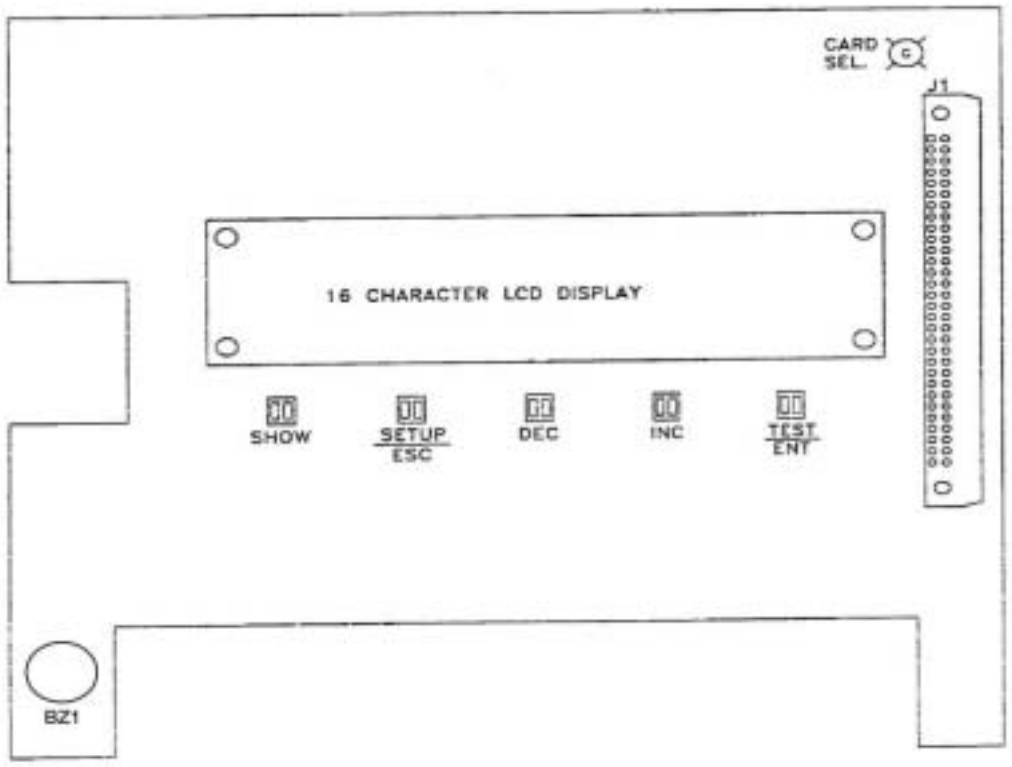


SK30003

Fig 3-2

A3.3 Keypad/Display CPT210005 (REF:607003)

This module contains a 16 character alphanumeric display and a keypad for database entry. The keypad sensors are infrared and can be activated through an enclosure window. It interconnects with the other modules via a 60 position ribbon cable. It is located in the controller stack (Section A4, Fig 4-2 and Interconnection Diagram, Fig 13-1).



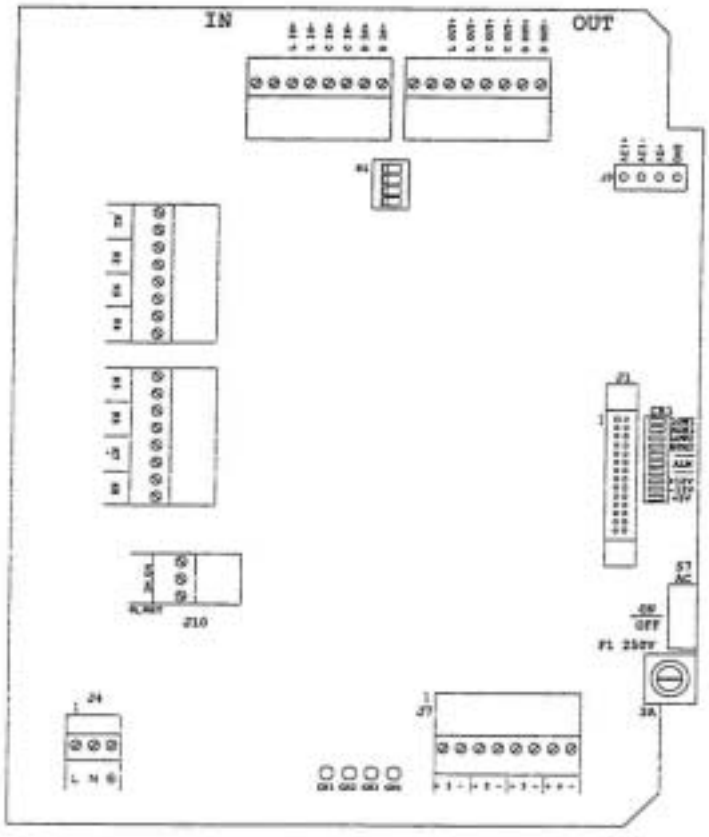
SK30004

DISPLAY BOARD LAYOUT

FIG 3-3

A3.4 PSUB CPT210016 (REF:607009)

The primary function of the PSUB is to provide power for the stack. It interconnects with the other modules via a 28 pin board to board connector. An additional relay is available as a system alarm. It can be equipped with up to four 4/20mA channels and up to 8 setpoint relays. It also has external stack driver circuitry for multiple stack applications (Section A4, Fig 4-2. Interconnection Diagrams, Figs 13-1, 13-5, 13-9).

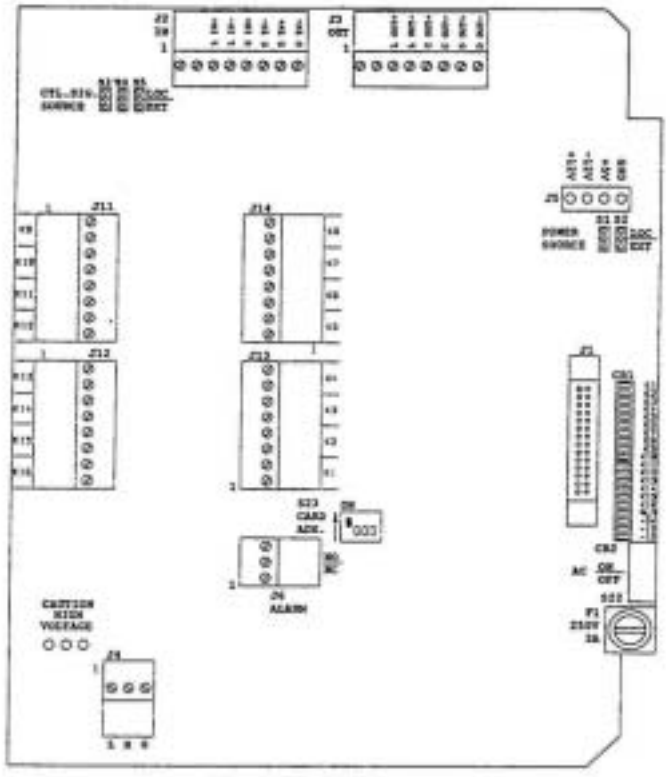


PSUB BOARD LAYOUT

FIG 3-4

A3.5 PSUA CPT210010 (REF:607002)

This module has the same primary function as the PSUB. The options are different. When installed in the controller stack it can be equipped with up to 8 relays plus an alarm relay . It can also be used as an external relay module. In this mode, it can be equipped with 16 relays. This module has no 4-20mA outputs. It can also be used for driving external stacks. The PSUA is also used to provide power for up to four 607006 or three 607020 4-20mA modules (Section A4, Fig 4-2). These can be connected in series for large systems (Interconnection Diagrams, Fig 13-8). Each PSUA has a 4 position address DIP switch. It also has a signal select switches (Appendix C5).

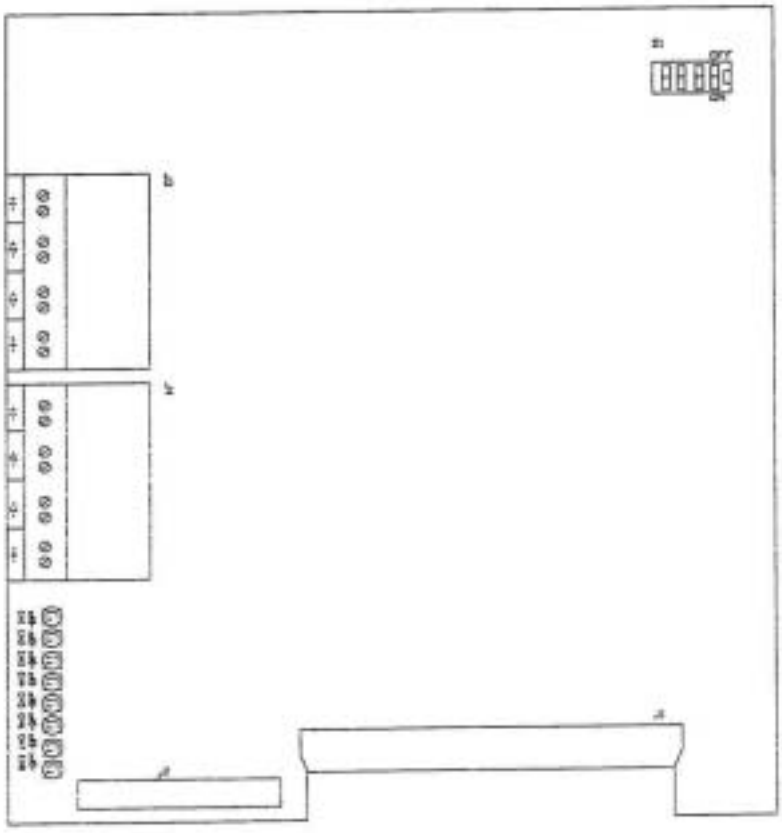


PSUA BOARD LAYOUT

FIG 3-5

A3.6 8 channel 4-20mA CPT210002 (REF:607020)

This module has eight 4-20mA circuits. It interconnects with the other modules via a 60 position ribbon cable. A single module can be mounted in the controller stack. It is installed beneath the CPU. It interconnects with the other modules via a 60 position ribbon cable. For larger systems, a separate stack can be built containing three of these modules together with a 607002 (Section A4, Fig 4-2). Each 4-20mA module has a four position address DIP switch. See (Appendix C5).

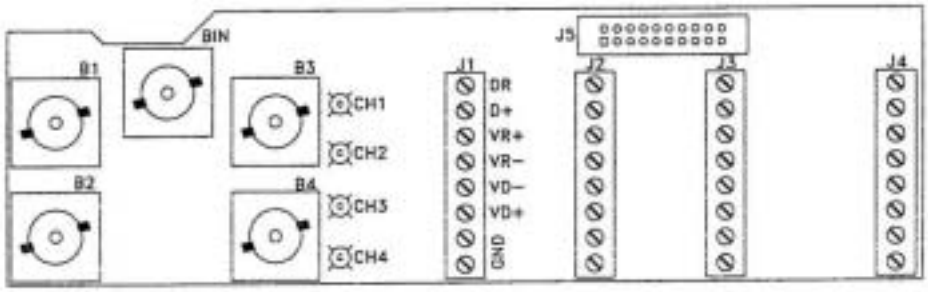


8 CHANNEL 4-20 mA BOARD LAYOUT

FIG 3-7

A3.7 4 Channel Expander CPT230027 (REF:607018)

This module is required for system with 2, 3 or 4 sensors. It connects to the DAS via a 20 conductor ribbon cable and a coax. It has coax and three pair connectors for four sensors. It mounts on the DAS module (Section A4, Fig 4-2 and Interconnection Diagram, Fig 13-2).

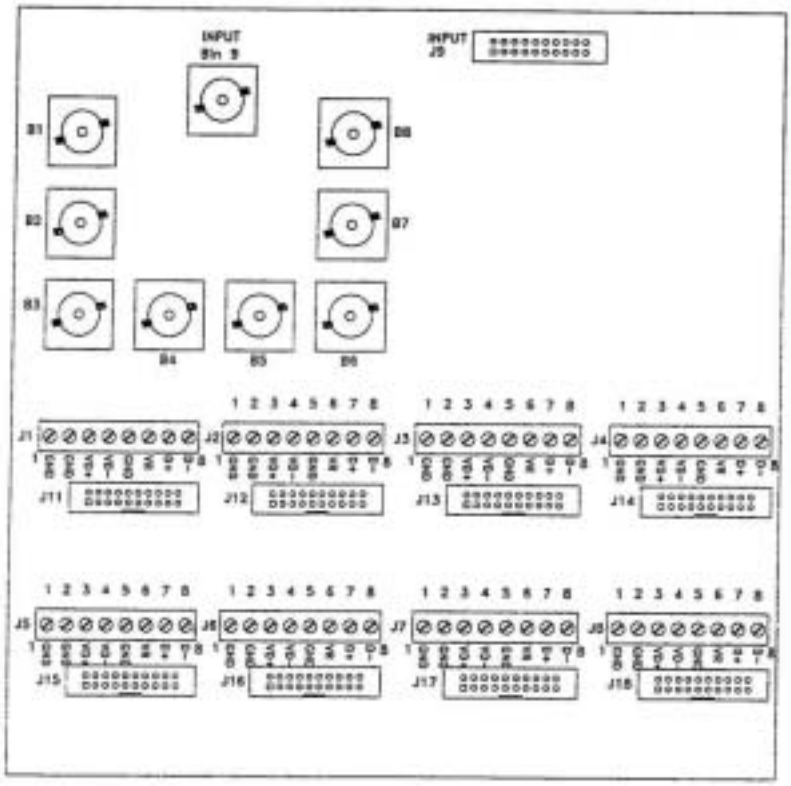


4 CHANNEL EXPANDER

FIG 3-8

A3.8 8 Channel Expander CPT210001 (REF:607017)

This module is similar to the CPT230027, but has a capacity of 8 sensors. It connects to the DAS via a 20 conductor ribbon cable and a coax. It can also be connected in tandem with six other CPT210001s (or with LM6450s for I.S. applications) to provide a system capacity of 24 sensors (Interconnection Diagrams, Figs 13-3, 13-4, 13-8).



607005 8 CHANNEL EXPANDER

FIG 3-9

A3.9 8 Channel I.S. Expander CPT210012 (REF:LM6450)

This module is used for multi-tank I.S. (intrinsic safety) applications. It has the same function as the CPT210001 expander. It consists of:

- A Motherboard - CPT210001

- An 8 channel switch module - CPT230038

- One or two four channel I.S. barriers - CPT210019

The switch module and the I.S. barriers are plug-in modules, installed in a card cage. The cage is mounted on the motherboard. All wiring to the sensor terminates on the motherboard. For up to eight sensors it is connected to the DAS via a 20 conductor ribbon cable and a coax. Eight of these modules can be connected to an eight channel expander to provide an I.S. system for up to 24 sensors (Interconnection Diagrams, Figs 13-7, 13-8).

A3.10 8 Channel I.S. Expander CPT210012

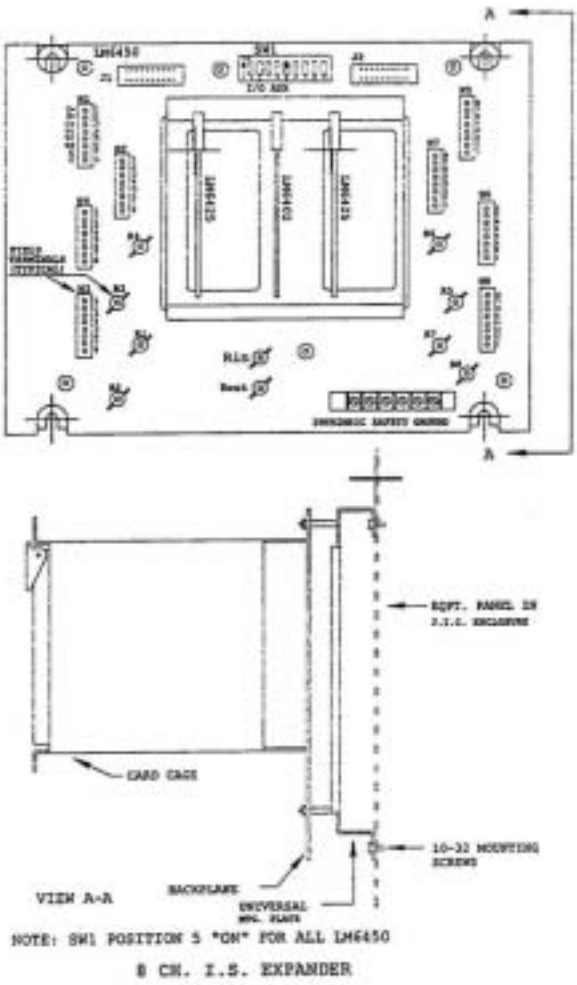
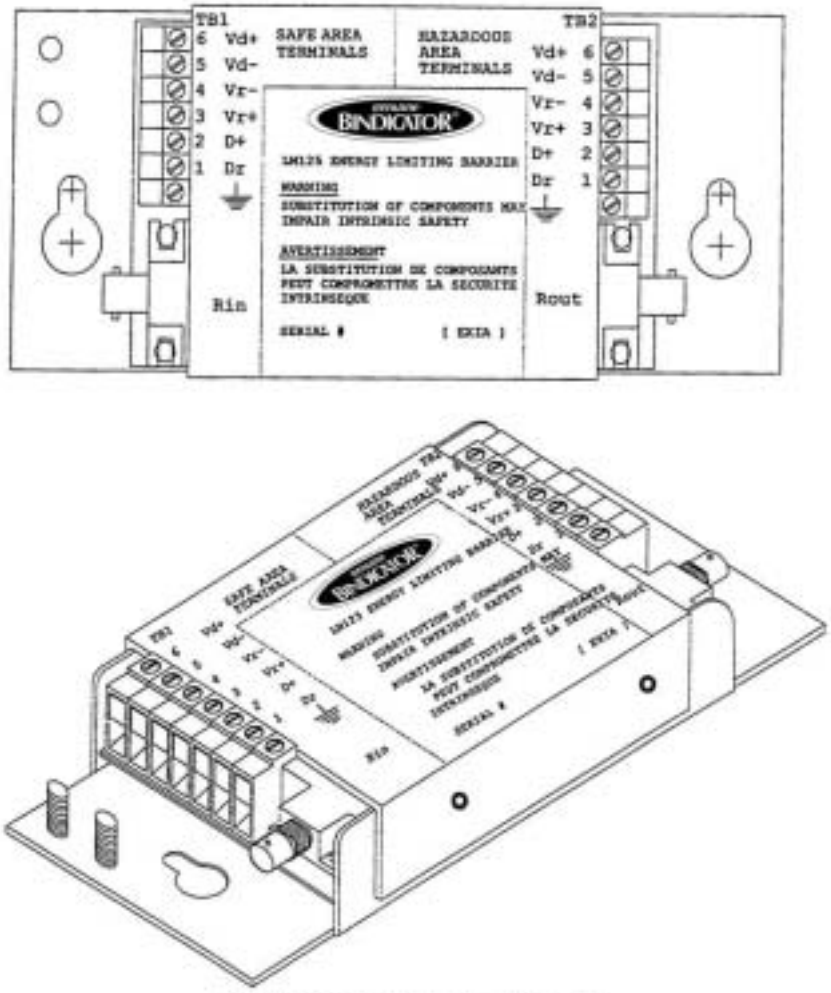


FIG 3-10

A3.11 1 Channel I.S. Barrier (LM125, LM125C)

This module is used in single tank hazardous applications. See Fig 13-5.



SINGLE CHANNEL I.S. BARRIER

FIG 3-11

A4 Installation

A4.1 General

A list of the most common installation problems are described at the end of this section. It is very important to study this section carefully before proceeding.

A4.2 Control unit location

The Control Unit should be installed in a well ventilated area. It should be mounted on a surface free from vibration. It should not be installed in direct sunlight without the use of a sun cover.

It should not be mounted close to high voltage or current runs, contactors or SCR control drives.

A4.3 Tools and connectors

Installation tools should include:

- A stripping tool (Paladin PA1225 or equal)
- A crimping tool (Paladin PA1317 or equal)

These are required for the coax cable (Section A4, Fig 4-1).

For the telephone modems, the following is required:

- Crimping tool (Panduit Part# CT-MP6 or equal)
- Connector (Panduit Part# MP66SO-L or equal)

Commissioning equipment should include:

- A digital multimeter with a diode tester.
- A PC equipped with setup and diagnostic software (refer to Section B).

A4.4 Wiring

Interconnection diagrams for different configurations are included at the back of this manual. These are categorized by system size and area classification. Select from the following table:

System size (# of sensors)	Area classification	Fig#
1	Ordinary	13-1
4	Ordinary	13-2
8	Ordinary	13-3
24	Ordinary	13-4
1	Hazardous	13-5
4	Hazardous	13-6
8	Hazardous	13-7
24	Hazardous	13-8

Fig 13-9 shows the wiring details for Relays and 4/20 outputs in large systems (more than 16 tanks). Fig 13-10 shows the interconnections for networked LM7000s. For non-standard applications, custom drawings are supplied.

