1 The Bendix G15 Diode Tester

A tester was developed to ease maintenance the Bendix G15 computer in the late 1950s. Many systems had these diode testers. Despite the prevalence of testers, no original documentation has been located describing how to use them and/or the circuit inside of them. Through a reverse engineering effort, this paper gives the schematic for the tester. It also describes each test that can be performed and provides the simplified drawings for each test.

The tester can be used to test the diodes on the D1, D2, D3, DC (Clamp) diode packages. Each package type has its own connector to plug into (one at a time). A series of switches are then used to select the diode on that pack to be tested in both the forward and reverse directions. A meter displays the results of the test.

Figure 1: Bendix G15 Diode Tester

Several testers are known to still exist. This author has two. One of those came from the U.S. Army out of St. Louis, Missouri. Fortunately, that unit had Dymo labels affixed to it that provided the readings for pass/fail and the battery type used as the power source.

The original tester ran on battery power supplied by a Burgess XX22 35Volt dry-cell battery. The Burgess company is no longer in business. The original Burgess battery had a three-pin connector. Although a source for 35V batteries has been identified, none with a connector. This author opted to replace the battery with a boost converter believing it to be a better longer term solution.

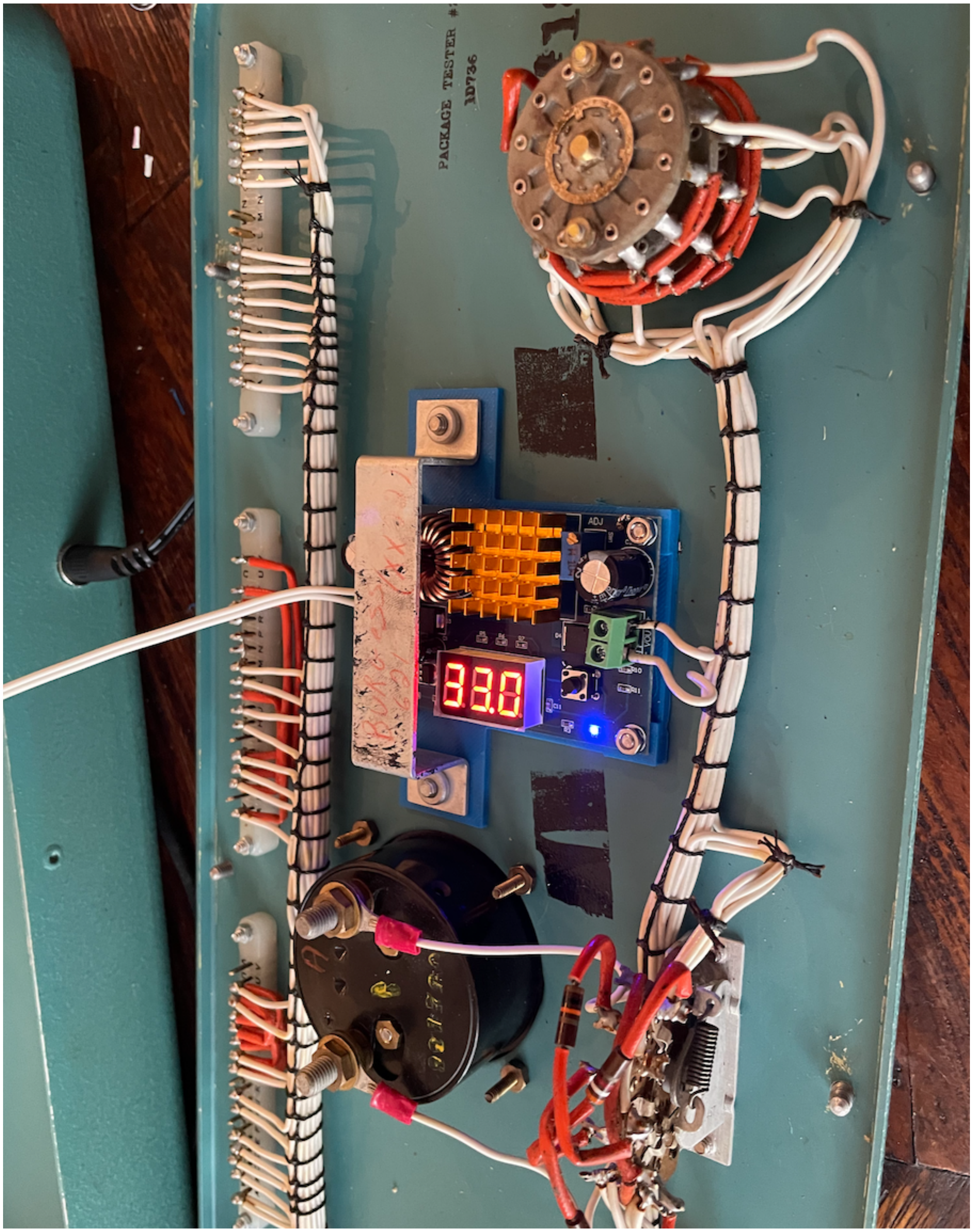


Figure 2: Diode test with boost converter connected instead of original battery

1 G15 Diode Test Usage

Using the tester is simple. The procedure is a little different for testing the D1, D2 and D3 packages versus the Diode Clamp package.

