FLUKE®

• 165X

Electrical Installation Testers

Service Information

January 2004

FLUKE®

• 165X

Electrical Installation Testers

Users Manual

September 2003

Manual Supplement

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This supplement contains information necessary to ensure the accuracy of the above manual. This manual is distributed as an electronic manual on the following CD-ROM:

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Change #1

On page 29, replace the second Note with the following:

Note

Model 1651 does not allow the Auto selection.

On page 33, replace step 2, with the following:

2. Press 1 to select the RCD current rating (10, 30,100, 300 or 500 mA).

On page 49, under *Loop and Line Impedance, (Z_l),* add the following to the table:

Maximum Test Current @ 400 V	20 A for 10 ms
Maximum Test Current @ 230 V	12 A for 10 ms

Replace the third table with the following:

Range	Resolution	Accuracy*
20 Ω	0,01 Ω	± (3% + 10 digits)
200 Ω	0,1 Ω	± 3%
2000 Ω	1 Ω	± 6% **
*Valid for resistance of neutral circuit <20 Ω **Valid for mains voltage >200 V		

On page 51, under RCD Testing, add the following:

For all RCD testing, Earth electrode resistance must be less than 100 Ω.

On page 52, delete the entire *Tripping Speed Test* ($_{\Delta}T$) table.

On page 53, under *Tripping Speed Test* ($_{\Delta}T$), delete “Models1652 and 1653”.

In the first table, replace the last row with the following:

10-30 mA	X 5	±10% -0%

In the second table, under **Trip Time Accuracy**, replace “digit” with “ms” in all occurrences.

On page 54, under Earth Resistance Test (R_E), Model 1653 Only, add the following:

This product is intended to be used to measure installations in process plants, industrial installations and residential applications.

Change #2

On page 50, under Range change:

From: 0 to 10 kA

To: 0 to 50 kA

Change #3

On page 25, add step 7, and page 27, add step 5, as follows:

If the mains is too noisy, ERR 5 will be displayed. (The measured value accuracy is degraded by the noise.) Press the down arrow to display the measured value. Press the up arrow to return to the ERR 5 display.

Change #4

On page 47, under Electrical Measurement Specifications, add the following tables:

Tables for the determination of maximum or minimum display values considering maximum instrument operating error per EN61557-1, 5.2.4.

Insulation Resistance

50 V		100 V		250 V		500 V		1000 V	
Limit Value	**Maximum Display Value**	**Limit Value**	**Maximum Display Value**	**Limit Value**	**Maximum Display Value**	**Limit Value**	**Maximum Display Value**	**Limit Value**	**Maximum Display Value**
1	1.12	1	1.12	1	1.3	1	1.3	1	1.3
2	2.22	2	2.22	2	2.4	2	2.4	2	2.4
3	3.32	3	3.32	3	3.5	3	3.5	3	3.5

4	4.42	4	4.42	4	4.6	4	4.6	4	4.6
5	5.52	5	5.52	5	5.7	5	5.7	5	5.7
6	6.62	6	6.62	6	6.8	6	6.8	6	6.8
7	7.72	7	7.72	7	7.9	7	7.9	7	7.9
8	8.82	8	8.82	8	9.0	8	9.0	8	9.0
9	9.92	9	9.92	9	10.1	9	10.1	9	10.1
10	11.02	10	11.02	10	11.2	10	11.2	10	11.2
20	22.02	20	22.02	20	22.2	20	22.2	20	22.2
30	33.02	30	33.2	30	33.2	30	33.2	30	33.2
40	44.02	40	44.2	40	44.2	40	44.2	40	44.2
50	55.02	50	55.2	50	55.2	50	55.2	50	55.2
		60	66.2	60	66.2	60	66.2	60	66.2
		70	77.2	70	77.2	70	77.2	70	77.2
		80	88.2	80	88.2	80	88.2	80	88.2
		90	99.2	90	99.2	90	99.2	90	99.2
		100	110.2	100	110.2	100	110.2	100	110.2
				200	220.2	200	220.2	200	220.2
						300	347	300	345
						400	462	400	460
						500	577	500	575
								600	690
								700	805
								800	920
								900	1035
								1000	1150

Continuity

Limit Value	Maximum Display Value
0.2	0.16
0.3	0.25
0.4	0.34
0.5	0.43
0.6	0.52
0.7	0.61
0.8	0.7
0.9	0.79
1	0.88
2	1.78
3	2.68
4	3.58
5	4.48
6	5.38
7	6.28
8	7.18
9	8.08
10	8.98
20	17.98
30	26.8

Loop Tests

Loop Zi		Loop Re	
Limit Value	**Maximum Display Value**	**Limit Value**	**Maximum Display Value**
2	1.72	2	1.82
3	2.57	3	2.72
4	3.42	4	3.62
5	4.27	5	4.52
6	5.12	6	5.42
7	5.97	7	6.32
8	6.82	8	7.22
9	7.67	9	8.12
10	8.52	10	9.02
20	17.02	20	18.02
30	25.52	30	27.2
40	34.02	40	36.2
50	42.52	50	45.2
60	51.02	60	54.2
70	59.52	70	63.2
80	68.02	80	72.2
90	76.52	90	81.2
100	85.02	100	90.2
200	170.02	200	180.2
300	257	300	272
400	342	400	362

500	427	500	452
600	512	600	542
700	597	700	632
800	682	800	722
900	767	900	812
1000	852	1000	902
2000	1702	2000	1802

RCD Tests

RCD Time		RCD Current	
Limit Value	**Maximum Display Value**	**Limit Value**	**Maximum Display Value**
20	18.1	0.5	0.43
30	27.1	0.6	0.52
40	36.1	0.7	0.61
50	45.1	0.8	0.7
60	54.1	0.9	0.79
70	63.1	1	0.88
80	72.1	2	1.78
90	81.1	3	2.68
100	90.1	4	3.58
200	180.1	5	4.48
300	271	6	5.38
400	361	7	6.28
500	451	8	7.18
600	541	9	8.08

700	631	10	8.98
800	721	20	17.98
900	811	30	26.8
1000	901	40	35.8
2000	1801	50	44.8
		60	53.8
		70	62.8
		80	71.8
		90	80.8
		100	89.8
		200	179.8
		300	268
		400	358
		500	448
		600	538
		700	628
		800	718
		900	808
		1000	898

Earth Tests

Limit Value	Maximum Display Value
10	8.8
20	17.8
30	26.8
40	35.8
50	44.8
60	53.8
70	62.8
80	71.8
90	80.8
100	89.8
200	179.8
300	268.0
400	358.0
500	448.0
600	538.0
700	628.0
800	718.0
900	808.0
1000	898.0
2000	1798.0

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165X

Electrical Installation Tester

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September 2003

LIMITED WARRANTY AND LIMITATION OF LIABILITY

Each Fluke product is warranted to be free from defects in material and workmanship under normal use and service. The warranty period is three years and begins on the date of shipment. Parts, product repairs, and services are warranted for 90 days. This warranty extends only to the original buyer or end-user customer of a Fluke authorized reseller, and does not apply to fuses, disposable batteries, or to any product which, in Fluke's opinion, has been misused, altered, neglected, contaminated, or damaged by accident or abnormal conditions of operation or handling. Fluke warrants that software will operate substantially in accordance with its functional specifications for 90 days and that it has been properly recorded on non-defective media. Fluke does not warrant that software will be error free or operate without interruption.

Fluke authorized resellers shall extend this warranty on new and unused products to end-user customers only but have no authority to extend a greater or different warranty on behalf of Fluke. Warranty support is available only if product is purchased through a Fluke authorized sales outlet or Buyer has paid the applicable international price. Fluke reserves the right to invoice Buyer for importation costs of repair/replacement parts when product purchased in one country is submitted for repair in another country.

Fluke's warranty obligation is limited, at Fluke's option, to refund of the purchase price, free of charge repair, or replacement of a defective product which is returned to a Fluke authorized service center within the warranty period.

To obtain warranty service, contact your nearest Fluke authorized service center to obtain return authorization information, then send the product to that service center, with a description of the difficulty, postage and insurance prepaid (FOB Destination). Fluke assumes no risk for damage in transit. Following warranty repair, the product will be returned to Buyer, transportation prepaid (FOB Destination). If Fluke determines that failure was caused by neglect, misuse, contamination, alteration, accident, or abnormal condition of operation or handling, including overvoltage failures caused by use outside the product's specified rating, or normal wear and tear of mechanical components, Fluke will provide an estimate of repair costs and obtain authorization before commencing the work. Following repair, the product will be returned to the Buyer transportation prepaid and the Buyer will be billed for the repair and return transportation charges (FOB Shipping Point).

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11/99

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⚠⚠Warnings: Read Before Using

To avoid possible electric shock or personal injury:

- **Use the tester only as specified in this manual, or the protection provided by the tester might be impaired.**
- **Do not use the tester in wet environments.**
- **Inspect the tester before using it. Do not use the tester if it appears damaged. Look for cracks or missing plastic. Pay particular attention to the insulation around the connectors.**
- **Inspect the test leads before use. Do not use them if insulation is damaged or metal is exposed. Check the test leads for continuity. Replace damaged test leads before using the tester. Use only test leads specified in the manual or safety may be impaired.**
- **Verify the tester's operation by measuring a known voltage before and after using it. Do not use the tester if it operates abnormally. Protection may be impaired. If in doubt, have the tester serviced.**
- **Have the tester serviced only by qualified service personnel.**
- **Do not apply more than the rated voltage, as marked on the tester, between the terminals or between any terminal and earth ground.**
- **Remove test leads from the tester before opening the tester case.**
- **Never operate the tester with the case open.**
- **Use caution when working with voltages above 30 V ac rms, 42 V ac peak, or 60 V dc. These voltages pose a shock hazard.**
- **Use only the replacement fuse specified in the users manual.**
- **Use the proper terminals, function, and range for your measurements.**
- **Do not operate the tester around explosive gas, vapor, or dust.**
- **When using probes, keep your fingers behind the finger guards.**
- **When making electrical connections, connect the common test lead before connecting the live test lead; when disconnecting, disconnect the live test lead before disconnecting the common test lead.**
- **Replace the battery as soon as the low battery indicator ( ) appears to avoid false readings that can lead to electric shock and injury.**
- **When servicing the tester, use only specified replacement parts.**
- **Do not use the tester in distribution systems with voltages higher than 550 V.**
- **When working on high energy systems, rubber gloves and flame-resistant face shield and clothing should be worn.**

Definition of Symbols Used			
⎓	Fuse	⚠	Caution! Risk of Electric Shock.
⧈	Double Insulated (Class II) Equipment	⏚	Earth Ground
⚠	Caution! Risk of Danger. Refer to Manual.	CE	Conforms to relevant European standard.
CAT III	CAT III meters are designed to protect against transients in fixed-equipment installations at the distribution level.		

Electrical Installation Tester

Introduction

The Fluke Model 1651, Model 1652, and Model 1653 are battery powered electrical installation testers. This manual applies to all three models. All figures show the Model 1653.

The 165X testers are designed to measure and test the following:

- Voltage and Frequency
- Insulation Resistance (EN61557-2)
- Continuity (EN61557-4)
- Loop/Line Resistance (EN61557-3)
- Residual Current Devices (RCD) Tripping Time (EN61557-6)
- RCD Tripping Current (EN61557-6)
- Earth Resistance (EN61557-5)
- Phase Sequence (EN61557-7)

Contacting Fluke

To contact Fluke, call one of the following telephone numbers:

USA: 1-888-99-FLUKE (1-888-993-5853)
Canada: 1-800-36-FLUKE (1-800-363-5853)
Europe: +31 402-675-200
Japan: +81-3-3434-0181
Singapore: +65-738-5655
Anywhere in the world: +1-425-446-5500

Or, visit Fluke's Web site at www.fluke.com.

To register your product, visit register.fluke.com.

Unpacking the Tester

The tester comes with the items listed in Table 1. If the tester is damaged or an item is missing, contact the place of purchase immediately.

Table 1. Standard Accessories

Description	Model					Part Number
	1651	1652	1653	Robin 1652	Robin 1653	
165X-8008 Probe, Multifunctional	√	√	√			2000757
Country Specific Mains Test Cord	√	√	√	√	√	Various – See Table 2
TL-L1, Test Lead, Red		√	√			2044945
TL-L2, Test Lead Green	√	√	√			2044950
TL-L3, Test Lead Blue	√	√	√			2044961
Probe, Test, Banana Jack, 4 mm Tip, Red			√			803459
Probe, Test, Banana Jack, 4 mm Tip, Green	√	√	√			2065297

Table 1. Standard Accessories (cont.)

Description	Model					Part Number
	1651	1652	1653	Robin 1652	Robin 1653	
Probe, Test, Banana Jack, 4 mm Tip, Blue	√	√	√			2068904
102-406-003, Probe cap,GS-38 Red	√	√	√	√	√	1942029
102-406-002, Probe cap,GS-38 Green	√	√	√			2065304
102-406-004, Probe cap,GS-38 Blue	√	√	√			2068919
AC285-5001,175-276-013 AC285 Large crocodile clip, Red		√	√			2041727
AC285-5001-02,175-276-012 AC285 Large crocodile clip, Green	√	√	√			2068133

Table 1. Standard Accessories (cont.)

Description	Model					Part Number
	1651	1652	1653	Robin 1652	Robin 1653	
AC285-5001-03,175-276-0114 AC285 Large crocodile clip, Blue	√	√	√			2068265
Test lead set, 600 V, Fused Probe - ST plug with crocodile clips, Red, Blue, Green Replacement fuse is a F 10 A 600 V, 50 kA fuse meeting the IEC60269-1 standard.				√	√	2068742
CD ROM, Users Manual	√	√	√	√	√	1674214
Quick Reference Card	√	√	√	√	√	1674804
Case, Tool Box, Yellow	√	√	√	√	√	1664213
Hard Case Insert, Foam, Polyurethane	√	√	√	√	√	2061011
Carrying Strap, Padded	√	√	√	√	√	2045406
Fluke-1653-2014, IR Adapter			√		√	2043365

Table 2. Country Specific Mains Cords

Mains Cord	Cord Type	Part Number
British	BS1363	2061367
Shuko Germany/France/Belgium	CEE 7/7	2061332
Denmark	AFSNIT 107-2-DI	2061371
Australia/New Zealand	AS 3112	2061380
Switzerland	SEV 1011	2061359
Italy	CEI 23-16/VII	2061344

Operating the Tester

Using the Rotary Switch

Use the rotary switch (Figure 1) to select the type of test you want to perform.

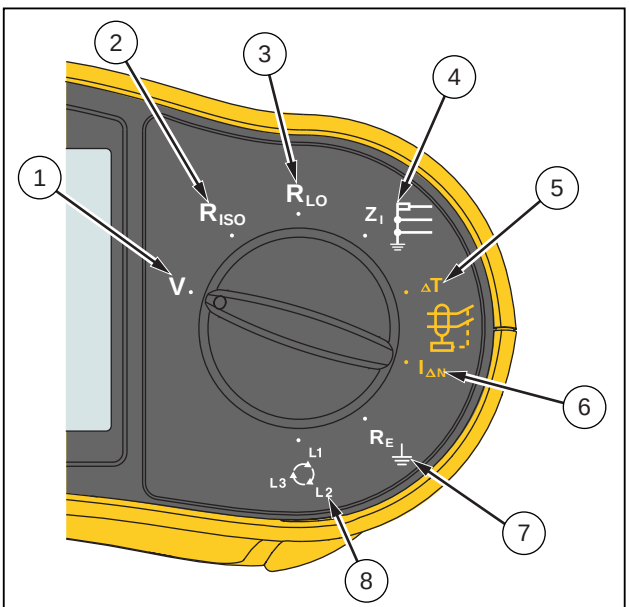

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Figure 1. Rotary Switch

Number	Symbol	Measurement Function
①	V	Volts.
②	R_{ISO}	Insulation resistance.
③	R_{LO}	Continuity.
④	Z_I	Loop impedance.
⑤	ΔT	RCD tripping time.
⑥	$I_{\Delta N}$	RCD tripping level.
⑦	R_E	Earth resistance.
⑧	↻	Phase rotation.

Understanding the Pushbuttons

Use the pushbuttons (Figure 2) to control operation of the tester, select test results for viewing, and scroll through selected test results.

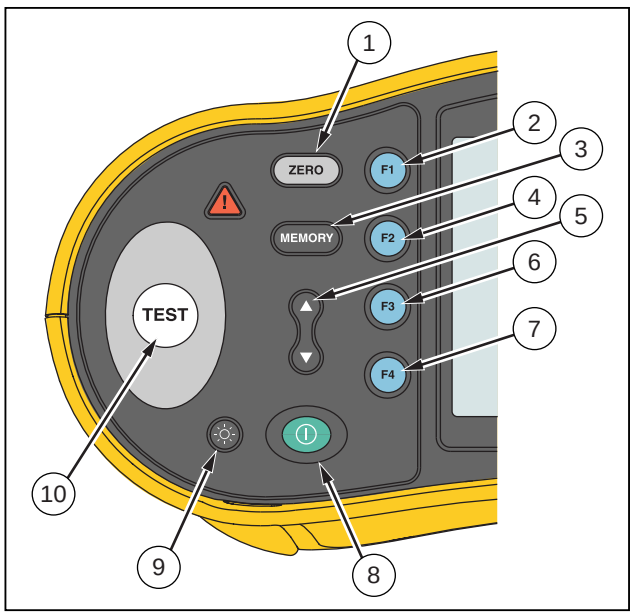

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Figure 2. Pushbuttons

No.	Button	Description
①	ZERO	Zero test lead resistance offset.
②	F1	• Loop input select (L-N, L-PE). • RCD current rating (10, 30, 100, 300, 500, or 1000 mA). • Memory SELECT.
③	MEMORY	• Enters Memory mode. • Activates memory soft key selections (F1, F2, F3, or F4).
④	F2	• RCD Current multiplier (x1/2, x1, x5, AUTO). • Memory STORE.
⑤	▲▼	• Scroll memory locations. • Set memory location codes. • Scroll Auto test results.

No.	Button	Description
⑥	F3	• RCD type (AC, DC, AC-S, or DC-S). • Memory RECALL.
⑦	F4	• RCD test polarity (0, 180 degrees). • Insulation test voltage (50, 100, 250, 500, or 1000 V). • Memory CLEAR.
⑧	⏻	Turns the tester on and off. The tester will also shut off automatically is there is no activity for 10 minutes.
⑨	☼	Turns the backlight on and off.

No.	Button	Description
⑩	TEST	Starts the selected test. The TEST key is surrounded by a “touch pad”. The touch pad measures the potential between the operator and the tester’s PE terminal. If you exceed a 100 V threshold, the ⚠ symbol above the touch pad is illuminated.

Understanding the Display

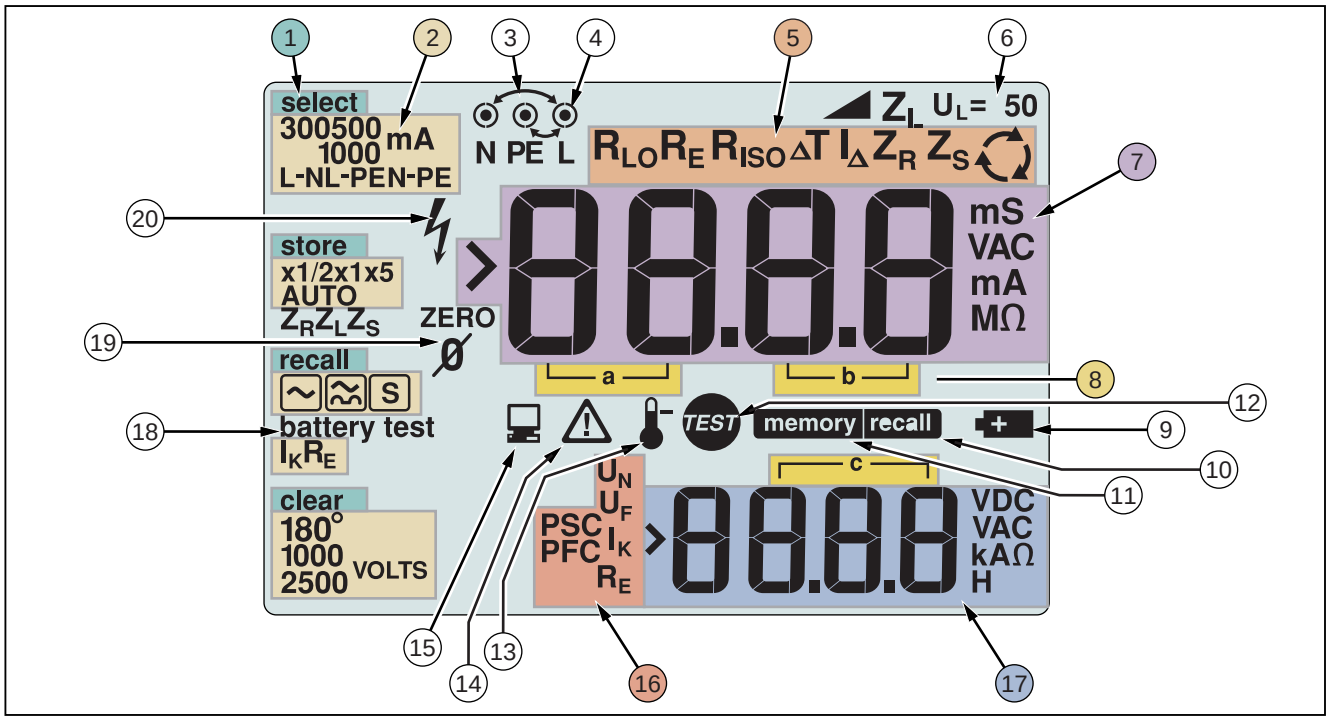

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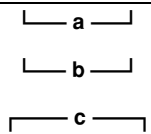
Figure 3. Display Features

No.	Annunciator	Meaning
①	select store recall clear	Displays the selected Memory mode. Memory modes are: Select (F1), Store (F2), Recall (F3), or Clear (F4).
②	300500 mA 1000 L-NL-PEN-PE x1/2x1x5 AUTO ~ ≈ S $I_K R_E$ 180° 1000 2500 VOLTS	Configuration options. Settings you can make within the measurement functions. For example, in the RCD Tripping Time function (ΔT) you can press F2 to multiply the test current by x1/2, x1, x5 or AUTO and you can press F3 to select the type of RCD you are testing.
③		Arrows above or below the terminal indicator symbol indicate reversed polarity. Check the connection or check the wiring to correct.
④	○	Terminal indicator symbol. A terminal indicator symbol with a dot (⊙) in the center indicates the terminal is used for the selected function. The terminals are: • L (Line) • PE (Protective Earth) • N (Neutral)

No.	Annunciator	Meaning
⑤	R_{LO} R_E R_{ISO} $_AT$ I_Δ 	Indicates the selected rotary switch setting. The measurement value in the primary display also corresponds to the switch setting. Rotary switch settings are: **V** Volts $\mathbf{R}_{ISO}$ Insulation $\mathbf{R}_{LO}$ Continuity $\mathbf{Z}_L$ Loop $_A\mathbf{T}$ RCD time $\mathbf{I}_\Delta$ RCD trip $\mathbf{R}_E$ Earth  Phase Rotation
⑥	$\mathbf{U}_L$=	Indicates the preset fault voltage limit. The default setting is 50 V. Some locations require the fault voltage be set to 25 V, as specified by local electrical codes. Press F4 when you turn on the tester to toggle the fault voltage between 25 V and 50 V. The value you set will appear on the display and will be saved when you turn the tester off.

No.	Annunciator	Meaning
⑦		Primary display and measurement units.
⑧		Memory locations. See “Storing and Recalling Measurements” on page 36 for detailed information on using memory locations.
⑨		Low battery icon. See “Testing and Replacing the Batteries” on page 41 for additional information on batteries and power management.
⑩	recall	Appears when you press the Recall button and you are looking at stored data.
⑪	memory	Appears when you press the Memory button.
⑫	TEST	Appears when you press the Test button. Disappears when the test is completed.
⑬		Appears when the instrument is overheated. The Loop test and RCD functions are inhibited when the instrument is overheated.
⑭		Appears when an error occurs. Testing is disabled. See “Error Codes” on page 17 for a listing and explanation of possible error codes.

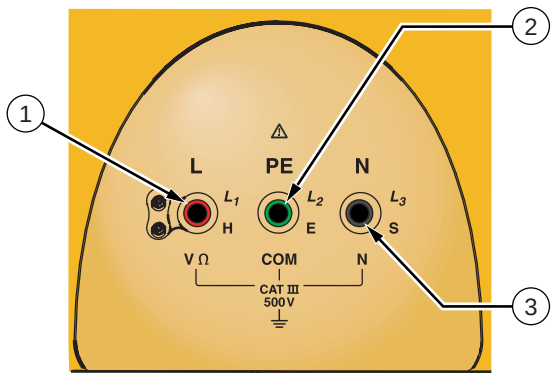
No.	Annunciator	Meaning
⑮		Appears when the instrument is uploading data using FlukeView Forms.
⑯	U_N U_F PSC I_K PFC R_E	Name of the secondary measurement function. U_N Test voltage for insulation test. U_F Fault voltage. Measures neutral to earth. PSC Prospective Short Circuit. Calculated from measured voltage and impedance when reading line to neutral. PFC Prospective Fault Current. Calculated from voltage and loop impedance which is measured line to protective earth. I_K Tripping current for RCDs. R_E Earth resistance.

No.	Annunciator	Meaning
⑰		Secondary display and measurement units. Some tests will return more than one result or return a computed value based on the test result. This will occur with: • Volts Secondary display shows line frequency. • Insulation tests Secondary display shows actual test voltage. • Loop impedance Secondary display shows PSC, PFC, or R_E. • RCD switching time Secondary display shows U_F fault voltage. • RCD tripping current Secondary display shows U_F fault voltage.

No.	Annunciator	Meaning
⑱	battery test	Appears when you are testing the batteries. For more information see “Testing and Replacing the Batteries” on page 41.
⑲	ZERO	Appears when you press the ZERO button to zero the leads. After the zeroing operation, the icon stays illuminated indicating that zeroing has been performed. Only used when performing continuity or loop testing.
⑳	ϟ	Potential danger. Appears when measuring or sourcing high voltages.

Input Terminals

Figure 4 shows the 165X input terminals.



Item	Description
①	L (Line)
②	PE (Protective Earth)
③	N (Neutral)

Figure 4. Input Terminals

Using the IR Port (Model 1653 Only)

The Model 1653 tester has an IR port (Figure 22) that allows you to connect the tester to a computer and upload test data using *Flukeview Forms Documenting Software*. This automates your troubleshooting or recording process, reduces the possibility of manual error and allows you to collect, organize, and display test data in a format that meets your needs. See “Uploading Test Results” on page 39 for additional information on using the IR port.

Error Codes

Various error conditions are detected by the tester and are indicated with the ⚠ icon, “Err”, and an error number on the primary display. These error conditions disable testing and, if necessary, stop a running test.

Error Condition	Code
Self-Test Fails	1
Over-Temp	2
Fault Voltage	4
Excessive Noise	5
Probe Resistance	6

Note

If the self-test fails, you will need to return the tester to Fluke for service.

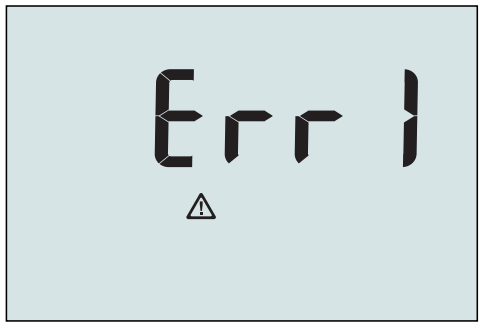


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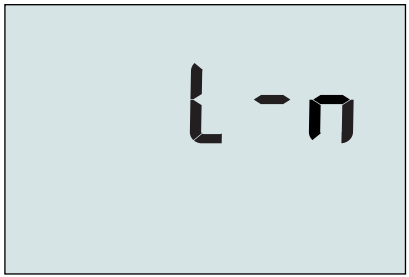
Figure 5. Error Display

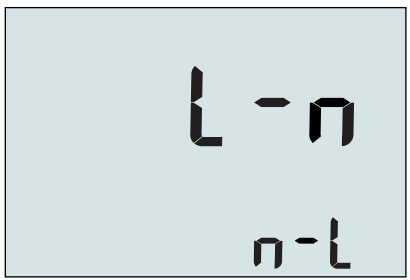
Power-On Options

To select a power-on option, press ⓘ and the function key simultaneously and then release the ⓘ button. Power-on options are retained when the tester is turned OFF.

Keys	Power-On Options
ⓘ F3	Line and Neutral Swap mode. There are two possible modes of operation when the tester detects that the Line and Neutral leads are swapped. The ⊙○⊙ icon on the display indicates a swapped test lead. You can configure the tester to operate in L-n mode or L-n n-L mode. • In L-n n-L mode the tester corrects the condition by swapping internal connections and testing continues.
ⓘ F3 (cont.)	• When a swapped lead is detected In L-n mode, testing is inhibited and you must manually swap the leads. L-n mode is intended for use in the UK. Selecting L-n mode also changes the x1/2 RCD trip time duration to 2 seconds as required in the UK. *Note* *In locations where polarized plugs and outlets are used, a swapped lead icon (⊙○⊙) may indicate that the outlet was wired incorrectly. Correct this problem before proceeding with any testing.*
ⓘ F4	Fault voltage limit. Toggles the fault voltage between 25 V and 50 V. The default is 50 V.



Manual Lead
Swapping
Mode Selected



Automatic Lead
Swapping
Mode Selected

apx026f.eps

Figure 6. Lead Swapping Modes

Making Measurements

Measuring Volts and Frequency

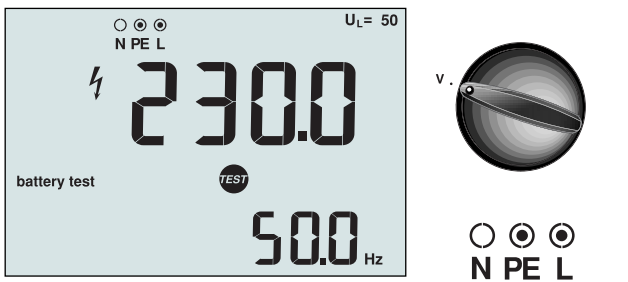


Figure 7. Volts Display/Switch and Terminal Settings

To measure voltage and frequency

1. Turn the rotary switch to the V position.
2. Use the L and PE (red and green) terminals for this test. You can use test leads or mains cord when measuring AC voltage.
   - The primary (upper) display shows the AC voltage. The tester reads AC voltage to 500 V.
   - The secondary (lower) display shows mains frequency.

Measuring Insulation Resistance

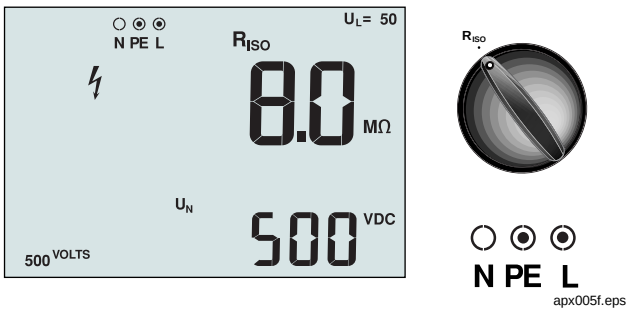


Figure 8. Insulation Resistance Display/Switch and Terminal Settings

⚠⚠ Warning

Measurements should only be performed on de-energized circuits.

To measure insulation resistance

1. Turn the rotary switch to the R_{ISO} position.
2. Use the L and PE (red and green) terminals for this test.
3. Use the F4 to select the test voltage. Most insulation testing is performed at 500 V, but observe local test requirements.
4. Press and hold TEST until the reading settles and the tester beeps. For most tests you will want to use the probe with the remote control TEST button.

Note

Testing is inhibited if voltage is detected in the line.

- The primary (upper) display shows the insulation resistance.
- The secondary (lower) display shows the actual test voltage.

Note

For normal insulation with high resistance, the actual test voltage (U_N) should always be equal to or higher than the programmed voltage. If insulation resistance is bad, the test voltage is automatically reduced to limit the test current to safe ranges.

Measuring Continuity

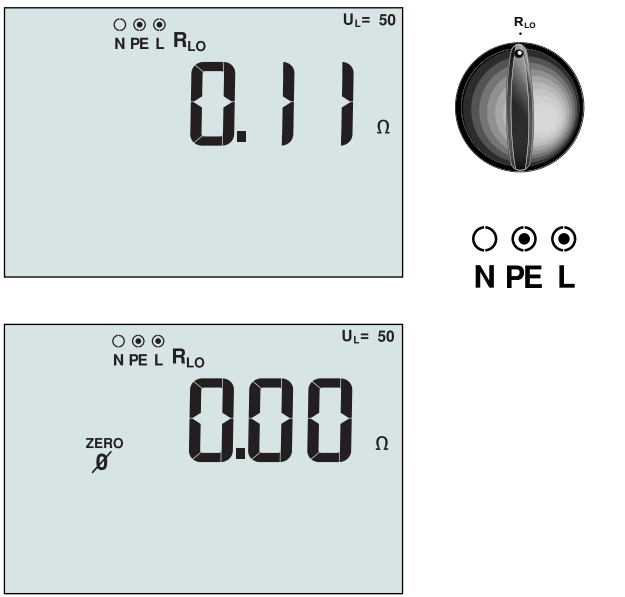


Figure 9. Continuity and Continuity Zero Display/Switch and Terminal Settings

A continuity test is used to verify the integrity of connections by making a high resolution resistance measurement. This is especially important for checking Protective Earth connections.

Note

In locales where electrical circuits are laid out in a ring, it is recommended that you make an end-to-end check of the ring at the electrical panel.

⚠⚠ Warning

- **Measurements should only be performed on de-energized circuits.**
- **Measurements may be adversely affected by impedances or parallel circuits or transient currents.**

To measure continuity

1. Turn the rotary switch to the R_{LO} position.
2. Use the L and PE (red and green) terminals for this test.

3. Before making a continuity test, short the ends of the probes together and press (ZERO). The tester measures probe resistance, stores the reading in memory, and subtracts it from readings. The resistance value is saved even when power is turned off so you don't need to repeat the operation every time you use the instrument.

4. Press and hold (TEST) until the reading settles and the tester beeps. If a circuit is live, the test is inhibited and the AC voltage appears in the secondary (lower) display.

Measuring Loop/Line Impedance

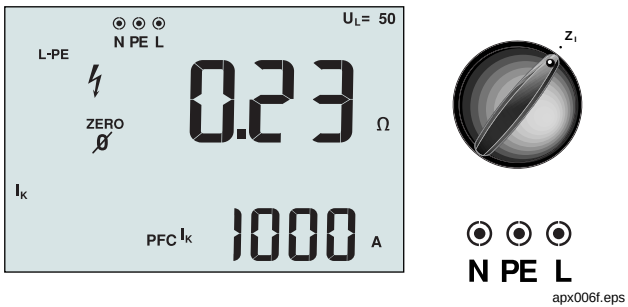


Figure 10. Loop/Line Impedance/Switch and Terminal Settings

Loop Impedance

Loop impedance is source impedance measured between Line and Protective Earth. You can also measure the Prospective Fault Current (PFC) which is the current that could potentially flow if the phase conductor is shorted to the protective earth conductor. The tester calculates the PFC by dividing the measured mains voltage by the loop impedance.

Note

If the L and N terminals are reversed, the tester will auto-swap them internally and continue testing. If the tester is configured for UK operation, testing will halt and you will need to manually swap the terminals. This condition is indicated by arrows above or below the terminal indicator symbol (◉○◉).

To measure loop impedance

1. Turn the rotary switch to the Z_I position.
2. Press (F1) to select L-PE.
3. Before measuring, zero the test probes by shorting all three leads together at the far end (away from the tester) and press the (ZERO) button. To zero the mains cord, wrap a piece of bare wire around the terminals of the plug and press the (ZERO) button. The tester saves the zero offset so you don't need to repeat the operation every time you use the tester.

⚠⚠ Warning

Remove the bare wire before proceeding with the test.

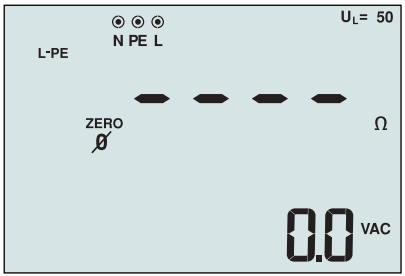


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Figure 11. Display After Zeroing

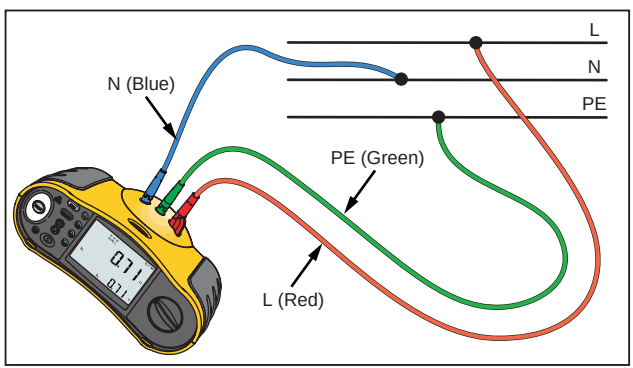
4. Press and release (TEST). Wait for the test to complete.
5. The primary (upper) display shows the loop impedance.
6. To read the Prospective Fault Current, press the (F3) key and select I_K. The PFC appears in amps or kiloamps in the secondary (lower) display.

Note

Errors may occur due to preloading the circuit under test.

Earth Resistance Testing by Loop Method

You can also use the tester to measure the earth resistance component of the total loop resistance. Check your local regulations to determine if this method is acceptable in your area. You can use three leads or the mains cord to perform this test. Use the connection shown in Figure 12 when making a 3-wire connection for earth resistance loop test.



apx024f.eps

Figure 12. 3-Wire Connection for Earth Resistance Loop Test

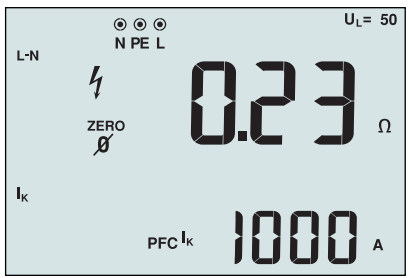
To measure earth resistance using the loop test method

1. Turn the rotary switch to the Z_I position.
2. Press F1 to select L-PE.
3. Press F3 to select R_E (resistance).
4. Press and release TEST. Wait for the test to complete.
   - The primary (upper) display shows the loop impedance.
   - The secondary (lower) display shows the earth resistance.

Line Impedance

Line impedance is source impedance measured between Line and Neutral. You can use this to measure:

- Impedance Line to Neutral.
- Line to Line impedance in 3-phase systems.
- L-PE loop measurement. This is a way of making a high current, 2-wire loop measurement. It cannot be used on circuits protected by RCDs because it will cause them to trip.



apx034f.eps

Figure 13. Line Impedance Display

To measure line impedance

1. Turn the rotary switch to the Z_I position.
2. Press F1 to select L-N.
3. You can use the mains cord or test leads for this measurement. With test leads use the red and blue leads connecting to L and N terminals on the tester.

4. Press and release TEST. Wait for the test to complete.
   - The primary (upper) display shows the line impedance.
   - The secondary (lower) display shows the Prospective Short Circuit Current (PSC). PSC is the current that would flow in case of a Line to Neutral short. It is calculated by dividing mains voltage by line impedance.

Use the connection shown in Figure 14 when measuring in a 3-phase system.

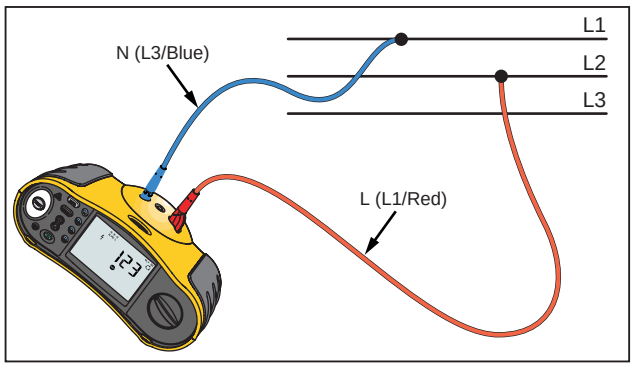


Figure 14. Measuring in a 3-Phase System

Measuring RCD Tripping Time

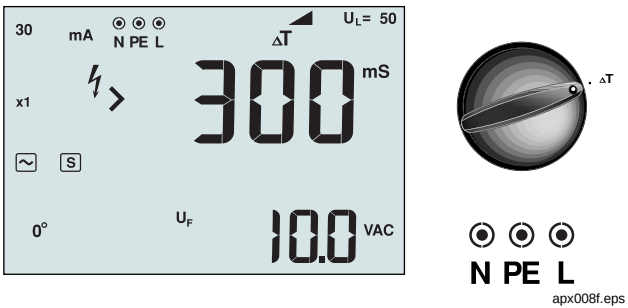


Figure 15. RCD Tripping Time Display/Switch and Terminal Settings

In this test, a calibrated fault current is induced into the circuit, causing the RCD to trip. The meter measures and displays the time required for the RCD to trip. You can perform this test with test leads or using the mains cord. The test is performed with a live circuit.

Note

When measuring trip time for any type RCD, the tester first does a pretest to determine if the actual test will cause a fault voltage exceeding the limit (25 or 50 V). To avoid having an inaccurate trip time for S type (time delay) RCDs, a 30 second delay is activated between the pretest and the actual test.

⚠⚠ Warning

- **Test the connection between the N-conductor and earth before starting the test. A voltage between the N-conductor and earth may influence the test.**
- **Leakage currents in the circuit following the residual current protection device may influence measurements.**
- **The displayed fault voltage relates to the residual operating current of the RCD.**
- **Potential fields of other earthing installations may influence the measurement.**

Note

If the L and N terminals are reversed, the tester will auto-swap them internally and continue testing. If the tester is configured for UK operation, testing will halt and you will need to manually swap the terminals. This condition is indicated by arrows above or below the terminal indicator symbol (⦿○⦿).See Power-On Options on page 18 for information on setting Line and Neutral Swap mode.

To measure RCD tripping time

1. Turn the rotary switch to the ΔT position.
2. Press F1 to select the RCD current rating (10, 30, 100, 300, 500, or 1000 mA).
3. Press F2 to select a test current multiplier (x ½, x 1, x 5, or Auto). Normally you will use x 1 for this test.

Note

Model 1651 only allows selection of the x1 multiplier.

4. Press F3 to select the RCD type. Valid types are:
   - ⏦ – Standard AC RCD, normal setting. (All models)
   - ⏦ – DC sensitive RCD. (Models 1652 and 1653 only)
   - ⏦ S – Delayed response AC RCD. (All models)
   - ⏦ S – Delayed response DC RCD. (Models 1652 and 1653 only)

5. Press (F4) to select the test current phase, 0° or 180°. RCDs should be tested with both phase setting, as their response time can vary significantly depending on the phase.
6. Press and release (TEST). Wait for the test to complete.
   - The primary (upper) display shows the trip time.
   - The secondary (lower) display shows any fault voltage (N to PE).

You can also use the tester to perform the RCD tripping time test in Auto mode, which makes it easier for one person to perform the test.

To measure RCD tripping time using Auto mode

1. Plug the tester into the outlet.
2. Turn the rotary switch to the ΔT position.
3. Press (F1) to select the RCD current rating (10, 30, 100, 300, 500, or 1000 mA).
4. Press (F2) to select Auto mode.
5. Press (F3) to select a standard AC RCD (⏦).

   The tester supplies ½x the rated RCD current for 310 or 510 ms (2 seconds in the UK). If the RCD trips, the test terminates. If the RCD does not trip, the tester reverses phase and repeats the test. The test terminates if the RCD Trips.

   If the RCD does not trip, the tester restores the initial phase setting and supplies 1x the rated RCD current for 2000 ms. The RCD should trip and the test results appear in the primary display.
6. Reset the RCD.
7. The tester reverses phases and repeats the 1x test. The RCD should trip and the test results appear in the primary display.
8. Reset the RCD.

9. The tester restores the initial phase setting and supplies 5x the rated RCD current for up to 50 ms. The RCD should trip and the test results appear in the primary display.

10. Reset the RCD.

11. The tester reverses phase and repeats the 5x test. The RCD should trip and the test results appear in the primary display.

12. Reset the RCD.

    You can use the ⇕ arrow keys to review test results. The first result shown is the last measurement taken, the 5x current test. Press the down arrow key ⇕ to move backward to the first test at ½x the rated current.

13. Test results are in temporary memory. If you want to store the test results, press (MEMORY) and proceed as described in “Storing and Recalling Measurements” on page 36 of this manual. Measurement storage and recall is available only on Model 1653.

Measuring RCD Tripping Current (Models 1652 and 1653 Only)

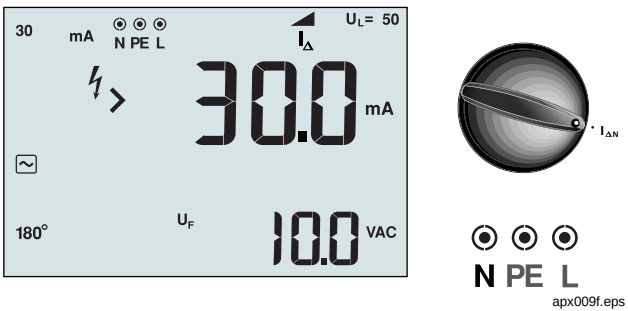


Figure 16. RCD Tripping Current/Switch and Terminal Settings

This test measures the RCD tripping current by applying a test current and then gradually increasing the current until the RCD trips. You can use the test leads or mains cord for this test. A 3-wire connection is required.

⚠⚠ Warning

- **Test the connection between the N-conductor and earth before starting the test. A voltage between the N-conductor and earth may influence the test.**
- **Leakage currents in the circuit following the residual current protection device may influence measurements.**
- **The displayed fault voltage relates to the residual operating current of the RCD.**
- **Potential fields of other earthing installations may influence the measurement.**

Note

If the L and N terminals are reversed, the tester will auto-swap them internally and continue testing. If the tester is configured for UK operation, testing will halt and you will need to manually swap the terminals. This condition is indicated by arrows above or below the terminal indicator symbol (◉○◉). See Power-On Options on page 18 for information on setting Line and Neutral Swap mode.

To measure RCD tripping current

1. Turn the rotary switch to the $I_{\Delta N}$ position.
2. Press F1 to select the RCD current rating.
3. Press F3 to select the RCD type. Valid types are:
   - ~ – Standard AC RCD, normal setting. (All models)
   - ≂ – DC sensitive RCD. (Models 1652 and 1653 only)
   - ~ S – Delayed response AC RCD. (All models)
   - ≂ S – Delayed response DC RCD. (Models 1652 and 1653 only)
4. Press F4 to select the test current phase, 0° or 180°. RCDs should be tested with both phase setting, as their response time can vary significantly depending on the phase.
5. Press and release TEST. Wait for the test to complete.
   - The primary (upper) display shows the RCD trip current.

RCD testing at locations with IT systems requires a special test procedure because the Protective Earth connection is grounded locally and is not tied directly to the power system.

The test cannot be conducted at an outlet but can be done at the electrical panel using probes. Use the connection shown in Figure 17 when performing RCD testing on IT electrical systems.

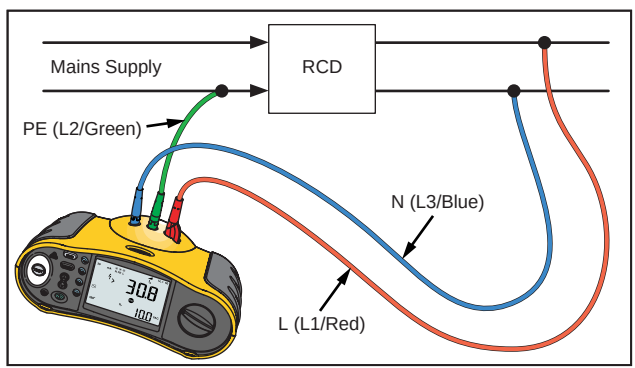


Figure 17. Connection for RCD Testing on IT Electrical Systems

The test current flows through the upper side of the RCD, into the L terminal, and returns though the PE terminal.

