USER MANUAL

MODEL 453-9

TWO-WIRE
CONDUCTIVITY TRANSMITTER
EXPLOSION PROOF, BARREL HOUSING

um-453-9-210

IC CONTROLS

CONTENTS

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453-9 MENUS

CHANGES

Areas shaded in dark orange indicate program settings which can be changed by the user.

Menu areas shaded in light blue indicate view-only.

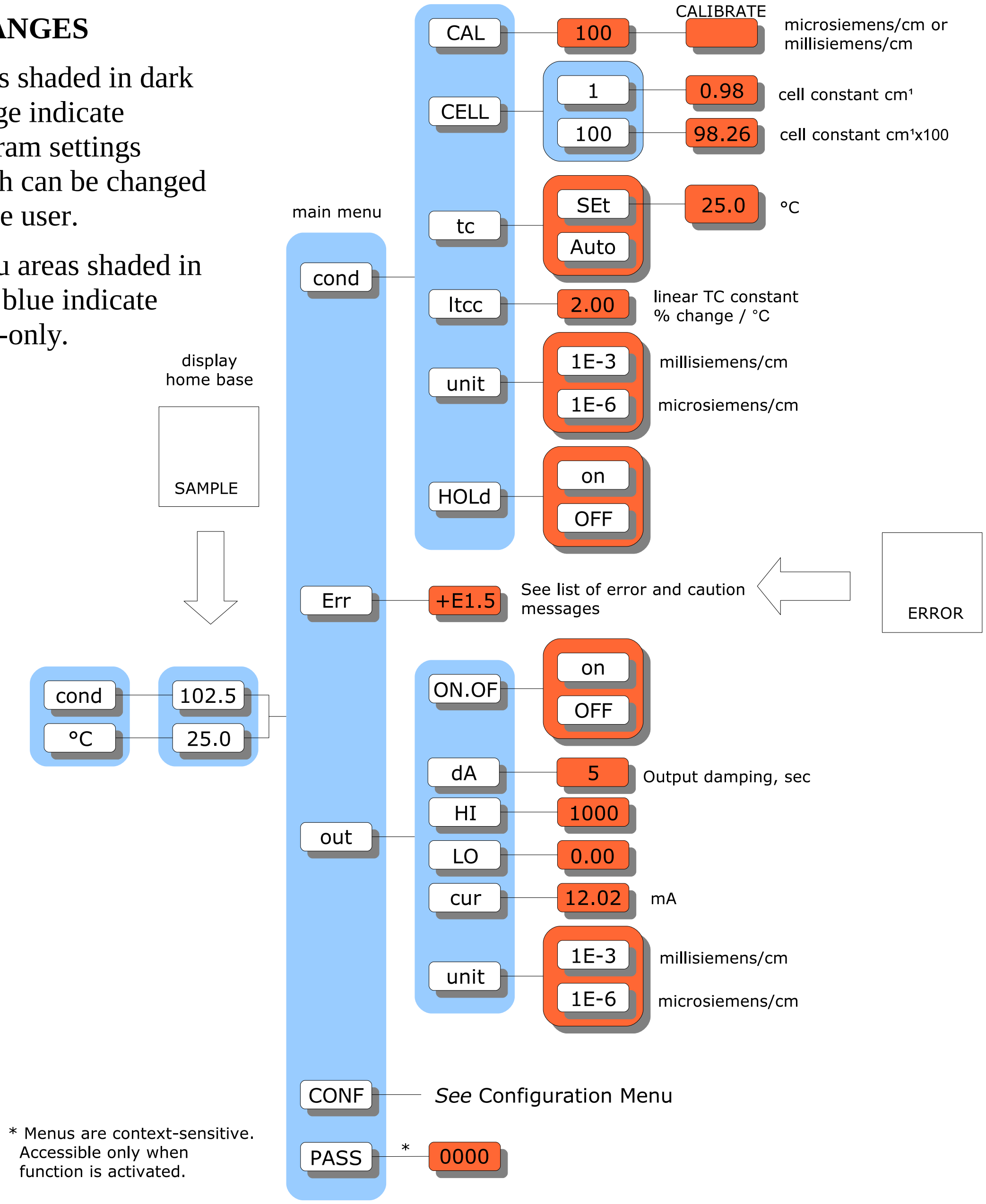


Illustration 1: Menu layout

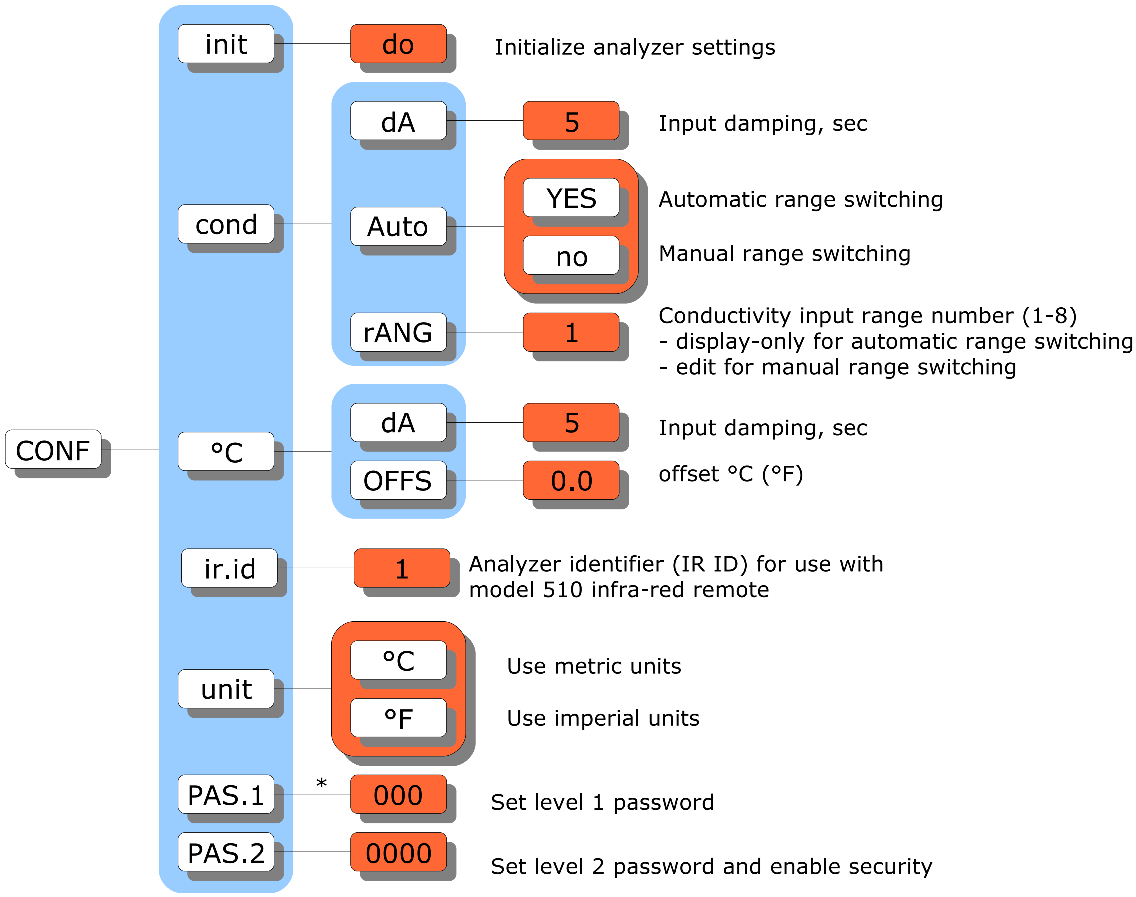


Illustration 2: Configuration menu

INTRODUCTION

The model 453-9 conductivity transmitter, as shipped from the factory, is calibrated and should not require recalibration other than a minor software zero and span adjustment to match the receiver or recorder being used. As received, the transmitter's span has been calibrated to 0 μS/cm to 10,000 μS/cm which covers most common processes.

General

The 453-9 is one of a series of explosion-proof, barrel housing type, two-wire transmitters. It is considered to be a two-wire device because both the power and signal use the same two wires. In the case of conductivity, a conductivity signal corresponding to the actual conductivity is converted to a 4 mA to 20 mA signal which is carried along the same two wires as the 24 VDC power used to power the device.

Features

1) **Instrument housing** which is:

   —Class 1, Groups B, C & D; Class 2, Groups E, F & G rated.
   —NEMA 4, Water- and dust-tight rated.
   —NEMA 7, Hazardous; for indoor use Class 1, Groups A, B, C & D as defined by NEC.
   —FM Approved.
   —CSA Certified.
   —Cenelec Certified, EExd IIC, IP66.

2) Ability to mount at any 90 degree angle from normal.
3) Operation via infra-red remote control; adjustable functions such as cell constant plus independent 4 mA to 20 mA zero and span controls.
4) Automatic temperature compensation.
5) Standard ¾ inch NPT feed-through conduit provides ample space for 4 mA to 20 mA signal and sensor wires to pass.
6) Steering diode protects 4 mA to 20 mA power from damaging electronics.

NOTE: Refer to *Appendix C* for complete transmitter specifications.

INSTALLATION

Transmitter Mounting

The sensor is typically supplied with a 5 foot lead as standard. The transmitter should be kept within this distance. The transmitter should be positioned to allow the sensor, while still connected, to be removed and the electrode tip placed in a beaker on the floor for cleaning or calibration. Assume the safest place for the beaker is on the floor the service person stands on. The electrical openings are on the case bottom; the electrode connections on the right and the 4 mA to 20 mA on the left, when viewed from the front. Horizontal separation between rows of transmitters should allow for periodic replacement of electrode leads and the electrical connections. IC Controls recommends 10 cm (4 inch) minimum separation between rows/columns.

As standard, the 453-9 comes with 2 inch pipe mounting components. Refer to drawing D4000076 for enclosure mounting dimensions.

Field Mounting Orientation

The 453-9 can be field mounted in any 90 degree increment from standard. Refer to drawing D4000074.

Use the procedure below to select the desired field mounting orientation.

1. First calibrate the transmitter to the desired range in the instrument shop.
2. Take the transmitter to field location to check orientation.
3. If the transmitter is in the correct orientation go to step 10.
4. If the transmitter is not in the correct orientation take it back to instrument shop.
5. Loosen the front cover tamper set screw and remove front cover.
6. Undo four Phillips screws and remove front panel and display PCB. Refer to drawing D4000075.
7. Undo the four ¼ inch diameter, ⅝ inch long hex standoffs and remove main PCB.
8. Orient main PCB in desired direction keeping in mind four-position header is the top.
9. Refasten standoffs using steps 6 and 7 in reverse order.
10. Mount transmitter with the hardware provided, pipe mount only.

Transmitter Wiring

The transmitter requires 24 VDC power via the 4 mA to 20mA, TB200 terminals 1 and 2. For stable operation, the microprocessor needs a good ground. A good ground connection can typically be made using a shielded 4 mA to 20 mA wire connected to ground in the transmitter and to a local earth rod, or earth at the 24 VDC power supply. The transmitter requires 24 VDC to operate properly. The "on board" regulation allows the supply to vary to any level between 16 VDC to 40 VDC without affecting the transmitted signal.

To hook up power to the transmitter, perform the following wiring procedure.

1. Ensure 24 VDC power is not hooked up at control room or DCS end.
2. Unscrew tamper resistant set screw and remove rear cover.
3. Using 18 AWG to 22 AWG wire, hook up the 4 mA to 20 mA power connections to TB200, + 24 VDC and RETURN terminals as shown in illustration 3.

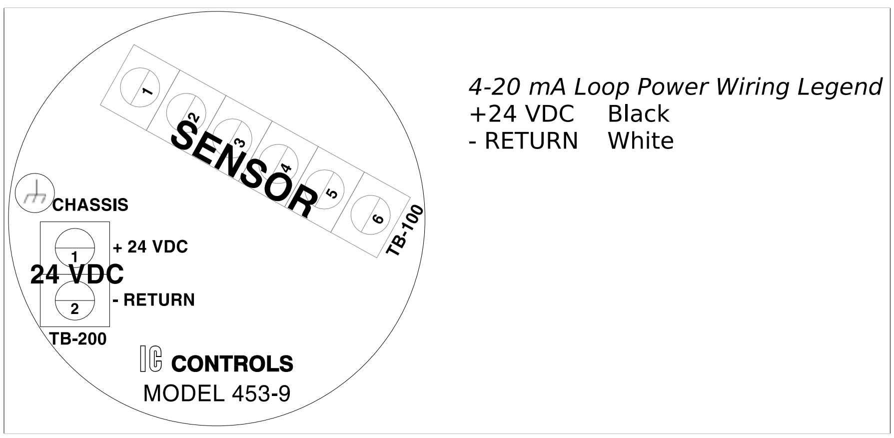


Illustration 3: Power wiring

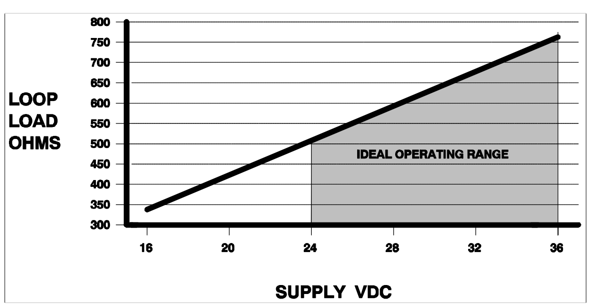


Illustration 4: Maximum loop resistance

Hazardous Location Information

Installation should be performed in compliance with all applicable local electrical safety codes. The 453-9 uses 24 VDC supply, generally considered low hazard in general purpose applications. However, IC Controls recommends that the following safety practices be followed.

- Conduit seals should be installed within 18 inches of the enclosure.
- Ensure all covers are on and firmly in place before power is applied.
- Set tamper resistant set screws.
- Disconnect power before opening covers.

NOTE: *Conductivity sensors and RTD temperature compensators are passive and meet the intrinsic safe definition of a simple device. A simple device is either a passive device such as an RTD or a component with such a small signal that a spark is not possible. Simple devices do not require certification as they are intrinsically safe.*

Sensor Mounting

Flow sensors can be in any orientation but should be mounted tip down at an angle anywhere from 15 degrees above horizontal to 15 degrees vertical; 15 degrees above horizontal is best because air bubbles will rise to the top and grit will sink, both bypassing the sensor.

Submersion sensors should not be mounted where a lot of air bubbles rise in the tank; they will cause spikes in the conductivity readout. If a bubble is allowed to lodge in the sensing tip, electrical continuity between the electrodes may be disrupted.

Sensor Wiring

Ensure 24 VDC power is disconnected at supply end.

The sensor is connected to TB100 which is a six-place terminal block. Color code for sensor wiring is shown in illustration 5. The wire colors in the legend refer to the sensor lead. Refer to drawing D5000240 or D5000241 for further wiring details.

