Grove Components for PiR2D ver F
by D@CC
as of 2021 A Jan 11

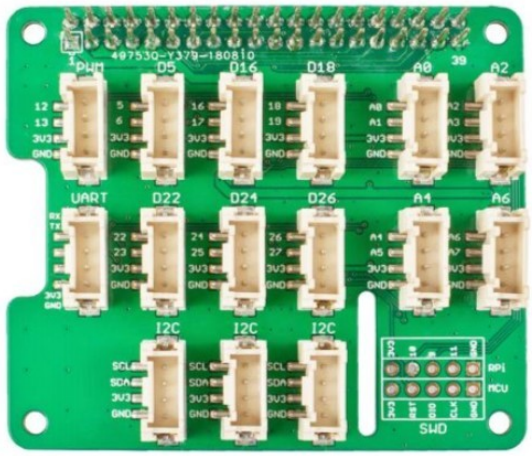
Introduction
I first encountered the Grove connector at SwitchDoc Labs who offer the INA3221 Breakout Board [US$ 9.95]. The INA3221 can measure analog voltage and current for 3 different 5 volt circuits with the results being reported using I2C via a Grove connector. If both voltage and current need NOT be measured, the WeatherHat Pro [CAD$34.95] measures 3 analog signals and other signals as well. The pinout of the WeatherHat Pro's I2C port differs from Grove but its accepts a cable that ends in a Grove connector. The WeatherHat Pro is a major subject of the article in Source 08.

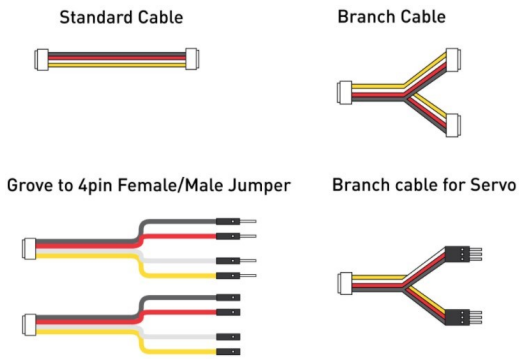
The PiR2D built on the Pi ProtoBoard [CAD $ 3.95] is the main (albeit tiny) electrical panel for the PiR2 area controller. It has a Red and a Green LED to send signals to the user (operator). It also has 2 CDS photocells and (to date) a Push-Button to accept commands from the user. They are all important at remote sites where monitors, audio and email are not available. Three or 4 Grove connectors can be included on this PiR2 board (one at the end of a 20" cable).

For the Raspberry Pi, Seeed Studios has designed a Grove Base Hat board which is their SKU 103030275 . They sell it for US$ 9.90 . It has 15 Grove connectors, of which 3 are I2C ports (all on the same bus, I believe). What is most interesting is that this board is of similar size to the boards of the Raspberry Pi models. It also provides the following interfaces:

Qty	Type	Description
1	PWM	Pulse-Width-Modulated Digital Output
1	UART	Serial I/O of an 8 bit character stream
6	DIO	digital input/output (any number of each)
4	ADC	each converts A-D yielding 12 bits
3	I2C	(Grove format) probably all on the same bus