No official documentation has been found. The test limits, described below, were copied from Dymo labels located on one of the testers.

1.1 TESTING THE D1, D2 and D3 PACKS:

The test sequence:

1. Turn the Clamp switch to "off".
2. Turn the Diode select switch to "off".
3. Ensure the Test switch is in the R (Reverse) position.
4. Insert the diode package into the appropriate edge connector socket.
5. Rotate the Diode select switch right one position (#1).
6. The current reading exceeds 0.07 mA, the diode is considered bad.
7. Move the Test switch to the F (Forward) position.
8. The current reading exceeds 0.28 mA, the diode is considered bad.
9. Release the Test switch back to the R position.
10. Rotate the Diode selector switch to the next diode.
11. Repeat steps 6-10 until all of the diodes on that pack have been tested.

    Note: D1 and D2 do not have the full possible complement of 13 diodes. If a diode is selected beyond what is physically present on the board, the current meter will peg out at maximum.

    Note: Discrete diodes may be tested by connecting the diode to the banana plugs and using the Test switch as described above.

1.2 TESTING THE DIODE CLAMP PACKS

The diode clamp package has two diodes for each of the thirteen "diode" positions. One diode clamps the voltage at the high (0V) level and one diode lamps the voltage at the low (-20V) level. All twenty-six diodes should be tested independently.

The test sequence:

1. Turn the Clamp switch to "off".
2. Turn the Diode select switch to "off".
3. Ensure the Test switch is in the R (Reverse) position.

4. Insert a diode clamp package into its edge connector socket.
5. Rotate the Diode select switch right one position (#1).
6. Rotate the Clamp Test switch slowly to the U-F (upper forward) position.
7. The current reading exceeds 0.28 mA, the diode is considered bad.
8. Rotate the Clamp Test switch slowly to the U-R (upper reverse) position.
9. The current reading exceeds 0.07 mA, the diode is considered bad.
10. Rotate the Clamp Test switch slowly to the L-F (lower forward) position.
11. The current reading exceeds 0.28 mA, the diode is considered bad.
12. Rotate the Clamp Test switch slowly to the L-R (lower reverse) position.
13. The current reading exceeds 0.07 mA, the diode is considered bad.
14. Rotate the Diode selector switch to the next diode.
15. Repeat steps 6-14 until all of the diodes on that pack have been tested.

    Note: The circuit used to test the clamp diodes is different than the circuit used to test the logic diode packs (D1, D2 D3). Only one set of test limits is known.

2 DIODE TESTER THEORY OF OPERATION

The diode tester is really two testers in one. One for the logic packs (D1, D2 and D3) and a second for the diode clamp packages. Refer to the attached schematic. Sheet 1 of the schematic depicts the diode logic packages, while sheet 2 depicts the diode clamp package.

Diode packs D1 and D3 have permutations of their cathodes and anodes connected together on the circuit pack. This permutation is continued in the wiring and is artificially generated in the wiring for pack D2. All three diode pack sockets are wired to produce four cathode wires and four anode wires. (The net names reveal which diode is connected to that particular wire.) The cathode and anode groups/sets do not have overlap which allows individual diodes to be selected/extracted from the eight wires.

The diode select switch has three wafers of which two are for the logic packs and the third is for the clamp diodes.

2.1 LOGIC DIODE PACKS

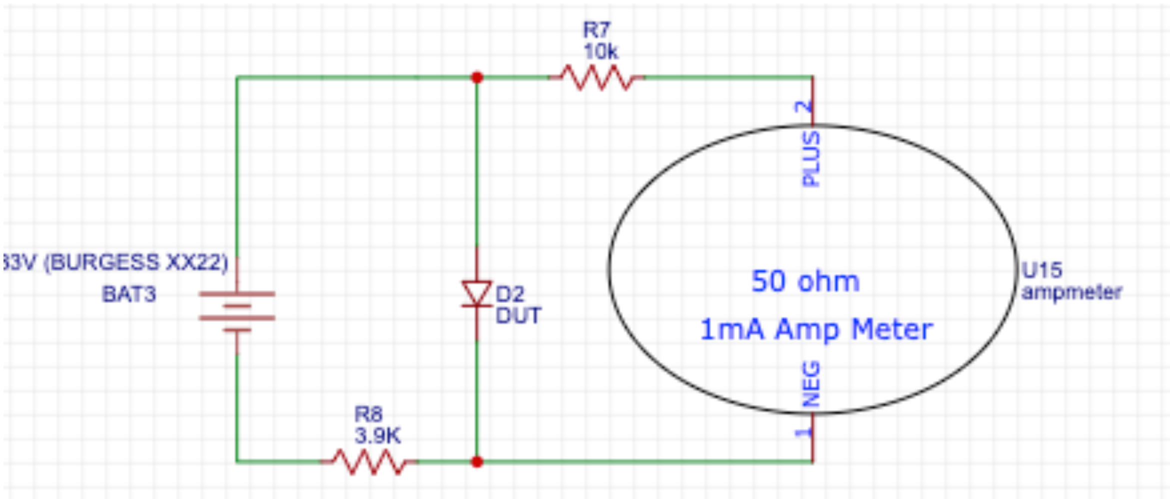
For the logic packs, one diode select switch wafer chooses one anode groupings and the second wafer selects one of the groupings. The result of the selection are the anode and cathode of the device under test (DUT). These are labelled DUT_ANODE and DUT_CATHODE on the schematic.

