BRS Tester User’s manual  
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A green electronic device with wires and wires

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# Introduction

This project implements a tester for the B/R/S series of DEC 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 series FlipChips are implemented with discrete transistors and do not use integrated circuits. They use 0V / -3V volts for the logical 0 / 1.

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

# Theory of Operation

## Power Inputs

The BRS Tester requires +/-5 VDC @ 2 A, and +/-15 VDC @ 1 A.

## PSU Board

The PSU Board plugs onto the Tester Backplane board. The external +/-5V and +/-15V inputs connect to the PSU board and are filtered by onboard electrolytic capacitors (C6-C9). Linear regulators are used to convert the +5V input to 3.3V VCC (IC5) and +3V3 (IC1). They are also used to 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.

The +15V is used on the Measurement Circuit. The +10V is fused at 250mA, then switched and used on the FlipChip. The +5 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) is used for Logic Chips, the Measurement Circuit, and signal pull-up resistors. The +3V3 (+3V3\_1) 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 Measurement Circuit, the Load Board, and fused at 250mA, then switched and used on the FlipChip.

## Level Converter Boards

B/R/S series FlipChips use 0V / -3V volts for the logical 0 and 1. 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.

## Backplane Board

The Backplane Board holds the Raspberry Pi, PSU Board, Load Board, Measurement Circuit, and Level Converter Boards.

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

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, receive test data from 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. Another GPIO signal, ENABLE\_AUX (JP1-15) is not used at this time.

### Measurement Circuit

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 used to measure the Current (AIN0) and Voltage (AIN1) signals. A 1.706V signal from OP AMP (IC7B) is used for the ADC reverence voltage (AIN3).

### Raspberry Pi

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

## 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