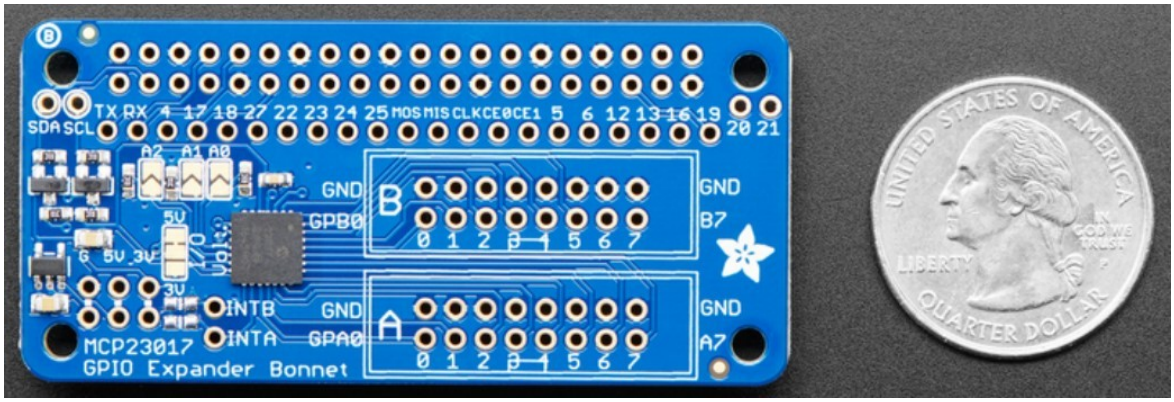
Grove Base Hat
Seeed also supplies a set of Python drivers for the Grove Base Hat. Seeed calls it "Grove.py".

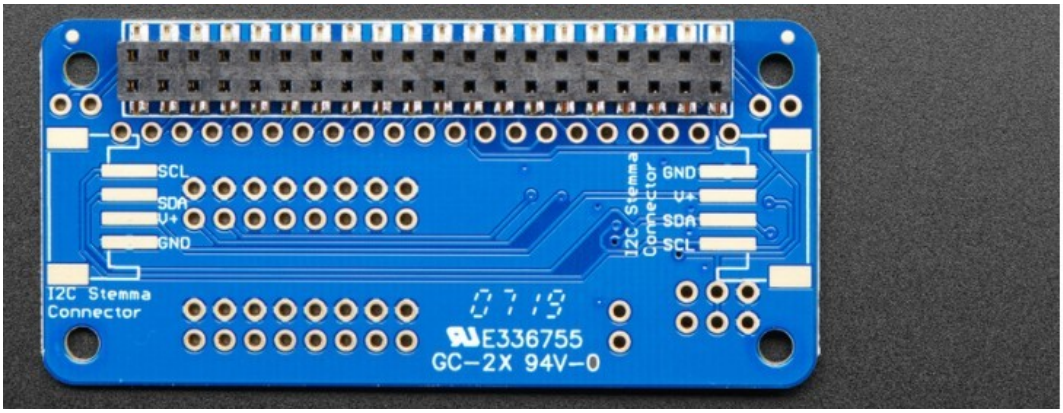




GPIO Pins Used

The Grove Base Hat uses Raspberry Pi GPIO pins: 2, 3, 5, 12, 13, 14, 15, 16, 18, 22, 24, 26.
All of these pins (except GPIO26) are also "brought out" on the Adafruit 4132 Expander Bonnet (shown below). But this Adafruit Bonnet provides an additional 16 pins. Each of these 16 pins can be defined as being Digital Input or Digital Output. The 4 I2C pinouts can also be found on this Bonnet.





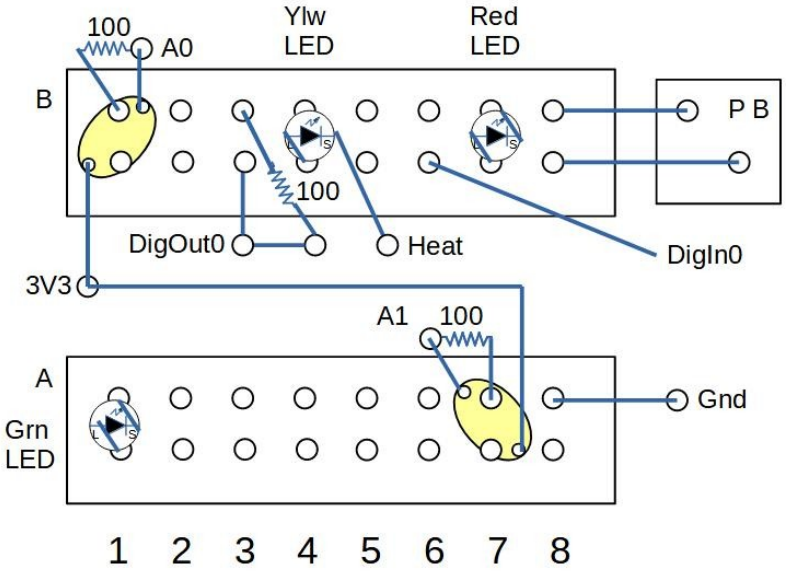
Note that 2 I2C headers can be soldered to the back of the Adafruit 4132 (webpage at Source 11 and PDF at Source 12). The pin positions of these headers correspond to the Grove connectors. These headers are available from Digi-Key (Source 20) as of 2020H Aug 30.