These wires are attached to the banana jack binding posts to allow discrete diodes to be tested when no circuit packs are inserted into the tester.

The F/R "test" switch is a 4PDT (four-pole double-throw) momentary switch is used to select either the forward or the reverse direction of the diode. Two poles are connected to the 35 Volt battery source. Two wires leave the switch and proceed to the clamp test switch. These two wires will be connected directly to the 1mA current meter when the clamp test is not activated.

Below are the simplified drawings showing the DUT without the complications of the switches.

2.1.1 LOGIC DIODE -FORWARD TEST



Simplified Forward Test – Logic Diode

The above drawing shows the DUT being tested in the forward current path. A little over 8mA flows through the DUT. The Voltage drop across the diode is measured with full scale set at 10V.

$$Idut = \frac{V}{R8} = \frac{33}{3.8k} = 8.7mA$$

A germanium diode has a V_f of approximately 0.3V. Thus, a nominal Ge diode will indicate 0.03mA; only 3% of full scale.

$$Imeter = \frac{Vdut}{R7} = \frac{0.3V}{10k} = 0.03mA$$

Full scale meter reading is 10V across the DUT.

$$Vdut = R7 * 1mA = 10k * 1mA = 10V$$

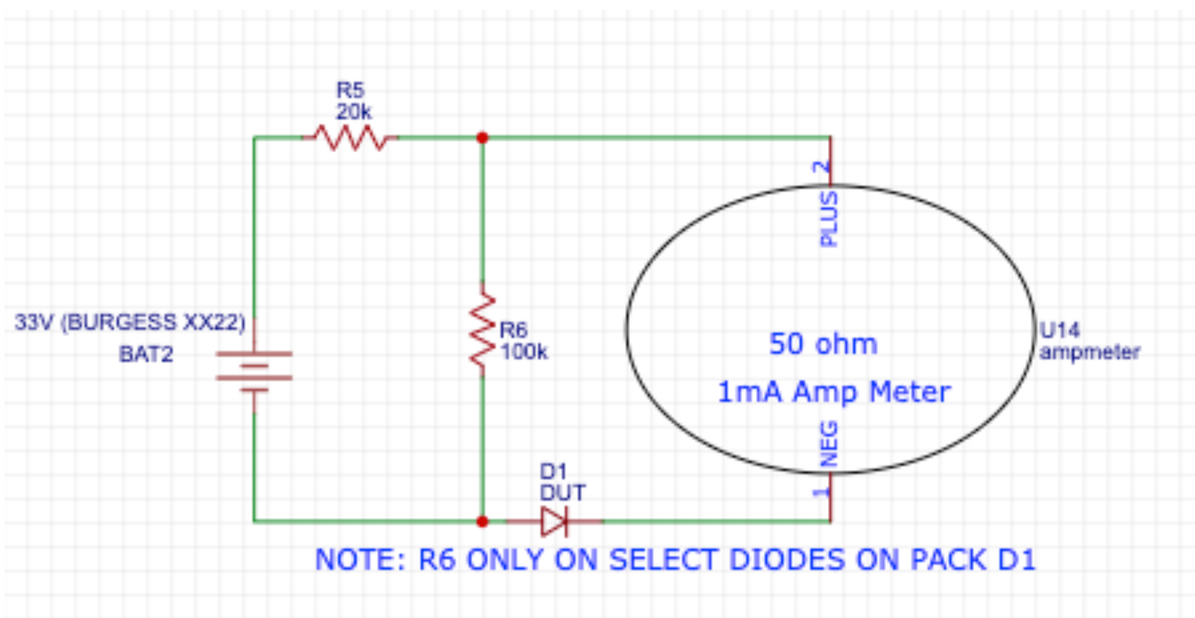
The test limit of 0.28mA (located on a Dymo label on one of the testers) gives a full scale reading of 2.8V.

$$Vdut = R7 * Ilimit = 10k * 0.28mA = 2.8V$$

Therefore, we conclude that the forward diode test is not targeting limits, just a go/no-go on current flow.

> *NOTE: If there is no diode card inserted and/or the diode selector switch is set to a diode beyond that present on a particular pack, the meter will peg beyond full scale when the forward test is selected.*

2.1.2 LOGIC DIODE -REVERSE TEST



Simplified Reverse Test – Logic Diode

The above drawing shows the DUT being tested in the reverse direction. The reverse diode test measures the leakage of the diode when given a negative bias of 27.5Volts.

