DAFTAR RIWAYAT HIDUP

Nama Lengkap : KALISA

NIM :061540351531

Tempat Tanggal Lahir : Baturaja , 01 November 1996

Alamat : Jl. Siak Hulu Balang Ds. Baturaja,
Kecamatan Baturaja Timur,
Kabupaten OKU. Provinsi
Sumatera Selatan. 31111

E-Mail : Kalisa592@gmail.com

Telepon 087755677062

RIWAYAT PENDIDIKAN FORMAL :

Pendidikan	**Nama Sekolah/Perguruan Tinggi**	**Jurusan/ Program Studi**	**Tahun**
SD	SD Negeri 09 OKU	-	2003 - 2009
SMP	SMP Negeri 01 OKU	-	2009 - 2012
SMA	SMA Negeri 05OKU	IPA	2012 - 2015

RIWAYAT PENDIDIKAN NON FORMAL :

JENIS PENDIDIKAN NON FORMAL	**TAHUN**
-	-

PENGHARGAAN/PENCAPAIAN :

NO	NAMA PENGHARGAAN/PENCAPAIAN	TAHUN
1	Sertifikat dari HMJ MI Sebagai Peserta Workshop 2nd Game Development	2016
2	Sertifikat Peserta Seminar Nasional NASA 2017 UKM Mars Polsri	2017
3	Piagam UKM Karisma sebagai Panitia Perlengkapan dalam kegiataan Karisma Expo 2017	2017
4	Piagam UKM Karisma sebagai Sekretaris Perlengkapan dalam kegiataan Musabaqol Tilawatil Qur'an 2016	2016
5	Piagam UKM Karisma sebagai Peserta dalam kegiataan TKK 2 2016	2016
6	Piagam UKM Karisma sebagai Panitia dalam kegiataan Karisma Expo 2016	2016
7	Piagam UKM Karisma sebagai Panitia Konsumsi dalam kegiataan Studi Islam Akhir Pekan (SIAP) 2016	2016
8	Piagam UKM Karisma sebagai Peserta dalam Kegiatan Workshop Jurnalistik UKM WPS Fair 2016	2016
9	Sertifikat UNJ sebagai Peserta FSLN Essay Competition	2017

PENGALAMAN ORGANISASI/BEKERJA :

NO	NAMA ORGANISASI	TAHUN PERIODE
1	Unit Kegiatan Mahasiswa Karisma Polsri Bidang MDP (Staff)	2015-2016
2	Unit Kegiatan Mahasiswa Karisma Polsri Bidang KPRT (Staff)	2016-2017
3	Unit Kegiatan Mahasiswa MARS Polsri Bidang Ristek (Staff)	2016-2017

4	Komisariat KAMMI Alhadid Bidang Humas (Staff)	2016-2017

PENGALAMAN PENELITIAN :

NAMA PENELITIAN	TAHUN
-	-

PENGALAMAN PENGABDIAN :

NAMA PENGABDIAN	TAHUN
GPM (Gerakan Polsri Mengabdi) merupakan Kegiatan BEM Polsri	2017

TEM MONITORING PERGESERAN TANAH DENGAN SENSOR YL-69 DAN ULTRASONIK BERBASIS INTERNET OF THINGS

Kalisa [1)], Ali Nurdin [2)], Mohammad Fadhli [3)]
[1),2),3)]Jurusan Teknik Elektro Program Studi Teknik Telekomunikasi, Politeknik Negeri Sriwijaya
Jl. Srijaya Negara, Bukit Besar Palembang
Email : kalisa592@gmail.com

ABSTRACT

In Indonesia, landslides are a natural disaster whose frequency is quite high. Areas prone to these disasters are in hilly areas, valleys and mountains. Land shifts and high rainfall are one of the factors that occur. This paper aims to design a land shifting system with two sensors, namely an ultrasonic sensor to detect ground shift distance and yl-69 to measure soil moisture. Using the Raspberry pi connected to the IoT platform as monitoring and warning buzzer will sound as if it would be a landslide. The soil moisture value and land shift read by the sensor will be sent to the thingspeak platform that records data in graphical form. For this, thingspeak as a monitoring system that can monitor in real time sensor measurement data via a web server.

Keywords: Landslides, Raspberry pi, Monitoring , IoT, Thingspeak

ABSTRAK

Di Indonesia, bencana tanah longsor merupakan bancana alam yang frekuensi terjadinnya cukup tinggi. Daerah yang rawan terkena bencana tersebut yaitu di daerah perbukitan, lembah dan pegunungan. Pergeseran Tanah dan curah hujan yang cukup tinggi merupakan salah satu faktor terjadinya. Pada Penelitian ini bertujuan untuk merancang sistem pergeseran tanah dengan dua sensor yaitu sensor ultrasonik sebagai pendeteksi jarak pergeseran tanah dan YL-69 untuk mengukur kelembaban tanah. Menggunakan Raspberry pi sebagai mikroprosessor yang terhubung dengan platform iot sebagai monitoring dan buzzer sebagai peringatan akan berbunyi jika akan terjadi longsor. Nilai Kelembaban tanah dan pergeseran tanah yang dibaca sensor akan dikirimkan ke *platform* iot thingspeak yang merekam data dalam bentuk grafik. Untuk hal ini, thingspeak sebagai sistem monitoring yang dapat memantau secara realtime data pengukuran sensor melalui *web server*.

Kata Kunci : Tanah longsor, Raspberry pi, Monitoring , IoT, Thingspeak

PENDAHULUAN

Tanah Longsor atau gerakan tanah merupakan bencana alam yang disebabkan oleh pergerakan tanah atau masa bebatuan seperti jatuhnya bebatuan atau gumpalan besar tanah. Potensi bencana tanah longsor di beberapa wilayah di Indonesia sangat besar , terutama di daerah perbukitan, lembah dan pegunungan. Dampak kerugian yang ditimbulkan secara langsung yaitu merusak lahan pertanian, menimbulkan korban jiwa, dapat mengganggu fasilitas umum dan transportasi serta kerugian harta benda. Menurut data informasi bencana Indonesia Badan Nasional Penanggulangan Bencana (BNPB) pada tahun 2017 telah terjadi bencana alam dengan total 2.862 kejadian dan tanah longsor sebanyak 848 kejadian yang mengakibatkan 163 orang meninggal dan hilang, 185 orang luka-luka, 59.641 warga terpaksa mengungsi dan kerusakan bangunan gedung,rumah dan fasilitas umum lainnya. Hal ini disebabkan banyaknya wilayah Indonesia yang merupakan daerah rawan terhadap tanah longsor[1].

Adapun beberapa penelitian terkait sistem pendeteksi pergeseran tanah. Pada penelitian yang dibuat oleh Ni Luh Desi Ratna Ari Sandi, et.all (2016), dengan judul "Rancang Bangun Sistem Pendeteksi Tanah Longsor Sederhana Berbasis Sensor Soil Moisture Dan Sensor Ultrasonik" menggunakan Arduino Uno sebagai mikrokontroller dan sistem pendeteksi ini memiliki tingkat sensitivitas sensor yang cukup tinggi. Namun sistem ini belum berbasis Iot sehingga tidak bisa memantau secara realtime [2]. Pada penelitian La Ode Hasnuddin S Sagala dan Muhammad Sainal Abidin (2017), dengan judul *"Internet Of Things For Early Detection Of Lanslides"* sistem yang dibuat bekerja secara real time, namun tidak menggunakan sensor jarak untuk mengetahui pergerakan tanah[3].