This means that the 16 "new" Digital I/O pins can be located remotely to the Raspberry Pi, at the end of a Grove cable. The Grove cables sold by Seeed can be as long as 20". But the other GPIO pins are not available remotely because they require that the 40 pin GPIO header be plugged into the GPIO pins on the Raspberry Pi.

PiR2B2 Wiring

The second version of the PiR2B2 is built by soldering components to the Adafruit 4132. The wiring diagram is shown below in Figure 1. The Adafruit 4132 was selected as the base because it requires a minimum amount of soldering. Yet the PiR2B2 provides 3 LEDS, 2 CDS photo-cells with analog signals, 2 Grove headers and 1 Push-Button. This provides all the (and even more) functionality than the PiR2A. DigOut0 can be a post in B3; DigIn0 can be a post in B6; Gnd can be a post in AG8. Pin 3V3 can be a post in the solder hole “3B3”. The two analog signals, A0 and A1, can be measured by connections to any of the following external boards:

-the Adafruit ADS1115 (16 bit) ADC
-the Adafruit ADS1015 (12 bit) ADC in Figure 2 (Source 13)
-WeatherHat Pro
-Grove Base Hat



Note 1 This wiring is for the AdaFruit 4132 Bonnet (Hat).
Note 2 This Bonnet defaults to using 5V. There is a jumper to swap between 3V and 5V. If you want to change it to 3V, you can cut the trace between the top two pads, and solder the bottom two pads.
Note 3 Analog signals A0 and A1 can be measured uisng the Grove Base Pro, the WeatherHat Pro, the Adafruit ADS1115 or ADS1015.

Dwg: PiR2B2_B.odg
For: Article 147
By: D@CC
As of: 2020H Aug 31

Figure 1. Simple PiR2B2 Circuitry on the Adafruit 4132 Bonnet

ADS1015 ADC Converter

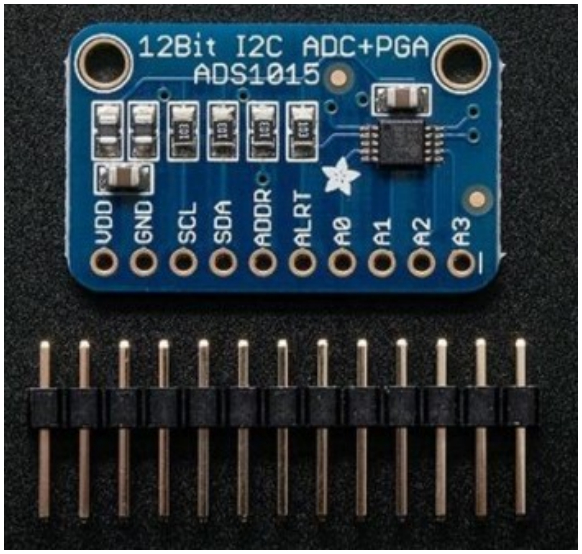
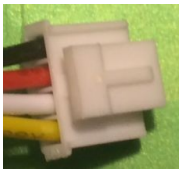


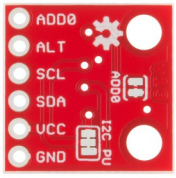
Figure 2. The Adafruit ADS1015 ADC Converter

Grove Connector Pinout

The pinout of the female end of a Grove cable (viewed as its wires enter the connector) is on the left below:

Gnd blk
3V3 red
SDA whi
SCL ylw

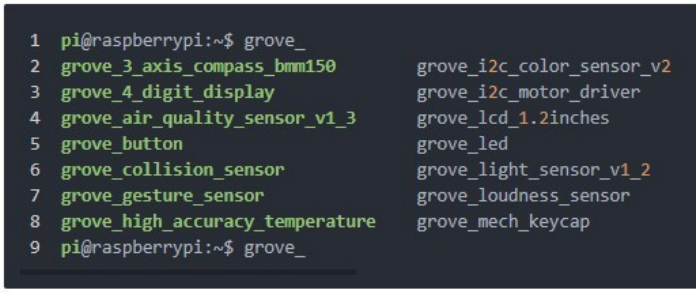


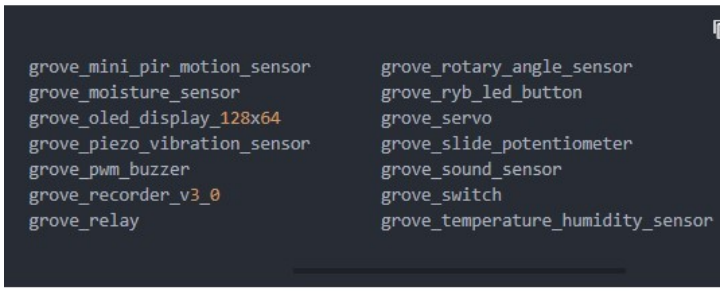


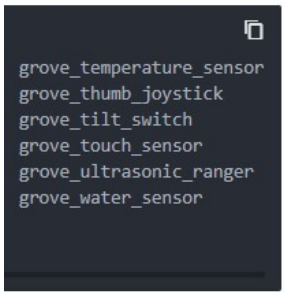
On the right, above, is the TMP102 I2C temperature sensor (viewed from its back). Note that a Grove female header (i.e. connector) can easily be soldered to the 4 lower pins by a rotation of 180 degrees. Equipped with this cable, the TMP102 is compatible with other I2C Grove devices. All of the I2C Grove devices are equipped with a female header that accepts the male end of a Grove cable. The PiR2B2 Area Controller can accept a M-M cable ending in an I2C Grove male connector. This cable can be used to connect to any I2C Grove device.

Hardware Modules (Sensors / Actuators)

Seeed has designed the Grove Base Hat so that the Raspberry Pi can easily connect to a wide range of Grove hardware devices (sensors and/or actuators) with no soldering. All that the user needs to do is to attach the Grove devices to something like a plastic back-plane using nuts and bolts. The list of Grove devices is constantly increasing (60 as of 2020 H Aug 27). Not all these devices connect via the I2C bus. A current list (as of 2020 H Aug 27) of them can be seen below:







The Grove set of Hat and Modules and Grove software (Source 03) greatly simplifies the development of an electronics lab based around the Raspberry Pi. To operate Grove sensors, the grove.py software depends on many hardware interface libraries such as that in Source 04. The only thing that seems to be missing is a “control panel” based upon a monitor screen and some user interface devices and software. That is what the PiR2 hardware and the PiR2B software can provide along with a comprehensive log (Source 09). At eLinux (Source 06) more info exists about the Grove Base Pro Hat software.

Description of Grove components

In the photo on the first page, on the left is the Grove Base Hat. On the right are the Grove cables that connect the Hat to other Grove devices. A large number (12) of the Grove Base Pro Hat connectors are not I2C. Along the top is a connector (header) to connect to pins on the GPIO header of any model of the Raspberry Pi. The PDF document in Source 02 is a data-sheet which gives an overview of the Grove Pi Hat. Source 01 is a web link to a sales article describing the Grove Base Pro Hat. The heart of this Hat is the STM32 MCU which is a microprocessor (the STM32F030F4P6) that controls many of the devices via the connectors. It is designed to only connect to 3.3v devices (not 5v devices).