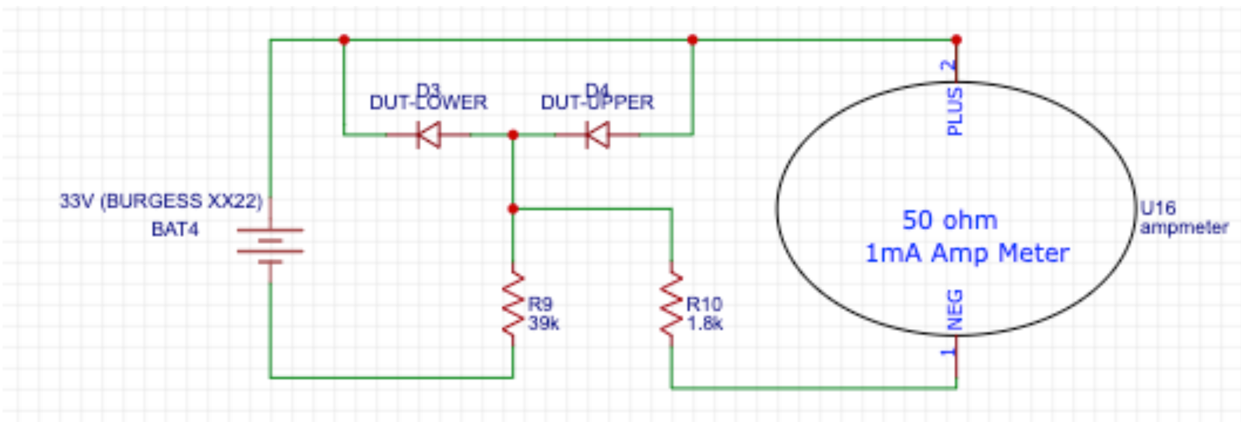
If the leakage current exceeds 0.07mA, the diode is considered bad.

2.2 CLAMP DIODE PACK

The diode clamp packages slightly more complicated. The pack is used to “clamp” up to thirteen signals to 0V in the positive direction and -20V in the negative direction. The diodes are in series - one end of the diode pair is connected to 0V and the other end is connected to the -20V power rail. The signal to be "clamped" is connected to the node where the two diodes are connected. As such, the diodes can not be tested in total isolation.

The thirteen diodes connected to the -20V rail are called the "upper" diodes. The thirteen diodes connected to the 0V rail are called the "lower" diodes. The drawings give the simplified schematic for testing the "upper" diode. The lower diode tests are similar.

2.2.1 CLAMP DIODE - FORWARD TEST



Simplified Clamp Diode Test (Upper Forward Direction)

The above drawing shows the simplified schematic of the upper diode in the clamp package being tested. The two diodes are connected back-to-back. Presumably, the lower diode's leakage current is small enough to be negligible. Given this assumption, the upper diode is biased with approximately 0.8mA of current and resultant voltage drop across the DUT is measured.

$$Idut = \frac{V}{R} = \frac{33 - 0.3}{39k} = 0.84mA$$

Full scale reading on the meter of 1mA is approximately 1.8V drop across the DUT.

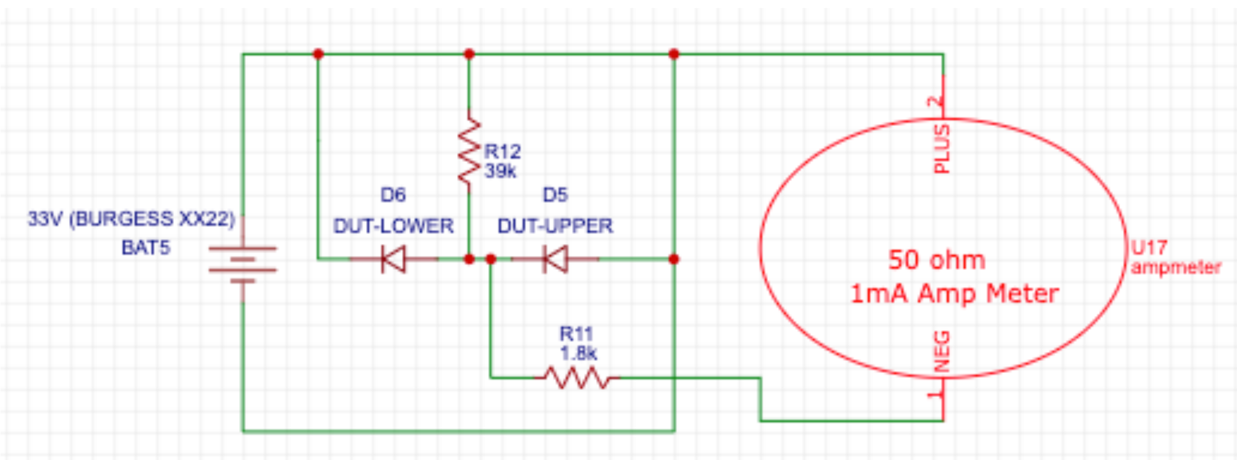
The test limit of 0.28mA corresponds with a DUT V_f of 0.5V Volts.

$$Vdut = Imeter * R10 = 0.28mA * 1.8k = 0.5V$$

Note: This forward test operates using 0.84mA. This seems lower than it should be. The clamp diode cards have 100K ohm resistor to +100V. This causes 2.6mA of current when clamping to 0V and even more when clamping to -20V.

Note: The 39K ohm resistor is located on the diode pack and not in the diode tester itself.