Pada penelitian ini sistem menggunakan sensor ultrasonik sebagai sensor jarak untuk mengukur jarak pergeseran tanah dan sensor YL-69 untuk mengukur kelembaban tanah dengan Raspberry Pi sebagai mikroprosessor. Sistem ini memanfaatkan teknologi IoT *(Internet of Things),* sehingga data pada sistem ini dapat dimonitoring di *web server* yang diakses melalui jaringan internet secara realtime. Dalam penelitian ini menggunakan salah satu layanan *platform* Iot yaitu Thingspeak. Thingspeak merupakan *platform* open source IoT dalam bentuk web yang digunakan untuk menyimpan, memvisualisasikan, menganalisa, dan membaca data sensor serta menampilkan dalam bentuk grafik

TINJAUAN PUSTAKA

Tanah Longsor

Tanah longsor merupakan peristiwa alam dimana pergerakan tanah atau material seperti gumpalan besar tanah atau jatuhnya bebatuan. Prinsipnya terjadi apabila gaya penahan lebih kecil dibandingkan gaya pendorong. Gaya pendorong dipengaruhi oleh beban, air, besarnya sudut lereng dan berat jenis tanah batuan sedangkan gaya pendorong dipengaruhi oleh kepadatan tanah dan kekuatan bebatuan[4].

Raspberry pi

Raspberry Pi merupakan mini komputer yang *low-cost* dan berukuran hampir sama seperti kartu kredit yang berfungsi untuk banyak hal seperti yang bisa dilakukan oleh komputer, seperti pemrograman,permainan, *spreadsheets*, dan *word processing*. Kelebihan Raspberry pi dibandingkan dengan mikrokontroller yaitu dapat mengontrol lebih dari 1 unit *device* yang ingin dikontrol baik dari jarak dekat maupun jarak jauh. Bahasa pemrograman yang digunakan raspberry pi adalah bahasa *python*. Dilengkapi dengan berbagai fitur, yaitu Micro SD, port Ethernet, port usb, HDMI Video, CPU 400-700 MHz,audio output, RCA video, HDMI Video, CPU 400-700 MHz, dan pin GPIO yang berfungsi untuk interface dengan berbagai perangkat elektronik[5]. Tipe terbaru dari Raspberry pi yaitu Raspberry pi 3 model b+ yang merupakan pengembangan dari tipe sebelumnya. Perbedaan dari tipe sebelumnya terletak pada kemampuan jaringan dan prosessor.

Internet of Things

Internet of Things atau IoT adalah konsep yang mengacu pada benda yang merupakan representasi virtual dalam struktur yang berbasis Internet. Kemampuannya dalam berbagi data, sebagai remote kontrol dan masih banyak kegunaan lainnya[6]. Dalam penelitian ini menggunakan *platform* IoT yaitu *Thingspeak*.

Sensor Ultrasonik

Sensor ultrasonik adalah sensor yang berfungsi untuk mengubah besaran listrik menjadi besaran fisis (bunyi) dan sebaliknya. Prinsip kerja sensor ultrasonik yaitu pantulan gelombang suara yang ditafsirkan dalam eksistensi (jarak) suatu benda dengan frekuensi tertentu. Sensor ini menggunakan gelombang ultrasonik(bunyi ultrasonik) yang memiliki frekuensi yang sangat tinggi sebesar 20.000 Hz. Pada sensor ultrasonik, gelombang bunyi ultrasonik dibangkitkan oleh alat yang disebut dengan piezoelektrik dengan frekuensi tertentu[7].

Sensor YL-69

Sensor YL-69 adalah sensor kelembaban tanah yang prinsipnya membaca kadar air dalam tanah disekitarnya. Sensor YL-69 menggunakan dua penghantar untuk melewati arus dalam tanah. Kelebihan dari sensor YL-69 yaitu murah, presisi dan stabil [8].

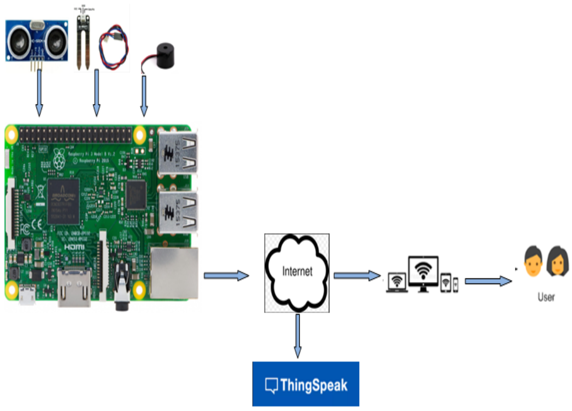
Buzzer

Buzzer termasuk komponen elektronika yang memiliki fungsi mengubah getaran listrik menjadi getaran suara. Buzzer biasanya dimanfaatkan untuk indikator bahwa terjadi suatu kesalahan pada sebuah alat (alarm) atau proses telah selesai [9].

METODE PENELITIAN

Desain Hardware

Desain *hardware* adalah langkah awal yang digunakan untuk membangun sistem monitoring pada prototipe pergeseran tanah. Komponen yang digunakan setidaknya memiliki kelebihan dan sesuai dengan yang diinginkan agar sistem yang dibangun menjadi optimal. Dibawah ini merupakan blok diagram pada sistem monitoring tersebut

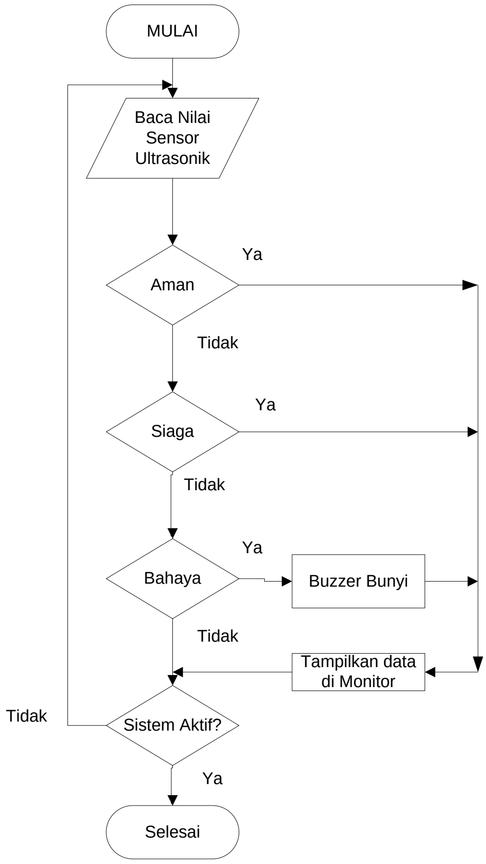


Gambar 1. Blok Diagram Sistem

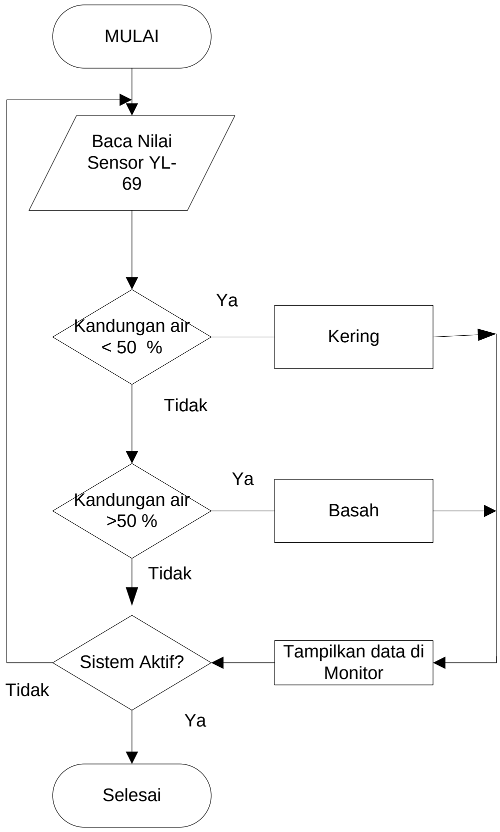
Dari gambar 1 merupakan blog diagram sistem monitoring pergeseran tanah yang berbasis *Internet of Things*. Menggunakan Raspberry pi 3 model B+ sebagai otak utama dalam menjalankan sistem ini. Dapat diketahui bahwa sensor kelembaban tanah YL-69 dan sensor ultrasonik merupakan input dari Raspberry pi 3 yang memiliki fungsi dalam mendeteksi parameter-parameter yang dibutuhkan. Kemudian input dihubungkan pada masing-masing port di raspberry pi dan nilai sensor akan terbaca. Nilai sensor YL-69 dan sensor ultrasonik akan dikirimkan raspberry pi yang terhubung internet ke *platform* IoT yaitu thingspeak. Thingspeak sebagai monitoring akan menyajikan nilai sensor dalam bentuk grafik yang bisa diakses melalui *smartphone* dan Komputer/ laptop*.* Output lain dari sistem ini yaitu akan memberikan notifikasi bahaya sebelum longsor berupa buzzer berbunyi.