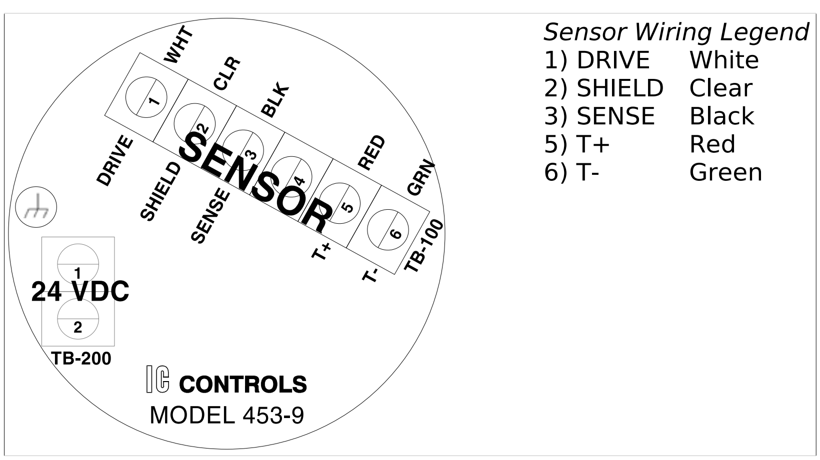


Illustration 5: Sensor wiring

Instrument Shop Test Startup

1. Apply 24 VDC power to the transmitter.
2. Hook up the sensor via TB100 and remove orange protective cap.
3. Place the dry sensor in air.
4. The 453-9 conductivity transmitter should come up reading 0.0 mS/cm ±5 mS/cm.
5. Run a zero calibration for a reading of 0.0 mS/cm ±5 mS/cm; allow 30 minutes warm-up time for the electronics to stabilize.
6. Run the span calibration; place the sensor in 1000 μS/cm standard. Change the units in [cond] menu to [1E-6]. The display should read approximately 1000 μS/cm ±10 μS/cm.
7. To check for general performance, place the sensor in 100 μS/cm standard. The display should read approximately 100 μS/cm.
8. Before putting the transmitter into operation, verify the settings to ensure that they agree with intended setup.
9. For the 4 mA to 20 mA output, set high limit and low limit.
10. Set preference for temperature units, °C or °F, in [CONF] [unit].
11. Set desired input signal damping if known; default is 5 seconds.
12. The transmitter is now ready for field installation.

NOTICE OF COMPLIANCE

US

This meter may generate radio frequency energy and if not installed and used properly, that is, in strict accordance with the manufacturer's instructions, may cause interference to radio and television reception. It has been type-tested and found to comply with the limits for a Class A computing device in accordance with specifications in Part 15 of FCC Rules, which are designed to provide reasonable protection against such interference in an industrial installation. However, there is no guarantee that interference will not occur in a particular installation. If the meter does cause interference to radio or television reception, which can be determined by turning the unit off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

* Reorient the receiving antenna
* Relocate the meter with respect to the receiver
* Move the meter away from the receiver
* Plug the meter into a different outlet so that the meter and receiver are on different branch circuits

If necessary, the user should consult the dealer or an experienced radio/television technician for additional suggestions. The user may find the following booklet prepared by the Federal Communications Commission helpful: *How to Identify and Resolve Radio-TV Interference Problems*. This booklet is available from the U.S. Government Printing Office, Washington, D.C., 20402. Stock No. 004-000-00345-4.

CANADA

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

Le present appareil numérique n' émet pas de bruits radioélectriques depassant les limites applicables aux appareils numériques (de la class A) prescrites dans le Règlement sur le brouillage radioélectrique édicté par le ministère des Communications du Canada.

STARTUP

If the transmitter is new and has not been installed, then follow the procedures described in *Installation*, *Electronic Hardware Alignment* and *Configuration of Program* before mounting. If the transmitter has been previously installed, all that is required is to attach the electrode to the transmitter and then turn on the power.

The transmitter will go through it's automatic startup procedure any time power to the transmitter was lost for more than a few seconds. The startup procedure will initialize the transmitter program, perform error checks, scroll the unique 10 digit serial number of the unit and then proceed to display the conductivity and function normally.

All program settings, calibration settings, and default values will have been retained by the transmitter.

Transmitter Startup Tests

The startup procedure will begin by scrolling a flashing [IC CONTROLS] across the display while performing memory tests. The transmitter will proceed to display, in sequence, the transmitter model number, in this case [453-9], any software option numbers, and the program version number, e.g.[2.10]. The program then moves on to perform display tests which will light each of the implemented display segments in turn. If the transmitter passes all the startup tests then the hardware is functioning properly and the transmitter will proceed to display conductivity, or error messages, if detected.

If the transmitter displays +Err or -Err, this indicates that the input is off-scale. An off-scale error can indicate that the electrode is not in solution, is off-scale, or is not connected properly. If the display periodically flashes [Err], go to the error display section; press *ERROR* key or select [Err] from main menu to view the error codes detected by the transmitter.

Calibration Settings

If the transmitter was calibrated previously, then the transmitter will use the calibration settings from the last successful calibration, otherwise default settings are used. Error and caution messages generated during the last calibration will remain in effect. Refer to *Calibration* section for calibration procedure.

Transmitter settings and parameters can be viewed and/or changed at any time. Refer to the menu on page 3; the areas shaded in dark orange indicate program settings.

Serial Number Display

The transmitter's unique serial number can be reviewed at any time. Press the *DIAG* key or the *SAMPLE* key 4 times to call up the startup display routine above. This does not change any of the settings. The serial number is the 10 digit number that scrolls across the screen.

EASY MENU

The layout of the program is shown in the menu found on page 3. The menu can be used as a quick reference guide to all of the transmitter functions.

Remembers Where You Were

The transmitter remembers where *home base* is, which areas of the menu were used last, and it will loop around the columns in the menu. The menu can be explored using the arrow keys to find any parameter. Pressing *SAMPLE* key will return display to home base. Pressing the → key will return the user to exactly the area of the menu most recently accessed.

Home Base — Press SAMPLE

The *SAMPLE* key's function is to give the user a known starting point displaying the *home sample* or *home input*. The *SAMPLE* key is usable from anywhere in the menu and can be used to return to the conductivity reading or *home base* display. The program will safely abort whatever it was doing at the time and return to displaying the conductivity sample reading.

The conductivity display is the home base display for the transmitter. The transmitter's two inputs, conductivity and temperature, are arranged underneath each other at the left-hand side of the menu. Use the ↑ or ↓ key to display each of the readings in turn.

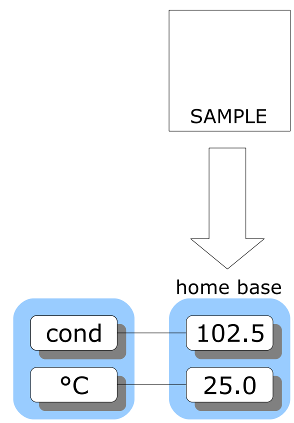


Illustration 6: Home base

Features

1. The transmitter has a built-in timer which returns the program to displaying the home base if no key has been pressed for 15 minutes. This time-out has the same effect as pressing the *SAMPLE* key.
2. If security has been enabled, the time-out will change the access level back to 0 or 1 automatically, which gives the user read-only access. The user will have to enter an appropriate password to go to a higher access level.
3. When in doubt as to what the transmitter is displaying, pressing the *SAMPLE* key will ensure it is displaying the conductivity reading. When home base is displayed, pressing the ← key will show the sample parameter being displayed. Pressing the → key will return to displaying the sample reading.

Arrow Keys

The arrow keys on the remote keypad are used to move around the menu. The same keys can have other functions as well, however, when moving from frame to frame in the menu, these keys work as expected.

Example:

Press *SAMPLE* key to ensure that *home base* is displayed. Press the → key. One of the prompts from the main menu (refer to illustration 7) will be displayed. Use the ↑ or ↓ keys to display the prompt above or below. If the prompt at the top or the bottom is displayed, the program will loop around. Press the ↑ or ↓ keys until [CONF] is displayed. Press *SAMPLE* to return to the conductivity sample display. Press the → key again and [CONF] will be displayed again.

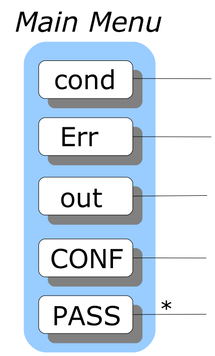


Illustration 7: Main menu

DIAG and ERR Keys

The *DIAG* and *ERROR* keys are used to access the diagnostic and error or alarm intelligence resident in the transmitter. Refer to *Caution and Error Messages* section for a description of these key functions.

ENTER Key

The *ENTER* key is used to access the ability to change values or edit settings.

EDIT MODE

Edit mode is used to change a numeric value or to select between different options. The values and settings which can be edited are identified by the darker shading in the menu. Any frame which has a white background cannot be modified by going into edit mode but can be viewed.

Selecting a Setting

Examples of selecting a value are on/off settings and switching between different units (eg. metric or imperial). Editing a value is like picking an option from a list; only one item on the list can be viewed at a time.

Example: Turning output off.

From the menu, select [out] [ON.OF]. The transmitter will now display either [on] or [OFF], which are the two choices. To change the setting, press *ENTER* to go into edit mode. The display will start blinking. Use the ↑ or ↓ keys to switch between the possible options, which in this case are [on] and [OFF]. When [on] is displayed, press *ENTER* again to accept the new setting and leave edit mode.

Editing a Numeric Value

Numeric values such as input damping are adjusted by going into edit mode and then adjusting each digit until the new value is displayed. Use the ← and → keys to move between digits and use the ↑ and ↓ keys to adjust each digit.

When *ENTER* is pressed to go into edit mode, two things will happen. First, the last digit will start blinking to show that this digit can be changed. Secondly, any blank spaces will change to zeros and a plus or minus sign will appear. Now each digit can be accessed. Change between positive and negative numbers by switching between plus and minus sign using the ↑ or ↓ key when the plus/minus segment is blinking.

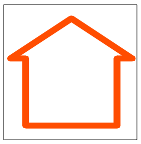
Press *ENTER* again to leave edit mode. Before the new value is changed, the transmitter will check the new value to make sure that it is within range. If the new value is lower than the lowest value allowed for that frame then the transmitter will use the lowest allowable value instead of the new value entered. Likewise, if the new value entered is higher than allowable then the highest allowable value is used instead. The transmitter will display whatever value it has stored in memory.

Example: Change the low from 0 mS/cm to 2 mS/cm.

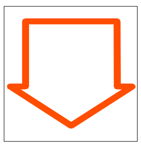
From the menu, select [out] [LO]. The current set-point (e.g. [0.00]) will be displayed. Press *ENTER* to select edit mode. The display will change to [+00.00] and the last digit will start blinking. Press ← twice to move left two digits. The third digit from the right will now be blinking. Press the ↑ key to change the ‘0’ to ‘2’. Press *ENTER* and the display will change from [+00.00] to [+02.00] indicating that the new value has been stored in memory.
The 4 mA to 20 mA low set-point has now been changed from 0.00 mS/cm to 2.00 mS/cm.
Press the ← key to display [LO], [out] etc..

Key Functions in Edit Mode

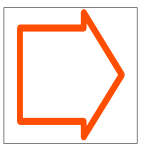
Enters edit mode. The entire display or a single digit will blink to indicate that the transmitter is in edit mode. Press the *ENTER* key again to leave edit mode and accept the new value.



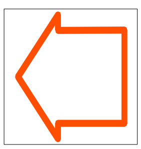
Adjusts blinking digit upward or selects the previous item from the list. If a '9' is displayed then the digit will loop around to show '0'.



Adjusts blinking digit downward or selects the next item from the list. If a '0' is displayed then the digit will loop around to show '9'.



Numeric values only: move right one digit. If the last digit is blinking, the display will loop to the +/- sign on the left.



Numeric values: move left one digit. If the +/- sign is blinking then the display will loop to the last character.
Settings: restore the initial value if it was changed. Otherwise leave edit mode without doing anything.

Illustration 8: Infra-red remote keys used in edit mode

510 REMOTE KEYPAD

The model 510 remote keypad is required to operate the model 453-9 transmitter. The 510 is a battery powered, infra-red light based remote control similar to a TV remote. In addition, the 510 has components that make it intrinsically safe.

The 510 operates through the front viewing window of the 453-9 case. It allows a fully functional modern transmitter with multiple external adjustments and access to microprocessor intelligence, without the cost and risks of multiple ports into the explosion proof enclosure.

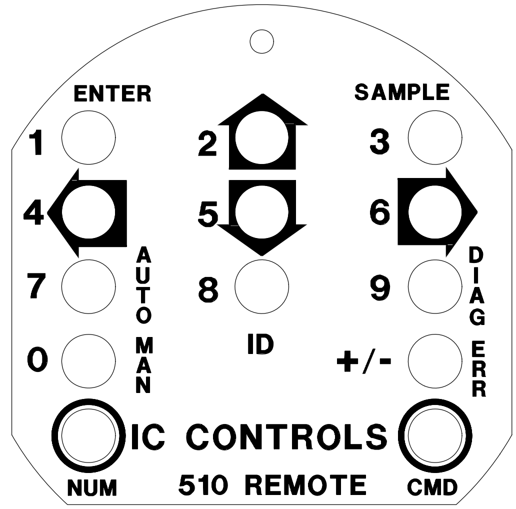


Illustration 9: Infrared Remote, model 510

Remote Keypad Operation

The 510 remote operates exactly like a front panel mounted keypad, with the exception that you have to point the IR diode at the front of the transmitter. The keys are laid out in the same format as a standard IC Controls front panel keypad, with their functions identified in orange. By default, the transmitter recognizes all these commands, and is said to be in CMD (command) mode.

The 510 remote has extra keys for AUTO, MAN (manual), DIAG (diagnostics), ERR (error), ID (identity), NUM (black numbers), CMD (orange commands). These keys allow optional functions available with particular IC Controls products.

ID Key

The ID key is used when an array of transmitters are grouped close together and it is possible for more than one transmitter to "see"and "respond to" the same IR remote signal. IC Controls ships the unit with ID equal to 01 by default; it can be field changed to any two digit number up to 99. Where an array is planed, it is easiest to preset the ID to a unique number before installation. However, by stepping *close enough* that *only one unit* sees the signal the ID can be changed in the installation. Unit ID's can be changed in the [CONF] menu under [ir.id].

Selecting the desired unit using ID

1. Press the 510 "ID" key once. All units that can "see" the signal will display their ID for 5 seconds.
   Example: the transmitter responds with [id.12].
2. Within the 5 seconds, type the ID code of the transmitter you want using the black numbers on the 510.
   Example: All transmitters respond with [id.1], then [id.12] as the digits are pressed.
3. Operate the identified (active) unit as normal. All the other inactive units will ignore the 510 signals, except for the ID key.
4. To activate a different transmitter, repeat steps 1 and 2.

NUM Key

The ID key is useful for entering numbers directly, rather than scrolling with the arrow keys. The unit responds to the NUM key with [—N—] and to CMD with [—C—]. Numbers update in the natural left to right sequence.

Entering numbers using NUM

1. Proceed to the value to be edited, then press *ENTER*.
2. With the display flashing (edit mode), press *NUM*, then the desired value.
3. With the correct number flashing, press *CMD* and then *ENTER*; the display will stop flashing and the edited number will be installed.

CONDUCTIVITY MEASUREMENT

What is conductivity?

Electrical conductivity is a measure of the ability of a solution to carry a current. Current flow in liquids differs from that in metal conductors in that electrons cannot flow freely, but must be carried by ions. Ions are formed when a solid such as salt is dissolved in a liquid to form electrical components having opposite electrical charges. For example, sodium chloride separates to form Na^+ and Cl^- ions. All ions present in the solutions contribute to the current flowing through the sensor and therefore, contribute to the conductivity measurement. Electrical conductivity can therefore be used as a measure of the concentration of ionizable solutes present in the sample.