Raspberry Pi Breakout Board v1.0

Seeed initially made a Raspberry Pi Breakout Board v1.0 designed for the early models of the Raspberry Pi that had 26 GPIO pins. It provided a "breadboard" that electronics could be soldered to. An example of each of the following come mounted on its board: key (push button), diode, led, NPN & PNP transistor, P-MOS and N-MOS fets, USB port / Power connector. This board does require soldering. It is described in Source 04.

GrovePi+

Seeed next made another device called the GrovePi+ (based on the ATMEGA328P microprocessor) which operates at 5v instead of 3v3. Therefore the Grove Base Hat is less complicated because the Raspberry Pi interfaces more easily with the 3v3 HC logic family and I2C devices.

Grove Base Hat Firmware

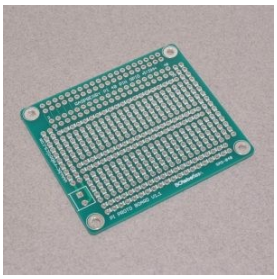
The SWD port is used to burn the firmware to this hat. It only uses GPIO09, GPIO10 and GPIO11 during the initial burn. Therefore these pins are fully available to the user.

Raspberry Pi pin usage by the Grove Pi Hat

PWM pins GPIO12 and GPIO13 (Software driver is only good for low frequencies).
UART pins GPIO14 and GPIO15
DIO connect to 6 pins of the Raspberry Pi (D5 / D16 / D18 / D22 / D24 / D26)
ADC only uses address 48 of the I2C bus #1 of the Pi and no other GPIO pins (see I2C pins next)
I2C pins SDA1 and SCL1

Pi Proto Board (Hat)

This board [from BC Robotics for CAD $3.95 shown below] has enough room to install 3 LEDs, 2 CDS photo-cells and a Push-Button. These are in addition to the 40 Raspberry Pi GPIO pins. This board can be plugged into the Raspberry Pi GPIO pins.



Combinations of Boards

Board Combination	Sensors / Actuators / Devices available
PiR2B into Pi	R/G Console wPB +I2C + TempId00
PiR2B into 4132 into Pi	R/G Console wPB + 16 DIO +I2C + TempId00
PiR2B remote to 4132 into Pi	R/G Console wPB + 8 DIO +I2C + TempId00
4132 into PiR2B into Pi	R/G Console wPB + 16 DIO +I2C + TempId00
PiR2B into WHat into Pi	R/G Console wPB + amb3 +I2C + TempId00&01 +3ADC
PiR2B into 3.14-2 into Pi	R/G Console wPB +I2C + TempId00 + camera

List of devices designed into the PiR2D
(as of 2020 H Aug 31)

These only need direct access to the Pi GPIO, I2C and 3 analog input ports. The PiR2D design uses 5 pins of Digital Output and 2 pins of Digital Input.

Device	**Use**	**Pi Pin/Code**	**DI/DO**	**Brd**
# usb0	amps charging an iPhone etc	I2C		I
# procTemp	temp in Pi processor	na		na
# pushButton	user data entry (On/Off)	GPIO22 tba	DI	P/B2/T/A
# redLED	errror signal	GPIO27	DO	P/B2/A
# greenLED	acknowledgement signal	GPIO04	DO	P/B2/A
# yellowLED	Caution (Heat On) signal	GPIO17 tba	DO	P/B2/A
# ambTemp1	local ambient temperature	I2C		P/W
ambTemp0	ambient temperature (TMP36)	analog 2		W
# ambHeat	artificial heat for ambTemp	GPIO17 tba	DO	R/B2/W
# digIn0	1 bit of Digital Input	GPIO22	DI	P/B2/A
# digOut0	1 bit of Digital Output	GPIO17	DO	P/B2/A
# tempId00	remote temperature	I2C		P/B2
tempId01	remote temperature*	I2C		W
# ambLight0	ambient Light (analog) #0	analog 0		W/D
# ambLight1	ambient Light (analog) #1	analog 1		W/D
ambHum	ambient Humidity*	I2C		W
ambPress	ambient barometric pressure*	I2C		W
camera	photo and video camera	cable		T
# moisture0	soil/floor moisture*	analog 3		W/D