The following wiring is required:

(a) 110/220 VAC. Use 3-wire connection per local code. Each stack has its own power supply. The maximum power consumption for a fully expanded system is less than 50 Watts.

(b) Coax cable from Control Unit to Sensor/Detector. This must be 50 ohm cable. Use RG58A/U, Belden 8219 or equal. Refer to Fig 4-1 for BNC connector assembly instructions.

(c) Twisted pair cable from Control Unit to sensor/detector -- 3 twisted pairs, 22 AWG minimum with an overall shield. Belden 8303 or equivalent. The coax and pairs can be run in the same conduit.

(d) 4 - 20mA. One twisted pair, 22 AWG minimum with an overall shield.

(e) Alarms. For Dry contact controls, use wire rated for external control voltage. Terminal blocks are rated up to 14 AWG. Contacts are rated for 5A, 1/6HP, 250VAC.

(f) RS232/networking. Use Belden 8132. The RS232 can be used for commissioning and troubleshooting. In applications where a telephone cable cannot be run to the LM7000, it is strongly recommended that a cable be run to an area equipped with a PC and a phone.

(g) Telephone cable. Use Belden 9562 or equal. This is used with a modem. This should be run to the nearest telephone outlet connected to an outside line.

Note: The main stack modules are shipped separately. These should not be installed until the voltage checks described in Section A6 are completed. These modules mount directly over the PSU (see Fig 4-2).

The designations (VR, GND), (VD+, VD-), (D+, D-) are for the three twisted pairs (pairs shown in brackets). Refer to the appropriate interconnection diagram at the back of the manual for the corresponding terminal numbers. Most twisted pair cables consist of a colored and a black wire. Ensure that each black is paired with its correct color.

A4.5 Conduit

To prevent water entering the Control unit or the sensor housing through the conduits, it is very important that a drip must be installed in the conduit. The entries must be properly sealed. Condulet sealing fittings such as Crouse Hinds EYS fittings and Chico sealing compound should be used. This will also prevent moist air entering through the conduit and condensing in the housing. In some applications, it may be necessary to install breathers in the conduit to prevent condensation in the sensor housing, particularly if the temperature inside the tank is higher than the ambient temperature.

A4.6 Sensor location

The following constraints must be observed:

- Do not install the sensor in the direct intake flowstream of the product.
- Choose a location such that the sensor will not get trapped against the wall of the tank. (The sensor reacts to objects or material closer than about 4 inches). It will not read correctly if it is in contact with the tank or other objects.
- Make sure that the sensor does not contact the draw off hopper.
- Do not use long sensor mounting standoff nozzles such that movement of the sensor could cause chafing against the tank inlet.
- In powders applications, orientate the sensor such that its web is at right angles to the tank radius.
- If a tether is required in a powders application, this should be as loose as possible while preventing the sensor from contacting the side of the vessel. For tether details refer to the appropriate sensor drawing in Section A2.

- If it is found that a weight is required after the sensor is shipped, do not bolt it on to the termination. The proximity of the weight will create erroneous readings. It must be connected through a link or a wire as shown in Fig 2-1. It is advisable to consult the factory before proceeding.

- If the sensor length is specified incorrectly, it cannot be adjusted in the field and must be returned to the factory.

A4.7 Common installation errors

The following is a list of commonly experienced installation errors that can cause subsequent damage to the equipment or poor performance.

1. Improperly made Coax cable connectors. This is the most common problem. Ensure that the correct tools are used (Section A4, Fig 4-1).

2. Incorrect coax cable. 50 Ohm coax must be used (Section A4.4, Wiring).

3. Interference from standpipe (Section A4.6, Sensor location).

4. Water in the sensor housing. This can enter through the conduit entry, particularly if the field wiring is not run in conduit. Condensation can also occur if the temperature in the tank is higher than the outside ambient temperature (Section A4.5, conduit). In some applications, it may be necessary to flood the housing with a silicone gel.

5. Improper sensor location. Sensor contact with any part of the tank or any metal objects within the tank may cause erratic readings (Section A4.6, sensor location).

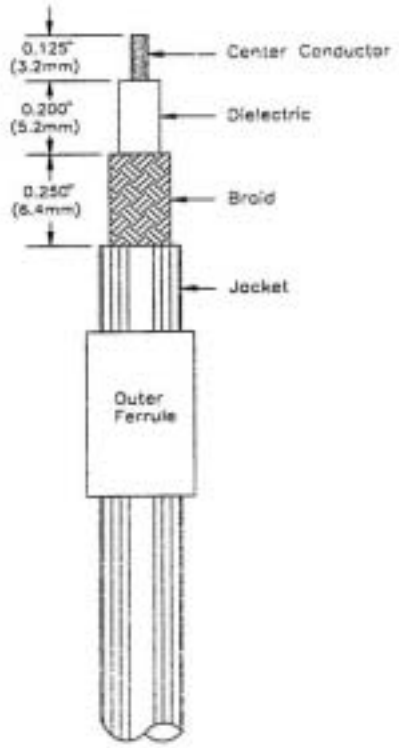
6. Weights bolted directly on to the bottom of the sensor. This can cause erroneous readings. A weight should be attached to the sensor using a wire or link (Section A2, Fig 2-1).

7. Incorrect sensor length specified. If the sensor is too long, it cannot be modified in the field and must be returned to the factory.

8. No 4-20mA outputs. These are self powered, isolated outputs. Ensure that the connected equipment is configured properly. The maximum load is 300 Ohms.

9. Poor grounding. Some materials, such as plastic pellets, generate high levels of static electricity. This is caused by the product rubbing on the sensor when tank levels are changing. Ensure that the sensor housing is connected to a local ground before any product is run through the tank (Section A4, Fig 4-3).

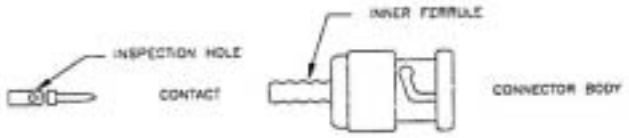
10. Twisted pair wiring errors. Black wires paired up with incorrect colored wires.



1. Strip cable jacket, braid, and dielectric to dimensions shown in drawing. All cuts are to be sharp and square.
2. Important: Do not nick braid, dielectric and center conductor. Tinning of center conductor is not necessary if contact is to be crimped. For solder method, tin center conductor avoiding excessive heat.
3. Slide outer ferrule onto cable as shown. Flare slightly end of cable braid to facilitate insertion onto inner ferrule.
4. Important: Do not comb out braid.
5. Place contact on cable center conductor so that it butts against cable dielectric. Center conductor should be visible through inspection hole in contact. Crimp or solder the contact in place before proceding.
6. Install cable assembly into connector body so that inner ferrule portion slides under braid. Push cable forward until contact snaps into place in connector insulator.
7. Slide outer ferrule over braid and up against connector body then crimp outer ferrule to finish termination.

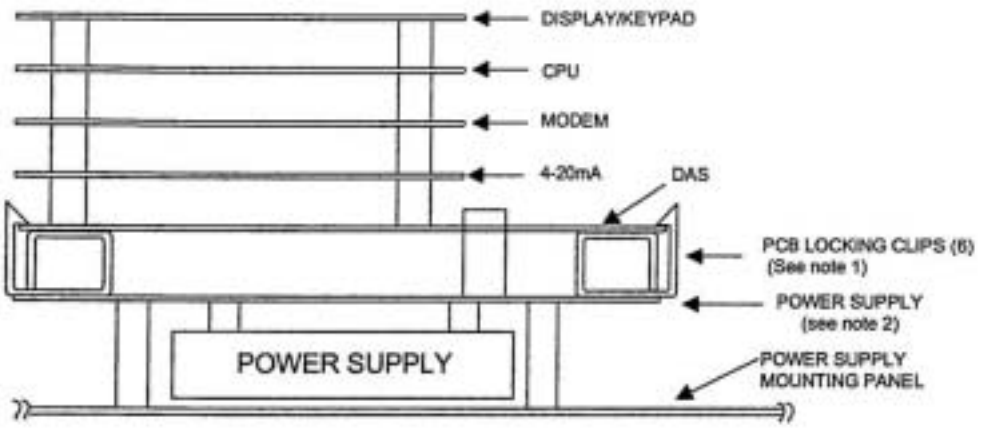
Recommended Tools: Paladin PA1317 Crimping Tool
Paladin PA1225 Stripping Tool

BNC Connector (Amphenol 31–320 Assembly)

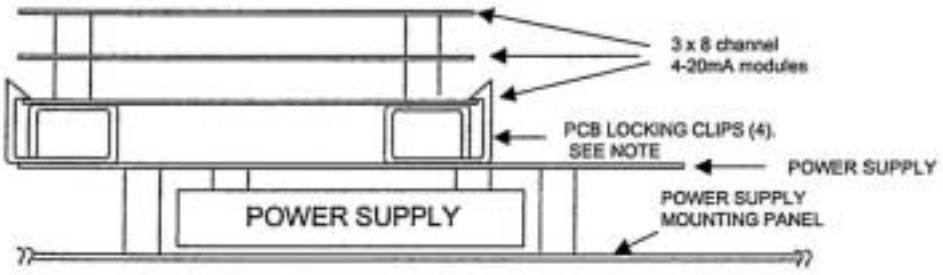


COAXIAL CONNECTOR ASSEMBLY

FIG 4-1



CONTROLLER STACK, TYPICAL LAYOUT (SIDE VIEW)



RELAY & 4/20mA STACK, TYPICAL LAYOUT (SIDE VIEW)

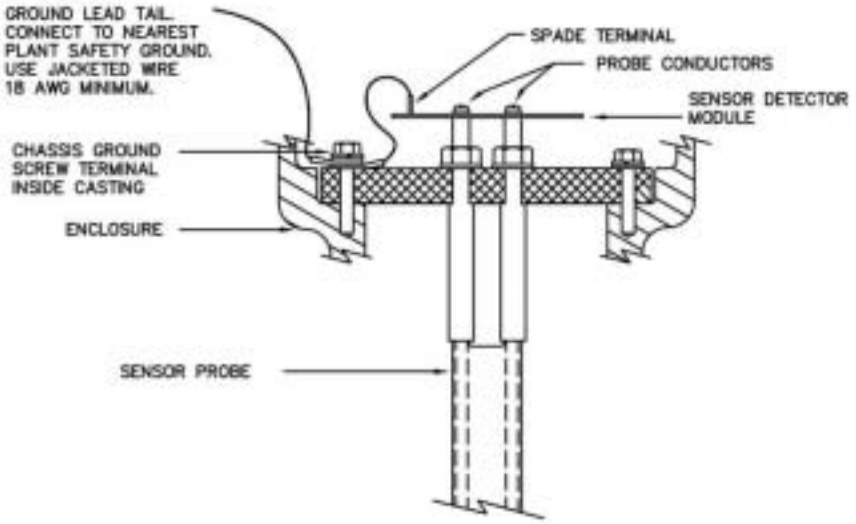
Notes: 1. Push clips away from edge and lift board to unlock PCB. Once all clips are unlocked, the assembly can be removed from the power supply module.

2. For systems with 4 or less sensors, the 4-20mA outputs are located on the power supply.

Fig 4-2

SENSOR GROUNDING

IMPORTANT



VERY IMPORTANT. PLEASE FOLLOW THESE INSTRUCTIONS

1. SENSORS INSTALLED IN DRY BULK PRODUCTS ARE EXPOSED TO STATIC ELECTRICITY. STATIC PROTECTION IS EQUIPPED ON THIS SENSOR. THIS IS EFFECTIVE ONLY WHEN THE ENCLOSURE SAFETY GROUND IS CONNECTED AS SHOWN.
   THIS GROUND MUST BE CONNECTED AT ALL TIMES.
   ON INSTALLATION THIS GROUND MUST BE CONNECTED BEFORE RUNNING ANY PRODUCT OVER THE SENSOR.

2. IF THE SENSOR DETECTOR MODULE IS REMOVED, GROUND BOTH PROBE CONDUCTORS TO THE CHASSIS GROUND SCREW. IF LEFT UNGROUNDED STATIC ELECTRICTY MAY DAMAGE THE TERMINATION AT THE BOTTOM OF THE SENSOR.

SK30002

A5 Hazardous area requirements

BULLETIN EB 4211

A5.1 General

This section describes the installation procedure for hazardous locations in conformance with the following standards:

CSA Standard C22.2 No. 157.

UL Standard - 913

CENELEC Standard EN 50 020.

This bulletin is intended only to supplement the requirements of the applicable local codes for electrical installations in hazardous locations.

A5.2 Enclosures

The Central Equipment forms part of an intrinsically safe system containing circuits which are not intrinsically safe. The Central Equipment must always be housed in an enclosure approved for its location.

A5.3 Intrinsically safe circuits

Intrinsic safety is achieved by:

a) Energy limiting circuits between the Central Equipment and the field sensors;

b) Separation of hazardous from safe area wiring within the Central Equipment enclosure.

A5.4 Energy limiting barriers

All signals to and from the remote sensors pass through energy limiting circuits. These circuits are incorporated on a printed circuit module which is normally installed in the LM7000 enclosure. A single (LM125) and a four (LM6425) channel (CSA, NRTL/C approved only) version is available.

Up to two LM6425 modules can be mounted on the LM6450 Expander. They connect to a motherboard through edge connectors. The I.S. sensor wiring (coax and pairs) is connected

to terminals R1 to R8 and H1 to H8. The NON I.S. signals are connected to the LM6450 module through a 20 conductor ribbon cable and a coax. The LM125 is mounted on the LM7000 back panel. Refer to Figs 3-10, 3-11 (Section A3), 13-5, 13-6, 13-7, 13-8.

Note: Follow warning on front panel of the LM6425 and LM125 modules. These sealed unit must not be repaired, modified or tampered with by the user. Two ground leads from each barrier must be connected to building safety ground installed per local code. Failed I.S. modules must be returned to factory for repair.

A5.5 Grounding

LM6425

Two 18AWG ground tails are provided with each LM6425 Barrier. These must be connected to terminal marked "intrinsic safety ground" on the LM6450. Connect two ground wires to the system I.S. system ground. Ground wire to be 18AWG minimum. The building ground must conform to local codes.

LM125

The LM125 has two grounding posts. These must be connected to the system I.S. ground. Ground wire to be 18AWG minimum. The building ground must conform to local codes.

Note: Ground continuity to the barriers is vital at all times to maintain intrinsic safety for the I/O field connected wiring and the Sensors.

A5.6 Repair

The CSA, NRTL/C, CENELEC approved barriers are enclosed in a metal housing which is riveted to the PCB. In the event of a failure in this module, it must be returned to the factory for repair. Field repairs must not be made.

A5.7 Wiring

The (I.S.) wiring between the Central Equipment and the sensor consists of a three pair instrument cable, a coax and an 18 AWG bare ground wire. AC power, 4-20mAs, relays and communications wiring is classified as NON I.S.

A minimum separation of 2" (50mm) is required between the I.S. and non-I.S. wiring. Refer to the appropriate equipment layout drawing supplied with each application. Where necessary, separate tiemounts are provided to maintain the required separation.

The I.S. wiring must be installed in separate conduit or in a raceway separated from other wiring by a grounded metal barrier. Refer to the applicable local electrical code.

A6 Preliminary checkout

A6.1 Field wiring

In addition to the normal wiring continuity checks, the following power off resistance and diode tests should be carried out with the twisted pair wiring connected at the sensor end and disconnected at the Control unit terminals. The values are ± 10%.

VD+ to VD-	11K Ohms (positive on VD+)
D+ to Dr	200 Ohms (LM6705 sensor only)
VR to GND	12V Relay ~ 1000-1800 Ohms 9V Relay ~ 1000 Ohms 5V Relay ~ 300 Ohms

Change the meter to diode test and measure the following voltages.

VD+ to VD-	0.3V (connect positive lead to VD-)
VR to GND	0.6V (connect positive lead to GND)

Before connecting the coax cable at either end, check for continuity between the center and outer conductors and for shorts at the BNC connectors.

A6.2 Power supply voltages

Apply AC Power and verify the DC voltages on the PSU Module (top right hand corner, Figs 3-4, 3-5). These should read:

+12V ± 1V, -12V ± 1V, +5.2 ± 0.05V + 24VDC on RF Amp INPUT

Switch off the power and mount the other modules on the PSU Module. Complete the remaining connections to these modules.

A6.3 Testing the telephone modem

The modem should be tested before calling for factory support. Dial the modem number from another phone. If it is functioning properly, the modem will generate the same tones as a fax machine.

The modem has seven, green, status LEDs. When the modem is not in use, only the following LEDs will be on.

PWR (Power), HS(High Speed)

When the number is dialed, the RI (Ring Indicator) LED will flash on and off. After two rings, the OH (Off Hook) LED will come on and, after a few seconds, the CD (Carrier Detect). The TD (Transmit) and RD (Receive) LEDs will be active while the PCBUS program is communicating with the LM7000.

A handset can be connected to the second phone jack (PHONE). This can be used for outgoing calls only. Incoming calls can only be received when the LM7000 is switched off.

A7 Startup

A7.1 How to use the keypad

The LM7000 has five infrared keys and a single line display 16 alphanumeric long. In the standard 8"x11" FRP enclosure the keys can be activated through the enclosure window. The purposes of this interface is as follows:

- To view the level in a specific tank in user selected units.
- To load the database parameters (sensor lengths, display units etc.).
- To view test data.
- To perform diagnostic tests.
- To provide more information on what is being currently displayed.

The keys are identified as follows:

SHOW SETUP/ESC DEC INC TEST/ENT

The data is arranged in a series of menus and submenus. A number of flow diagrams are shown in this section to illustrate how data is viewed and changed. Keystrokes with direction arrows indicate how to change from one display to another. They show what key strokes are necessary to get to any part of the database. When the same key has to be pressed more than once, the number of keystrokes is shown in brackets. Fig 7-1 shows the main flow diagram. The power up mode is "RUN". The unit can be forced into this mode by pressing the "Reset" on the CPU (Section A.3, Fig 3-1). A sample sensor datasheet is included at the back of the manual (Appendix C10).

A7.2 Types of data

There are three types of data stored:

- numeric,
- logical
- alphanumeric

Fig 7-2 illustrates how to change sensor length.

A logical database is one where the user toggles between multiple choices. "Unit" (system parameter #1) is an example of this. It allows the user to choose between different length units including feet and meters. See Fig 7-3.

User designated tank names are examples of an alphanumeric database. Fig 7-4 illustrates how a tank name is changed.

The "Show" key is used where the information currently being displayed needs clarification. "Esc" returns to the previous display.

A7.3 Sensor addressing

Each sensor has a unique address. This is determined by the location where it is connected. These addresses are shown on each interconnection diagram at the back of this manual.

Prior to entering the sensor and system parameters, the user should first enter a tank name for each sensor position. Each tank name can have up to 7 characters. Fig 7-4 shows how a name can be entered. The sensor and system parameters should be entered next.

A7.4 Test features

For initial startup, a number of tests can be carried out. This can be done by following the steps on the hardware test menu (Fig 7-6).

1. Not used

2. Vref

This test measures the level of the transmitted signal at the sensor. The displayed values are mostly dependent on the length of the coax cable. Both "H" and "L should exceed 700. An "L" value less than 300 could indicate that the coax run is more than 400ft (120m). If the values are less than 100 or negative, check the coax connectors and the VD+, VD- pair.

3. Not used

4. Not used

5. Vof

Improperly made coax connectors are the most common installation problem. This test is primarily intended to check for these. It also checks the output signal from the DAS (607017) module. Typically the values are 6000 ("H") and 4000 ("L"). If the ratio of H/L is more than 5, check the connector at the sensor end. If both values are more than 9000 or less than 1000, check the controller end connector. With the connector removed at the DAS (Bout) "H" and "L" should be about 13,000 and 10,000 respectively.

6. 4-20mA

CPT210002, CPT210016

There are no zero or span adjustments for these circuits. Enter 100 to force the output to 20mA. Enter 0 to force the output to 4mA. Each channel is equipped with a red LED. This can be used to verify the 4/20mA loop. If the loop is open or the impedance of the receiving device exceeds 600 Ohms, the LED will come on when the output is forced to any value.

7. Hlev

Use this parameter to force the high level relay.

8. Llev

Use this parameter to force the low level relay.

9. Alrm

Use this parameter to force the Alarm relay.