Conductivity Units

Electrical resistivity uses the unit of ohm meter or Ω·m. Electrical conductivity is the reciprocal of electrical resistivity. Rather than use the units $\Omega^{-1}\cdot m^{-1}$, in 1971 the unit "siemens" (symbolized by the capital letter S) was adopted by the General Conference on Weights and Measures as an SI derived unit. The unit for electrical conductivity becomes siemens per meter. The siemens unit is named after Werner von Siemens, the 19th century German inventor and entrepreneur in the area of electrical engineering.

MEASUREMENT	***UNITS***
resistance	ohm
conductance	siemens, mho
resistivity	ohm
conductivity	$siemens\cdot cm^{-1}$,ohm·cm

Table 1 Electrical conductivity measuring units

North American practice continues to see the use of unit mho/cm to measure conductivity, where the unit "mho" is a reciprocal ohm. The word "mho" is the word "ohm" spelled backwards. Because of the history of conductivity measurements in micromho/cm and millimho/cm, it is common to see these measurements translated to microsiemens/cm and millisiemens/cm because there is a one-to-one correspondence between these units.

What is a Cell Constant?

The volume of the liquid between the electrodes must be exact so that the analyzer can determine how much current will flow through a known amount of liquid. The controlled volume of a conductivity sensor is referred to as its *cell constant*.

A cell constant of 1.0/cm describes a cell with an enclosed volume equal to 1.0 cm^3. A cell constant of 1.0/cm is the easiest constant to work with as conductivity describes the amount of current flow per centimeter.

A cell constant is usually chosen to produce a steady flow of current between the two electrodes. Moderate current and voltage levels can usually be achieved by selecting the proper cell constant. A high cell constant is used for solutions with high conductivity, and a low cell constant is used for solutions with low conductivities.

Measurement Range

The 453-9 conductivity transmitter is an auto-range transmitter. The transmitter input circuit for the conductivity input has the ability to increase/decrease gain so changing the sensor to one with a different cell constant is not often needed to avoid going off-scale.

NOTE: *There is no relationship between the range of the conductivity input circuit and the output range feature of the 4 mA to 20 mA output — these two functions are completely independent of each other.*

The measuring range of the instrument, e.g. 0 µS/cm to 10 000 µS/cm, is determined by the gain used by the transmitter itself and the cell constant of the conductivity sensor. The range described in this manual is based on a cell constant of 1.0/cm. The displayed measuring range is determined by multiplying the cell constant by the transmitter range gain factor.

The transmitter input range gain, combined with the cell constant of the conductivity sensor, determine the full scale of the transmitter.

Sensor Constant and Range

Changing the sensor cell constant to 0.01/cm provides the transmitter with a range of 0 µS/cm to 100 µS/cm, while a sensor constant of 0.1/cm achieves a range of 0 µS/cm to 1 000 µS/cm, and a 10.0/cm cell constant allows a 0 µS/cm to 100 000 µS/cm range.

When the sensor is replaced with a sensor having a different cell constant, ensure that the cell constant is changed in the program memory. Press *SAMPLE*, then *SELECT* to access main menu. Use the ↑ to display [cond], press *SELECT*, press ↑ to display [CELL], press *SELECT* to display [1], press *SELECT* then edit the cell constant. The program will allow cell constants between 0.001/cm and 99.99/cm to be entered.

Displayed Conductivity Units

Since the transmitter display has 4 digits, the highest number that can be displayed is 9999. When the main sample is set to display using microsiemens per centimeter, [1E-6], in [cond] [unit] and the conductivity goes higher than 9999 µS/cm, the transmitter shows [+Err] instead of a reading. Internally the transmitter is still calculating the conductivity reading correctly, but it cannot be displayed properly. While this condition occurs, caution CA1.9 will appear in the error menu.

A program setting allows you to display the conductivity using either microsiemens per centimeter (µS/cm) or millisiemens per centimeter (mS/cm) units, where 1 mS/cm equals 1 000 µS/cm. Normally it is best to display the conductivity using µS/cm for maximum resolution, and to switch to mS/cm units only if the sample exceeds the maximum display capability of 9999 µS/cm. By changing the display units, a reading of 9000 µS/cm would change to 9.00 mS/cm.

Switch between units by changing the setting in [cond] [unit]. The options are [1E-3] for millisiemens per centimeter (1E-3 is scientific notation for milli) and [1E-6] for microsiemens per centimeter (1E-6 is scientific notation for micro). This setting is independent of the units selected for the output. For example, the display units for the sample frame can be mS/cm, while the output units selection, [out] [unit], can be set to [1E-6] for µS/cm. Refer to the *4 mA to 20 mA Output Signal* section for further information on setting the output.

Temperature Compensation (TC)

Ionic movement, and therefore conductivity measurement, is directly proportional to temperature. The effect is predictable and repeatable for most chemicals, although unique to each chemical. The effect is instantaneous and quite large, typically between a 1% to 3% change per degree Celsius, with reference to the value at 25 °C. Many industrial applications encounter fluctuating temperature and thus require automatic compensation. IC Controls' conductivity sensors include a temperature compensator built into the sensor. By default, the 453-9 is configured for automatic temperature compensation.

Manual Compensation

If automatic temperature compensation is not available, manual temperature compensation may be used. If the temperature of the sample is constant, set the manual TC temperature to reflect the process temperature. If the process temperature varies or is unknown, the default temperature of 25 °C or 77 °F is normally used.

CALIBRATION

The conductivity sensor-transmitter system is usually calibrated using standard conductivity solutions. Alternatively, grab-sample analysis on a previously calibrated laboratory reference conductivity meter can be used. Both methods are described in this section.

Overall system accuracy is maintained by calibrating the sensor and transmitter together in a concentration close to the expected sample concentration. The transmitter is generally calibrated in one of the standard concentration ranges 0 µS/cm to 100 µS/cm, 0 µS/cm to 1000 µS/cm, or 0 µS/cm to 10 000 µS/cm.

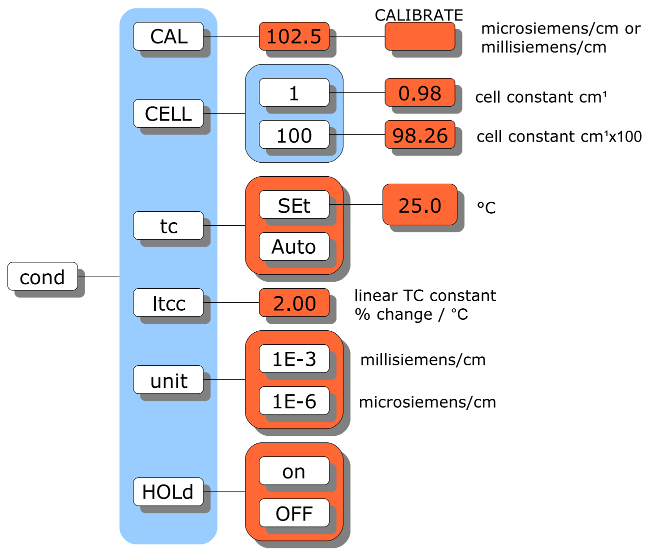


Illustration 10: Conductivity menu

Calibration determines the effective cell constant of the conductivity sensor. The cell constant is affected by the shape of the sensing surface and surface characteristics of the electrode surface. The effective cell constant will change over time as surface conditions on the electrodes change, deposits form, and anything else that affects either the controlled volume or the effective electrode surface area.

Output Hold

The 453-9 features an **output hold**. Output hold goes into effect as soon as it is turned on. Select [Hold] [on]; if desired, edit the output value, then press *SAMPLE* to return to the conductivity display, then start the calibration. The output hold will stay in effect until:

a) you select [Hold] then [OFF]

b) no key is pressed for 15 minutes

c) the startup routine is called by pressing *SAMPLE* four times

d) the power is interrupted so the transmitter reboots

The output hold feature avoids erratic signal output caused by a routine calibration.

Calibration Using Standard Solutions

Select a conductivity standard with a concentration which is close to the expected sample concentration. A second conductivity standard can be used to verify that the conductivity sensor is responding properly. This second standard can be any value, but typically 10% of the first standard works well, giving checks at 100% and 10% of range.

NOTE: *IC Controls manufactures conductivity standards and QC's them to NIST materials. Certificates of traceability to NIST materials are available as P/N A1900333. IC Controls also offers complete calibration kits. Refer to* Appendix B *for ordering information.*

1. Obtain calibration supplies such as a graduated cylinder or beaker which is large enough to submerse the conductivity sensor, and distilled or deionized water in a squeeze bottle for rinsing.
2. Remove the conductivity sensor from the process and inspect the sensor for any deposits. If the sensing surface is coated, clean the sensor before proceeding (refer to *Sensor Maintenance, Chemical Cleaning* section). Rinse the sensor cell area with distilled water.
3. Rinse the graduated cylinder or beaker and pour some of the selected higher conductivity standard into the graduated cylinder or beaker.
4. Immerse the sensor into the beaker or cylinder. Ensure the sensor electrode area is completely submerged. If the sensor has vent holes then the sensor must be submerged below the vent holes and there must be no air bubbles inside.

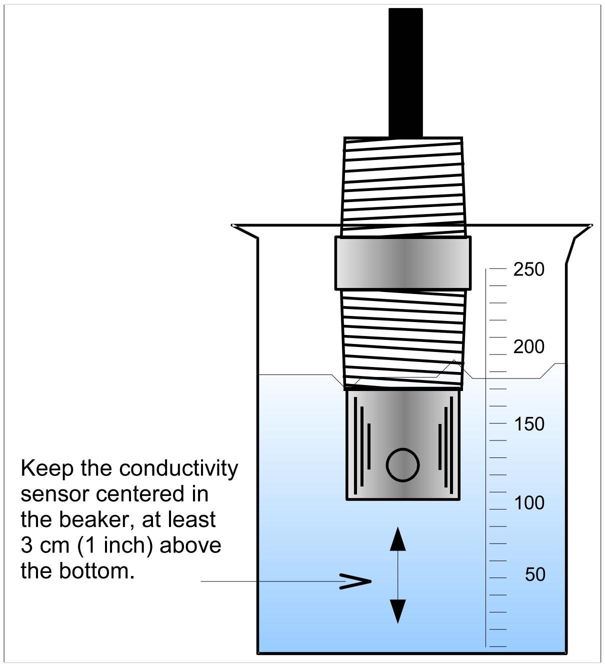


Illustration 11: Conductivity calibration

Important:

a) Air bubbles inside the controlled volume area of the conductivity sensor cause major upsets to ion flow and result in large errors in the reading.

b) If the analyzer is not reading on-scale at this point, it may be because the wrong concentration range is selected. Go to [cond] [unit] and select either [1E-3] for millisiemens or [1E-6] for microsiemens.

5. Press *SAMPLE* to view conductivity reading. Press → to access main menu. Use the up arrow key to display [cond], press → then use up arrow key to display [CAL]. Press → to view present conductivity standard value. If different from the value being used, edit the value as per section *Edit Mode, Editing a Numeric Value*. The transmitter will display in units of millisiemens/cm or microsiemens/cm, depending on the setting of [cond] [unit].

6. Press → to start the calibration. The transmitter will display a flashing concentration reading. From here on the calibration process is automatic. Wait until the reading has stabilized. As soon as the reading is stable, press the *ENTER* key. The transmitter calculates the cell constant automatically using the temperature-compensated value of the conductivity standard. At this point the display stops blinking and displays the conductivity based on the adjusted cell constant or standardized reading.

   NOTE:

   a) *It is possible to repeat or restart the calibration at any time. Simply press* SAMPLE*, then → as needed to restart or to repeat the calibration.*

   b) *If an error occurs during calibration, an* [Err] *message will be displayed. Refer to the* Error Messages *section for the appropriate action to be taken.*

7. The conductivity sensor and transmitter pair are now calibrated. The system should not require calibration for one month or more. Used conductivity standard should be discarded because exposure to air and contamination causes the conductivity value of standards to change.

   NOTE:

   a) *You can inspect and/or manually adjust the cell constant for the conductivity sensor by pressing* SAMPLE, → [cond] → [CELL] → [1] *from the menu. The cell constant should correspond closely to the constant stamped on the cell.*

   b) *The sensor condition can be verified by measuring the concentration of a second conductivity standard.*
   Rinse the sensor surface with deionized water and then measure the concentration of the second standard (refer to step 4). If the transmitter reads correctly then the sensor condition is good. If the transmitter does not read correctly then the sensor may not be responding properly and may need to be cleaned.

Editing the Cell Constant

The cell constant for the conductivity sensor can be adjusted either by doing a calibration or by directly editing the value stored in memory.

To edit the cell constant, press *SAMPLE* → [cond] → [CELL] → [1] from the menu. The cell constant will be displayed with a multiplication factor of 1, which is the actual cell constant. To edit the displayed constant, press *ENTER* to go into edit mode. The [1] frame will accept cell constants between 0.01/cm and 99.99/cm.

For pure-water applications, conductivity sensors with low cell constants are used. When working with cell constants smaller than 0.1/cm, you can view the cell constant with more resolution by selecting [CELL] [100] from the menu. The cell constant will be multiplied by 100 to give two extra digits of resolution.

Calibration by Grab-Sample; Sensor in-line

The grab-sample technique is quicker and easier if the sensor is not easily accessible or if standard solutions are unavailable or impractical. This procedure describes how to calibrate the transmitter without taking the sensor out of the process. The procedure requires that the sample be measured with a second transmitter.

1. Obtain the following materials:
   - a second conductivity transmitter
   - calibration supplies
   - clean beaker
   - calculator
2. Calibrate the second conductivity unit.
3. Record the 453-9 cell constant for the sensor. The cell constant is displayed by selecting [cond], [CELL], [1], ,from the menu.
4. Using the clean beaker, draw a representative sample from the process.
5. Record the conductivity of the sample as displayed by the 453-9 conductivity transmitter.
6. Measure the conductivity of the sample using the second conductivity transmitter and record the conductivity reading. For best results, the sample should be at the same temperature and the transmitters should use the same temperature compensation method.
7. Calculate the new cell constant to be entered into the 453-9 transmitter using the following formula:

$$new\ cell\ constant = \frac{(lab\ reading)}{(field\ reading)}\ x\ old\ cell\ constant$$

   For example, if the 453-9 transmitter is reading 820 μS/cm, the cell constant (from step 3) is 1.0/cm, and the reading from the second method is 890 μS/cm, then the new cell constant becomes

$$new\ cell\ constant = \frac{890}{820}\ \mu S/cm\ x\ 1.0/cm = 1.09/cm$$

8. Adjust the cell constant to the new value, e.g. 1.09/cm, as per the example. The cell constant is adjusted by selecting [cond], [CELL], [1] from the menu. Press *ENTER* to go into edit mode, then adjust the displayed value and press *ENTER*.
9. The transmitter is now calibrated and should read accurately.

Manual Calibration

It is possible to bypass the regular calibration procedures and manually edit the cell constant.

When the cell constant is manually edited, there is no way for the transmitter to verify the accuracy of the adjustments made - warnings are given, however, if the edits fall outside the preset ‘safe’ regions. Unlike a normal calibration, the manual edits allow values outside reasonable limits. Error messages will come up but the new values will be installed nonetheless.

IC Controls advises that the operator use one of the regular calibration procedures whenever possible.

