BRS Tester

User’s Manual  
26-Aug-24

A green electronic device with wires and wires

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# Introduction

This project implements a tester for the Digital Equipment B/R/S series of FlipChips. These FlipChips are used in the PDP-8 Classic, PDP-8/S, PDP-9 and in the PDP-10 with KA processor. B/R/S FlipChips are implemented with discrete transistors and diodes, and do not use integrated circuits. They use 0V / -3V volts for logic levels. Depending on how a B/R/S FlipChip is used in the circuit either 0V or -3V can be a logic 1.

Since the B/R/S FlipChips use just transistors and diodes there are many easy to detect faults where a transistor or diode is either shorted or open. There are also many more difficult to find faults where transistor or diode is partially shorted, or a transistor has low gain or high leakage. For these reasons the BRS Tester is significantly more complicated than the M series FlipChip tester that Warren Stearns designed.

This project was created as a part of the restoration of Anders Sandahl’s PDP-9, serial number 203.

# Theory of Operation

## Backplane Board

The Backplane Board holds the Raspberry Pi, PSU Board, Load Board, and Level Converter Boards. The Measurement and ADC circuit, Power Relays, Output Selection Decoder circuit, and Level Converter Board Latch circuit are also on the Backplane Board.

### Power Circuitry

The +10V from the PSU Board is fused at 250mA, then switched and used on the FlipChip under test. The +5 from the PSU Board is used for the Power LED (LED1), Power and AUX Relays, Load and Level Converter Boards, Serial Debug Port, and the Raspberry Pi. The VCC (+3V3) from the PSU Board is used for Logic Chips, the Measurement Circuit, and signal pull-up resistors. The +3V3 (+3V3\_1) from the PSU Board is used for the Load and Level Converter Boards. The -3V is used for the Load and Level Converter Boards. The -15V is used on the Load Board, and fused at 250mA, switched, and used on the FlipChip.

### Measurement Circuit

The Measurement Circuit is powered by the +15V/-15V and +3V3 from the PSU board.

The Level Converter and Load boards are connected to the Measurement Bus. The Measurement Bus Current signal is MEAS2 and the Measurement Bus Voltage signal is MEAS1. The Measurement Bus Voltage signal is also available on the BNC connector X1 that can be connected to an oscilloscope. Operational Amplifiers are used to buffer the Measurement Bus signals which are then connected to an ADS1115 ADC (IC9). The ADC is connected to the Raspberry Pi through the I2C bus. The ADC is used to measure the Current (AIN0) and Voltage (AIN1) signals, and a 1.706V signal from OP AMP (IC7B) for the ADC reverence voltage (AIN3).

### Raspberry Pi

The Raspberry Pi is installed in connector JP1. Its I2C signals SDA\_1 (JP1 pin 3) and SCL\_1 (JP1 Pin 5) are used to interact with the ADC in the Measurement Circuit. Its I2C signals are also wired to, but are not currently used on the Load Board.

An 8-bit Digital Data Bus interconnects GPIO pins on the Raspberry Pi to the Load and Level Converter Boards. The Digital Data Bus is used to send configuration information to the Load and Level Converter Boards, and receive test data from the Level Converter Boards.

A 4-bit Output Select Bus on JP1 pins 22 (SELECT\_A), 24 SELECT\_B), 26 (SELECT\_C), and 28 (SELECT\_AD) and the SELECT\_OUT signal on JP1 pin 18 and the Output Selection Decoder circuit is used to select the Load and individual Level Converter Boards.

A 4-bit Input Bus in JP1 pins 16 (INP\_A), 27 (INP\_B), 7 (INP\_C), and 19 (INP\_D) and the LATCH\_IN signal on JP1 pin 32 enables one of the four 74LVC573 latches for the Level Converter Boards.

A GPIO signal, ENABLE\_POWER (JP1-13), from the Raspberry Pi is used to enable the 10V\_SWITCHED and -15V\_SWITCHED power to the FlipChip under test. Another GPIO signal, ENABLE\_AUX (JP1-15) is not used at this time.

A serial console can be connected to the Raspberry Pi through the SERIAL connector JP5 on the back of the Backplane Board. The default configuration is 115200, N, 8, 1. The pinout is:

Pin Signal

1 +5V

2 TXD to terminal

3 RXD from terminal

4 E\_IO1

5 E\_IO2

6 GND

## PSU Board

The PSU Board plugs onto the Tester Backplane board. The external +/-5V (J2) and +/-15V (J1) power inputs connect to the PSU board and are filtered by onboard electrolytic capacitors (C6-C9). Linear regulators convert the +5V input to 3.3V VCC (IC5) and +3V3 (IC1). They also convert the +15 V input to +10 V (IC2), and convert the -5V input to -3 V (IC4). The -15V passes through the PSU board to the tester Backplane Board.

## Level Converter Boards

B/R/S series FlipChips use 0V / -3V volts for the logical 0 and 1 signals. Fifteen boards implement the level converting circuitry that converts 0V /-3V at the FlipChip to 0V / +3.3V at the Measurement Bus.

The Level Converter Boards contains a 74LVC573D Octal Transparent D-Type Latch with 3-State Outputs that latches the data from the Digital Data Bus on the Backplane Board. Each Level Converter board has an individual LATCH signal.