10. Initializing the Database

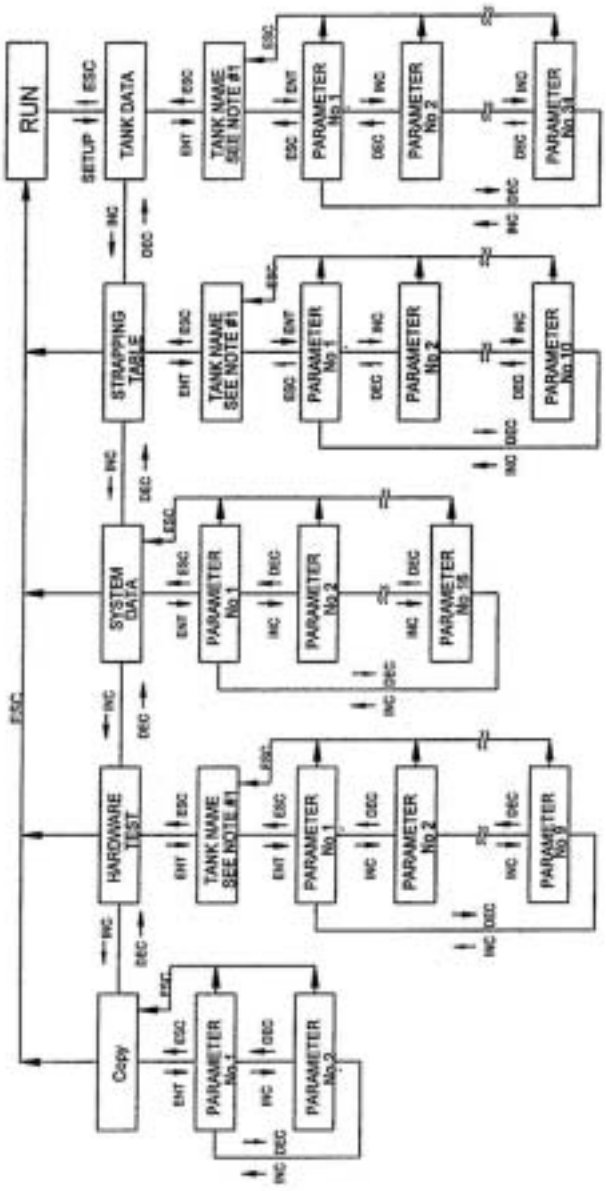
See Fig 7-5. Function #2 can be used to initialize the database to its default values. Function #4 (copy) is not used.

A7.5 Show key

Press this key to clarify the information on the display. Press "ESC" to return to the previous display.

A7.6 Test key

Application type problems can be identified using the test key. Refer to Sections A8, A9.



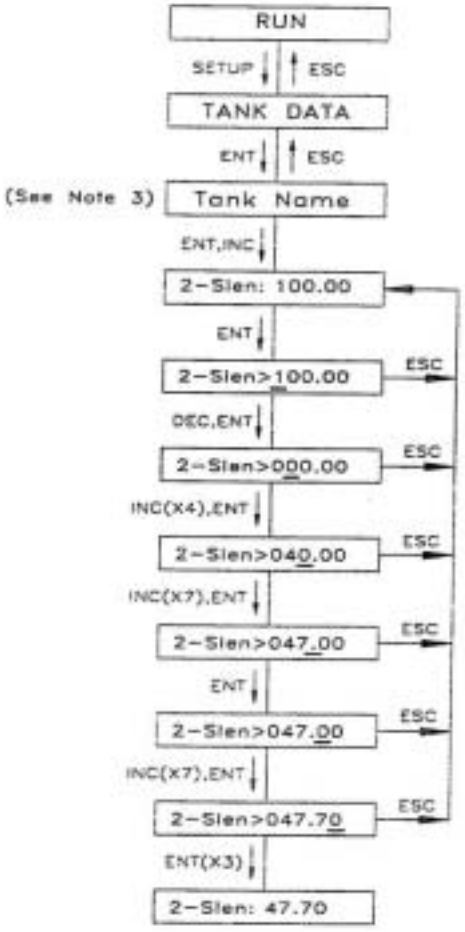
NOTES:

1 - PRESS INC (OR DEC) TO SELECT DEFINED TANK NAME

2 - LM7000 POWERS UP IN "RUN" MODE

MAIN FLOW CHART

Fig 7-1

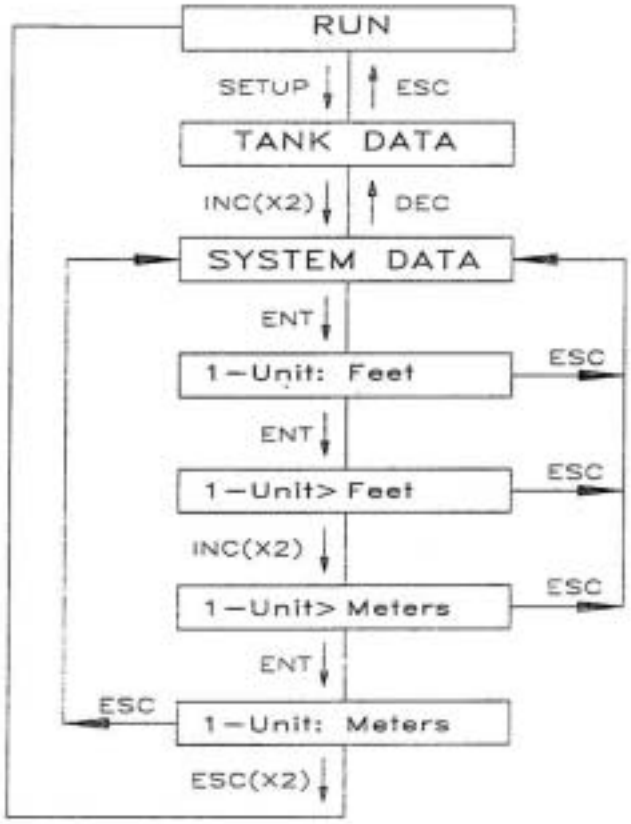


NOTES:

1. TO CHANGE A PARAMETER VALUE, PRESS ENT THEN INC (OR DEC) UNTIL CORRECT VALUE IS DISPLAYED. PRESS ENT TO SAVE.
2. TO RETURN TO TANK DATA FROM ANY PARAMETER PRESS ESC.
3. PRESS INC (OR DEC) TO SELECT DEFINED TANK NAME.

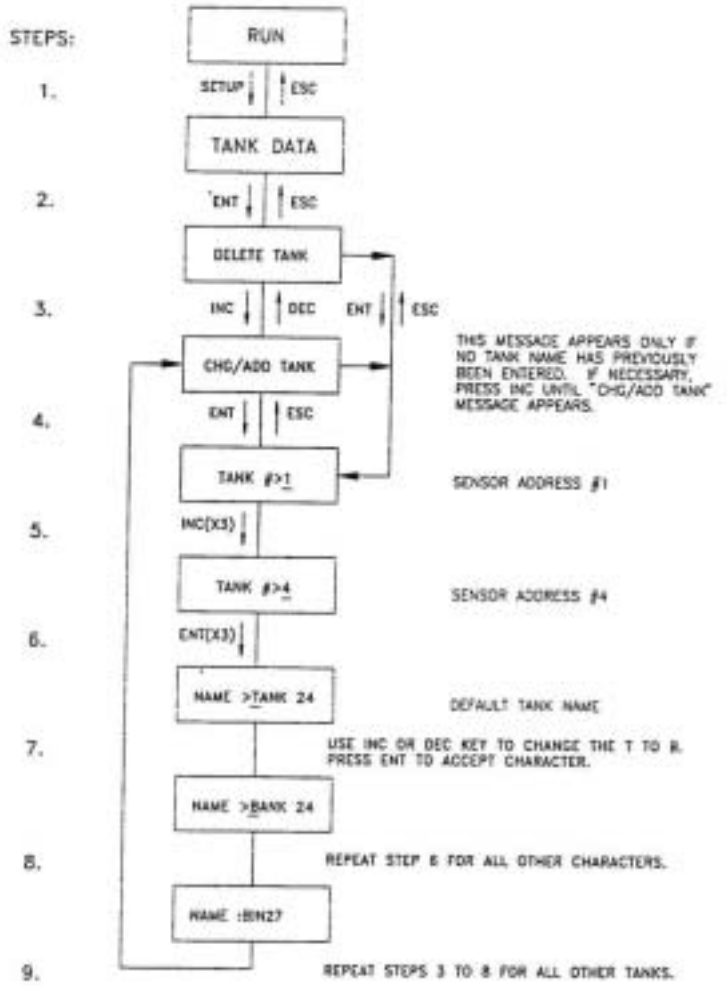
EXAMPLE
CHANGE SENSOR LENGTH
(TANK DATA PARAMETER No. 2)

FIG 7-2



EXAMPLE
CHANGE UNITS FROM FEET TO METERS
(SYSTEM DATA PARAMETER No 1)

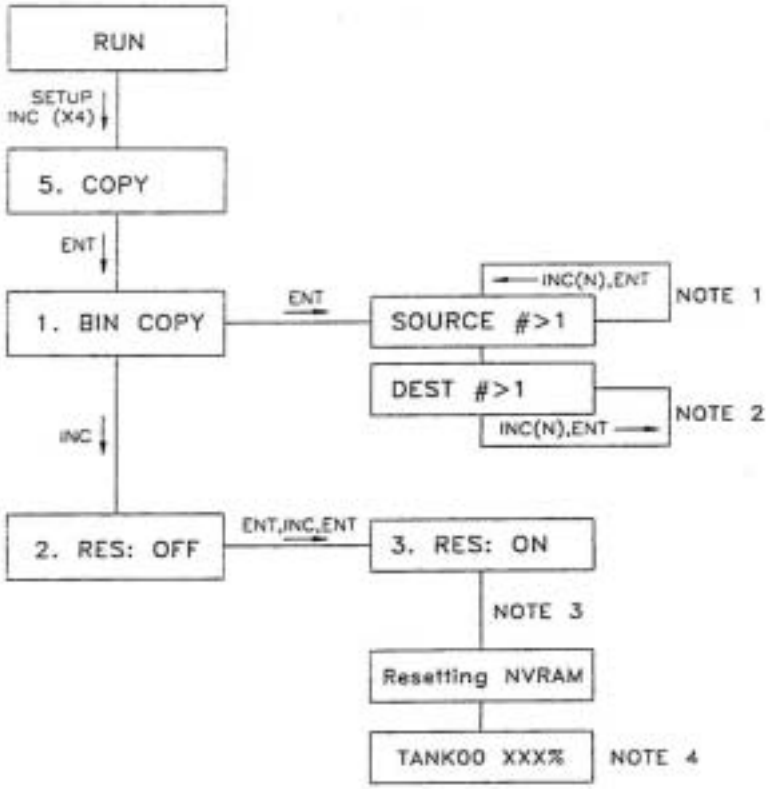
FIG 7-3



EXAMPLE

ENTER USER TANK NAME "Bin27" CONNECTED TO SENSOR POSITION #4.

FIG 7-4

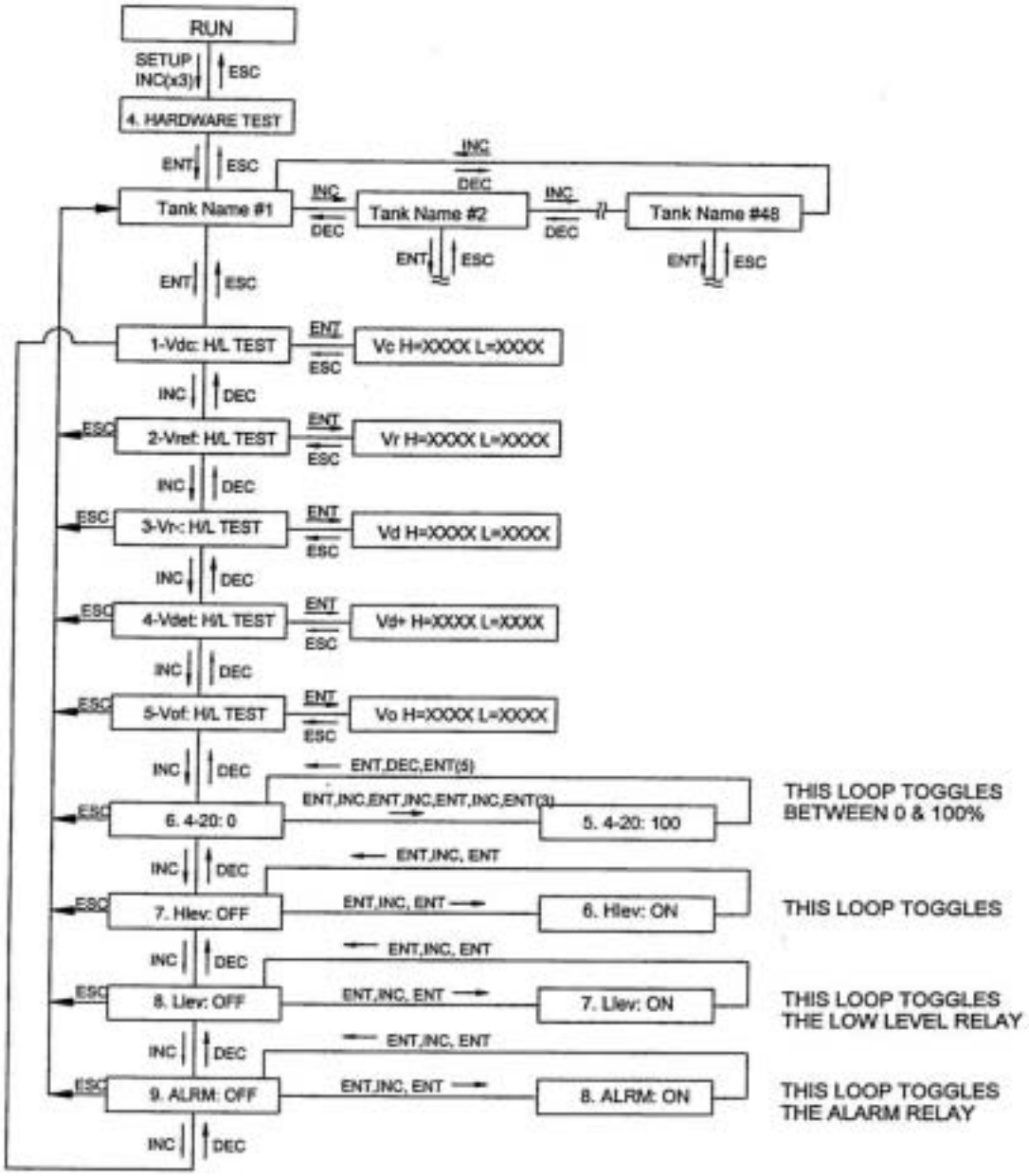


NOTES:

1. THIS LOOP SETS THE ADDRESS OF THE TANK TO BE COPIED FROM.
2. THIS LOOP SETS THE ADDRESS OF THE TANK TO BE COPIED TO.
3. PRESS THE RESET PUSHBUTTON (S2) ON THE CPU BOARD.
4. THE DATABASE IS NOW INITIALIZED.

COPY FUNCTION

FIG 7-5



HARDWARE TEST

Fig 7-6

A8 System alignment

A8.1 General

A number of parameters are application dependent. For most products, the factory settings will work satisfactorily. In some applications, fine tuning may be necessary. This is best done after the sensor is installed and the product is cycled in the tank.

A8.2 Critical parameters

#2 (Sensor length). Ensure that this is entered correctly in feet (meters x 3.28)

#25 (Blanking). This is the length in feet of the unused portion of the sensor that the product never reaches. Refer to Appendix C2.

#11 (Method). This is the computation method used to determine level. For applications in solids in tanks greater than 20ft (6m), it should remain at the default setting ("Autoscan"). For more information, refer to Appendix C2.

The LM7000 computes test data while a tank is being scanned. This can be viewed by using the "Test" and "Inc" keys. On multi-tank systems, the data is overwritten by test data from the next tank. For this reason, the data should be collected as soon as a reading for the tank is displayed. If this is not practical, temporarily turn off the scans for other tanks while the test is in progress.

A8.3 Zero adjust (Done in AutoScan Mode)

1. Ensure that the tank is empty.
2. Note the %full value on the display. The reading should be less than 20%. (It not, refer to Section A9).
3. Immediately press the following keys and record the displayed test data.

KEYSTROKE	LCD Display
"TEST"	1- QF XX.X
"INC"	2- DVmt XX.X
"INC"	3- Dair XX.X

If QF is greater than 65, copy the Dair value into Vair (Sensor Parameter #4). Change %ext (Sensor Parameter #6) to 3. Otherwise refer to Section A9. The revised Vair is usually a few percent (less than 5) lower than the default value. If Dair is more than 5% different for the default value, it could indicate that the tank is not empty or that the sensor length in the database is not the correct value.

A8.4 Span adjust

Complete steps 1 to 6 if the "Autoscan" method (parameter #11) is selected. It is preferable to do this adjustment when the level is more than 50%. Complete step 7 only if the "Basic" method is selected.

1. Determine the actual empty space (in feet) in the tank (i.e. the length of the exposed portion of the sensor). Temporarily change sensor parameter #11 (Method) to "Extended" and parameter #17 (averaging) to 1. Change the system parameters to read empty space in feet. (#1 – Feet, #2 – Empty, #3 – Units).

2. Reset the LM7000. Wait until a reading is displayed.

3. Compare this value to the actual empty space. Adjust Vmat (in increments of 1 or less) to reduce the difference between the two readings (increasing Vmat will decrease the empty space reading and vice versa).

4. Repeat steps 2 and 3 until the difference between the two readings is less than 1ft.

5. After Vmat is determined, change VmatHi (parameter #35) to Vmat + 2.

6. Return the sensor and system parameters (changed in step 1) to their previous values.

7. Determine what percentage of the sensor is immersed when the tank is considered to be 100% full. Round it off to the nearest 1%. Enter it into the second strapping point under Disp%. To enable the strapping tables, go to the System Data and change parameter #1 to "Strap Tbl".

A9 Troubleshooting using the keypad

A9.1 General

Section A6 describes how to identify wiring faults and/or defective modules. This section describes how to identify and correct problems inside the tank. Incorrect readings can be caused by one or more of the following:

- There is a false echo from the support stand of the sensor.
- There is heavy product buildup on the sensor.
- In low dielectric products (such as plastics), the echo from the bottom of the sensor is larger than the echo from the product surface.

Any of the above problems may cause erratic readings. The following procedure shows how to identify and reject any false echoes.

1. Set the scan to "OFF" for all other tanks while this test is in progress.

2. Change the following sensor parameters to the values shown below (#31 must be returned to 75 at the completion of the test):

   #31 (QFT) to 0.
   #34 (Vmat) to 50
   #25 (Blnk) to 0

3. Press the "Reset" button and wait until a level reading is displayed.

4. Enter the keystrokes shown in Table 1 and fill in the values under "TEST DATA".

5. Press the "ESC" key to return to "RUN" mode.

KEYSTROKES	TEST DATA	KEYSTROKES	TEST DATA
TEST	1-QF	INC	10-Len2
INC	2-DVmt	INC	11-Amp2
INC	3-Dair	INC	12-Len3
INC	4-AttL	INC	13-Amp3
INC	5-AttH	INC	14-Len4
INC	6-Len0	INC	15-Amp4
INC	7-Amp0	INC	16-Len5
INC	8-Len1	INC	17-Amp5
INC	9-Amp1	INC	18-Sdg

Table 1

Amp0, 1, 2, 3, 4, 5 are the five largest echoes sorted in order of magnitude, Amp0 being the largest (In most cases, there are less than 5). Len0, 1, 2, 3, 4, 5 are their corresponding distances in feet (meters x 3.28) from the top of the sensor. To assist troubleshooting, these echoes can be sketched out as in Fig 9-1. Echoes that are less than 5% of Amp0 can be disregarded. The "DEC" key can be used to display a previous value. Press the "ESC" key to return to the "RUN" mode.

In the example in Fig 9-1, there are three echoes. Len0 (False top echo) is caused by the mounting flange. Len1 (False bottom echo) is the echo from the end of the sensor. Len2 is the true echo from the product surface.

Physically determine the actual empty space in the tank. Examine the collected data and identify the correct echo. The following procedure shows how to eliminate the remaining echoes.

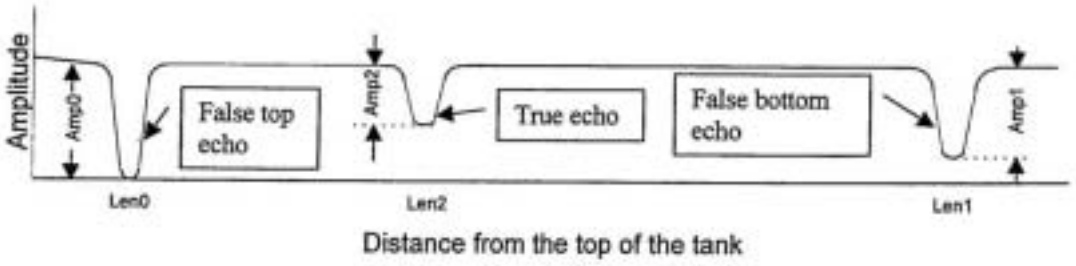


Fig 9-1, Typical echo graph

A9.2 False top echo

This echo may occur within the top 5ft of the sensor. Parameter #22 (Slope) can be used to minimize it. It has seven settings (A to G). Repeat the above test for each of the seven Slope settings. Choose the Slope that has the smallest top echo. If the echo is not less than about half the true echo, increase "Autotune" (Parameter #29), until it is larger than the distance to the false echo by 2. (Example: If the echo is at 6ft, set "Autotune" to 8). This value should not exceed 15ft (4.5m) or 25% of sensor length. If there is no false echo, return this value to its default (5).