Selecting a Conductivity Standard

Conductivity standards provide the simplest and most accurate method of calibrating the 453-9 transmitter. The transmitter has been programmed to recognize the three standards most commonly used for calibration: 100 µS/cm, 1000 µS/cm, and 10,000 µS/cm, at 25 °C (77 °F). Simply place the sensor in the standard and the transmitter will use the correct temperature adjusted value for the standard.

Temperature Dependence of Standards

The conductivity of a solution is dependent on temperature, typically changing by about two percent per degree Celsius (2%/°C). To achieve greater accuracy, the temperature-compensated values for the 100 µS/cm, 1 000 µS/cm, and 10 000 µS/cm conductivity standards are calculated by the transmitter. If manual temperature compensation has been selected, then the manual temperature compensation set-point is used as the standard's temperature.

Other standards or Custom standards

If a standard with a conductivity value other than 100 µS/cm, 1 000 µS/cm, or 10 000 µS/cm is to be used, from the [cond] menu, select [Cal] [100], then press *ENTER* to edit to the known value. Values entered this way are not temperature-compensated - the standard is assumed to have the specified conductivity value at the current temperature.

Sensor Life

The conductivity sensor needs to be calibrated periodically to maintain accurate conductivity measurement. IC Controls recommends electrodes be calibrated every 30 days. Depending on the process, they may need to be calibrated more frequently, or less frequently.

4 mA to 20 mA OUTPUT SIGNAL

A 4 mA to 20 mA output is provided over the 24 VDC power leads. The output has an on/off switch and adjustable low and high span (or scale) adjustment. This makes it possible, for example, to transmit short span conductivity signals such as 40 µS/cm to 70 µS/cm, using the high and low adjustments.

To adjust the output span or **output "window"** for conductivity signals, set [LO] to correspond to the low end of the scale or 4 mA output, and set [HI] to correspond to the high end of the scale or 20 mA output. The transmitter will automatically scale the output according to the new settings.

Reversing the 4 mA to 20 mA Output

The low scale setting will normally be lower than the high scale setting. It is possible to reverse the output or "flip the window" by reversing the settings of the low and high scale.

Example:
Define an output window from 70 µS/cm to 20 µS/cm with 70 µS/cm corresponding to 4 mA output and 20 µS/cm corresponding to 20 mA output. Set [LO] to 70 and set [HI] to 20.

Simulated 4 mA to 20 mA Output

Select [cur] from the output menu to display the output current in mA that is presently being transmitted by the output signal. The display will be updated as the output signal changes based on the input signal and the program settings. From here, the output response to the change in the input signal can be observed. This is useful for verifying program settings and for testing the hardware calibration.

To simulate a different 4 mA to 20 mA output signal, press *ENTER* to enter edit mode. Edit the displayed mA value to display the desired output needed for testing the output signal. Press *ENTER* to select the displayed value. The output signal will be adjusted to put out the desired current. This process can be repeated as often as necessary.

The output signal is held at the displayed level until the program leaves this part of the menu.

Output Specifications

	4 mA to 20 mA
Maximum Span	0% to 100% scale
Span Adjustment	0.1 mA steps
Output Resolution	0.01 mA steps

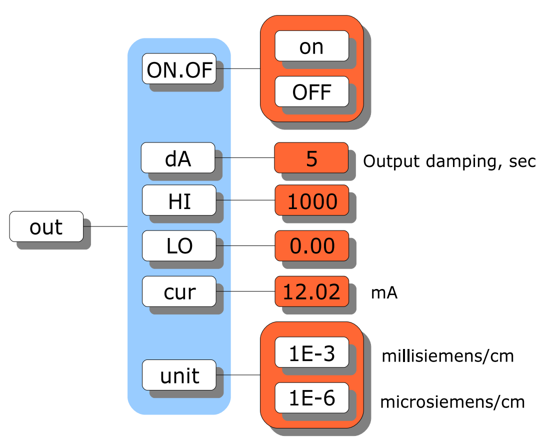


Illustration 12: Output menu

CAUTION AND ERROR MESSAGES

Detected errors and/or cautions are displayed by the transmitter. From the keypad press *ERROR* or from the main menu select [Err]. If there are no error or caution messages, [NONE] will be displayed, otherwise scroll through the error list using the ↑ or ↓ keys. Errors and/or cautions cannot be removed from this list directly; each error/caution will be removed automatically when appropriate, e.g. errors associated with improper calibration will be cleared after a successful calibration.

Input/Source	***Input Number for Error/Caution Messages***
Conductivity	1
Temperature	2

Table 2: Input values for error/caution messages

Caution and error messages are numbered. Messages 1 through 5 are identified as [E*n*.*e*] where *n* is the input number and *e* is the error number. Messages 6 through 9 are less serious and are identified as cautions instead, e.g. [CA*n*.*e*].

Off-scale errors are not numbered but are identified as [+Err] and [-Err], depending on whether the input is at the top or the bottom of the scale. The off-scale error is displayed instead of the sample reading and does not show up in the error menu with the numbered error messages, if any.

Error and Caution Messages for Conductivity

Error	***Description***	***Causes***	***Solutions***
E1.2	Cell constant less than 0.001/cm. Previous cell constant retained.	Incorrect or bad standard used for calibration.	Redo calibration, specifying correct standard value. Refer to troubleshooting section.
E1.3	Cell constant greater than 100/cm. Previous offset retained.	Incorrect standard used for calibration.	Redo calibration, specifying correct standard value. Refer to troubleshooting section.
E1.5	Temperature compensator is off-scale.	Process outside of TC operating range of -10 °C to 210 °C.	Use manual temperature compensation.
			Check TC connections or install TC.
E1.6	Input is at maximum.	The A/D is seeing a full scale signal. The transmitter cannot measure higher.	If transmitter on manual range, switch to auto range so it can switch to next range.
			If transmitter on range 1 and still at it's limit, use a different sensor with a higher cell constant.
E1.7	Conductivity shows negative value.	Linear temperature compensation constant is set too high.	Determine a lower LTCC to use to correctly compensate for temperature. A typical value is 2.00 (for 2% change per °C).
CA1.9	Conductivity shows +Err	Display units set to [1E-6], microsiemens, and reading is too high to display.	Select [1E-3], millisiemens units.

Error Messages for Temperature

Error	***Description***	***Causes***	***Solutions***
E2.1	Temperature reading off-scale. Temperature less than -10 °C. Display shows [-Err].	Temperature less than -10 °C.	Verify process and sensor location.
		Electronic calibration necessary.	Follow procedure in *Hardware Alignment* section.
E2.2	Temperature reading off-scale. Temperature greater than 210 °C. Display shows [+Err].	Temperature compensator not attached.	Attach temperature compensator.
			Verify process and sensor location.
		Electronic calibration necessary.	Follow procedure in *Hardware Alignment* section.

SENSOR INSTRUCTIONS

Preparation for use

1. Moisten the sensor body with tap water and remove the lower (storage) plastic cap. Keep cap for future use. Rinse the exposed conductivity elements with tap water.
2. For first time use, or after long term storage, immerse the lower end of the sensor in a conductivity standard for 30 minutes. This wets the conductivity electrodes and prepares them for stable reading using test solutions.

NOTE: *IC Controls' sensors are shipped dry. These electrodes are often ready for use immediately with typical accuracy of ± 2% conductivity without calibration. It is recommended that the sensor be soaked in conductivity standard plus calibrated using an appropriate conductivity standard to achieve optimal accuracy.*

Calibration for Conductivity Measurement

Overall system accuracy is maintained by calibrating the sensor and transmitter together in a concentration close to the expected sample concentration. The cell and transmitter can generally be calibrated in two of four typical ranges: 0 µS/cm to 100 µS/cm, 0 µS/cm to 1 000 µS/cm, 0 µS/cm to 10 000 µS/cm, and 0 µS/cm to 100 000 µS/cm.

Where to do Conductivity Calibrations

A suitable place to conduct a calibration is at a counter or bench with a sink, in an instrument shop or laboratory. However, since this is not always practical, IC Controls' conductivity calibration kits are kept small and portable so that they can be taken to installation sites, together with a bucket of water (for cleaning/rinsing) and a rag/towel (for wiping/drying).

NIST Traceable Standards

IC Controls QC's conductivity standards with NIST (National Institute of Standards and Technology) materials. Certificates of traceability to NIST are available as P/N A1900333.

Electrode Storage

Short term: Rinse the sensor electrodes in deionized water, allow to dry and store dry.

Long term: Rinse the sensor electrodes in deionized water, allow to dry, cover tip with the plastic shipping cap and store dry.

Restoring Sensor Response

Mechanical Cleaning of Sensor

The sensor will require cleaning if sludge, slime, or other tenacious deposits build up in the internal cavities of the sensor or on the sensing elements.

Wherever possible, clean with a soft brush and detergent. General debris, oil films and non-tenacious deposits can be removed in this way.

For flat-surface sensors, use a potato brush and a beaker or bucket of water with a good liquid detergent. Take care not to scratch the electrode surfaces. Internal cavities of standard sensors can be brushed with a soft ¼ inch diameter brush.

All wetted surfaces of the sensor should be washed with a soft cloth. This will return their appearance to like-new condition and remove sites for buildups to occur.

Check the sensor calibration against a conductivity standard and calibrate if necessary. If the sensor is still not responding properly, proceed to the *Chemical Cleaning of Sensor* procedure, otherwise return the sensor to the process.

Chemical Cleaning of Sensor

Obtain a supply of IC Controls' Conductivity Sensor Cleaning and Conditioning solution, P/N A1100005, or as part of the Conductivity Chemical Cleaning kit, P/N A1400054.

NOTE 1: *A suitable place to do chemical cleaning is at a counter or bench with a laboratory sink with a chemical drain where waste is contained and treated before release.*

NOTE 2: *IC Controls' kits are kept small and portable so that they can be taken to installation sites, together with a plastic bucket of water (for rinsing) and a rag/towel (for wiping/drying). Waste materials (particularly acid leftovers) should be returned to the laboratory for proper disposal*.

CAUTION: ***Use extra caution when handling cleaning solution as it contains acid.***

1. Wear rubber gloves and adequate facial protection when handling acid**.** *Follow all P/N A1100005 MSDS safety procedures.*
2. Set up the cleaning supplies where cleaning is to be performed. Lay out the sensor cleaning brush, syringe, cleaning solutions and rinse solutions, plus the beakers and sensor if already at hand.
   Note: *Ensure your cleaning solution beaker is on a firm flat surface since it will contain acid*.
3. Remove the conductivity sensor from the process and examine it for deposits. Use the sensor cleaning brush and tap water to loosen and flush away any deposits within the cell measurement area. Detergent can be added to remove oil films and non-tenacious deposits. Hard scale and other tenacious deposits may require chemical cleaning.

4. **CHEMICAL CLEANING**
Fill a beaker ¾ full of cleaning and conditioning solution, P/N A1100005, or for flow-through sensors with internal passages, seal one end to form a container inside the sensor body.
5. Lower the conductivity cell into the center of the beaker until the top hole is submerged, or pour the solution into the flow sensor until it is full.
6. Keep removing and re-immersing the sensor until the sensor electrodes appear clean. Stubborn deposits can be worked on with the brush and syringe to squirt cleaner into hard to reach areas.
CAUTION: *Use great care when brushing and squirting acid.* ***Wear rubber gloves and facial protection.***
7. Rinse the cleaned sensor thoroughly in tap water followed by a rinse using deionized water before calibration.
8. Check the sensor against a conductivity standard near full scale. If the sensor is still not developing the proper cell constant ± 5%, or reading in the standard, re-clean or proceed to troubleshoot or replace the sensor.
9. A clean, rinsed and dried conductivity sensor should read near zero in air. If it does not, troubleshoot the sensor, wiring, and transmitter.

If the sensor cannot be returned to proper working condition, it may need replacement. As a general rule of thumb, the cell constant, as calculated by the transmitter, should be within 25% of the original or intended value stamped on the sensor.

NOTE: *If none of the above procedures succeed in restoring your sensor response, it is near the end of its useful life and should be replaced.*

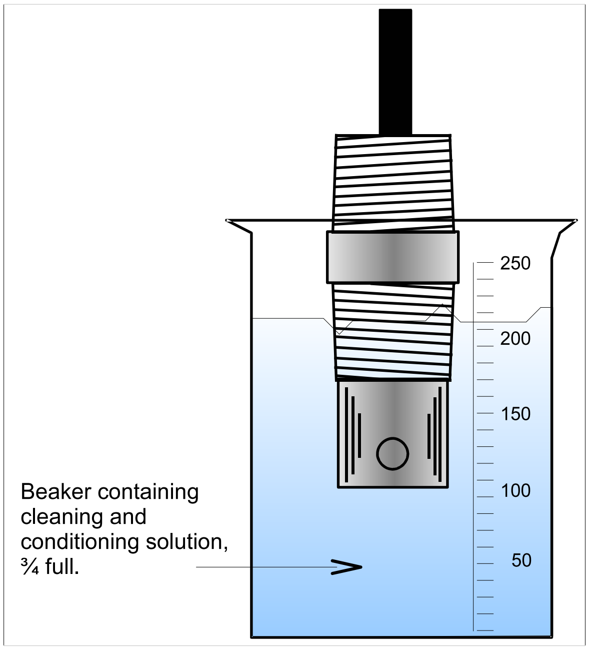


Illustration 13: Conductivity cleaning

CONFIGURATION OF PROGRAM

The 453-9 transmitter has been designed with ease-of-use in mind. In most cases the transmitter has been configured to ordered specifications at the factory and no configuration of the transmitter is necessary. However, several hardware options are available and if they are changed, the program configuration settings need to be set accordingly for the program to function properly.

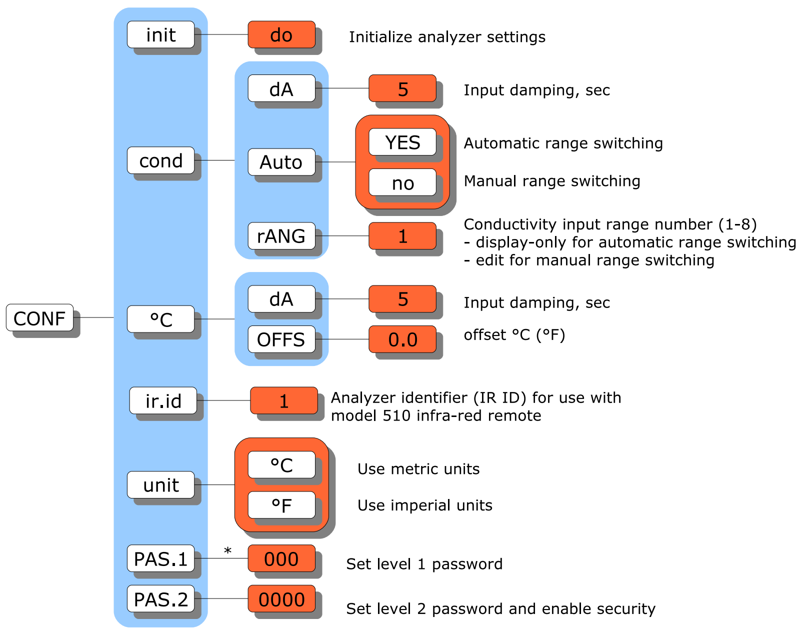


Illustration 14: Configuration menu

Initializing All Program Settings

Occasionally it may be desirable to reinitialize all of the program settings to bring them back to default. Executing the initialization procedure will cause the transmitter to reset all the program variables and settings to factory default and then proceed with the normal startup display.