Desain Software

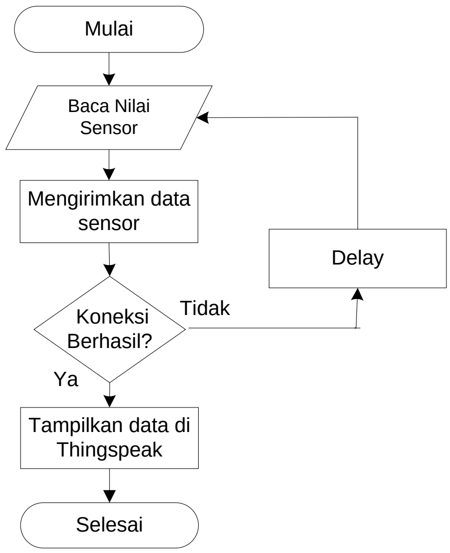
Pada langkah ini memuat diagram alir untuk sistem pergeseran tanah dengan sensor YL-69 dan Ultrasonik. Pada perancangan ini menggunakan bahasa pemrograman *Python* yang tersedia dalam OS Raspbian pada mikro komputer Raspberry Pi. Perancangan *software* pada sistem ini merupakan perancangan yang dilakukan untuk mengukur pergerakan tanah dan kelembaban tanah. Perancangan *software* pada sistem monitoring merupakan perancangan yang dilakukan untuk mengirmkan data ke layanan web IOT yaitu Thinkspeak yang selanjutnya data harus ditampilkan dalam Thingspeak dalam bentuk grafik.



Gambar 2. Diagram Alir Untuk Sensor Ultrasonik



Gambar 3. Diagram Alir Untuk Sensor Kelembaban YL-69



Gambar 4. Diagram Alir Sistem Monitoring

Pada gambar 2 merupakan diagram alir sensor ultrasonik pada prototipe pergeseran tanah. Sensor ultrasonik membaca jarak pergerakan tanah dalam satuan sentimeter (cm). Nilai yang terbaca sensor terbagi menjadi tiga kategori yaitu bahaya, siaga dan aman.

Pada gambar 3 merupakan diagram alir untuk sensor YL-69 yang akan membaca nilai kelembaban, jika kering maka mengandung air kurang dari 50% dan jika lebih dari 50% maka disebut basah.

Pada gambar 4 merupakan diagram alir sistem monitoring. Nilai sensor ultrasonik dan YL-69 yang terbaca akan dikimkan dari raspberry pi melalui jaringan internet ke *platform* IoT yaitu thingspeak. Data akan ditampilkan di web thingspeak dalam bentuk *chart* yang bisa diakses dimanapun.

HASIL DAN PEMBAHASAN

Pengujian sensor YL-69 dan Ultrasonik bertujuan untuk mengetahui nilai output pada masing–masing sensor dan menentukan nilai sensor dengan beberapa kondisi. Pengujian sensor YL-69 dilakukan dengan cara menancapkan sensor ke dalam tanah. Sedangkan sensor ultrasonik pada prototipe diletakkan di depan tanah miring sehingga semakin pergerakan tanah cepat dan mendekati maka status bahaya. Setelah itu output sensor akan ditampilkan pada modul monitor Raspberry pi. Tabel 1.1 adalah tabel hasil nilai sensor YL-69.

Tabel 1.1 Hasil Pengujian sensor YL-69

No	YL-69	Kondisi
1	0	Kering
2	1	Basah

Pada peneitian ini sensor kelembaban YL-69 menggunakan input digital sehingga outputnya berupa 0 dan 1. Untuk kadar kandungan air lebih dari 50 %(basah) maka outputnya 1(*HIGH*) dan untuk kadar kandungan air kurang dari 50% (kering) maka outputnya 0 (*LOW*).

Tabel 1.2 Hasil Pengujian Sensor Ultrasonik

No	Jarak(cm)	Status
1	33	Aman
2	21	Siaga
3	10	Bahaya
4	31	Aman
5	24.33	Siaga
6	11	Bahaya

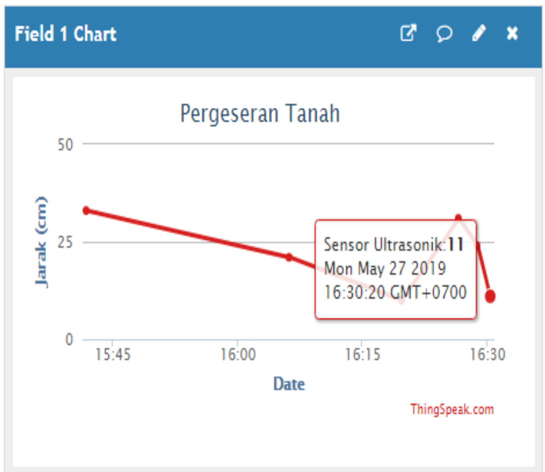
Sensor ultrasonik membaca jarak pergeseran tanah dalam satuan sentimeter(cm). Terbagi menjadi tiga status yaitu aman, siaga dan bahaya. Untuk aman jarak pergeseran tanah dengan sensor ultrasonik > 25 cm atau tidak adanya pergerakan tanah sama sekali. Untuk status siaga 15-25 cm dan untuk status bahaya maka pergerakan tanah mendekati sensor ultrasonik dengan jarak <15 cm.
Berikut tabel 1.3 nilai output dari kedua sensor tersebut

Tabel 1.3 Hasil Output kedua sensor

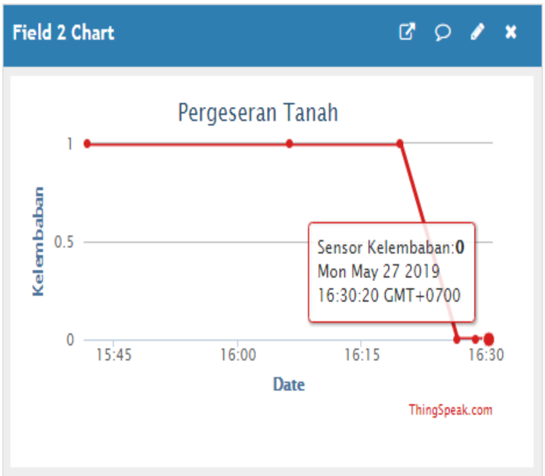
Pengukuran			Output
YL-69	Jarak (cm)	Status	Buzzer
1	33	aman	Tidak berbunyi
1	21	siaga	Tidak berbunyi
1	10	Bahaya	Bunyi nyaring
0	31	Aman	Tidak berbunyi
0	24.33	Siaga	Tidak berbunyi
0	11	bahaya	Bunyi Nyaring

Montoring dengan Platform IoT Thingspeak

Data nilai yang terbaca sensor YL-69 dan sensor ultrasonik pada tabel 1.3 akan dikirimkan raspberry pi ke *thingspeak* untuk sistem monitoring. Tampilan data pada thingspeak yaitu dalam bentuk grafik.