In some applications, this echo may occur in the unused top portion of the sensor. Refer to Appendix C2, Parameter #25 (Blanking).

A9.3 False bottom echo

To correct this, wait until the tank is empty and do the Zero Adjust (Section A8). A temporary solution is to reduce %ext in increments of 1, repeating the test each time until the bottom echo is eliminated. If after the above steps, QF is now greater than 75, copy DVmt into Vmat (Parameter #34) and return QFT (Parameter #31) to 75.

A9.4 Product buildup

In applications where product buildup occurs, the quality factor (QF) may be below 75. In these cases, Vmat has to be determined by trial and error.

1. Temporarily change "Method" (Parameter #11) to "Extended" and "Averaging" (Parameter #17) to 1.

2. Return to run mode and wait until the display has updated.

3. Compare the reading with the actual level in the tank.

4. Keep adjusting Vmat (returning to "RUN" mode each time to view the reading) until the correct reading is displayed (Increase "Vmat" to increase the level reading and vice versa). Typically, values for "Vmat" are between 50 and 77. VmatHi should then be set to Vmat + 2.

5. Return "Method" to "Autoscan" and "Averaging" to its previous value. Ensure that QF is set to its default value (75).

Section B – Diagnostic Software

B1 General

This section describes how to commission and troubleshoot the LM7000 using the PCBUS diagnostic software. PCBUS is supplied on a 3.5" diskette with each system.

B2 PC Requirements

The following are the minimum requirements:

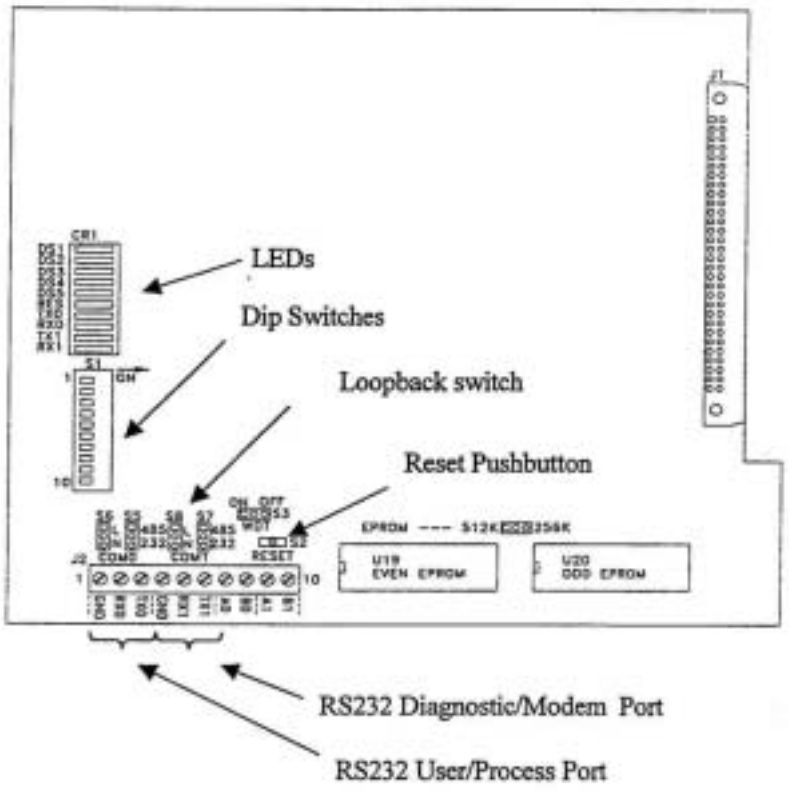
- IBM compatible.
- A 386 with a math coprocessor.
- 640K RAM
- 3.5", 740K floppy drive.
- MS-DOS 5.0 or later
- RS232 Port (COM1 or COM2)

B3 RS232 Connection

The LM7000 has two communications ports (Fig 3-1, in this Section). These are designated COM0 and COM1. COM1 is used for diagnostics. This port is also used to interface with a built-in telephone modem. For a local RS232 connection, first remove the jumper cable to the modem board.

LM7000	**Computer**		
CPU (607001) (Connector J2, COM1)	PC (DB9)	or	PC (DB25)
PIN 6 (TX) ----------PIN 2 (RX)			PIN 3 (RX)
PIN 5 (RX) ----------PIN 3 (TX)			PIN 2 (TX)
PIN 4 (GND) ----------PIN 5 (GND)			PIN 7 (GND)

For runs in excess of 50ft (15m), a line extender (short haul modem) is recommended. Refer to Fig 3-2 in this Section.


LEDs
Dip Switches
Loopback switch
Reset Pushbutton
RS232 Diagnostic/Modem Port
RS232 User/Process Port
CPU BOARD LAYOUT

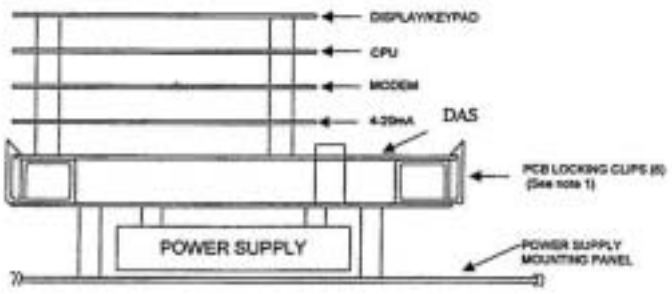
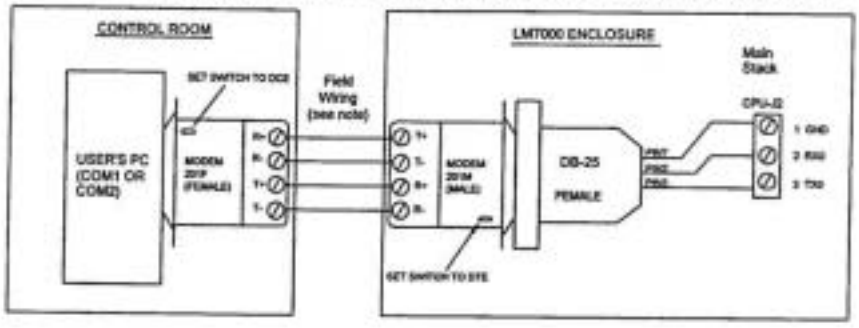
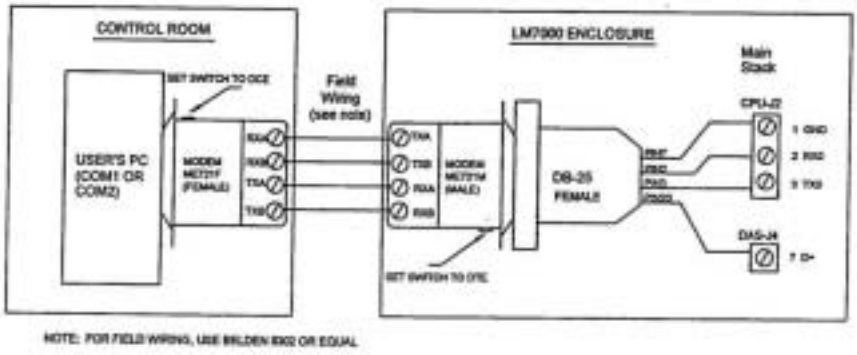

DISPLAY/KEYPAD
CPU
MODEM
4-20mA
DAS
POWER SUPPLY
POWER SUPPLY MOUNTING PANEL
CONTROLLER STACK, TYPICAL LAYOUT (SIDE VIEW)

Fig 3-1, CPU

SERIAL INTERFACE USING TELEBYTE MODEL 201 SHORT HAUL MODEMS.



SERIAL INTERFACE USING BLACK BOX SHORT HAUL MODEMS.



NOTE: FOR FIELD WIRING, USE BELDEN 8302 OR EQUAL

Fig 3-2, Short Haul Modems

B4 Startup

Create a directory on the hard disk. Copy the complete contents of the Diagnostic disk to this directory. To run the PCBUS program, type in the following:

LM7000 [Enter] (or LM7000 /2 [Enter] if COM2 is used)

The Main Page (Fig 5-1) will be displayed. The message "Remote data load" should now appear at the bottom of the page. If there is a problem, the message "Communications fail" will be displayed (Refer to Section B7, troubleshooting), if not, the message "Remote on line" will appear after about 10 seconds.

The PCBUS program is organized in a series of menus and submenus. The Arrow (Cursor) and Enter keys are used to select different menus and pages. The "Esc" key is used to return to the previous menu.

B5 Data Entry

Appendix C2 contains a list of all sensor and system parameters. The default values for most of the parameters should work in the most common applications, i.e. powders and granular materials in tanks greater than 20ft (6m). For different applications, refer to Appendix C2.

Fig 5-1, Main Page

B5.1 Initial settings

On the Main Page (Fig 5-1), the cursor will highlight "Setup". Press the Enter key 3 times to access the Tank Data Page (Fig 5-2). This figure highlights the parameters that must first be adjusted or verified before the system checkout can be completed.

There are three types of data:- Numeric (Example: Sensor length), Logical (Example: Display format) and Alphanumeric (Example: Tank name). To change a parameter, use the arrow keys to highlight it. For numeric and alphanumeric data, type in the new value. For logical data, press the Enter key until the correct setting is displayed. The command line at the bottom of the page provides more information on the selected parameter.

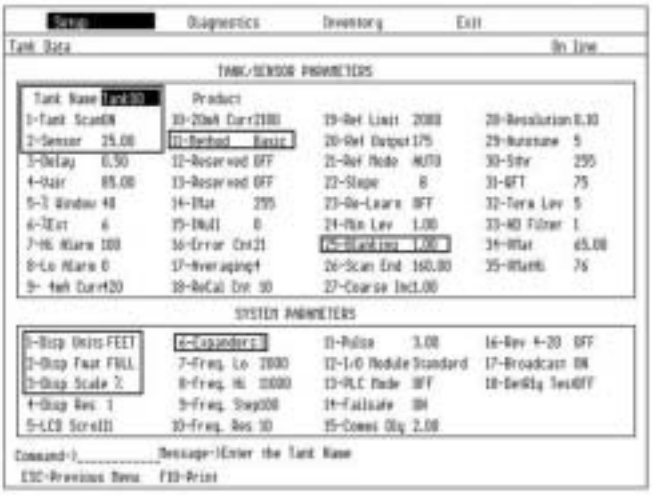


Fig 5-2, Tank Data Page

This is the sensor database for single tank systems or for the first sensor in a multi-tank system. This page also contains the system parameters. These parameter appear on every Tank Data Page but only need to be modified on the first page. Check "Expanders" (System Parameter #6). This specifies the number of expander boards connected directly to sensors (1 for 1-8 sensors, 2 for 9-16, 3 for 17-24 etc.). Ensure that this is set correctly. If this value must be changed, it is necessary to reset the system. This can be done by pressing the reset pushbutton (S2) on the CPU (Section B3.1, Fig 3-1). If this has to be done, wait until the "Remote on line" message reappears.

First choose a display format (System Parameters #1, #2, #3). The display choices are described in Appendix C2.

Move the cursor to the right of "Tank Name". Enter the tank name (up to 7 alpha-numeric characters). Ensure that "Tank Scan" is "ON". Enter the sensor length in feet (to one decimal place) next to "Sensor".

"Method" (Parameter #11) is the computation method used to determine level. For applications in solids in tanks greater than 20ft (6m) in solids, it should remain at the default setting ("Autoscan"). For more information, refer to Appendix C2.

"Blanking" (Parameter #25) is the length in feet of the unused portion at the top of the sensors that the product never reaches. For more information, refer to Appendix C2.

If there is more than one sensor, press "Esc" to return to the sensor map page (Fig 5-3). Use the Arrow and Enter keys to select the next position. Repeat the above procedure for all sensors. On completion, return to the main Page (Esc, Esc, Esc).

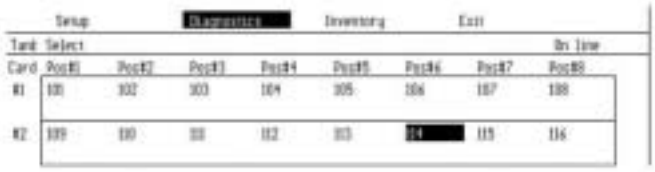


Fig 5-3, Address Map

B6 Fine tuning the parameters

This section describes the method of verifying and, if necessary, adjusting application sensitive parameters. From the main PCBUS page, arrow right to select "Diagnostics". Press Enter and choose "Hardware Test" from the Diagnostics Menu (Fig 6.1).

Fig 6-1, Diagnostics Menu

Cursor to the selected tank. Press Enter to select the Hardware Test page (Fig 6-2).

Step 1. Press Enter to the display the Graph Function menu (Fig. 6-3).

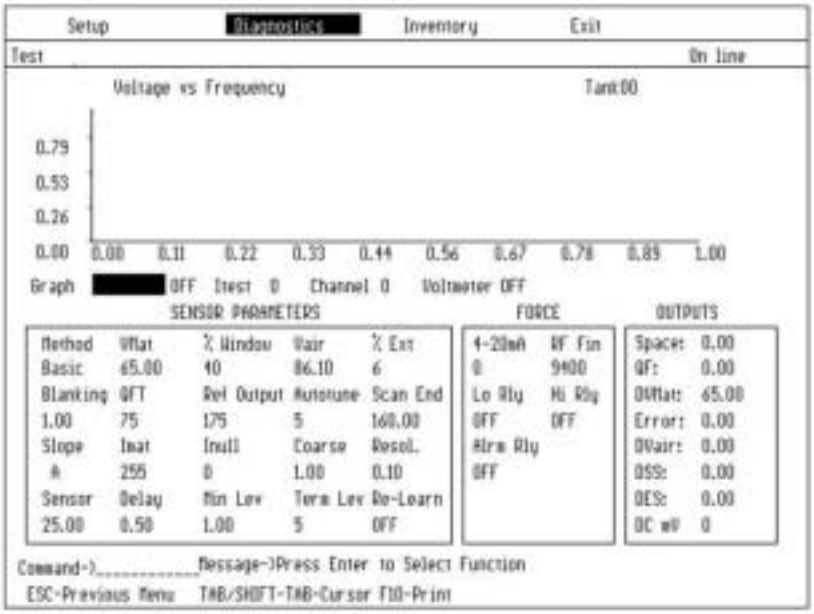


Fig 6-2, Hardware Test Page

Step 2. Press Enter to select "Calibr"(ate).

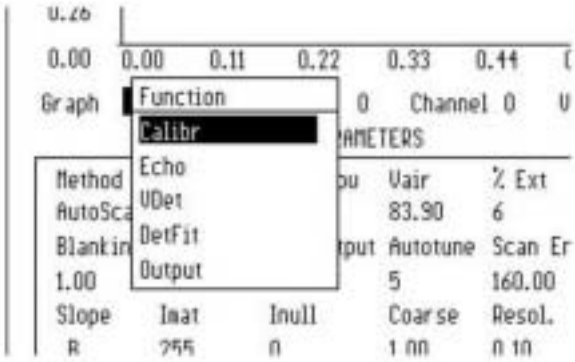


Fig 6-3, Graph Function Menu

Step 3. Cursor to "OFF" and press Enter to draw the graph.

Step 4. The largest value on the vertical axis must exceed 1000. If not, refer to Section B7.

Step 5. Check here for an error message (non-zero value). These are described in Appendix C4.

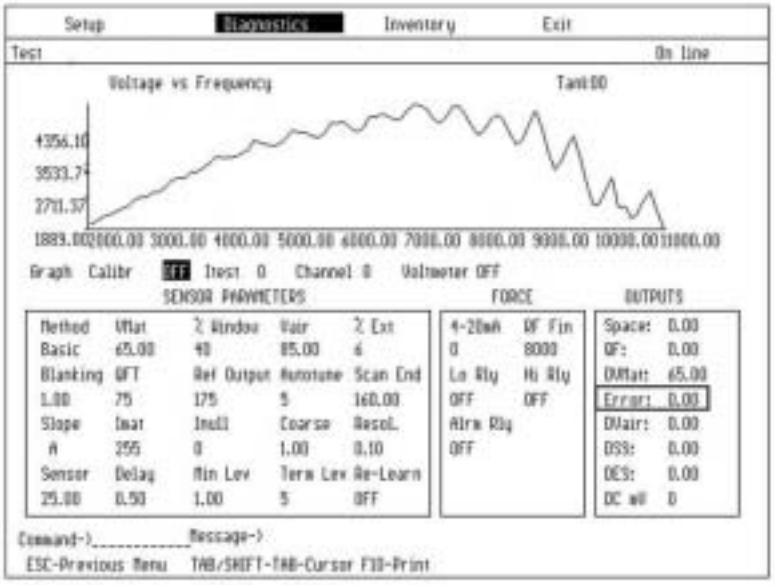


Fig 6-4, Calibrate Graph

If any problems exist, correct them before proceeding and return to **Step 1**. Otherwise continue with **Step 6**.

Step 6. Cursor to Calibr(ate) and press Enter to display the function menu. (Fig 6-3).

Step 7. Cursor to Echo and press Enter to select.

Step 8. Copy Imat into Itest

Step 9: Cursor to OFF. Press Enter to draw the graph.

Fig 6-5, Echo Pattern Generation

Skip steps 10 and 11 (Slope adjustment) unless the tank is empty or there is at least 20ft (6m) of empty space.

Step 10. Note the size of the false echo (if any) in the portion of the graph near the vertical axis.

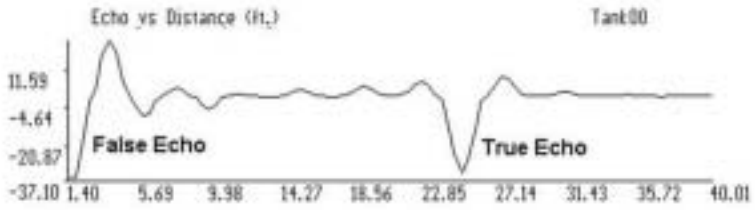


Figure 6.6, Echo Graph with interference

Step 11: Cursor to "Slope" and press Enter to select "B". Toggle "OFF" to redraw graph. Again, note the size of the false echo.

Fig 6.7, Slope Selection

Repeat step 11 for Slopes C, D, E, F, G. Choose the Slope that minimizes the false echo as in Fig 6-9.

In many applications, a portion of the sensor is still exposed when the tank is full. If this length (in feet) can be determined, it should be entered under "Blanking" (Fig 6-8). This will filter out any false echoes that might be caused by the sensor support nozzle.

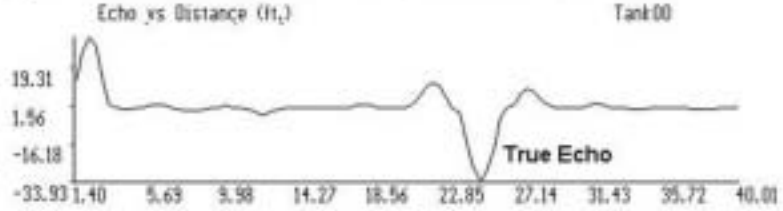
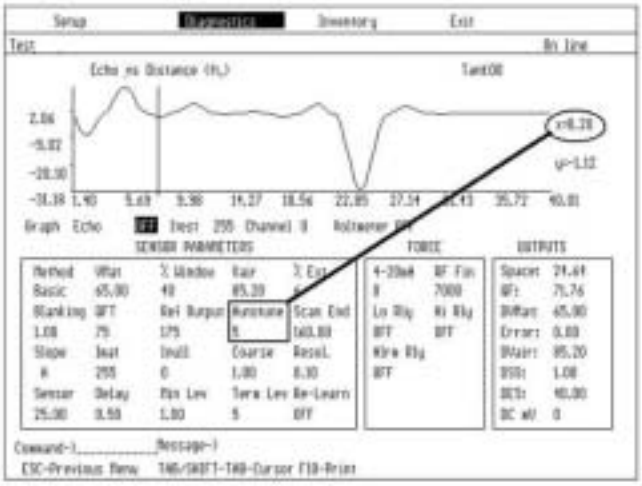
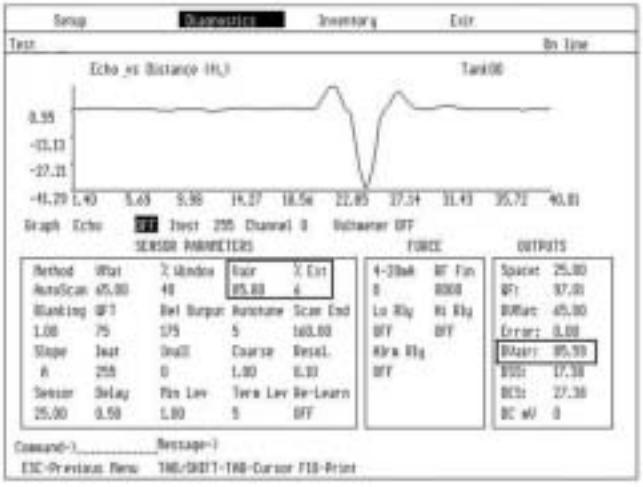


Fig 6.8, Corrected Echo Graph



Step 12. If step 11 does not reduce the false echo to at least half the true echo, use the "TAB" and "SHIFT" keys to place a line cursor to the right of the false echo as shown. Round off the "X" value to the nearest whole number and copy it into "Autotune". The "X" value is the distance from the top of the tank.