The initialization procedure is not to be used unless the user is absolutely sure that they want to restore the transmitter to factory default configuration.

After the transmitter program has been initialized, the user will need to re-enter the output signal setting, as well as the program configuration if it was different from the factory default settings.

To reinitialize the unit, select [CONF] from the main menu. Press → and use ↑ or ↓ key to display [init]. Press → to display a flashing [do]. Nothing will happen if you press ← or *SAMPLE*. The transmitter will only reinitialize if you press *ENTER*. The transmitter will then go through the normal boot-up procedure.

Temperature Calibration

The temperature compensator in the sensor can sometimes show a small variance in its offset. To make the sensor read correctly use the following procedure.

The current temperature, as measured by the temperature sensor, needs to be known. If the sensor is in the process, the known temperature of the process can be used.

Select [CONF] [°C] [OFFS] from the menu. A frame showing the current temperature offset will be displayed.

Use the following formula to calculate the new offset value:

$$new\ offset = (correct\ temperature - displayed\ temperature) + current\ offset$$

For example, if the temperature input is reading 24.6 °C and it should be reading 25.0 °C and the current offset is 0.2 °C:

$$new\ offset = (25.0\,°C - 24.6\,°C) + 0.2\,°C = 0.6\,°C$$

The calculation works both for Celsius and Fahrenheit units.

Select [CONF] [°C] [OFFS] from the menu. Press → to display numeric value. Press *ENTER*, then change the temperature offset to the new offset value. Press *ENTER* again to leave edit mode.

Return to the sample menu and verify that the temperature input is now displaying the correct temperature.

Selecting Temperature Units

By default, the transmitter uses metric units - display is degrees Celsius and the prompt for temperature is [°C]. The transmitter is also selectable for imperial units - display is degrees Fahrenheit and the prompt for temperature input will be [°F].

To select Fahrenheit units for the transmitter, select [unit] from the configuration menu, then go into edit mode and change the [°C] prompt to [°F].

Input Damping

Both the measurement and the temperature can be damped to provide the user with a means to deal with rapidly varying or noisy signals. Damping range is 0 seconds to 60 seconds. With 0 seconds, there is no damping and each reading the transmitter makes is used to directly update the display and 4 mA to 20 mA output. The factory default 5 seconds adds the next 4 seconds of readings to the first and divides by five giving very fast response. Selecting 60 seconds adds the readings for all 60 seconds and divides by 60 providing an excellent smooth damping out of turbulent readings. Any selection between 0 seconds and 60 seconds can be made.

Select [CONF] [cond] [dA] [0005] from the menu. Press *ENTER*, then change the conductivity damping to the new number of seconds. Press *ENTER* again to leave edit mode. For temperature damping, select [CONF] [°C] [dA] [0005] from the menu. Press *ENTER*, then change the temperature damping to the new number of seconds.

Infra-Red Identity

When mounted close together, more than one transmitter could possibly see the signal from a single 510 infra-red remote keypad. To make the transmitters individually selectable, they have a unique ID capability. IC Controls ships the units by default as ID equals 1 - it can be field changed to any two digit number up to 99. Where an array is planed, it is easiest to preset the ID to a unique number before installation. However, by stepping *close enough* that *only one unit* sees the signal the ID can be changed in the installation.

Select [CONF] [ir.id] [0001] from the menu. Press *ENTER*, then change the ID number to the new number. Press *ENTER* again to leave edit mode.

TROUBLESHOOTING

When trying to determine what the problem is with a conductivity loop, there are a few simple steps to follow:

ISOLATING THE PROBLEM

FIRST: Write down the symptoms.

a) conductivity reading

b) temperature reading

c) conductivity cell constant in analyzer

d) conductivity cell constant on the sensor label

SECOND: Separate the sensor from the transmitter so that the problem can be isolated.

Disconnect the sensor from the transmitter at the terminal block. In this way, it is much easier to test and determine if the problem is in the conductivity sensor or in the transmitter.

THIRD: See if the transmitter reads correctly without the sensor.

a) With sensor leads removed from transmitter, the transmitter should read zero or close to zero.

b) Insert a 1000 Ω 1% resistor across the sensor cell connections and a second one across the sensor TC terminals.
Note the temperature reading - if it is approximately 0 °C (or 32 °F) then the transmitter looks alright.

c) Change the transmitter cell constant setting to 1.00/cm.
Note the conductivity reading - if it is approximately 1000 µS/cm (or 1.00 if reading mS/cm) then the analyzer looks alright.

d) If the reading is far from 1000 µS/cm, do a calibration with [Cal] set to 1000 and note the conductivity cell constant in [CELL].

FOURTH: Problem isolated.

If the [CELL] is within 10% of 1.00, then the transmitter is good. If the transmitter and the equipment are good then the problem is in the sensor — refer to the *Sensor Instructions* section. If the [CELL] is greater than 10%, the problem may be in the transmitter — refer to the *Electronic Hardware Alignment* section.

Readings at maximum—"+Err" message under all conditions

First verify that the transmitter is displaying conductivity using mS/cm units. The transmitter will display "+Err" if conductivity is above 9999 µS/cm with microsiemens/cm units selected for the display. This condition is indicated by CA1.9.

If unit selection is not the problem, then the sensor may be shorted. This condition is indicated by E1.6. Test for sensor shorts by checking between black and white lead with sensor in air. Value should exceed 1 MΩ (megohm).

If the sensor tests OK, and the transmitter is OK with substitute resistors, but the "+Err" message and E1.6 error still occur, then the conductivity is too high for the cell constant used. Resolve by determining the actual conductivity and selecting a new conductivity sensor with the correct cell constant.

Elevated readings on low conductivity

The transmitter will give a low reading even with the conductivity sensor in air. Look first at shielding between leads and ensure the shield is connected to the transmitter shield terminal rather than electrical ground. Other known causes include incorrect cable or cable lengths too long for the application.

ELECTRONIC HARDWARE ALIGNMENT

The electronics go through factory alignment to setup default conditions. Typically, it should not be necessary to make any field adjustments, however, electronic **zero** and **span** adjustments can be performed. This allows the user to adjust settings and/or re-range the instrument to accommodate for specific application details.

Devices referred to in the following descriptions are shown on component location drawings D5000226. Proper field wiring for hookup is shown on drawing D5000240 and D5000241.

These instructions assume 24 VDC power is hooked up, the calibration of input electronics are operational, and field wiring is in place.

NOTE: *The following instructions are for instrument personnel to adjust the transmitter, if necessary, in the instrument shop or safe area location; NOT in the field.*

Calibration of Conductivity Input

Sensor Drive: Place a 100 Ω 1% resistor across TB-100, terminals 1 & 3 (found in terminal end of housing). Ground lead of scope to TB-100, terminal 2 (shield). Place probe of scope to "TP D" test-point on main board. Measure drive voltage - it should be 0.050 VPP, 700 Hz, square wave. Adjust "drive" using gray trimpot VR100.

Conductivity Sense: Input remains 100 Ω 1% as above. Place black lead of voltmeter to TB-100, terminal 2 (shield). Place red lead of voltmeter to "TP C" test-point on main board. Measure test voltage - it should be 0.500 VDC. Adjust "conductivity input" voltage using gray trimpot VR100.

Isolated side: Put black lead of voltmeter to TP3 (common) test point on main board. Put red lead of voltmeter to "TP1" test-point on top left of main board (U107 pin 7). Input remains 100 Ω 1% as above; test voltage at "TP1" should be 0.833 VDC with display board attached. Adjust with R118 on main board to 0.833 VDC.

Temperature Input

The temperature input of the 453-9 is very reliable and no adjustable electronic parts are needed. The stability and repeatability of the 1000 Ω RTD temperature circuit typically needs no adjustment. If it is adjusted, it often leads to lower accuracy due to the difficulty of knowing the true temperature without a controlled temperature bath. If minor adjustments are required, they are addressed via the software. To adjust, refer to heading *Temperature Calibration* in *Configuration of Program* section.

DISPLAY PROMPTS

[1E-3]	Conductivity units in mS/cm, millisiemens.
[1E-6]	Conductivity units in μS/cm, microsiemens.
[Acc.n]	Access level for security. Displayed after password entered by user.
[Auto]	Automatic.
[°C]	Temperature in degrees Celsius; temperature input.
[CAL]	Calibrate transmitter.
[CELL]	Conductivity sensor cell constant.
[cond]	Conductivity input.
[CONF]	Configuration of program to match hardware.
[cur]	Signal output in mA, or current.
[dA]	Damping of input signal.
[do]	Do - press ENTER to do reset/clear action.
[donE]	Done – reset/clear action has been accepted.
[Err]	Error
[°F]	Temperature in degrees Fahrenheit; temperature input.
[HI]	High limit (20 mA) for 4 mA to 20 mA output window.
[Hold]	Output hold during calibration.
[ir.id]	Infra-red identity number, editing (change) frame.
[LO]	Low limit (4 mA) for 4 mA to 20 mA output window.
[ltcc]	Temperature compensation; linear, 2%/°C.
[OFF]	Off.
[OFFS]	Offset.
[ON]	On.
[ON.OF]	On/Off switch.
[out]	4 mA to 20 mA analog output channel.
[PAS.1]	Set password 1, operator access.
[PAS.2]	Set password 2, complete access.
[PASS]	Enter password to change access level.
[rang]	Transmitter conductivity input range selection.
[SEt]	Set-point; select manual temperature compensation.
[tc]	Temperature compensation.
[unit]	Unit selection.

GLOSSARY

Cell Constant
Describes the enclosed volume between electrodes in the conductivity sensor. Units are cm^{-1}. Higher cell constants produce higher transmitter ranges, lower cell constants produce lower ranges.

Conductivity
The amount of electrical current that flows through a liquid. Generally reported as microsiemens/cm or millisiemens/cm.

EPROM (Erasable/Programmable Read Only Memory)
The EPROM chip holds the program which determines the functioning of the 453-9 transmitter. Replacing the EPROM chip with a chip containing a new or an updated program changes the way the transmitter functions. The EPROM chip is programmed by the manufacturer.

EEPROM (Electronically Erasable/Programmable Read Only Memory)
The EEPROM memory holds the customer settings for the program which determines the site functioning of 453-9 transmitter. The customer settings in the EEPROM chip will not disappear even if the chip loses power.

Menu
The series of prompts which determine the layout of the program used by the transmitter.

Millisiemens per centimeter (mS/cm)
Unit of conductivity. 1 millisiemens/cm = 1,000 microsiemens/cm. The "milli" prefix is an SI (metric system) prefix meaning a multiple of a thousandth.

Microsiemens per centimeter (µS/cm)
Unit of conductivity. 1,000 microsiemens/cm = 1 millisiemens/cm. The "micro" prefix is an SI (metric system) prefix meaning a multiple of a millionth.

Sensor
Measuring device consisting of a sense electrode and drive electrode; both are needed in order for the transmitter to measure conductivity. Typically these two electrodes are built into one sensor. A temperature detector may be built into the sensor as well.

Siemens (symbol: S)
The siemens is the SI (metric system) derived unit of electric conductance where 1 siemens = 1/ohm.

TC
Temperature Compensator.

Temperature Compensation
Correction for the influence of temperature on the conductivity measurement. The transmitter reads out concentration as if the process were at 25 °C, regardless of actual solution temperature.
LTCC, linear temperature compensation constant: the default LTCC of 2.0 adjusts the conductivity reading by 2% per degree Celsius so that the effective conductivity at 25 °C can be displayed.

Appendix A — Default Settings

The following program settings are the default settings for the transmitter. New transmitters will have these settings unless the setup has already been customized for the user's specific application.

Conductivity sensor constant

Cell constant set to 1.00/cm

Output

Input to be transmitted:	conductivity
Low setting:	0.00 mS/cm
High setting:	10.0 mS/cm
ON/OFF switch:	ON
Units	[1E-3]

Global units

Conductivity units; [1E-3] for millisiemens per centimeter

Metric units; temperature in degrees Celsius (°C)

Temperature compensation method

Automatic TC using temperature input

Input signal damping

Signal damping for: $Conductivity = 5\ seconds$
$Temperature = 5\ seconds$

Appendix B — Parts List

Part Number	*Description*	*Reference Drawing Number*
	453-9 conductivity transmitter	
A9051050	Assembly; 453-9 conductivity main PCB	D5020226
A9051046	Assembly; M53-9 micro board	D5000224
A9051045	Assembly; M53-9 display PCB, complete	D5000223
A9051047	Assembly,M53-9 feedthrough PCB	D5000225
A9051051	Assembly, 453-9 conductivity front panel	
A9141026	Assembly, M53-9 case, complete	
A2500270	2 inch pipe mount kit; M53-9 series	D4000076
510	Infra-red remote control	
540	24 VDC power supply	
	Consumable Supplies	
A1400051	Low conductivity calibration kit for cell constants 0.01/cm to 0.2/cm, 1 year supply	
A1400052	Medium conductivity calibration kit for cell constants 1.0/cm to 5.0/cm, 1 year supply	
A1400053	High conductivity calibration kit for cell constants 10.0/cm to 50.0/cm, 1 year supply	
A1400054	Conductivity chemical cleaning kit, 1 year supply	
A1100161	100 µS/cm conductivity standard, 500 mL (A11000161-6P for 6-pack)	
A1100162	1 000 µS/cm conductivity standard, 500 mL (A11000162-6P for 6-pack)	
A1100163	10 000 µS/cm conductivity standard, 500 mL (A11000163-6P for 6-pack)	
A1100164	100 000 µS/cm conductivity standard, 500 mL (A11000164-6P for 6-pack)	
A1100192	Deionized rinse water, 500 mL (A11000192-6P for 6-pack)	
A1100005	Cleaning and conditioning solution, 500 mL (A11000005-6P for 6-pack)	
A1100007	Plastic, 100 mL graduated cylinder (for sensor cell constant 0.01/cm)	
A1100020	Plastic, 250 mL beaker	
A1100016	Sensor cleaning brush, ¼ inch	
A7400031	Syringe, 120 mL	

Appendix C — 453-9 Conductivity Transmitter Specifications

Physical Data

PROPERTY	***CHARACTERISTIC***
Display	Four and one half LCD digits, 1.5 cm (0.6 in) displays for conductivity, temperature, error codes, prompts and diagnostic information.
Display Ranges	Conductivity: 0 µS/cm to 1 µS/cm; 0 µS/cm to 1,000 µS/cm, and 0 mS/cm to 1,000 mS/cm Temperature: -10.0 °C to 210 °C (14.0 °F to 410 °F)
Operation	Via intrinsically safe infra-red remote control.
Enclosure	Explosion-proof, barrel housing
Mounting	Any 90 degree increment from standard; supplied with 2 in pipe mounting kit (*may be used to surface mount*).
Weight	3.5 kg (7.7 lb)
Shipping Weight	4.1 kg (9.0 lb)
Shipping Dimensions	46 cm × 30 cm × 23 cm (18 in × 12 in × 9 in)

Environmental Data

PROPERTY	***CHARACTERISTIC***
Temperature	Operational: 5.0 °C to 40 °C (41.0 °F to 104 °F) Storage: -10.0 °C to 55 °C (14.0 °F to 131 °F) Relative Humidity: 80 % maximum; non-condensing
Enclosure Ratings	-Class 1 Groups B, C & D; Class 2 Groups E, F & G rating. -NEMA 4, water- and dust-tight rating. -NEMA 7, hazardous; for indoor use Class 1, Groups A, B, C & D as defined by NEC. -FM Approved. -CSA certified. -Cenelec Certified, EExd IIC, IP66.
Electrical Ratings	24 VDC (min. 16 VDC, max. 40 VDC); lift off voltage 16 VDC; 4 mA to 20 mA.
Electrical Requirements	16 VDC to 40 VDC, 24 VDC nominal. Quality ground required for microprocessor.