Measuring Earth Resistance (Model 1653 Only)

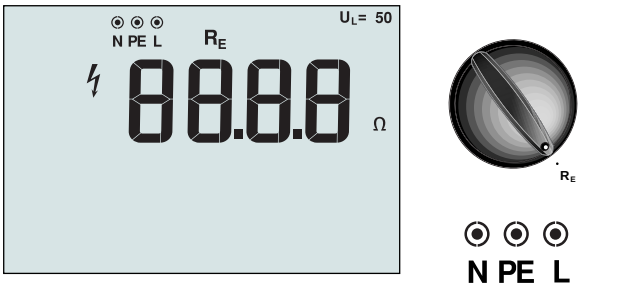


Figure 18. Earth Resistance Display/Switch and Terminal Settings

The earth resistance test is a 3-wire test consisting of two test stakes and the earth electrode under test. This test requires an accessory stake kit. Connect as shown in Figure 19.

- Best accuracy is achieved with the middle stake at 62% of the distance to the far stake. The stakes should be in a straight line and wires separated to avoid mutual coupling.
- The earth electrode under test should be disconnected from the electrical system when conducting the test. Earth resistance testing should not be performed on a live system.

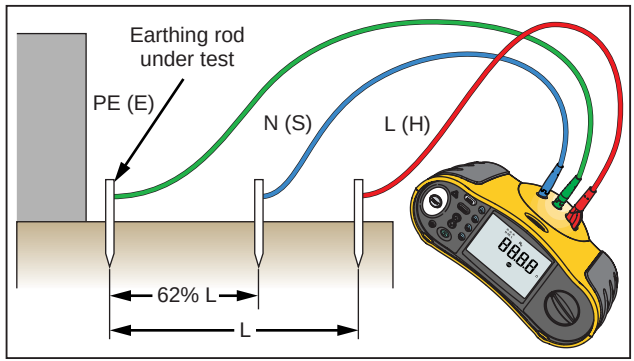


Figure 19. Earth Resistance Test Connection

To measure earth resistance

1. Turn the rotary switch to the R_E position.
2. Press and release (TEST). Wait for the test to complete.
   - The primary (upper) display shows the earth resistance reading.
   - Voltage detected between the test rods will be displayed in the secondary display. If greater than 10 V, the test is inhibited.

Testing Phase Sequence (Model 1653 Only)

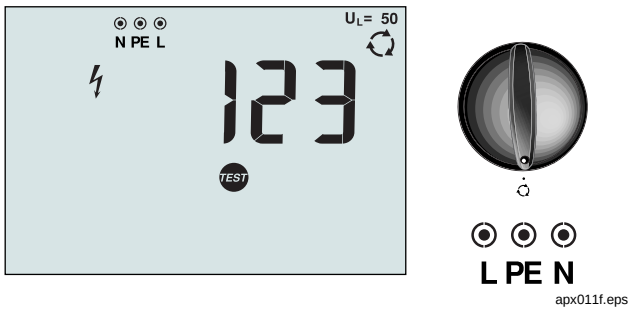


Figure 20. Phase Sequence Display/Switch and Terminal Settings

Use the connection shown in Figure 21 when making a phase sequence test connection.

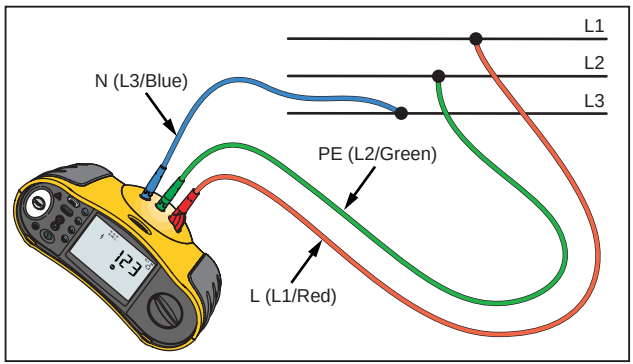


Figure 21. Phase Sequence Test Connection

To perform a phase sequence test

1. Turn the rotary switch to the ↻ position.
2. The primary (upper) display shows:
   - 123 for correct phase sequence.
   - 321 for reversed phase sequence.
   - Dashes (---) instead of numbers if insufficient voltage is sensed.

Storing and Recalling Measurements (Model 1653 Only)

Using Memory Mode

You can store up to 500 measurements on the tester. The information stored for each measurement consists of the test function and all user selectable test conditions.

Data for each measurement is assigned a data set number, data subset number, and a data id number. Memory location fields are used as described below.

Field	Description
a	Use the data set field (a) to indicate a location such as a room or electrical panel number.
b	Use the data subset field (b) for circuit number.
c	The data id number field (c) is the measurement number. The measurement number automatically increments. The measurement number can also be set to a previously used value to overwrite an existing measurement.

To enter Memory mode

1. Press the MEMORY button to enter Memory mode. The display changes to a memory mode display. In Memory mode, the **memory** icon appears on the display. The primary numeric display will be active with the left two digits (a) indicating the data set number (1-99) and the right two digits (b) indicating the data subset number. The decimal point separating these two values will be active. The secondary numeric display (c) will be active indicating the data id number (1-500). The memory locations (a, b, or c) will flash, indicating that you can change the number using the arrow keys ⇕.

2. To enable the data subset number to be changed, press F1. The data subset number will now be flashing. To enable the data sub number to be changed, press F1 again. The data set number will now be flashing. Press F1 again to change the data id number.

3. Press the down arrow key (⇓) to decrement the enabled number or press the up arrow key (⇑) to increment the enabled number. For storing data, the number can be set to any value, overwriting existing data is allowed. For recalling data, the number can only be set to used values.

Note

If you press the up or down arrow key (⇕) once, the number increments or decrements by one. If you press and hold the up or down arrow, the numbers increment or decrement quickly by approximately 10 digits per second.

Storing a Measurement

To store a measurement

1. Press MEMORY to enter Memory mode.

2. Press F1 and use the arrow keys (⇕) to set the data identity.

3. Press F2 to save the data.

   - If memory is full, FULL will appear on the primary display. Press F1 to choose another data identity, press MEMORY to exit Memory mode.

   - If the memory is not full, the data will be saved, the tester will automatically exit Memory mode and the display will revert back to the previous test mode.

- If the data identity has been previously used, the display will show STO? Press F2 again to store the data, press F1 to choose another data identity, press MEMORY to exit Memory mode.

Recalling a Measurement

To recall a measurement

1. Press MEMORY to enter the Memory mode.
2. Press F3 to enter the Recall mode.
3. Use F1 and the arrow keys(↑↓) to set the data identity. If no data has been saved, all fields will be dashes.
4. Press F3 to recall the data. The tester display will revert to the Test mode used for the recalled test data, however, the **memory** icon still appears, indicating the tester is still in Memory mode.
5. Press F3 to toggle between the data id screen and the recalled data screen to check the recalled data id or to select more data to recall.
6. Press MEMORY to exit Memory mode at any time.

Clearing Memory

To clear all memory

1. Press MEMORY to enter Memory mode.
2. Press F4. The primary display will show Clr?. Press F4 again to clear all memory locations.
3. Press MEMORY to exit Memory mode.

Note

All memory locations are cleared when you clear memory. Single memory locations cannot be cleared, but they can be overwritten. See "Storing a Measurement" earlier in this manual.

Uploading Test Results (Model 1653 Only)

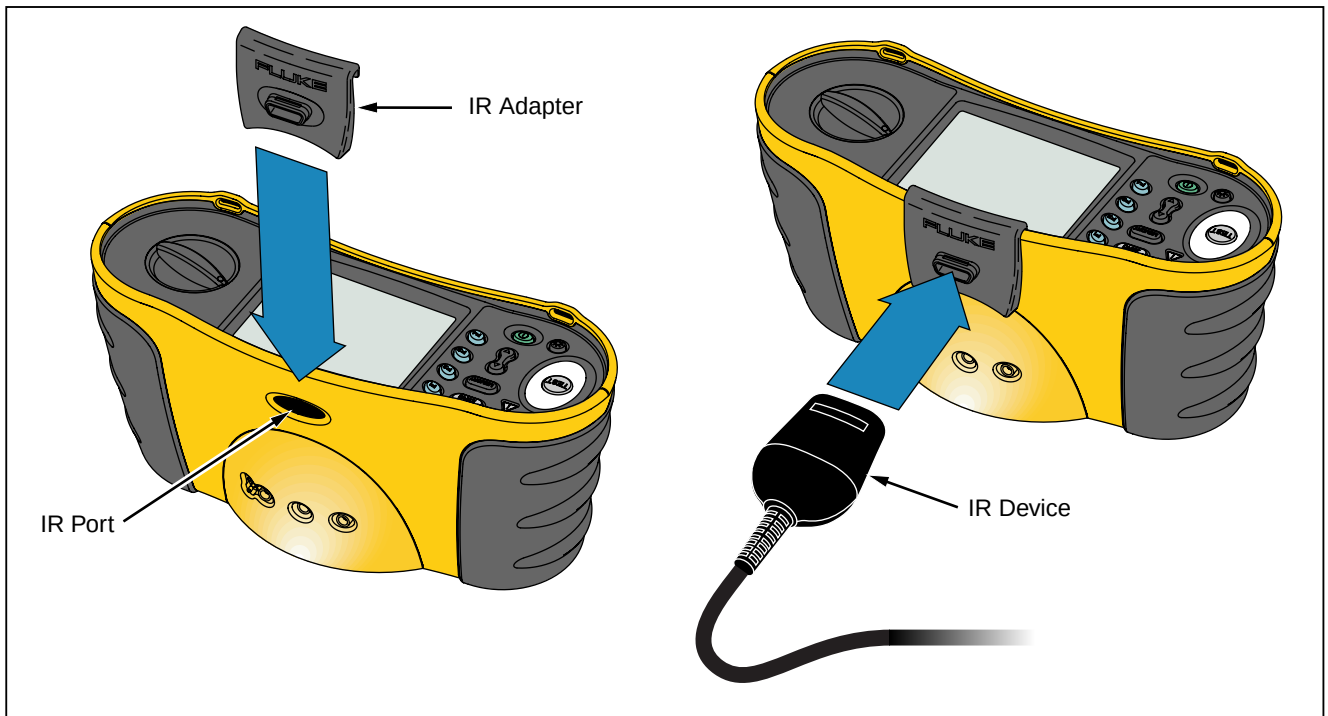


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Figure 22. Attaching the IR Adapter

To upload test results

1. Connect the IR serial cable to the serial port on the PC.
2. Attach the IR adapter and the device to the tester as shown in Figure 22. Be sure to align the IR adapter to the IR port on the tester.

   Note

   The IR data port is disabled when test leads are plugged in. Disconnect test leads before attempting to upload test results.
3. Start FlukeView Forms.
4. Select the form template you want to use by opening the File menu and selecting New Blank Form. Highlight the form template in the New Blank Form dialog box and click OK.
5. Press ⏻ to turn on the tester.
6. On the FlukeView Forms Meter menu, select Get Meter Data to upload the data to the active form. The Get Meter Data dialog box appears.
7. You can also press the Get Meter Data button to access the dialog box.
8. Data readings are copied directly into the active form. Refer to the *FlukeView Forms Documenting Software Users Manual* for additional information.

Maintaining the Tester

Cleaning

Periodically wipe the case with a damp cloth and mild detergent. Do not use abrasives or solvents.

Dirt or moisture in the terminals can affect readings.

To clean the terminals

1. Turn the meter off and remove all test leads.
2. Shake out any dirt that may be in the terminals.
3. Soak a new swab with alcohol. Work the swab around each terminal.

Testing and Replacing the Batteries

Battery voltage is continuously monitored by the tester. If the voltage falls below 6.0 V (1.0 V/cell), the low battery icon appears on the display, indicating that there is minimal battery life left. The low battery icon continues to appear on the display until you replace the batteries.

⚠⚠ Warning

To avoid false readings, which could lead to possible electric shock or personal injury, replace the batteries as soon as the battery icon ( ) appears.

Replace the batteries with six AA batteries. Alkaline batteries are supplied with the tester but you can also use 1.2 V NiCd or NiMH batteries. You can also check the battery charge so that you can replace them before they discharge.

⚠⚠ Warning

To avoid electrical shock or personal injury, remove the test leads and any input signals before replacing the battery or fuses. To prevent damage or injury, install ONLY specified replacement fuses with the amperage, voltage, and speed ratings shown in the General Specifications section of this manual.

To test the batteries

1. Turn the rotary switch to the V position.
2. Press the F3 button to initiate the battery test. The Voltage function display clears and is replaced by the measured battery voltage in the secondary display for 2 seconds, the Voltage function display then returns.

To replace the batteries (Refer to Figure 23)

1. Press ⏻ to turn the tester off.
2. Remove the test leads from the terminals.
3. Remove the battery door by using a standard-blade screwdriver to turn the battery door screws (3) one-quarter turn counterclockwise.
4. Press the release latch and slide the battery holder out of the tester.
5. Replace the batteries and the battery door.

Note

All stored data will be lost if the batteries are not replaced within approximately one minute (Model 1653 only).

6. Secure the door by turning the screws one-quarter turn clockwise.

Testing and Replacing the Fuse

⚠⚠ Warning

To avoid electrical shock or damage to the tester, only use replacement fuses shown in the General Specifications section of this manual.

A fuse test is performed each time you turn on the tester. If leads are plugged in to the L and PE terminals, the fuse test is skipped. If a blown fuse is detected, testing is disabled, FUSE appears on the primary display, and the tester issues a warning beep.

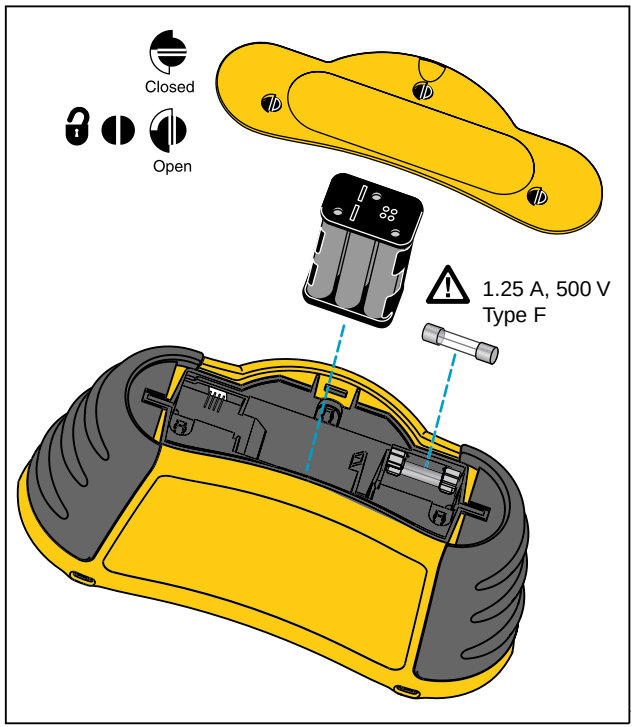
You can also perform a manual check of the fuse.

To manually check the fuse

1. Turn the rotary switch to either R_{ISO} or R_{LO} switch setting.
2. Short the leads and press and hold TEST.
3. If the fuse is bad, FUSE will appear on the display.

To replace the fuse (See Figure 23)

1. Press ⏻ to turn the tester off.
2. Remove the test leads from the terminals.
3. Remove the battery door by using a standard-blade screwdriver to turn the battery door screws one-quarter turn counterclockwise.
4. Remove the fuse by gently prying one end loose, then sliding the fuse out of its bracket.
5. Insert the new 1,25 A, 500 V, 50 kA FAST fuse (PN 2040349).
6. Secure the door by turning the screws one-quarter turn clockwise.



apx028f.eps

Figure 23. Replacing the Fuse and Batteries

Specifications

Features by Model

Measurement Function	1651	1652	1653
Voltage & Frequency	√	√	√
Wiring polarity checker	√	√	√
Insulation Resistance	√	√	√
Continuity & Resistance	√	√	√
Loop & Line Resistance	√	√	√
PFC, PSC (short-circuit current)	√	√	√
RCD switching time	√	√	√
RCD tripping level		√ ramp test	√ ramp test
Automatic RCD test sequence		√	√
Test DC-sensitive RCD's		√	√
Earth Resistance			√
Phase Sequence Indicator			√
Other Features			
Self-test	√	√	√
Illuminated Display	√	√	√
Memory, Interface			
Memory			√
Computer Interface			√
Time and date (When used with FlukeView software)			√
Software			√
Included Accessories			
Hard case	√	√	√
Remote control probe	√	√	√

General Specifications

Specification	Characteristic
Size	10 cm (L) x 25 cm (W) x 12.5 cm (H)
Weight (with batteries)	1,5 Kg
Battery size, quantity	Type AA, 6 ea.
Battery type	Alkaline supplied. Usable with 1,2 V NiCd or NiMH batteries (not supplied)
Battery life (typical)	200 hours idling
Fuse	1,25 A, 500 V, 50 kA FAST fuse (PN 2040349).
Operating Temperature	-10°C to 40 °C
Storage Temperature	-10 °C to 60 °C indefinitely (to -40 °C for 100 hrs)
Relative Humidity	Noncondensing <10 °C 95% 10 to 30 °C; 75% 30 to 40 °C

Specification	Characteristic
Operating Altitude	0 to 2000 meters
Shock, Vibration	Vibration to Class 3 per Mil-Prf-28800F 1 meter drop test, six sides, oak floor
Sealing	IP-40
EMI Immunity	3 V/meter
EMC	Complies with EN61326
Safety	Complies with UL 3111, ANSI/ISA-S82.01 – 1992 CSA C22.2 No. 1010.1-92 and IEC1010-1 Overvoltage Category III (CAT III), 600 V Measurement Category III is for measurements performed in the building installation. Examples are distribution panels, circuit breakers, wiring and cabling.
Maximum voltage between any terminal and earth ground	500 V
Surge Protection	6 kV peak per IEC 1010.1-92

Electrical Measurement Specifications

The accuracy specification is defined as ± (% reading +digit counts) at 23 °C ± 5 °C, ≥ 80% RH. Between -10 °C and 18 °C and between 28 °C and 40 °C, accuracy specifications may degrade by 0,1 x (accuracy specification) per °C.

AC Voltage Measurement (V)

Range	**Resolution**	**Accuracy** 50Hz - 60Hz	**Input Impedance**	**Overload Protection**
500 V	0,1 V	0,8% + 3	3,3 MΩ	660 V rms

Continuity Testing (R_{LO})

Range (Autoranging)	**Resolution**	**Open Circuit Voltage**	**Accuracy**
20 Ω	0,01 Ω		± (1,5%+3 digits)
200 Ω	0,1 Ω	> 4 V	± (1,5%+3 digits)
2000 Ω	1 Ω		± (1,5%+3 digits)
The test current is 200 mA for resistances of 2 Ω or less. The number of possible continuity tests with a fresh set of batteries is 3000.			

Test Probe Zeroing	• Press the ZERO button to zero the test probe. • Can subtract up to 2 Ω of lead resistance. • Error message for >2 Ω.

Live Circuit Detection	Inhibits test if terminal voltage > 10 V ac detected prior to initiation of test.

Insulation Resistance Measurement (R_{ISO})

Test Voltages			**Accuracy of Test Voltage** (at rated test current)
Model 1651	Model 1652	Model 1653	
500-1000 V	250-500-1000 V	50-100-250-500-1000 V	+10%, -0%

Test Voltage	**Insulation Resistance Range**	**Resolution**	**Test Current**	**Accuracy**
50 V	10 kΩ to 50 MΩ	0,01 MΩ	1 mA @ 50 kΩ	± (3%+3 digits)
100 V	100 kΩ to 20 MΩ	0,01 MΩ	1 mA @ 100 kΩ	± (3%+3 digits)
	20 MΩ to 100 MΩ	0,1 MΩ	1 mA @ 100 kΩ	± (3%+3 digits)
250 V	100 kΩ to 200 MΩ	0,1 MΩ	1 mA @ 250 kΩ	± (1,5%+3 digits)
500 V	100 kΩ to 200 MΩ	0,1 MΩ	1 mA @ 500 kΩ	± (1,5%+3 digits)
	200 MΩ to 500 MΩ	1 MΩ	1 mA @ 500 kΩ	± 10%
1000 V	100 kΩ to 200 MΩ	0,1 MΩ	1 mA @ 1 MΩ	± (1,5%+3 digits)
	200 MΩ to 1000 MΩ	1 MΩ	1 mA @ 1 MΩ	± 10%
The number of possible insulation tests with a fresh set of batteries is 2000.				

Auto Discharge	Discharge time constant < 0.5 second for C = 1 uF or less.
Live Circuit Detection	Inhibits test if terminal voltage > 30 V prior to initiation of test.
Maximum Capacitive Load:	Operable with up the 5 uF load.

Loop and Line Impedance (Z_l)

Measuring Range	100 - 500 V ac (50/60 Hz)
Input Connection (soft key selection)	Loop Impedance: phase to earth
	Line impedance: phase to neutral
Limit on Consecutive Tests	Automatic shutdown when internal components are too hot. There is also a thermal shutdown for RCD tests.

Range	Resolution	Accuracy*
20 Ω	0,01 Ω	± (3% + 10 digits)
200 Ω	0,1 Ω	± (3% + 10 digits)
2000 Ω	1 Ω	± (3% + 10 digits)
*Valid for resistance of neutral circuit <20 Ω		

PFC, PSC Test

Computation	PFC or PSC determined by dividing measured mains voltage by measured loop (L-PE) resistance or line (L-N) resistance.	
Range	0 to 10 kA	
Resolution and Units	Resolution	Units
	I_K < 1000 A	1 A
	I_K > 1000 A	0.1 kA
Accuracy	Determined by accuracy of loop resistance and mains voltage measurements.	

RCD Testing

RCD Types Tested

RCD Type*		Model 1651	Model 1652	Model 1653
[1]AC	[2]G	√	√	√
AC	[3]S	√	√	√
[4]A	G		√	√
A	S		√	√

[1]AC – Responds to AC

[2]G – General, no delay

[3]S – Time delay

[4]A – Responds to pulsed signal

*RCD test inhibited for V > 280 V ac

Test Signals

RCD Type	Test Signal Description
AC	The waveform is a sinewave starting at zero crossing, polarity determined by phase selection (0º phase starts with low to high zero crossing, 180º phase starts with high to low zero crossing). The magnitude of the test current is $I_{\Delta}n$ x Multiplier for all tests.
A	The waveform is a half wave rectified sinewave starting at zero, polarity determined by phase selection (0º phase starts with low to high zero crossing, 180º phase starts with high to low zero crossing). The magnitude of the test current is 2.0 x $I_{\Delta}n$ x Multiplier for all tests for $I_{\Delta}n$ = 0.01A. The magnitude of the test current is 1.4 x $I_{\Delta}n$ x Multiplier for all tests for all other $I_{\Delta}n$ ratings.

Tripping Speed Test ($_{\Delta}T$)

Model 1651

Current Settings	Multiplier	Current Accuracy	*RCD Type	Maximum Test Time
10–30–100–300-500-1000 mA	x 1	+10% -0%	G	310 ms
10–30–100–300-500-1000 mA	x 1	+10% -0%	S	510 ms
*G – General, no delay *S – Time delay				

Tripping Speed Test ($_{\Delta}T$)

Models 1652 and 1653

Current Settings	Multiplier	Current Accuracy
10–30–100–300-500-1000 mA	x ½	+0% -10% of test current
10–30–100–300-500-1000 mA	x 1	+10% -0%
10-30 mA	x 5	±10%

Current Multiplier	*RCD Type	Measurement Range		Trip Time Accuracy
		Europe	UK	
x ½	G	310 ms	2000 ms	±(1% Reading + 1 digit)
x ½	S	510 ms	2000 ms	±(1% Reading + 1 digit)
x 1	G	310 ms	310 ms	±(1% Reading + 1 digit)
x 1	S	510 ms	510 ms	±(1% Reading + 1 digit)
x 5	G	50 ms	50 ms	±(1% Reading + 1 digit)
x 5	S	160 ms	160 ms	±(1% Reading + 1 digit)

*G – General, no delay
*S – Time delay

Tripping Current Measurement/Ramp Test ($I_{\Delta N}$)

Models 1652 and 1653

Current Range	Step Size	Dwell Time		Measurement Accuracy
		Type G	Type S	
50% to 110% of RCD's rated current	10% of $I_{\Delta N}$	300 ms/step	500 ms/step	± 5 %

Earth Resistance Test (R_E)

Model 1653 Only

Range	Resolution	Accuracy
200 Ω	0,1 Ω	± (2% + 5 digits)
2000 Ω	1 Ω	± (3,5% + 10 digits)

Frequency	Compliance Voltage
128 Hz	+ 25 V

Live Circuit Detection	Inhibits test if terminal voltage > 10 V ac is detected prior to start of test.

Phase Sequence Indication

Model 1653 Only

Icon	icon Phase Sequence indicator is active.
Display of Phase Sequence	Displays “1-2-3” in digital display field for correct sequence. Displays “3-2-1” for incorrect phase. Dashes in place of a number indicate a valid determination could not be made.

Mains Wiring Test

Icons ( ,  , ) indicate if L-PE or L-N terminals are reversed. Instrument operation is inhibited and an error code is generated if the input voltage is not between 100 V and 500 V.

FLUKE®

Calibration Information

- ***1651, 1652, & 1653***

Installation Testers

The following table contains the specifications and remote commands for adjusting the 165X via its IR adapter cable and MET/CAL. The 165X have no physical adjustments and are adjusted over an RS-232 Serial bus. There is no front panel adjustment capability. For a complete set of remote commands see the 165X Serial Interface Specification document.

Step #	Kryten Function	Kryten Range	Required Accuracy	Equipment Used	Equipment Specifications	Connections	Remote SetupCommands via IR (Press TEST to execute cal.)
	Volts		Source VDC ±0.1% @ >1mA		(% of Output + Floor)		
1		0V		Wavetek 9100	(0.006% + 4.16uV) = 4.16uV	Figure 1	&xc1
2		8V	8V * 0.1% = 8mV	Wavetek 9100	(0.0065% + 416uV) = 546uV	Figure 1	&xc2
3		25V	25V * 0.1% = 25mV	Wavetek 9100	(0.0065% + 416uV) = 2.041mV	Figure 1	&xc3
4		750V	750V * 0.1% = 750mV	Wavetek 9100	(0.006% + 19.95mV) = 64.95mV	Figure 1	&xc4
5		1000V	1000V * 0.1% = 1.0V	Wavetek 9100	(0.006% +19.95mV) = 79.95mV	Figure 2	&xc5
	Leakage Current		Source ADC ±0.1% @ >2.5VDC compliance		(% of Output + Floor)		
6		0uA	None	None		None	&xc6
7		1200uA	1200uA * 0.1% = 1.2uA	Wavetek 9100	(0.014% + 83nA) = 251nA	Figure 3	&xc7
8		300uA	300uA * 0.1% = 300nA	Wavetek 9100	(0.014% + 11nA) = 53nA	Figure 3	&xc8
9		75uA	75uA * 0.1% = 75nA	Wavetek 9100	(0.014% + 11nA) = 21.5nA	Figure 3	&xc9
10		20uA	20uA * 0.1% = 20nA	Wavetek 9100	(0.014% + 11nA) = 13.8nA	Figure 3	&xc10
11	**Earth Voltage Measurement**		Source 10.0VAC ±0.1%, 128Hz ±0.1% @ >1mA 10.0VAC * 0.1% = 10mV	Wavetek 9100	(% of Output + Floor) = (0.04% +1.92mV) = 5.92mV Freq. Acc. = 25ppm	Figure 4	&xc11
12	**High Voltage Inverter**		None	None		None	&xc12
	Low Voltage Current Source (LVCS)		Resistance ±0.1%	A34401	A34401: (% of Reading + % of Range)		
13		5mA * 2% = 100uA	100µA * 0.1% = 0.1µA	A34401		Figure 5	&xc13, then $xsp CSI=0.000xxxxx
14		5mA * 6% = 300µA	300µA * 0.1% = 0.3µA	A34401		Figure 5	&xc14, then $xsp CSI=0.000xxxxx
15		5mA * 10% = 500µA	500µA * 0.1% = 0.5µA	A34401		Figure 5	&xc15, then $xsp CSI=0.000xxxxx

16		5mA * 90% = 4500µA	4500µA * 0.1% = 4.5µA	A34401		Figure 5	&xc16, then $xsp CSI=0.00xxxxx
17		200mA * 10% = 20mA	20mA * 0.1% = 20µA	A34401		Figure 5	&xc17, then $xsp CSI=0.0xxxxx
18		200mA * 90% = 180 mA	180mA * 0.1% = 180uA	A34401		Figure 5	&xc18, then $xsp CSI=0.xxxxx
	RCD Current Source		Source VDC ±5%, measure ADC ±0.5%		A6030: (% of Output + Floor + other) A34401: (% of Reading + % of Range)		
19		0.10 * 0.22A = 22mA	100V * 5% = 5V 22mA * 0.5% = 110uA	A6030, A34401	(0.035% + 145mV + 32mV) = 0.212V (0.05% + 0.006%) = 17uA	Figure 6	&xc19, then $xsp RCD1=0.0xxxxx to set the current
20		0.90 * 0.22A = 198mA	100V * 5% = 5V 198mA * 0.5% = 990uA	A6030, A34401	(0.035% + 145mV + 32mV) = 0.212V (0.05% + 0.006%) = 159uA	Figure 6	&xc20, then $xsp RCD2=0.xxxxxx to set the current
21		0.10 * 2.2A = 0.22A	100V * 5% = 5V 0.22A * 0.5% = 1.1mA	A6030, A34401	(0.035% + 145mV + 32mV) = 0.212V (0.05% + 0.006%) = 170uA	Figure 6	&xc21, then $xsp RCD3=0.xxxxx to set the current
22		0.90 * 2.2A = 1.98A	100V * 5% = 5V 1.98A * 0.5% = 9.9mA	A6030, A34401	(0.035% + 145mV + 32mV) = 0.212V (0.05% + 0.006%) = 1.17mA	Figure 6	&xc22, then $xsp RCD4=x.xxxx to set the current
	Loop Resistance		Source VDC ±5%, measure ADC ±0.5%		A6030: (% of Output + Floor + other) A34401: (% of Reading + % of Range)		
23		0.025A	20V * 5% = 1.0V 25mA * 0.5% = 0.125mA	A6030, A34401		Figure 7	&xc23, then $xsp lci=0.xxxxx to set the current
24		0.25A	60V * 5% = 2.5V 0.25A * 0.5% = 1.25mA	A6030, A34401	(0.035% + 145mV + 32mV) = 0.194V (0.05% + 0.006%) = 185uA	Figure 7	&xc24, then $xsp lci=x.xxxx to set the current
25		2.5A	60V * 5% = 2.5V 2.5A * 0.5% = 12.5mA	A6030, A34401	(0.035% + 145mV + 32mV) = 0.194V (0.05% + 0.006%) = 1.43mA	Figure 7	&xc25, then $xsp lci=x.xxxx to set the current

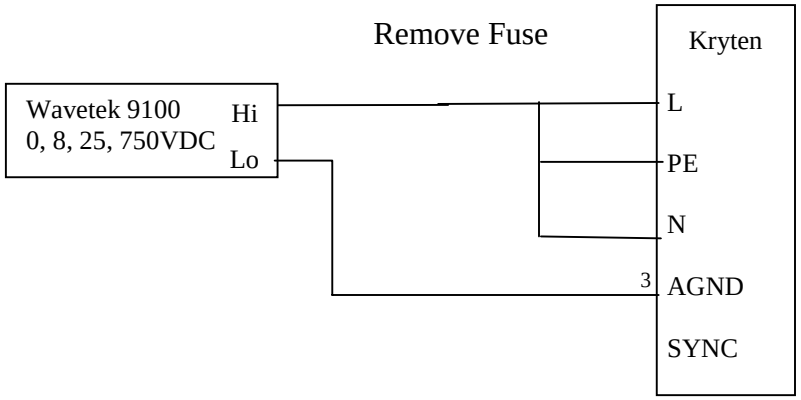


Figure 1. Voltage Calibration (except 1000V)

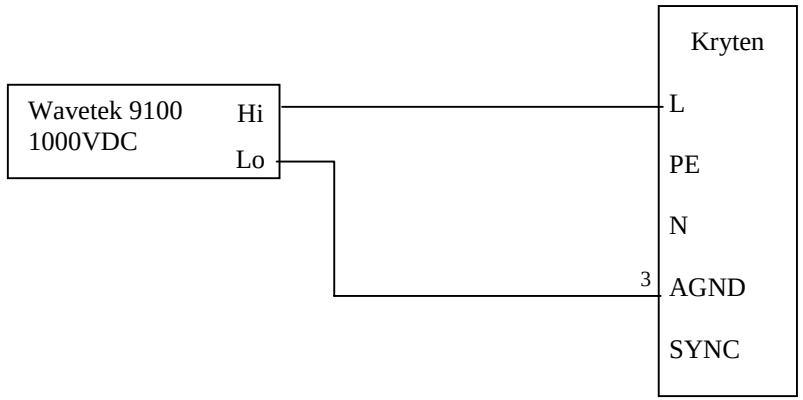


Figure 2. Voltage Calibration 1000V

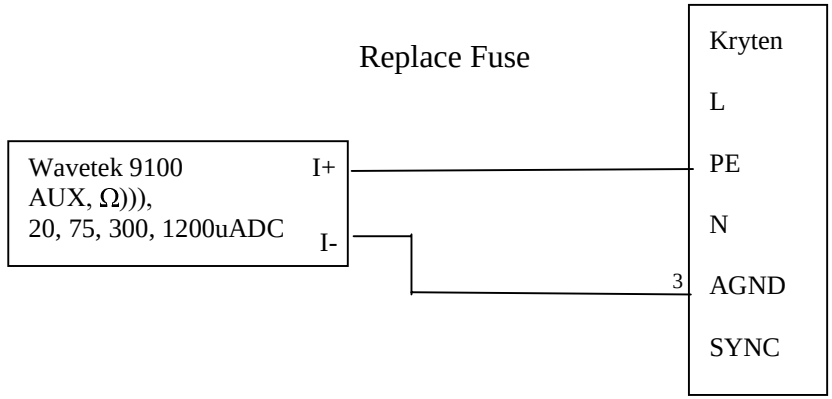


Figure 3. Leakage Current Calibration

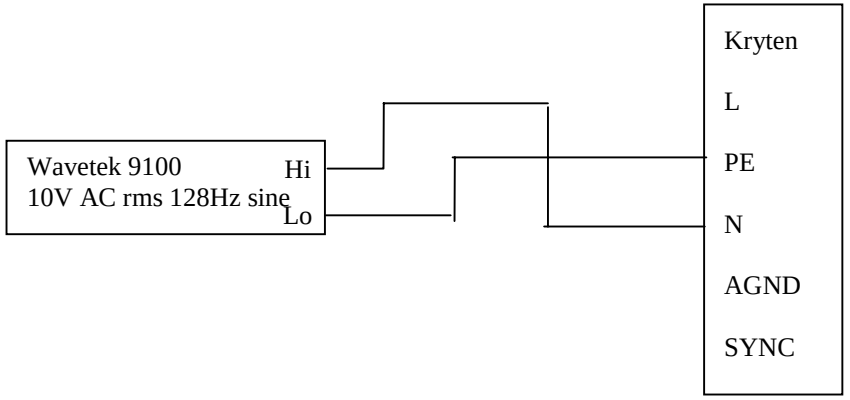


Figure 4. Earth Calibration

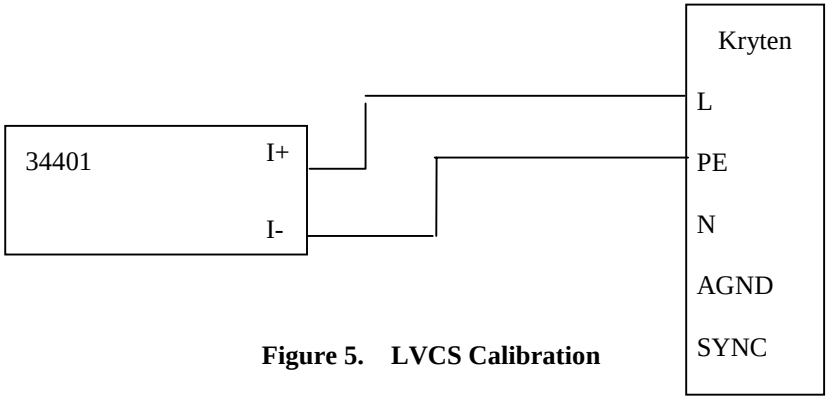


Figure 5. LVCS Calibration

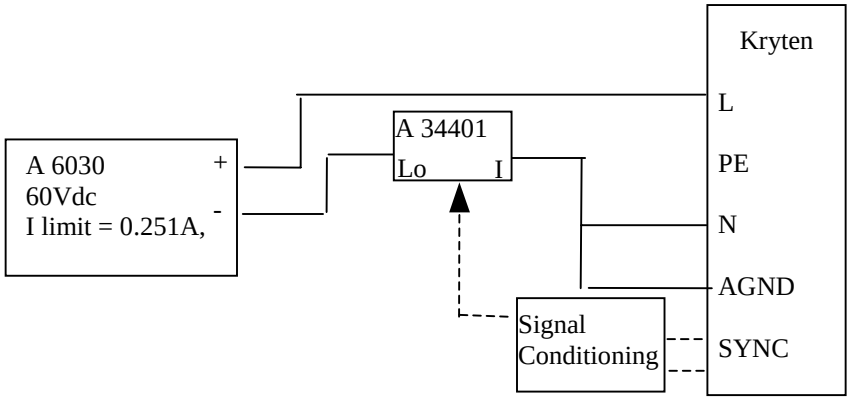


Figure 7. Loop Calibration

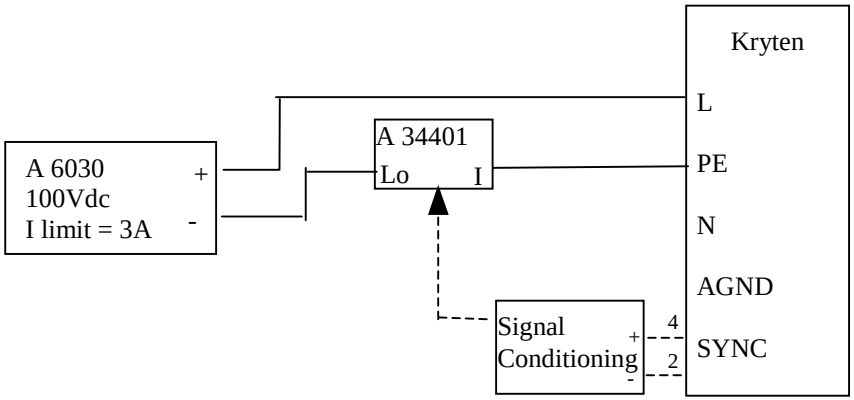


Figure 6. RCD Calibration

Agilent 34401 Setup Instructions

From power on:

select DC current	(shift) DCI	
select fast 5 digit resolution		
	(shift) <	' Menu on/off '
	down arrow	' Meas menu '
	>, >, >, >	' 5. Resolution '
	down arrow, <	' Fast 5 digit '
	Enter	
select trigger	Single	' Trigger '

select current range from 10.0000 mADC, 100.000 mADC, 1.00000 ADC, 10.0000 ADC
(with up and down arrows)

Calibration Notes:

1. Each calibration step is setup using the &xc<step number> command
2. All RCD calibration steps must be performed consecutively and if any of the steps fail, all must be performed again.
3. All Loop calibration steps must be performed consecutively and if any fail, all must be performed again.

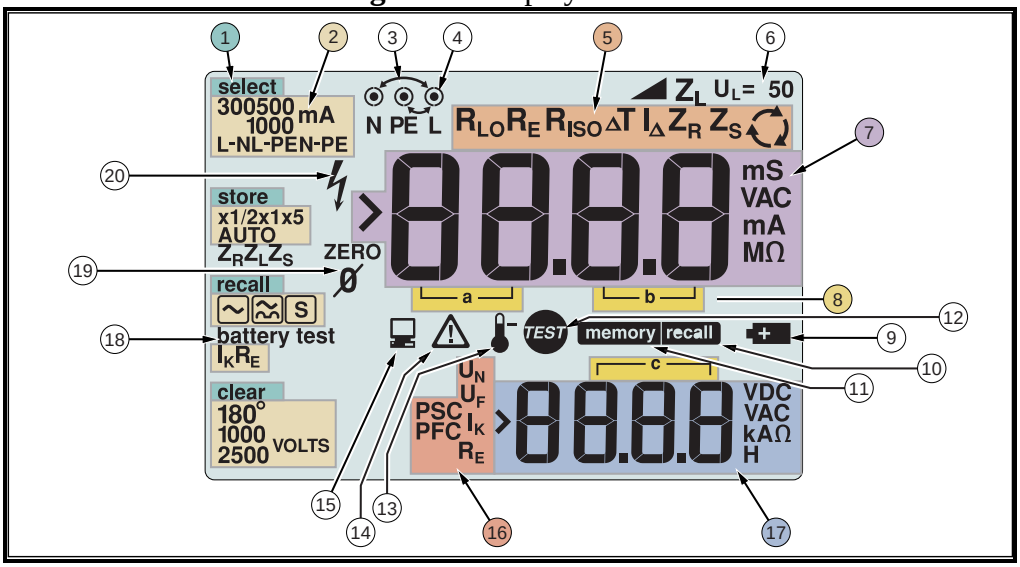
The YC serial command returns the status (busy or idle) and an error code of the current step. The command is detailed in the 165X Serial Interface Spec.

Functional Tests

Test	Equipment	Instructions	Result Displayed on 165X
Setup			
	165X Calibration Fixture	Remove battery door and battery pack from 165X	
		Install 165X on 165X Calibration Fixture as shown in **Figure 1.**	
	165X Battery Power Supply	Connect 165X Battery Power Supply Output to the 165X Calibration Fixture, BATT terminals. Set output of 165X Battery Power Supply to Nom (Approx. 9.6 volts)	
Display Test			
		Press and hold the F1 key and turn the meter on. See **Figure 2.**	All Display Segments illuminated
Backlight Test			
		Turn meter on and allow completion of self test	
		Press Backlight button	Backlight On
		Press Backlight Button	Backlight Off
Split Jack Sense			
		Install test leads into PE and L jacks	
		Remove test lead from PE jack. Meter display should show " LEAD"	"Leads" On
		Reinsert test lead into PE jack. Display should no longer show "LEAD"	"Leads" Off
		Remove test lead from "L" jack. Meter should display "LEAD"	"Leads" On
		Reinsert test lead into "L" jack. Display should no longer show "LEAD"	"Leads" Off
Low Batt Test			
		Set 165X Battery Power Supply to 5.8 volts	Battery Symbol On
		Set 165X Battery Power Supply to Nom	Battery Symbol should remain "ON"
		Cycle meter power to turn battery symbol off	

Figure 1. Setup

Figure 2. Display Test

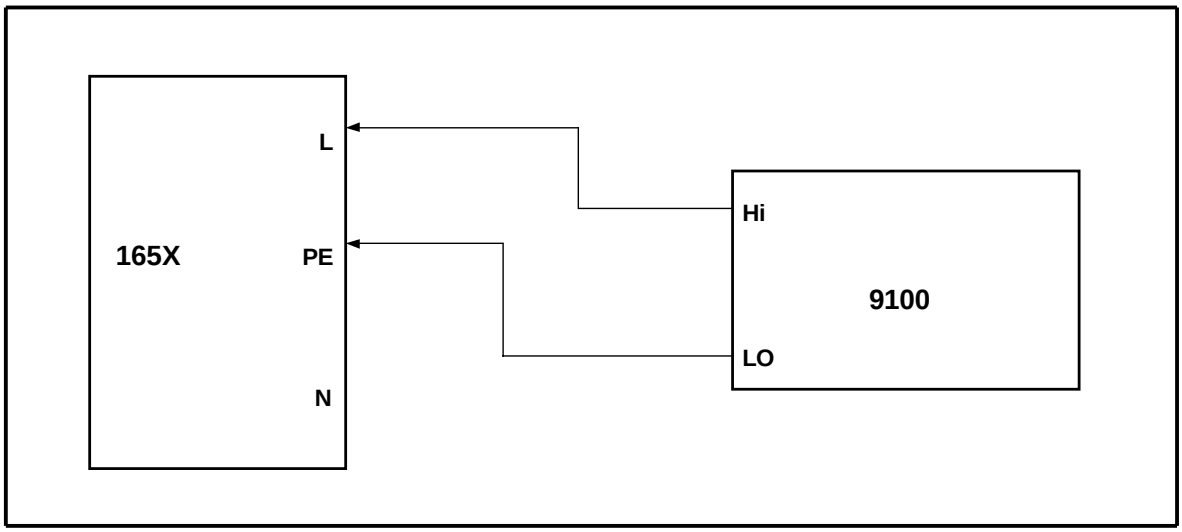


Functional Test, cont...

Test	Equipment	Instructions	Result Displayed on 165X
Touch Pad Sensing Test		**Warning ⚠ Care should be taken with the following procedure, as potentially dangerous voltage is applied to an exposed surface.**	
	WaveTek 9100	Set UUT to Volts	
		Connect lead from 9100_Lo to UUT PE jack	
		Using Test lead probe, connect 9100_Hi to UUT Touch Pad. See **Figure 3.**	
		Apply "100V, 50 Hz" from the 9100	⚠ warning symbol illuminates
		Program 9100 Calibrator to standby. Remove test probes	
Memory Test			
	9100	Connect 9100 to 1653 L -PE (Hi to L and Lo to PE)	
		Set output of 9100 to 25V, 50 Hz	
		Push Memory, Store Reading, Recall reading	Meter Displays 25V

Figure 3. Touch Pad Sense Test

Figure 4. Volts, Insulation and Continuity



Voltage Test (Figure 4.)

Step	165X Function	Source (9100)	Spec.	Count	Resolution	Display Limits	
						Low Limit	Hi Limit
1.	Volts	25V, 50 Hz	0.80%	3	0.1	25.5	24.5
2.	Volts	250V, 50 Hz	0.80%	3	0.1	252.3	247.7
3.	Volts	475, 50 Hz	0.80%	3	0.1	479.1	470.9

Insulation Test (Figure 4.)

Step	165X Function	Source: 9100 w/135 option	165X Voltage Range	Specs	Counts	Resolution	Current (9100)	Display Limits	
								Low Limit	Hi Limit
4.	Insulation	34Vdc	Push Test Button						
			Meter Senses voltage and gives garbled beep					Displays 34Vdc with Lightning bolt	
		Set 9100 for Insulation test							
5.		2.5 MΩ	50V	3.00%	3	0.01		2.40	2.61
6.		45 MΩ	50V	3.00%	3	0.01		43.62	46.38
7.		50 MΩ	50V	3.00%	3	0.01		48.47	51.53
8.		100 kΩ	100V	3.00%	3	0.01	1 mA	0.07	0.13
9.		1 MΩ	100V	3.00%	3	0.01		0.94	1.06
10.		18 MΩ	100V	3.00%	3	0.01		17.43	18.57
11.		22 M	100V	3.00%	3	0.1		21.0	23.0
12.		90 MΩ	100V	3.00%	3	0.1		87.0	93.0
13.		250 kΩ	250V	1.50%	3	0.1	1 mA	0.0	0.6
14.		10 MΩ	250V	1.50%	3	0.1		9.5	10.5
15.		180 MΩ	250V	1.50%	3	0.1		177.0	183.0
16.		500 kΩ	500V	1.50%	3	0.1	1 mA	0.2	0.8
17.	Insulation	10 MΩ	500V	1.50%	3	0.1		9.6	10.5

Step	165X Function	Source: 9100 w/135 option	165X Voltage Range	Specs	Counts	Resolution	Current (9100)	Display Limits	
								Low Limit	Hi Limit
18.		180 MΩ	500V	1.50%	3	0.1		177.0	183.0
19.		220 MΩ	500V	10.00%	0	1		198	242
20.		450 MΩ	500V	10.00%	0	1		405	495
21.		1 MΩ	1000V	1.5%	3	0.1	1 mA	0.7	1.3
22.		180 MΩ	1000V	1.50%	3	0.1		177.0	183.0
23.		220 MΩ	1000V	10.00%	0	1		198	242
24.		900 MΩ	1000V	10.00%	0	1		810	990

Continuity Test

(Refer to figure 4.)