Fig 6-9. Autotune Adjustment



Step 13: Perform this step **ONLY IF** the tank is empty! Copy DVair into Vair. Change the value in % Ext to 3.

Fig 6-10, Zero Adjust

Note: In applications where product buildup may occur, Step 14 should be repeated after the product has been cycled in the tank several times.

Note: Perform Step 14 when the level in the tank is as high as possible, preferably more than 50%.

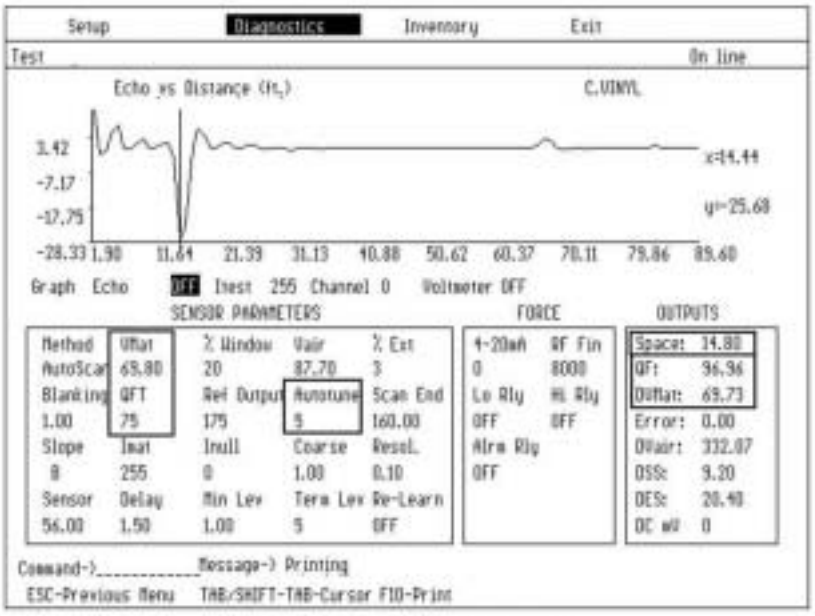


Fig 6-11, Span (Vmat) Adjust

Step 14. Verify the following on Fig 6-11:

"QF" is greater than "QFT"
"Space" is greater than "Autotune"
"DVmat" is not equal to "Vmat"

If all the above conditions are true, copy "DVmat" into "Vmat". If not, do one of the following:

1. Check the actual empty space in the tank. If it matches the "Space" value, reduce "Autotune" to 1 less than this value. Repeat the echo graph and update Vmat. Return "Autotune" to its previous value.

2. Copy the Vmat from another tank with a similar product.

3. Repeat the test when the level is lower.

When Vmat has been determined, go to the Tank Data page and change VmatHi (sensor parameter #35) to Vmat + 2.

Step 15. **100% Adjust**. Determine what percentage of the sensor is immersed when the tank is considered to be 100%full. Round it off to the nearest 1%. Return to the Main menu (Esc, Esc, Esc), select "Setup" "Strapping Tbl" and select the tank. Copy the %full value into the location indicated in Fig 6-13.

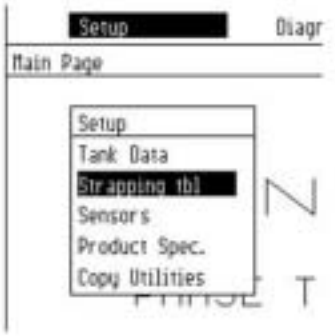


Fig 6-12, Setup Menu

Strap#	Displayed % Full	Corrected Ouput
1	0	0.00
2	100	100.00
3	100	100.00
4	100	100.00
5	100	100.00
6	100	100.00
7	100	100.00
8	100	100.00
9	100	100.00
10	100	100.00

Fig 6-13, Strapping Table

Step 16: Return to the Setup menu (Esc, Esc). Select "Tank Data" and press Enter twice. Toggle System Parameter #1 to "STRAP TBL". This activates the strapping table.

Note: Multi-point strapping tables can b configured to correct for different shaped vessels. Refer to Appendix C3.

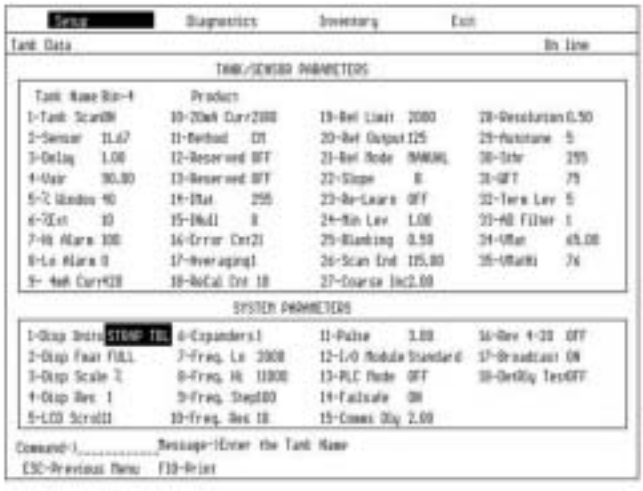


Fig 6-14, Tank Data Page

To view the level in all tanks, return to the Main Page (Esc, Esc, Esc), cursor to "Inventory" and press Enter (Fig 6-15).

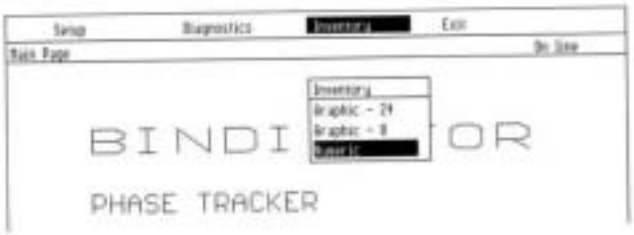


Fig 6-15, Inventory Menu

Cursor to "Numeric" and press Enter. After a few seconds, the levels will be displayed (Fig 6-16).

Fig 6-16, Numeric Display

To exit PCBUS, return to the Main Menu (Esc, Esc). Cursor to "Exit" and press Enter.

B7 Troubleshooting using the computer

B7.1 Wiring checks

The System Alignment (Section B6, steps 3-5) will reveal any faults in the coax and two of the three twisted pairs (VD+ VD-, VR Gnd). The third pair, D+ D-, supplies a bias current (Imat) to control the magnitude of the bottom echo from the free end of the sensor. It can be verified by observing its effect on the Echo graph.

Execute the Calibrate graph. With Itest set to the Imat value, execute the "Echo" graph. Change "Itest" to 0 and redraw the "Echo" graph. The amplitude (Ampl) of the second echo with "Itest" at 0 should be at least twice as large. See Fig 7-1.

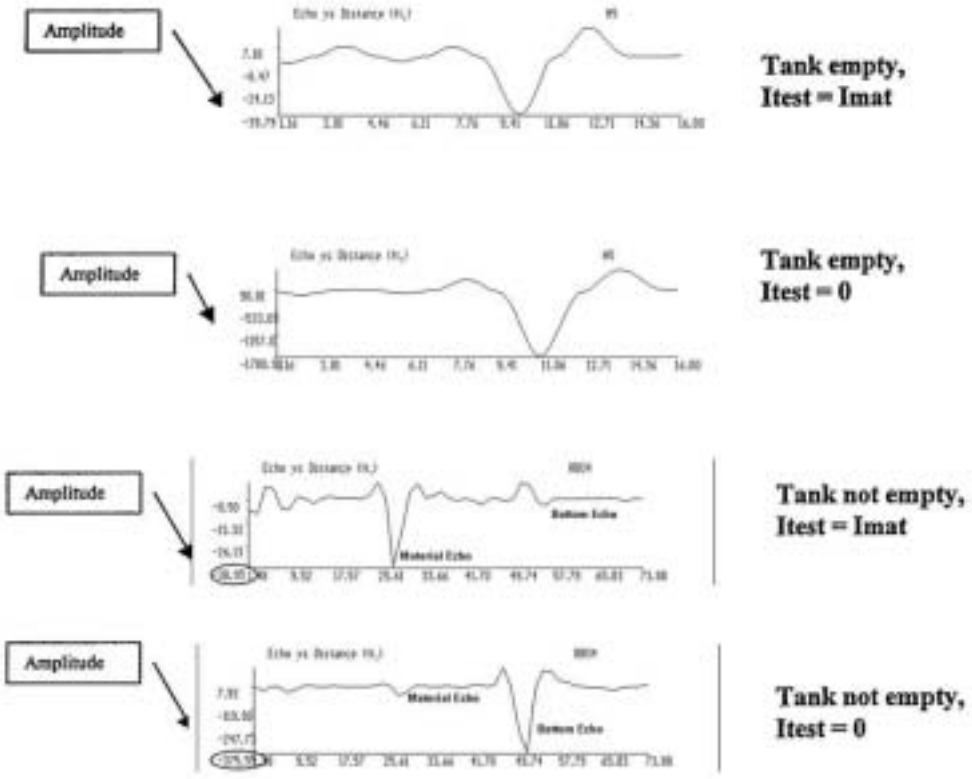


Fig 7-1 Typical Echo Graphs

If there is no observable change with Itest, check the D+, D- pair.

Caution

In large tanks (90ft, 30m+) of high dielectric products (such as grain), This test may not work at high tank levels because the signal is attenuated. The change in the bottom echo with Itest may not be observable. In these cases, repeat the test at lower tank levels.

B7.2 4/20mA

There are no zero or span adjustments for these circuits. Enter 100 under "4-20mA" (Force) to force the output to 20mA. Enter 0 to force the output to 4mA. Each channel is equipped with a red LED. This can be used to verify the 4/20mA loop. If the loop is open or the impedance of the receiving device exceeds 300 Ohms, the LED will come on when the output is forced to any value.

B7.3 Setpoint Relays

The two set point (Hi, Lo) relays and the alarm relay can be forced by toggling the "OFF" underneath each relay in the "FORCE" box.

When the LM7000 returns to "Run" mode, the "FORCE" will be automatically cancelled.

B7.4 RS232 Connection

The RS232 connection can be verified by using Hyper Terminal setup for direct connection to the COM port you are using on your computer. This can be used to test the COM port on the PC, the RS232 wiring and the transmit/receive circuitry on the LM7000.

A blank page will be displayed. In this mode, any keystroke will be transmitted on the COM port. Any printable character received on the COM port will be displayed on the screen. The signal received at the LM7000 will be looped back by putting switch S8 on the CPU board (Section B3, Fig 3-1) in the "L" position. S8 is located near connector J2. Turn on the power to the LM7000. Any printable keystrokes should now be echoed back to the screen. Keep any key pressed and TX1, RX1 LED's on the CPU will be on.

A Malfunction could be caused by any of the following:
- The PC COM port is defective
- The incorrect PC COM port is selected
- An error in the field wiring
- A defective CPU

To Identify the problem, do the following:
- Remove the connector from J2 and short the Transmit and Receive wires together. Any keystroke should now echo back to the screen if the COM port is functioning.
- Select the other COM port.
- Reverse the transmit and receive wiring.

On Completion of the test, ensure that CPU switch S8 is returned to the "N" position.

A malfunction could be caused by any of the following:

- The PC COM port is defective
- The incorrect PC COM port is selected
- An error in the field wiring
- A defective CPU

To identify the problem, do the following:

- Remove the connector from J2 and short the transmit and receive wires together. Any keystroke should now echo back to the screen if the COM port is functioning.
- Select the other COM port.
- Reverse the transmit and receive wiring.

On completion of the test, ensure that CPU switch S8 is returned to the "N" position.

B7.5 Memory Initialization

This is normally only required on an existing system where the software has been upgraded. In some other instances, the NVRAM data may be corrupted. This feature allows the memory to be initialized to the factory default settings.

From the Main Page, Select "Setup", "Copy Utilities". Cursor on Menu option #4 and press Enter. This will reset the database to factory default values. Menu option #3 resets the LM7000. This is the same as switching the power off and on. Menu options #1 and #2 are not used.

Section C - Appendices

Appendix C1: Theory of operation

C1.1 General

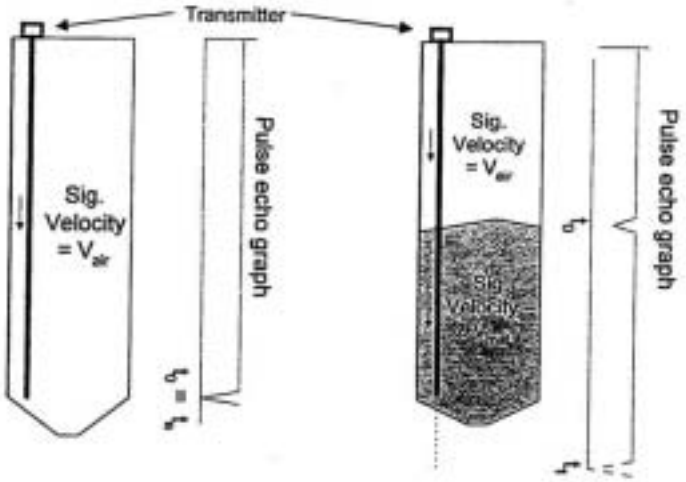
A two conductor unshielded sensor is suspended in the tank. Its impedance is a function of the material in the air space around the sensor. When a high frequency signal is transmitted into the sensor, a part of the signal will be reflected from any point where the impedance changes. This will normally occur at the product surface. A reflection will also occur at the end of the sensor.

This can be illustrated graphically. Refer to Figs 1, 2 and 3. The pulse echo graphs show the time taken by different echoes to return to the transmitter. When the tank is empty (Fig 1), t_e is the transit time of the signal from the end of the sensor. When there is product in the tank (Fig 2), t_0 (surface echo) is the transit time of the signal from the product surface. The signal velocity in air (V_{air}) is a known constant and is not product dependent. From this, the empty space in the tank can be calculated. By subtracting the empty space from the sensor length, the level in the tank can be determined. The magnitude of this echo is a function of the properties of the product in the tank. For light materials, it can be as low as 3% of the transmitted signal.

The velocity of the signal below the product surface (V_{mat}) is dependent on the properties of the product (density, moisture content etc.,) It is always less than V_{air}. Because of this, the transit time of the signal t_1 (bottom echo) increases with rising level. If V_{mat} is known, this echo can also be used to determine the level in the tank. Because all of the transmitted signal is reflected, this echo is equal to 100% of the transmitted signal.

Fig 3 shows product buildup on the sensor. An additional echo (t_b) is generated. Because of this, the level can not be distinguished from the echo caused by the buildup, as both echoes occur between 0 and time t_e. Because the transit time for the bottom echo is always greater than t_e, it can be reliably used to determine level, as echoes caused by buildup, etc., can be rejected.

Phase tracking uses both surface and bottom echoes to determine level. When there is only one dominant echo from the product surface (i.e. less than t_e), the program automatically calibrates V_{mat} from t_0, t_1 and V_{air} (this is described in Section C1.3). When there are multiple echoes, V_{mat} is not updated.

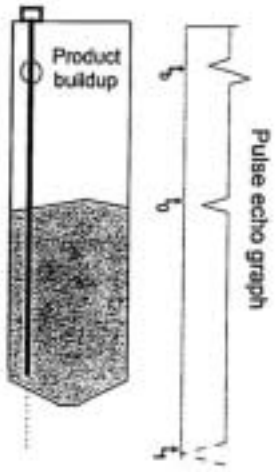


Tank empty

Fig 1

Tank not empty

Fig 2



Product buildup on sensor

Fig 3

C1.2 Signal quality measurement

Each time a measurement is taken, a validity check is carried out. This is called the Quality Factor (QF). See Fig 4.

PULSE ECHO GRAPH

FIG 4

$$QF = \frac{(X - Y)100}{X}$$

Where X and Y are the amplitudes of the two largest echoes.

The QF is a measure of confidence in the reading. For example, a QF of 100% is an indication of a single, dominant, echo, whereas a QF of 0% indicates two echoes of equal magnitude. A high QF ensures that the reading will be correct and V_{mat} is updated.

C1.3 V_{mat} computation

Refer to Figs 1 and 2. T_0 and t_1 are first computed. As previously noted, the flight time of t_1 is proportional to the level in the tank. $T_1 - t_e$ is equal to 0 when the tank is empty and is a maximum when the tank is full. It can be seen that

$$\frac{(t_e - t_0)}{(t_1 - t_0)} = \frac{V_{ma}}{V_{air}}$$

By rearranging the above

$$Vmat = \frac{(t_e - t_0)Vair}{(t_1 - t_0)}$$

C1.4 Level computation using the bottom echo

The level (L) can be computed from V_{mat}, V_{air}, t_e and t_1 using the following formula:

$$L = \frac{(t_1 - t_e)Vmat}{(V_{air} - V_{mat})}$$

Appendix C2: Parameter description

C2.1 Sensor parameters

PARM#	NAME	DESCRIPTION
#1	SCAN	Enables or disables measurement of a sensor position. This is used in multiple tank applications to disable measurements from positions where no sensor is connected. Set to "OFF" for these positions.
#2	SENSOR	Enter the sensor length in feet (meters x 3.28). See parameter #3.
#3	DELAY	If the sensor is mounted on a standpipe, add the height of the standpipe to the existing value and reduce sensor length (parameter #2) by the same amount.
#4	V_{air}	This is the velocity of the signal in the exposed portion of the sensor expressed as a percentage of the speed of light. This factor is dependent on the type of sensor used. Choose from one of the following: LM705/735 (Tefzel) - 86.3 LM720 (Bare SS Rod) - 100.0 LM790 (Bare SS Cable) - 97.0 This parameter may require a final adjustment to compensate for product buildup. Refer to Section A8 (keypad) or B6 (PC).

#5	%WINDOW	This is used to filter out echoes due to product buildup. It should remain at its default value (40).
#6	%EXT	This is a tolerance parameter on V_{air}. It should only be adjusted when V_{air} is adjusted. Refer to Section A8 (keypad) or B6 (PC).
#7	HIGH ALARM	This is the high level relay setpoint. Units are in %full. Enter a value in percent to a resolution of 1%. The relay deenergizes (contact opens) when the level exceeds the setpoint.
#8	LOW ALARM	This is the low level setpoint. Units are in %full. Enter value in percent to a resolution of 1%. The relay deenergizes (contact opens) when the level drops below the setpoint. The relay logic can be reversed by changing System parameter # 14 (Fail-safe) from "ON" to "OFF".
#11	METHOD	This is the computation method used to process the signal from the sensor. The two most commonly used methods are "Basic" And" Autoscan". The "Basic" method is used in liquids and heavy granular products. The "Autoscan" method utilizes both surface and bottom echoes. The Autoscan method is used when the surface echo is weak (for example, plastics) or where there is a possibility of buildup. For sensors less than 20ft (6m) and "Blanking" (see #25) is at least 4ft (1.2m), the Basic method is usually sufficient. Otherwise use the "Autoscan". The scan time for the autoscan method is about 6-8 seconds. The Basic method is 2-3 seconds.
#12, #13		Not used.
#14	I_{mat}	Terminating network bias current. This is set to match the expected dielectric constant in the measured product (and minimize the bottom echo). The default is 255. This is the correct setting for all applications using the LM6405 flexible sensor. For liquids and applications using rigid sensors, adjust this value to minimize the bottom echo. This should be done when there is at least 6ft (2m) of product covering the sensor. Repeat the echo graph (Section B6) for

		different values of Imat. Choose the value that gives the smallest bottom echo.
#15	I_{mdl}	This identifies the type of terminating network at the end of the sensor. The value for the LM6405/6470/6490 sensors is 0. For other types, enter 255.
#16	ERROR COUNT	Error count. When an error condition is present, the 4/20 output will be forced to 0mA. This parameter can be used to filter out occasional errors. The error count is the number of successive error messages which must occur before the 4/20 output goes to 0mA. The range is 1 - 255. The recommended setting is 4.
#17	AVERAGING	2-16 successive readings can be averaged. Increasing this value will reduce jitter in the readings. This should only be done in applications where the rate of level change is slow.
#18	RECAL COUNT	This parameter sets the number of measurements between recalibrations. This should remain at its default value (10).
#19, #20, #21		These parameters control the output signal level. These are used for factory testing and development. These should remain at their default values shown below in brackets. 19 Ref Limit (2000). 20 Ref Output (175) 21 Ref Mode (AUTO)
#22	SLOPE	This parameter is used to correct for interference from the sensor mounting nozzle. Refer to Section A9 (keypad) or B7 (PC).