Operational Data

Accuracy	Conductivity: ± 0.5 % of measured range Temperature: ± 0.3 °C
Precision	Conductivity: ± 1 digit (0.01 µS/cm) Temperature: ± 1 digit (0.1 °C)
Response Time	90% within 5 s (default), function of flow and temperature. Damping adjustment: 0 s to 40 s
Temperature Compensation	Automatic 1000 Ω RTD Auto: -10.0 °C to 210 °C (14.0 °F to 410 °F) Manual: -10.0 °C to 210 °C (14.0 °F to 410 °F)
Auto-Range Multipliers	Cell constant ×100, ×1000, ×10,000, or ×100,000
Cell Constant Range	0.01/cm to 100.0/cm
Output	One continuous, programmable 4 mA to 20 mA output; isolated, max. load 500 Ω. Convertible to 1 VDC to 5 VDC.

Temperature compensation types:

Compensation Type	***Function***	***Characteristic***
Linear	Default Adjustable	2 % per °C 0.1 % to 5.0 % per °C

es-453_9-1.5

Appendix D — Security

The 453-9 has a built-in password protection system. This security system is disabled by default and does not need to be enabled if no password protection is necessary. If the password protection system is not enabled, then the user will have unrestricted access to all transmitter settings available through the menu as described in this manual.

Having security disabled provides the same access to the program as being at access-level 2 at all times.

With security enabled, anyone can view settings anywhere in the program. When proper access rights are not warranted, the program will display [PASS] for 2 seconds, indicating that a proper password must be entered before being allowed to proceed.

Access-Level	***Description***
0	View-only access to all settings
1	Access to all settings except for configuration menu. **Usage:** Operator access. No changes can be made to configuration and passwords cannot be changed.
2	Access to all settings. This allows the same access to program as when password security is not enabled. **Usage:** Installation, management.

Table 3: Security access levels

Enabling Password Security

When security is disabled both password 1 and password 2 are set to “0000.” Security is enabled by setting password 2 to a non-zero value.

Select [CONF] [PAS.2] from the menu. The transmitter will display [0000]. Use the arrow keys to change the display to the desired password for level 2. Pressing *SAMPLE* at any time will safely cancel password entry. Press *ENTER* to enter the password into memory and to enable password security. The transmitter program automatically returns to the configuration menu.

With only password 2 set to a non-zero value: level 2 access is required to make changes in the configuration menu but all other settings are unprotected. Effectively, the user will always have at least level 1 access.

At this point password 1 is still “000.” You may optionally enable operator access control or level 1 security by changing the level 1 password from “000" to a non-zero value. Change the password by selecting [CONF] [PAS.1] from the menu, then entering an appropriate 3-digit password.

Write down the passwords set and store them in a secure place; once a password has been set, there is no way to redisplay it. Since passwords are set in the configuration menu, level 2 access is required to change either password. If the level 2 password has been forgotten, there is no simple way to regain access to the transmitter. Contact the factory if you find yourself locked out of the transmitter.

Disabling Password Security

Password security can be disabled by setting the level 2 password to "0000." In order to change the password, level 2 access is required to enter the program.

Select [CONF] [PAS.2] from the menu, then press *ENTER* when the program displays [0000]. Both passwords 1 and 2 are set to "0000" and security is now disabled. The main menu will be changed to exclude the [PASS] frame, and the configuration menu will no longer have the [PAS.1] frame.

Entering a Password

With security enabled, select [PASS] from the main menu. The transmitter will display [0000]. Using the arrow keys, edit to display level 1 or level 2 password, then press *ENTER*. The program will display [good], followed by the access level before returning to the main menu. If an incorrect password was entered, the program displays [bAd] instead. Refer to illustration 15 to see how the program validates a password.

Level 1 or level 2 access is now acquired for as long as the transmitter is being operated. The access level will automatically be restored to level 0 after no key has been pressed for 15 minutes. This 15-minute time-out will also redisplay the main sample.

It is good practice to return the transmitter to level 0 access (or level 1 access if password 1 is set to "000") once the access-level user has finished using the transmitter. This is accomplished by selecting [PASS] from the main menu, then pressing *ENTER* with [0000] displayed.

Password Example — a Quick Tour

With security disabled, select [CONF] [PAS.2] from the menu. Set the level 2 password to "0002". Select [CONF] [PAS.1] from the menu. Set the level 1 password to "001." Security is now enabled.

Select [PASS] from the main menu. Press *ENTER* with [0000] displayed. The transmitter will display [ACC.0] to indicate we are now at access level 0.

Try changing the output low setting. Select [out] [LO] from the menu. The current value will be displayed. Press *ENTER* to go into edit mode. The transmitter will display [PASS] for 2 seconds because a password needs to be entered first. Level 1 security is needed to change this setting.

Select [PASS] from the main menu again. Change the displayed value to [0001], which is the level 1 password and press *ENTER*. The transmitter will display [good], followed by [ACC.1], indicating that the password is valid and that level 1 access has been achieved.

Try changing the output low setting again. This time, edit mode can be attained unhindered.

Select [PASS] from the main menu again. Enter the level 2 password, which is "0002." Change the level 2 password to "0000" in order to disable password security. Password 2 is found in the configuration menu and therefore requires level 2 access before it can be accessed. Select [CONF] [PAS.2] from the menu. Press *ENTER* with [0000] displayed. Both passwords are set to "0000" again and password security is disabled.

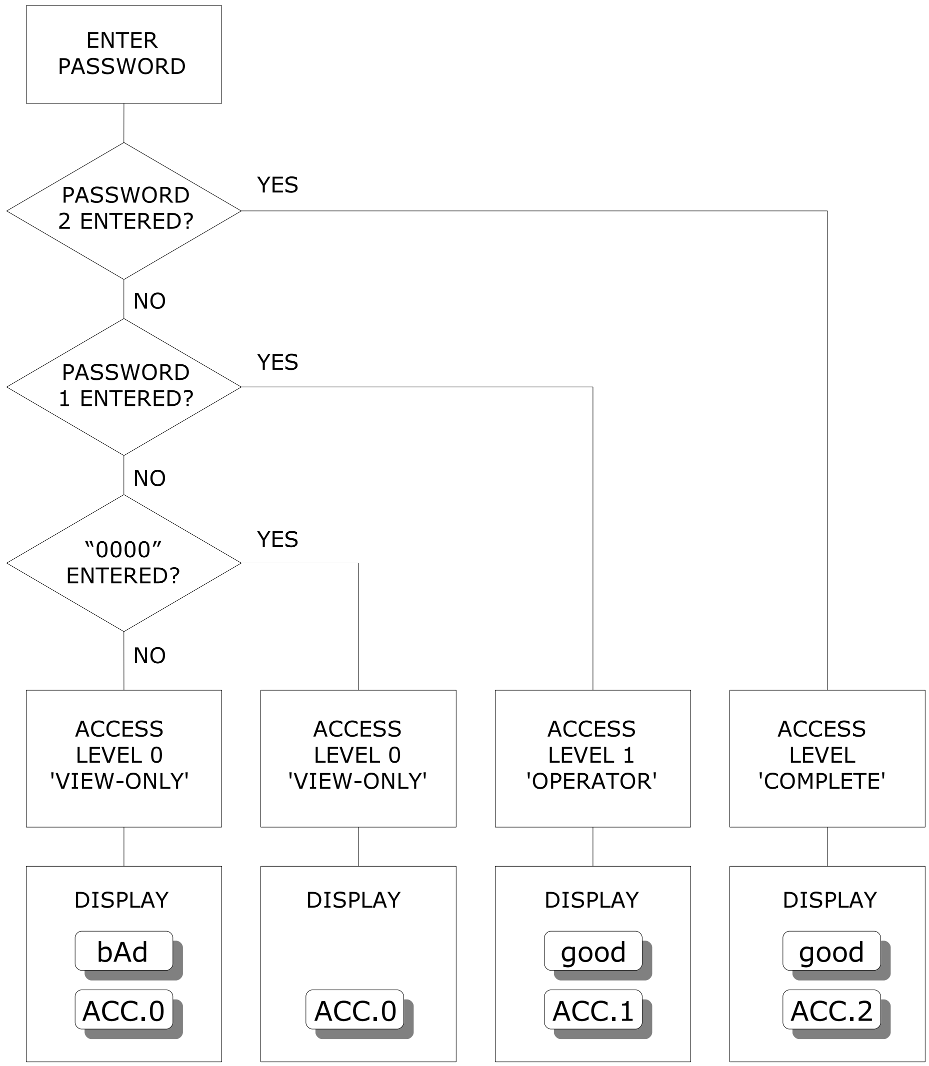
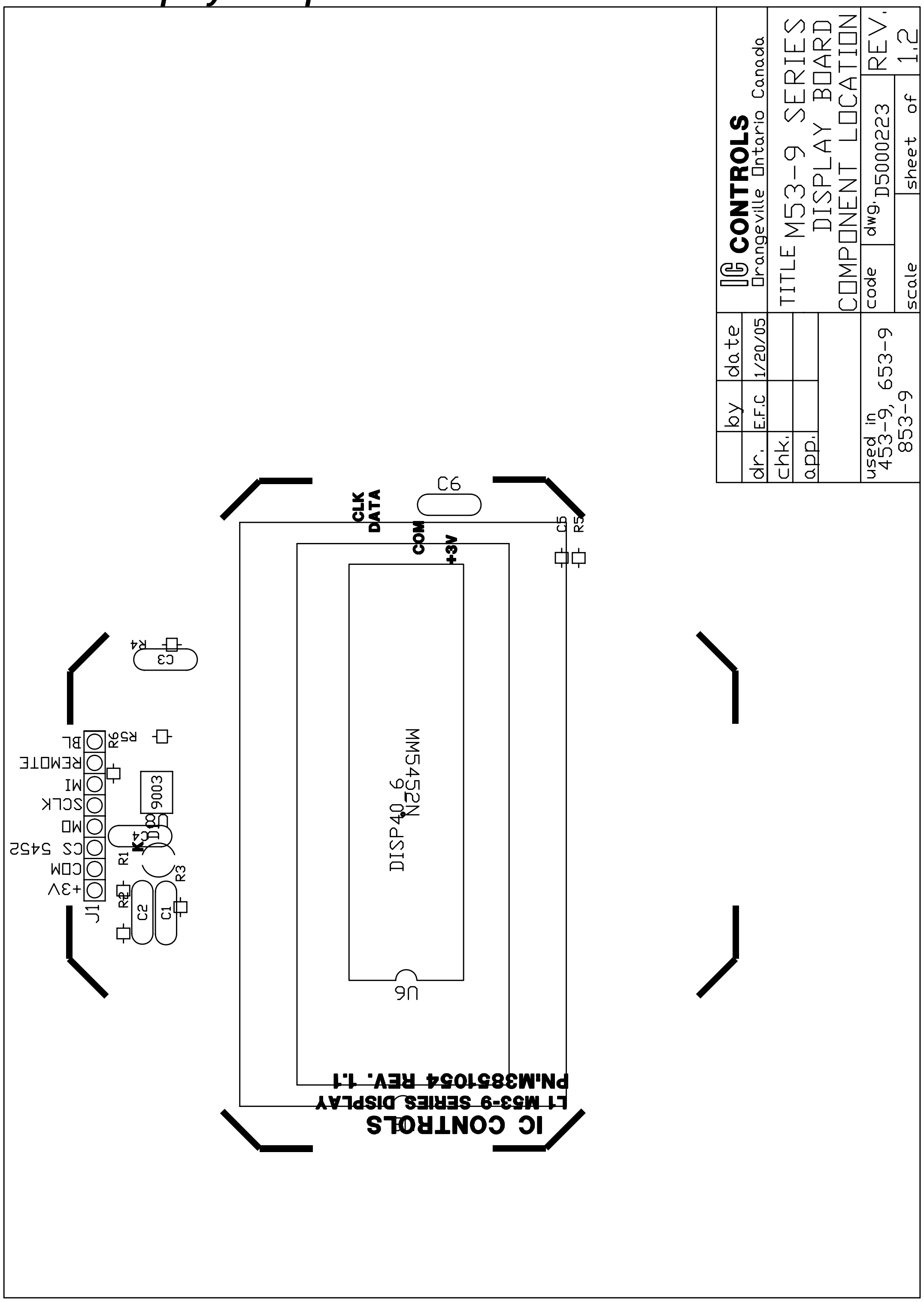