Gambar 5. Tampilan Grafik Sensor Ultrasonik



Gambar 6. Tampilan Grafik Sensor YL-69

KESIMPULAN DAN SARAN

Kesimpulan

Sistem monitoring pergeseran tanah dibangun dengan sensor YL-69 sebagai pendeteksi kelembaban tanah dan sensor ultrasonik yang dikontrol dengan Raspberry pi. Dari hasil pengamatan bahwa untuk sensor ultrasonik dibagi menjadi tiga status yaitu aman, siaga dan bahaya. Untuk sensor YL-69 terdapat dua kondisi yaitu kering dan basah. Kondisi pergeseran tanah bisa dimonitoring secara online di web thingspeak. Sistem yang dibuat sudah mampu mengirimkan data ke *web server* thingspeak dan menghidupkan buzzer ketika status bahaya.

Saran

Agar alat ini dapat berfungsi lebih baik lagi, beberapa hal yang perlu dikembangkan yaitu: *Web server* ThingSpeak bisa diganti dengan web *server* sendiri agar keamanan data lebih terjaga dan bisa ditambahkan notifikasi ketika status bahaya

Referensi

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DATASHEET

Raspberry Pi Compute Module 3+

Raspberry Pi Compute Module 3+ Lite

Release 1, January 2019

Table 1: Release History

Release	Date	Description
1	28/01/2019	First release

The latest release of this document can be found at `https://www.raspberrypi.org`

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1 Introduction

The Raspberry Pi Compute Module 3+ (CM3+) is a range of DDR2-SODIMM-mechanically-compatible System on Modules (SoMs) containing processor, memory, eMMC Flash (on non-Lite variants) and supporting power circuitry. These modules allow a designer to leverage the Raspberry Pi hardware and software stack in their own custom systems and form factors. In addition these modules have extra IO interfaces over and above what is available on the Raspberry Pi model A/B boards, opening up more options for the designer.

The CM3+ contains a BCM2837B0 processor (as used on the Raspberry Pi 3B+), 1Gbyte LPDDR2 RAM and eMMC Flash. The CM3+ is currently available in 4 variants, CM3+/8GB, CM3+/16GB, CM3+/32GB and CM3+ Lite, which have 8, 16 and 32 Gigabytes of eMMC Flash, or no eMMC Flash, respectively.

The CM3+ Lite product is the same as CM3+ except the eMMC Flash is not fitted, and the SD/eMMC interface pins are available for the user to connect their own SD/eMMC device.

Note that the CM3+ is electrically identical and, with the exception of higher CPU z-height, physically identical to the legacy CM3 products.

CM3+ modules require a software/firmware image dated November 2018 or newer to function correctly.

2 Features

2.1 Hardware

- Low cost
- Low power
- High availability
- High reliability
  - Tested over millions of Raspberry Pis Produced to date
  - Module IO pins have 15 micro-inch hard gold plating over 2.5 micron Nickel

2.2 Peripherals

- 48x GPIO
- 2x I2C
- 2x SPI
- 2x UART
- 2x SD/SDIO
- 1x HDMI 1.3a
- 1x USB2 HOST/OTG
- 1x DPI (Parallel RGB Display)
- 1x NAND interface (SMI)
- 1x 4-lane CSI Camera Interface (up to 1Gbps per lane)
- 1x 2-lane CSI Camera Interface (up to 1Gbps per lane)
- 1x 4-lane DSI Display Interface (up to 1Gbps per lane)
- 1x 2-lane DSI Display Interface (up to 1Gbps per lane)

2.3 Software

- ARMv8 Instruction Set
- Mature and stable Linux software stack
  - Latest Linux Kernel support
  - Many drivers upstreamed
  - Stable and well supported userland
  - Full availability of GPU functions using standard APIs

3 Block Diagram

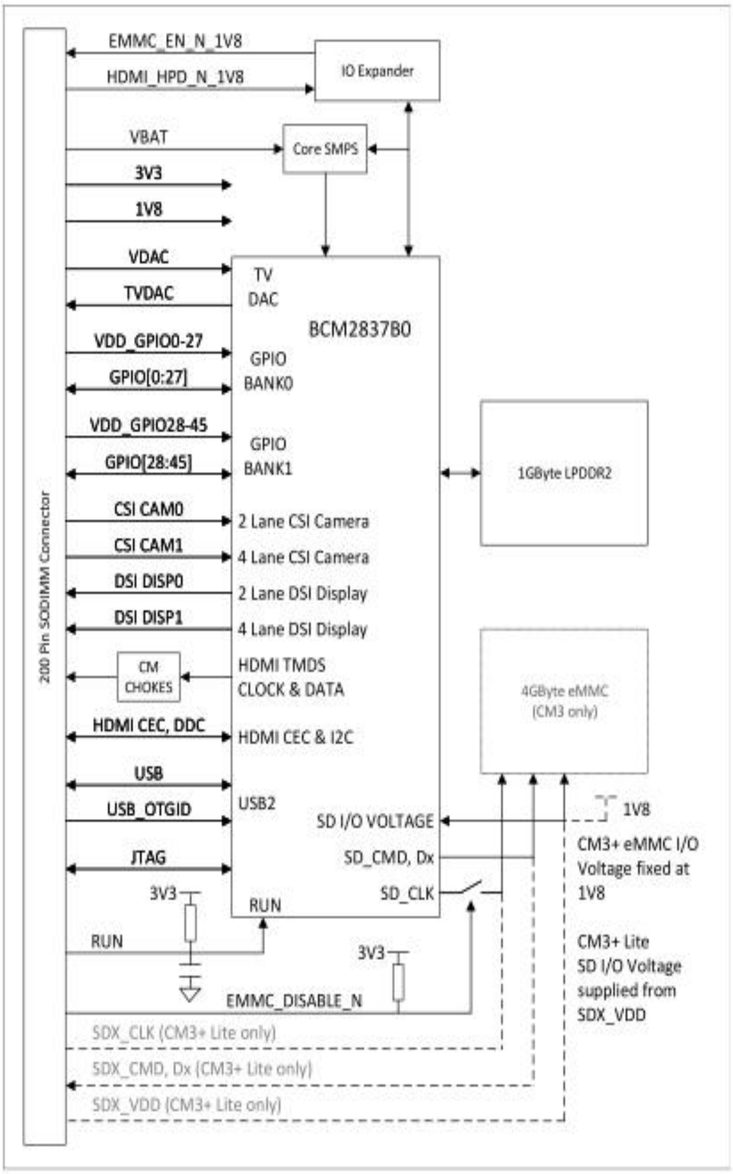


Figure 1: CM3+ Block Diagram

4 Mechanical Specification

The CM3+ modules conform to JEDEC MO-224 mechanical specification for 200 pin DDR2 (1.8V) SODIMM modules and therefore should work with the many DDR2 SODIMM sockets available on the market. **(Please note that the pinout of the Compute Module is not the same as a DDR2 SODIMM module; they are not electrically compatible.)**

The SODIMM form factor was chosen as a way to provide the 200 pin connections using a standard, readily available and low cost connector compatible with low cost PCB manufacture.

The maximum component height on the underside of the Compute Module is 1.2mm.

The maximum component height on the top side of the Compute Module is 2.5mm.

The Compute Module PCB thickness is 1.0mm +/- 0.1mm.

Note that the location and arrangement of components on the Compute Module may change slightly over time due to revisions for cost and manufacturing considerations; however, maximum component heights and PCB thickness will be kept as specified.

Figure 2 gives the CM3+ mechanical dimensions.