“tba” means that another pin should be assigned. * means “new” # in PiR2B2

Compound PiR2E

The next version of the PiR2 area controller will be the PiR2E. It will be comprised of at least 4 boards including the Raspberry Pi. The 3 additional boards will be:

I	INA219 Board	uses I2C to report the Volt/Amps going through a USB conn.
	and either	
P	Pi Hat Prototype Board	containing the PiR2B electronic console
	or	
B2	Adafruit 4132 Bonnet	containing the PiR2B2 electronic console
	and either	
D	Adafruit ADS1015	4 ADC 12bit
	or	
G	Grove Base Hat	6 DIO, 4 ADC, 3 I2C Grove
	or	
W	WeatherHat Pro Board	containing the Temp/Press/Hum & remote temp & 3 ADC & I2C
	with an optional camera	
T	Twin Ind. 3.14-2 Board	adding the Pi Camera to the PiR2 electronic console
	and an optional 16 pins of Digital I/O	
A	Adafruit 4132 Bonnet	containing additional pins of DIO using an MCP23017 (optionally remote via a 20” Grove cable)

Note 1. The Grove Base Hat has more DIO and 3 I2C Grove headers
Note 2. The Weather Pro Board has more sensors, no DIO and only 1 I2C Grove header
Note 3. It is possible to mount ALL of the PiR2B devices (albeit tight) on the Adafruit Bonnet
Note 4. An ADC chip can probably be added to the Twin Ind. Board (to provide some ADC)

The combination of boards I, B2 plus A are recommended (# above) as of 2020H Aug 31. I will proceed with buying these various materials and preparing the PiR2 software that supports them. As I work with each of the boards, I will undoubtedly discover other advantages and disadvantages of these various configurations. I am now attempting to reduce the soldering work required and to use as many boards exactly as they come from each supplier. This means that I will use more Grove cables and create a less complicated PiR2 electronic module e.g. the PiR2B2.

The PiR2B

My current vision of the PiR2B is a board that has one of the following headers or connectors:

a) 40 pin GPIO connector to plug into the GPIO pins of the Raspberry Pi.
b) a header with a single row of 8 female pins to plug into the GPIO pins of the Rasp Pi.
c) a header that plugs into the 8 male pins on the connectors on the Adafruit 4132 Bonnet
d) a header that plugs into a new connector on the Twin Industries 3.14-2 Board
e) a PiR2B2 built onto the Adafruit 4132 Bonnet (Figure 1 above)
f) a PiR2B that has a female Grove connector to become a “Grove device” that plugs into the Grove Base Hat

is my current recommendation (as of 2020H Aug 31)

The Adafruit 4132 Bonnet

The Adafruit 4132 Bonnet (Hat) for the Raspberry Pi can support all the pins that were on the original PiR2A. But they are located in different (asymmetric) locations. The 4132 is only lacking an ADC for the ambient Light sensor(s) and the ambTemp thermometer, which is handled by the ADS1115. It has a pair of 4 pins; each pair can be used to attach a Grove cable to other I2C devices.

MEMS microphones

The software runs on the STM32 and includes drivers and middleware for audio data acquisition from MEMS digital microphones (MP34DT06J) and analog microphones (MP23ABS1), and USB streaming of the recorded signals. See Source 10 for more information. I have not yet decided to attempt the use of voice commands.

Grove Analog Microphone (MEMS)

Grove's best Microphone Amplifier is probably their SKU 101020852 [US$ 6.90] based on the SiSonic MEMS technologywhich is equipped with a female Grove (non I2C) header. It requires the Mini USB Microphone (compatible with the Raspberry Pi 4 for $4.90).

Stemma Cables and Sockets

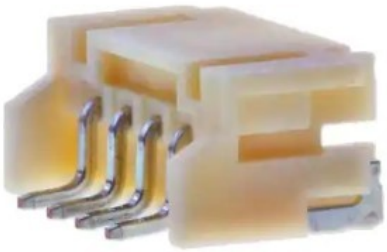
Stemma says: "Totally 220 pieces, this **JST-PH Connector Kit** is a must-have for your workstation. You'll have enough sockets and plugs to fuel your maker tendencies for days on end!"