Step	165X Function	9100 Output (Continuity Function 4 wire connection)	Specs	Counts	Resolution	Minimum Current	Display Limits	
							Low Limit	Hi Limit
25.	Continuity	2.00 Ω	1.50%	3	0.01	200 mA	1.94	2.06
26.		18 Ω	1.50%	3	0.01		17.70	18.30
27.		22 Ω	1.50%	3	0.1		21.4	22.6
28.		180 Ω	1.50%	3	0.1		177.0	183.0
29.		220 Ω	1.50%	3	1		214	226
30.		1800 Ω	1.50%	3	1		1770	1830

Loop Tests

(Refer to figures for setup and connections)

Step	165X Function	Figure	R in Line	Source	Spec	Counts	Resolution	Display Limits	
								Lo Limit	Hi limit
31.	Loop Zero	Figure 5.	Short L-PE-N (Loop Zero)	Push Zero Button and read display				0.00	0.150
32.	Loop L-N	Figure 6.	2 Ω	230V, 50 Hz	3%	10	0.01	1.84	2.16
33.	Loop L-N	Figure 6	25 Ω	230V, 50 Hz	3%	10	0.1	23.2	26.8
34.	Loop L-N	Figure 6	1850 Ω	230V, 50 Hz	3%	10	1	1784	1916
	Loop L-PE		**R in Earth**						
35.	Loop L-PE	Figure 7	2 Ω	230V, 50 Hz	3%	10	0.01	1.84	2.16
36.	Loop L-PE	Figure 7	25 Ω	230V, 50 Hz	3%	10	0.1	23.2	26.8
37.	Loop L-PE	Figure 7.	1850 Ω	230V, 50 Hz	3%	10	1	1784	1916
38.	Loop Fault Voltage	Figure 8.	Select 165X Fault voltage to 50V	230V, 50 Hz and Variac for 45V or 55V	10%		0.1	45V = No Error	55V = Error 4

Figure 5. Loop Zero Test

(Connect 165X test leads to shorting Bar)

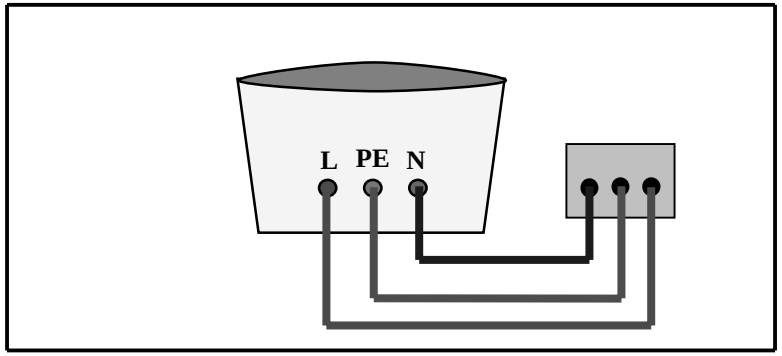


Figure 6. Loop L-N Test (Push 165X F1 key for L-N)

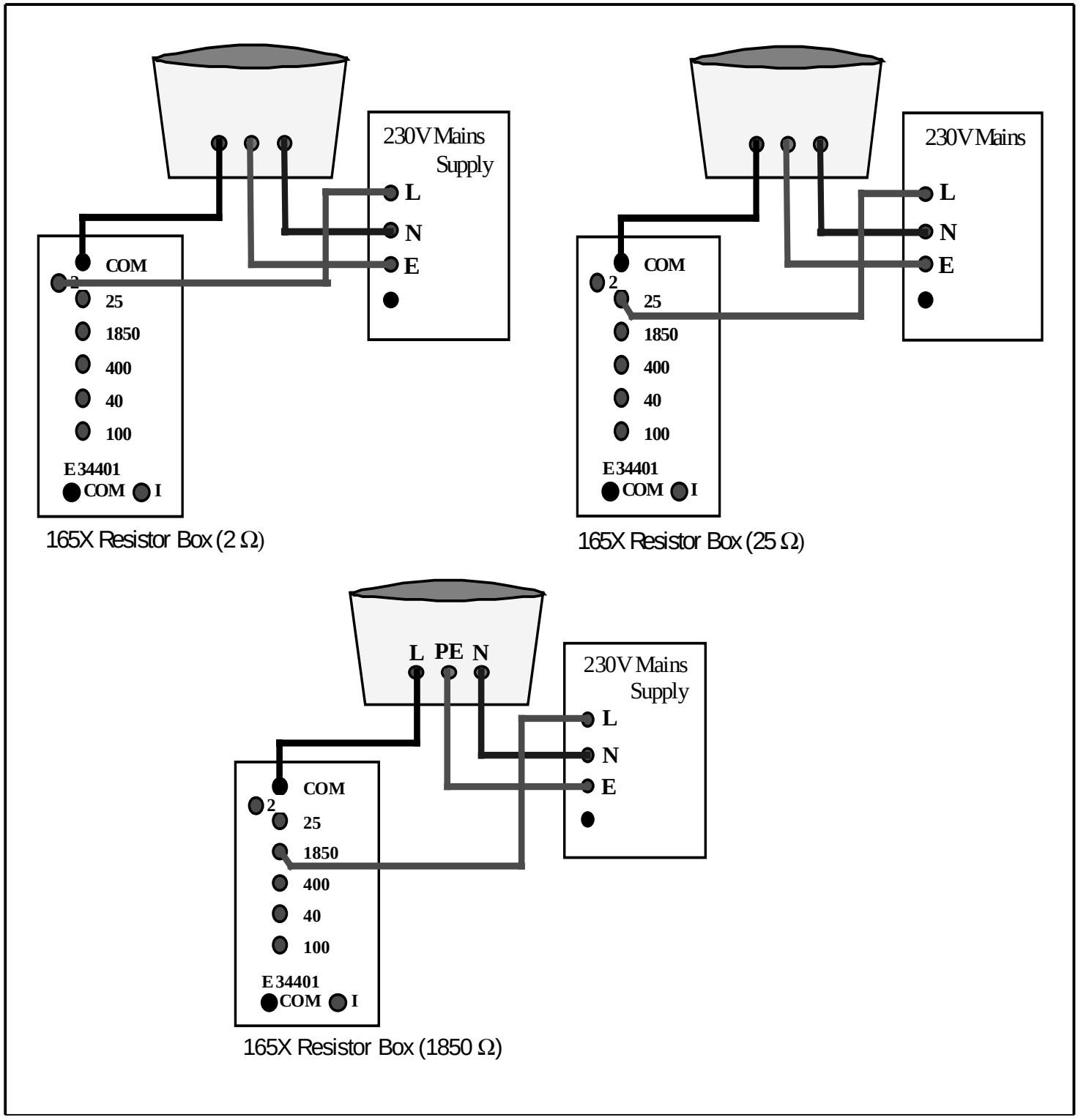


Figure 7. Loop L-PE Test (Push 165X F1 key for L-PE)

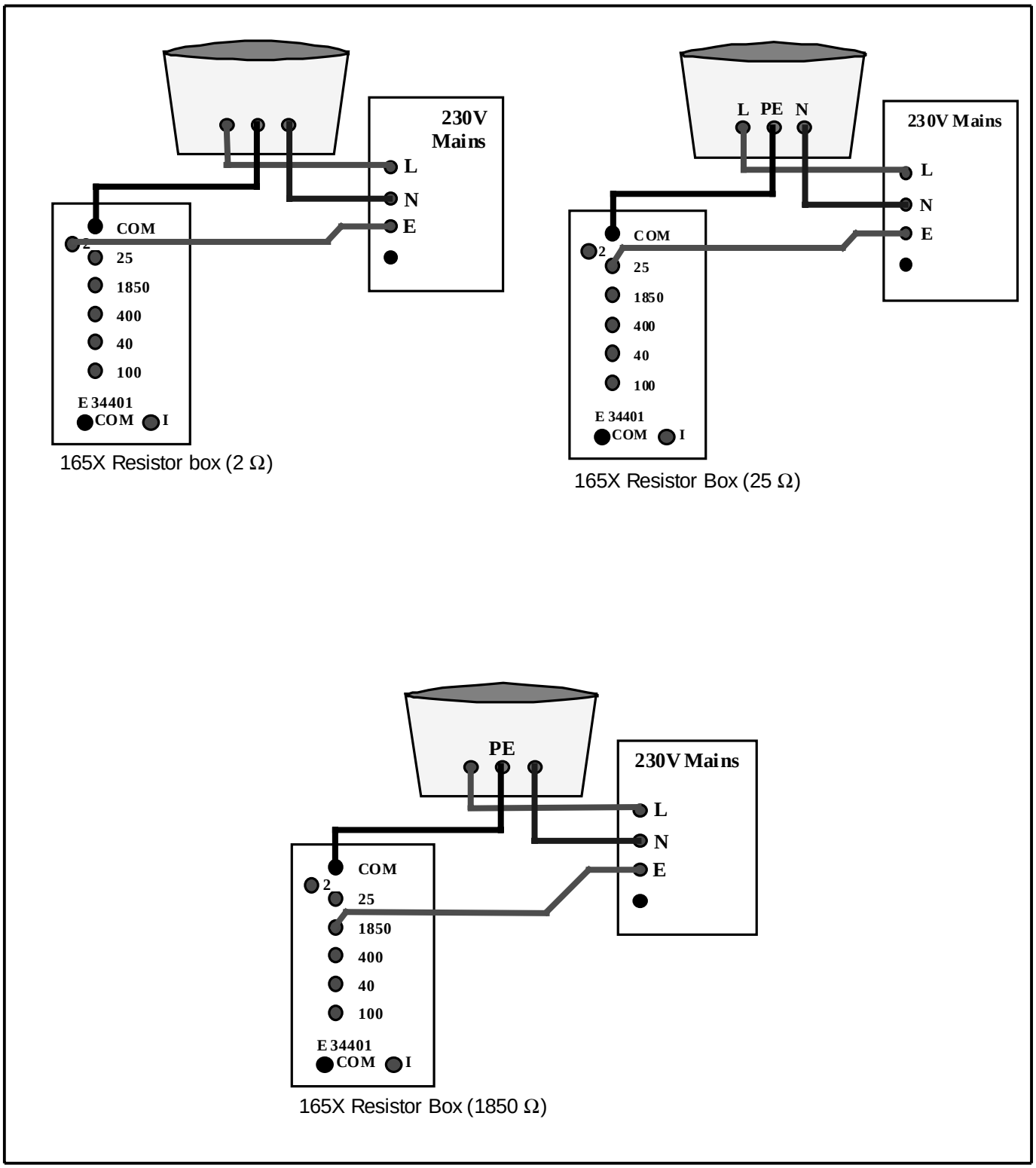
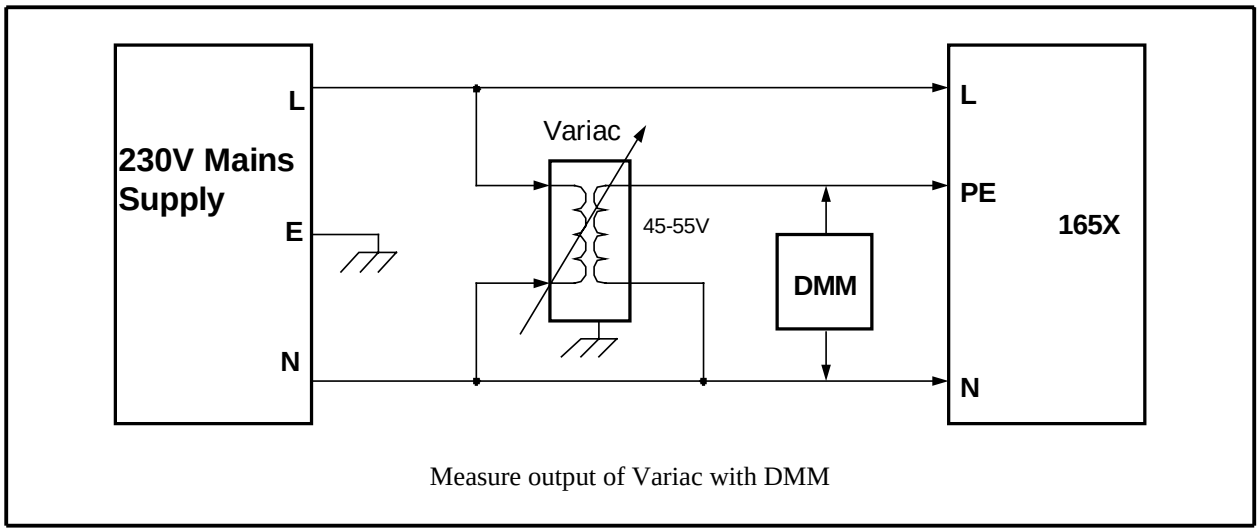


Figure 8. Loop Fault Voltage Test



RCD Tests

(Refer to figures for setup and connections**)**

Step	165X Function	Test Current Magnitude	Figure	165X Setting			Spec	Counts	*DMM reading	
				F3	F1	F2			Lo Limit	Hi Limit
39.	ΔT	$I_{\Delta n}$ x Mult.	Figure 9	AC	10mA	x1/2	-10%	0%	4.50	5.00
40.		2.0 x $I_{\Delta n}$ x Mult.	Figure 9	A	10mA	x1/2	-10%	0%	4.50	5.00
41.		$I_{\Delta n}$ x Mult.	Figure 9	AC	10mA	x5	+10%	0%	50.0	55.0
42.		$I_{\Delta n}$ x Mult.	Figure 9	AC	30mA	x1	+10%	0%	30.0	33.0
43.		1.4 x $I_{\Delta n}$ x Mult.	Figure 9	A	30mA	x1	+10%	0%	30.0	33.0
44.		$I_{\Delta n}$ x Mult.	Figure 9	AC	30mA	x1/2	-10%	0%	13.5	15.0
45.		$I_{\Delta n}$ x Mult.	Figure 9	AC	1000 mA	x1	+10%	0%	1000	1100
46.		(1.4 x $I_{\Delta n}$ x Mult.)	Figure 9	A	1000 mA	x1	+10%	0%	1000	1100
47.	ΔT	RCD Trip Time Test (30 ms)			30mA	x1	1%	1	29	31
48.		RCD Trip Time Test (50 ms)			30mA	x1	1%	1	49	52
49.		RCD Trip Time Test (150ms)			30mA	x1	1%	1	148	153
50.	ΔT	RCD Fault Voltage accuracy	Figure 10	AC	30mA	x1	+20%	-0%	12.0	14.4

***** When using the Fluke 189 in Fast Min/Max mode, the Max reading is displayed as peak value. Divide Max reading by 1.414, for "AC" type (F3). For "A" type (F3) divide Max reading by 1.414 and then by 2.0 for Step 40, or 1.4 for Steps 43 and 46.

Figure 9. RCD "I" Trip Accuracy Test

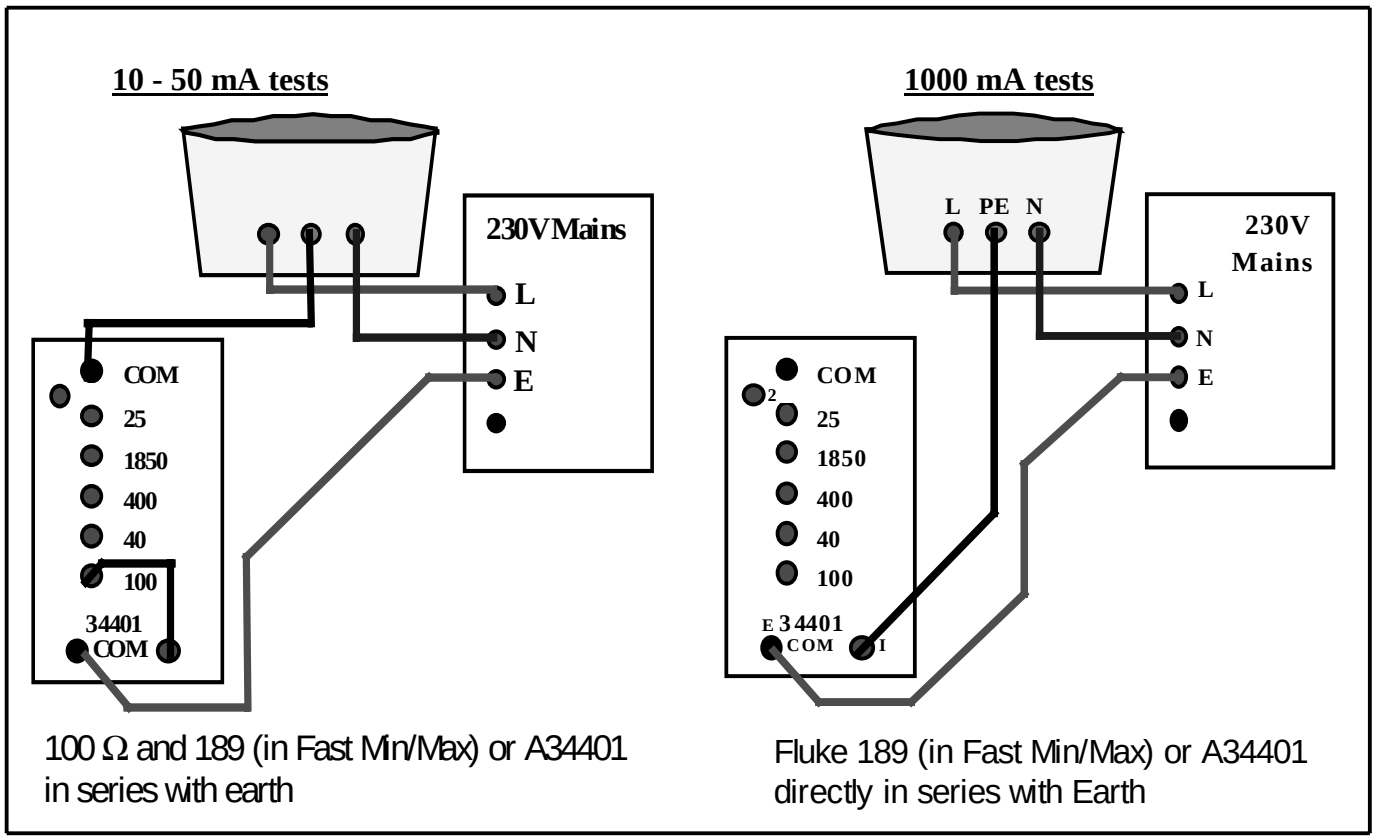
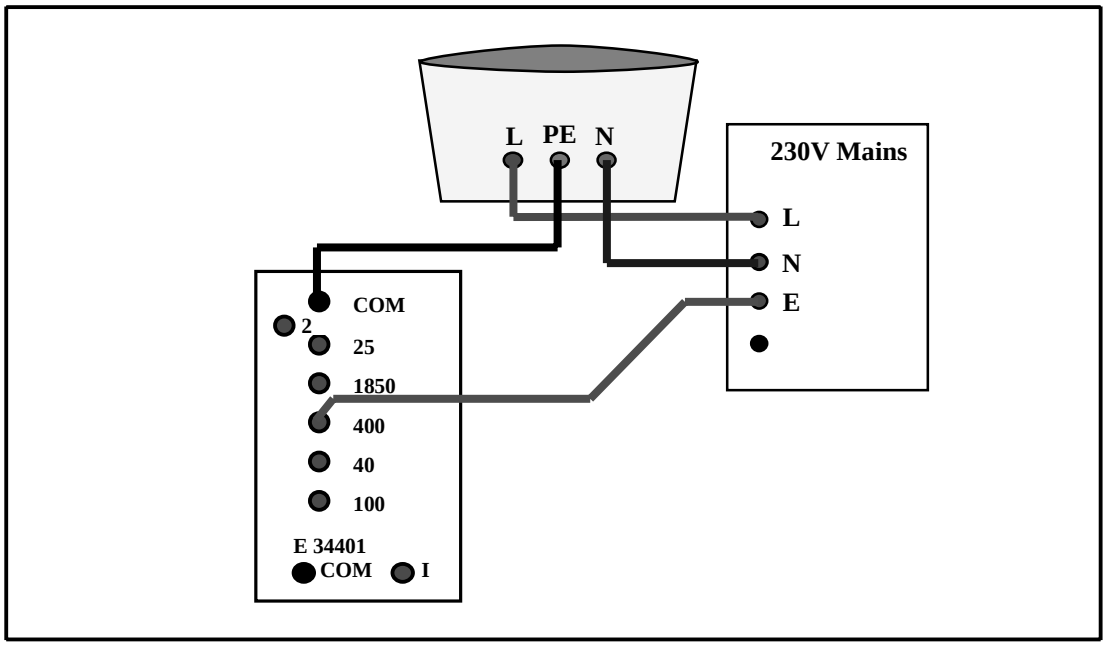


Figure 10. RCD Fault Voltage Accuracy Test



Earth Test (1653)

(Refer to figures for setup and connections)

Step	Function	Figure	R	Source	Spec.	Counts	Resolution	Display Reading	
								Lo Limit	Hi Limit
51.	**(RE) Earth**	Figure 11	2Ω	Decade R Box	2%	5	0.1	1.5	2.5
52.		Figure 11	2 Ω	Decade R Box	2%	5	0.1	1.5	2.5
53.		Figure 12	1800 Ω	Decade R Box	3.5%	10	1	1737	1863
54.		Figure 12	1800 Ω	Decade R Box	3.5%	10	1	1737	1863

Figure 11. Earth Test #1 (1653)

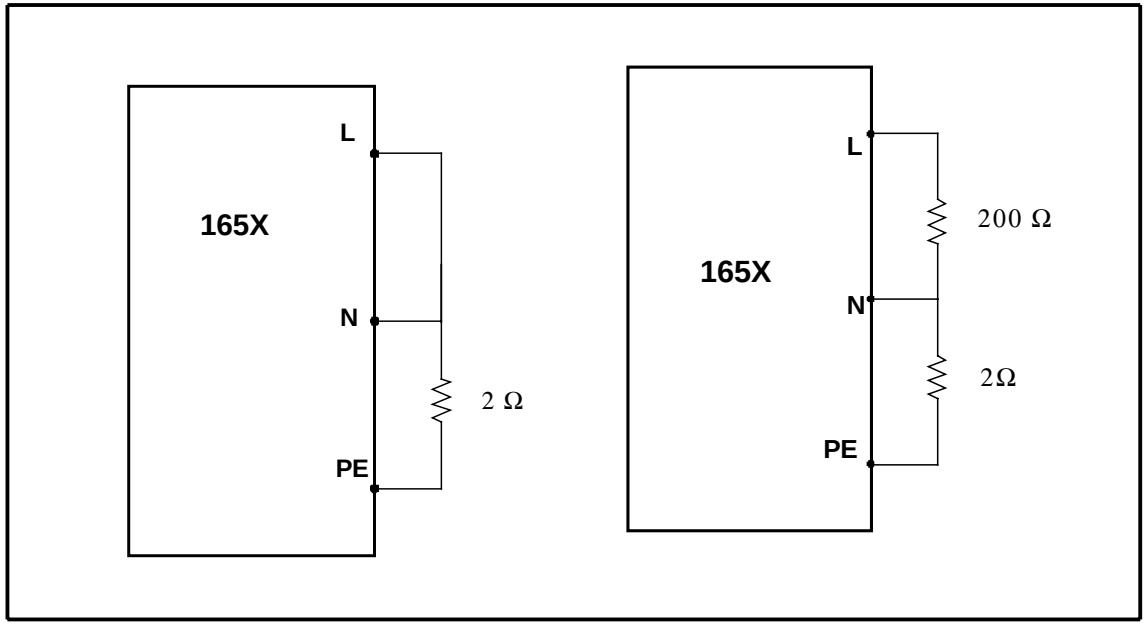
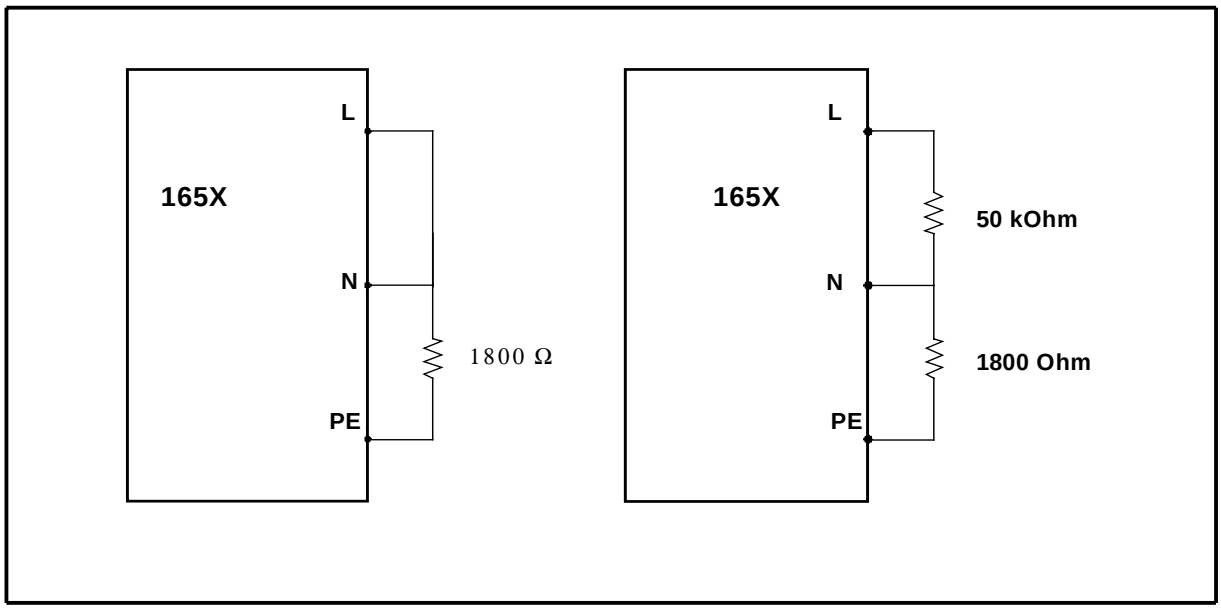


Figure 12. Earth Test #2 (1653)



Phase Leakage Test

(Refer to figures for setup and connections)

Step	Function	Figure	Source	Voltage	Current
55.	**Volts**	Figure 13	9100	270V, 50 Hz	<3.5 mA
56.	**Volts**	Figure 14	9100	270V, 50 Hz	<3.5 mA
57.	**Volts**	Figure 15	9100	270V, 50 Hz	<3.5 mA

Figure 13. Phase Leakage Test

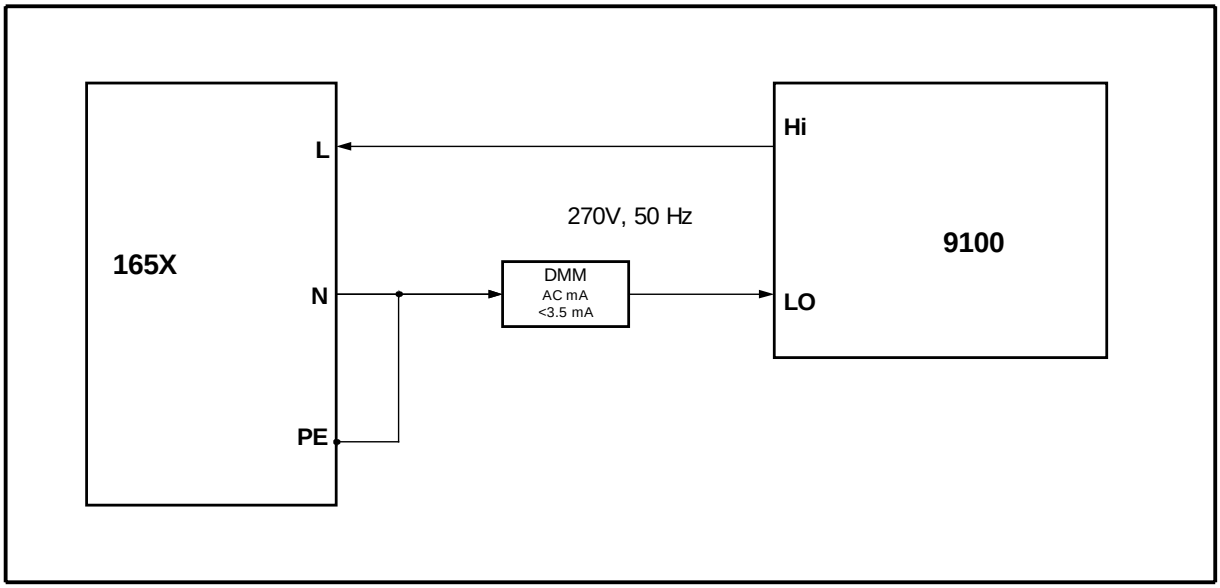


Figure 14. Phase Leakage Test

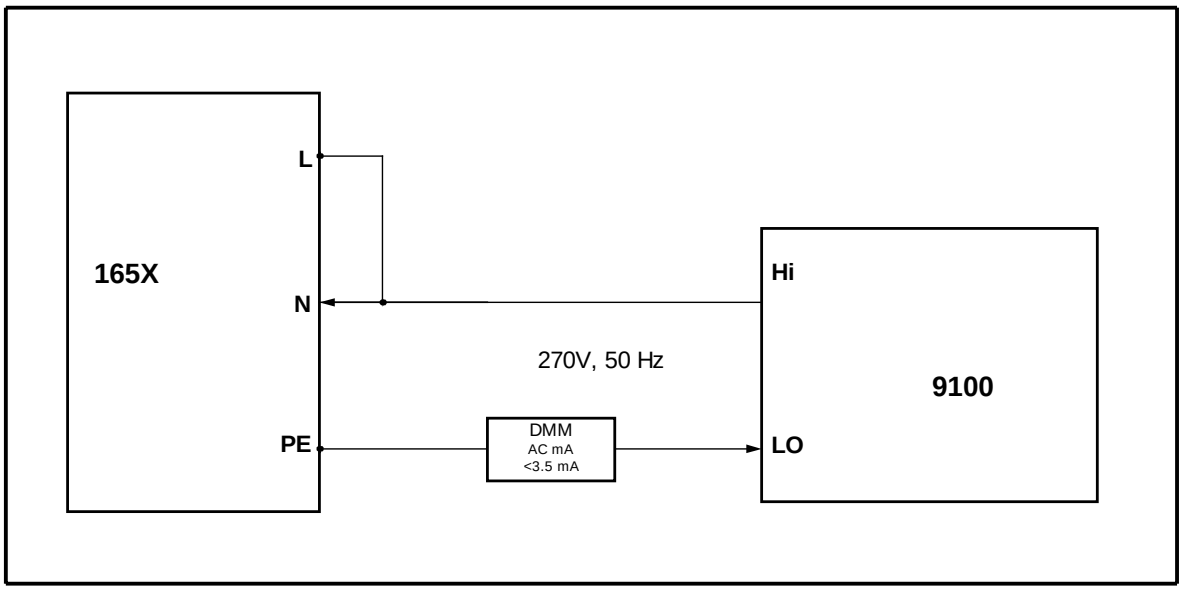
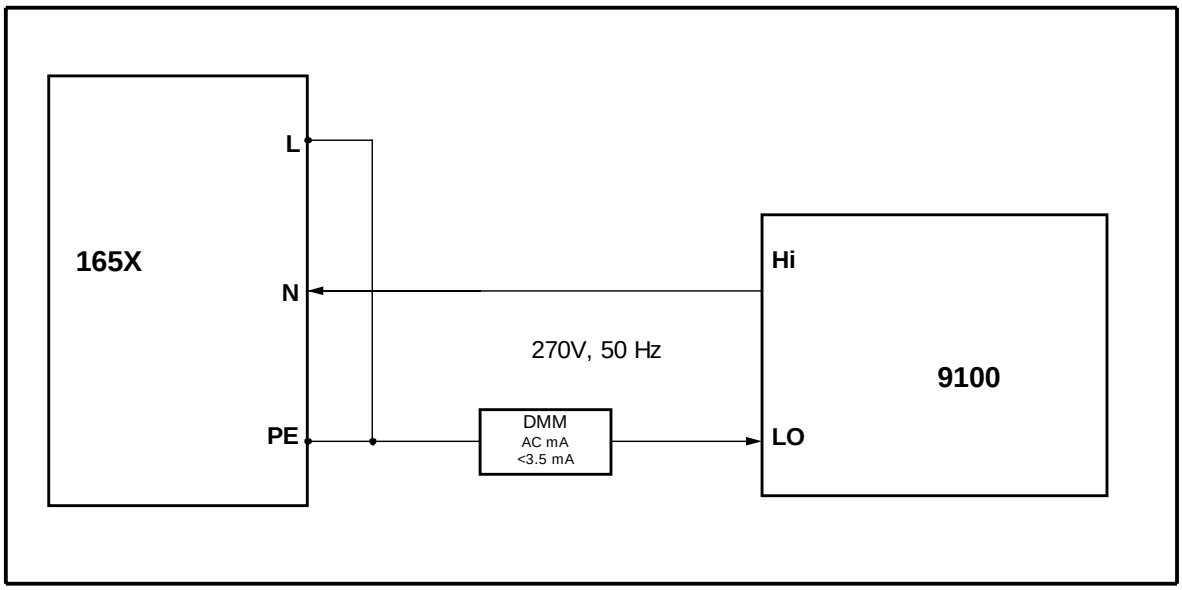


Figure 15. Phase Leakage Test



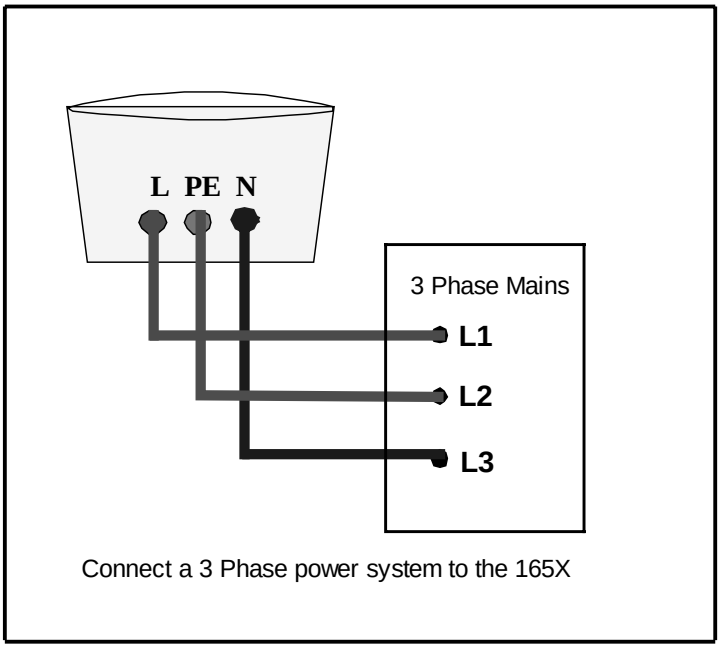
Phase Sequence Test (1653)

(Refer to figures for setup and connections)

Step	Function	Figure	Source	Voltage	Display
58.	Volts	Figure 16	*3 Phase voltage	230V, 50 Hz, 3 ∅	1,2,3

*Can use 3 each 5520As or equivalent that are synchronized

Figure 16. Phase Sequence Test (1652, 1653)



Fluke 1653
Circuit Descriptions

Revision: 1.0
September, 2003

Company Confidential

Fluke Corporation
Everett, Washington

Document Change Record

Revision	Date Revised	Change Description
1.0	September, 2003	Initial Version

Scope
The document contains descriptions of the circuits of the Fluke 165X series of Installation Testers. Except for the digital board, these circuits will be discussed in relation to the main functions of the instrument. This document is intended to be used in conjunction with a set of colored schematics (Fluke 1653 Circuit Descriptions.pdf) which highlight the circuits being discussed.

Purpose
This document is intended as an aid in understanding and trouble-shooting these instruments. It is not intended to be a tutorial on measurement techniques or tester capabilities.

Overview
Each member of the Fluke 165X family contains three circuit boards, one digital and two analog. There are two microprocessors, one on the digital board and one on the analog 2 board. The digital board microprocessor is the instrument master. It performs all user interface functions and controls testing by communicating with the analog processor. The analog processor controls the hardware and runs the tests as commanded by the digital processor. There is one 20-pin cable connecting the digital board to analog board 2 and two 20-pin cables connecting analog board 2 to analog board 1.

Digital Board
The digital board contains the following functional blocks.

- Keypad: The keypad is a conductive rubber keypad with pull-up resistors
- Rotary Switch: The rotary switch block consists of switch-on-board, pull-ups and an encoder. No analog signals are switched.
- IR Port: These are the standard circuits used in other Fluke meters.
- EEPROM: This is the memory for the saved measurements of the 1653.
- Touchpad: This circuit is capacitively coupled via W101 and W102 to a metal plate surrounding the TEST key on the front panel. It's function is to measure the potential of the user relative to the earth jack and if greater than 90V light LED DS103 on the front panel.
- Beeper: This circuit is self-explanatory.
- Backlight: This circuit is self-explanatory.
- JTAG/Flash port: This connector can be used to reprogram the microprocessor.
- Microprocessor: This unit is flash based with built-in LCD drivers.
- LCD: 4 backplanes and 137 segments

Remote Test
Included with Kryten is a probe with a remote TEST switch. This probe plugs into the line jack and the switch connector on the front of Kryten. This remote TEST key has the same function as the TEST key on the front panel. The circuitry on analog board 1 performs the functions of ESD protection and signal filtering. The node labeled REMOTE connects to the analog processor.

Relay Drive
The relay drive circuitry is on analog board 1. U1 is a 5V voltage regulator supplying power for the relay coils. All drive signals originate from the analog processor and are buffered by Q5-Q8.

Jack Detect
While all jacks are split jacks, only line and earth have detection circuits. The detection circuitry is isolated from the jacks by transformers T2 and T3. The signal JOSC from the analog processor causes the transistor to turn on when no test lead is plugged in. This results in a logic 0 at the output (JPD or JED). With a lead plugged in, the transistor does not turn on and the output will be a logic 1.

Volts
Each of the three inputs has 3 Megohm input impedance. The resistors comprising the high end of the divider are on analog board 1. The low end of the dividers, the switches to select the gain settings and output buffers are on analog board 2. Earth and neutral channels have 8V, 25V and 750V ranges. Line has an additional 1200V range for insulation test. All ranges except the 1200V are referenced to VREF/2 to allow bipolar measurements with the unipolar A/D. The outputs of the three buffers along with the insulation test current measurement channel are muxed into a buffer amp which feeds the A/D.

Insulation
The insulation test measures high values of resistance by sourcing a specified DC voltage out the line jack and measuring the return current into the earth jack. Voltage is constantly monitored at the line jack both to guarantee correct resistance measurements and to display the actual output voltage. The high voltage inverter is located on analog board 1. Its on/off state is controlled by the analog processor and its output voltage is controlled by the DAC on analog board 2 which is controlled by the analog processor. The HV circuit uses RT3, R49 and Q14 to discharge the load. Current measurement is accomplished with R366 and the following gain stage with four selectable gains.

DAC
The DAC located on analog board 2 not only controls the HV inverter by also the current source used for continuity, loop resistance L-PE and earth tests and the active load for RCD tests.

Continuity
Continuity forces a DC current out the line jack, measures the resulting voltage at the jack and computes the resistance. There is a clamp circuit on analog board 1 which protects the current source from over-voltages when it is not in use. The current source itself is on analog board 2. It has two ranges. It receives power from voltage boost circuit also on analog board 2 which has two output levels; 8V and 24V. The 8V output is used for continuity due to the 200mA current requirement. The 24V level is used in the other functions to provide more compliance voltage.

Loop L-N
The two wire loop impedance test consists of voltage measurement pairs of unloaded and loaded line voltage. This is done via the L and N jacks and can be phase to neutral, phase to earth or phase to phase. The load is 20 Ohms for ½ cycle at a time. This loading is controlled by the processor turning on SCR1. The gate drive of the SCR is isolated by transformer T4 so that the tester can perform loop tests on phase to phase or swapped L and N configurations. Depending on line noise, from two to ten of these measurement pairs occur about 100ms apart to generate one impedance value. Due to the power dissipated, resistors R9 and R10 can become very hot. To prevent overheating, two thermistors, one under each resistor, are used in redundant temperature measurement system. Metal clips are used to both fix the height of the resistors above the thermistors and to ensure the resistors cannot come off the board if overheating occurs to the point that the solder melts. The voltage at each thermistor is monitored independently by the analog processor. This data is used to inhibit testing when the temperature limit is reached. When the tester cools down, testing is re-enabled.

Loop L-PE
To measure loop impedance L-PE, a three wire configuration is used. First, the L-N measurement is performed. Next, the continuity current source is used to force a 50mA peak sine wave in the neutral – earth loop to calculate the resistance of this loop. Then, the L-PE impedance can be calculated. The N-PE current takes about one second per cycle to not trip RCDs.

RCD trip time & trip current
Both types of RCD tests use the same circuitry. All three input jacks are involved as well as the RCD active load located on analog board 1. This circuit is controlled by the DAC and generates a sine (for type AC RCDs) or half-wave rectified (for type A RCDs) sine wave current load o specified value from L to PE. There are two current ranges switched with Q19. The four output transistors operate in parallel and are

mounted on a 50g heat sink. The heat sink mounts to the circuit board and has a cavity in its bottom surrounding thermistor RT4 which monitors the heat sink temperature. Testing is inhibited when the temperature limit is reached.

Earth

Earth resistance testing uses the three in jacks and the continuity current source. The current source generates a 128Hz square wave which is sourced out the L jack and returns through the PE jack (connected to the earth rod under test). The neutral jack is used as a voltage sense. 128Hz was chosen to reject 50, 60, 400 and 16 2/3 Hz frequencies. Knowing the value of the current and measuring the voltages at N and PE, the resistance can be calculated.

Phase Sequence

Phase sequence uses the same hardware as volts measurement. Phasing is calculated in software.