#23	RE-LEARN	This is for factory testing. This should remain at its default (OFF).
#24	MINLEV	This is an amplitude threshold (Amp) for the surface echo. The default value is 1.0. This is suitable for most products. This echo is part of the test data (see Section A9). It can also be viewed on the echo graph (Section B6). In some low density/dielectric products, the echo may be less than 1.0. In these cases, set this parameter to 0.2.
#25	BLANKING	This parameter can be used to filter out any echoes caused by the sensor mounting nozzle. Determine the length in feet of the exposed portion of the sensor when the tank is considered to be completely full. Set the parameter as close to this value as possible. **Caution:** If the level in the tank goes higher than this setting, erroneous readings may result. If this number cannot be determined, this parameter should remain at its default value (1.0).
#26	SCAN END	This is the upper limit of the search window for the bottom echo. This is a percent of sensor length. This should only be changed from its default (160) if the response time needs to be reduced (see Appendix C6).
#27	COARSE INC	This is a coarse measurement resolution. The level is first determined to this resolution. The default is 1.
#28	RESOL.	This is the measurement resolution in percent. The default is 0.1%. Parameters 26, 27 and 28 can be adjusted to reduce the scan time. Refer to Appendix C6.
#29	AUTOTUNE	This is minimum distance in feet from the sensor flange where the surface echo provides a reliable measurement. At higher tank levels, the bottom echo is used to determine level. Refer to Section A9 or B6.
#30	STHR	This is the threshold on the generator output. This should remain at its default value (255).
#31	QFT	Quality Factor Threshold (QFT). Refer to Appendix

		C1. When the Signal Quality Factor exceeds this value, the level is Determined from the surface echo. Otherwise the bottom echo is used. This should remain at its default value (75).
#32	TERM LEV	This is an amplitude threshold for the bottom echo. The default value is 5. This is suitable for most applications. In some applications, it may be attenuated below this value. This may occur at high levels in tanks > 90ft (27m) with heavy products such as wheat. In these cases, reduce this parameter to 2.
#33	AD FILTER	Used for signal filtering. This should remain at its default value (1).
#34	Vmat	This is the velocity of propagation of the signal in the stored Product. This parameter is used only with the Autoscan Methods. This is the default value on power up. The program then continuously recalibrates this value. This is called the Dynamic Vmat (DVmat). It is saved in RAM. Refer to Appendix C1 (Theory of Operation).
#35	VmatH	This is the upper limit for Vmat. When Vmat is computed, values greater than VmatH are rejected. This value should only be set after Vmat is computed when the tank level is at a maximum. It should then be set to Vmat + 2.

C2.2 System parameters

PARM#	NAME	DESCRIPTION
1.	UNITS	The selected units are for the display only. Select feet, inches, meters or centimeters. To activate the strapping tables, select "Stp Tbl".
2.	DISPL. FORMAT	Select "Full" to display level of product or "Empty" to measure space (outage).
3.	SCALE	Select % or units (chosen in parameter #1).
4.	DISPL RESOL	Select 1, 2 or 3 decimal places. This will determine the resolution of the display and any other numeric database entries. This value should be set to give a display resolution of about 0.1% of sensor length.
5.	SEQ.	Set to 1 to scroll the display through all tanks. Set to 0 to display a single tank. Use the "Inc" and "Dec" keys to select other tanks.
6.	EXPANDERS	Enter the total number of expanders that are connected directly to sensors (1 – 6).
7-11.		These parameters relate to frequency settings. The default settings are listed on the LM7000 Datasheet. These values should not be changed by the user.
12.	APPLICATION	This parameter is used for backward compatibility with the original version of the 606450 IS Barrier. For all equipment shipped after Jan/97, select "Standard".
14.	FAILSAFE	This parameter controls the operating logic for the high and low setpoint relays. In fail-safe mode (ON), high level relays break on rising level and low level relays break on falling level. These states are reversed when set to "OFF".
15.	COMMS DLY	This parameter controls the serial communications rate. Leave at the default value (2.0).
16.	4-20REV	Set this parameter to "ON" to reverse the 4/20 output (100% = 4mA, 0% = 20mA). The default is "OFF".

17.	BROADCAST	Level data is continuously transmitted from the COM0 port. To disable this feature, set this parameter to "OFF".
18.	Det_Rly_Ts	Detector Relay Test. This parameter default is "OFF".

Appendix C3: Strapping tables

The LM7000 determines the percentage of the sensor that is immersed in the product in the tank. This does not take into account product below the end of the sensor. Also, in powders, because of the surface slope, a part of the sensor may still exposed when the tank is full (100%). The example shown below shows how to correct for this. Strapping tables may be used to do any or all of the following:

- Define the "top" (100%) and "bottom" (0%) points if these are at locations other than the top and bottom of the sensor.
- Convert linear measurements to volumetric measurements in tanks and vessels that have complex shapes.
- Obtain even greater accuracy through linearization of the response of the LM7000.
- Convert to more unusual units of measurement that are not available under the basic settings (Tons, Gallons, Litres, Pounds etc.).
- Compensate for any repeatable vessel conditions that affect the readings.
- Compensate for the amount of material that is below the end of the sensor.

A strapping table may be loaded with as little as two or as many as ten points (Refer to Fig C-1). Each sensor/tank has its own table. To configure a strapping table, first determine the desired values (weight, volume or %) for up to ten %full readings on the display. Arrange these values in ascending order in two columns. The left column being the displayed %full and the right column the corrected outputs. The first and final points on the left hand column must be 0 and 100% respectively. Intermediate values must be in increasing order. Enter these values into memory locations x % (displayed %full) and x Corrected Output, where x is the strapping point. To activate the strapping tables, go to the "system data" menu and change parameter #1 (unit) to "Strap Tbl" and parameter 3 to % if the final output is in %. otherwise, set this parameter to "Units".

C3.1 Example

- Sensor length is 50ft.
- When 1% of sensor is covered, there is 5% in the tank.
- 3ft (6%) of the sensor is still exposed when the tank is 100% full.

5% of the product is below the bottom of the sensor. When the tank is 100% full, the display will read 94%. To correct these readings, enter the following values into the strapping table.

Strap#	Displayed % Full	Corrected Output
1	0	0
2	1	6
3	94	100
4	100	100
5	100	100
6	100	100
7	100	100
8	100	100
9	100	100
10	100	100

Fig C-1, Typical strapping table

The above table is a conversion from % to %. When converting to other units, such as tons, construct a similar table. Note that the final strapping point must have a 100 on the left column and the tank capacity in tons on the right.

When a strapping table is activated, the RS232, LCD display, 4/20 and relay outputs are all determined by the corrected values on the right hand column.

Appendix C4: Error messages

Error Type 0

0.0 This may occur during auto-calibration

Recommended action

None. This condition will clear automatically

Error Types 11, 14

11.7 Scan freq. decreases in middle of sweep
14.1 NVRAM test fail

Recommended action

1. Cycle the power.
2. Erase database and reprogram.
3. Replace Controller Stack.

Error Type 15

15.1, 15.2 System frequencies set incorrectly

Recommended action

Verify System Parameters 8, 9 and 10 against the datasheet.

Error Type 16

16.1 A/D failure
16.2 A/D read error
16.3 A/D calibration error
16.4 Phase lock error

Recommended action

1. Initialize the database
2. Check the +5V, ± 12V supply on the PSU Board
3. Replace the Controller Stack

Error type 20

20.1 Loss of signal

Recommended action

Check the coax and the VD+, VD- pair.

Error Type 21

21.0 Detector relay not switching

Recommended action

Turn off system parameter 18

Error Types 30, 31, 33, 34, 35

30.1 All scans turned off.
30.2 Scan turned off for this tank
31.2 Parameter #17 not between 1 and 16
33.1 20mA parameter less the 4mA parameter
34.1 Coarse Inc = 0
34.2 Fine Inc = 0
34.3 Delay Length = 0
34.4 Signal velocity = 0
34.5 Strapping table error
34.6 Divide by zero
34.7 Vmat $\geq$ Vair
34.8 Parameter #31 > 100
34.9 Vmat > Vair
35.1 Frequency steps greater than 130
35.2 Echo buffer greater than 40
35.3 Processed readings greater than 160

Recommended action

Check the sensor, system and strapping table databases.

Error Types 40, 45, 46

These apply to communications with a PLC only.

Recommended action

Verify communications wiring and PLC programming.

Error Types 47, 48

These apply only in the PCBUS program.

Recommended action

Verify communications wiring. Problems could be caused by incompatibility between the EPROMs and the PCBUS version. Check with factory, if necessary.

Error Type 51

51.1 NVRAM failure

Recommended action

1. Erase database and reprogram.
2. Replace CPU board.

Error Type 57

57.1 No signal on VD+, VD- pair.
57.2 Level > 6000mV. Keep increasing parameter 20 in steps of 5 until problem disappears.

Recommended action

Check the coax cable and the VD+, VD- pair.

Error Type 59

59.4 No echo from sensor termination.

Recommended action

Reduce sensor parameter #32 in steps of 1 until the error is cleared. If necessary, reduce it to 0. This parameter is the echo threshold.

Appendix C5: Dipswitch settings

C5.1 CPU and DAS

Module#	Switch#	Description
CPT210053	S1,1 to S1,5	These are used for network addressing . For single LM7000 systems, all five positions are set to "OFF". For networking applications, refer to Interconnection Diagram, Fig 13-10.
	S1,6	Not used.
	S1,7	Used for software identification of LCD type. Set to "OFF".
	S1,8	DAS type. CPT210007 = "OFF" CPT210124 = "ON"
	S1,9	4/20 module type. Set to "ON" for equipment shipped after Jan/96.
	S1,10	Set to "ON" to disable Keypad.
	S2	Reset pushbutton. Used to initialize system.
	S3	Watch Dog Timer. Used in "OFF" position only for factory test. Normal position = "ON".
	S4	EPROM memory size. Normal position :- 512K.
	S5, S6	COM0 serial port. Select RS232 or RS485. Normal position:- "N".
	S7, S8	COM1 serial port. Select RS232 or RS485. Normal position:- "N"
CPT210007	S5	DC Bias current factory test. Normal position:- "Normal".
CPT210124	S5 – S10, S14, S22, S23	These are for factory test only. The normal position for all switches is "N".

C5.2 PSUA (CPT210010), Dipswitch S2

Sensor Addresses	1	2	3	4
1-8	OFF	OFF	OFF	OFF
9-16	ON	OFF	OFF	OFF
17-24	OFF	ON	OFF	OFF
25-32	ON	ON	OFF	OFF
33-40	OFF	OFF	ON	OFF
41-48	ON	OFF	ON	OFF
Dipswitch S2				
All Auxiliary Stacks	OFF	OFF	OFF	OFF
Main (Controller) Stack	ON	OFF	OFF	OFF

C5.3 4-20mA Module (CPT210002), 4 Posn Dipswitch S1

	Dipswitch#			
Sensor Positions	1	2	3	4
1-8	OFF	OFF	OFF	OFF
9-16	ON	OFF	OFF	OFF
17-24	OFF	ON	OFF	OFF
25-32	ON	ON	OFF	OFF
33-40	OFF	OFF	ON	OFF
41-48	ON	OFF	ON	OFF

Appendix C6: System scan time

The response time of the LM7000 is dependent primarily on the measurement resolution (Sensor Parameters #27, #28) and the computation method (Sensor Parameter #11) and the size of the search window (Sensor Parameters #25, #26).

C6.1 Measurement resolution

Parameter #28 defines the measurement resolution. The default is 0.1%. In many applications, this may not be necessary. The larger this value is, the faster the response time. The table shows different resolutions. Enter the desired resolution into parameter #28. Parameter #27 is the coarse resolution. This is a percent of sensor length. For sensors up to 20ft (6m), select #27 from the table below.

% resolution (#28)	% Coarse Inc (#27)
0.01	1.0
0.05	2.0
0.1	3.0
1.0	5.0
2.0	10.0

Note: "%Coarse Inc" must not equal more than 2ft (0.6m). If necessary, calculate what % of sensor length 2ft(0.6m) is and enter it into #27.

C6.2 Computation method

The two computation methods are "Autoscan" and "Basic". The "Autoscan" method has additional checks to filter out interference from the sensor support mount, product buildup, or attenuation of the real echo at low tank levels in large tanks. Because of this, the "Autoscan" method is recommended for sensors longer than 20ft (6m). The scan time is about twice the time required by the "Basic" method.

In many applications, the "Basic" method can be used up to 30ft (9m) to 40ft (12m), particularly if at least the top 5ft (1.5m) of the sensor is not used and can be blanked out (Sensor Parameter #25). If the product is granular or free flowing (no buildup), the "Autoscan" filtering features are not necessary and the "Basic" method can be used.

C6.3 Search window

The window is defined by the parameters #25 (Blanking) and #26 (Scan End). Parameter #25 represents the amount of "dead space" (in feet) at the top of the tank. This should be the distance to the product surface when the tank is 100% full. The setting for parameter #26 is dependent on Vmat and the method used (Parameter #11). Determine the value from the following table.

Parameter #11 (Method)	Parameter #26 (Scan end)
Basic	110
Autoscan	$\frac{\text{Vair (\#4)} \times 110}{\text{Vmat (\#34)}}$

Appendix C7: RS232 protocol

When the LM7000 computes level in any tank, the data is automatically transmitted on the RS232 User port (Section B3, Fig 3-1) continuously transmits level data. The communication parameters are as follows:

Baud Rate:	2400
Parity:	None
Start Bits:	1
Stop Bits:	1
Data Bits	8

These are fixed in the firmware and cannot be modified.

C7.1 Broadcast string format and definition

Data is transmitted by the LM7000 in only three situations as follows:

1. Initially at power-up or by depressing the reset button, S2, on the CPT210006 CPU board.
2. On every update of level readings.
3. On any error condition.

It cannot be prompted to transmit data on request.

The corresponding formats of these possible transmissions formats is given below in bold type:

1. **BddSTRTD<CR><LF>**

2. **Bdd%Lev=ddd.ddddxSndg=ddd.ddddxddd.ddddx-ddd.ddddxddd.ddddxddd.dddd<CR><LF>**

3. **BddErrr=ddd.dddd<CR><LF>**

where

<CR> Carriage Return (ASCII 13)
<LF> Line Feed (ASCII 10)
B signifies start of transmission
x one space (ASCII 32)
d {'0','1','2', ..., '9'}

The first two digits following the **B** indicate the tank number (e.g. '**01**' through '**48**'). "**STRTD**" indicates that the LM7000 Control unit reset, the tank number will be '**00**' for this case only. **%Lev=** indicates a level reading in %full and is followed by ASCII digits representing the floating point number associated with that reading.

Sndg= indicates the space in feet measured from the sensor mounting flange to the product surface.

The remaining four sets of floating point numbers indicate the Extended Method space measurement, the signal amplitude, the dynamic Vmat (DVMat) and the Quality Factor. These are used mainly for diagnostic purposes.

- indicates the sign, a + signifies a positive value, while a - signifies a negative value. It is either one or the other (i.e. a sign is always present).

Errr= indicates an error condition and is followed by ASCII digits representing the error code associated with that particular tank.

Please note that the broadcast string is case sensitive. Anything other than the pre-defined formats should be flagged as communication errors. Note also the single spaces separating the numerical values. The string is terminated with a carriage return - line feed combination. *Bindicator reserves the right to append other pieces of data in the future.* However, the string will always be terminated with a carriage return-line feed. Allowances should be made for this possibility.

C7.2 Networked LM7000 Controllers

Up to 16 LM7000 controllers can be linked on an internal Celtek network. A Master Controller is used to communicate with the user's receiving device.

The possible data format are as follows:

1. **BddddSTRTD<CR><LF>**
2. **Bdddd%Lev=ddd.ddddxSndg=ddd.ddddxddd.ddddx-ddd.ddddxddd.ddddxddd.dddd<CR><LF>**
3. **BddddErrr=ddd.dddd<CR><LF>**

The first two digits following the **B** indicate the system number, (they can only range from 01 to 16) and the following two digits represent the tank number (e.g. '01' through '48'). The rest of the data is the same as for the single controller.

C7.3 Checking the transmitted broadcast data

Using Hyper Terminal set up for a direct connection to the COM port you are using. This is described in Section B7.4. Connect the computer to COM0 on the Phase Tracker. The Broadcast data will be displayed on the terminal page. The Broadcast can be disabled by setting System Parameter #17 (Broadcast) to "OFF".

Appendix C8: Typical application problems

Some applications problems can be corrected by modifying sensor parameters.
The following is a list of typical problems and recommended solutions.

Case#	SYMPTOM	RECOMMENDED SOLUTION
1	Output reads less than 100% when the tank is full.	Use the strapping table to set the 100% point (Appendix C3).
2	Output does not read 0% when the tank is empty.	Adjust Vair the next time the tank is empty (Sections A8.3 or B6).
3	Output drops to 0% at low levels.	Reduce %ext in steps of 1. If the problem is not cleared, adjust Vair the next time the tank is empty (see case 2).
4	The output is unstable, varies by up to 10%.	Increase "Averaging" (Sensor parameter #17) until the output is stable. The maximum is 16.
5	Output is stable and repeatable but is not accurate.	Use the strapping table to linearize the readings (Appendix C3).
6	Output reads 50% or more when the tank is empty.	Increase %ext in steps of 1% until the output reads 0%.
7	Reading becomes erroneous after the power is cycled.	Update Vmat (Sections A8.4 or B6).

Appendix C9: Factory support

The most effective way to use this assistance is to have the factory access your system via the modem. If this is not possible, run the PCBUS program while in phone contact with the factory. If neither option is possible, the user should determine as much of the following information as possible before calling the factory.

C9.1 System description

- System size (# of sensors)
- Sensor type and length. The types are described in Section A2.
- EPROM version. This is shown on the EPROM labels on the CPU module. It also appears on the main page of the PCBUS program.
- Does the system have IS (606450 or LM125) barriers ?.
- Record all sensor parameters. If necessary, fill in datasheets. A sample sensor datasheet is included in this manual (Appendix C8).

C9.2 Application description

- Describe the product in the tank (granular, powder or liquid).
- What is the maximum temperature in the tank ?.
- How long does it take to fill or empty the tank ?.
- Is the tank outdoors ?. If so, describe local weather conditions (high humidity, heavy rains etc).
- If the sensor is mounted on a standpipe, what is the height and diameter ?.
- Is there active equipment inside the tank (Air cannons, fluidizers etc) ?.

C9.3 Problem description

The following list of questions is intended to help the factory personnel to quickly identify and correct most problems.

- Is there an error message on the LCD display ?.
  If so, which one ?.
- Does the LCD display match the 4-20mA output ?.
- Is the reading erratic ?. Does it jump to 0 or 100% ?.
- Does the unit always read the same even when the level changes ?.
- Does the error appear to be a percent of span ?.
- If the reading is currently in error, what is the current empty space (feet or meters) in the tank ?

Appendix C10: LM7000 datasheet

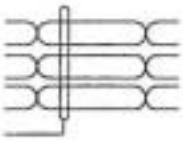
Customer: _____ Location: _____
Sensor Type: _____ Product: _____
Serial N°: _____ Date: _____
Tank Name: _____ Position: _____

PARM#	SENSOR DATA	VALUE/ STATUS (DEFAULT)	PARM#	SENSOR DATA	VALUE/ STATUS (DEFAULT)
1-Scan	Scan		18-RCal	Recal Count	(10)
2-Slen	Sensor length	(100)	19-RefL	Ref Limit	(2000)
3-Dlen	Delay Length	(0.5)	20-RefO	Ref Output	(175)
4-Vair	Sig Vel in air	(85.2)	21-RefM	Ref Mode	(Auto)
5-%Wdw	Window	(40)	22-Slp	Slope	(A)
6-%Ext	%Extention	(6)	23-Rlm	Reset DVmat	(OFF)
7-Halm	High Alarm	(100)	24-Mlev	MinLev	(1.0)
8-Lalm	Low Alarm	(0)	25-Blnk	Blanking	(1.0)
9-4mA	Not used		26-SEnd	Scan End	(160)
10-20mA	Not used		27-Cinc	Coarse Inc.	(1)
11-Meth	Method	(Autosn)	28-%Res	%Resolution	(0.1)
12-DNM1	Not used		29-ATne	Autotune	(5)
13-DNM2	Not used		30-Sthr	Sig. Excur	(255)
14-IMat	Imaterial	(255)	31-QFT	Qual. Fact. Thrsh.	(75)
15-INul	Inull	(0)	32-Tlev	Term Level	(5)
16-Ecnt	Error Count	(21)	33-Filt	AD Filter	(1)
17-Avg	Averaging	(4)	34-Vmat	Sig Vel (material)	(65)
			35-VmHi	Vmat maximum	(76)

Notes:

1. Sensor length, delay and scan start must be entered in feet (meters x 3.28).
2. This data sheet applies to EPROM version 64V8.8 and later.
3. For a description of these parameters, refer to Appendix C2.

List of symbols

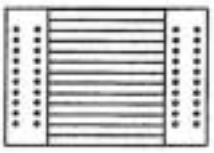


Twisted pair, 22 AWG min, overall shield.