2.2.2 CLAMP DIODE - REVERSE TEST



Simplified Clamp Diode Test (Upper Reverse Direction)

The logic diode reverse test measured leakage current directly. The clamp diode reverse test uses a more indirect method. Similar to previously described clamp diode forward test, it assumes the other diode in the clamp pair leakage current is negligible. But unlike the logic diode reverse test, the meter indicates the voltage drop across a 39k ohm resistor to obtain the diode leakage current.

The test applies a reverse bias of 33V to the DUT through a 39k ohm resistor. Voltage across the resistor indicates the leakage current through the diode.

$$Idut = \frac{V}{R12} = \frac{Imeter * R11}{R12} = \frac{Imeter * 1.8k}{39k}$$

At full scale, this is 46uA of current.

At the test limit of 0.07mA, this is 3.2uA of leakage current.

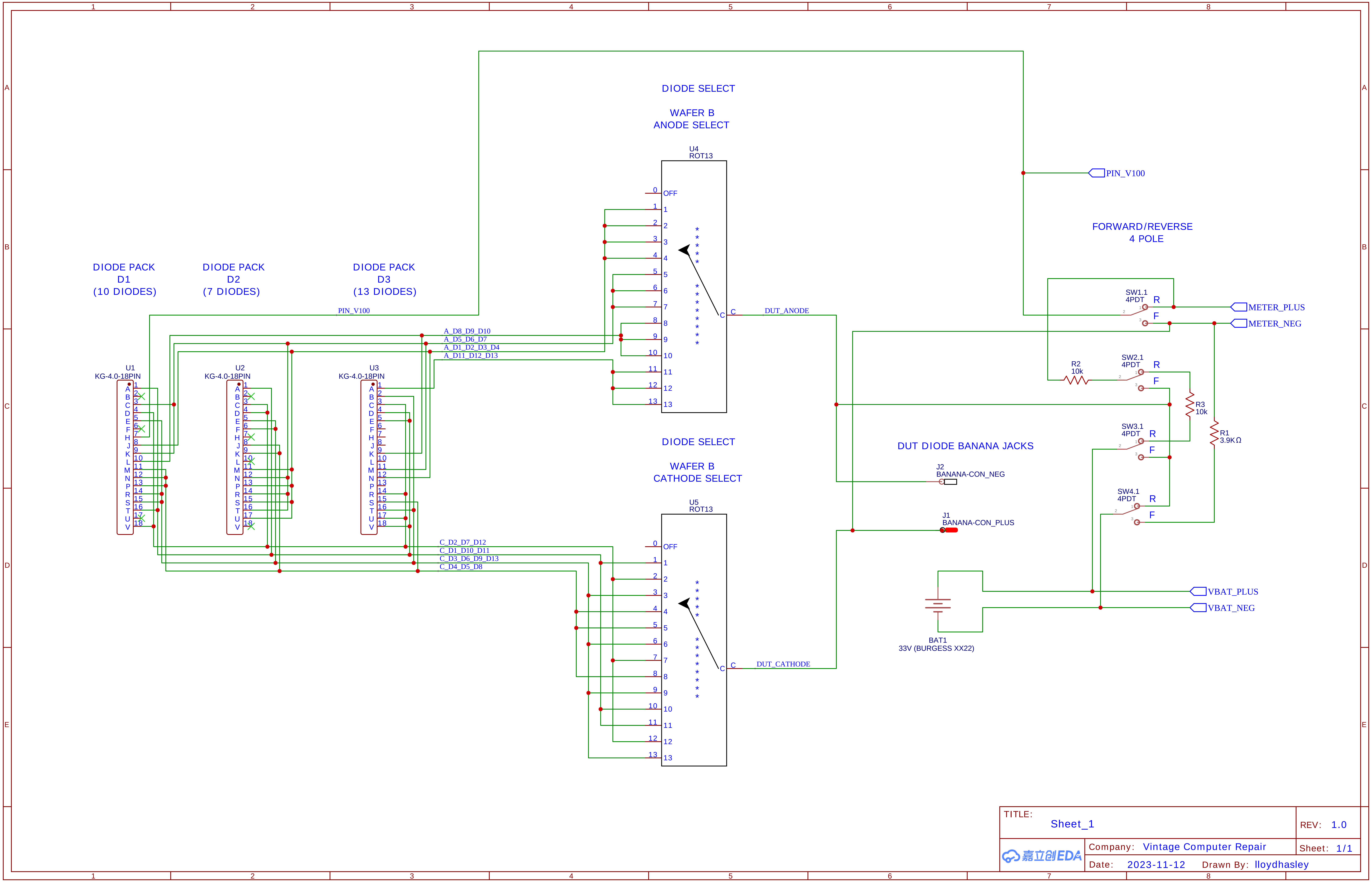
$$Idut = \frac{0.07mA * 1.8k}{39k} = 0.0032mA$$