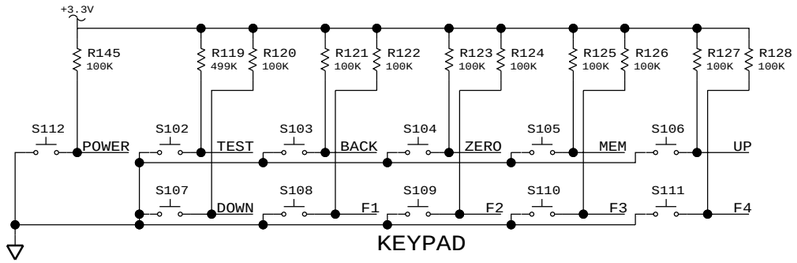
DWG NO.	SH
FLUKE-16XX-1001	1

REVISIONS

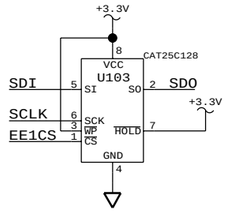
REV	DESCRIPTION	DRAWN
008	W1035959	JH 26JUN03

NO LOAD PARTS
P101

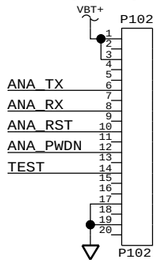
KEYPAD



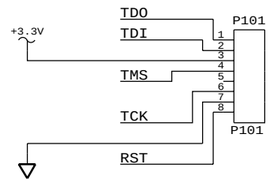
EEPROM



ANALOG BOARD CONN



JTAG/FLASH PORT



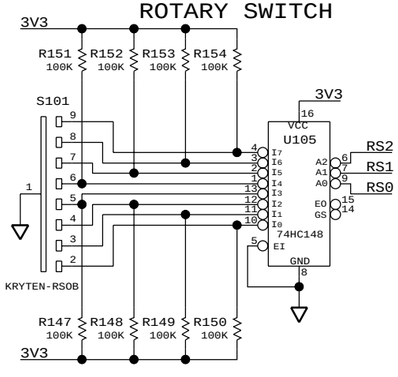
LCD DISPLAY

U104
KRYTEN-LCD

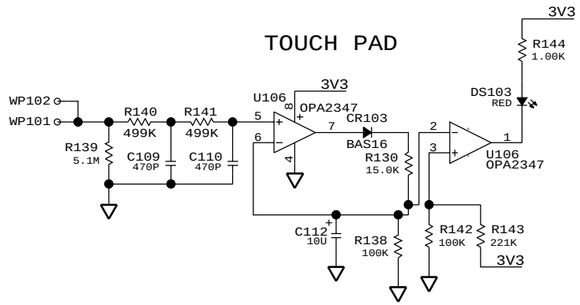
COM1	1	COM1	---	---	---
COM2	2	---	COM2	---	---
COM3	3	---	---	COM3	---
COM4	4	---	---	---	COM4
1	5	S53	S55	S57	S58
2	6	S52	S54	S56	S59
3	7	---	---	---	S60
4	8	S46	S63	S64	---
5	9	S61	S62	S66	S47
6	10	---	S65	---	S48
7	11	5F	5G	5E	S49
8	12	5A	5B	5C	5D
9	13	6F	6G	6E	S49A
10	14	6A	6B	6C	6D
11	15	7F	7G	7E	P3
12	16	7A	7B	7C	7D
13	17	8F	8G	8E	P4
14	18	8A	8B	8C	8D
15	19	---	S70	S69	S72
16	20	S67	S68	---	S71
17	21	S50	S51	---	S45
18	22	S39	S40	S37	S38
19	23	---	S24	S28	S36
20	24	---	S26	S25	S27
21	25	---	---	---	---
22	26	S22	S23	---	---
23	27	S20	S21	---	---
32	28	4A	4B	4C	4D
31	29	4F	4G	4E	P2
30	30	3A	3B	3C	3D
29	31	3F	3G	3E	P1
28	32	2A	2B	2C	2D
27	33	2F	2G	2E	---
26	34	1A	1B	1C	1D
25	35	1F	1G	1D	---
24	36	S19	S18	CIR3	---
33	37	S17	S16	CIR2	S13
34	38	S15	S14	CIR1	---
35	39	S6	S12	S34	S35
36	40	S5	S4	S3	S1
37	41	S8	S7A	S7	S2
38	42	S11	S10	S9	S29
39	43	S33	S32	S31	S30
40	44	S42	S43	S44	S41
COM1	45	COM1	---	---	---
COM2	46	---	COM2	---	---
COM3	47	---	---	COM3	---
COM4	48	---	---	---	COM4

LCD<1..40>

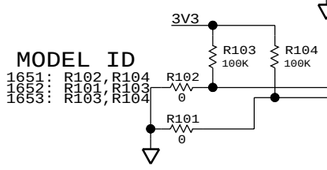
ROTARY SWITCH



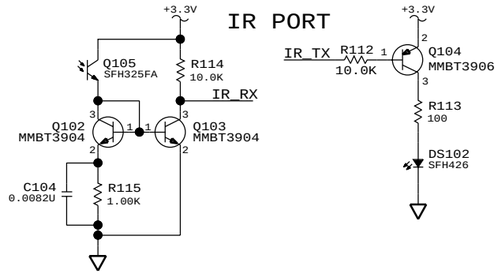
TOUCH PAD



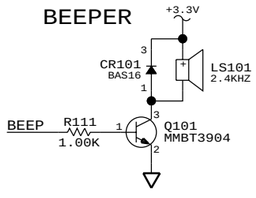
MODEL ID



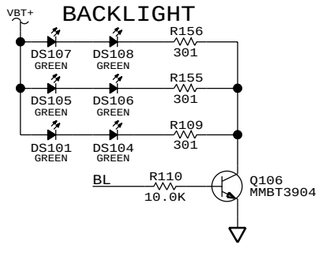
IR PORT



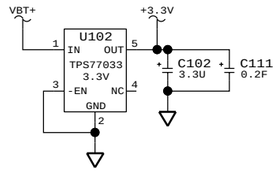
BEEPER



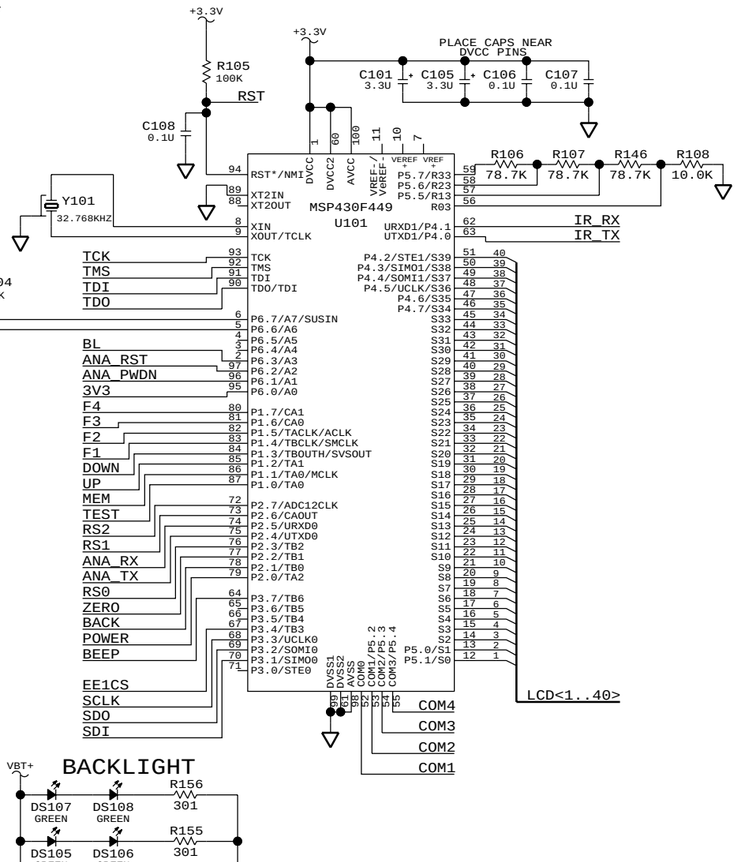
BACKLIGHT



POWER SUPPLY



MSP430F449 (U101)



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89536 DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED
TOLERANCE
.XX = +/-
.XXX = +/-
ANGLES=+/-
DIMENSIONS IN INCHES
XC =

DWN	JCH	18APR03
CHK		
PROJ ENGR		
MFG ENGR		
FINISH		

SCHEMATIC,
DIGITAL BOARD

PART NO.	SIZE	DRAWING NO.
	D	FLUKE-16XX-1001
SCALE	SH 1 OF 1	REV 008

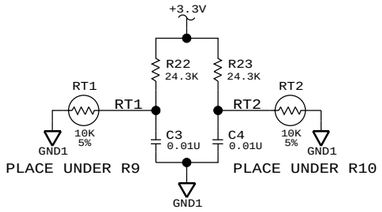
PROPRIETARY

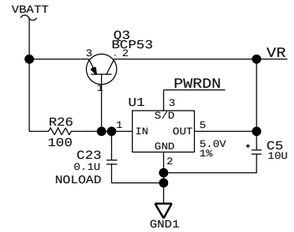
DWG NO. FLUKE-16XX-1002 SH 2

REVISIONS

SEE SHEET 1 FOR REVISIONS

POWER RES THERMISTORS





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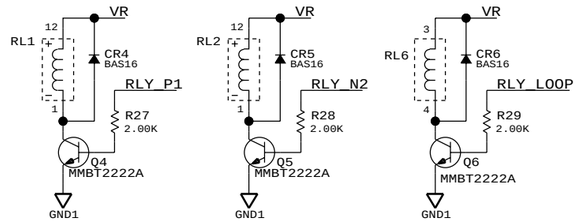

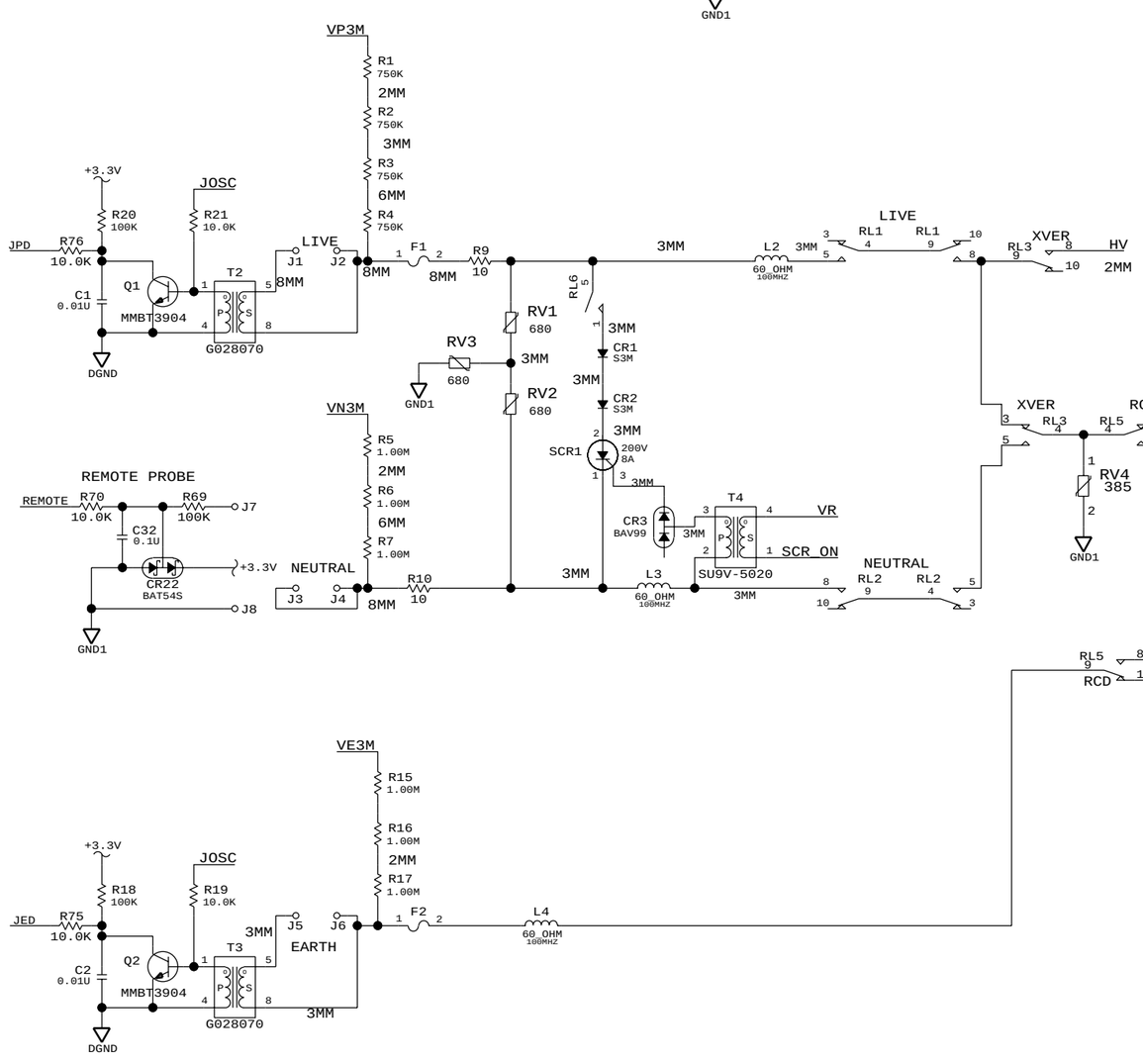

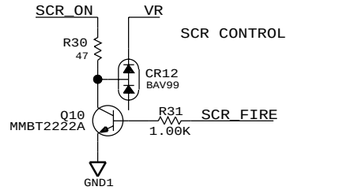

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SCHEMATIC, ANALOG BOARD 1

PART NO.	SIZE	DRAWING NO.
	D	FLUKE-16XX-1002
SCALE	SH 2 OF 3	REV 012

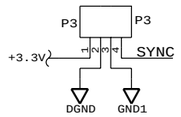
PROPRIETARY

DWG NO.	SH
FLUKE-16XX-1002	3

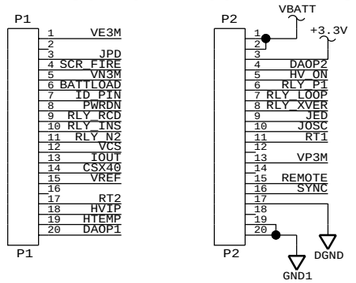
REVISIONS

SEE SHEET 1 FOR REVISIONS

CAL CONNECTOR



ANALOG BOARD CONNECTORS



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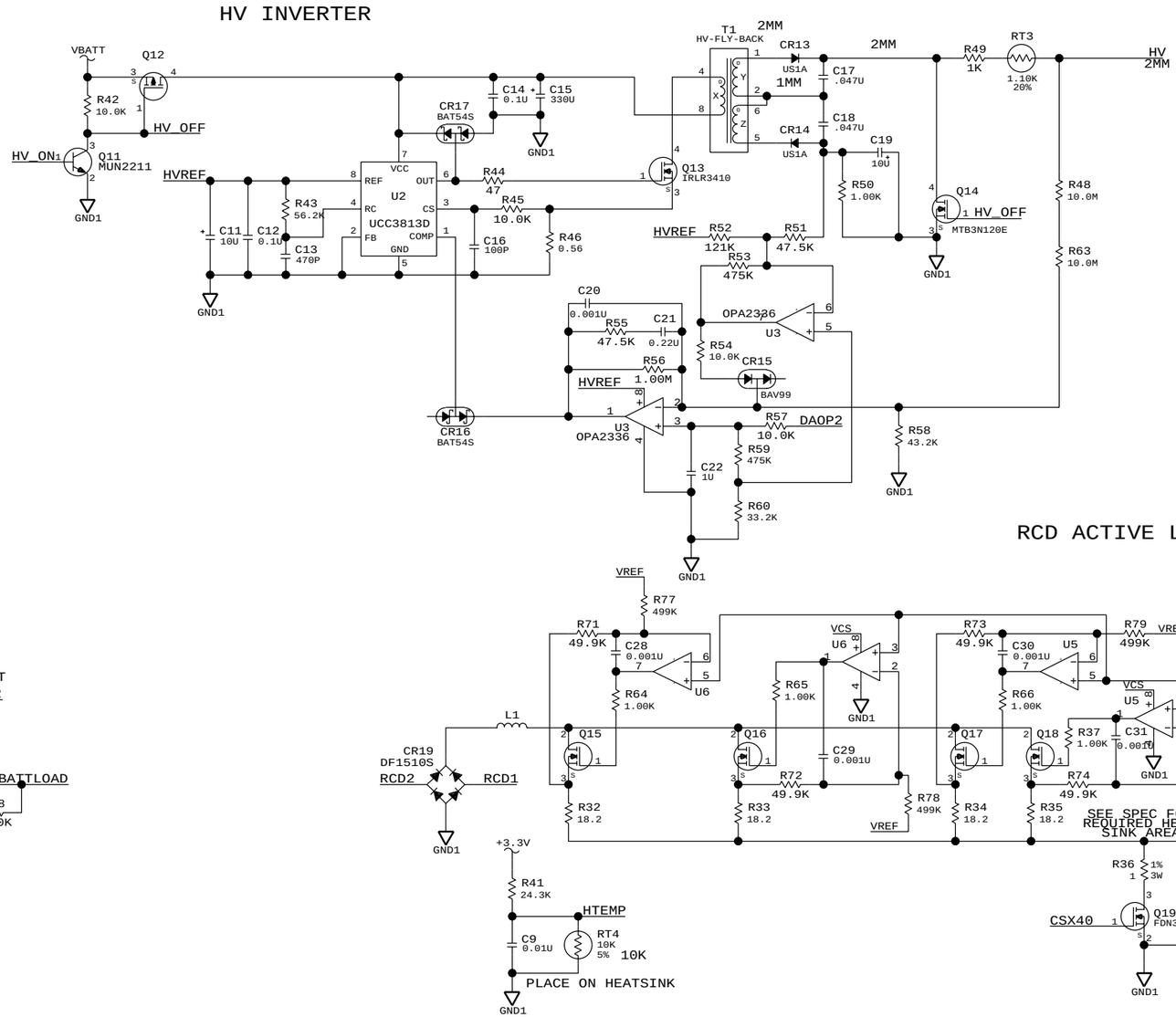

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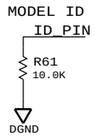

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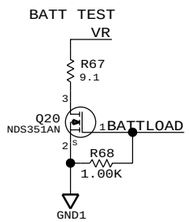

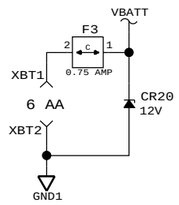

HEATSINK HARDWARE

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MP6	SCREW	M3X0.5X8	2089239	
MP7	SCREW	M3X0.5X8	2089239	
MP8	SPRING-CLIP	GULLWING	2075096	
MP9	SPRING-CLIP	GULLWING	2075096	

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SCHEMATIC, ANALOG BOARD 1

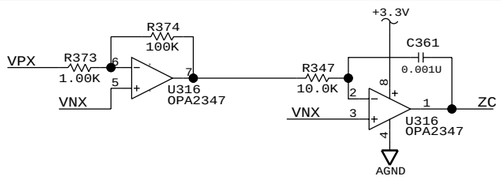
PART NO.	SIZE	DRAWING NO.
	D	FLUKE-16XX-1002
SCALE	SH 3 OF 3	REV 012

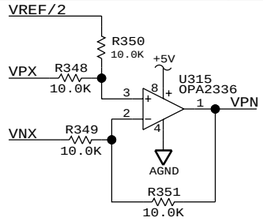
PROPRIETARY

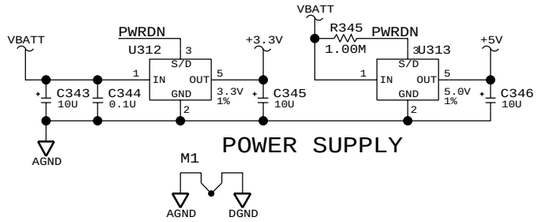
REVISIONS

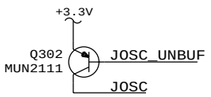
SEE SHEET 1 FOR REVISIONS

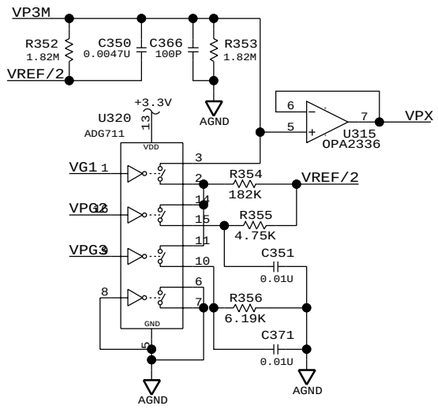
VOLTAGE MEASUREMENT

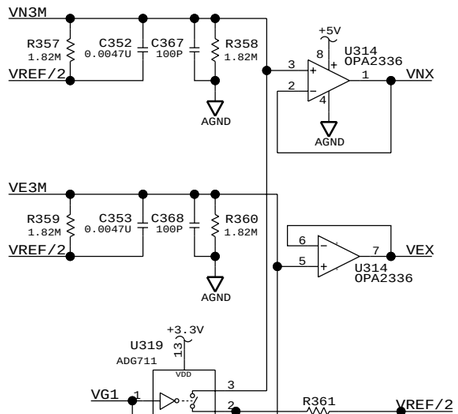


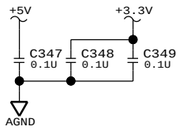


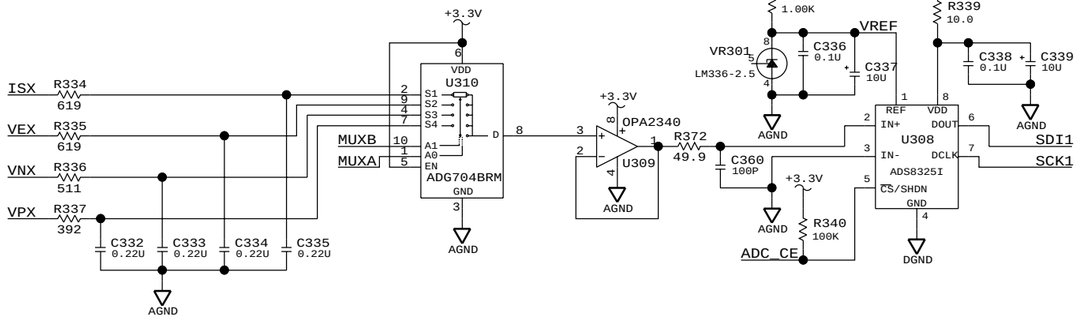












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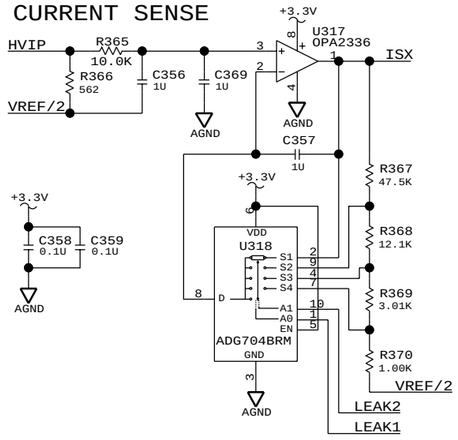

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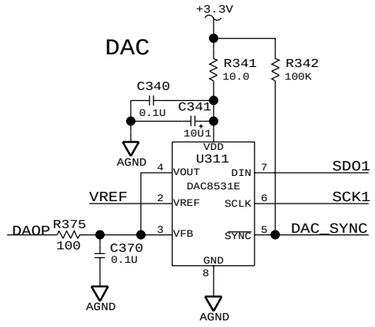

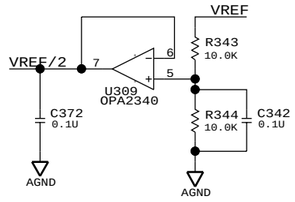

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89536	DO NOT SCALE DRAWING

SCHEMATIC,
ANALOG BOARD 2

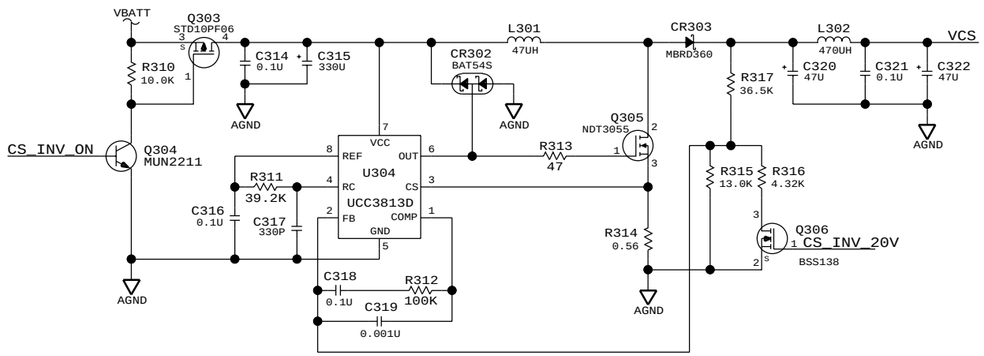
PART NO.	SIZE	DRAWING NO.
	D	FLUKE-16XX-1003
SCALE	SH 2 OF 3	REV ~~007~~

PROPRIETARY

REVISIONS

SEE SHEET 1 FOR REVISIONS

CURRENT SOURCE POWER SUPPLY



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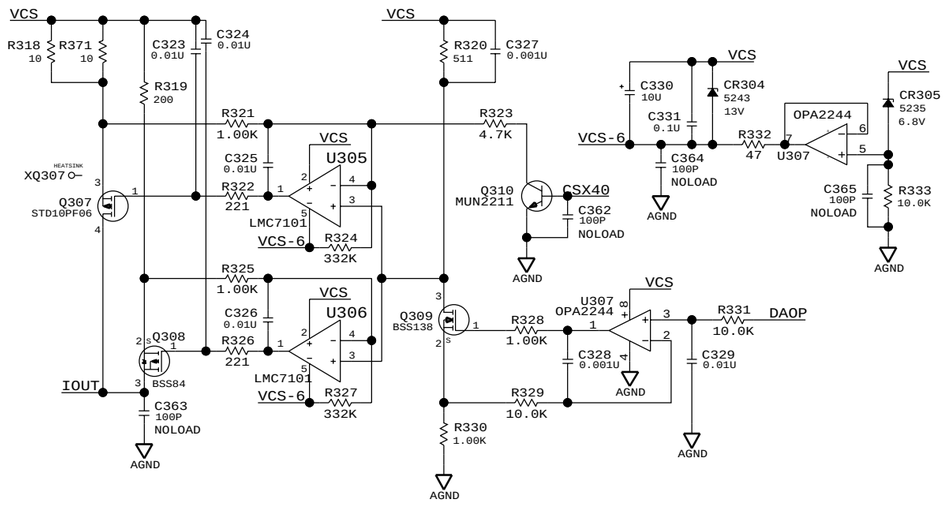

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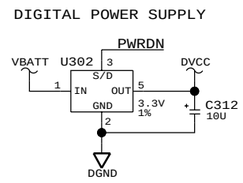

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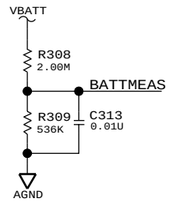
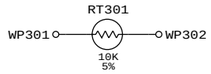
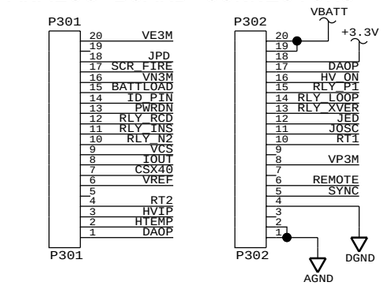


MODEL ID

RT301



ANALOG BOARD CONNECTORS



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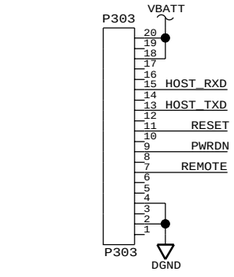
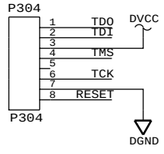


JTAG/FLASH



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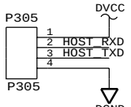

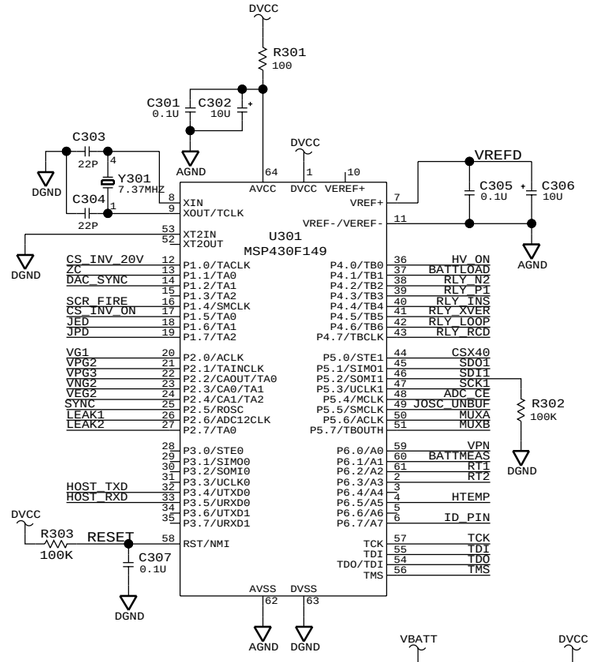

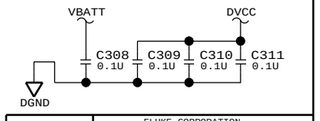

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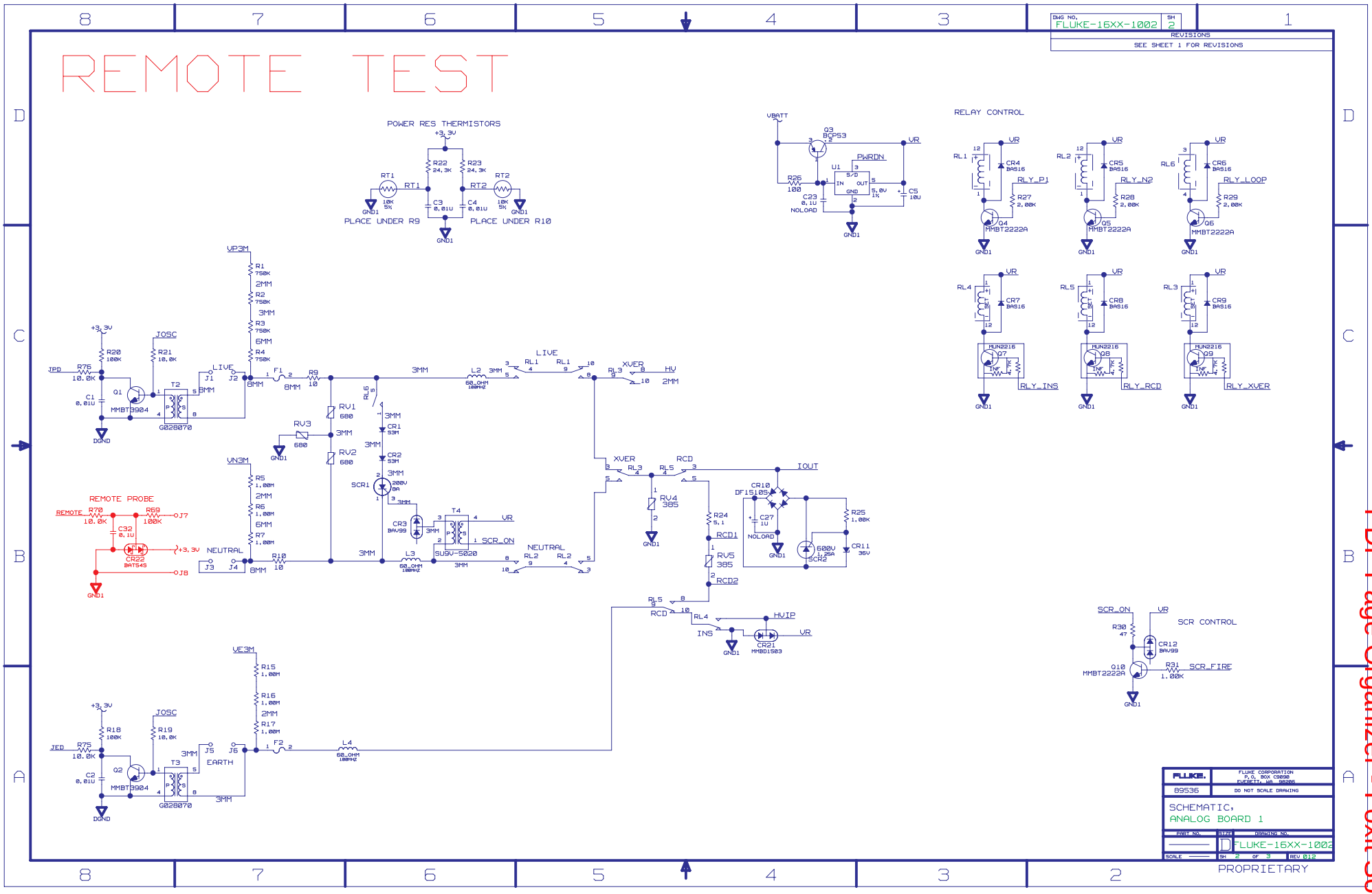
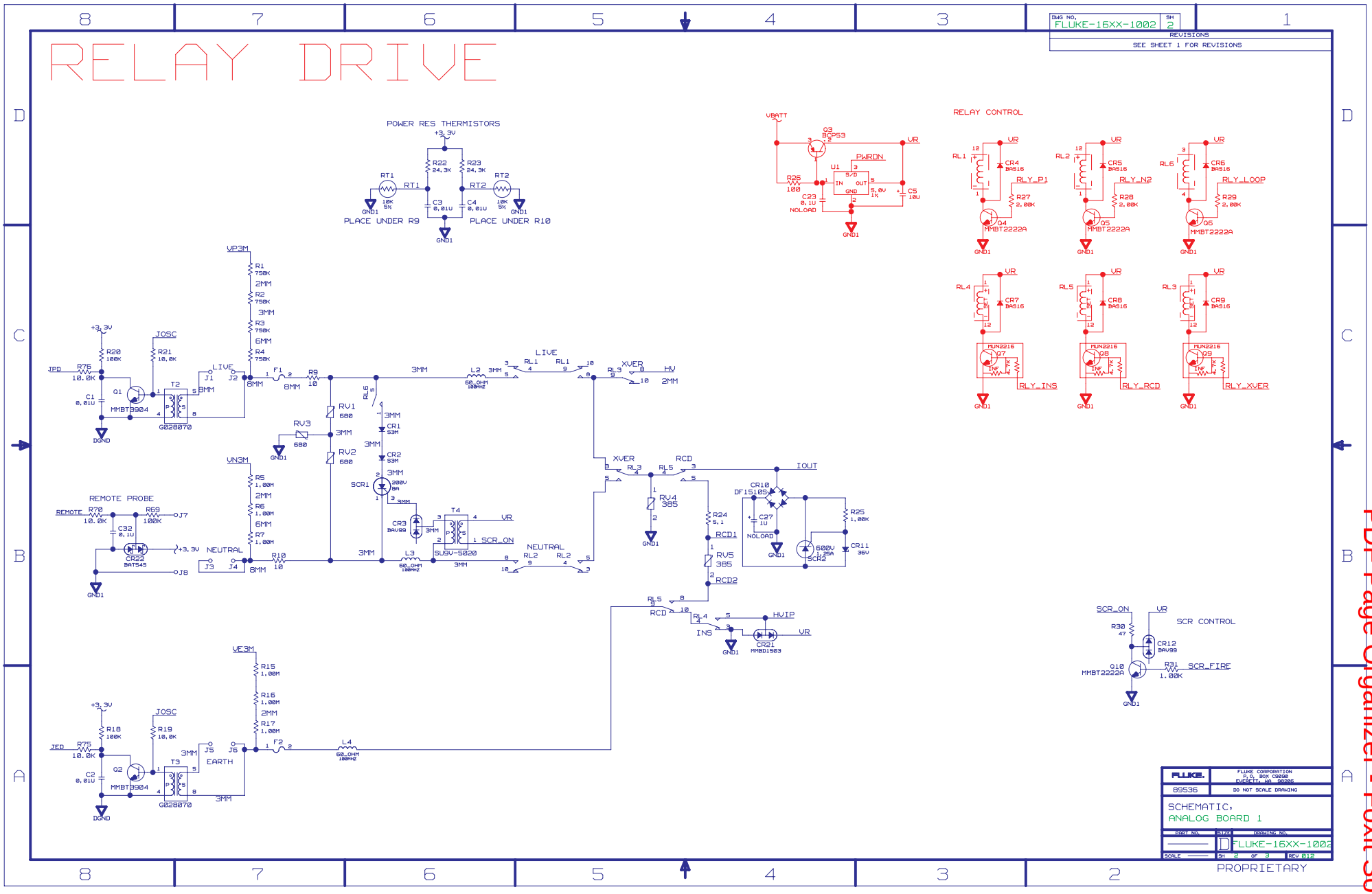
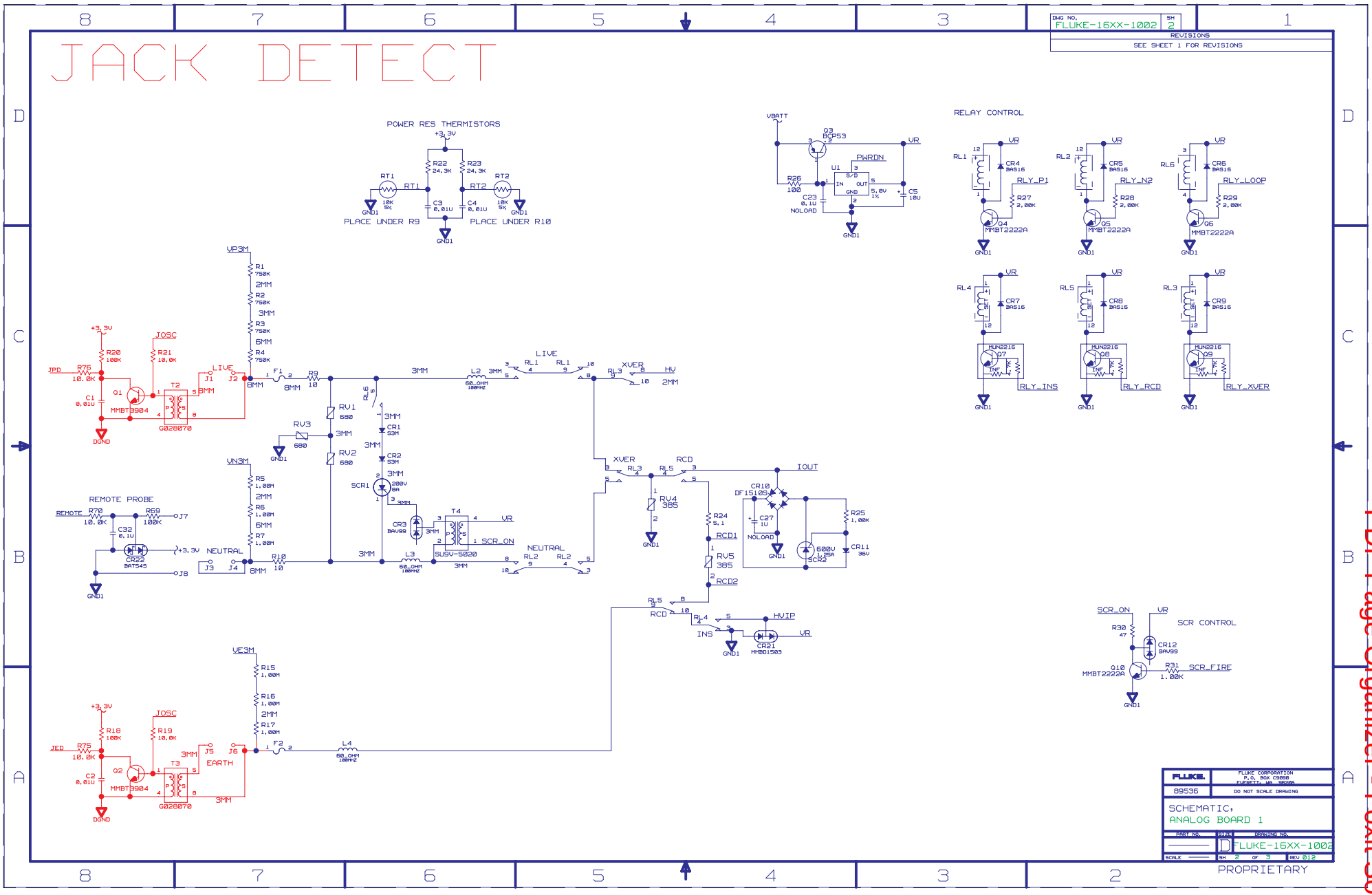
SCHEMATIC,
ANALOG BOARD 2