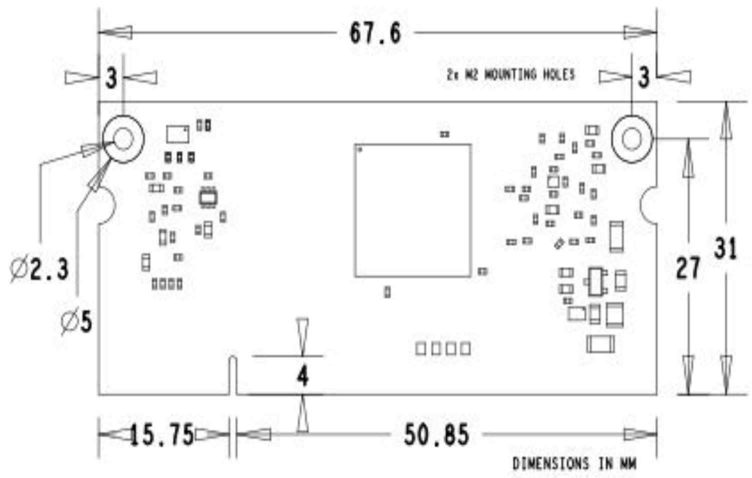


Figure 2: CM3+ Mechanical Dimensions

5 Pin Assignments

CM3+	CM3+ Lite	PIN	PIN	CM3+	CM3+ Lite
GND		1	2	EMMC_DISABLE_N	
GPIO0		3	4	NC	SDX_VDD
GPIO1		5	6	NC	SDX_VDD
GND		7	8	GND	
GPIO2		9	10	NC	SDX_CLK
GPIO3		11	12	NC	SDX_CMD
GND		13	14	GND	
GPIO4		15	16	NC	SDX_D0
GPIO5		17	18	NC	SDX_D1
GND		19	20	GND	
GPIO6		21	22	NC	SDX_D2
GPIO7		23	24	NC	SDX_D3
GND		25	26	GND	
GPIO8		27	28	GPIO28	
GPIO9		29	30	GPIO29	
GND		31	32	GND	
GPIO10		33	34	GPIO30	
GPIO11		35	36	GPIO31	
GND		37	38	GND	
GPIO0-27_VDD		39	40	GPIO0-27_VDD	
		KEY			
GPIO28-45_VDD		41	42	GPIO28-45_VDD	
GND		43	44	GND	
GPIO12		45	46	GPIO32	
GPIO13		47	48	GPIO33	
GND		49	50	GND	
GPIO14		51	52	GPIO34	
GPIO15		53	54	GPIO35	
GND		55	56	GND	
GPIO16		57	58	GPIO36	
GPIO17		59	60	GPIO37	
GND		61	62	GND	
GPIO18		63	64	GPIO38	
GPIO19		65	66	GPIO39	
GND		67	68	GND	
GPIO20		69	70	GPIO40	
GPIO21		71	72	GPIO41	
GND		73	74	GND	
GPIO22		75	76	GPIO42	
GPIO23		77	78	GPIO43	
GND		79	80	GND	
GPIO24		81	82	GPIO44	
GPIO25		83	84	GPIO45	
GND		85	86	GND	
GPIO26		87	88	HDMI_HPD_N_1V8	
GPIO27		89	90	EMMC_EN_N_1V8	
GND		91	92	GND	
DSI0_DN1		93	94	DSI1_DP0	
DSI0_DP1		95	96	DSI1_DN0	
GND		97	98	GND	
DSI0_DN0		99	100	DSI1_CP	
DSI0_DP0		101	102	DSI1_CN	
GND		103	104	GND	
DSI0_CN		105	106	DSI1_DP3	
DSI0_CP		107	108	DSI1_DN3	
GND		109	110	GND	
HDMI_CLK_N		111	112	DSI1_DP2	
HDMI_CLK_P		113	114	DSI1_DN2	
GND		115	116	GND	
HDMI_D0_N		117	118	DSI1_DP1	
HDMI_D0_P		119	120	DSI1_DN1	
GND		121	122	GND	
HDMI_D1_N		123	124	NC	
HDMI_D1_P		125	126	NC	
GND		127	128	NC	
HDMI_D2_N		129	130	NC	
HDMI_D2_P		131	132	NC	
GND		133	134	GND	
CAM1_DP3		135	136	CAM0_DP0	
CAM1_DN3		137	138	CAM0_DN0	
GND		139	140	GND	
CAM1_DP2		141	142	CAM0_CP	
CAM1_DN2		143	144	CAM0_CN	
GND		145	146	GND	
CAM1_CP		147	148	CAM0_DP1	
CAM1_CN		149	150	CAM0_DN1	
GND		151	152	GND	
CAM1_DP1		153	154	NC	
CAM1_DN1		155	156	NC	
GND		157	158	NC	
CAM1_DP0		159	160	NC	
CAM1_DN0		161	162	NC	
GND		163	164	GND	
USB_DP		165	166	TVDAC	
USB_DM		167	168	USB_OTGID	
GND		169	170	GND	
HDMI_CEC		171	172	VC_TRST_N	
HDMI_SDA		173	174	VC_TDI	
HDMI_SCL		175	176	VC_TMS	
RUN		177	178	VC_TDO	
VDD_CORE (DO NOT CONNECT)		179	180	VC_TCK	
GND		181	182	GND	
1V8		183	184	1V8	
1V8		185	186	1V8	
GND		187	188	GND	
VDAC		189	190	VDAC	
3V3		191	192	3V3	
3V3		193	194	3V3	
GND		195	196	GND	
VBAT		197	198	VBAT	
VBAT		199	200	VBAT	

Table 2: Compute Module 3+ SODIMM Connector Pinout

Table 2 gives the Compute Module 3+ pinout and Table 3 gives the pin functions.

Pin Name	DIR	Voltage Ref	PDN[a] State	If Unused	Description/Notes
RUN and Boot Control (see text for usage guide)					
RUN	I	3V3[b]	Pull High	Leave open	Has internal 10k pull up
EMMC_DISABLE_N	I	3V3[b]	Pull High	Leave open	Has internal 10k pull up
EMMC_EN_N_1V8	O	1V8	Pull High	Leave open	Has internal 2k2 pull up
GPIO					
GPIO[27:0]	I/O	GPIO0-27_VDD	Pull or Hi-Z[c]	Leave open	GPIO Bank 0
GPIO[45:28]	I/O	GPIO28-45_VDD	Pull or Hi-Z[c]	Leave open	GPIO Bank 1
Primary SD Interface[d,e]					
SDX_CLK	O	SDX_VDD	Pull High	Leave open	Primary SD interface CLK
SDX_CMD	I/O	SDX_VDD	Pull High	Leave open	Primary SD interface CMD
SDX_Dx	I/O	SDX_VDD	Pull High	Leave open	Primary SD interface DATA
USB Interface					
USB_Dx	I/O	-	Z	Leave open	Serial interface
USB_OTGID	I	3V3		Tie to GND	OTG pin detect
HDMI Interface					
HDMI_SCL	I/O	3V3[b]	Z[f]	Leave open	DDC Clock (5.5V tolerant)
HDMI_SDA	I/O	3V3[b]	Z[f]	Leave open	DDC Data (5.5V tolerant)
HDMI_CEC	I/O	3V3	Z	Leave open	CEC (has internal 27k pull up)
HDMI_CLKx	O	-	Z	Leave open	HDMI serial clock
HDMI_Dx	O	-	Z	Leave open	HDMI serial data
HDMI_HPD_N_1V8	I	1V8	Pull High	Leave open	HDMI hotplug detect
CAM0 (CSI0) 2-lane Interface					
CAM0_Cx	I	-	Z	Leave open	Serial clock
CAM0_Dx	I	-	Z	Leave open	Serial data
CAM1 (CSI1) 4-lane Interface					
CAM1_Cx	I	-	Z	Leave open	Serial clock
CAM1_Dx	I	-	Z	Leave open	Serial data
DSI0 (Display 0) 2-lane Interface					
DSI0_Cx	O	-	Z	Leave open	Serial clock
DSI0_Dx	O	-	Z	Leave open	Serial data
DSI1 (Display 1) 4-lane Interface					
DSI1_Cx	O	-	Z	Leave open	Serial clock
DSI1_Dx	O	-	Z	Leave open	Serial data
TV Out					
TVDAC	O	-	Z	Leave open	Composite video DAC output
JTAG Interface					
TMS	I	3V3	Z	Leave open	Has internal 50k pull up
TRST_N	I	3V3	Z	Leave open	Has internal 50k pull up
TCK	I	3V3	Z	Leave open	Has internal 50k pull up
TDI	I	3V3	Z	Leave open	Has internal 50k pull up
TDO	O	3V3	O	Leave open	Has internal 50k pull up