### Level Converter Board Connections

|  |  |  |  |
| --- | --- | --- | --- |
| Signal Name | Converter Board | Cable Connector | FlipChip Connector |
| 10V\_SWITCHED | N/C | BOARD A Pin 4 | AA2 |
| -15V\_SWITCHED | N/C | BOARD A Pin 6 | AB2 |
| GND | N/C | BOARD A Pin 8 | AC2 |
| PIN\_AD | D1 | BOARD A Pin 10 | AD2 |
| PIN\_AE | D1 | BOARD A Pin 12 | AE2 |
| PIN\_AF | D2 | BOARD A Pin 14 | AF2 |
| PIN\_AH | D2 | BOARD A Pin 16 | AH2 |
| PIN\_AJ | D3 | BOARD A Pin 18 | AJ2 |
| PIN\_AK | D3 | BOARD A Pin 20 | AK2 |
| PIN\_AL | D4 | BOARD A Pin 22 | AL2 |
| PIN\_AM | D4 | BOARD A Pin 24 | AM2 |
| PIN\_AN | D5 | BOARD A Pin 26 | AN2 |
| PIN\_AP | D5 | BOARD A Pin 28 | AP2 |
| PIN\_AR | D6 | BOARD A Pin 30 | AR2 |
| PIN\_AS | D6 | BOARD A Pin 32 | AS2 |
| PIN\_AT | D7 | BOARD A Pin 34 | AT2 |
| PIN\_AU | D7 | BOARD A Pin 36 | AU2 |
| PIN\_AV | D8 | BOARD A Pin 38 | AV2 |
|  |  |  |  |
| 10V\_SWITCHED | N/C | BOARD B Pin 4 | BA2 |
| -15V\_SWITCHED | N/C | BOARD B Pin 6 | BB2 |
| GND | N/C | BOARD B Pin 8 | BC2 |
| PIN\_BD | D8 | BOARD B Pin 10 | BD2 |
| PIN\_BE | D9 | BOARD B Pin 12 | BE2 |
| PIN\_BF | D9 | BOARD B Pin 14 | BF2 |
| PIN\_BH | D10 | BOARD B Pin 16 | BH2 |
| PIN\_BJ | D10 | BOARD B Pin 18 | BJ2 |
| PIN\_BK | D11 | BOARD B Pin 20 | BK2 |
| PIN\_BL | D11 | BOARD B Pin 22 | BL2 |
| PIN\_BM | D12 | BOARD B Pin 24 | BM2 |
| PIN\_BN | D12 | BOARD B Pin 26 | BN2 |
| PIN\_BP | D13 | BOARD B Pin 28 | BP2 |
| PIN\_BR | D13 | BOARD B Pin 30 | BR2 |
| PIN\_BS | D14 | BOARD B Pin 32 | BS2 |
| PIN\_BT | D14 | BOARD B Pin 34 | BT2 |
| PIN\_BU | D15 | BOARD B Pin 36 | BU2 |
| PIN\_BV | D15 | BOARD B Pin 38 | BV2 |

## Load Board

The Load Board can connect different value resistors to the measurement bus in order to load test the outputs from FlipChips.

A 74LVC573D Octal Transparent D-Type Latch with 3-State Outputs is connected to the Digital Data Bus from the Raspberry Pi and latches data when the

The programmable load from the Load Board is connected to the MEAS1 signal that is used to measure Voltage on the Measurement Bus. The MEAS2 signal is wired to the Load Board, but is currently not used.

## Software

The tester software runs on Raspberry Pi OS 11/12 on a Raspberry Pi 3/4/5. The current implementation of the software is a shell that accepts different input parameters. Enter the command ***brs-tester --help*** to get help text. When a board is tested it takes a file with test vectors.

At startup a udev rule triggered on the start of the GPIO subsysten will run a shell script that will export all necessary GPIO pins and run 'brs-tester init'. This will initialize the tester and put the hardware in a known state.

# Tester Setup and Operation

## Power Supply Connections

The BRS Tester requires +15V/-15V @ 1A and +5V/-5V @ 2A. The power supply connections are shown in Figure 1 Power Supply Connections.

A group of green electrical components

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Figure 1 Power Supply Connections

## Raspberry Pi Installation

Install the Raspberry Pi onto connector JP1 and fasten with spacers and nuts.

## Setting up the Raspberry Pi Software

In /boot/config.txt Enable I2C, Set I2C clock to 400kHz:

dtparam=i2c\_arm=on

dtparam=i2c\_arm\_baudrate=400000

Enable support for ADS1115 ADC:

dtoverlay=ads1115

dtparam=cha\_enable

dtparam=chb\_enable

dtparam=chc\_enable

dtparam=chd\_enable

If you want a serial console connected to the pin header on the back:

enable\_uart=1

The default speed is 115200 baud, if you want something else, change /boot/cmdline.txt

Install tools for build:

sudo apt install git

sudo apt install autoconf

sudo apt install autoconf-archive

Install libgpiod:

cd ~/

git clone https://git.kernel.org/pub/scm/libs/libgpiod/libgpiod.git

cd libgpiod

./autogen.sh

make

sudo make install

Get and install the brs-tester (this package):

cd ~/

git clone https://github.com/anders-bzn/brs-tester.git

cd brs-tester

make

sudo make install

## Using the Tester Software

Initialize the hardware

$ brs-tester init

Run a selftest of the hardware, no test object should be in the tester

$ brs-tester selftest

Run test on a board, loop logical test loop number of times.

$ brs-tester test --vector=vectors/b104.fct --loop=10

Turn on power to the test object.

$ brs-tester debug --power-enable=on