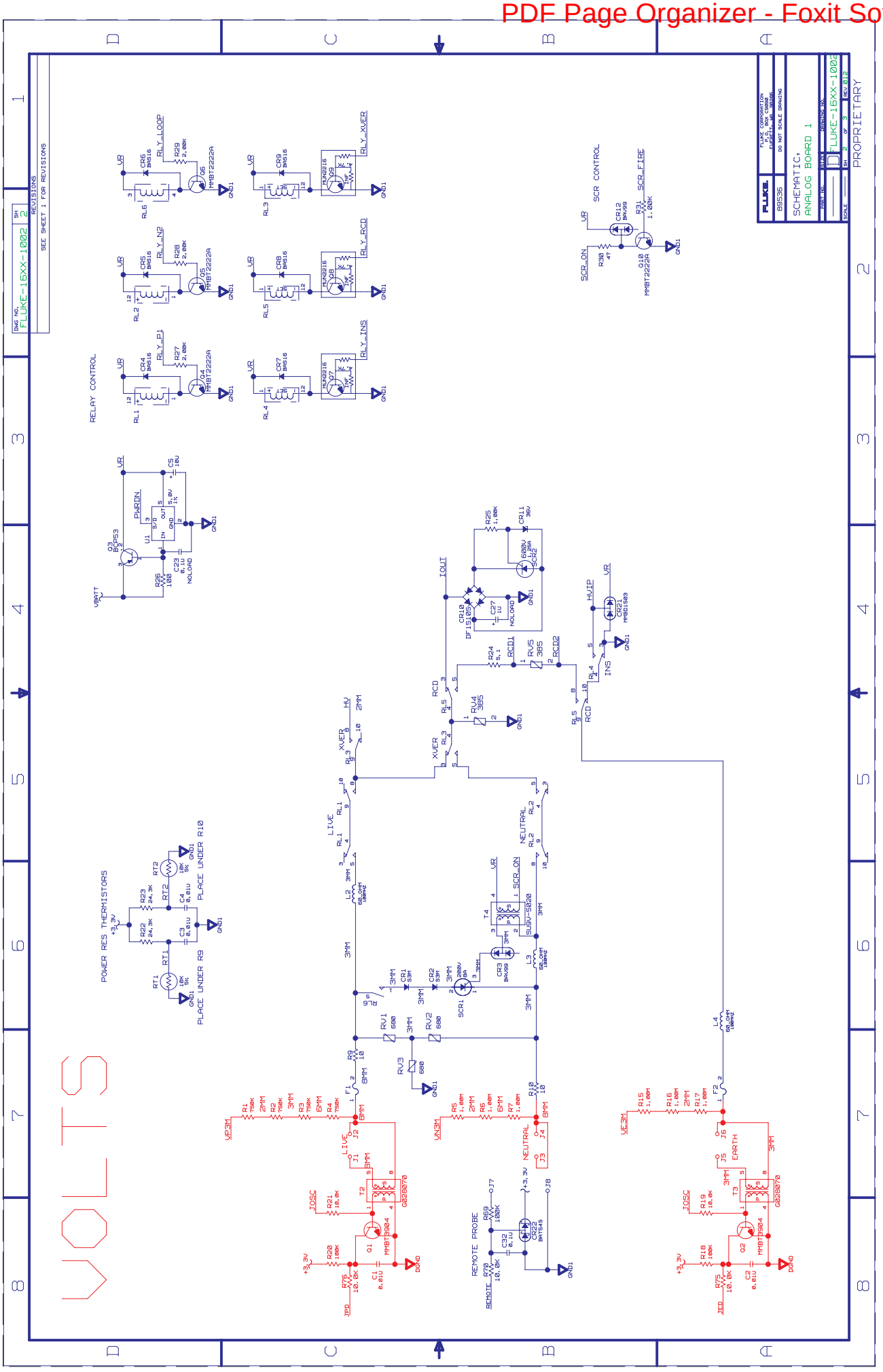
PART NO.	SIZE	DRAWING NO.
———	D	FLUKE-16XX-1003
SCALE ———	SH 3 OF 3	REV 007

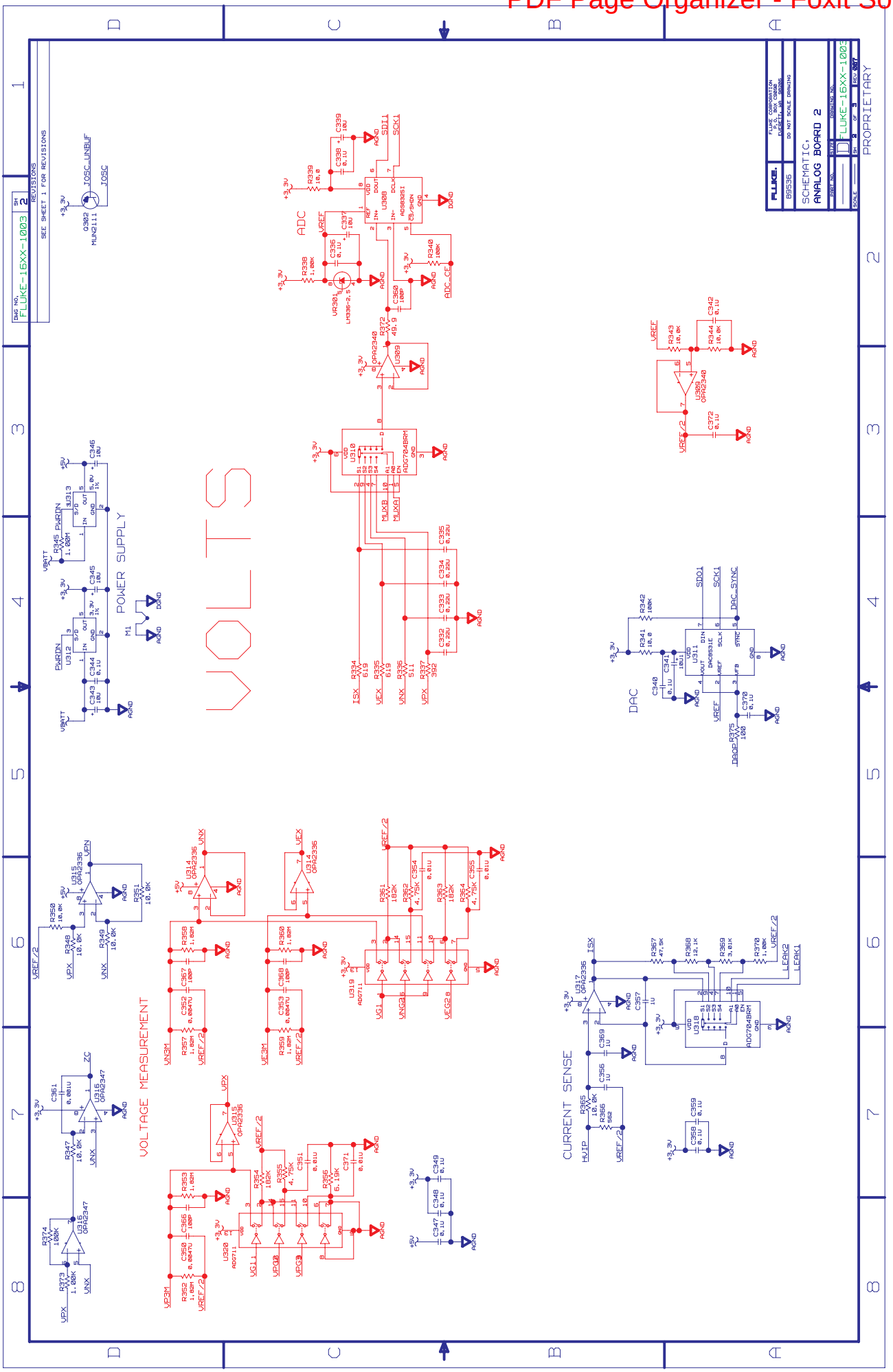
PROPRIETARY

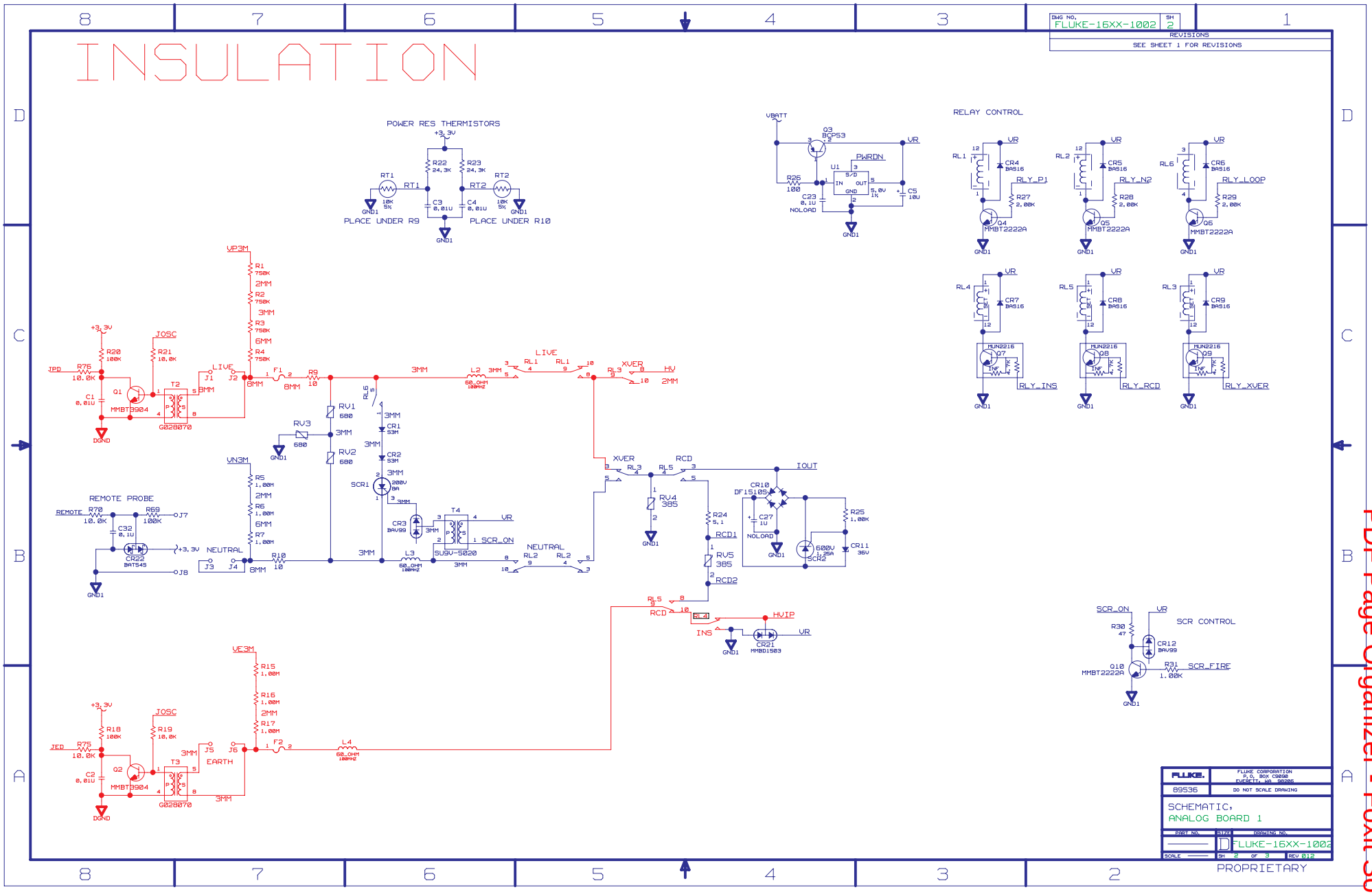


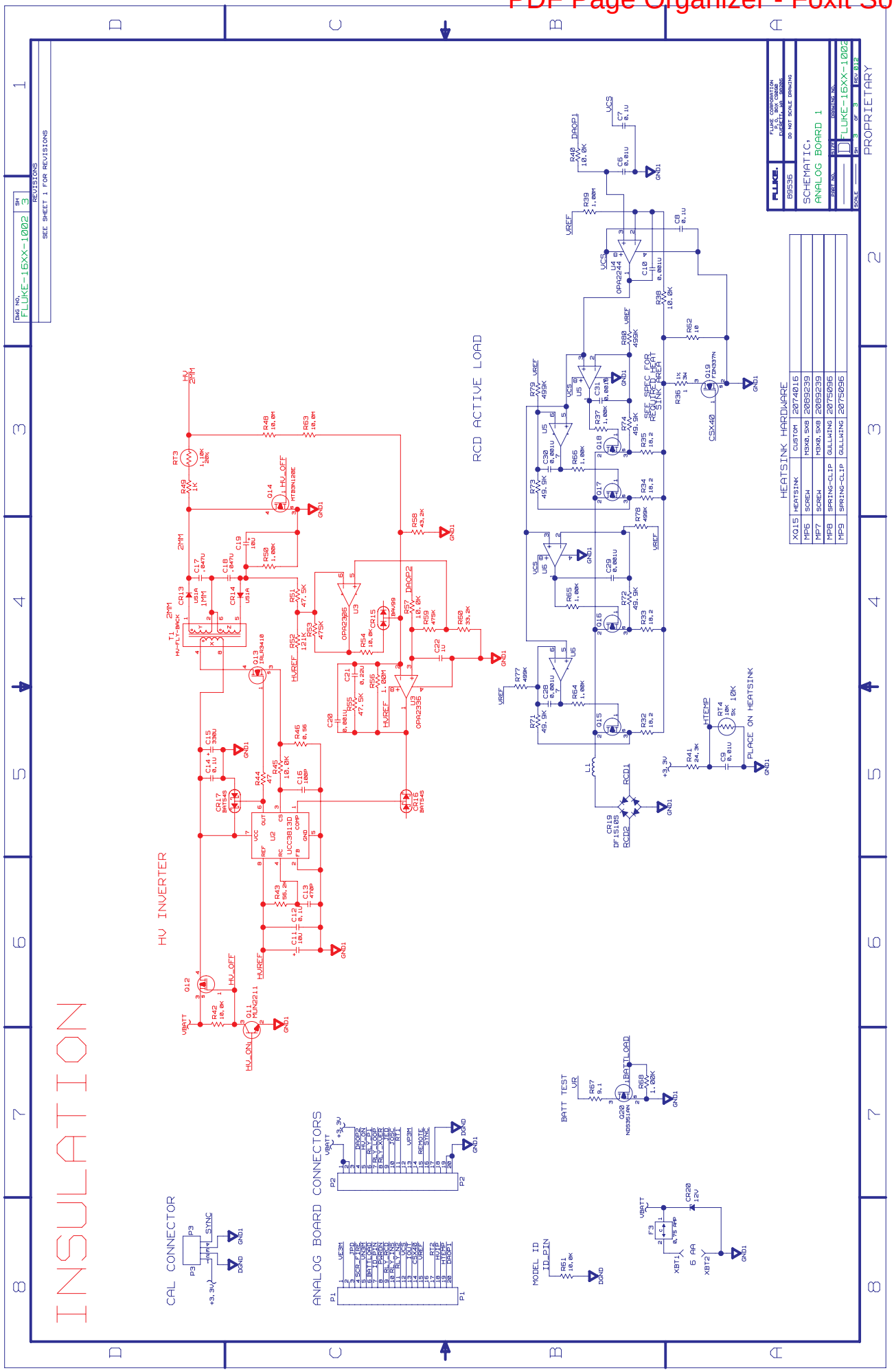


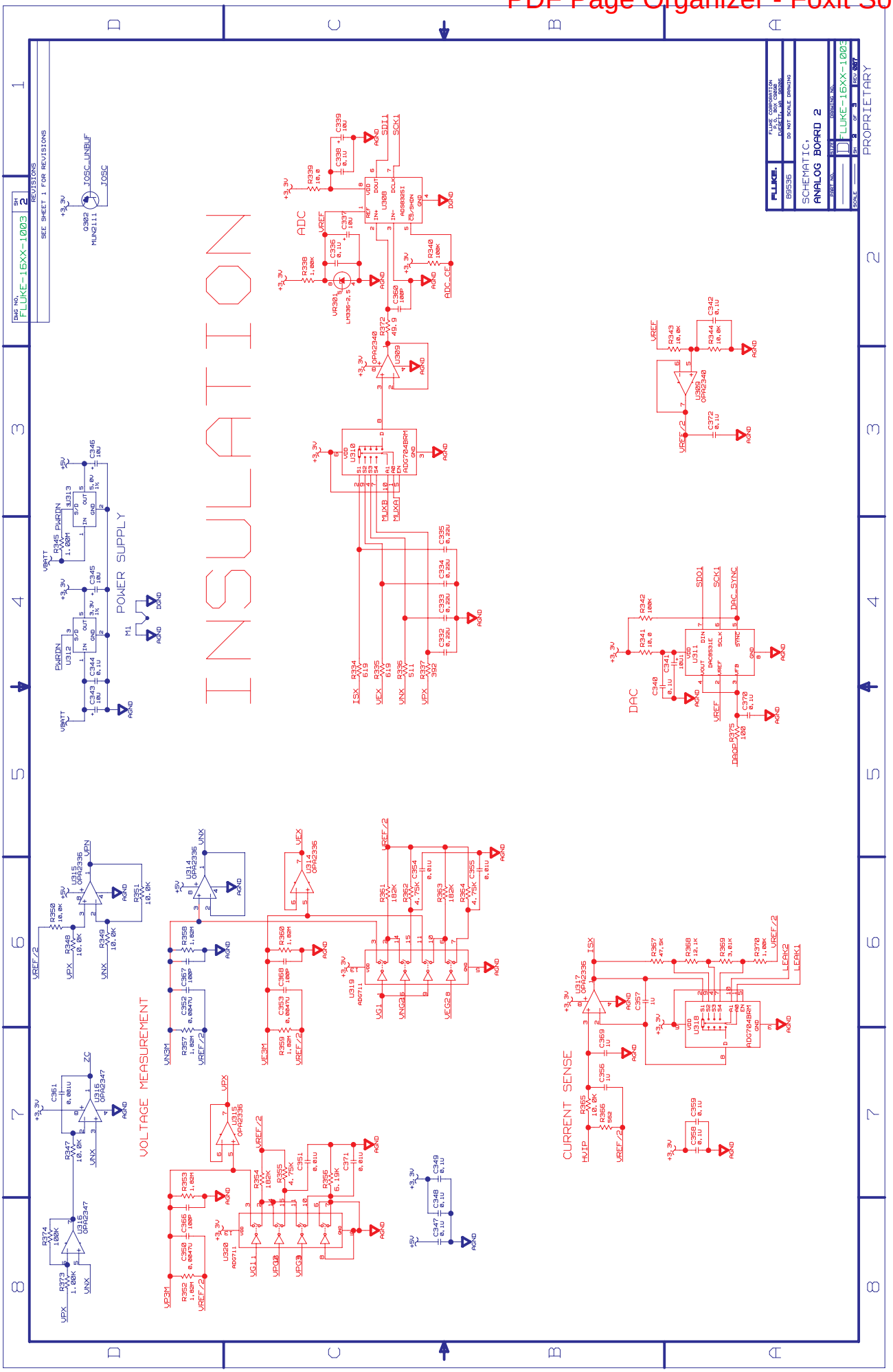


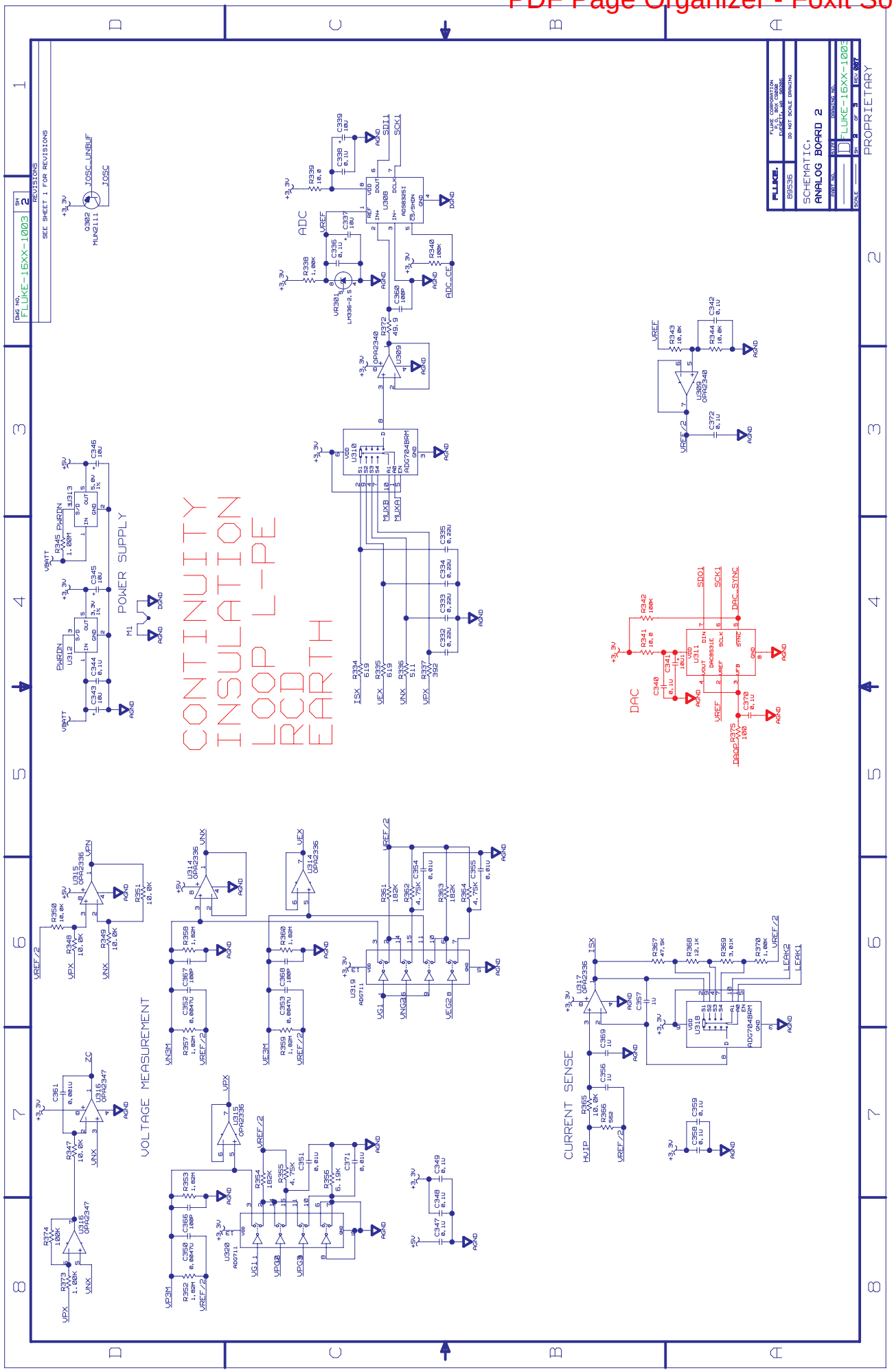


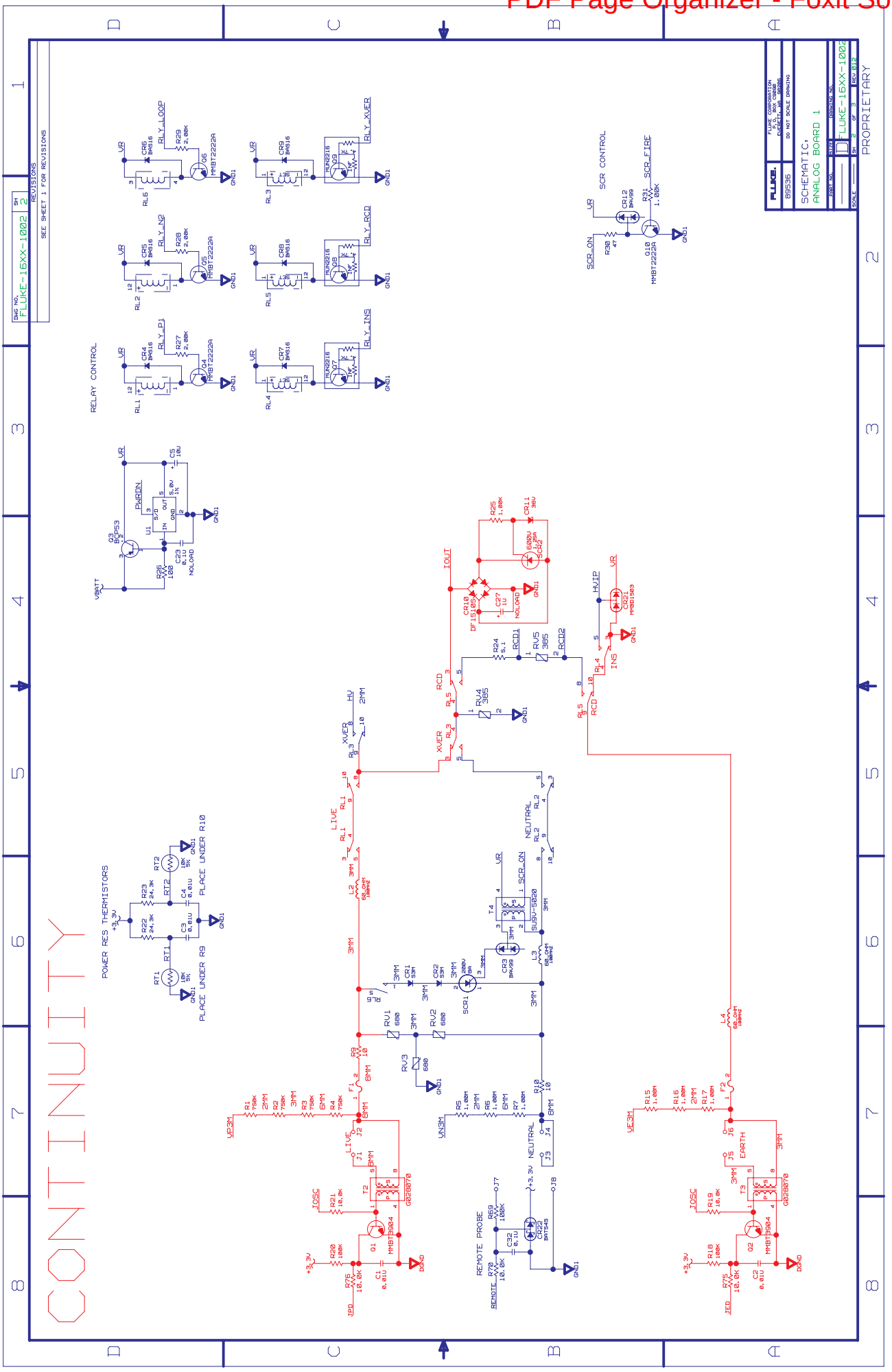


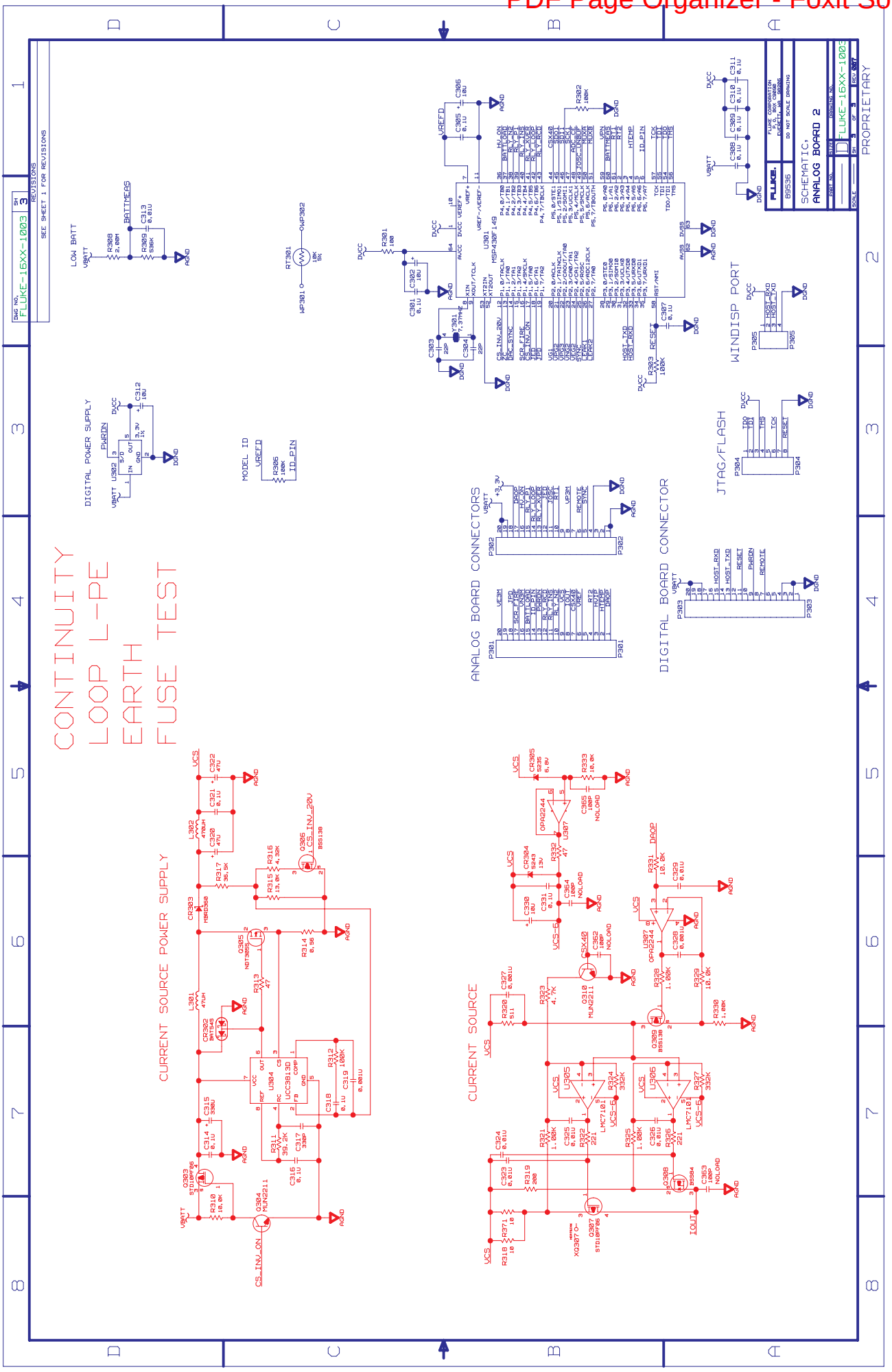


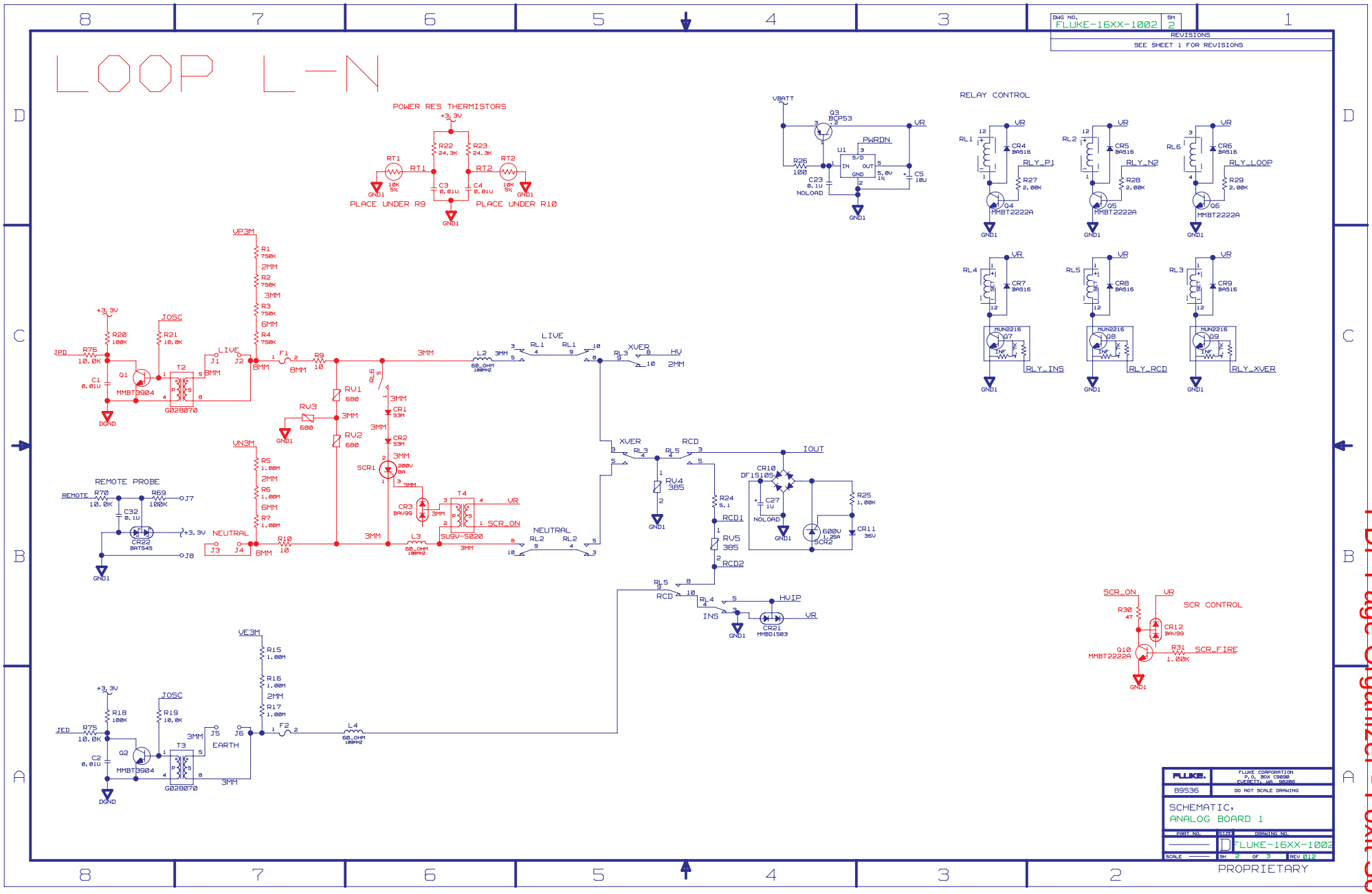


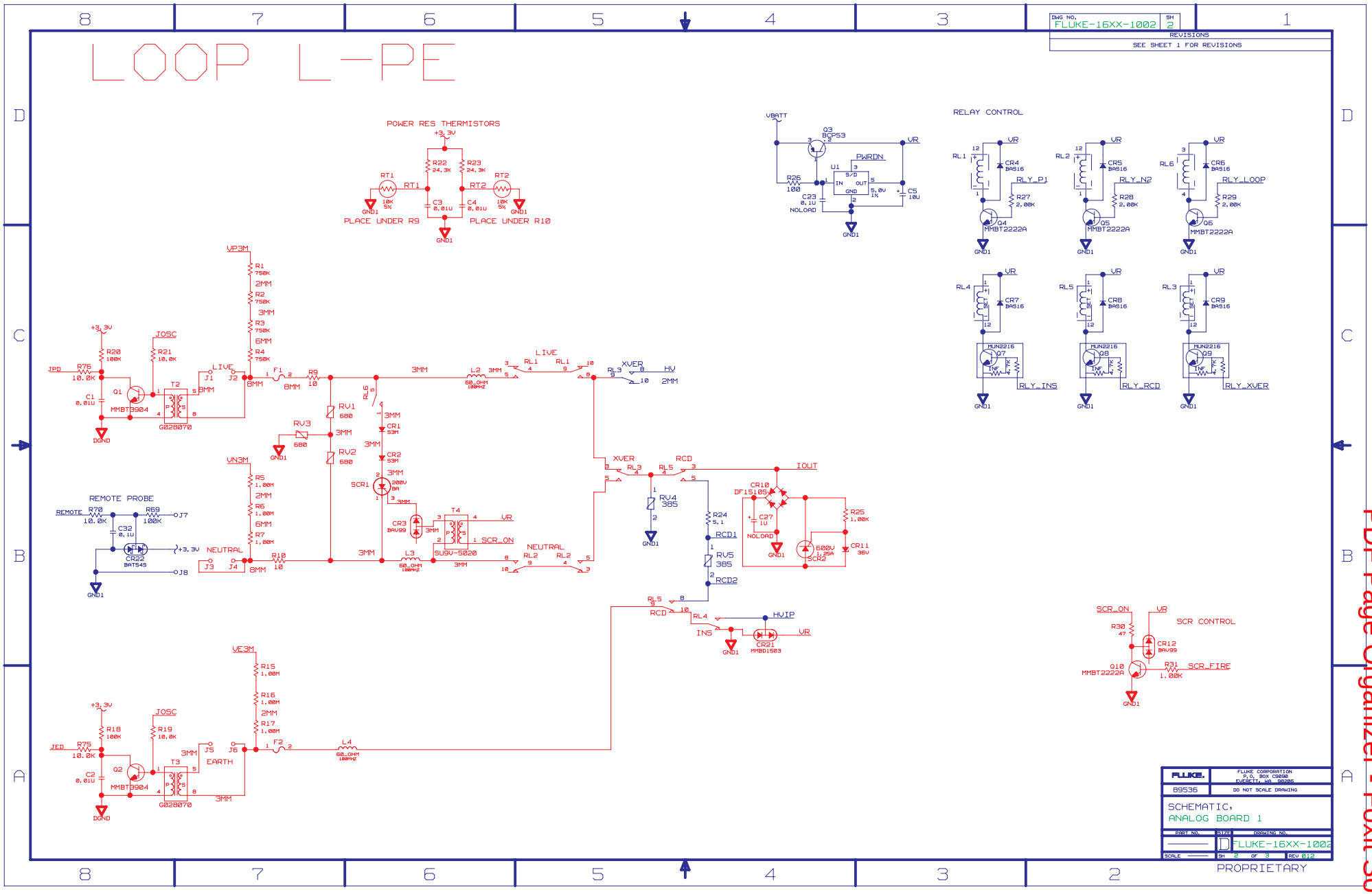


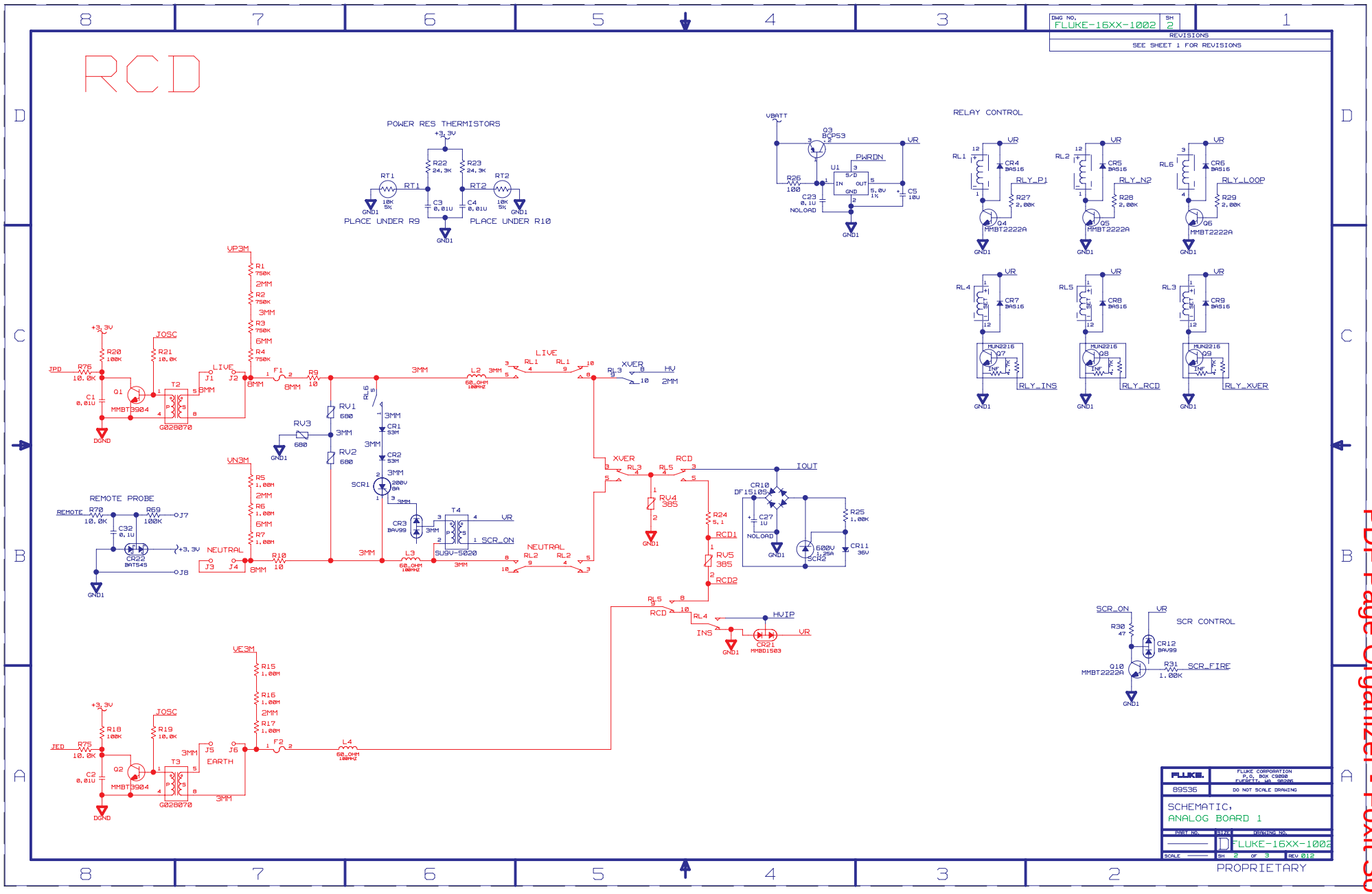


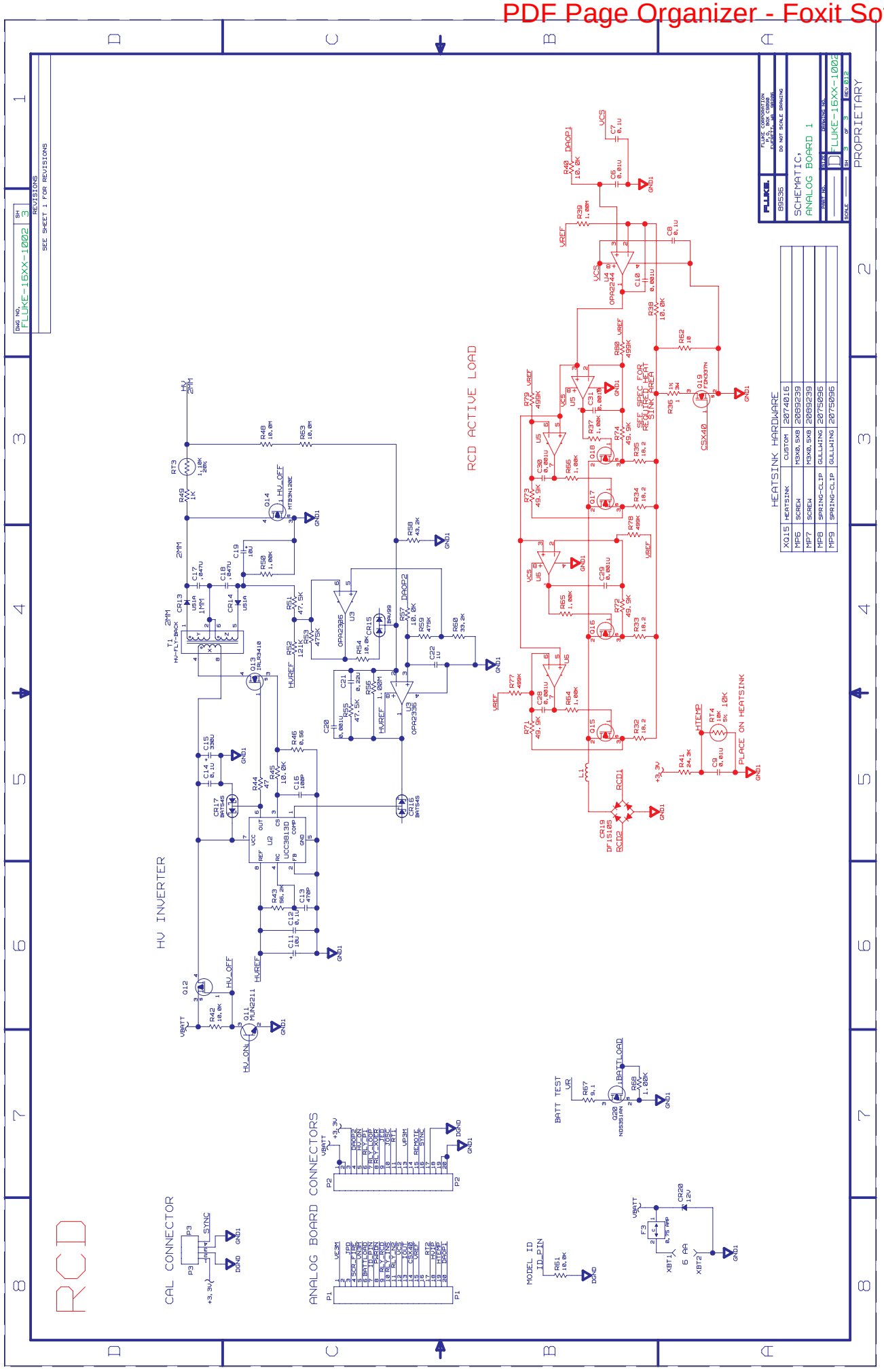


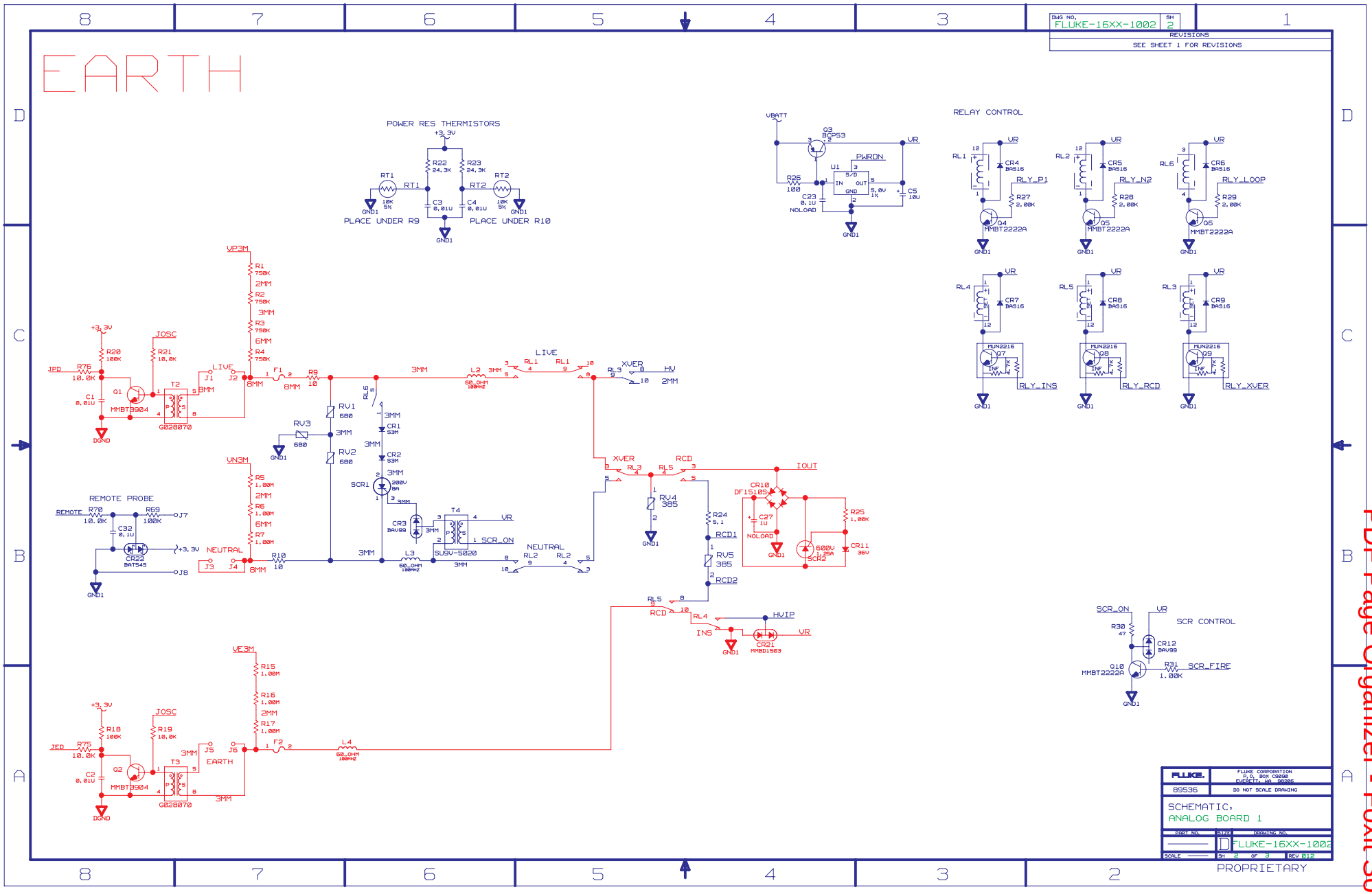


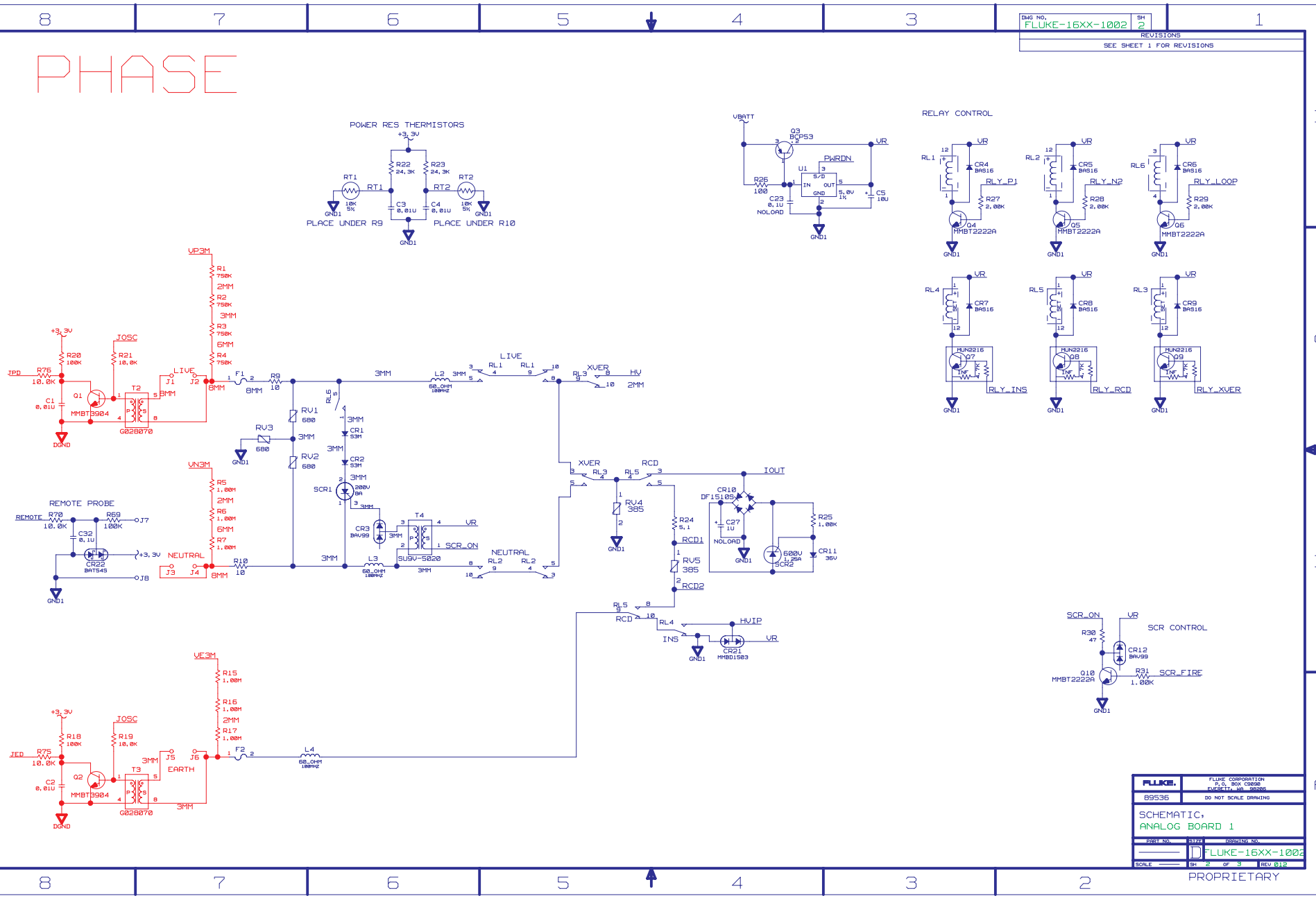












Introduction

165X is a multi-function tester intended for use by qualified electricians to test domestic and industrial mains wiring in accordance with international wiring regulations. It is aimed at the European market. This circuit description should be read in conjunction with the Block Diagram and Circuit Diagram.

Note: throughout the documentation the Line terminal is also called the Phase or Line terminal.

Block Diagram Description

Introduction

The instrument measures the voltage at the three front panel terminals (Line, Neutral and Earth) with respect to internal ground. For all tests, except RCD, internal ground is connected to the Earth terminal.

The instrument has two groups of tests, those where the circuit under test is energized, and those where tests are carried out on de-energized circuits. For the energized tests the voltage at the terminals is measured with a variety of loads applied for the various tests. For the de-energized tests the voltage at the terminals is measured with currents/voltages applied to the circuit under test.

All circuit references in this block diagram description refer to the Block Diagram schematic.

Voltage measurement

There are three voltage measurement channels, one for each terminal, the voltage is measured with respect to internal ground via three high voltage resistors (R3,R4 & R5 on the block diagram). There are up to four measurement ranges as described later. The phase sequence test uses these voltages to calculate phase direction.

Loop Test (Line-Neutral)

The Line-Neutral loop test measures the AC voltage between the Line and Neutral terminals unloaded, then connects a resistive load for a half cycle. From the unloaded voltage, the loaded voltage and load resistance the supply impedance is calculated by the microprocessor.

The load resistors (R9 & R10 on the block diagram) are connected via an isolating relay (RL6) and SCR (SCR1). The relay is present to improve safety in fault conditions and prevent spurious firing of SCR1 when transients are present on the supply.

RCD Test

The RCD test loads the mains supply with a constant current AC load of between 3mA and 1.1A rms. As the current sink is unipolar it is configured within a bridge rectifier (CR10 on the block diagram). The

voltage at the terminals is measured and the time from the start of the application of the current load to the RCD operating (loss of measured voltage) is displayed. The maximum voltage for the RCD test is 275V RMS. The RCD test is carried out between either the Line or Neutral terminals and the Earth terminal. The minimum value of F2 is determined by this test.

Continuity Test
The continuity test is carried out on deactivated circuits using two leads connected to the Line and Earth terminals. The instrument supplies a constant current and the voltage at the terminals is measured to calculate the resistance. The maximum current is just over 200mA from the 8.0V Current Source Power Supply.

Earth Test
The Earth test is a three wire test that uses the same current source as continuity, but the test current is switched on and off at 128Hz to allow additional filtering. This method is more representative of the impedance at the mains supply frequency. The compliance of the current source is increased to nominally 24V.

Loop L-PE
To measure loop impedance L-PE, a three wire configuration is used.

First, an L-N loop measurement is performed as follows: Multiple loaded and unloaded voltage measurements are taken at the L-N inputs. The resultant difference voltages can be used with the know calibrated load impedance of the 165X, to calculated the L-N loop impedance.

Next, the low current N-PE loop test injects a current into the N-PE loop that starts at zero and ramps up to 50mA then back down to zero. The current comes from the same current source as the continuity test but the supply voltage is increased to a nominal 24V, this extra compliance allows for extra noise in the N-PE mains supply. The voltage at the terminals is measured and combined with the test current to enable the microprocessor to apply filtering and calculate the resistance of the N-PE loop. A slowly ramping current is used to avoid tripping an RCD that may be in circuit. The N-PE current takes about one second per cycle to not trip the RCD.

After L_N and N-PE are known then L-PE loop impedance is calculated by the processor.

Insulation test

The insulation test is carried out on deactivated circuits using two leads connected to the Line and Earth terminals. The instrument supplies a high voltage (up to 1050V with the current limited to about 1.5mA) and measures the voltage at the terminals. The current is measured via the voltage across a current sensing resistor (R366).

A high voltage MOS FET (Q14) is switched in circuit after the test to discharge any capacitive loads that may be charged up to hazardous levels.

Detailed Circuit description.

See circuit diagrams

Front End (Analog 1, pg.2)
This page of the circuit diagram houses most of the high power, high current and high voltage components. These include the split jack detection, transient protection, Loop test components, Relays and the current source crowbar.

Split Jack Detection. – The Line and Earth terminals have identical split jack detection, the Line terminal circuit is described. As the test sockets may be at high voltage with respect to the internal measurement circuitry, the sockets are electrically isolated from the measurement circuitry by means of an isolation transformer. This isolation transformer (T2) is arranged to have one winding connected to the split jack and the other to the measurement circuits. Inserting a test lead shorts the split jack contacts and consequently a winding of the transformer.

The other winding of the transformer is connected to JOSC (A clock signal, derived from the microprocessor) via a current limiting resistor, R21. When the split jack contacts are open circuit the signal from the clock switches on the transistor, Q1, which discharges the capacitor C1 to a logical 0. When the split jack contacts are shorted the inductance of the secondary winding of the transformer is reduced to its leakage inductance. This prevents Q1 from turning on and allows R20 to charge C1, so the voltage across C1 becomes a logical 1.

Transient Protection - Transient protection is provided by the MOV's VR1 to VR5. The current is limited by series resistors R9,R10 and R24.

Loop test components - The high current Loop test components consist of the power resistors R9 and R10, the relay RL6 and SCR1 with its associated components. The transient rating across VDR1 and VDR2 is 3kV, RL6 has a large contact gap and can withstand this transient. When RL6 is closed in the reverse direction the combined rating of D4,D5 & SCR1 is 3kV, in the forward direction SCR1 is allowed to break-over without damage.

SCR1 is triggered by an isolating pulse transformer, T4. CR3 prevents SCR1 gate currents from flowing through the transformer when SCR1 has fired. SCR1 is fired by a pulse train from the microprocessor, buffered by Q10 in the SCR Control circuit.

The power resistors R9 and R10 have thermistors, RT1 and RT2, coupled to them to sense their temperature. An A/D in the microprocessor monitors this temperature and can disable the high current loop test when R9 and R10 working temperature is exceeded.

Relays – Relays RL1 and RL2 are arranged to isolate circuits from the mains supply except when the correct voltages are present at the terminals for the test requested. The two contacts are arranged in series to increase the voltage rating. For all other relays the transient voltage rating is determined by the MOV, RV4, and the current rating of F2.

Current Source Crowbar. – This circuit (CR10,SCR2,R25 & D11) is designed to blow the F2 in the event of a high voltage being applied tot he input terminals during a test using the low voltage current source (continuity, low current loop, Earth). When the voltage across the current source exceeds approximately

26V SCR2 will be fired by current through the Zener diode D11. The i^2t rating of SCR2 must be greater than the i^2t rating of F2. SCR2 needs to be low leakage (<5uA) in order not to load the current source.

Voltage Measurement
Analog 2, page 2, contains circuit diagrams that measure the voltage from the three input terminals with respect to internal ground. The three measurement channels are identical except that the Line terminal (VP3M) circuit has an extra voltage range. This extra range is used to measure 1200 volts DC in the insulation test function. This is the channel that will be described.

Voltage measurement - The voltage sense resistors (R1-R4) form a 3MΩ chain with a high voltage rating (8kV pulse, 1.2kV AC/DC - note the other channels only require 600 Vac so 3 resistors are adequate). To achieve the high voltage rating mini melf resistors have been specified. The bottom end of this resistor chain is connected to U315 and U320. U320 switches several combinations of resistors and capacitors to provide the four voltage measurement ranges. The output of U315, low leakage unity gain buffer, is fed to the ADC.