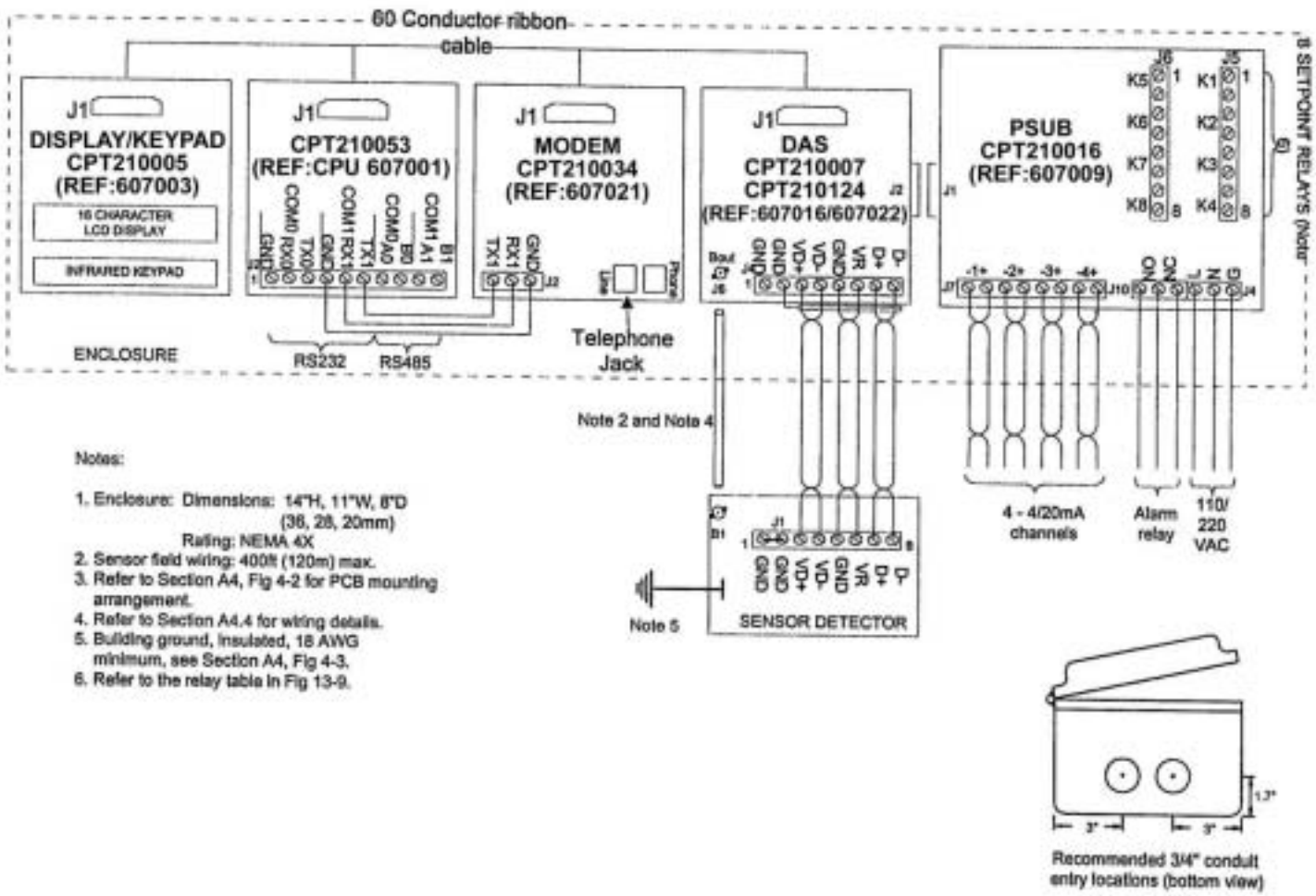
BNC coax connector. See Section A4, Fig 4-1.

RG58 50 OHM coax cable. Do not substitute.
See Section A4.4

Building ground. 18 AWG min. See Section A4, Fig 4-3.



20 conductor ribbon cable with plug-in connector.

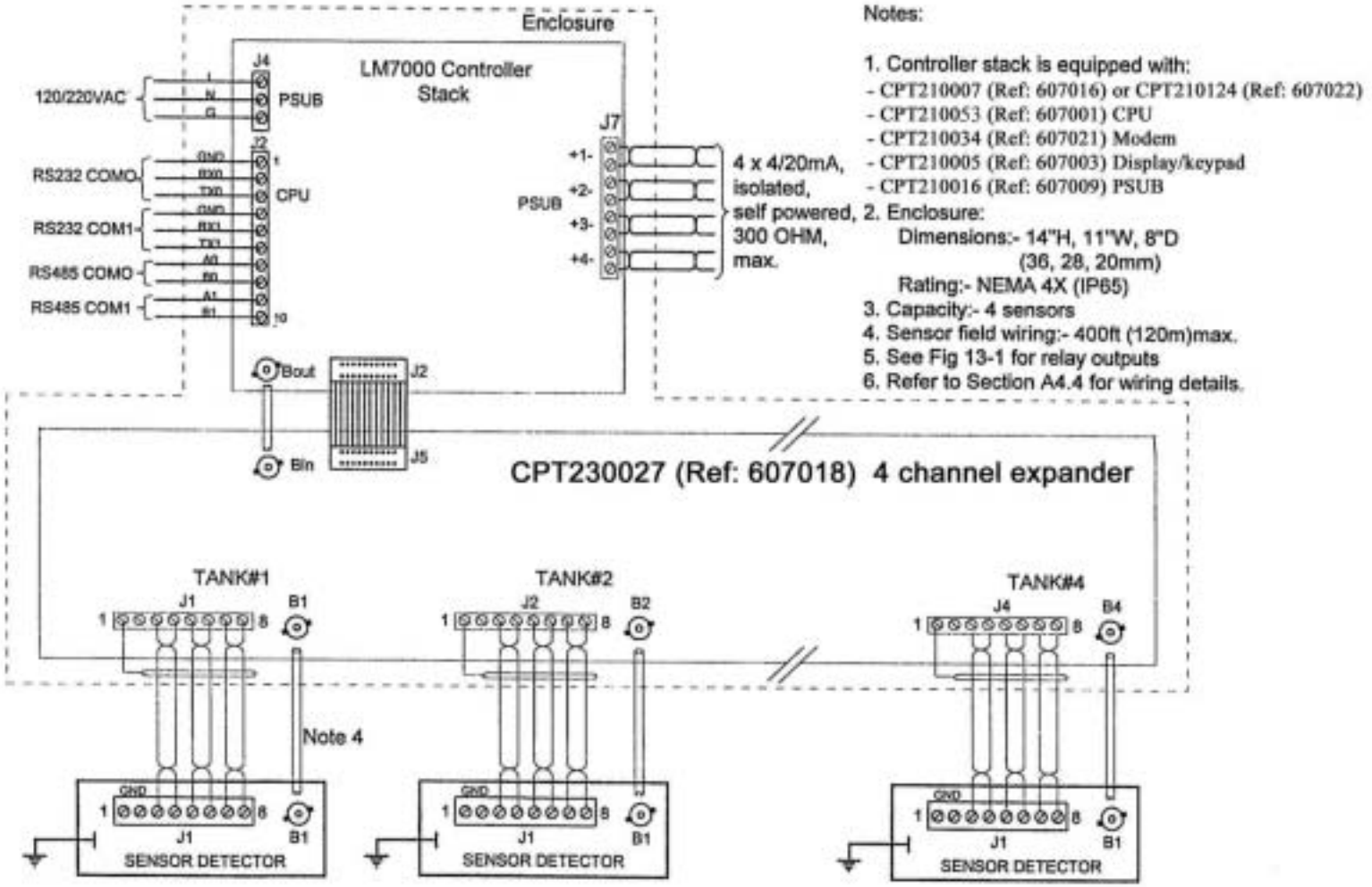


Notes:

1. Enclosure: Dimensions: 14"H, 11"W, 8"D (36, 28, 20mm)
   Rating: NEMA 4X
2. Sensor field wiring: 400ft (120m) max.
3. Refer to Section A4, Fig 4-2 for PCB mounting arrangement.
4. Refer to Section A4.4 for wiring details.
5. Building ground, insulated, 18 AWG minimum, see Section A4, Fig 4-3.
6. Refer to the relay table in Fig 13-9.

Fig 13-1

SINGLE TANK, ORDINARY LOCATION



Notes:

1. Controller stack is equipped with:
   - CPT210007 (Ref: 607016) or CPT210124 (Ref: 607022)
   - CPT210053 (Ref: 607001) CPU
   - CPT210034 (Ref: 607021) Modem
   - CPT210005 (Ref: 607003) Display/keypad
   - CPT210016 (Ref: 607009) PSUB
2. Enclosure:
   Dimensions:- 14"H, 11"W, 8"D
   (36, 28, 20mm)
   Rating:- NEMA 4X (IP65)
3. Capacity:- 4 sensors
4. Sensor field wiring:- 400ft (120m)max.
5. See Fig 13-1 for relay outputs
6. Refer to Section A4.4 for wiring details.

Fig 13-2

4 TANKS, ORDINARY LOCATIONS

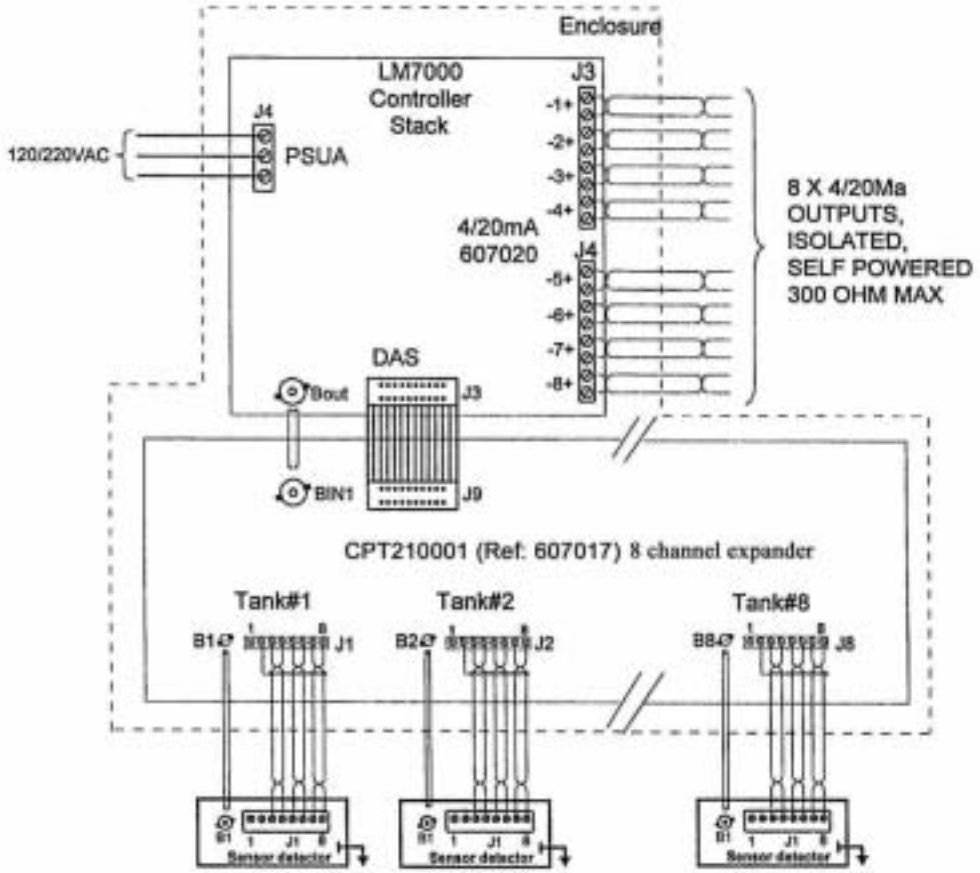


Fig 13-3

Notes:

1. Controller stack is equipped with:
   - CPT210007 (Ref. 607016 or 607022) DAS
   - CPT210053 (Ref: 607001) CPU
   - CPT210034 (Ref: 607021) Modem
   - CPT210002 (Ref: 607020) 8x4/20mA
   - CPT210010 (Ref: 607002) PSUA
   - CPT210005 (Ref: 607003) Display/keypad
2. Sensor field wiring 400ft (120m) max.
3. Refer to Section A4.4 for wiring details.
4. Refer to Fig 13-1 for RS232 wiring.

8 TANKS, ORDINARY LOCATIONS

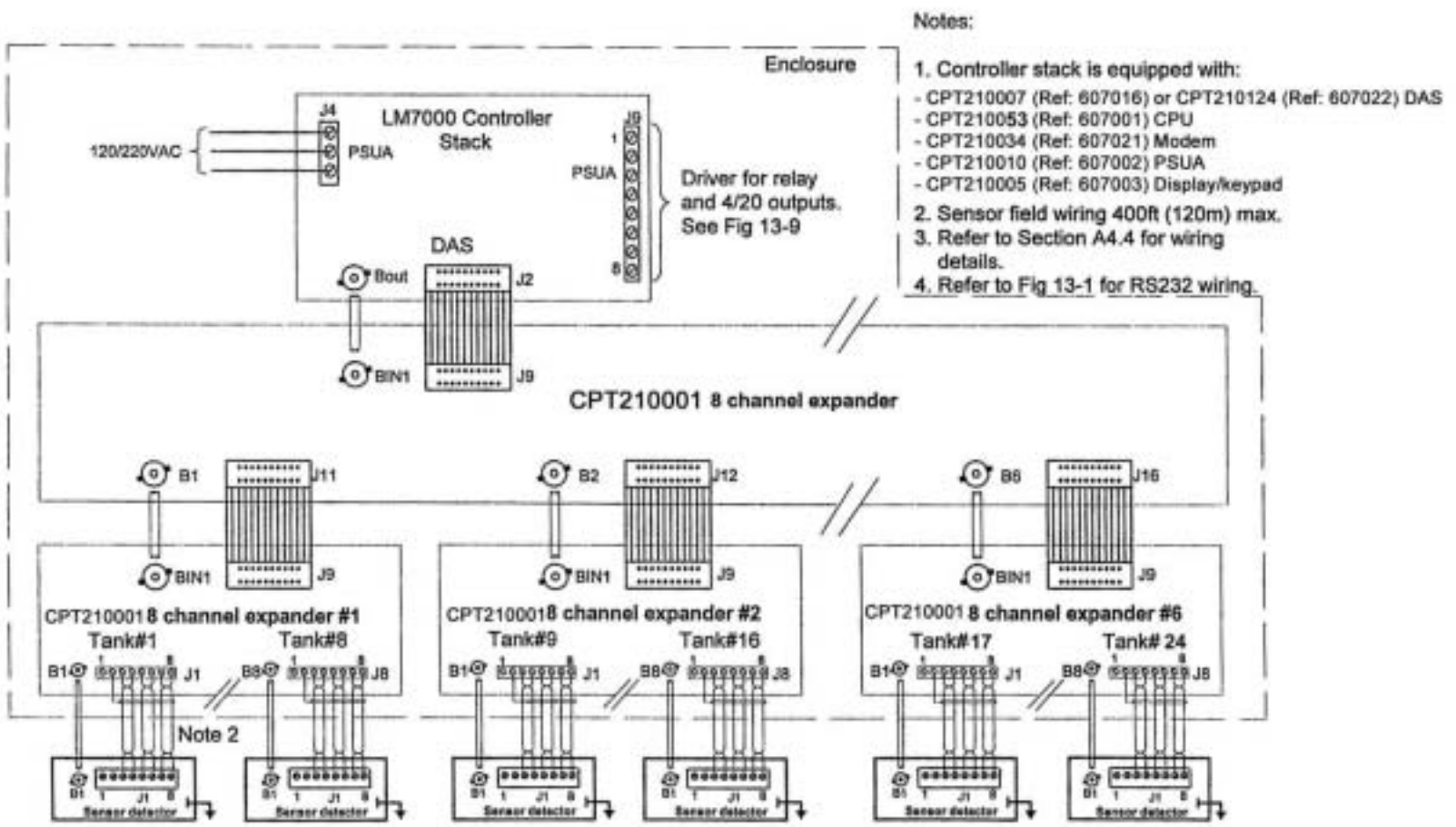
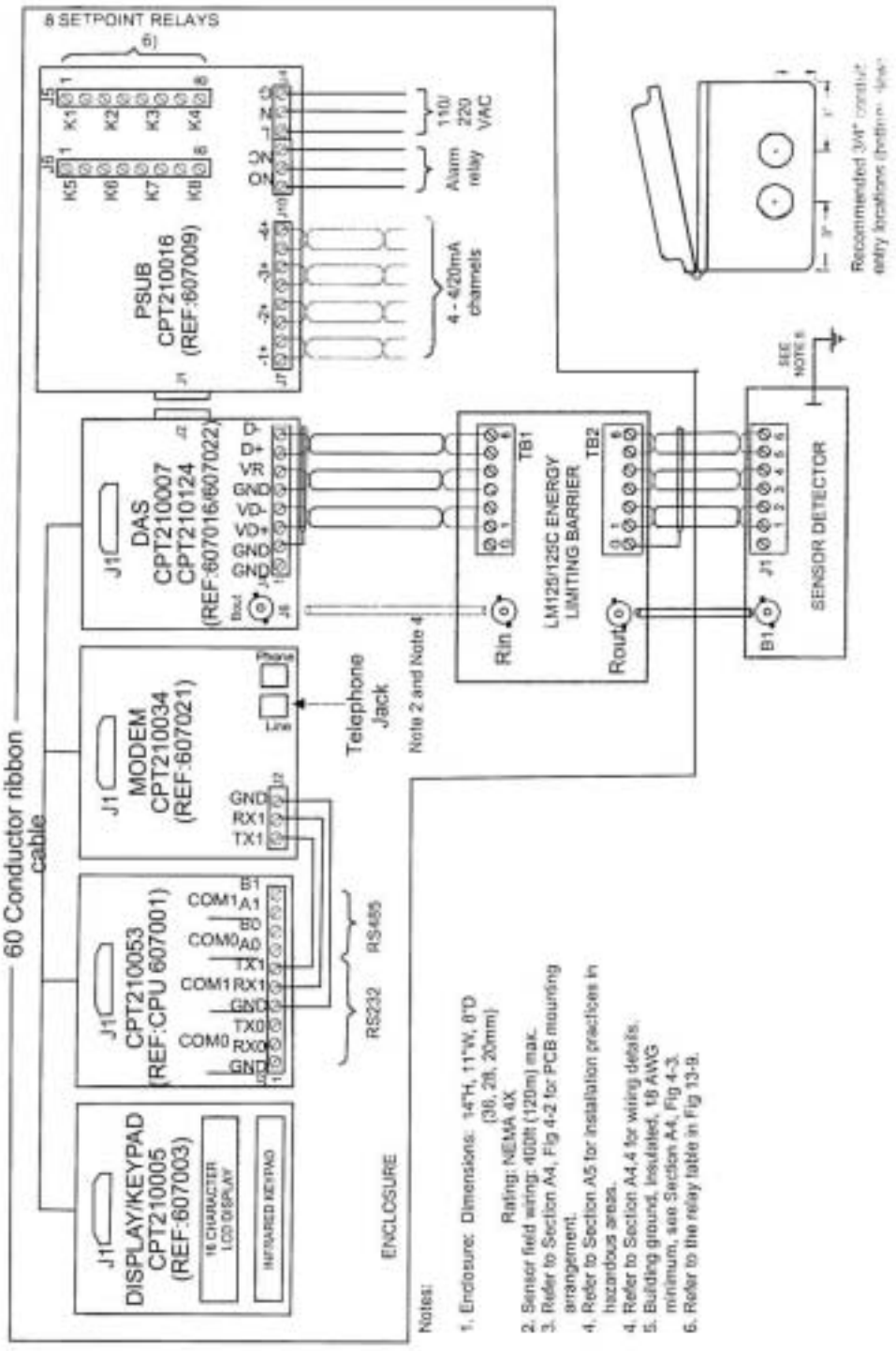