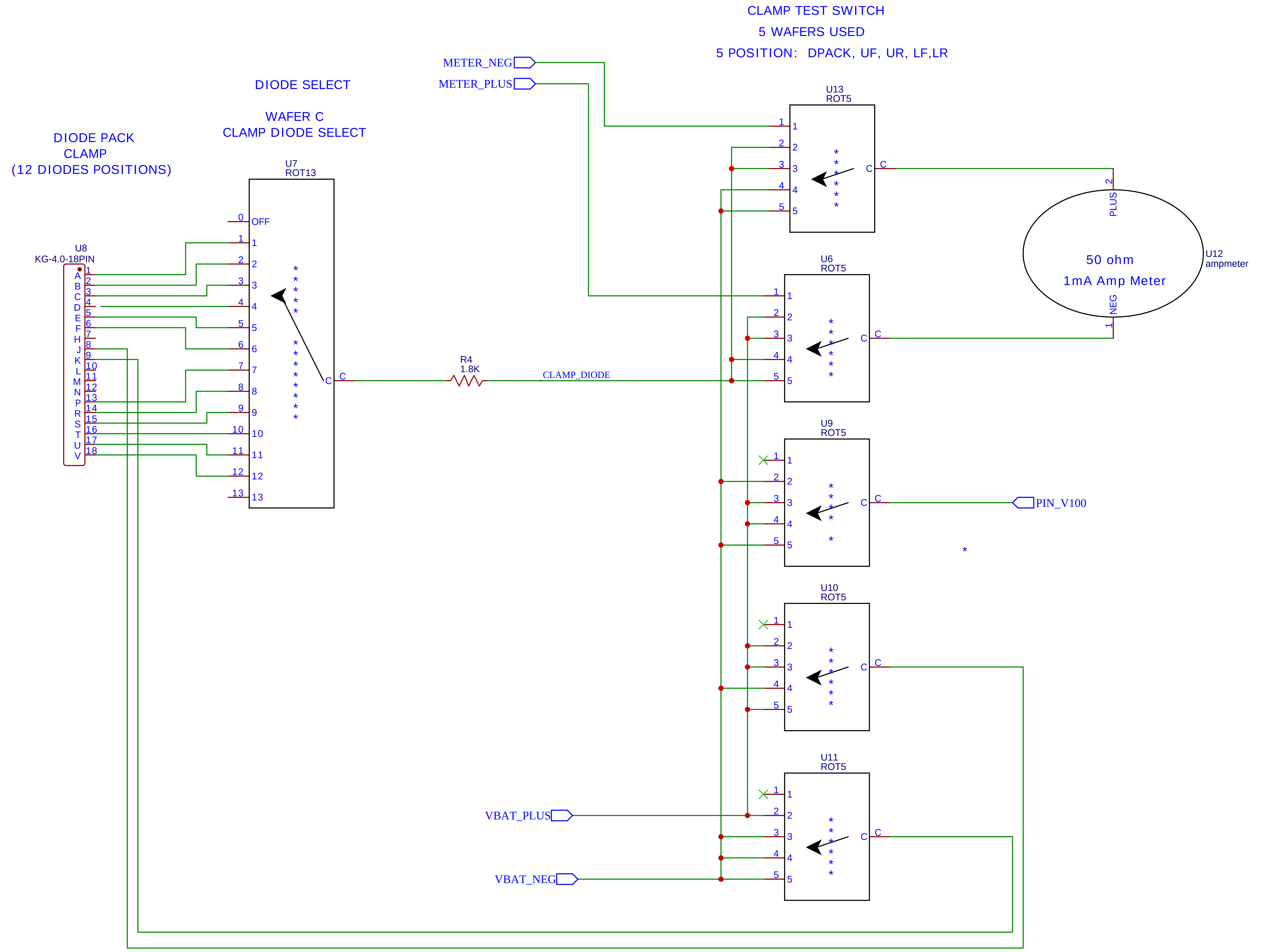
3 SUMMARY

The Bendix G15 Diode pack tester has been reversed engineered. The complete schematics are given on the following pages. One of the surviving testers had attached Dymo labels that provided the original power source and the limits used during the testing of the diodes. A test procedure has been created and presented. The tester made extensive use of multi-wafer rotary switches to perform diode selector and to effectively rewire the tester for different tests. Simplified schematics for each test type have been presented.

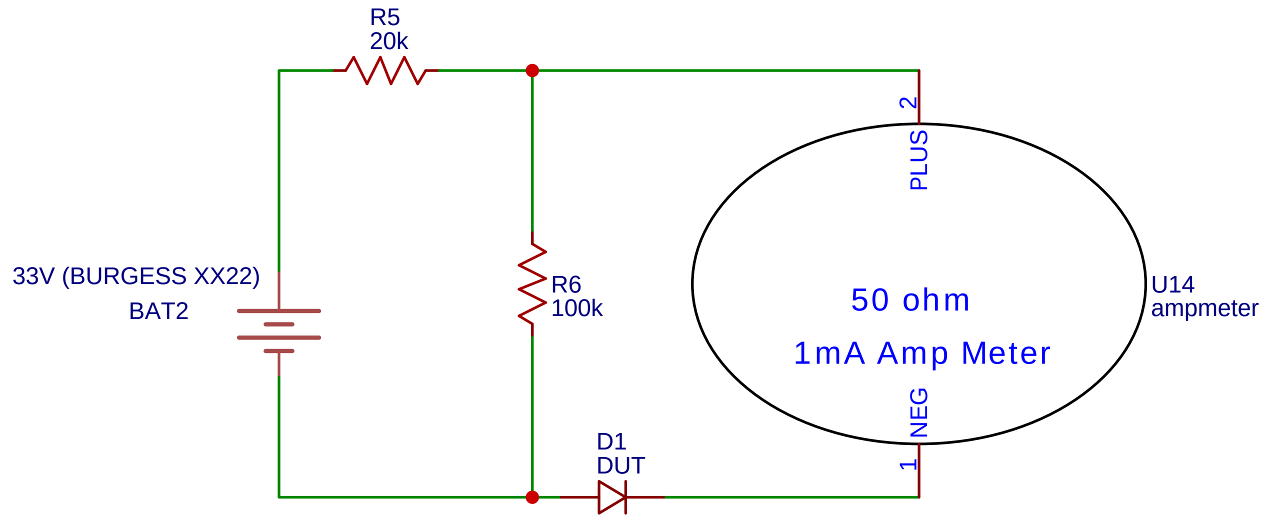
Examination of the currents used during the tests and the test limits that decided pass/fail, it appears that the diode tester was a simple go/no-go box. Open and shorts. Using the tester the measure Germanium diode parametrics under normal load conditions does not appear to be its purpose. It also appears that modern silicon diodes will pass the same test limits despite their large V_f voltage drop.