"8 volt range" has a worst case measurement range of –2.0 to 8.5V. The 3dB frequency is 49Hz. The switch U320, 2-3 is open for this range.

"25 volt range" This range has a worst case measurement range of –22.0V to 28V. The 3dB frequency is 237Hz. The switch U320, 2-3 is closed, U320, 14-15 and 10-11 are open.

"750 volt range" This range has a worst case measurement range of –795V to 785V. The 3dB frequency is 3.4kHz. The switch U320 2-3 and 14-15 are closed, U320, 10-11 is open.

"1200 volt range" This range has a worst case measurement range of –21V to 1202V. The 3dB frequency is 2.8kHz. The switch U320, 2-3 and 10-11 are closed, U320, 14-15 is open.

Zero crossing detector – U316 detects the zero crossings between the Line and Neutral terminals. The capacitor C361 provides some positive feedback to suppress noise.

Line Neutral Amplifier – Differential amplifier, U315, provides a difference signal between the Line and Neutral terminals, its output is fed directly to the microprocessor A to D converter and is used for the RCD trip detection.

Current Source (Analog 2, pg. 3)
The page contains the 200mA and the 50mA current source and the Current Source Power Supply. The Current Source Power Supply output (VCS) is switched between 8.0V and 24V to achieve the required compliance voltage for the low current loop test and Earth test. The 8.0V limits the power for the continuity range 200mA output.

Level Shifter – This circuit (U307, Q309 and associated components) is a voltage controlled current source that generates a voltage across R320 proportional to the voltage output (DAOP) from the Digital to Analog converter (U311, Analog 2, pg. 2). The voltage gain is given by R320/R330.

Negative rail generator – U307 is also used to generate a negative rail (VCS-6) at a constant voltage below VCS. The purpose of this is to prevent the Max VGS of Q307 and Q308 from being exceeded, and

allow the use of lower voltage OP-Amp's for U305 and U306. An additional use for the regulated negative rail is to provide a negative bias for the output current.

Current Sources – The 50mA current source is on for all currents, the 200mA current source is disabled by Q310. When this transistor is switched on the negative input of U305 is pulled low causing it to be turned hard off. It is a requirement of the current source to be able to output small currents, because of this the inputs to the OP-AMPS are biased negative. Consequently a signal from the D to A converter is always needed to produce an output current, this allows for the offset voltages of the D to A converter and OP-AMPS.

The 200mA output FET (Q307) is chosen for low leakage as well as being able to dissipate approx 1.5 Watts. Its VGS pinch off voltage determines the minimum value of the 8.0V VGS supply (in conjunction with R317, R318 and U305). The current sense resistors (R317 and R318) can self heat and need a low temperature coefficient to maintain accuracy. The capacitors, C323 and C324, are present to improve stability of the current source with inductive loads.

Power Supplies
The batteries are connected to the instrument via a 0.75A PTC Analog 1 PCA, pg. 3. Zener diode, CR20, provides protection against over-voltage and reverse battery connection.

The Analog 2 PCA has three regulators, U312 (3.3V), U313 (5V), and U302 (3.3V). All three regulators are turned on via the digital processor, R345 provides bias to turn the instrument on when the digital processor poles PWRDN.

The 5V regulator is only used for "Voltage Measurement" circuits.

Relay Control
Analog 2 PCA, pg.2, contains the Relay Drivers, Relay power supply (U1 and Q3), and the driver for the SCR pulse transformer. These circuits are all quite self explanatory.

A to D /and D to A
The Analog 2 PCA, pg. 2, contains the MUX and its filters, the Analog to digital converter with its buffer amplifier, the voltage references, Digital to Analog converter and the Current Sense Amplifier for insulation tests.

Current Sense Amplifier - The measurement of the insulation test leakage current (HVIP) is referenced to VREF/2, this allows for up to 1mA of ac noise superimposed on the signal being measured. The leakage current produces a voltage across R366 that is filtered by R365 and C356 to reduce mains noise. This signal is then amplified by the OP-AMP U317 that can be configured by U318 and R367-R370 to have 4 gain settings (x1, x4, x16 and x63). C357 provides extra mains rejection on the higher gain ranges.

MUX and Filters – These filters (R334-R337, and C332-C335) serve several purposes. The prime function is to selectively delay the voltage measurement channels to allow for the MUX sample rate, this is to improve common mode rejection of the difference signal between the voltage measurement channels. The voltage measurement circuits operate from 5V, so, the series resistors also limit the current into the 3.3V MUX in overload conditions. They also provide an extra pole of filtering for anti-aliasing. The capacitors must be large enough so that when the MUX channel is switched the associated stray capacitances do not introduce cross talk.

Analog to Digital Converter and Buffer Amplifier - The buffer amplifier (U309), for the Analog to digital converter input, is selected to operate between ground and VREF with a fast settling time and low noise. The A to D switches in a capacitive load, so, this amplifier must be stable under these conditions.

The Analog to digital converter is a 16 bit sampling successive approximation type.

A bandgap diode (VR301) is used to generate the reference voltage. A signal of half the reference voltage (VREF/2) is generated by a resistive divider and buffer amplifier (U309).

Digital to Analog Converter- The output of the D to A is used for the current source (continuity, Earth and low current loop test), RCD current sink, and the HV Inverter. Software contained in the analog processor ultimately controls these circuits through the D to A.

RCD + Inverter

Analog 1 PCA, pg. 3, contains circuit diagrams for the RCD current sink, and the HV Inverter used in insulation testing.

RCD Current Sink – This circuit provides an active load for the mains supply. The load current is proportional to the D to A output and there are two ranges (2.5A peak and 0.25A peak).

The signal from the D to A is arranged by the microprocessor to be either a half (A type RCD), or full wave rectified sine wave (AC type RCD) phase locked to the mains supply. This signal is passed to an active current sink based around Op-AmpsU4, U5 and U6, which drives 4 large power FET's Q15 -Q18). The bias resistor R39 and R77-R79 (in conjunction with R38 and R71-R74), compensates for the worst case offset voltages of the Op-Amps and D to A. The dominant pole of the loop frequency response is determined by C10.

A major aspect of the design is the ability to dissipate large amounts of power for the higher current RCD tests (approx 300 Watts). This power is predominantly dissipated in the FET's Q15, Q16, Q17 and Q18. The source resistors (R32, R33, R34 and R35) equalize the current through each FET and compensate for variations in the FET's gate source operating voltage.

There are two current sense resistors (R36 and R62) which provide the two operating ranges. The high current range is enabled by switching on the low drain source resistance (R36) through FET Q19. Due to the high power that can be dissipated the temperature of Q19's heatsink is monitored by a thermistor (RT4) to allow the microprocessor to stop further tests when the FET's get too hot. R62 serves as the low current sense resistor.

Current Source Inverter – The inverter for the current source has two switched output voltages a nominal 8.0V @ 200mA, and a nominal 24V @ 50mA. The minimum battery voltage is 6V, note the maximum output voltage can rise above 8.0V for the maximum battery voltage.

The main components of the inverter are U304, CR302, L301, and Q303-Q306. The Inverter is switched on under microprocessor control via a P channel MOS FET (Q303). The inverter is a boost configuration and has a current mode controller (U304).

The output voltage is set by the resistive dividers R315 and R316 that provide feedback into the controller. Q306 switches on for the high current mode (8.0V, 200 mA).

The inverter output is filtered by the L302 and reservoir capacitors C320-C322. CR302 prevents transient damage to the controller when the inverter is switched off.

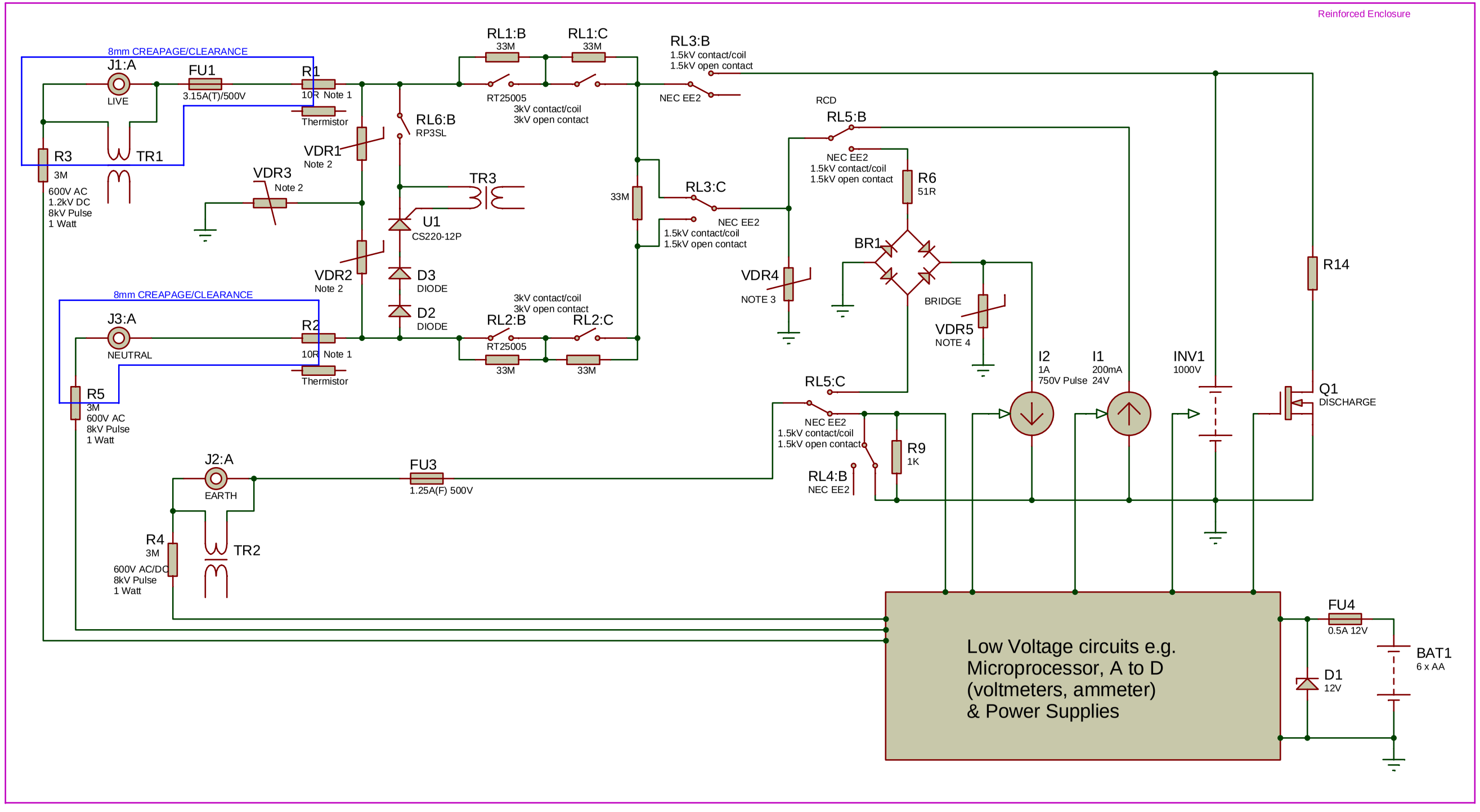
HV Inverter (Page 8/8)
The HV Inverter is used for the insulation tests and produces voltages up to 1kV into a 1MΩ load at the terminals.

Power to the HV Inverter is switched under microprocessor control by Q11 and the P MOS FET Q12. When the inverter is switched off the output discharge FET (Q14) is switched on, this FET discharges any capacitive loads that may be charged up by the inverter. To limit the power during discharge there is a positive temperature coefficient thermistor (RT3).

The inverter is a fly back configuration and has a PWM current mode controller (U2) as in the current source inverter. The operating frequency is nominally 19kHz.

The high voltage output is divided down by R48, R63 and R58, and compared to the D to A converter output by the OP-AMP U3A. R56 determines the loop compensation and sets the open loop gain. C21 and R55 set the first pole, and C20 is present to suppress switching noise from the inverter.

The current out of the inverter is sensed across R50 (note polarity of C19), this signal is passed to the instrumentation amplifier U3B which both subtracts the effect of the D to A voltage setting, and compares the signal to HVREF from the controller (U2). The output of this OP-AMP is fed to the Voltage controller network via a R54, to limit the current loop gain, and a CR15 to isolate current control when in voltage control mode. HV adjusts according to load current sensed by R50.



RELAY POSITIONS

ENERGISED TESTS

VOLTS	NONE
PHASE ROT	NONE
L-N LOOP	NONE
N-E LOOP	RL2, RL3, (OR RL1 IF PHASE SWAP)
RCD	RL1, RL5, (OR RL2, RL3, RL5 IF PHASE SWAP)

DE-ENERGISED TESTS

CONT.	RL1
EARTH	RL1, [OR RL2, RL3 FOR PSPIKE)
INSULATION	RL1, RL3, RL4
LOOP ZERO	RL1, RL2, RL3
FUSE - F1, F2	RL2, RL3,
FUSE - F3	NONE

Note 1
R1 and R2 - 300V AC, 8kV Pulse, 10W
Thermistor to prevent overheating damaging the PCB in normal use. Maximum surface temperature 350C.

Note 2
460V AC.
Any 2 in series :-
200uA max at 1200V DC,
3000V max at 420A pulse.
Maida Type D61ZOV461RA50

Note 3
300V AC, 1000V max at 600A pulse.
Maida Type D61ZOV301RA45

Note 4
300V AC, 775V max at 5A pulse.
Maida Type D73ZOV301RA25

Buckman Hardy Associates

TITLE: MFT Block Diagram Modified

DATE: 06/08/02

PAGE: 1/1

BY: W. Hardy

REV: 2.3

FLUKE-165X	REV	DESCRIPTION
SH 1 OF 3	006	WI037879: SEE PDM RECORD FOR DESCRIPTION OF REVISION.

NOTES: UNLESS OTHERWISE SPECIFIED

1. 

2. ASSEMBLE PER WORKMANSHIP QSD 111.1.

3. ITEM 2 (SCREW) TO BE TORQUED 4.5 TO 5.5 INCH/LBS.

4. ITEM 2 (SCREW) TO BE TORQUED 10 TO 12 INCH/LBS.

5. APPLY SUPERLUBE MULTI-PURPOSE SYNTHETIC GREASE WITH TEFLON (82328) TO KNOB DETENT WALL OF TOP CASE AS SHOWN ON SHEET 3.

6. APPLY SUPERLUBE MULTI-PURPOSE SYNTHETIC GREASE WITH TEFLON (82328) TO BATTERY CONTACTS AS SHOWN ON SHEET 3.

7. FINAL TEST PER TEST PROCEDURE.

MODEL	CALIBRATION/FINAL	FINAL
1651	1651.15	1651.150
1652	1652.15	1652.150
1653	1653.15C	1653.150

8. FLUKE-1653 VERSION SHOWN, SEE BOM FOR SPECIFIC PART CONFIGURATION OF EACH VERSION AVAILABLE IN PRODUCT SERIES.

9. COMPONENTS SHOWN ON CIRCUIT BOARDS ARE FOR REFERENCE ONLY.

10. ALL CHANGES TO PRODUCT TO BE REVIEWED/APPROVED BY PRODUCT SAFETY FOR IMPACT TO CURRENT AGENCY APPROVALS.

11. REFER TO VIEW ON PAGE 2 FOR PACKAGING SEQUENCE.

TABLE 1

PART NUMBER	NOUN	DESCRIPTION
1672050	FLUKE-1651	ELECTRICAL INSTALLATION TESTER
1674289	FLUKE-1651-01	ELECTRICAL INSTALLATION TESTER, FRN
1674292	FLUKE-1651-02	ELECTRICAL INSTALLATION TESTER, GER
1674303	FLUKE-1651-03	ELECTRICAL INSTALLATION TESTER, ITA
1674422	FLUKE-1651-04	ELECTRICAL INSTALLATION TESTER, SPA
1674431	FLUKE-1651-05	ELECTRICAL INSTALLATION TESTER, EUR
2065906	FLUKE-1651-06	ELECTRICAL INSTALLATION TESTER, SW
2065914	FLUKE-1651-07	ELECTRICAL INSTALLATION TESTER, DEN
2065923	FLUKE-1651-08	ELECTRICAL INSTALLATION TESTER, AU
1777679	FLUKE-1651-5002	FINAL COMMON PARTS
1672061	FLUKE-1652	ELECTRICAL INSTALLATION TESTER W/AUTOTEST
1674446	FLUKE-1652-01	ELECTRICAL INSTALLATION TESTER W/AUTOTEST, FRN
1674454	FLUKE-1652-02	ELECTRICAL INSTALLATION TESTER W/AUTOTEST, GER
1674468	FLUKE-1652-03	ELECTRICAL INSTALLATION TESTER W/AUTOTEST, ITA
1674487	FLUKE-1652-04	ELECTRICAL INSTALLATION TESTER W/AUTOTEST, SPA
1674493	FLUKE-1652-05	ELECTRICAL INSTALLATION TESTER W/AUTOTEST, EUR
2065945	FLUKE-1652-06	ELECTRICAL INSTALLATION TESTER W/AUTOTEST, SW
2065950	FLUKE-1652-07	ELECTRICAL INSTALLATION TESTER W/AUTOTEST, DEN
2065961	FLUKE-1652-08	ELECTRICAL INSTALLATION TESTER W/AUTOTEST, AU
2066450	FLUKE-1652R	ELECTRICAL INSTALLATION TESTER W/AUTOTEST, ROBIN
1777687	FLUKE-1652-5002	FINAL COMMON PARTS BOM
2069105	FLUKE-1652-5002R	FINAL COMMON PARTS, ROBIN
1672077	FLUKE-1653	ELECTRICAL INSTALLATION TESTER W/AUTOTEST & INTERFACE
1674507	FLUKE-1653-01	ELECTRICAL INSTALLATION TESTER W/AUTOTEST & INTERFACE, FRN
1674518	FLUKE-1653-02	ELECTRICAL INSTALLATION TESTER W/AUTOTEST & INTERFACE, GER
1674529	FLUKE-1653-03	ELECTRICAL INSTALLATION TESTER W/AUTOTEST & INTERFACE, ITA
1674534	FLUKE-1653-04	ELECTRICAL INSTALLATION TESTER W/AUTOTEST & INTERFACE, SPA
1674541	FLUKE-1653-05	ELECTRICAL INSTALLATION TESTER W/AUTOTEST & INTERFACE, EUR
2065977	FLUKE-1653-06	ELECTRICAL INSTALLATION TESTER W/AUTOTEST & INTERFACE, SW
2065989	FLUKE-1653-07	ELECTRICAL INSTALLATION TESTER W/AUTOTEST & INTERFACE, DEN
2065992	FLUKE-1653-08	ELECTRICAL INSTALLATION TESTER W/AUTOTEST & INTERFACE, AU
2066489	FLUKE-1653R	ELECTRICAL INSTALLATION TESTER W/AUTOTEST & INTERFACE, ROBIN
1777693	FLUKE-1653-5002	FINAL COMMON PARTS
2069110	FLUKE-1653-5002R	FINAL COMMON PARTS, ROBIN

FLUKE CORPORATION
P.O. BOX 9090
EVERETT, WA 98206-9090

FSCM 89536

ELECTRICAL INSTALLATION TESTER

PART NO.	SIZE	DWG. NO.	REV
TABLED	D	FLUKE-165X	006

SCALE: 1.000 SHEET 1 OF 3

NOTES: UNLESS OTHERWISE SPECIFIED

12 TABLE 2 RECEPTACLES

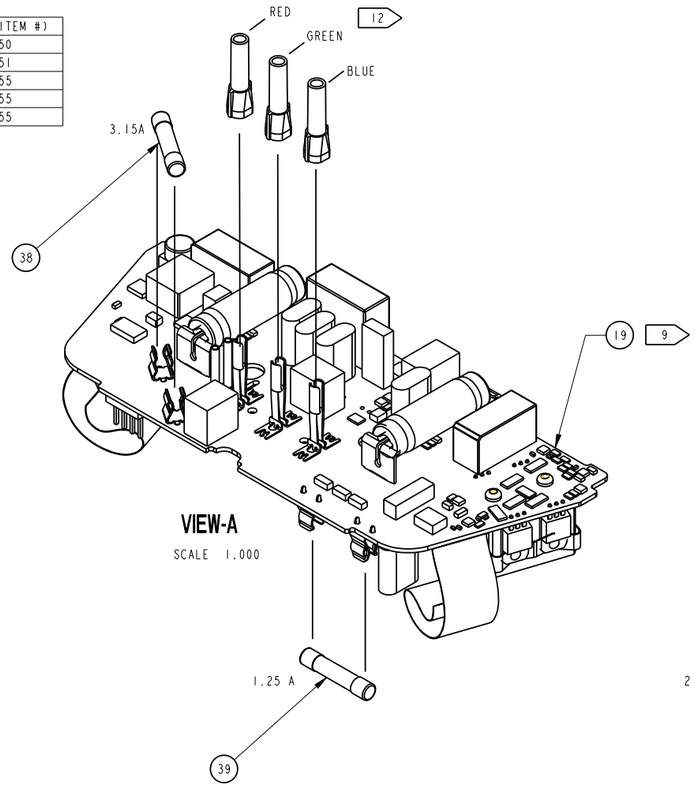
VERSION	BLUE (ITEM #)	GREEN (ITEM #)	RED (ITEM #)
FLUKE-1651	52	51	50
FLUKE-1652	53	52	51
FLUKE-1653	57	56	55
FLUKE-1652R	57	56	55
FLUKE-1653R	57	56	55

13 DUPLICATE ITEM NUMBERS.
- (2) BATTERY COMPARTMENT-COMMON PARTS LIST
  GRAPHICS PLATE-STANDARD BOM
- (3) DOOR ACCESS-COMMON PARTS LIST
  ROBIN MASK BRACKET-STANDARD BOM

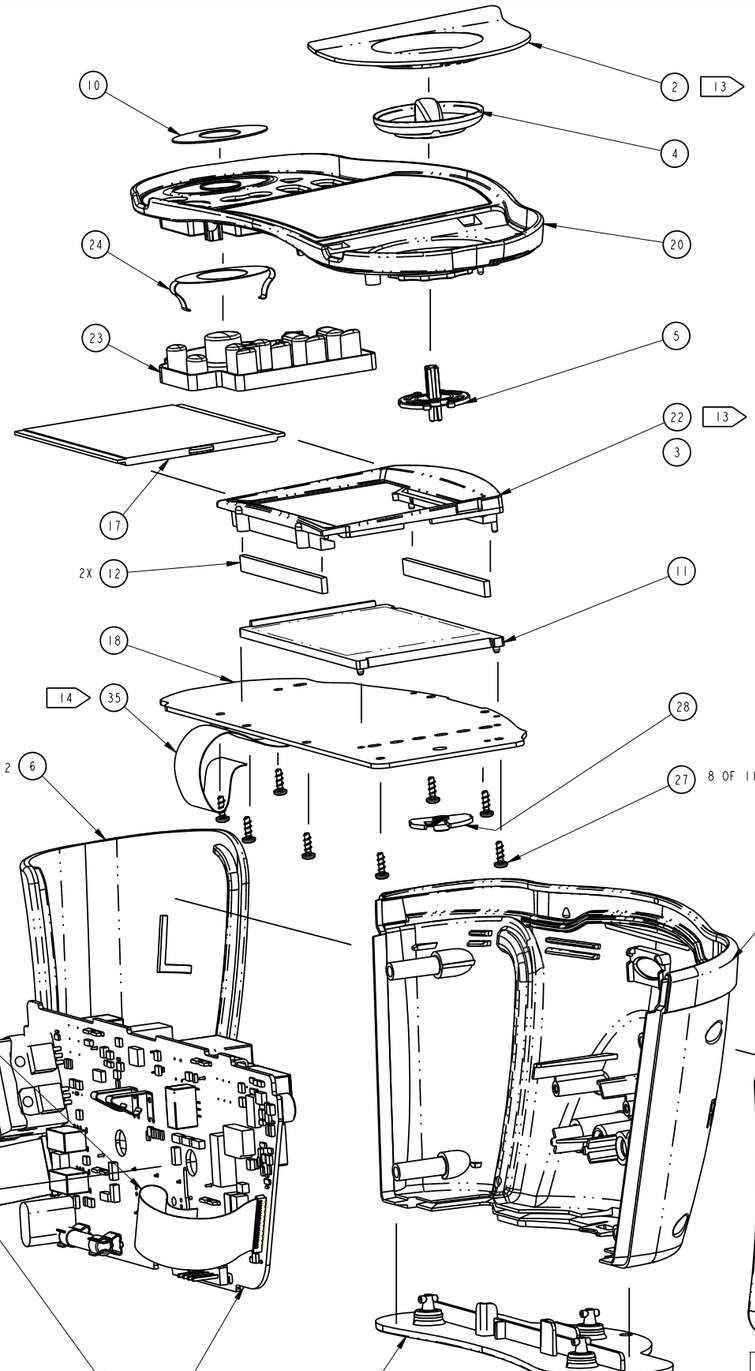
14 ITEM 35 TO CONNECTOR AT LOCATION A.

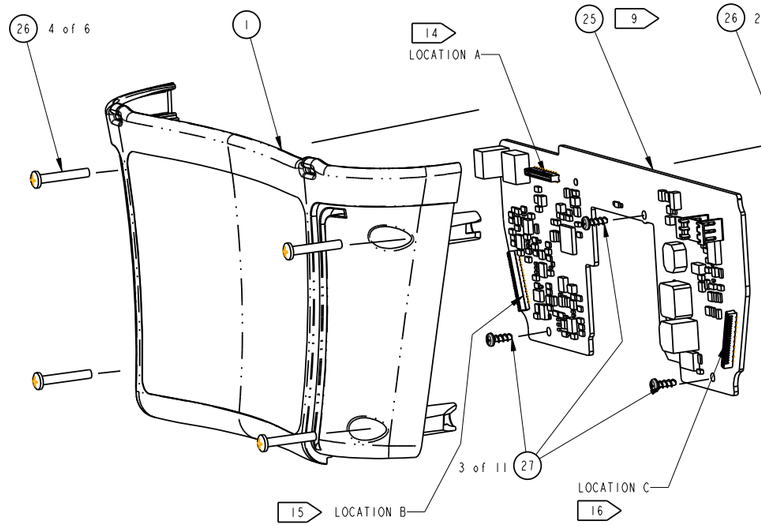
15 ITEM 35 TO CONNECTOR AT LOCATION B

16 ITEM 35 TO CONNECTOR AT LOCATION C

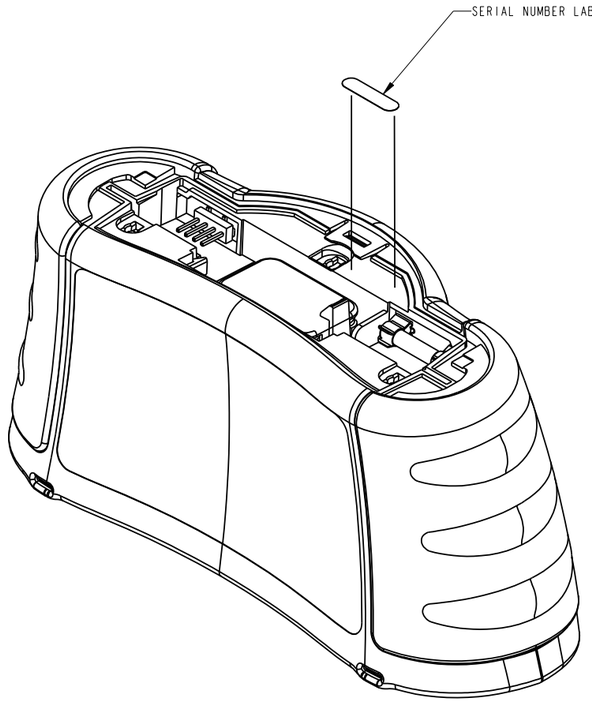


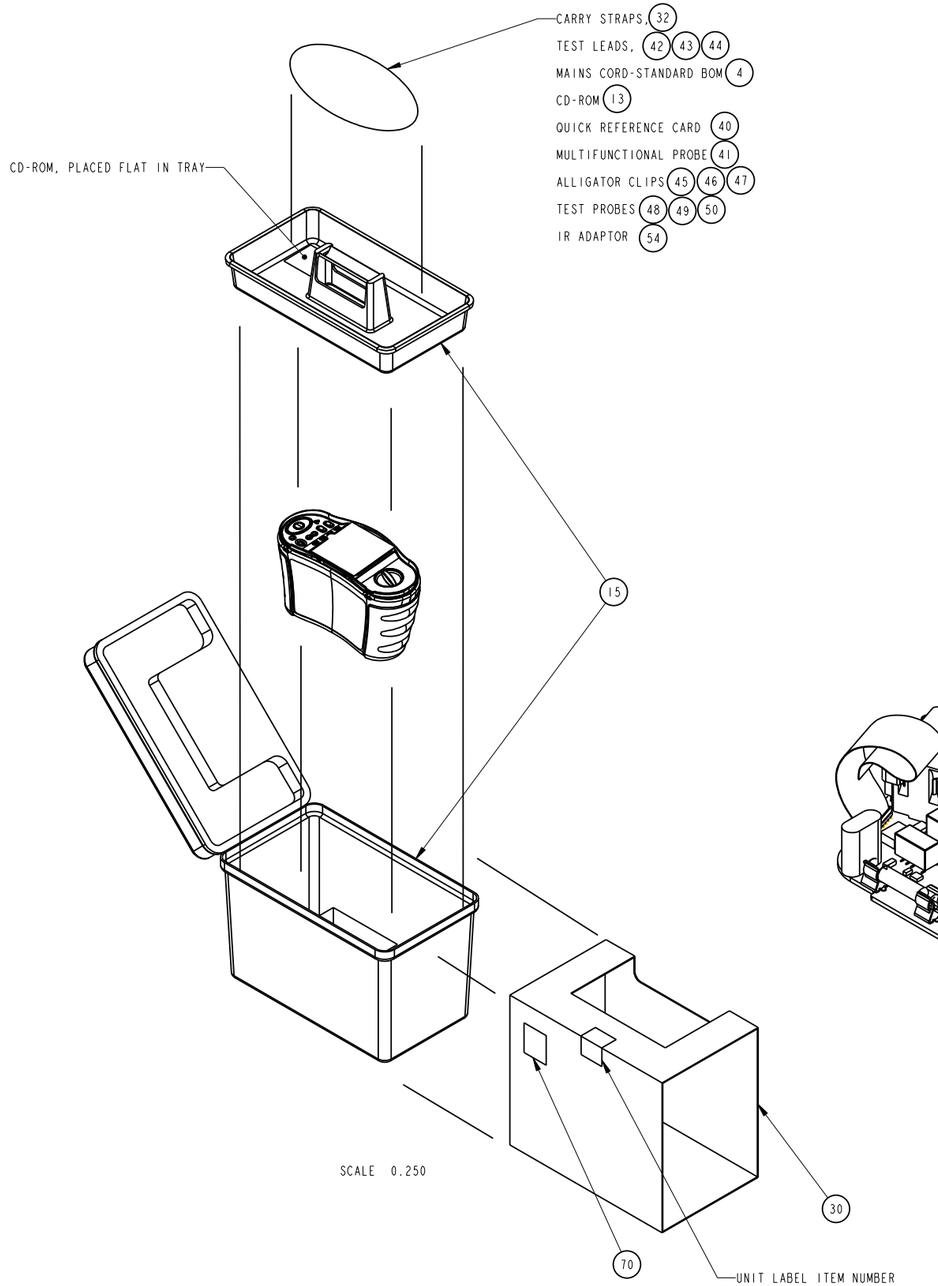
VIEW-A
SCALE 1.000





FLUKE	FLUKE CORPORATION P.O. BOX 9090 EVERETT, WA 98206-9090	FSCM	89536
ELECTRICAL INSTALLATION TESTER			
PART NO. TABLED	SIZE D	DWG. NO. FLUKE-165X	REV 006
SCALE: 0.950		SHEET 2 OF 3	





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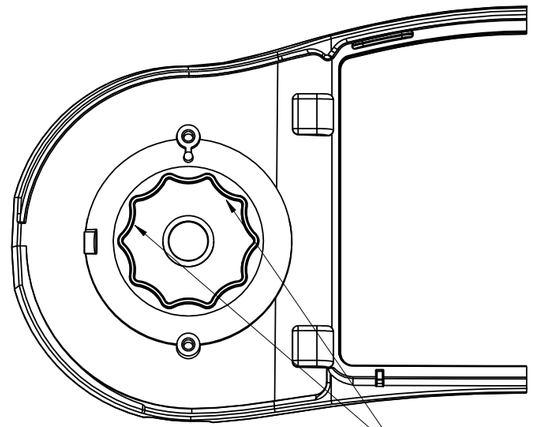

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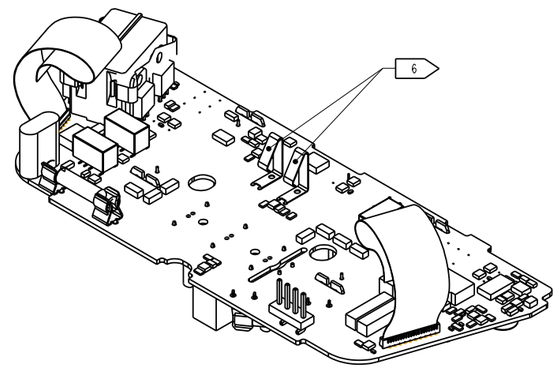


UNIT LABEL ITEM NUMBER
(1653,1652,1651)

FLUKE

FLUKE CORPORATION
P.O. BOX 9090
EVERETT, WA 98206-9090

FSCM 89536

ELECTRICAL INSTALLATION TESTER

PART NO.	SIZE	DWG. NO.	REV
TABLED	D	FLUKE-165X	006

SCALE: 0.200 SHEET 3 OF 3

DWG NO. FLUKE-16XX-4001	SH 1

REVISIONS

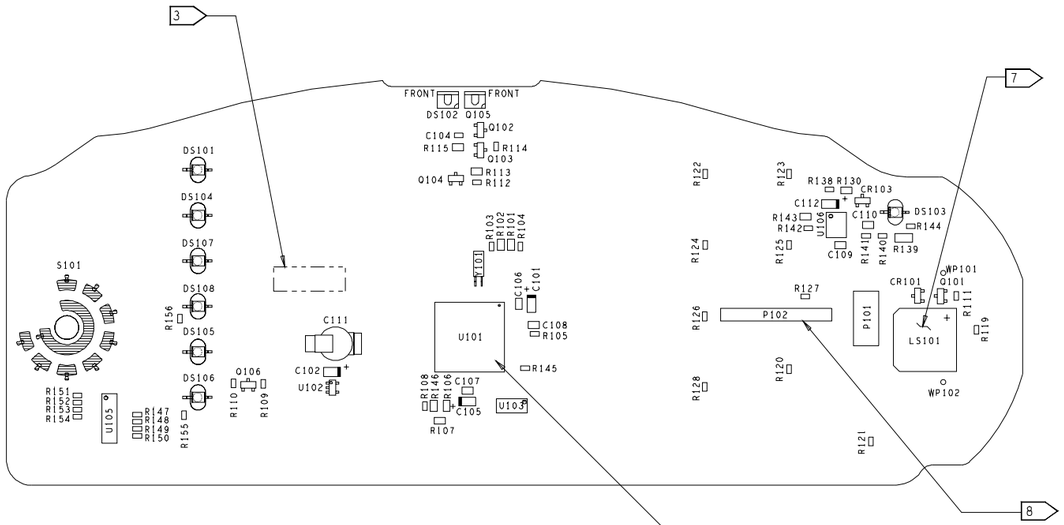
REV	DESCRIPTION	DWN
010	W1038524: ADDED FLAGNOTE 9	KD 31OCT03

NOTES: UNLESS OTHERWISE SPECIFIED

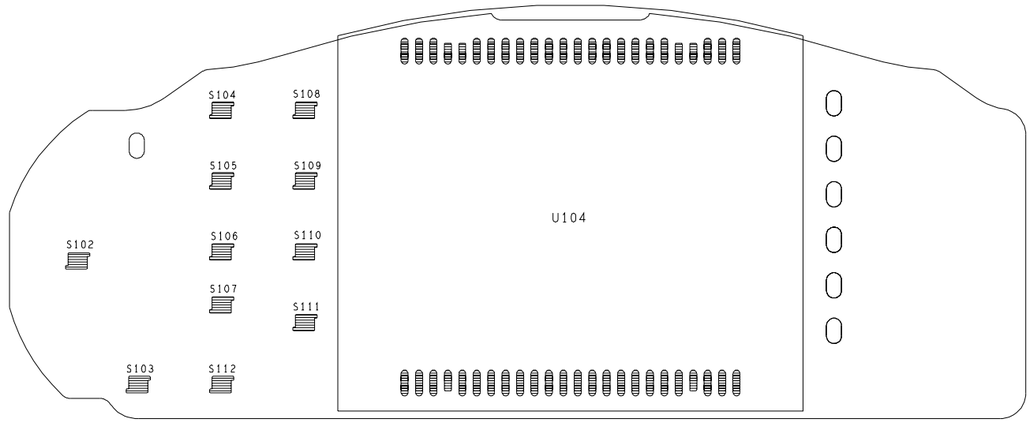
1. FOR SCHEMATIC DIAGRAM, SEE FLUKE-16XX-1001.
2. ASSEMBLE PER QSD 111.1.
3. MARK ASSEMBLY REVISION LETTER IN SPACE PROVIDED WITH PERMANENT MARKER.
4. TEST PER 16XX-4001-151.
5. PARTS NOT INSTALLED U104,P101,WP101 AND WP102. S1-S12 ARE ETCH COMPONENTS NO PARTS INSTALLED.
6. FOR MODEL CONFIGURATIONS SEE TABLE I.
7. REMOVE BEEPER TAPE AFTER WASH.
8. PART IS NOT POLARIZED.
9. VERIFY SOFTWARE REVISION PRIOR TO ICT TESTING. SEE LABEL FILE DIRECTORY FOR CORRECT REVISION (m/usr0/pcasmalp/public/kryten_label). ICT ADD REVISION LABEL 867184 TO U101 AFTER ICT TESTING. ICT PROGRAM U101, P/N 1643131. USE P/N 2118628, FLUKE-165X-9001 FIRMWARE, MSP430F449, SEE P/N 2118626. D1101636 FOR SOFTWARE REVISION.

TABLE I 6

MODEL NOUN	PART NUMBER	REF DES LOADED
1651-4001	1645464	R102
1652-4001	1672160	R101
1653-4001	1672172	R103, U103



REFERENCE DESIGNATORS
CKT 1, BOTTOM



REFERENCE DESIGNATORS
CKT 2, TOP

CAUTION
SUBJECT TO DAMAGE BY STATIC ELECTRICITY

DWN	DARREN HERMSEN	10-30-01
CHK		
APPRVD		
APPRVD		

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89536

PCA, DIGITAL

PART NO.	SIZE	DWG NO.	REV
SEE TABLE	D	FLUKE-16XX-4001	010

SCALE 2:1 SH 1 OF 1

PROPRIETARY

List of Replaceable Parts

Fluke 1653 Final Common Parts

Item	P/N	Qty	Ref Des	Description
1	1673624	1	MP1	FLUKE-165X-2002,CASE, BACK
2	1673636	1	MP2	FLUKE-165X-2005,COMPARTMENT, BATTERY
3	2101935	1	MP3	FLUKE-165X-2006-01,DOOR, ACCESS, VDE
4	1673608	1	MP4	FLUKE-165X-2008,KNOB
5	1673594	1	MP5	FLUKE-165X-2009,SHAFT, DETENT
6	1673575	1	MP6	FLUKE-165X-2010,GRIPS,SET OF
10	1673935	1	MP7	FLUKE-165X-8004,PAD, TOUCH
11	1673947	1	MP8	FLUKE-165X-8005,BACKLIGHT
12	1674117	2	MP9-10	CONNECTOR,ELASTOMERIC,.010INCTR,.231 HIGH,.090 THICK,2.720 LONG,BULK
13	1674214	1	TM1	CD ROM, USER MANUAL, FLUKE 165X SERIES
14	2068191	1	MP22	LABEL,1653 PACKAGE
15	1664213	1	MP11	CASE,TOOL BOX ,YELLOW
16	1676850	1	MP12	CONNECTOR,HOLDER,BATTERY,6AA,2 X 3 LAYOUT,9V SNAP CONFIG,BULK
17	1777654	1	MP13	LCD,1/4-DUTY,1/3-BIAS,TRANSFLECTIVE,FLUKE-165X SERIES
18	1672172	1	MP14	FLUKE-1653-4001,PCA DIGITAL
19	1672197	1	MP15	FLUKE-1653-4002,PCA ANALOG 1
20	1673726	1	MP16	FLUKE-1653-2003,CASE,TOP WITH FULL MEMORY
21	1673744	1	MP17	FLUKE-165X-2001,CASE, FRONT WITH IR LENS
22	1673566	1	MP18	FLUKE-1653-2012,BRACKET, MASK PAD XFER
23	1673920	1	MP19	FLUKE-1653-8003,KEYPAD
24	1884378	1	MP20	FLUKE-165X-8006,TOUCH PLATE
25	2030528	1	MP21	FLUKE-1653-4003,PCA ANALOG 2
26	832246	6	H1-6	SCREW,5-14,.750,PAN,PHILLIPS,STEEL,BLK CHROMATE,THREAD FORMING
27	642931	11	H7-17	SCREW,4-14,.312,PAN,PHILLIPS,STEEL,ZINC-CLEAR,THD FORM,#3 HEAD
28	822676	1	MP23	FLUKE 87-8004 ,CONTACT,PTF
30	2068080	1	MP24	SLEEVE,FLUKE 165X
31	2061011	1	MP25	HARD CASE INSERT,FOAM,POLYURETHANE,FLUKE-165X
32	2045406	1	MP26	CARRYING STRAP,PADDED,51.00 IN-63.00 IN ADJUSTABLE,FLUKE-165X
35	2075675	3	MP27-29	CABLE,FLAT FLEX,1.00 MM PITCH,20 COND,102 MM L
36	376756	6	BT1-6	BATTERY,PRIMARY,MNO2-ZN,1.5V,2.24AH,15A,LR6,ALKALINE,AA,14X50MM,BULK
38	2030852	1	F1	FUSE,3.15A,500V,SLOW,6.35 X 32MM,BULK
39	2040349	1	F2	FUSE,1.25A,500V,FAST,6.35 X 32MM, BULK
40	1674804	1	TM2	QUICK REFERENCE CARD,,FLUKE-165X SERIES
41	2000757	1	MP30	FLUKE-165X-8008,PROBE,MULTIFUNCTIONAL
42	2044961	1	MP31	TL-L3,TEST LEAD, BLUE
43	2044950	1	MP32	TL-L2,TEST LEAD, GREEN
44	2044945	1	MP33	TL-L1,TEST LEAD, RED
45	2068265	1	MP34	AC285-5001-03,,175-276-014 AC285 LARGE ALLIGATOR CLIP BLUE,BULK
46	2068133	1	MP35	AC285-5001-02,175-276-012 AC285 LARGE ALLIGATOR CLIP GREEN,BULK
47	2041727	1	MP36	AC285-5001,175-276-013 AC285 LARGE ALLIGATOR CLIP RED,BULK
48	2068904	1	MP37	PROBE,TEST,BANANA JACK,4MM TIP,BLUE W/CAP,175-290-

Item	P/N	Qty	Ref Des	Description
				007
49	2065297	1	MP38	PROBE,TEST,BANANA JACK,4MM TIP,GREEN W/CAP,175-290-006
50	2099044	1	MP39	PROBE,TEST,BANANA JACK,4MM TIP,RED W/CAP,175-290-003
53	1942029	1	MP40	102-406-003,PROBE CAP,GS-38 RED
54	2043365	1	MP41	FLUKE-1653-2014,IR ADAPTOR
55	1673672	1	MP42	FLUKE-165X-2013-01,INSULATOR, RECEPTACLE RED
56	1673685	1	MP43	FLUKE-165X-2013-02,INSULATOR, RECEPTACLE GREEN
57	1673697	1	MP44	FLUKE-165X-2013-03,INSULATOR, RECEPTACLE BLUE

Item	P/N	Qty	Ref Des	Description
1001	1556998	1	A01U102	IC,VOLTAGE REGULATOR, LINEAR, TPS77033,3.3V,50MA,LDO,LOW POWER,SOT-23-5,TAPE
1002	930222	3	A01R106-107 A01R146	RESISTOR SMR,RES,CERM,78.7K,+-1%,0.1W,100PPM,0805
1005	643863	23	A01R103-105 A01R120-128 A01R138 A01R142 A01R145 A01R147-154	RESISTOR SMR,RES,CERM,100K,+-1%,.063W,100PPM,0603
1031	928937	1	A01R113	RESISTOR SMR,RES,CERM,100,+-1%,0.1W,100PPM,0805
1032	605052	4	A01R108 A01R110 A01R112 A01R114	RESISTOR SMR,RES,CERM,10K,+-1%,.063W,100PPM,0603
1035	928713	1	A01R115	RESISTOR SMR,RES,CERM,1K,+-1%,0.1W,100PPM,0805
1036	649720	2	A01R111 A01R144	RESISTOR SMR,RES,CERM,1K,+-1%,.063W,100PPM,0603
1043	742676	4	A01Q101-103 A01Q106	NPN,MMBT3904 SMR,TRANSISTOR,SI,NPN,60V,350MW,SOT-23
1046	1568518	1	A01Q105	PHOTOTRANSISTOR, SFH325FA, 900NM, 35V, 15MA, 165MW, RT ANG, P-LCC-2, TAPE
1047	1643431	1	A01U101	IC,MICROCONTROLLER,MSP430F449,16 BIT,1.8-3.6V,3.3MHZ,FLASH,PQFP100,TRAY
1048	1568507	1	A01DS102	LED,INFRARED,SFH426,4MW/SR,100MA,1.8V, RT ANG 120 DEG VIEW ANGLE,PLCC2,TAPE
1049	1611291	1	A01DS103	LED,RED,AM2520,300MCD,20MA,2.2V,30 DEG VIEW ANGLE,Z BEND LEAD PREP,T3/4,TAPE
1053	830489	2	A01CR101 A01CR103	DIODE,SI,BAS16,75V,200MA,6NS,SOT-23,TAPE
1057	942941	3	A01C101-102 A01C105	CAPACITOR SMR,CAP,TA,3.3UF,+-20%,6V,3216
1060	942529	3	A01C106-108	CAPACITOR SMR,CAP,CER,0.1UF,+-10%,25V,X7R,0805
1063	641404	1	A01C104	CAPACITOR SMR,CAP,CER,8200PF,+-10%,50V,X7R,0603
1064	690271	1	A01LS101	AUDIO TRANSDUCER,MAGNETIC,SOUNDER,2.4KHZ,5V,TOP PORT,13MM SQ,TAPE
1065	2102474	1	A01U103	IC,MEMORY,EEPROM,25128,128KB,16KX8,2.7-6V,5MHZ,SERIAL,SPI,SO8,TAPE
1077	742684	1	A01Q104	TRANSISTOR,SI,PNP,MMBT3906,40V,200MA,250MHZ,225MW,SOT-23,TAPE
1078	1618826	1	A01U106	IC,OP AMP,OPA2347,2.3 - 5.5V,6MV OFFSET,350KHZ,DUAL,U-PWR,R/R,SO8,TAPE
1079	1626907	1	A01U105	IC,LOGIC,74HC148,2.0-6.0V,8-3 LINE PRIORITY ENCODER,SOIC16,TAPE
1080	1627036	1	A01Y101	CRYSTAL,32.768KHZ,30/105PPM,7PF,CLIP CAN,SMD,TAPE
1081	105954	1	A01C112	CAPACITOR SMR,CAP,TA,10UF,+-20%,6V,3216
1082	2070071	1	A01C111	CAPACITOR,ELECTRIC DOUBLE