Fig 13-4

24 TANKS, ORDINARY LOCATIONS



SINGLE TANK, HAZARDOUS LOCATION

Fig 13-5

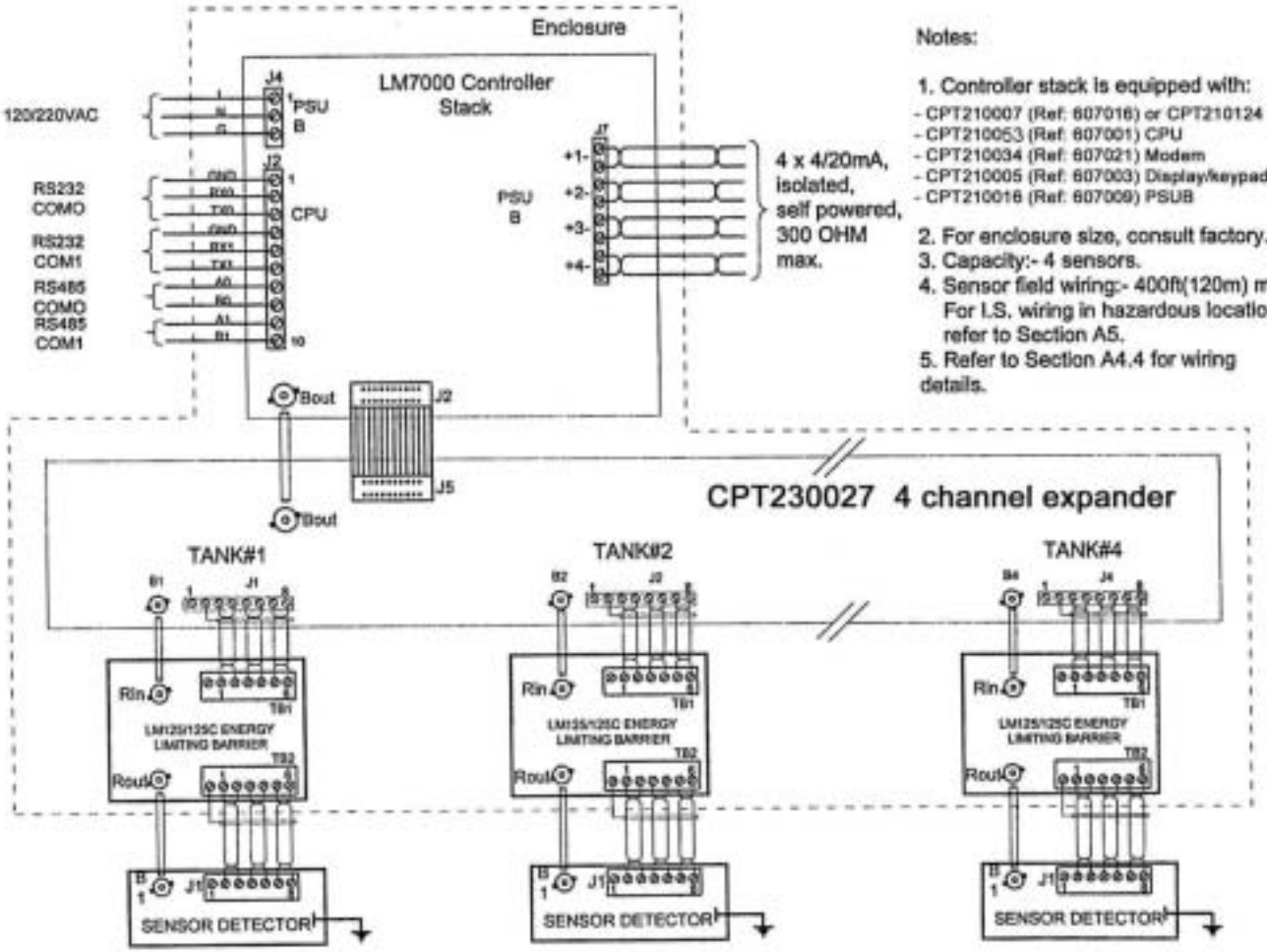


Fig 13-6

4 TANKS, HAZARDOUS LOCATIONS

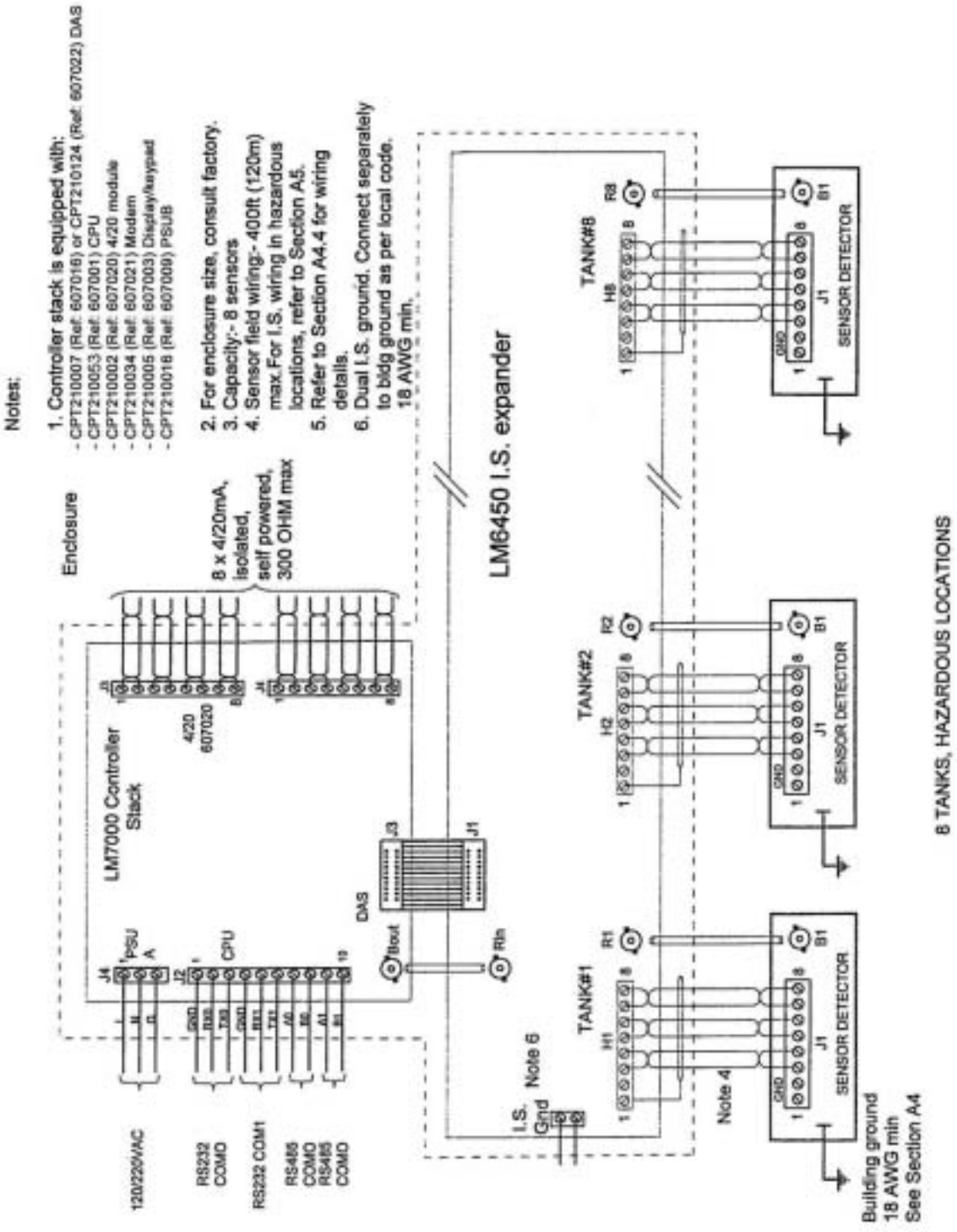

Notes:
1. Controller stack is equipped with:
- CPT210007 (Ref: 6070016) or CPT210124 (Ref: 607022) DAS
- CPT210053 (Ref: 6070001) CPU
- CPT210002 (Ref: 607020) 4/20 module
- CPT210034 (Ref: 6070021) Modem
- CPT210005 (Ref: 6070003) Display/keypad
- CPT210016 (Ref: 6070009) PSUB
2. For enclosure size, consult factory.
3. Capacity:- 8 sensors
4. Sensor field wiring:- 400ft (120m) max.For I.S. wiring in hazardous locations, refer to Section A5.
5. Refer to Section A4.4 for wiring details.
6. Dual I.S. ground. Connect separately to bldg ground as per local code. 18 AWG min.
Enclosure
8 x 4/20mA, isolated, self powered, 300 OHM max
LM6450 I.S. expander
LM7000 Controller Stack
4/20 607020
DAS
PSU A
CPU
120/220VAC
RS232 COM0
RS232 COM1
RS485 COM0
RS485 COM0
I.S. Gnd
Note 6
Note 4
TANK#1
TANK#2
TANK#8
SENSOR DETECTOR
8 TANKS, HAZARDOUS LOCATIONS
Building ground 18 AWG min See Section A4

Fig 13-7

Notes:

1. Controller stack is equipped with:
   - CPT210007 (Ref: 607016) or CPT210124 (Ref: 607022) DAS
   - CPT210053 (Ref: 607001) CPU
   - CPT210034 (Ref: 607021) Modem
   - CPT210010 (Ref: 607002) PSUA
   - CPT210005 (Ref: 607003) Display/keypad
2. Refer to Section A5 for installations requirements in hazardous areas.
3. Sensor field wiring 400ft (120m) max.
4. Refer to Section A4.4 for wiring types.
5. Refer to Fig 13-1 for RS232 wiring.
6. Dual I.S. ground. Connect separately to bldg ground as per local code. 18 AWG min.

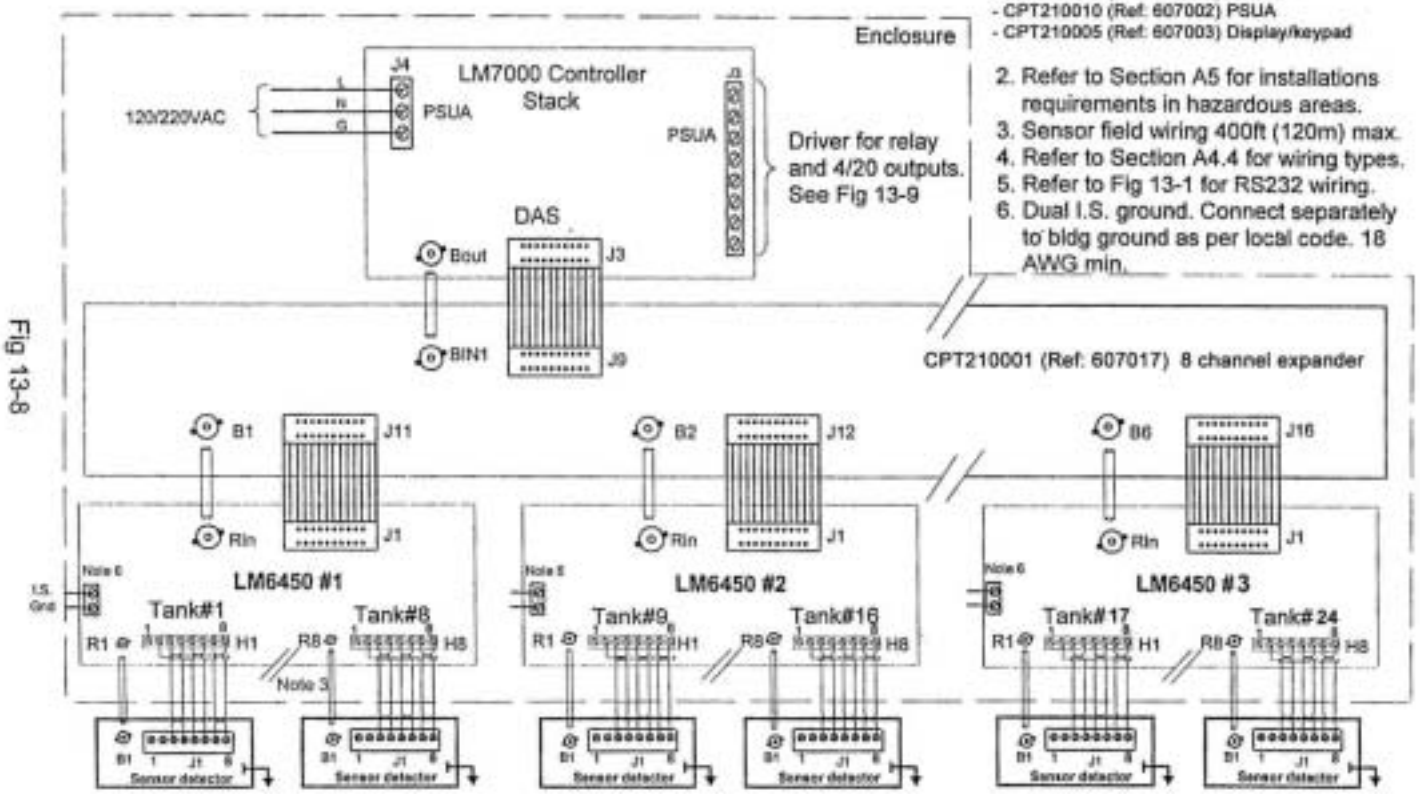


Fig 13-8

24 TANKS, HAZARDOUS LOCATIONS

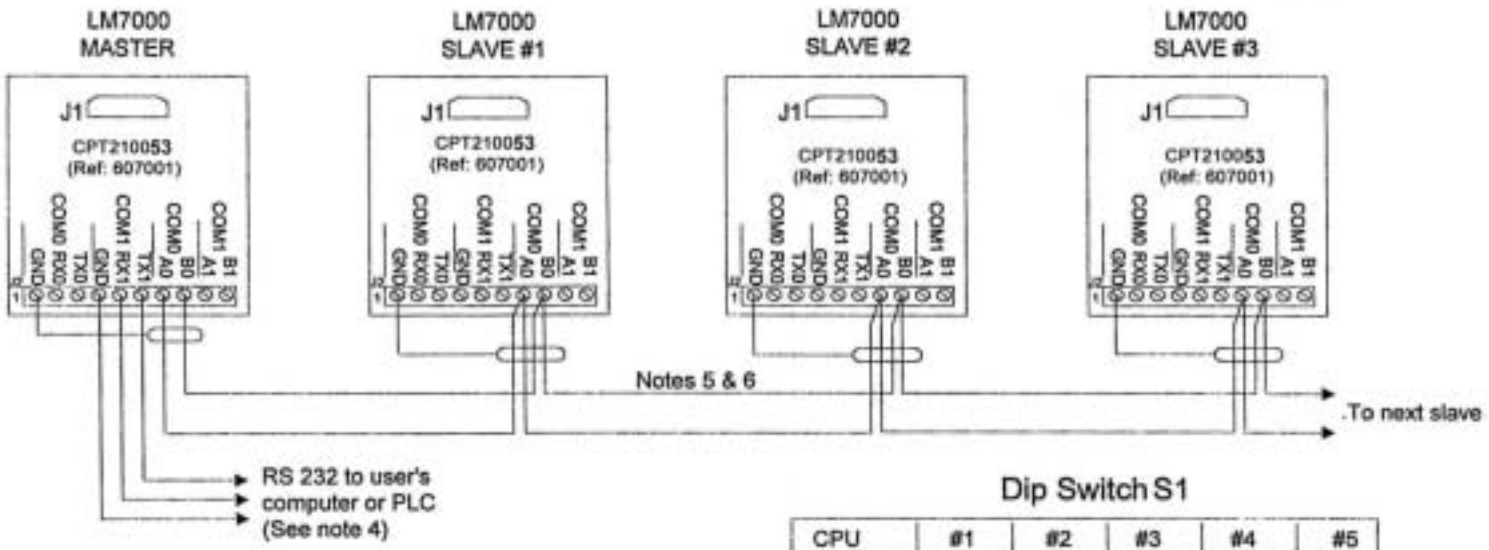


Fig 13-10

Notes:

1. Set Jumper S5 on all CPU boards (Master and Slaves) to "485" position.
2. Set Dip switch S1 (Positions 1 thru 5) on each slave CPU according to to the table.
3. Set Dip Switch S1 on the master to the same position as the highest slave value.
4. For runs longer than 50ft, use short haul modems. See Section B3, Fig 3-2.
5. Use a shielded twisted pair (22 AWG minimum). The maximum total length must not exceed 5000ft (1500m).
6. Wiring between units must be daisy chained. Do not use "T" connections off a main run.
7. The maximum number of slaves is 16. Increment the S1 binary value for each successive slave.

Dip Switch S1

CPU	#1	#2	#3	#4	#5
Slave#1	ON	OFF	OFF	OFF	OFF
Slave#2	OFF	ON	OFF	OFF	OFF
Slave#3	ON	ON	OFF	OFF	OFF
Slave#4	OFF	OFF	ON	OFF	OFF
Slave#5	ON	OFF	ON	OFF	OFF
Slave#6	OFF	ON	ON	OFF	OFF
Slave#7	ON	ON	ON	OFF	OFF
Slave#8	OFF	OFF	OFF	ON	OFF

Interconnection Diagram for networked LM7000s

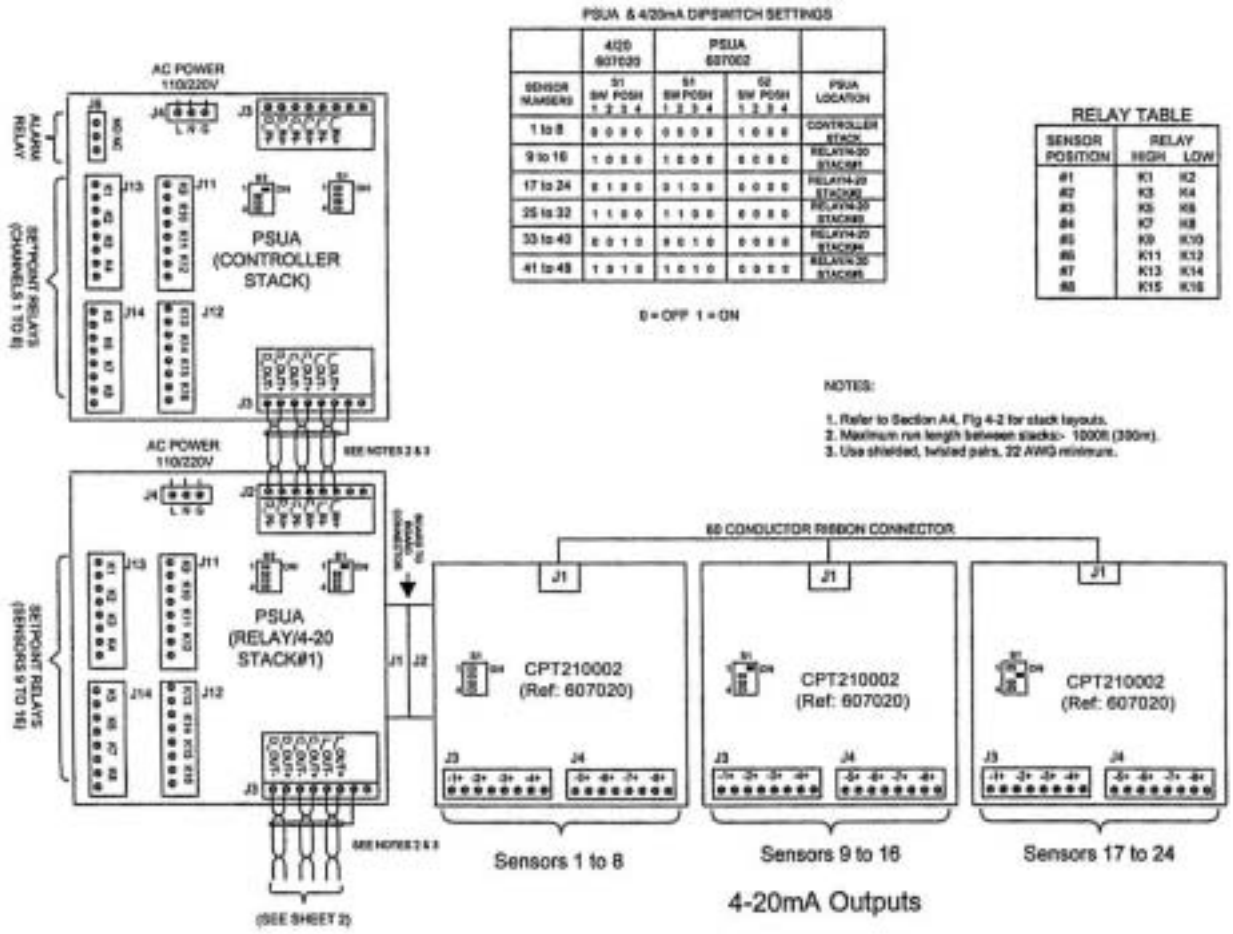


Fig 13-9

RELAY AND 4-20mA OUTPUT FOR LARGE SYSTEMS

Phase Tracker PCBA Cross Reference Table

Inventory Part Number	Reference Board Number	Description
CPT210005	607003	Display / Keypad
CPT210053	607001	CPU with Math Coprocessor
CPT210034	607021	Modem, Internal
CPT210002	607006	4 Channel 4/20mA Output module (OBS)
CPT210002	607020	8 Channel 4/20mA Output module
CPT210007	607016	ANALOG DAS (OBS)
CPT210124	607022	DIGITAL DAS (CURRENT)
CPT230027	607004	4 CHANNEL EXPANDER NON I/S (OBS)
CPT230027	607018	4 CHANNEL EXPANDER NON I/S
CPT210001	607005	8 CHANNEL EXPANDER NON I/S (OBS)
CPT210001	607017	8 CHANNEL EXPANDER NON I/S
CPT210001	606450	I/S EXPANDER MOTHERBOARD
CPT230038	606402	8 CHANNEL SWITCH CARD, I/S
CPT210019	606425	4 CHANNEL BARRIER BOARD ASSEMBLY
CPT210016	607009	PSUB Board Assembly
CPT210010	607002	PSUA Board Assembly

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