Hopefully some day, some original surviving documentation will surface that will augment this description.


DIODE SELECT
WAFER B
ANODE SELECT
U4
ROT13
OFF
DUT_ANODE
PIN_V100
FORWARD/REVERSE
4 POLE
DIODE PACK
D1
(10 DIODES)
DIODE PACK
D2
(7 DIODES)
DIODE PACK
D3
(13 DIODES)
U1
KG-4.0-18PIN
U2
KG-4.0-18PIN
U3
KG-4.0-18PIN
A_D8_D9_D10
A_D5_D6_D7
A_D1_D2_D3_D4
A_D11_D12_D13
SW1.1
4PDT
METER_PLUS
METER_NEG
SW2.1
4PDT
R2
10k
R3
10k
R1
3.9KΩ
SW3.1
4PDT
SW4.1
4PDT
DIODE SELECT
WAFER B
CATHODE SELECT
U5
ROT13
DUT DIODE BANANA JACKS
J2
BANANA-CON_NEG
J1
BANANA-CON_PLUS
C_D2_D7_D12
C_D1_D10_D11
C_D3_D6_D9_D13
C_D4_D5_D8
DUT_CATHODE
VBAT_PLUS
VBAT_NEG
BAT1
33V (BURGESS XX22)
TITLE: Sheet_1
REV: 1.0
Company: Vintage Computer Repair
Sheet: 1/1
Date: 2023-11-12
Drawn By: lloydhasley

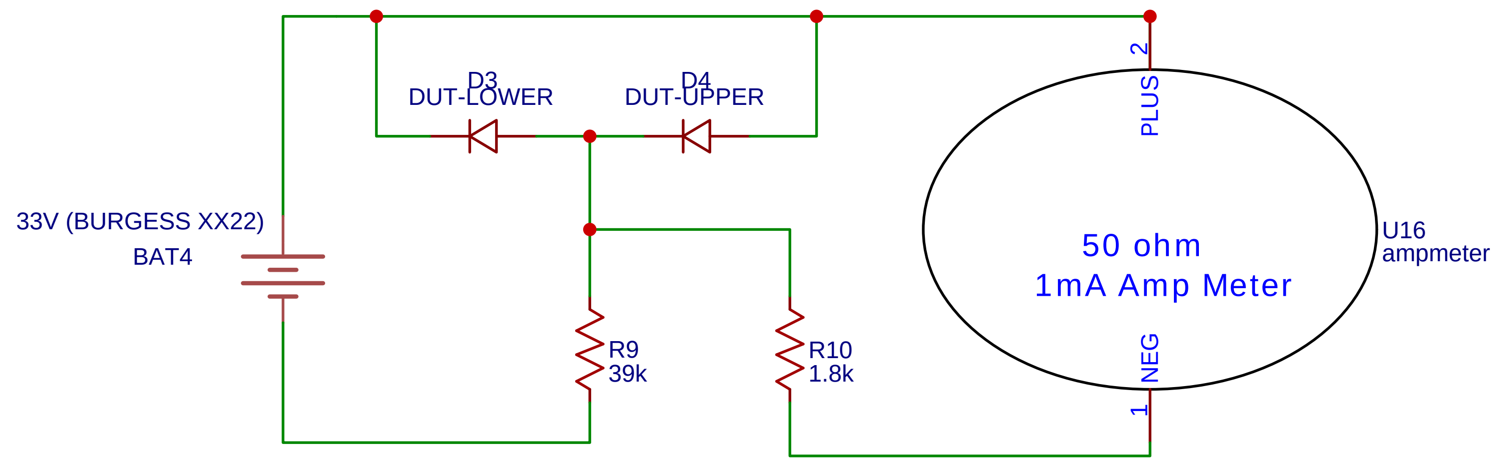


TITLE: Sheet_2	REV: 1.0
Company: VINTAGE COMPUTER REPAIR	Sheet: 1/1
Date: 2023-11-12 Drawn By: lloydhasley	