Item	P/N	Qty	Ref Des	Description
				LAYER,0.2F,+80-20%,3.3V,SMT,TAPE
1083	1567271	6	A01DS101 A01DS104-108	LED,GREEN,AM2520,100MCD,20MA,2.5V,30 DEG VIEW ANGLE,Z BEND LEAD PREP,T3/4,TAPE
1084	643913	3	A01R119 A01R140-141	RESISTOR SMR,RES,CERM,499K,+-1%,.063W,100PPM,0603
1085	876490	1	A01R139	RESISTOR SMR,RES,CERM,5.1M,+-5%,.125W,300PPM,1206
1086	929476	2	A01C109-110	CAPACITOR SMR,CAP,CER,470PF,+-1%,50V,C0G,0805
1087	928890	1	A01R143	RESISTOR SMR,RES,CERM,221K,+-1%,0.1W,100PPM,0805
1088	2075627	1	A01P102	CONNECTOR,FLAT-FLEX,RECEPTACLE,DUAL CONTACTS,1.0MM CTR,VERTICAL SMD,20 POS,TAPE
1089	1585205	3	A01R109 A01R155-156	RESISTOR,CERMET,301,+-1%,0.063W,100PPM,0603,TAPE
1090	943316	1	A01R130	RESISTOR SMR,RES,CERM,15K,+-1%,0.1W,100PPM,0805

Item	P/N	Qty	Ref Des	Description
1	1673624	1	MP1	FLUKE-165X-2002,CASE, BACK
2	1673636	1	MP2	FLUKE-165X-2005,COMPARTMENT, BATTERY
3	2101935	1	MP3	FLUKE-165X-2006-01,DOOR, ACCESS, VDE
4	1673608	1	MP4	FLUKE-165X-2008,KNOB
5	1673594	1	MP5	FLUKE-165X-2009,SHAFT, DETENT
6	1673575	1	MP6	FLUKE-165X-2010,GRIPS,SET OF
10	1673935	1	MP7	FLUKE-165X-8004,PAD, TOUCH
11	1673947	1	MP8	FLUKE-165X-8005,BACKLIGHT
12	1674117	2	MP9-10	CONNECTOR,ELASTOMERIC,.010INCTR,.231 HIGH,.090 THICK,2.720 LONG,BULK
13	1674214	1	TM1	CD ROM, USER MANUAL, FLUKE 165X SERIES
14	2068184	1	MP22	LABEL,1652 PACKAGE
15	1664213	1	MP11	CASE,TOOL BOX ,YELLOW
16	1676850	1	MP12	CONNECTOR,HOLDER,BATTERY,6AA,2 X 3 LAYOUT,9V SNAP CONFIG,BULK
17	1777654	1	MP13	LCD,1/4-DUTY,1/3-BIAS,TRANSFLECTIVE,FLUKE-165X SERIES
18	1672160	1	MP14	FLUKE-1652-4001,PCA DIGITAL
19	1672197	1	MP15	FLUKE-1653-4002,PCA ANALOG 1
20	1673715	1	MP16	FLUKE-1652-2003,CASE,TOP WITH ARROW CONTROL
21	1673744	1	MP17	FLUKE-165X-2001,CASE, FRONT WITH IR LENS
22	1673553	1	MP18	FLUKE-1652-2012,BRACKET, MASK PAD XFER
23	1673912	1	MP19	FLUKE-1652-8003,KEYPAD
24	1884378	1	MP20	FLUKE-165X-8006,TOUCH PLATE
25	2030528	1	MP21	FLUKE-1653-4003,PCA ANALOG 2
26	832246	6	H1-6	SCREW,5-14,.750,PAN,PHILLIPS,STEEL,BLK CHROMATE,THREAD FORMING
27	642931	11	H7-17	SCREW,4-14,.312,PAN,PHILLIPS,STEEL,ZINC-CLEAR,THD FORM,#3 HEAD
28	822676	1	MP23	FLUKE 87-8004 ,CONTACT,PTF
30	2068080	1	MP24	SLEEVE,FLUKE 165X
31	2061011	1	MP25	HARD CASE INSERT,FOAM,POLYURETHANE,FLUKE-165X
32	2045406	1	MP26	CARRYING STRAP,PADDED,51.00 IN-63.00 IN ADJUSTABLE,FLUKE-165X
35	2075675	3	MP27-29	CABLE,FLAT FLEX,1.00 MM PITCH,20 COND,102 MM L
36	376756	6	BT1-6	BATTERY,PRIMARY,MNO2-ZN,1.5V,2.24AH,15A,LR6,ALKALINE,AA,14X50MM,BULK
37	2000757	1	MP30	FLUKE-165X-8008,PROBE,MULTIFUNCTIONAL
38	2030852	1	F1	FUSE,3.15A,500V,SLOW,6.35 X 32MM,BULK
39	2040349	1	F2	FUSE,1.25A,500V,FAST,6.35 X 32MM, BULK
40	1674804	1	TM2	QUICK REFERENCE CARD,,FLUKE-165X SERIES
41	2044945	1	MP31	TL-L1,TEST LEAD, RED
42	2044950	1	MP32	TL-L2,TEST LEAD, GREEN
43	2044961	1	MP33	TL-L3,TEST LEAD, BLUE
44	2068265	1	MP34	AC285-5001-03,,175-276-014 AC285 LARGE ALLIGATOR CLIP BLUE,BULK
45	2068133	1	MP35	AC285-5001-02,175-276-012 AC285 LARGE ALLIGATOR CLIP GREEN,BULK
46	2068904	1	MP37	PROBE,TEST,BANANA JACK,4MM TIP,BLUE W/CAP,175-290-007
47	2065297	1	MP38	PROBE,TEST,BANANA JACK,4MM TIP,GREEN W/CAP,175-

Item	P/N	Qty	Ref Des	Description
				290-006
48	2099044	1	MP39	PROBE,TEST,BANANA JACK,4MM TIP,RED W/CAP,175-290-003
49	2041727	1	MP36	AC285-5001,175-276-013 AC285 LARGE ALLIGATOR CLIP RED,BULK
50	1942029	1	MP40	102-406-003,PROBE CAP,GS-38 RED
51	1673672	1	MP42	FLUKE-165X-2013-01,INSULATOR, RECEPTACLE RED
52	1673685	1	MP43	FLUKE-165X-2013-02,INSULATOR, RECEPTACLE GREEN
53	1673697	1	MP44	FLUKE-165X-2013-03,INSULATOR, RECEPTACLE BLUE

Item	P/N	Qty	Ref Des	Description
1001	1556998	1	A01U102	IC,VOLTAGE REGULATOR, LINEAR, TPS77033,3.3V,50MA,LDO,LOW POWER,SOT-23-5,TAPE
1002	930222	3	A01R106-107 A01R146	RESISTOR SMR,RES,CERM,78.7K,+-1%,0.1W,100PPM,0805
1005	643863	22	A01R103 A01R105 A01R120-128 A01R138 A01R142 A01R145 A01R147-154	RESISTOR SMR,RES,CERM,100K,+-1%,.063W,100PPM,0603
1031	928937	1	A01R113	RESISTOR SMR,RES,CERM,100,+-1%,0.1W,100PPM,0805
1032	605052	4	A01R108 A01R110 A01R112 A01R114	RESISTOR SMR,RES,CERM,10K,+-1%,.063W,100PPM,0603
1035	928713	1	A01R115	RESISTOR SMR,RES,CERM,1K,+-1%,0.1W,100PPM,0805
1036	649720	2	A01R111 A01R144	RESISTOR SMR,RES,CERM,1K,+-1%,.063W,100PPM,0603
1039	928705	1	A01R101	RESISTOR SMR ,RES,JUMPER,0,+.05 MAX,.100W,0805
1043	742676	4	A01Q101-103 A01Q106	NPN,MMBT3904 SMR,TRANSISTOR,SI,NPN,60V,350MW,SOT-23
1046	1568518	1	A01Q105	PHOTOTRANSISTOR, SFH325FA, 900NM, 35V, 15MA, 165MW, RT ANG, P-LCC-2, TAPE
1047	1643431	1	A01U101	IC,MICROCONTROLLER,MSP430F449,16 BIT,1.8-3.6V,3.3MHZ,FLASH,PQFP100,TRAY
1048	1568507	1	A01DS102	LED,INFRARED,SFH426,4MW/SR,100MA,1.8V,RT ANG 120 DEG VIEW ANGLE,PLCC2,TAPE
1049	1611291	1	A01DS103	LED,RED,AM2520,300MCD,20MA,2.2V,30 DEG VIEW ANGLE,Z BEND LEAD PREP,T3/4,TAPE
1053	830489	2	A01CR101 A01CR103	DIODE,SI,BAS16,75V,200MA,6NS,SOT-23,TAPE
1057	942941	3	A01C101-102 A01C105	CAPACITOR SMR,CAP,TA,3.3UF,+-20%,6V,3216
1060	942529	3	A01C106-108	CAPACITOR SMR,CAP,CER,0.1UF,+-10%,25V,X7R,0805
1063	641404	1	A01C104	CAPACITOR SMR,CAP,CER,8200PF,+-10%,50V,X7R,0603
1064	690271	1	A01LS101	AUDIO TRANSDUCER,MAGNETIC,SOUNDER,2.4KHZ,5V,TOP PORT,13MM SQ,TAPE
1077	742684	1	A01Q104	TRANSISTOR,SI,PNP,MMBT3906,40V,200MA,250MHZ,225MW,SOT-23,TAPE
1078	1618826	1	A01U106	IC,OP AMP,OPA2347,2.3 - 5.5V,6MV OFFSET,350KHZ,DUAL,U-PWR,R/R,SO8,TAPE
1079	1626907	1	A01U105	IC,LOGIC,74HC148,2.0-6.0V,8-3 LINE PRIORITY ENCODER,SOIC16,TAPE
1080	1627036	1	A01Y101	CRYSTAL,32.768KHZ,30/105PPM,7PF,CLIP CAN,SMD,TAPE
1081	105954	1	A01C112	CAPACITOR SMR,CAP,TA,10UF,+-20%,6V,3216
1082	2070071	1	A01C111	CAPACITOR,ELECTRIC DOUBLE LAYER,0.2F,+80-20%,3.3V,SMT,TAPE

Item	P/N	Qty	Ref Des	Description
1083	1567271	6	A01DS101 A01DS104-108	LED,GREEN,AM2520,100MCD,20MA,2.5V,30 DEG VIEW ANGLE,Z BEND LEAD PREP,T3/4,TAPE
1084	643913	3	A01R119 A01R140-141	RESISTOR SMR,RES,CERM,499K,+-1%,.063W,100PPM,0603
1085	876490	1	A01R139	RESISTOR SMR,RES,CERM,5.1M,+-5%,.125W,300PPM,1206
1086	929476	2	A01C109-110	CAPACITOR SMR,CAP,CER,470PF,+-1%,50V,C0G,0805
1087	928890	1	A01R143	RESISTOR SMR,RES,CERM,221K,+-1%,0.1W,100PPM,0805
1088	2075627	1	A01P102	CONNECTOR,FLAT-FLEX,RECEPTACLE,DUAL CONTACTS,1.0MM CTR,VERTICAL SMD,20 POS,TAPE
1089	1585205	3	A01R109 A01R155-156	RESISTOR,CERMET,301,+-1%,0.063W,100PPM,0603,TAPE
1090	943316	1	A01R130	RESISTOR SMR,RES,CERM,15K,+-1%,0.1W,100PPM,0805

List of Replaceable Parts

Fluke 1651 Final Common Parts

Item	P/N	Qty	Ref Des	Description
1	1673624	1	MP1	FLUKE-165X-2002,CASE, BACK
2	1673636	1	MP2	FLUKE-165X-2005,COMPARTMENT, BATTERY
3	2101935	1	MP3	FLUKE-165X-2006-01,DOOR, ACCESS, VDE
4	1673608	1	MP4	FLUKE-165X-2008,KNOB
5	1673594	1	MP5	FLUKE-165X-2009,SHAFT, DETENT
6	1673575	1	MP6	FLUKE-165X-2010,GRIPS,SET OF
10	1673935	1	MP7	FLUKE-165X-8004,PAD, TOUCH
11	1673947	1	MP8	FLUKE-165X-8005,BACKLIGHT
12	1674117	2	MP9-10	CONNECTOR,ELASTOMERIC,.010INCTR,.231 HIGH,.090 THICK,2.720 LONG,BULK
13	1674214	1	TM1	CD ROM, USER MANUAL, FLUKE 165X SERIES
14	2068178	1	MP22	LABEL,1651 PACKAGE
15	1664213	1	MP11	CASE,TOOL BOX ,YELLOW
16	1676850	1	MP12	CONNECTOR,HOLDER,BATTERY,6AA,2 X 3 LAYOUT,9V SNAP CONFIG,BULK
17	1777654	1	MP13	LCD,1/4-DUTY,1/3-BIAS,TRANSFLECTIVE,FLUKE-165X SERIES
18	1645464	1	MP14	FLUKE-1651-4001,PCA DIGITAL
19	1672197	1	MP15	FLUKE-1653-4002,PCA ANALOG 1
20	1673703	1	MP16	FLUKE-1651-2003, CASE, TOP
21	1673744	1	MP17	FLUKE-165X-2001,CASE, FRONT WITH IR LENS
22	1673548	1	MP18	FLUKE-1651-2012,BRACKET, MASK PAD XFER
23	1673901	1	MP19	FLUKE-1651-8003,KEYPAD
24	1884378	1	MP20	FLUKE-165X-8006,TOUCH PLATE
25	2030528	1	MP21	FLUKE-1653-4003,PCA ANALOG 2
26	832246	6	H1-6	SCREW,5-14,.750,PAN,PHILLIPS,STEEL,BLK CHROMATE,THREAD FORMING
27	642931	11	H7-17	SCREW,4-14,.312,PAN,PHILLIPS,STEEL,ZINC-CLEAR,THD FORM,#3 HEAD
28	822676	1	MP23	FLUKE 87-8004 ,CONTACT,PTF
30	2068080	1	MP24	SLEEVE,FLUKE 165X
31	2061011	1	MP25	HARD CASE INSERT,FOAM,POLYURETHANE,FLUKE-165X
32	2045406	1	MP26	CARRYING STRAP,PADDED,51.00 IN-63.00 IN ADJUSTABLE,FLUKE-165X
35	2075675	3	MP27-29	CABLE,FLAT FLEX,1.00 MM PITCH,20 COND,102 MM L
36	376756	6	BT1-6	BATTERY,PRIMARY,MNO2-ZN,1.5V,2.24AH,15A,LR6,ALKALINE,AA,14X50MM,BULK
37	2000757	1	MP30	FLUKE-165X-8008,PROBE,MULTIFUNCTIONAL
38	2030852	1	F1	FUSE,3.15A,500V,SLOW,6.35 X 32MM,BULK
39	2040349	1	F2	FUSE,1.25A,500V,FAST,6.35 X 32MM, BULK
40	1674804	1	TM2	QUICK REFERENCE CARD,,FLUKE-165X SERIES
41	2044961	1	MP31	TL-L3,TEST LEAD, BLUE
42	2044950	1	MP32	TL-L2,TEST LEAD, GREEN
43	2068265	1	MP34	AC285-5001-03,,175-276-014 AC285 LARGE ALLIGATOR CLIP BLUE,BULK
44	2068133	1	MP35	AC285-5001-02,175-276-012 AC285 LARGE ALLIGATOR CLIP GREEN,BULK
45	2068904	1	MP37	PROBE,TEST,BANANA JACK,4MM TIP,BLUE W/CAP,175-290-007
46	2065297	1	MP38	PROBE,TEST,BANANA JACK,4MM TIP,GREEN W/CAP,175-290-006
49	1942029	1	MP40	102-406-003,PROBE CAP,GS-38 RED
50	1673672	1	MP42	FLUKE-165X-2013-01,INSULATOR, RECEPTACLE RED

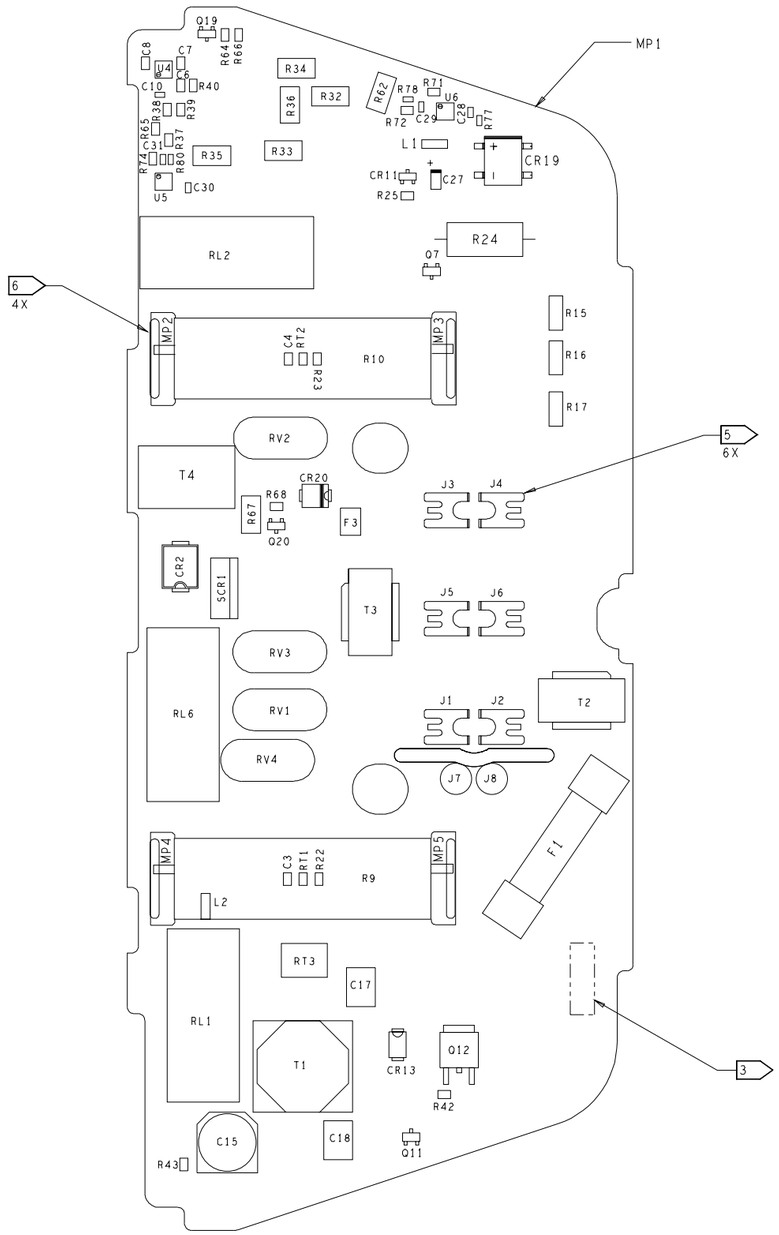
Item	P/N	Qty	Ref Des	Description
51	1673685	1	MP43	FLUKE-165X-2013-02,INSULATOR, RECEPTACLE GREEN
52	1673697	1	MP44	FLUKE-165X-2013-03,INSULATOR, RECEPTACLE BLUE

Item	P/N	Qty	Ref Des	Description
1001	1556998	1	A01U102	IC,VOLTAGE REGULATOR, LINEAR, TPS77033,3.3V,50MA,LDO,LOW POWER,SOT-23-5,TAPE
1002	930222	3	A01R106-107 A01R146	RESISTOR SMR,RES,CERM,78.7K,+-1%,0.1W,100PPM,0805
1005	643863	22	A01R104-105 A01R120-128 A01R138 A01R142 A01R145 A01R147-154	RESISTOR SMR,RES,CERM,100K,+-1%,.063W,100PPM,0603
1031	928937	1	A01R113	RESISTOR SMR,RES,CERM,100,+-1%,0.1W,100PPM,0805
1032	605052	4	A01R108 A01R110 A01R112 A01R114	RESISTOR SMR,RES,CERM,10K,+-1%,.063W,100PPM,0603
1035	928713	1	A01R115	RESISTOR SMR,RES,CERM,1K,+-1%,0.1W,100PPM,0805
1036	649720	2	A01R111 A01R144	RESISTOR SMR,RES,CERM,1K,+-1%,.063W,100PPM,0603
1039	928705	1	A01R102	RESISTOR SMR ,RES,JUMPER,0,+.05 MAX,.100W,0805
1043	742676	4	A01Q101-103 A01Q106	NPN,MMBT3904 SMR,TRANSISTOR,SI,NPN,60V,350MW,SOT-23
1046	1568518	1	A01Q105	PHOTOTRANSISTOR, SFH325FA, 900NM, 35V, 15MA, 165MW, RT ANG, P-LCC-2, TAPE
1047	1643431	1	A01U101	IC,MICROCONTROLLER,MSP430F449,16 BIT,1.8-3.6V,3.3MHZ,FLASH,PQFP100,TRAY
1048	1568507	1	A01DS102	LED,INFRARED,SFH426,4MW/SR,100MA,1.8V,RT ANG 120 DEG VIEW ANGLE,PLCC2,TAPE
1049	1611291	1	A01DS103	LED,RED,AM2520,300MCD,20MA,2.2V,30 DEG VIEW ANGLE,Z BEND LEAD PREP,T3/4,TAPE
1053	830489	2	A01CR101 A01CR103	DIODE,SI,BAS16,75V,200MA,6NS,SOT-23,TAPE
1057	942941	3	A01C101-102 A01C105	CAPACITOR SMR,CAP,TA,3.3UF,+-20%,6V,3216
1060	942529	3	A01C106-108	CAPACITOR SMR,CAP,CER,0.1UF,+-10%,25V,X7R,0805
1063	641404	1	A01C104	CAPACITOR SMR,CAP,CER,8200PF,+-10%,50V,X7R,0603
1064	690271	1	A01LS101	AUDIO TRANSDUCER,MAGNETIC,SOUNDER,2.4KHZ,5V,TOP PORT,13MM SQ,TAPE
1077	742684	1	A01Q104	TRANSISTOR,SI,PNP,MMBT3906,40V,200MA,250MHZ,225MW,SOT-23,TAPE
1078	1618826	1	A01U106	IC,OP AMP,OPA2347,2.3 - 5.5V,6MV OFFSET,350KHZ,DUAL,U-PWR,R/R,SO8,TAPE
1079	1626907	1	A01U105	IC,LOGIC,74HC148,2.0-6.0V,8-3 LINE PRIORITY ENCODER,SOIC16,TAPE
1080	1627036	1	A01Y101	CRYSTAL,32.768KHZ,30/105PPM,7PF,CLIP CAN,SMD,TAPE
1081	105954	1	A01C112	CAPACITOR SMR,CAP,TA,10UF,+-20%,6V,3216
1082	2070071	1	A01C111	CAPACITOR,ELECTRIC DOUBLE LAYER,0.2F,+80-20%,3.3V,SMT,TAPE

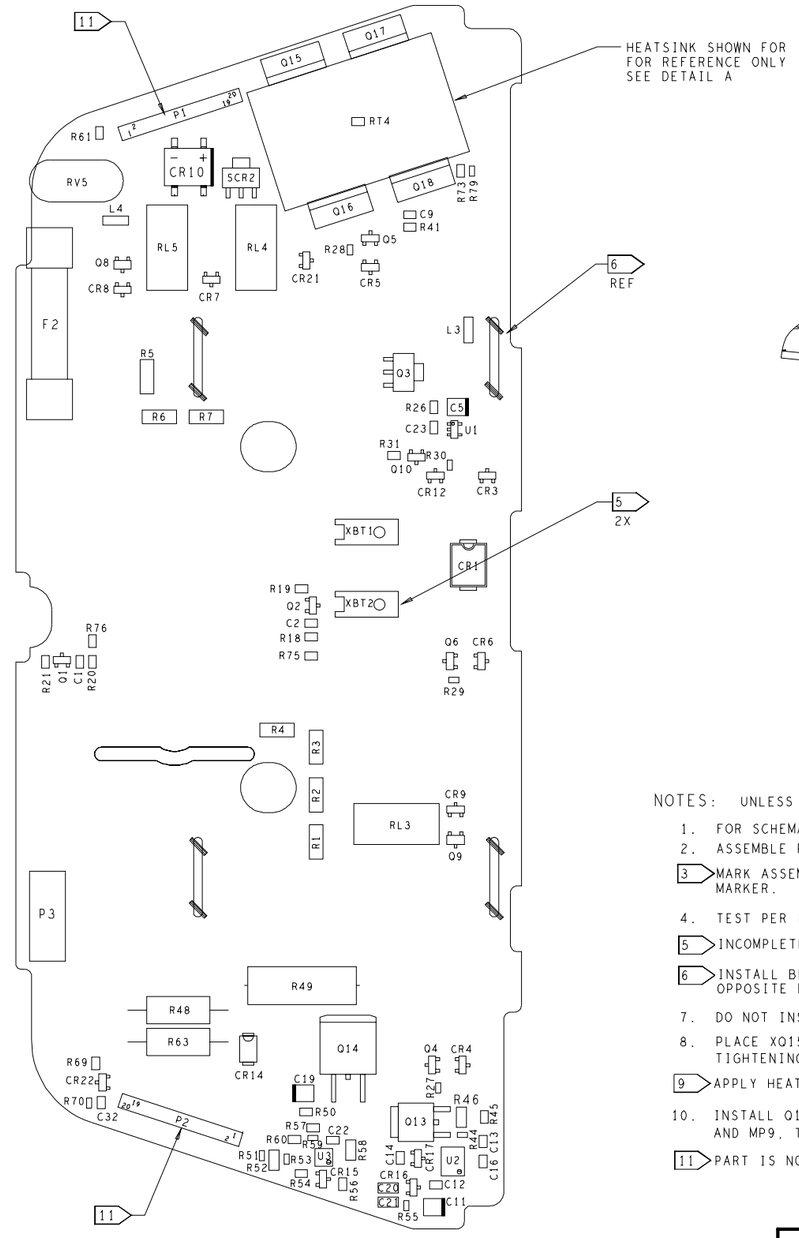
Item	P/N	Qty	Ref Des	Description
1083	1567271	6	A01DS101 A01DS104-108	LED,GREEN,AM2520,100MCD,20MA,2.5V,30 DEG VIEW ANGLE,Z BEND LEAD PREP,T3/4,TAPE
1084	643913	3	A01R119 A01R140-141	RESISTOR SMR,RES,CERM,499K,+-1%,.063W,100PPM,0603
1085	876490	1	A01R139	RESISTOR SMR,RES,CERM,5.1M,+-5%,.125W,300PPM,1206
1086	929476	2	A01C109-110	CAPACITOR SMR,CAP,CER,470PF,+-1%,50V,C0G,0805
1087	928890	1	A01R143	RESISTOR SMR,RES,CERM,221K,+-1%,0.1W,100PPM,0805
1088	2075627	1	A01P102	CONNECTOR,FLAT-FLEX,RECEPTACLE,DUAL CONTACTS,1.0MM CTR,VERTICAL SMD,20 POS,TAPE
1089	1585205	3	A01R109 A01R155-156	RESISTOR,CERMET,301,+-1%,0.063W,100PPM,0603,TAPE
1090	943316	1	A01R130	RESISTOR SMR,RES,CERM,15K,+-1%,0.1W,100PPM,0805

DWG NO.	FLUKE-1653-4002	SH 1

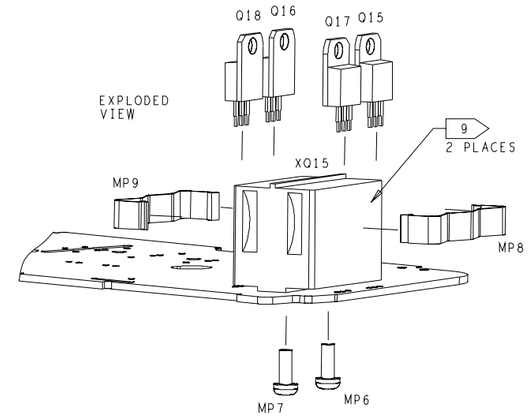
REVISIONS		
REV	DESCRIPTION	DWN
013	W1039654: CHGED NOTE 9 AND BOM CHGES ONLY	KD 04DEC03

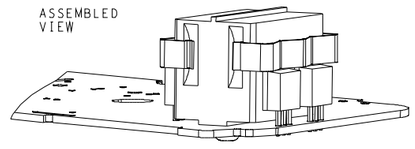


TOP ASSEMBLY



BOTTOM ASSEMBLY





DETAIL A

NOTES: UNLESS OTHERWISE SPECIFIED

1. FOR SCHEMATIC DIAGRAM, SEE FLUKE-16XX-1002.
2. ASSEMBLE PER QSD 111.1.
3. MARK ASSEMBLY REVISION LETTER IN SPACE PROVIDED WITH PERMANENT MARKER.
4. TEST PER 1653-4001-151.
5. INCOMPLETE SOLDER FILLET ACCEPTABLE ON THRU-HOLE LEADS.
6. INSTALL BRACKET,(MP2-5) FROM TOP,(CKT 4) SIDE, BEND TABS,IN OPPOSITE DIRECTIONS, TO APPROXIMATELY 45 DEGREES.
7. DO NOT INSTALL: C23 AND C27.
8. PLACE XQ15 ON PCB AND SECURE BY STARTING BOTH SCREWS BEFORE TIGHTENING EITHER ONE.TIGHTEN EACH TO 5 INCH POUNDS.
9. APPLY HEATSINK COMPOUND P/N 2126927 OR EQUIVALENT TO AREAS SHOWN.
10. INSTALL Q15-Q18 INTO PCB HOLES AND CLAMP WITH CLIPS, MP8 AND MP9, THEN SOLDER Q15-Q18.
11. PART IS NOT POLARIZED.

CAUTION
SUBJECT TO DAMAGE BY
STATIC ELECTRICITY

DWN	DARREN HERMSEN	12FEB02
CHK		
APPRVD		
APPRVD		

FLUKE CORPORATION
P.O BOX 9090
EVERETT, WA 98206-9090

89536

PCA, ANALOG 1

PART NO.	SIZE	DWG NO.	REV
1672197	D	FLUKE-1653-4002	013

SCALE 2 : 1 SH 1 OF 1

PROPRIETARY

Item	P/N	Qty	Ref Des	Description
1002	561431	4	A02XF1-4	FUSE CLIP ,FUSE CLIP,PCB,1/4X1-1/4
1003	1672452	6	A02J1-6	FLUKE-1653-8001,RECEPTACLE,CONTACT
1009	1577653	2	A02XBT1-2	FLUKE 112-8007,CONTACT,BATTERY LEADED
1011	1999841	2	A02R9-10	RESISTOR,WIREWOUND,10,+-5%,12W,RADIAL,LONG LEADS,BULK
1012	2052325	4	A02R1-4	RESISTOR,METAL FILM,750K,+-1%,1W,50PPM,CYLINDRICAL 0207,TAPE
1013	2002382	1	A02CR20	ZENER,UNCOMP,SMBJ12A,12V,5%,1MA,600W,TRANSIENT SUPRESSOR,SMB,TAPE
1014	830489	6	A02CR4-9	DIODE,SI,BAS16,75V,200MA,6NS,SOT-23,TAPE
1020	2052333	1	A02T4	TRANSFORMER,SIGNAL,2MH,1:1,COMMON MODE CHOKE,DIP4,BULK
1021	944996	1	A02U1	IC,VOLTAGE REGULATOR,LINEAR,LP2980,5V,50MA,LDO,LO PWR,W/SHUT DOWN,SOT-23-5,TAPE
1026	2102488	2	A02RV4-5	VARISTOR,558VDC MIN @1MA,385VRMS CONT,505VDC CONT,67J,7.5MM RADIAL,BULK
1027	2030909	2	A02RT1-2	THERMISTOR,NTC,10K,+-5%,NON-LINEAR,0805,TAPE
1029	2030909	1	A02RT4	THERMISTOR,NTC,10K,+-5%,NON-LINEAR,0805,TAPE
1030	2002646	1	A02SCR1	THYRISTOR,SCR,1000V,12A,120A SURGE,TO-220,TUBE
1032	1883740	3	A02RL3-5	RELAY,ARMATURE,2 FORM C,5V,15X9MM,SMT,TAPE
1033	2002654	1	A02SCR2	THYRISTOR,SCR,600V,800MA,25A SURGE,SENSITIVE GATE,SOT-223,TAPE
1035	2030615	1	A02RL6	RELAY,ARMATURE,1 FORM A,5VDC,110MA,16A,PCB,29X13X26,BULK
1036	2030632	2	A02RL1-2	RELAY,ARMATURE,2 FORM C,5VDC,80MA,8A,GOLD,PCB,29X13X16,BULK
1038	2052316	1	A02R24	RESISTOR,WIREWOUND,5.1,+-5%,2.5W,600PPM,AXIAL,TAPE/AMMO
1039	605268	2	A02R51 A02R55	RESISTOR SMR,RES,CERM,47.5K,+-1%,.063W,100PPM,0603
1040	2040372	3	A02R5-7	RESISTOR,METAL FILM,1M,+-1%,1W,50PPM,CYLINDRICAL 0207,TAPE
1041	2040372	3	A02R15-17	RESISTOR,METAL FILM,1M,+-1%,1W,50PPM,CYLINDRICAL 0207,TAPE
1042	943345	1	A02R60	RESISTOR,CERMET,33.2K,+-1%,0.1W,100PPM,0805,TAPE
1043	1580020	2	A02R53 A02R59	RESISTOR,CERMET,475K,+-1%,0.063W,100PPM,0603,TAPE
1044	2052279	4	A02R32-35	RESISTOR,CERMET,18.2,+-1%,1W,100PPM,2512,TAPE
1045	928866	3	A02R18 A02R20 A02R69	RESISTOR SMR,RES,CERM,100K,+-1%,0.1W,100PPM,0805
1046	887109	1	A02R58	RESISTOR SMR,RES,CERM,43.2K,+-1%,.125W,100PPM,1206
1047	928937	1	A02R26	RESISTOR SMR,RES,CERM,100,+-1%,0.1W,100PPM,0805

Item	P/N	Qty	Ref Des	Description
1048	928791	8	A02R19 A02R21 A02R45 A02R54 A02R57 A02R61 A02R75-76	RESISTOR SMR,RES,CERM,10K,+-1%,0.1W,100PPM,0805
1049	943071	2	A02R22-23	RESISTOR,CERMET,24.3K,+-1%,0.1W,100PPM,0805,TAPE
1050	2053905	1	A02R46	RESISTOR,CERMET,0.56,+-1%,0.5W,100PPM,1206,TAPE
1051	1996635	2	A02R48 A02R63	RESISTOR,CERMET,10M,+-1%,0.5W,200PPM,AXIAL,TAPE
1052	2062933	1	A02R62	RESISTOR,METAL FILM,10,+-1%,1W,50PPM,2512,TAPE
1053	928791	3	A02R38 A02R40 A02R42	RESISTOR SMR,RES,CERM,10K,+-1%,0.1W,100PPM,0805
1054	943071	1	A02R41	RESISTOR,CERMET,24.3K,+-1%,0.1W,100PPM,0805,TAPE
1057	928697	1	A02R73	RESISTOR SMR,RES,CERM,49.9K,+-1%,0.1W,100PPM,0805
1058	928945	1	A02R39	RESISTOR SMR,RES,CERM,1M,+-1%,0.1W,200PPM,0805
1059	928945	1	A02R56	RESISTOR SMR,RES,CERM,1M,+-1%,0.1W,200PPM,0805
1060	928697	3	A02R71-72 A02R74	RESISTOR SMR,RES,CERM,49.9K,+-1%,0.1W,100PPM,0805
1061	928713	2	A02R31 A02R50	RESISTOR SMR,RES,CERM,1K,+-1%,0.1W,100PPM,0805
1062	928713	6	A02R25 A02R37 A02R64-66 A02R68	RESISTOR SMR,RES,CERM,1K,+-1%,0.1W,100PPM,0805
1074	2030603	1	A02Q3	TRANSISTOR,SI,PNP,BCP53,100V,1.5A,50MHZ,1.5W,SOT-223,TAPE
1075	1609811	1	A02U3	IC,OP AMP,OPA2336,2.3-5.5V,0.5MV OFFSET,100KHZ,DUAL,SS,R/R OUT,U-PWR,MSOP-8,TAPEPurchased Item
1076	930052	1	A02Q11	NPN,MUN2211 SMR,TRANSISTOR,SI,NPN,50V,200MW,SC-59
1077	742676	2	A02Q1-2	NPN,MMBT3904 SMR,TRANSISTOR,SI,NPN,60V,350MW,SOT-23
1078	2002486	2	A02Q8-9	TRANSISTOR,SI,NPN,MUN2216,50V,100MA,4.7K BIAS RESISTOR,230MW,SC-59,TAPE
1079	2002486	1	A02Q7	TRANSISTOR,SI,NPN,MUN2216,50V,100MA,4.7K BIAS RESISTOR,230MW,SC-59,TAPE
1082	837484	4	A02Q4-6 A02Q10	NPN,MMBT2222A SMR,TRANSISTOR,SI,NPN,75V,250MW,SOT-23
1085	2062925	1	A02Q19	MOSFET,SI,N,FDN337N,30V,2.2A,65 MOHMS,500MW,SOT-23,TAPE
1086	1543520	1	A02Q14	MOSFET,SI,N,MTB3N120,1200V,3A,5 OHMS,125W,D2-PAK,TAPE

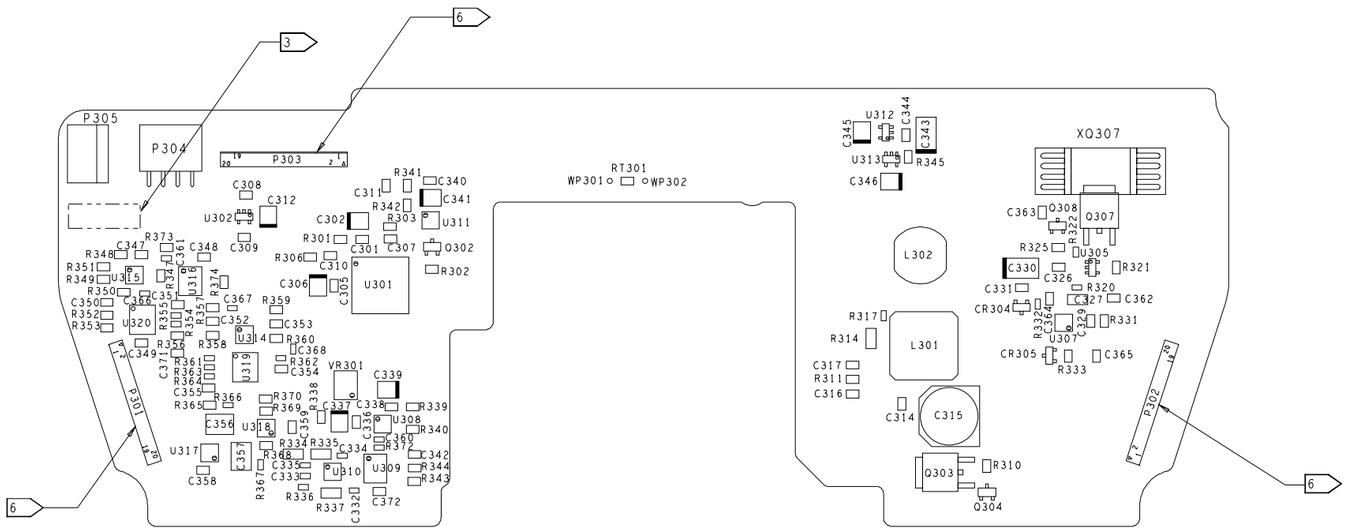
Item	P/N	Qty	Ref Des	Description
1087	1579273	1	A02Q13	MOSFET,SI,N,IRLR3410,100V,17A,105 MOHMS,3W,D-PAK,TAPE
1089	2002394	1	A02F3	THERMISTOR,PTC,0.26 OHM,0.75A HOLD,1.5A TRIP,1812,TAPE
1090	2087962	1	A02CR13	DIODE,SI,PN,S1K,800V,1A,75NS,SMA,TAPE
1091	2087962	1	A02CR14	DIODE,SI,PN,S1K,800V,1A,75NS,SMA,TAPE
1092	2087943	1	A02CR1	DIODE,SI,PN,S3M,1KV,3A,2.5US,SMC,TAPE
1093	2087943	1	A02CR2	DIODE,SI,PN,S3M,1KV,3A,2.5US,SMC,TAPE
1094	742320	3	A02CR3 A02CR12 A02CR15	DIODE,SI,PN,BAV99,70V,215MA,6NS,DUAL,SERIES ,SOT-23,TAPE
1096	643913	1	A02R79	RESISTOR SMR,RES,CERM,499K,+-1%,.063W,100PPM,0603
1097	643913	3	A02R77-78 A02R80	RESISTOR SMR,RES,CERM,499K,+-1%,.063W,100PPM,0603
1098	603032	3	A02C5 A02C11 A02C19	CAPACITOR SMR,CAP,TA,10UF,+-20%,10V,3528
1100	929476	1	A02C13	CAPACITOR SMR,CAP,CER,470PF,+-1%,50V,C0G,0805
1101	601028	1	A02C16	CAPACITOR SMR,CAP,CER,100PF,+-5%,100V,C0G,0805
1103	106625	1	A02C21	CAPACITOR SMR,CAP,CER,0.22UF,+-10%,25V,X7R,1206
1104	942529	3	A02C12 A02C14 A02C32	CAPACITOR SMR,CAP,CER,0.1UF,+-10%,25V,X7R,0805
1105	942529	2	A02C7-8	CAPACITOR SMR,CAP,CER,0.1UF,+-10%,25V,X7R,0805
1106	605342	5	A02C10 A02C28-31	CAPACITOR SMR,CAP,CER,1000PF,+-10%,50V,X7R,0603
1107	1644007	1	A02C22	CAPACITOR,CERAMIC,1UF,+80-20%,16V,Y5V,0805,TAPE
1109	2063190	2	A02C17-18	CAPACITOR,CERAMIC,.047UF,+-10%,1000V,X7R,1825,TAPE
1111	106146	3	A02C3-4 A02C6	CAPACITOR,CERAMIC,0.01UF,+-10%,50V,X7R,0805,TAPE
1113	106146	3	A02C1-2 A02C9	CAPACITOR,CERAMIC,0.01UF,+-10%,50V,X7R,0805,TAPE
1117	929745	3	A02CR16-17 A02CR22	DIODE,SI,SCHOTTKY,BAT54S,30V,200MA,5NS,DUAL-SERIES,SOT-23,TAPE
1119	2087970	1	A02CR10	DIODE,SI,PN,DF1510S,1KV,1.5A,BRIDGE,DFS,TAPE
1120	2087970	1	A02CR19	DIODE,SI,PN,DF1510S,1KV,1.5A,BRIDGE,DFS,TAPE
1121	943456	1	A02CR11	ZENER,UNCOMP,MMBZ5258B,36V,5%,3.4MA,225MW,SOT-23,TAPE
1122	643681	1	A02Q20	FET,N,NDS351AN SMR,TRANSISTOR,SI,N-MOS,500MW,SOT-23
1123	2040403	3	A02U4-6	IC,OP AMP,OPA2244,+-1.1V TO +-18V,1.5MV OFFSET,430KHZ,DUAL,U-POWER,S/S,SO8,TAPE
1124	1277360	1	A02RT3	THERMISTOR,POSITIVE,1.1K,+-

Item	P/N	Qty	Ref Des	Description
				20%,COATED,RADIAL,TAPE
1125	602687	1	A02R43	RESISTOR SMR,RES,CERM,56.2K,+-1%,0.1W,100PPM,0805
1126	2062377	1	A02R36	RESISTOR,CERMET,1,+-1%,3W,100PPM,2512,TAPE
1127	867408	1	A02C20	CAPACITOR SMR,CAP,CER,1000PF,+-5%,50V,C0G,1206
1128	927707	2	A02R30 A02R44	RESISTOR SMR,RES,CERM,47,+-5%,.0625W,200PPM,0603
1129	867437	1	A02R52	RESISTOR SMR,RES,CERM,121K,+-1%,.125W,100PPM,1206
1130	1558777	1	A02R49	RESISTOR,CERMET COMPOSITION,1K,+-10%,1W,-1300+-300PPM,25MM PREP,BULK
1131	2032219	1	A02Q12	MOSFET,SI,P,STD10PF06,60V,10A,200 MOHMS,1.5W,D-PAK,TAPE
1132	2040397	1	A02U2	IC,PULSE WIDTH MODULATOR,UCC3813-5,4V,200MA,31KHZ,10V SUPPLY,SO8,TAPE
1133	2040351	4	A02Q15-18	MOSFET,SI,N,STP5NB80,800V,5A,2.2 OHMS,110W,TO220,BULK
1136	2066181	1	A02P3	CONNECTOR,HEADER,1 ROW,.156INCTR,VERTICAL SMT,4PIN,TUBE
1137	944645	2	A02L3-4	INDUCTOR,BEAD,60 OHMS@100MHZ,6ADC,10MOHM,1806,TAPE
1140	944645	2	A02L1-2	INDUCTOR,BEAD,60 OHMS@100MHZ,6ADC,10MOHM,1806,TAPE
1141	2075627	2	A02P1-2	CONNECTOR,FLAT-FLEX,RECEPTACLE,DUAL CONTACTS,1.0MM CTR,VERTICAL SMD,20 POS,TAPE
1143	2032204	1	A02T1	TRANSFORMER,FLY-BACK,6V,20KHZ,1:10:10,1.5W,HV,FLUKE-165X,RM6,SMT8,TAPE
1144	928143	1	A02CR21	DIODE,SI,PN,MMBD1503A,150V,200MA,DUAL,SERIES,LOW LEAKAGE,SOT-23,TAPE
1145	2030644	2	A02T2-3	TRANSFORMER,SIGNAL,2.5MH,9:1,1MA,VERTICAL TOROID,8 LEAD SMT,TRAYS
1147	1673895	2	A02J7-8	FLUKE-1653-8002,RECEPTACLE, REMOTE
1149	1597110	1	A02C15	CAPACITOR,ELECTROLYTIC,ALUMINUM,330UF,+-20%,35V,LOW ESR,105C,10X10 SMT,TAPE
1150	2044010	4	A02MP2-5	FLUKE-1653-8009,BRACKET, RESISTOR
1155	688424	1	A02R67	RESISTOR SMR,RES,CERM,9.1,+-5%,1W,400PPM,2512
1157	2074016	1	A02XQ15	FLUKE-1653-8011,HEATSINK
1158	2040415	3	A02RV1-3	VARISTOR,723V,+-10%,1.0MA,10MM,RADIAL,BULK
1160	2089239	2	A02MP6-7	SCREW,M3X0.5,8 MM, PAN,TORX,STEEL, ZINC-CLEAR,LOCK
1161	2075096	2	A02MP8-9	HEAT SINK ACCESSORY,GULL WING CLIP,2 X TO-220
1162	605086	3	A02R27-29	RESISTOR SMR,RES,CERM,2K,+-1%,.063W,100PPM,0603
1163	605052	1	A02R70	RESISTOR SMR,RES,CERM,10K,+-1%,.063W,100PPM,0603

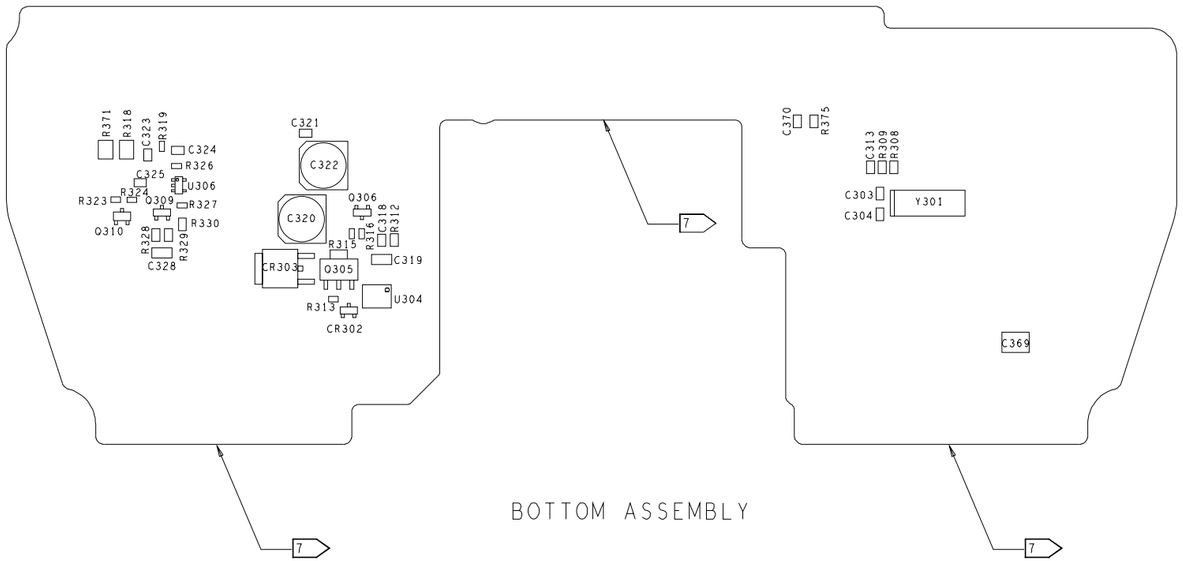
DWG NO.	SH
FLUKE-1653-4003	1

REVISIONS

REV	DESCRIPTION	DWN
006	W1035959	KD 08JUL03
007	W1037015	D W H 21AUG03
008	W1037615	JHG 15SEP03
009	W1037908: C370 WAS 0.1 MRCROFARAD	KD 26SEP03



TOP ASSEMBLY



BOTTOM ASSEMBLY

NOTES: UNLESS OTHERWISE SPECIFIED

1. FOR SCHEMATIC DIAGRAM, SEE FLUKE-16XX-1003.
2. ASSEMBLE PER QSD 111.1.
3. MARK ASSEMBLY REVISION LETTER IN SPACE PROVIDED WITH PERMANENT MARKER.
4. TEST PER FLUKE-16XX-4003.151.
5. DO NOT INSTALL P304, P305, AND C362-C365.
6. PART IS NOT POLARIZED.
7. TAB NOT TO EXCEED .020 INCHES.