[a] The PDN column indicates power-down state (when RUN pin LOW)
[b] Must be driven by an open-collector driver
[c] GPIO have software enabled pulls which keep state over power-down
[d] Only available on Lite variants
[e] The CM will always try to boot from this interface first
[f] Requires external pull-up resistor to 5V as per HDMI spec

Table 3: Pin Functions

6 Electrical Specification

Caution! Stresses above those listed in Table 4 may cause permanent damage to the device. This is a stress rating only; functional operation of the device under these or any other conditions above those listed in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Symbol	Parameter	Minimum	Maximum	Unit
VBAT	Core SMPS Supply	-0.5	6.0	V
3V3	3V3 Supply Voltage	-0.5	4.10	V
1V8	1V8 Supply Voltage	-0.5	2.10	V
VDAC	TV DAC Supply	-0.5	4.10	V
GPIO0-27_VDD	GPIO0-27 I/O Supply Voltage	-0.5	4.10	V
GPIO28-45_VDD	GPIO28-45 I/O Supply Voltage	-0.5	4.10	V
SDX_VDD	Primary SD/eMMC Supply Voltage	-0.5	4.10	V

Table 4: Absolute Maximum Ratings

DC Characteristics are defined in Table 5

Symbol	Parameter	Conditions	Minimum	Typical	Maximum	Unit
V_{IL}	Input low voltage[a]	VDD_IO = 1.8V	-	-	0.6	V
		VDD_IO = 2.7V	-	-	0.8	V
		VDD_IO = 3.3V	-	-	0.9	V
V_{IH}	Input high voltage[a]	VDD_IO = 1.8V	1.0	-	-	V
		VDD_IO = 2.7V	1.3	-	-	V
		VDD_IO = 3.3V	1.6	-	-	V
I_{IL}	Input leakage current	TA = +85°C	-	-	5	μA
C_{IN}	Input capacitance	-	-	5	-	pF
V_{OL}	Output low voltage[b]	VDD_IO = 1.8V, IOL = -2mA	-	-	0.2	V
		VDD_IO = 2.7V, IOL = -2mA	-	-	0.15	V
		VDD_IO = 3.3V, IOL = -2mA	-	-	0.14	V
V_{OH}	Output high voltage[b]	VDD_IO = 1.8V, IOH = 2mA	1.6	-	-	V
		VDD_IO = 2.7V, IOH = 2mA	2.5	-	-	V
		VDD_IO = 3.3V, IOH = 2mA	3.0	-	-	V
I_{OL}	Output low current[c]	VDD_IO = 1.8V, VO = 0.4V	12	-	-	mA
		VDD_IO = 2.7V, VO = 0.4V	17	-	-	mA
		VDD_IO = 3.3V, VO = 0.4V	18	-	-	mA
I_{OH}	Output high current[c]	VDD_IO = 1.8V, VO = 1.4V	10	-	-	mA
		VDD_IO = 2.7V, VO = 2.3V	16	-	-	mA
		VDD_IO = 3.3V, VO = 2.3V	17	-	-	mA
R_{PU}	Pullup resistor	-	50	-	65	kΩ
R_{PD}	Pulldown resistor	-	50	-	65	kΩ

[a] Hysteresis enabled
[b] Default drive strength (8mA)
[c] Maximum drive strength (16mA)

Table 5: DC Characteristics

AC Characteristics are defined in Table 6 and Fig. 3.

Pin Name	Symbol	Parameter	Minimum	Typical	Maximum	Unit
Digital outputs	t_{rise}	10-90% rise time[a]	-	1.6	-	ns
Digital outputs	t_{fall}	90-10% fall time[a]	-	1.7	-	ns
GPCLK	t_{JOSC}	Oscillator-derived GPCLK cycle-cycle jitter (RMS)	-	-	20	ps
GPCLK	t_{JPLL}	PLL-derived GPCLK cycle-cycle jitter (RMS)	-	-	48	ps

[a] Default drive strength, CL = 5pF, VDD_IOx = 3.3V

Table 6: Digital I/O Pin AC Characteristics

Figure 3: Digital IO Characteristics

7 Power Supplies

The Compute Module 3+ has six separate supplies that must be present and powered at all times; you cannot leave any of them unpowered, even if a specific interface or GPIO bank is unused. The six supplies are as follows:

1. VBAT is used to power the BCM2837 processor core. It feeds the SMPS that generates the chip core voltage.
2. 3V3 powers various BCM2837 PHYs, IO and the eMMC Flash.
3. 1V8 powers various BCM2837 PHYs, IO and SDRAM.
4. VDAC powers the composite (TV-out) DAC.
5. GPIO0-27_VREF powers the GPIO 0-27 IO bank.
6. GPIO28-45_VREF powers the GPIO 28-45 IO bank.

Supply	Descripion	Minimum	Typical	Maximum	Unit
VBAT	Core SMPS Supply	2.5	-	5.0 + 5%	V
3V3	3V3 Supply Voltage	3.3 - 5%	3.3	3.3 + 5%	V
1V8	1V8 Supply Voltage	1.8 - 5%	1.8	1.8 + 5%	V
VDAC	TV DAC Supply[a]	2.5 - 5%	2.8	3.3 + 5%	V
GPIO0-27_VDD	GPIO0-27 I/O Supply Voltage	1.8 - 5%	-	3.3 + 5%	V
GPIO28-45_VDD	GPIO28-45 I/O Supply Voltage	1.8 - 5%	-	3.3 + 5%	V
SDX_VDD	Primary SD/eMMC Supply Voltage	1.8 - 5%	-	3.3 + 5%	V

[a] Requires a clean 2.5-2.8V supply if TV DAC is used, else connect to 3V3

Table 7: Power Supply Operating Ranges

7.1 Supply Sequencing

Supplies should be staggered so that the highest voltage comes up first, then the remaining voltages in descending order. This is to avoid forward biasing internal (on-chip) diodes between supplies, and causing latch-up. Alternatively supplies can be synchronised to come up at exactly the same time as long as at no point a lower voltage supply rail voltage exceeds a higher voltage supply rail voltage.

7.2 Power Requirements

Exact power requirements will be heavily dependent upon the individual use case. If an on-chip subsystem is unused, it is usually in a low power state or completely turned off. For instance, if your application does not use 3D graphics then a large part of the core digital logic will never turn on and need power. This is also the case for camera and display interfaces, HDMI, USB interfaces, video encoders and decoders, and so on.

Powerchain design is critical for stable and reliable operation of the Compute Module 3+. We strongly recommend that designers spend time measuring and verifying power requirements for their particular use case and application, as well as paying careful attention to power supply sequencing and maximum supply voltage tolerance.

Table 8 specifies the recommended minimum power supply outputs required to power the Compute Module 3+.

Supply	**Minimum Requirement**	**Unit**
VBAT (CM1)	2000[a]	mW
VBAT (CM3,3L)	3500[a]	mW
3V3	250	mA
1V8	250	mA
VDAC	25	mA
GPIO0-27_VDD	50[b]	mA
GPIO28-45_VDD	50[b]	mA
SDX_VDD	50[b]	mA

[a] Recommended minimum. Actual power drawn is very dependent on use-case
[b] Each GPIO can supply up to 16mA, aggregate current per bank must not exceed 50mA

Table 8: Mimimum Power Supply Requirements

8 Booting

The eMMC Flash device on CM3+ is directly connected to the primary BCM2837 SD/eMMC interface. These connections are not accessible on the module pins. On CM3+ Lite this SD interface is available on the SDX_ pins.