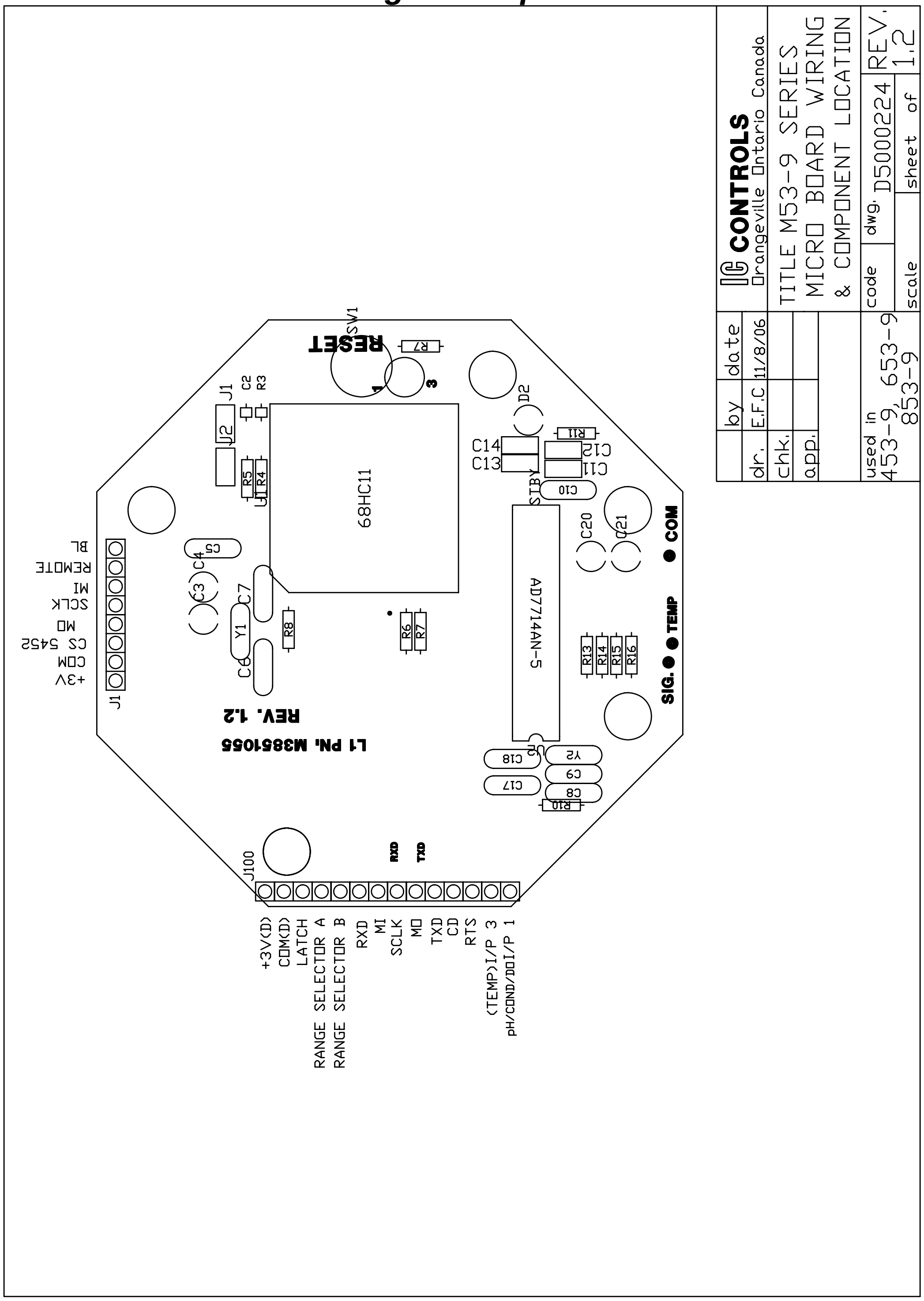
Illustration 15: Password validation

DRAWINGS

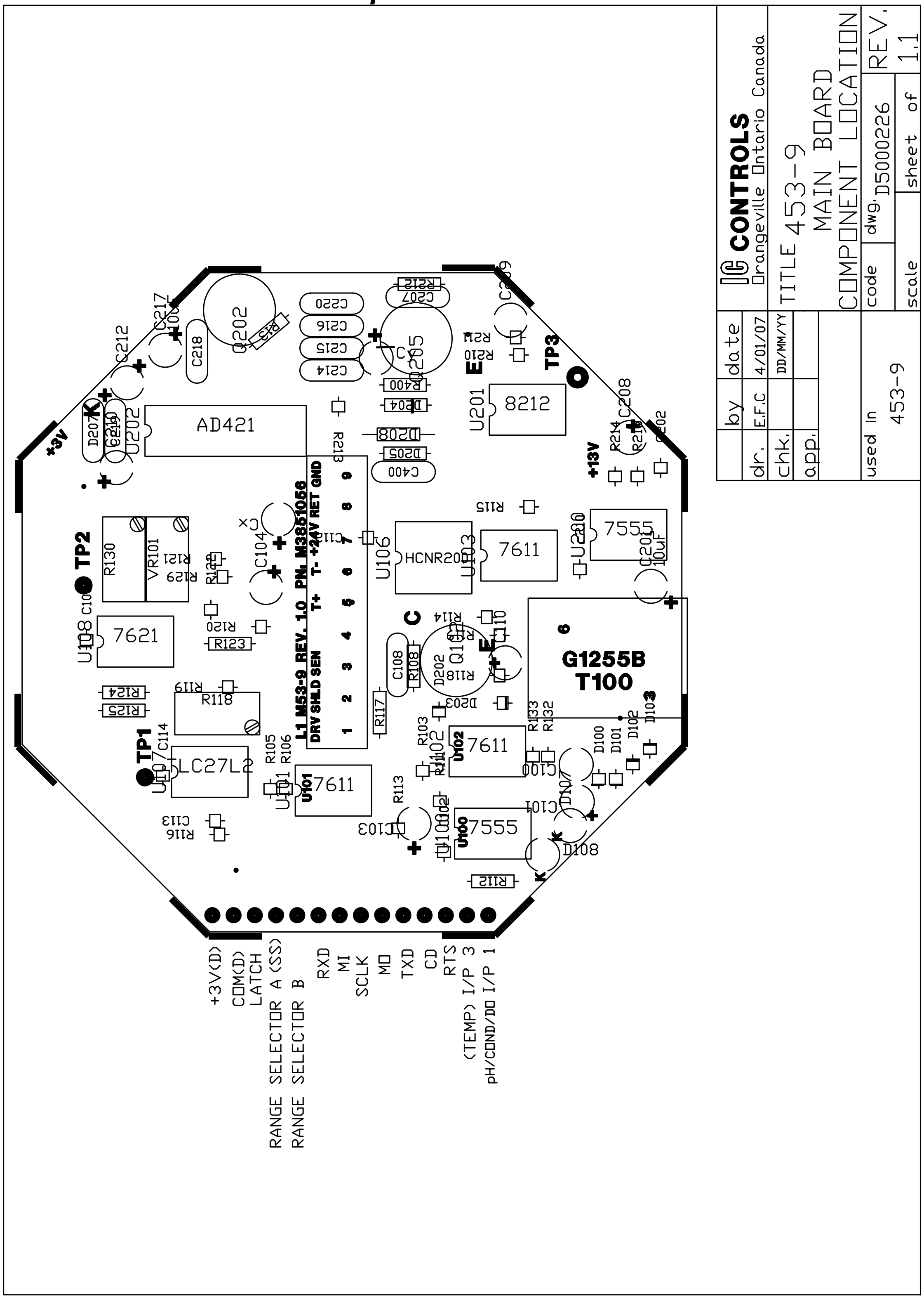
D5000223: Display Component Location



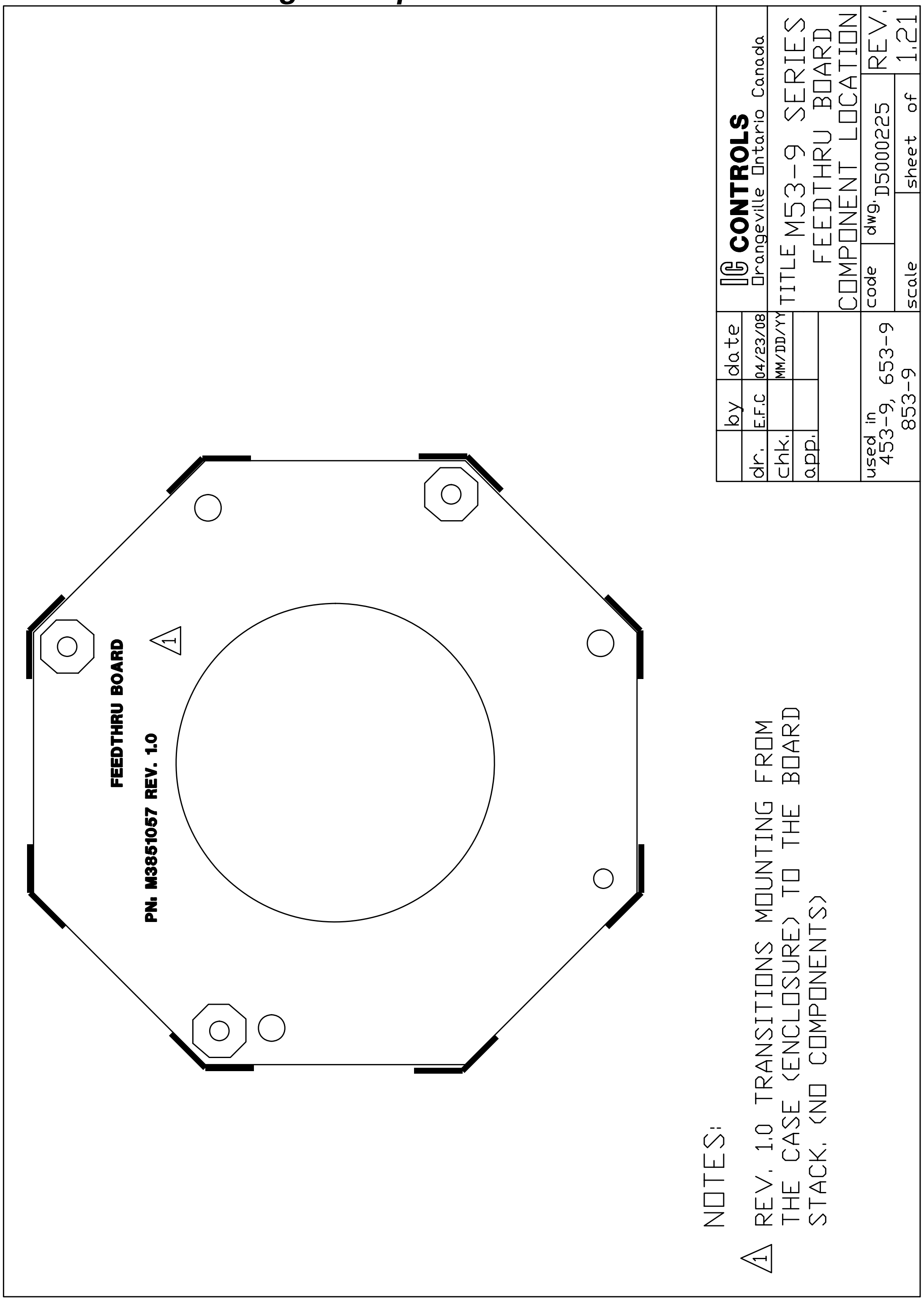
D5000224: Micro Board Wiring & Component Location



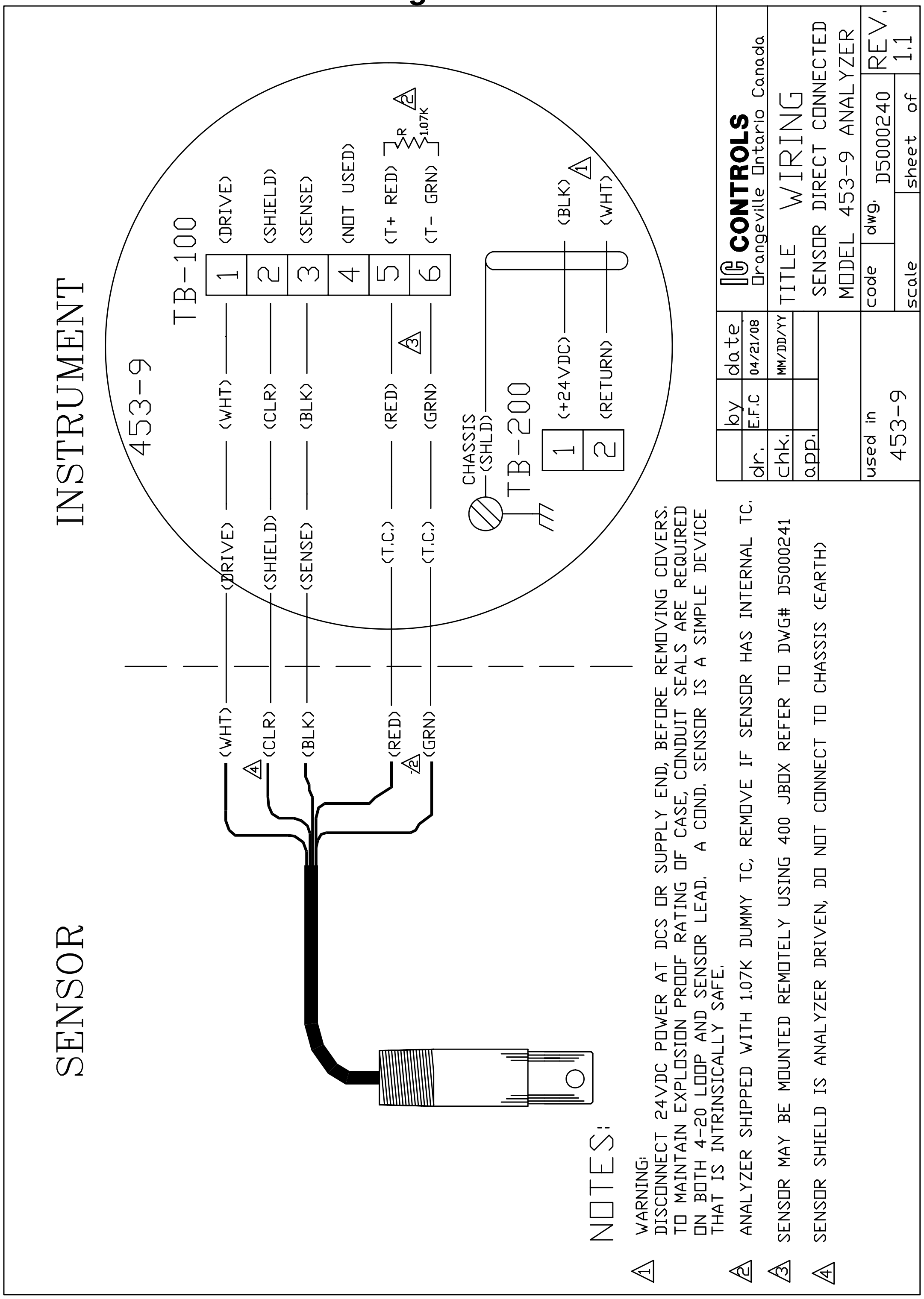
D5000226: Main Board Component Location



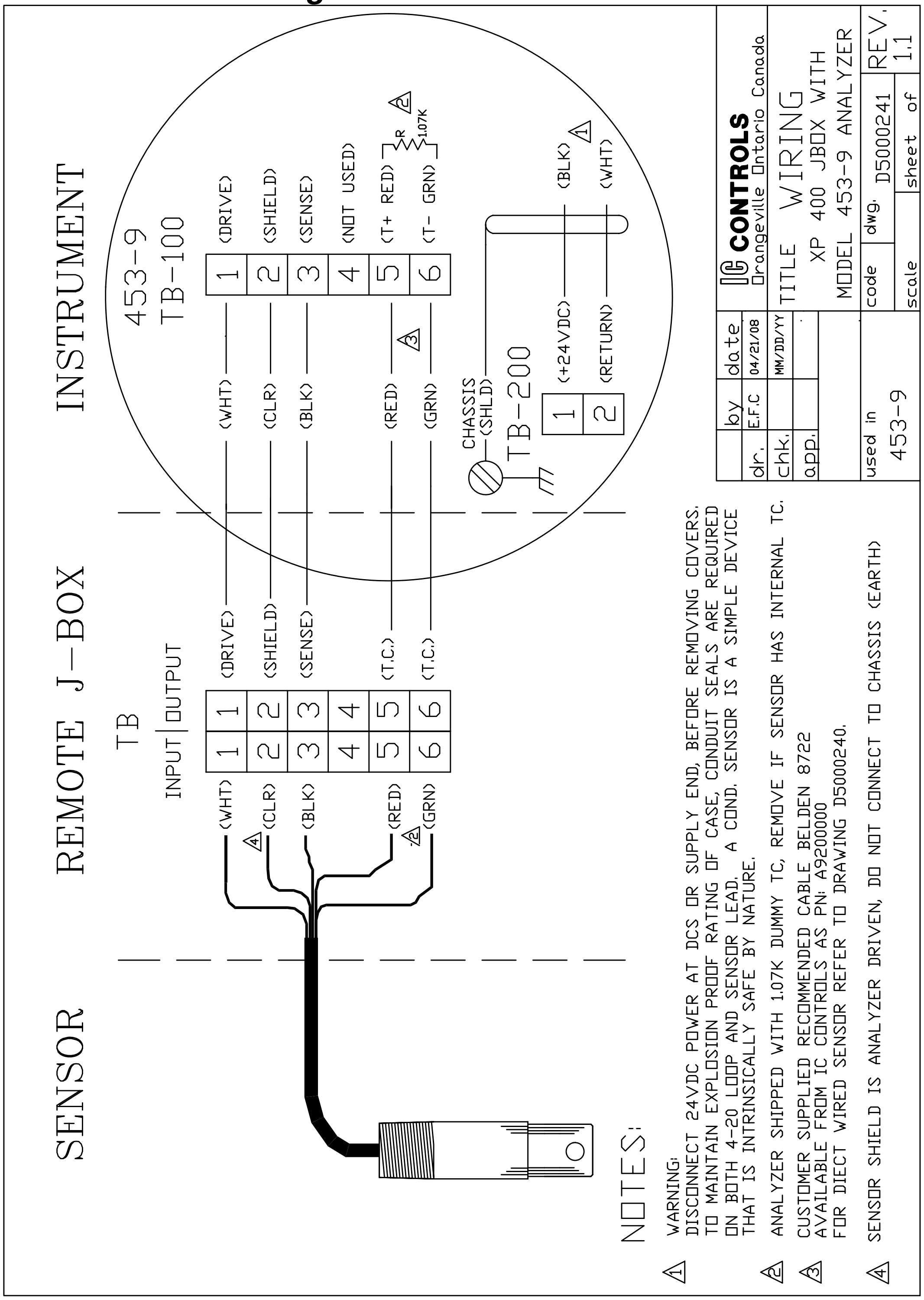
D5000225: Feed-through Component Location