CAUTION
SUBJECT TO DAMAGE BY
STATIC ELECTRICITY

DWN	DARREN HERMSEN	11OCT02
CHK		
APPRVD		
APPRVD		

FLUKE CORPORATION
P.O. BOX 9090
EVERETT, WA 98206-9090

89536

PCA, ANALOG 2

PART NO.	SIZE	DWG NO.	REV
2030528	D	FLUKE-1653-4003	009

SCALE 2 : 1 SH 1 OF 1

PROPRIETARY

Item	P/N	Qty	Ref Des	Description
3	944996	1	A03U313	IC,VOLTAGE REGULATOR, LINEAR, LP2980, 5V, 50MA,LDO,LO PWR,W/SHUT DOWN,SOT-23-5,TAPE
4	605268	1	A03R367	RESISTOR SMR,RES,CERM,47.5K,+-1%,.063W,100PPM,0603
5	928945	1	A03R345	RESISTOR SMR,RES,CERM,1M,+-1%,0.1W,200PPM,0805
6	928866	6	A03R302-303 A03R306 A03R340 A03R342 A03R374	RESISTOR SMR,RES,CERM,100K,+-1%,0.1W,100PPM,0805
7	642477	1	A03CR304	ZENER,UNCOMP,MMBZ5243B,13V,5%,9.5MA,225MW,SOT-23,TAPE
8	928866	1	A03R312	RESISTOR SMR,RES,CERM,100K,+-1%,0.1W,100PPM,0805
9	928937	1	A03R375	RESISTOR SMR,RES,CERM,100,+-1%,0.1W,100PPM,0805
11	943092	1	A03R311	RESISTOR,CERMET,39.2K,+-1%,0.1W,100PPM,0805,TAPE
12	2053905	1	A03R314	RESISTOR,CERMET,0.56,+-1%,0.5W,100PPM,1206,TAPE
13	928937	1	A03R301	RESISTOR SMR,RES,CERM,100,+-1%,0.1W,100PPM,0805
14	928791	11	A03R310 A03R331 A03R333 A03R343-344 A03R347-351 A03R365	RESISTOR SMR,RES,CERM,10K,+-1%,0.1W,100PPM,0805
15	2030883	1	A03R356	RESISTOR,CERMET,6.19K,+-1%,0.1W,50PPM,0805,TAPE
16	1598101	1	A03R366	RESISTOR,CERMET,562,+-1%,0.063W,100PPM,0603,TAPE
24	928791	1	A03R329	RESISTOR SMR,RES,CERM,10K,+-1%,0.1W,100PPM,0805
26	928713	5	A03R321 A03R325 A03R338 A03R370 A03R373	RESISTOR SMR,RES,CERM,1K,+-1%,0.1W,100PPM,0805
29	928713	2	A03R328 A03R330	RESISTOR SMR,RES,CERM,1K,+-1%,0.1W,100PPM,0805
33	1609811	3	A03U314-315 A03U317	IC,OP AMP,OPA2336,2.3-5.5V,0.5MV OFFSET,100KHZ,DUAL,SS,R/R OUT,U-PWR,MSOP-8,TAPEPurchased Item
36	930052	1	A03Q310	NPN,MUN2211 SMR,TRANSISTOR,SI,NPN,50V,200MW,SC-59
37	930052	1	A03Q304	NPN,MUN2211 SMR,TRANSISTOR,SI,NPN,50V,200MW,SC-59
38	2030909	1	A03RT301	THERMISTOR,NTC,10K,+-5%,NON-LINEAR,0805,TAPE
40	603032	8	A03C302 A03C306	CAPACITOR SMR,CAP,TA,10UF,+-20%,10V,3528

Item	P/N	Qty	Ref Des	Description
			A03C312 A03C337 A03C339 A03C341 A03C345-346	
48	942529	21	A03C301 A03C305 A03C307-311 A03C314 A03C316 A03C331 A03C336 A03C338 A03C340 A03C342 A03C344 A03C347-349 A03C358-359 A03C372	CAPACITOR SMR,CAP,CER,0.1UF,+-10%,25V,X7R,0805
58	929476	1	A03C370	CAPACITOR SMR,CAP,CER,470PF,+-1%,50V,C0G,0805
59	942529	2	A03C318 A03C321	CAPACITOR SMR,CAP,CER,0.1UF,+-10%,25V,X7R,0805
70	106146	6	A03C326 A03C329 A03C351 A03C354-355 A03C371	CAPACITOR,CERAMIC,0.01UF,+-10%,50V,X7R,0805,TAPE
72	106146	4	A03C313 A03C323-325	CAPACITOR,CERAMIC,0.01UF,+-10%,50V,X7R,0805,TAPE
76	929745	1	A03CR302	DIODE,SI,SCHOTTKY,BAT54S,30V,200MA,5NS,DUAL-SERIES,SOT-23,TAPE
77	2040403	1	A03U307	IC,OP AMP,OPA2244,+-1.1V TO +-18V,1.5MV OFFSET,430KHZ,DUAL,U-POWER,S/S,SO8,TAPE
78	867408	2	A03C319 A03C328	CAPACITOR SMR,CAP,CER,1000PF,+-5%,50V,C0G,1206
79	867408	1	A03C327	CAPACITOR SMR,CAP,CER,1000PF,+-5%,50V,C0G,1206
81	927707	1	A03R332	RESISTOR SMR,RES,CERM,47,+-5%,.0625W,200PPM,0603
82	927707	1	A03R313	RESISTOR SMR,RES,CERM,47,+-5%,.0625W,200PPM,0603
83	2032219	2	A03Q303 A03Q307	MOSFET,SI,P,STD10PF06,60V,10A,200 MOHMS,1.5W,D-PAK,TAPE
85	2040397	1	A03U304	IC,PULSE WIDTH MODULATOR,UCC3813-5,4V,200MA,31KHZ,10V SUPPLY,SO8,TAPE
86	2075627	3	A03P301-303	CONNECTOR,FLAT-FLEX,RECEPTACLE,DUAL CONTACTS,1.0MM CTR,VERTICAL SMD,20 POS,TAPE
89	837195	1	A03CR305	ZENER,UNCOMP,MMBZ5235B,6.8V,5%,20MA,225MW,SOT-23,TAPE
90	106119	2	A03U302 A03U312	BIPOLAR LP2980 SMR,IC,VOLT REG,3.3V,LDO,50MA,SOT23-5

Item	P/N	Qty	Ref Des	Description
92	1295229	1	A03VR301	IC,VOLTAGE REFERENCE,LM336,2.5V,2%,35PPM/C,1MA,SO8,TAPE
93	686763	1	A03R309	RESISTOR SMR,RES,CERM,536K,+-1%,0.1W,100PPM,0805
94	1573313	2	A03R320 A03R336	RESISTOR,CERMET,511,+-1%,0.063W,100PPM,0603,TAPE
95	2002523	2	A03R318 A03R371	RESISTOR,METAL FILM,10,+-1%,0.25W,50PPM,1210,TAPE
96	605029	1	A03R323	RESISTOR SMR,RES,CERM,4.7K,+-5%,.063W,200PPM,0603
97	1580012	3	A03R355 A03R362 A03R364	RESISTOR,CERMET,4.75K,+-1%,0.063W,100PPM,0603,TAPE
100	605250	1	A03R316	RESISTOR SMR,RES,CERM,4.32K,+-1%,.063W,100PPM,0603
101	644705	2	A03R334-335	RESISTOR SMR,RES,CERM,619,+-1%,.125W,100PPM,1206
103	1544281	1	A03R369	RESISTOR,METAL FILM,3.01K,+-0.1%,0.1W,25PPM,0805,TAPE
104	689130	1	A03R319	RESISTOR SMR,RES,CERM,200,+-1%,.063W,100PPM,0603
106	2071267	6	A03R352-353 A03R357-360	RESISTOR,CERMET,1.8M,+-1%,0.1W,100PPM,0805,TAPE
112	943621	1	A03R308	RESISTOR,CERMET,2M,+-1%,0.1W,400PPM,0805,TAPE
113	944884	1	A03R337	RESISTOR SMR,RES,CERM,392,+-1%,.125W,100PPM,1206
114	643897	2	A03R324 A03R327	RESISTOR SMR,RES,CERM,332K,+-1%,.063W,100PPM,0603
116	642212	1	A03R315	RESISTOR SMR,RES,CERM,13.0K,+-1%,.063W,100PPM,0603
117	1544270	1	A03R368	RESISTOR,METAL FILM,12.1K,+-0.1%,0.1W,25PPM,0805,TAPE
118	928924	2	A03R339 A03R341	RESISTOR SMR,RES,CERM,10,+-1%,0.1W,100PPM,0805
120	1715430	1	A03R317	RESISTOR,CERMET,36.5K,+-1%,0.063W,100PPM,0603,TAPE
121	1728134	1	A03R326	RESISTOR,CERMET,221,+-1%,0.063W,100PPM,0603,TAPE
122	1728134	1	A03R322	RESISTOR,CERMET,221,+-1%,0.063W,100PPM,0603,TAPE
123	1777739	3	A03R354 A03R361 A03R363	RESISTOR,CERMET,182K,+-1%,0.063W,100PPM,0603,TAPE
126	930045	1	A03Q302	PNP,MUN2111 SMR,TRANSISTOR,SI,PNP,50V,200MW,SC-59
127	2002499	1	A03Q308	MOSFET,SI,P,BSS84,50V,130MA,10 OHMS,225MW,SOT-23,TAPE
128	2068234	1	A03U309	IC,OP AMP,OPA2340,2.7V TO 5V,500UV OFFSET,5.5 MHZ,DUAL,R/R,S/S,SO8,TAPE
129	641537	1	A03U306	CMOS 7101 SMR,IC,OP AMP,RAIL-RAIL,LOW PWR,SOT23-5

Item	P/N	Qty	Ref Des	Description
130	641537	1	A03U305	CMOS 7101 SMR,IC,OP AMP,RAIL-RAIL,LOW PWR,SOT23-5
131	2002435	2	A03Q306 A03Q309	MOSFET,SI,N,BSS138,50V,200MA,3.5 OHMS,225MW,SOT-23,TAPE
132	2002447	1	A03Q305	MOSFET,SI,N,NDT3055,60V,4A,100 MOHMS,1.1W,SOT-223,TAPE
134	2002133	1	A03U301	IC,MICROCONTROLLER,MSP430F149,16 BIT,1.8-3.6V,8MHZ,60K FLASH,2K RAM,PQFP64,TRAY
135	2030596	1	A03L301	INDUCTOR,47UH,20%,1.8ADC,78MOHM,SHIELDED, 4747,TAPE
136	2044453	1	A03L302	INDUCTOR,470UH,20%,0.37A,1.6OHM,SHIELDED,3936,TAPE
137	1599214	1	A03XQ307	HEAT DISSIPATOR,DPAK,10 C/W,SM,.315,.900,.400
138	943097	1	A03CR303	DIODE,MBRD360 SMR,DIODE,SI,SCHOTTKY,60V,3A,D-PAK
139	2030865	1	A03U311	IC,DAC,DAC8531,2.7V-5.5V,16-BIT,VOLTAGE,1V/US,SERIALUSOIC8,TAPE
140	106648	1	A03Y301	CRYSTAL,7.3728MHZ,50/100PPM,20PF,PLASTIC ENCAPSULATED,SMD,TAPE
141	1618826	1	A03U316	IC,OP AMP,OPA2347,2.3 - 5.5V,6MV OFFSET,350KHZ,DUAL,U-PWR,R/R,SO8,TAPE
142	2030570	2	A03C320 A03C322	CAPACITOR,ELECTROLYTIC,ALUMINUM,47UF,+-20%,35V,8X6 SMD,TAPE
144	867572	2	A03C330 A03C343	CAPACITOR SMR,CAP,TA,10UF,+-20%,16V,6032
146	512038	1	A03C317	CAPACITOR SMR,CAP,CER,330PF,+-5%,50V,C0G,0805
147	643459	2	A03C303-304	CAPACITOR SMR,CAP,CER,22PF,+-5%,200V,C0G,0805
149	1597706	2	A03C356-357	CAPACITOR,CERAMIC,1UF,+-10%,50V,X7R,1812,TAPE
150	1597706	1	A03C369	CAPACITOR,CERAMIC,1UF,+-10%,50V,X7R,1812,TAPE
151	1648909	4	A03C332-335	CAPACITOR,CERAMIC,0.22UF,+-10%,16V,X5R,0603,TAPE
155	604231	3	A03C350 A03C352-353	CAPACITOR SMR,CAP,CER,4700PF,+-10%,50V,X7R,0805
161	644325	1	A03R372	RESISTOR SMR,RES,CERM,49.9,+-1%,.063W,100PPM,0603
162	2040385	2	A03U310 A03U318	IC,ANALOG SWITCH,ADG704,1.8-5.5V,4.5 OHMS,4:1 MUX/DEMUX,USOIC10,TAPE
164	2030659	1	A03U308	IC,ADC,ADS8325,2.7V-5.5V,16-BIT,100KHZ,SERIAL,USOIC8,TAPE
165	1279292	2	A03U319-320	IC,ANALOG SWITCH,ADG711,1.8-5.5V,4.5OHMS,QUAD,SPST,TSSOP16,TAPE
167	1597110	1	A03C315	CAPACITOR,ELECTROLYTIC,ALUMINUM,330UF,+-20%,35V,LOW ESR,105C,10X10 SMT,TAPE
168	605359	1	A03C366	CAPACITOR SMR,CAP,CER,100PF,+-10%,50V,C0G,0603
169	605359	3	A03C360 A03C367-368	CAPACITOR SMR,CAP,CER,100PF,+-10%,50V,C0G,0603
170	605342	1	A03C361	CAPACITOR SMR,CAP,CER,1000PF,+-10%,50V,X7R,0603

DWG NO.	SH
FLUKE-16XX-1002	1

REVISIONS

REV	DESCRIPTION	DRAWN
012	W1037297	JH 28AUG03

NOTES:

NET_PHYSICAL_TYPE DEFINITIONS

LOOP_PATH_WIDTH	0.100
RCD_PATH_WIDTH	0.050
CONT_PATH_WIDTH	0.030
VR_PATH_WIDTH	0.030

LAST_MODIFIED=Wed Aug 27 10:02:42 2003

FLUKE CORPORATION
P.O. BOX C9900
EVERETT, WA 98206

89536 DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED
TOLERANCE
.XX = +/-
.XXX = +/-
ANGLES=+/-
DIMENSIONS IN INCHES
XC =

DWN JCH	26AUG03
CHK	
PROJ ENGR	
MFG ENGR	
FINISH	

SCHEMATIC,
ANALOG BOARD 1

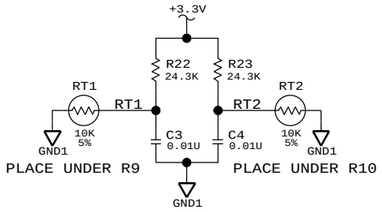
PART NO.	SIZE	DRAWING NO.
	D	FLUKE-16XX-1002
SCALE	SH 1 OF 3	REV 012

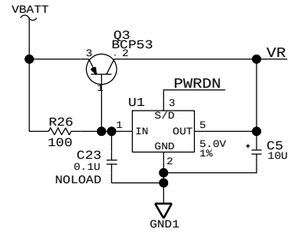
PROPRIETARY

REVISIONS

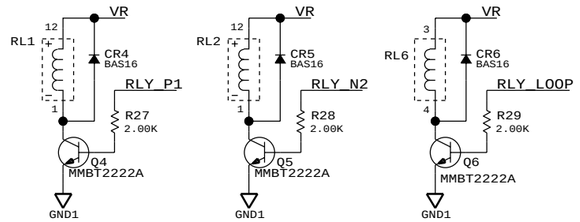
SEE SHEET 1 FOR REVISIONS

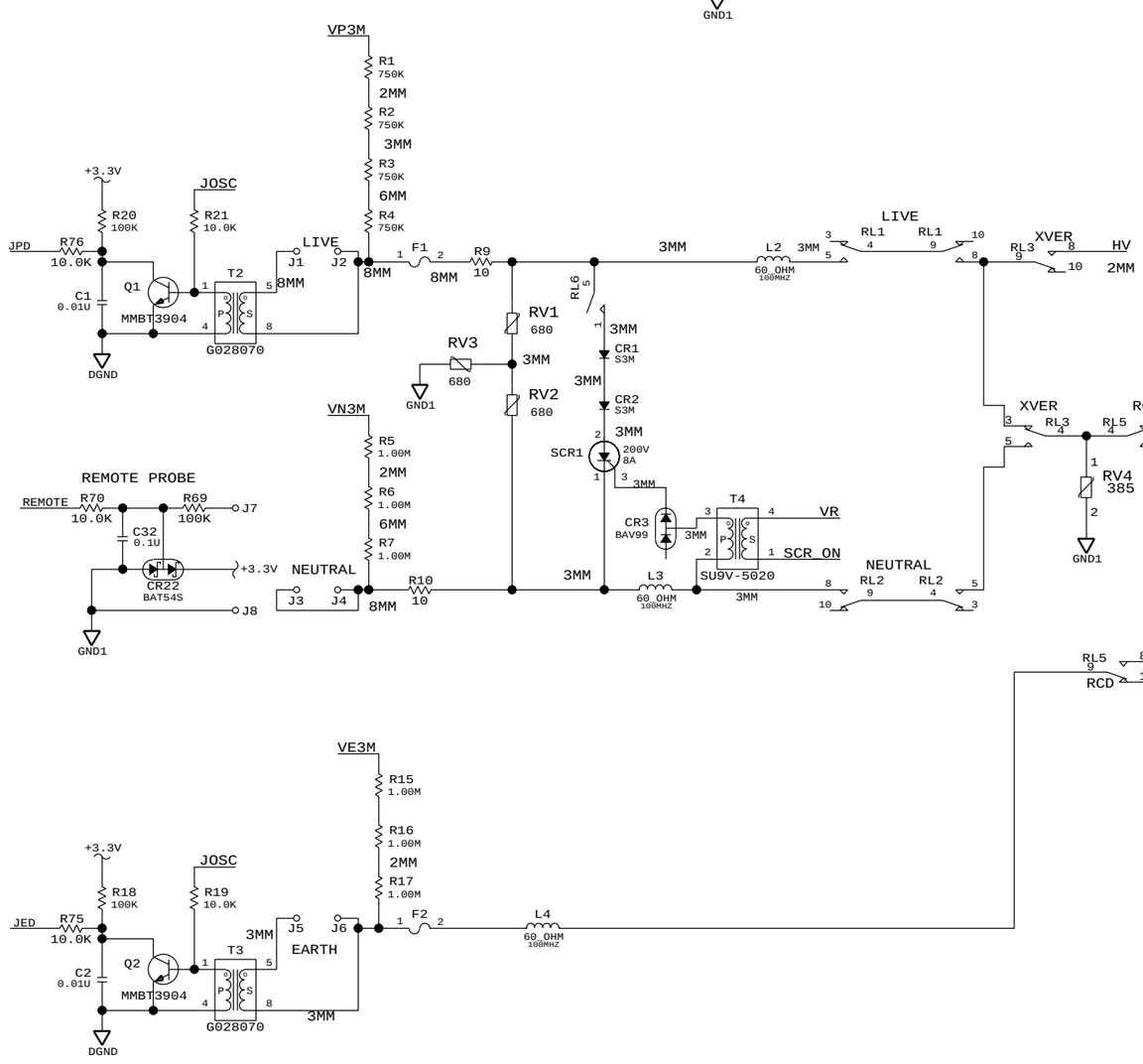
POWER RES THERMISTORS

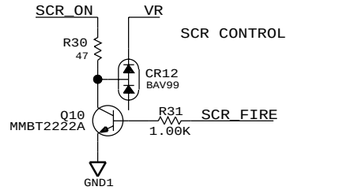




RELAY CONTROL







FLUKE.	FLUKE CORPORATION P.O. BOX C9090 EVERETT, WA 98206
89536	DO NOT SCALE DRAWING

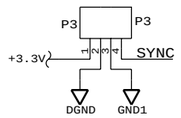
SCHEMATIC, ANALOG BOARD 1

PART NO.	SIZE	DRAWING NO.
	D	FLUKE-16XX-1002
SCALE	SH 2 OF 3	REV 012

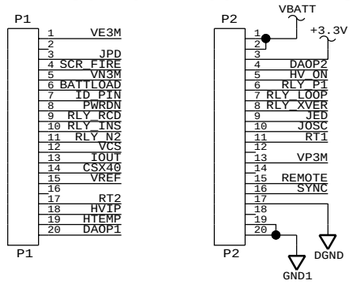
REVISIONS

SEE SHEET 1 FOR REVISIONS

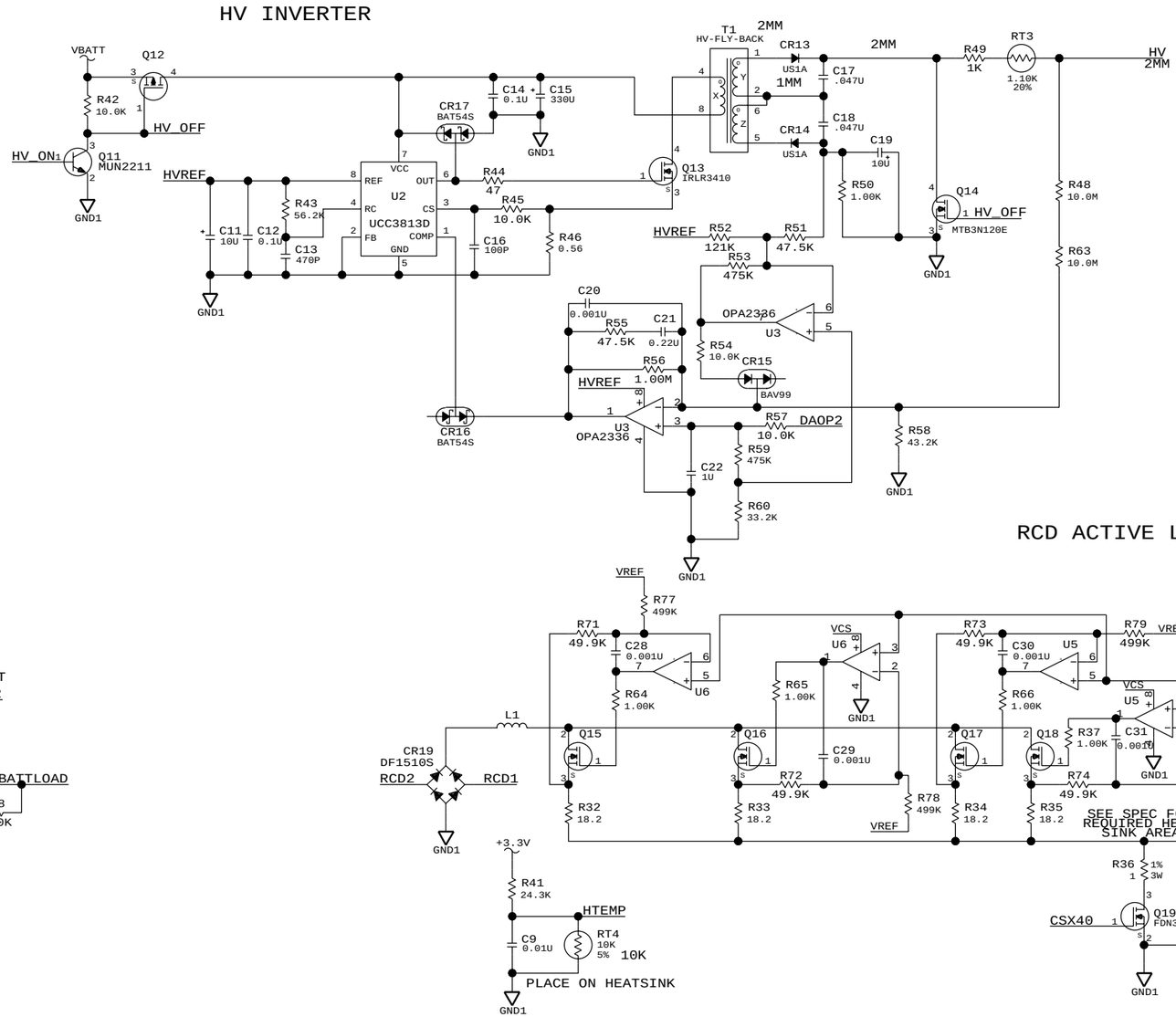
CAL CONNECTOR



ANALOG BOARD CONNECTORS

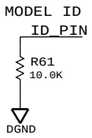


HV INVERTER

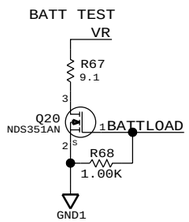


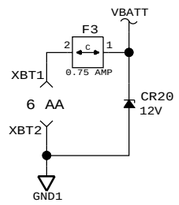
RCD ACTIVE LOAD

MODEL ID



BATT TEST





HEATSINK HARDWARE

XQ15	HEATSINK	CUSTOM	2074016	
MP6	SCREW	M3X0.5X8	2089239	
MP7	SCREW	M3X0.5X8	2089239	
MP8	SPRING-CLIP	GULLWING	2075096	
MP9	SPRING-CLIP	GULLWING	2075096	

FLUKE. FLUKE CORPORATION P.O. BOX C9090 EVERETT, WA 98206

89536 DO NOT SCALE DRAWING

SCHEMATIC, ANALOG BOARD 1

PART NO.	SIZE	DRAWING NO.
———	D	FLUKE-16XX-1002
SCALE ———	SH 3 OF 3	REV 012

PROPRIETARY

DWG NO.	SH
FLUKE-16XX-1003	1

REVISIONS

REV	DESCRIPTION	DRAWN
006	W1035959	JH 20JUN03
009	W1037908:C370 WAS 0.1 MICROFARAD	KD 26SEP03

NO LOAD PARTS
P304
P305

FLUKE CORPORATION
P.O. BOX C9900
EVERETT, WA 98206

89536 DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED
TOLERANCE
.XX = +/-
.XXX = +/-
ANGLES= +/-
DIMENSIONS IN INCHES
XC =

DWN	JCH	21AUG03
CHK		
PROJ ENGR		
MFG ENGR		
FINISH		

SCHEMATIC,
ANALOG BOARD 2

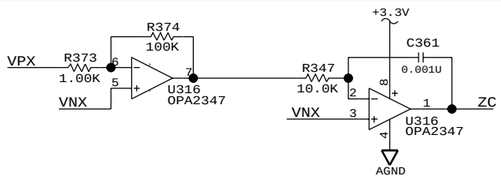
PART NO.	SIZE	DRAWING NO.
	D	FLUKE-16XX-1003
SCALE	SH 1 OF 3	REV 009

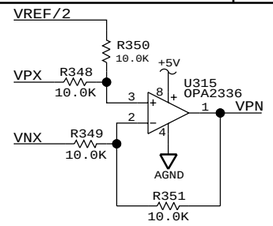
PROPRIETARY

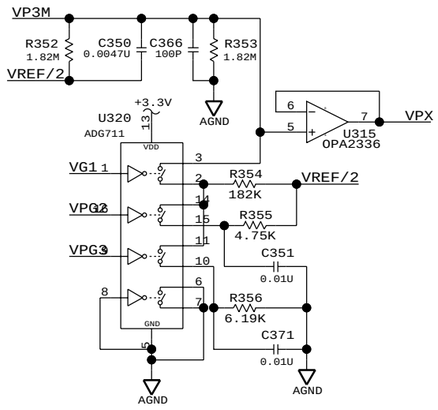
REVISIONS

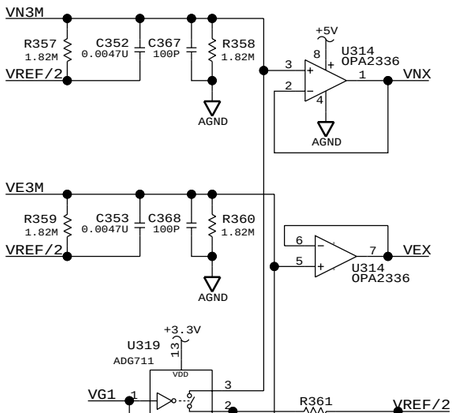
SEE SHEET 1 FOR REVISIONS

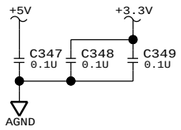
VOLTAGE MEASUREMENT



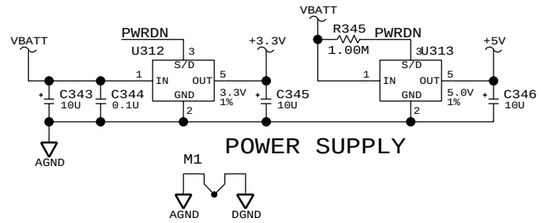


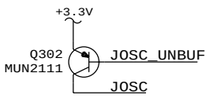


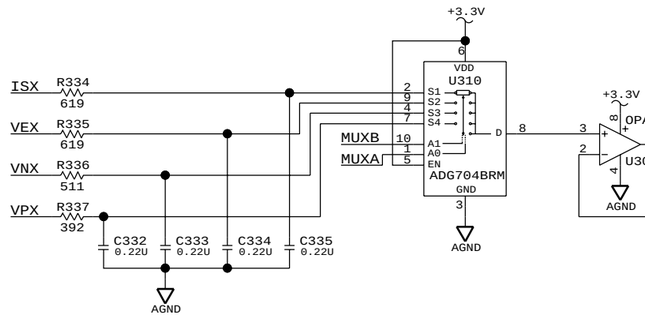


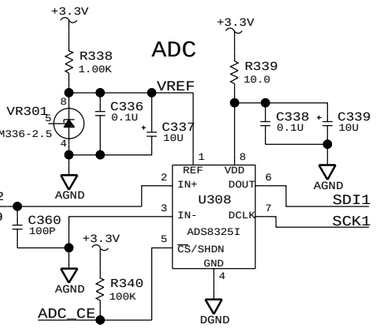


POWER SUPPLY

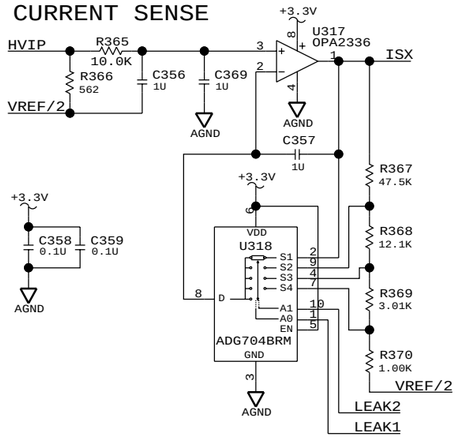








CURRENT SENSE



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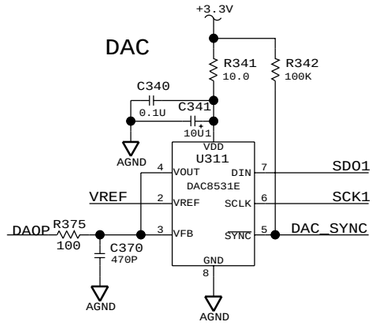
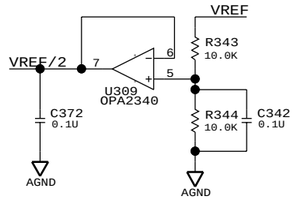




FLUKE.	FLUKE CORPORATION P.O. BOX C9090 EVERETT, WA 98206
89536	DO NOT SCALE DRAWING

SCHEMATIC,
ANALOG BOARD 2

PART NO.	SIZE	DRAWING NO.
	D	FLUKE-16XX-1003
SCALE	SH 2 OF 3	REV ~~009~~

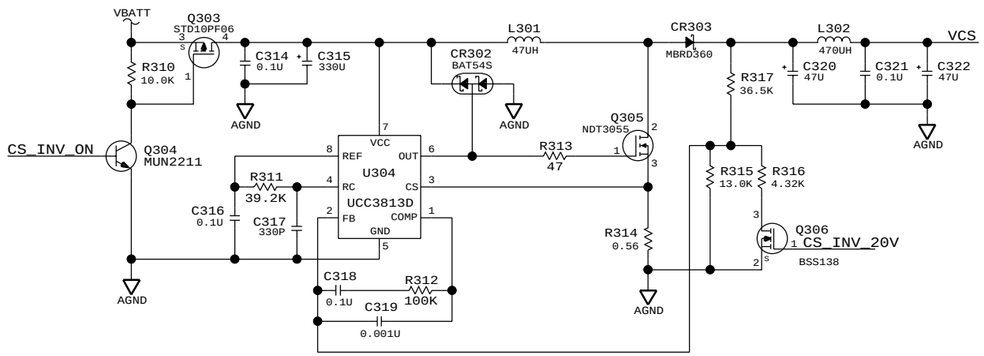
PROPRIETARY

DWG NO. FLUKE-16XX-1003 SH 3

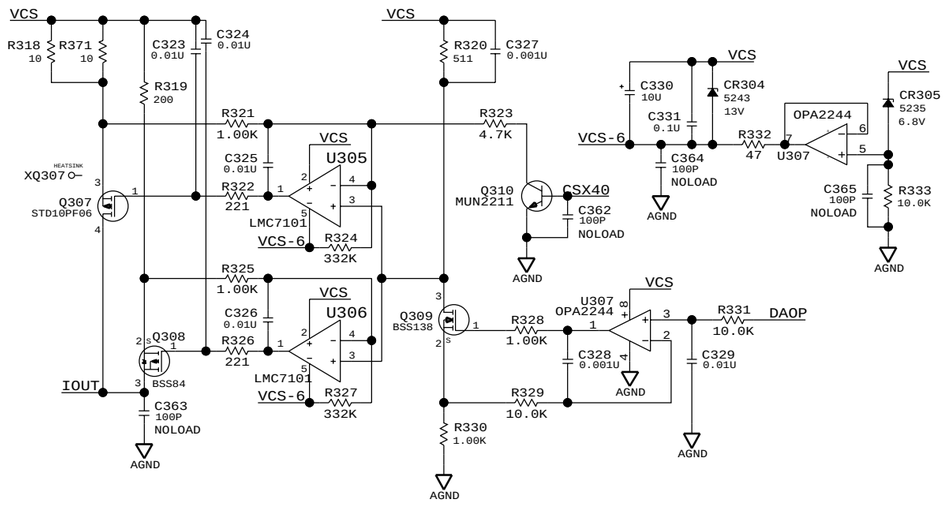
REVISIONS

SEE SHEET 1 FOR REVISIONS

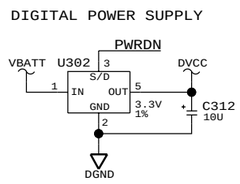
CURRENT SOURCE POWER SUPPLY



CURRENT SOURCE



DIGITAL POWER SUPPLY



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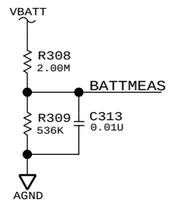
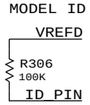
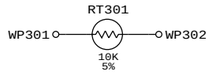
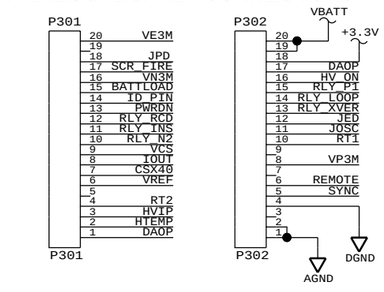


MODEL ID

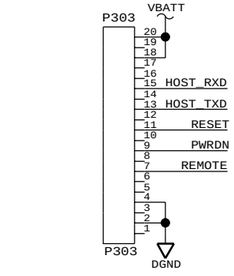




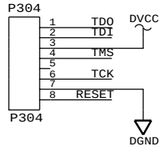
ANALOG BOARD CONNECTORS



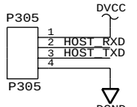
DIGITAL BOARD CONNECTOR

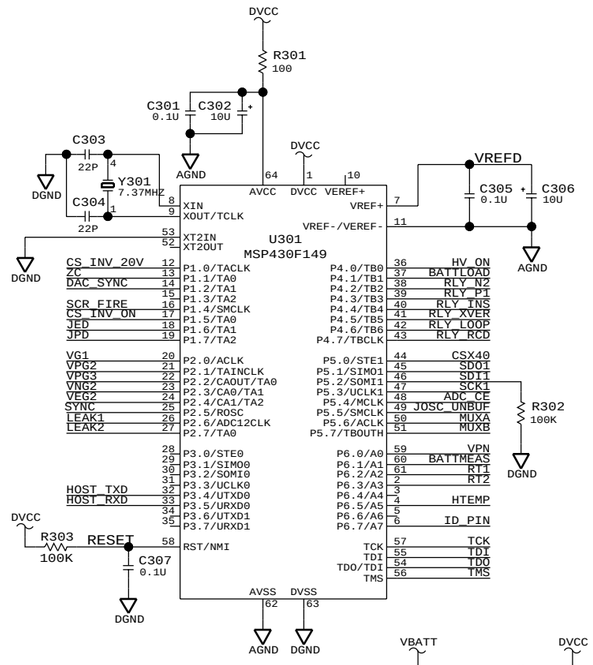


JTAG/FLASH



WINDISP PORT





FLUKE.	FLUKE CORPORATION P.O. BOX C9090 EVERETT, WA 98206
89536	DO NOT SCALE DRAWING

SCHEMATIC,
ANALOG BOARD 2

PART NO.	SIZE	DRAWING NO.
———	D	FLUKE-16XX-1003
SCALE ———	SH 3 OF 3	REV ~~009~~

PROPRIETARY

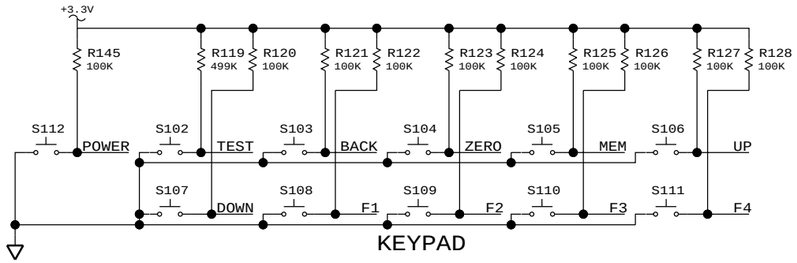
DWG NO.	SH
FLUKE-16XX-1001	1

REVISIONS

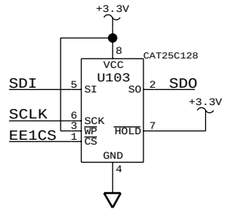
REV	DESCRIPTION	DRAWN
008	W1035959	JH 26JUN03

NO LOAD PARTS
P101

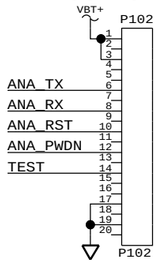
KEYPAD



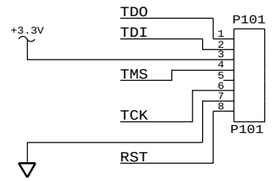
EEPROM



ANALOG BOARD CONN



JTAG/FLASH PORT



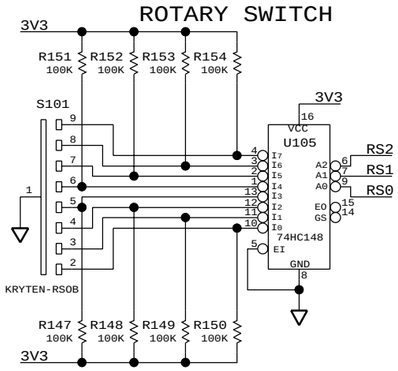
LCD DISPLAY

U104
KRYTEN-LCD

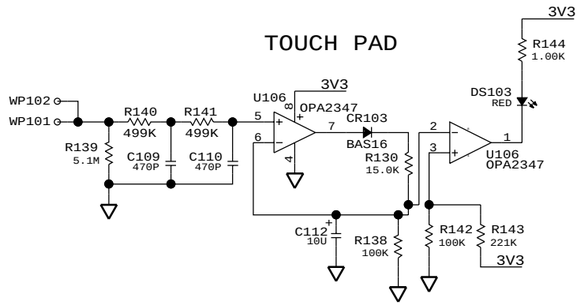
COM1	1	COM1	---	---	---
COM2	2	---	COM2	---	---
COM3	3	---	---	COM3	---
COM4	4	---	---	---	COM4
1	5	S53	S55	S57	S58
2	6	S52	S54	S56	S59
3	7	---	---	---	S60
4	8	S46	S63	S64	---
5	9	S61	S62	S66	S47
6	10	---	S65	---	S48
7	11	5F	5G	5E	S49
8	12	5A	5B	5C	5D
9	13	6F	6G	6E	S49A
10	14	6A	6B	6C	6D
11	15	7F	7G	7E	P3
12	16	7A	7B	7C	7D
13	17	8F	8G	8E	P4
14	18	8A	8B	8C	8D
15	19	---	S70	S69	S72
16	20	S67	S68	---	S71
17	21	S50	S51	---	S45
18	22	S39	S40	S37	S38
19	23	---	S24	S28	S36
20	24	---	S26	S25	S27
21	25	---	---	---	---
22	26	S22	S23	---	---
23	27	S20	S21	---	---
32	28	4A	4B	4C	4D
31	29	4F	4G	4E	P2
30	30	3A	3B	3C	3D
29	31	3F	3G	3E	P1
28	32	2A	2B	2C	2D
27	33	2F	2G	2E	---
26	34	1A	1B	1C	1D
25	35	1F	1G	1D	---
24	36	S19	S18	CIR3	---
33	37	S17	S16	CIR2	S13
34	38	S15	S14	CIR1	---
35	39	S6	S12	S34	S35
36	40	S5	S4	S3	S1
37	41	S8	S7A	S7	S2
38	42	S11	S10	S9	S29
39	43	S33	S32	S31	S30
40	44	S42	S43	S44	S41
COM1	45	COM1	---	---	---
COM2	46	---	COM2	---	---
COM3	47	---	---	COM3	---
COM4	48	---	---	---	COM4

LCD<1..40>

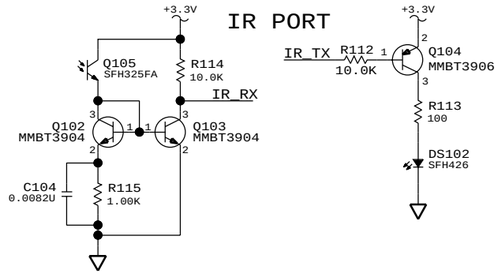
ROTARY SWITCH



TOUCH PAD

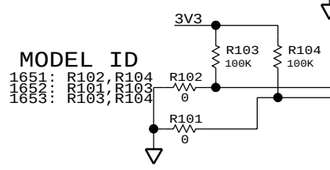


IR PORT

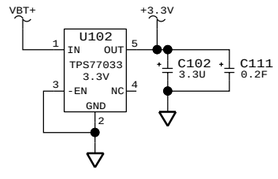


MODEL ID

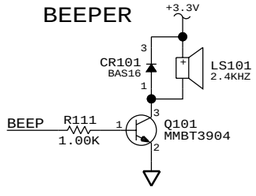
1651: R102,R104
1652: R101,R103
1653: R103,R104



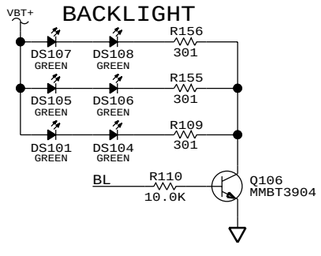
POWER SUPPLY

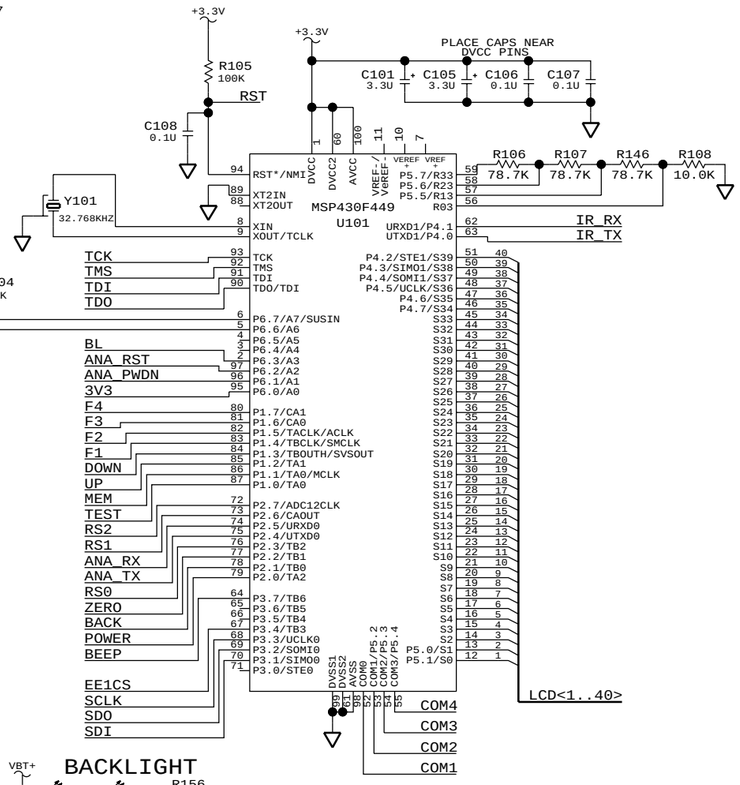


BEEPER



BACKLIGHT





LAST_MODIFIED=Tue Jul 8 08:16:12 2003

FLUKE CORPORATION
P.O. BOX C9090
EVERETT, WA 98206

89536 DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED
TOLERANCE
.XX = +/-
.XXX = +/-
ANGLES=+/-
DIMENSIONS IN INCHES
XC =

DWN	JCH	18APR03
CHK		
PROJ ENGR		
MFG ENGR		
FINISH		

SCHEMATIC,
DIGITAL BOARD

PART NO.	SIZE	DRAWING NO.
———	D	FLUKE-16XX-1001
SCALE ———	SH 1 OF 1	REV 008

PROPRIETARY