When initially powered on, or after the RUN pin has been held low and then released, the BCM2837 will try to access the primary SD/eMMC interface. It will then look for a file called bootcode.bin on the primary partition (which must be FAT) to start booting the system. If it cannot access the SD/eMMC device or the boot code cannot be found, it will fall back to waiting for boot code to be written to it over USB; in other words, its USB port is in slave mode waiting to accept boot code from a suitable host.

A USB boot tool is available on Github which allows a host PC running Linux to write the BCM2837 boot code over USB to the module. That boot code then runs and provides access to the SD/eMMC as a USB mass storage device, which can then be read and written using the host PC. Note that a Raspberry Pi can be used as the host machine. For those using Windows a precompiled and packeged tool is available. For more information see here.

The Compute Module has a pin called EMMC_DISABLE_N which when shorted to GND will disable the SD/eMMC interface (by physically disconnecting the SD_CMD pin), forcing BCM2837 to boot from USB. Note that when the eMMC is disabled in this way, it takes a couple of seconds from powering up for the processor to stop attempting to talk to the SD/eMMC device and fall back to booting from USB.

Note that once booted over USB, BCM2837 needs to re-enable the SD/eMMC device (by releasing EMMC_DISABLE_N) to allow access to it as mass storage. It expects to be able to do this by driving the EMMC_EN_N_1V8 pin LOW, which at boot is initially an input with a pull up to 1V8. If an end user wishes to add the ability to access the SD/eMMC over USB in their product, similar circuitry to that used on the Compute Module IO Board to enable/disable the USB boot and SD/eMMC must be used; that is, EMMC_DISABLE_N pulled low via MOSFET(s) and released again by MOSFET, with the gate controlled by EMMC_EN_N_1V8. **Ensure you use MOSFETs suitable for switching at 1.8V (i.e. use a device with gate threshold voltage, Vt, suitable for 1.8V switching).**

9 Peripherals

9.1 GPIO

BCM2837 has in total 54 GPIO lines in 3 separate voltage banks. All GPIO pins have at least two alternative functions within the SoC. When not used for the alternate peripheral function, each GPIO pin may be set as an input (optionally as an interrupt) or an output. The alternate functions are usually peripheral I/Os, and most peripherals appear twice to allow flexibility on the choice of I/O voltage.

GPIO bank2 is used on the module to connect to the eMMC device and for an on-board I2C bus (to talk to the core SMPS and control the special function pins). On CM3+ Lite most of bank2 is exposed to allow a user to connect their choice of SD card or eMMC device (if required).

Bank0 and 1 GPIOs are available for general use. GPIO0 to GPIO27 are bank0 and GPIO28-45 make up bank1. GPIO0-27_VDD is the power supply for bank0 and GPIO28-45_VDD is the power supply for bank1. SDX_VDD is the supply for bank2 on CM3+ Lite. These supplies can be in the range 1.8V-3.3V (see Table 7) and are not optional; each bank must be powered, even when none of the GPIOs for that bank are used.

Note that the HDMI_HPD_N_1V8 and EMMC_EN_N_1V8 pins are 1.8V IO and are used for special functions (HDMI hot plug detect and boot control respectively). Please do not use these pins for any other purpose, as the software for the module will always expect these pins to have these special functions. If they are unused please leave them unconnected.

All GPIOs except GPIO28, 29, 44 and 45 have weak in-pad pull-ups or pull-downs enabled when the device is powered on. It is recommended to add off-chip pulls to GPIO28, 29, 44 and 45 to make sure they never float during power on and initial boot.

9.1.1 GPIO Alternate Functions

GPIO	Default Pull	ALT0	ALT1	ALT2	ALT3	ALT4	ALT5
0	High	SDA0	SA5	PCLK	-	-	-
1	High	SCL0	SA4	DE	-	-	-
2	High	SDA1	SA3	LCD_VSYNC	-	-	-
3	High	SCL1	SA2	LCD_HSYNC	-	-	-
4	High	GPCLK0	SA1	DPI_D0	-	-	ARM_TDI
5	High	GPCLK1	SA0	DPI_D1	-	-	ARM_TDO
6	High	GPCLK2	SOE_N	DPI_D2	-	-	ARM_RTCK
7	High	SPI0_CE1_N	SWE_N	DPI_D3	-	-	-
8	High	SPI0_CE0_N	SD0	DPI_D4	-	-	-
9	Low	SPI0_MISO	SD1	DPI_D5	-	-	-
10	Low	SPI0_MOSI	SD2	DPI_D6	-	-	-
11	Low	SPI0_SCLK	SD3	DPI_D7	-	-	-
12	Low	PWM0	SD4	DPI_D8	-	-	ARM_TMS
13	Low	PWM1	SD5	DPI_D9	-	-	ARM_TCK
14	Low	TXD0	SD6	DPI_D10	-	-	TXD1
15	Low	RXD0	SD7	DPI_D11	-	-	RXD1
16	Low	FL0	SD8	DPI_D12	CTS0	SPI1_CE2_N	CTS1
17	Low	FL1	SD9	DPI_D13	RTS0	SPI1_CE1_N	RTS1
18	Low	PCM_CLK	SD10	DPI_D14	-	SPI1_CE0_N	PWM0
19	Low	PCM_FS	SD11	DPI_D15	-	SPI1_MISO	PWM1
20	Low	PCM_DIN	SD12	DPI_D16	-	SPI1_MOSI	GPCLK0
21	Low	PCM_DOUT	SD13	DPI_D17	-	SPI1_SCLK	GPCLK1
22	Low	SD0_CLK	SD14	DPI_D18	SD1_CLK	ARM_TRST	-
23	Low	SD0_CMD	SD15	DPI_D19	SD1_CMD	ARM_RTCK	-
24	Low	SD0_DAT0	SD16	DPI_D20	SD1_DAT0	ARM_TDO	-
25	Low	SD0_DAT1	SD17	DPI_D21	SD1_DAT1	ARM_TCK	-
26	Low	SD0_DAT2	TE0	DPI_D22	SD1_DAT2	ARM_TDI	-
27	Low	SD0_DAT3	TE1	DPI_D23	SD1_DAT3	ARM_TMS	-

Table 9: GPIO Bank0 Alternate Functions

GPIO	Default Pull	ALT0	ALT1	ALT2	ALT3	ALT4	ALT5
28	None	SDA0	SA5	PCM_CLK	FL0	-	-
29	None	SCL0	SA4	PCM_FS	FL1	-	-
30	Low	TE0	SA3	PCM_DIN	CTS0	-	CTS1
31	Low	FL0	SA2	PCM_DOUT	RTS0	-	RTS1
32	Low	GPCLK0	SA1	RING_OCLK	TXD0	-	TXD1
33	Low	FL1	SA0	TE1	RXD0	-	RXD1
34	High	GPCLK0	SOE_N	TE2	SD1_CLK	-	-
35	High	SPI0_CE1_N	SWE_N	-	SD1_CMD	-	-
36	High	SPI0_CE0_N	SD0	TXD0	SD1_DAT0	-	-
37	Low	SPI0_MISO	SD1	RXD0	SD1_DAT1	-	-
38	Low	SPI0_MOSI	SD2	RTS0	SD1_DAT2	-	-
39	Low	SPI0_SCLK	SD3	CTS0	SD1_DAT3	-	-
40	Low	PWM0	SD4	-	SD1_DAT4	SPI2_MISO	TXD1
41	Low	PWM1	SD5	TE0	SD1_DAT5	SPI2_MOSI	RXD1
42	Low	GPCLK1	SD6	TE1	SD1_DAT6	SPI2_SCLK	RTS1
43	Low	GPCLK2	SD7	TE2	SD1_DAT7	SPI2_CE0_N	CTS1
44	None	GPCLK1	SDA0	SDA1	TE0	SPI2_CE1_N	-
45	None	PWM1	SCL0	SCL1	TE1	SPI2_CE2_N	-

Table 10: GPIO Bank1 Alternate Functions

Table 9 and Table 10 detail the default pin pull state and available alternate GPIO functions. Most of these alternate peripheral functions are described in detail in the Broadcom Peripherals Specification document and have Linux drivers available.