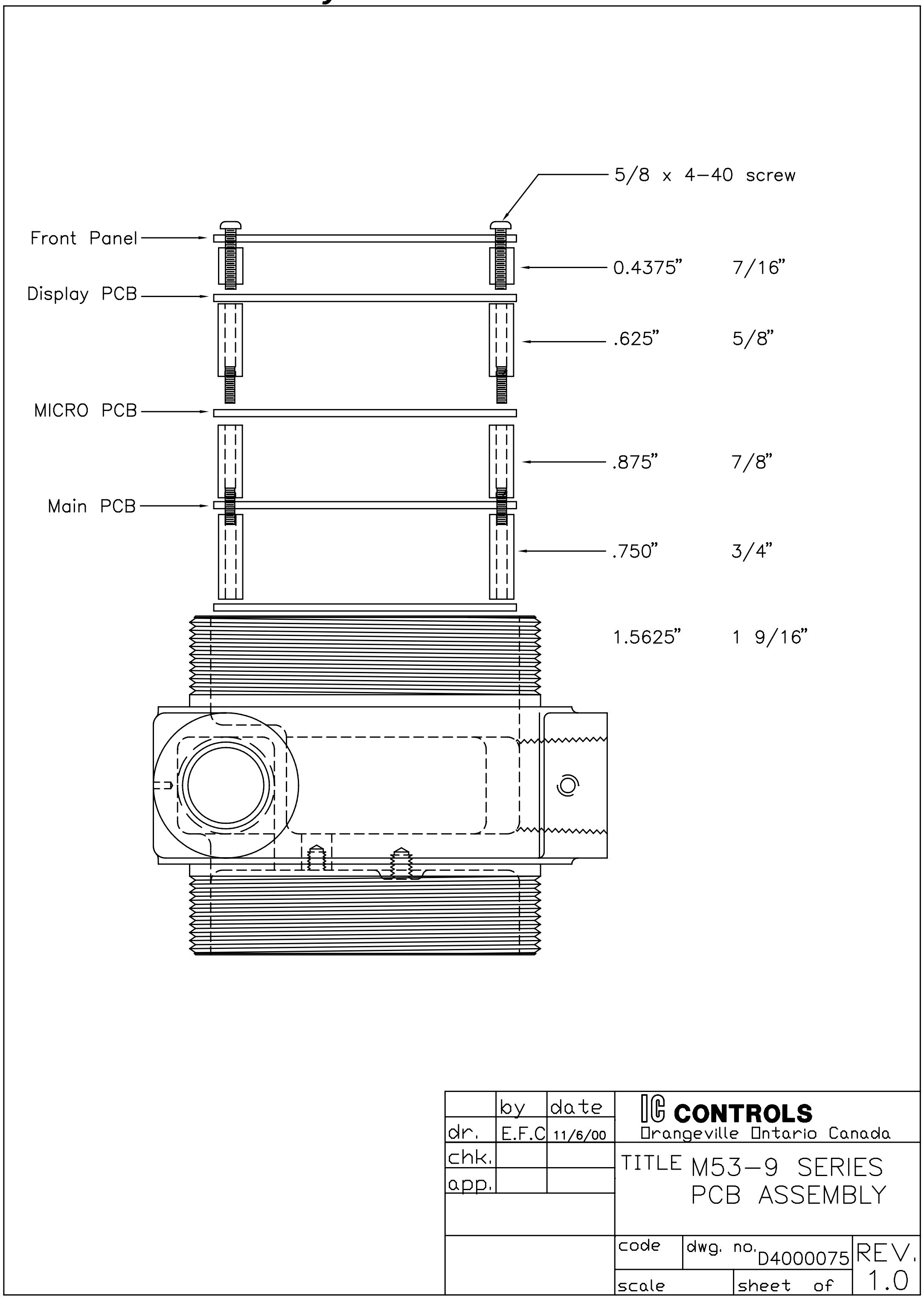
D5000240: Direct Sensor Wiring



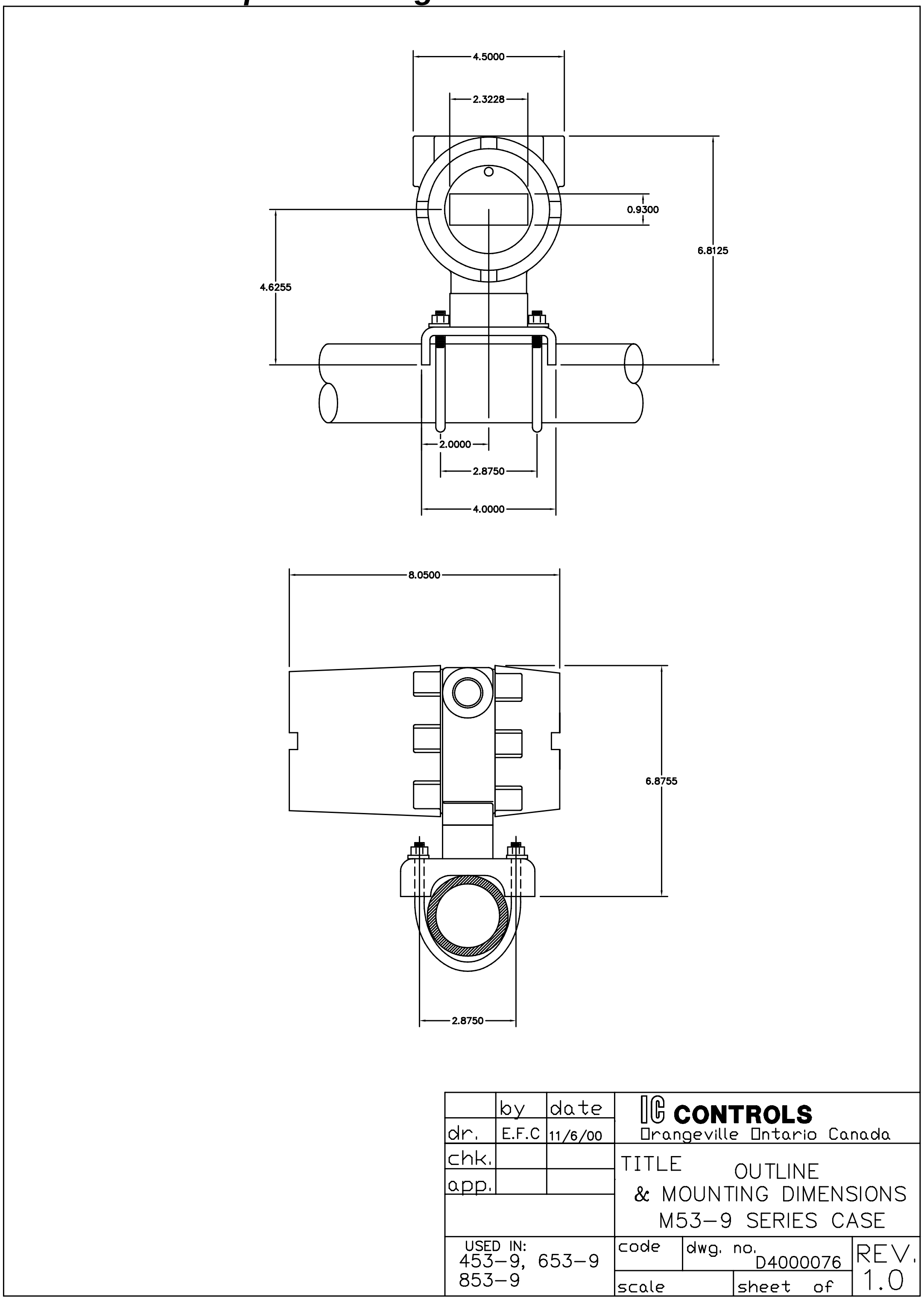
D5000241: Sensor Wiring with 400 J-Box



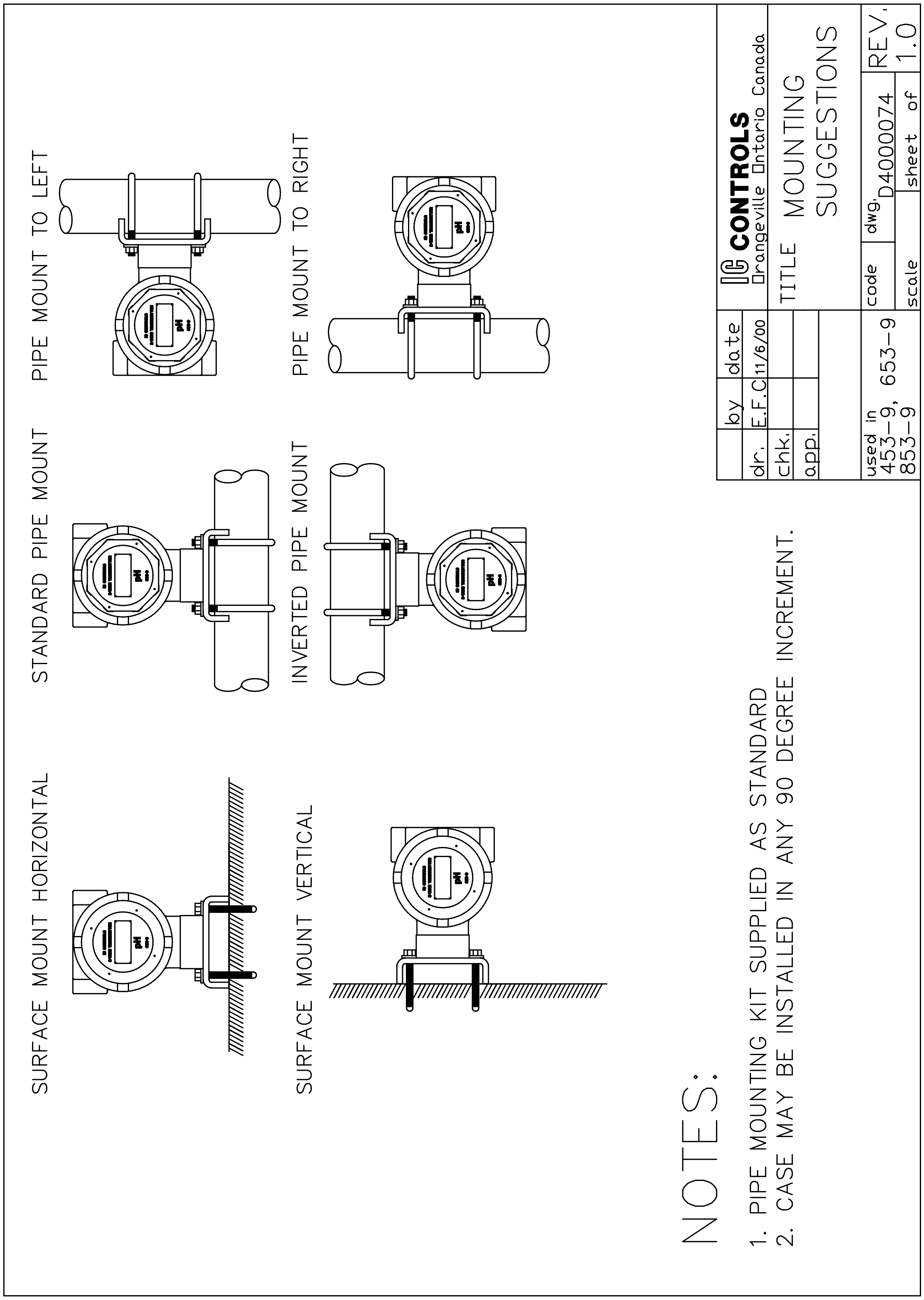
D4000075: PCB Assembly



D4000076: 2 inch Pipe Mounting



D4000074: Mounting Options



INDUSTRIAL PRODUCTS WARRANTY

Industrial instruments are warranted to be free from defects in material and workmanship for a period of twelve (12) months from the date of installation or eighteen (18) months from the date of shipment from IC CONTROLS whichever is earlier, when used under normal operating conditions and in accordance with the operating limitations and maintenance procedures in the instruction manual, and when not having been subjected to accident, alteration, misuse, or abuse. This warranty is also conditioned upon calibration and consumable items (electrodes and all solutions) being stored at temperatures between 5 °C and 45 °C (40 °F and 110 °F) in a non-corrosive atmosphere. IC CONTROLS consumables or approved reagents must be used or performance warranty is void. Accessories not manufactured by IC CONTROLS are subject to the manufacturer's warranty terms and conditions.

Limitations and exclusions:

Industrial electrodes, and replacement parts, are warranted to be free from defects in material and workmanship for a period of three (3) months from the date of installation or eighteen (18) months from the date of shipment when used under normal operating conditions and in accordance with the operating limitations and maintenance procedures given in the instruction manual and when not having been subjected to accident, alteration, misuse, abuse, freezing, scale coating, or poisoning ions.

Chemical solutions, standards or buffers carry an "out-of-box" warranty. Should they be unusable when first "out-of-box", contact IC CONTROLS immediately for replacement. To be considered for warranty, the product shall have an RA (Return Authorization) number issued by IC CONTROLS service department for identification and shall be shipped prepaid to IC CONTROLS at the above address.

In the event of failure within the warranty period, IC CONTROLS, or its authorized dealer will, at IC CONTROLS option, repair or replace the product non-conforming to the above warranty, or will refund the purchase price of the unit.

The warranty described above is exclusive and in lieu of all other warranties whether statutory, express or implied including, but not limited to, any implied warranty of merchantability or fitness for a particular purpose and all warranties arising from the course of dealing or usage of trade. The buyer's sole and exclusive remedy is for repair, or replacement of the non-conforming product or part thereof, or refund of the purchase price, but in no event shall IC CONTROLS (its contractors and suppliers of any tier) be liable to the buyer or any person for any special, indirect, incidental or consequential damages whether the claims are based in contract, in tort (including negligence) or otherwise with respect to or arising out of the product furnished hereunder.

Representations and warranties made by any person, including its authorized dealers, distributors, representatives, and employees of IC CONTROLS, which are inconsistent or in addition to the terms of this warranty shall not be binding upon IC CONTROLS unless in writing and signed by one of its officers.

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