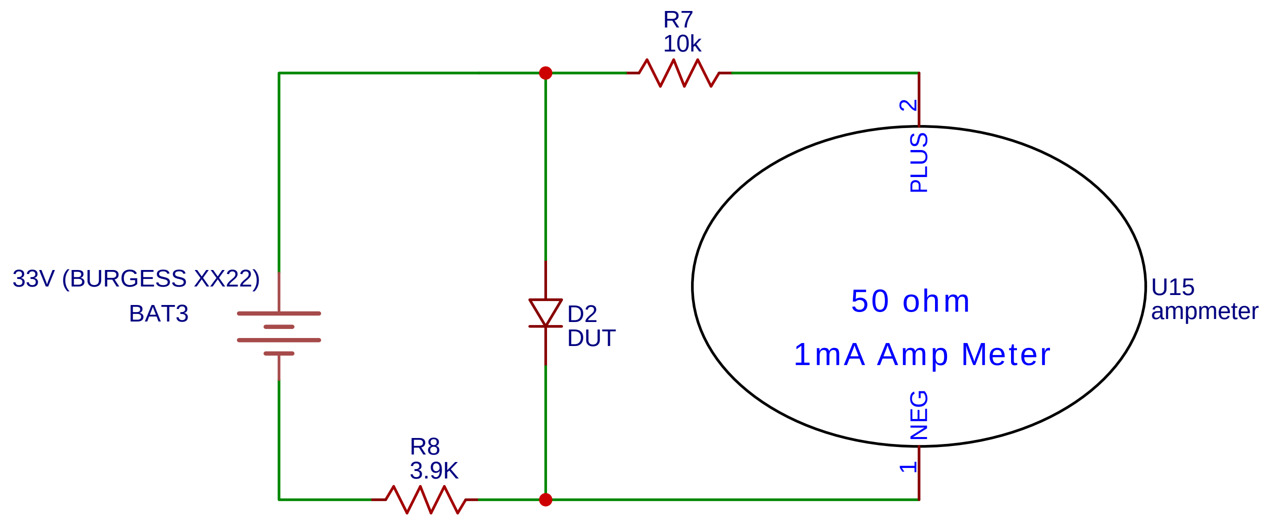


NOTE: R6 ONLY ON SELECT DIODES ON PACK D1

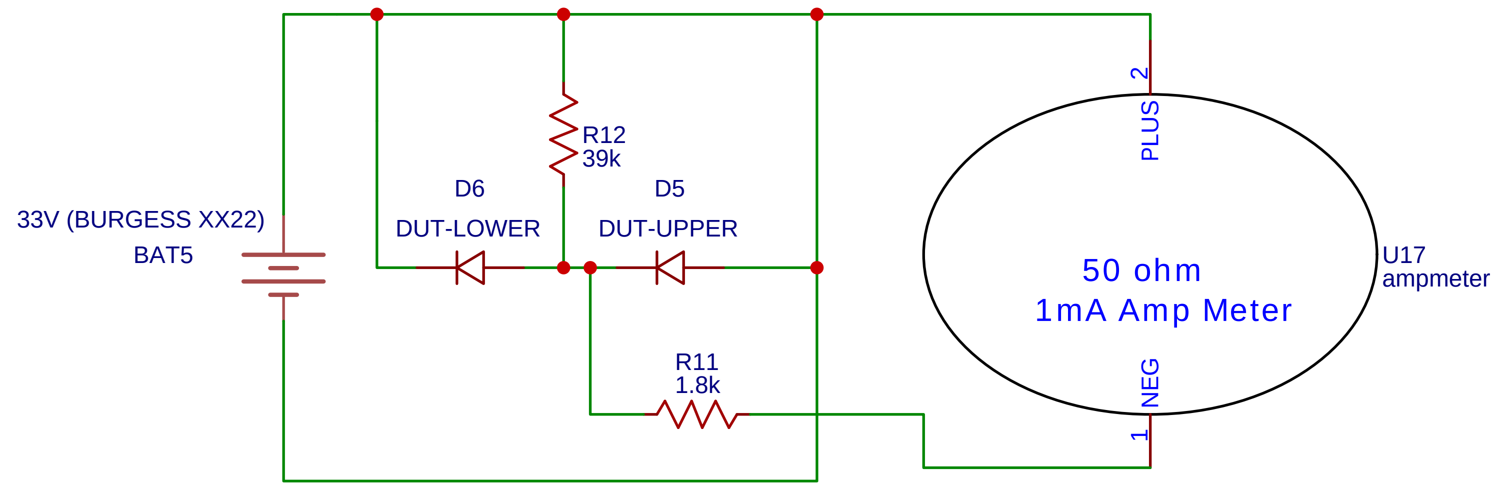
SIMPLIFIED DRAWING - LOGIC DIODE - REVERSE DIRECTION



SIMPLIFIED DRAWING - CLAMP DIODE - UF (pos2)



SIMPLIFIED DRAWING - LOGIC DIODE - FORWARD DIRECTION



SIMPLIFIED DRAWING - CLAMP DIODE - UR (pos3)

TITLE: BENDIX G15 DIODE TESTER/REVERSE		REV: 1.0
嘉立创EDA	Company: VINTAGE COMPUTER REPAIR	Sheet: 1/1
	Date: 2023-11-16	Drawn By: lloydhasley