These connectors are really common in electronics, we use the 2 pin ones for our batteries and battery packs. The 3 pin and 4 pin are used for STEMMA connectors. The 4 pin size is even compatible with Grove! They are large enough you can crimp without too much difficulty, but not as chunky as 0.1" / 2.5mm JST XH. See these connectors in the box below.

Prebuilt STEMMA cables with either Male or Female end are available from Mouser or Adafruit.

Mouser 1 485-3955 Adafruit3955 JST PH 4-pin-Male Hdr Cable 20cm $ 2.25 (Adafruit $1.50)
Mouser 1 485-3950 Adafruit3950 JST PH 4-pin-Fem Sckt Cable 20cm $ 2.25 (Adafruit $1.50)

On page 3 of Source 17 from JST, we see that SMT connectors mean “Surface Mount Technology”. There are 2 SM4 types: side entry type and top entry type. PHR-4 means 4 pins. Perhaps the connector that I need is JST PN: S4B-PH-SM4-TB (shown below).



S4B-PH-SM4-TB-LF-SN

As of 2020I Sep 02, I have found that Digi-Key is a source for the STEMMA JST PH 4-pin female sockets that can be soldered to the back of an Adafruit 4132.

Source 19 Describes 3 different STEMMA connectors:

STEMMA 4 Pin JST PH (2.0mm pitch) for I2C use
STEMMA 3 Pin JST PH (2.0mm pitch) for PWM/Analog/Digital use
STEMMA QT 4 pin JST SH (1.0mm pitch)

Stemma Purchasing information

JST #: S4B-PH-SM4-TB(LF)(SN) DigiKey #: 455-1751-1-ND White Hdr US$ 0.79
JST #: A04KR04KR26E305B DigiKey #: 455-3155-ND 12” M-M Cbl US$ 1.37

References

Source 01: https://wiki.seeedstudio.com/Grove_Base_Hat_for_Raspberry_Pi/
Source 02: Grove-Magnetic_Switch_v1.3_PDF_File.pdf
Source 03: grove.py-master.zip Grove Python software.
Source 04: https://wiki.seeedstudio.com/Raspberry_Pi_Breakout_Board_v1.0/
Source 05: mraa/smbus2/rpi.gpi/rpi_ws281x
Source 06: https://elinux.org/RPi_Expansion_Boards#Grove_Base_Hat_for_Raspberry_Pi
Source 07: http://ephotocaption.com/a/143/INA3221_PiR2_V06.pdf
Source 08: http://ephotocaption.com/a/146/146.html
Source 09: http://www.MehInCharge.com
Source 10: https://www.st.com/en/embedded-software/x-cube-memsmic1.html
Source 11: https://learn.adafruit.com/gpio-expander-bonnet/overview
Source 12: https://cdn-learn.adafruit.com/downloads/pdf/gpio-expander-bonnet.pdf?timestamp=1598804792
Source 13: https://www.adafruit.com/product/1083
Source 14: https://forums.adafruit.com/viewtopic.php?f=57&t=166801&p=817436&hilit=4132#p817436 STEMMA connectors Adafruit 3995
Source 15: https://www.adafruit.com/product/4527 SparkFun STEMMA QT / Qwiic JST SH Adapter
Source 16: http://www.jst.com/home8.html JST Web Site for Stemma Connectors
Source 17: JST_ePH.pdf data sheet for JST PH connectors
Source 18: https://www.digikey.com/product-detail/en/jst-sales-america-inc/S4B-PH-SM4-TB-LF-SN/455-1751-1-ND/926848#images-2
Source 19: https://learn.adafruit.com/introducing-adafruit-stemma-qt STEMMA Connectors
Source 20: https://www.digikey.com/short/zf4hbr STEMMA 2mm Hdr US$ 0.79

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