9.1.2 Secondary Memory Interface (SMI)

The SMI peripheral is an asynchronous NAND type bus supporting Intel mode80 type transfers at 8 or 16 bit widths and available in the ALT1 positions on GPIO banks 0 and 1 (see Table 9 and Table 10). It is not publicly documented in the Broadcom Peripherals Specification but a Linux driver is available in the Raspberry Pi Github Linux repository (bcm2835_smi.c in linux/drivers/misc).

9.1.3 Display Parallel Interface (DPI)

A standard parallel RGB (DPI) interface is available on bank 0 GPIOs. This up-to-24-bit parallel interface can support a secondary display. Again this interface is not documented in the Broadcom Peripherals Specification but documentation can be found here.

9.1.4 SD/SDIO Interface

The BCM283x supports two SD card interfaces, SD0 and SD1.

The first (SD0) is a proprietary Broadcom controller that does not support SDIO and is the primary interface used to boot and talk to the eMMC or SDX_x signals.

The second interface (SD1) is standards compliant and can interface to SD, SDIO and eMMC devices; for example on a Raspberry Pi 3 B+ it is used to talk to the on-board CYW43455 WiFi device in SDIO mode.

Both interfaces can support speeds up to 50MHz single ended (SD High Speed Mode).

9.2 CSI (MIPI Serial Camera)

Currently the CSI interface is not openly documented and only CSI camera sensors supported by the official Raspberry Pi firmware will work with this interface. Supported sensors are the OmniVision OV5647 and Sony IMX219.

It is recommended to attach other cameras via USB.

9.3 DSI (MIPI Serial Display)

Currently the DSI interface is not openly documented and only DSI displays supported by the official Raspberry Pi firmware will work with this interface.

Displays can also be added via the parallel DPI interface which is available as a GPIO alternate function - see Table 9 and Section 9.1.3

9.4 USB

The BCM2837 USB port is On-The-Go (OTG) capable. If using either as a fixed slave or fixed master, please tie the USB_OTGID pin to ground.

The USB port (Pins USB_DP and USB_DM) must be routed as 90 ohm differential PCB traces.

Note that the port is capable of being used as a true OTG port however there is no official documentation. Some users have had success making this work.

9.5 HDMI

BCM283x supports HDMI V1.3a.

It is recommended that users follow a similar arrangement to the Compute Module IO Board circuitry for HDMI output.

The HDMI CK_P/N (clock) and D0-D2_P/N (data) pins must each be routed as matched length 100 ohm differential PCB traces. It is also important to make sure that each differential pair is closely phase matched. Finally, keep HDMI traces well away from other noise sources and as short as possible.

Failure to observe these design rules is likely to result in EMC failure.

9.6 Composite (TV Out)

The TVDAC pin can be used to output composite video (PAL or NTSC). Please route this signal away from noise sources and use a 75 ohm PCB trace.

Note that the TV DAC is powered from the VDAC supply which must be a clean supply of 2.5-2.8V. It is recommended users generate this supply from 3V3 using a low noise LDO.

If the TVDAC output is not used VDAC can be connected to 3V3, but it must be powered even if the TV-out functionality is unused.

10 Thermals

The BCM2837 SoC employs DVFS (Dynamic Voltage and Frequency Scaling) on the core voltage. When the processor is idle (low CPU utilisation), it will reduce the core frequency and voltage to reduce current draw and heat output. When the core utilisation exceeds a certain threshold the core votlage is increased and the core frequency is boosted to the maximum working frerquency of 1.2GHz. The voltage and frequency are throttled back when the CPU load reduces back to an 'idle' level OR when the silicon temperature as mesured by the on-chip temperature sensor exceeds 80C (thermal throttling).

A designer must pay careful attention to the thermal design of products using the CM3+ so that performance is not artificially curtailed due to the processor thermal throttling, as the Quad ARM complex in the BCM2837 can generate significant heat output under load.

10.1 Temperature Range

The operating temperature range of the module is set by the lowest maximum and highest minimum of any of the components used.

The eMMC and LPDDR2 have the narrowest range, these are rated for -25 to +80 degrees Celsius. Therefore the nominal range for the CM3+ and CM3+ Lite is -25C to +80C.

However, this range is the maximum for the silicon die; therefore, users would have to take into account the heat generated when in use and make sure this does not cause the temperature to exceed 80 degrees Celsius.

11 Availability

Raspberry Pi guarantee availability of CM3+ and CM3+ Lite until at least January 2026.

12 Support

For support please see the hardware documentation section of the Raspberry Pi website and post questions to the Raspberry Pi forum.

Ultrasonic Ranging Module HC - SR04

Product features:

Ultrasonic ranging module HC - SR04 provides 2cm - 400cm non-contact measurement function, the ranging accuracy can reach to 3mm. The modules includes ultrasonic transmitters, receiver and control circuit. The basic principle of work:

(1) Using IO trigger for at least 10us high level signal,

(2) The Module automatically sends eight 40 kHz and detect whether there is a pulse signal back.

(3) IF the signal back, through high level , time of high output IO duration is the time from sending ultrasonic to returning.

Test distance = (high level time×velocity of sound (340M/S) / 2,

Wire connecting direct as following:

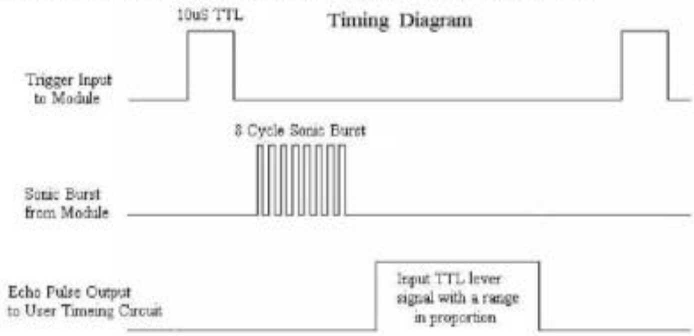
- 5V Supply
- Trigger Pulse Input
- Echo Pulse Output
- 0V Ground

Electric Parameter

Working Voltage	**DC 5 V**
Working Current	**15mA**
Working Frequency	**40Hz**
Max Range	**4m**
Min Range	**2cm**
MeasuringAngle	**15 degree**
Trigger Input Signal	**10uS TTL pulse**
Echo Output Signal	**Input TTL lever signal and the range in proportion**
Dimension	**45*20*15mm**

Timing diagram

The Timing diagram is shown below. You only need to supply a short 10uS pulse to the trigger input to start the ranging, and then the module will send out an 8 cycle burst of ultrasound at 40 kHz and raise its echo. The Echo is a distance object that is pulse width and the range in proportion .You can calculate the range through the time interval between sending trigger signal and receiving echo signal. Formula: uS / 58 = centimeters or uS / 148 =inch; or: the range = high level time * velocity (340M/S) / 2; we suggest to use over 60ms measurement cycle, in order to prevent trigger signal to the echo signal.



Attention:

- The module is not suggested to connect directly to electric, if connected electric, the GND terminal should be connected the module first, otherwise, it will affect the normal work of the module.
- When tested objects, the range of area is not less than 0.5 square meters and the plane requests as smooth as possible, otherwise ,it will affect the results of measuring.

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