GLOSSARY

PWM: Pulse Width Modulation

ADC: Analog to Digital Converter

ECU: Electronic Control Unit

I2C: Inter-Integrated Circuit

USB: Universal Serial Bus

VCU: Vehicle Control Unit

RTC: Real-time Clock

IDE: Integrated Development Environment

BLDC: Brushless Direct Current Motor

AC: Alternating Current

DC: Direct Current

REFERENCES

[1] Zigwheel and Gaadi, "Electric Vehicle," *Electric Vehicle*. https://www.zigwheels.com/.

[2] A. Wicaksana, "Suzuki to Launch Electric Motorcycle in the Next 1-2 years," *Https://Medium.Com/*, 2016. https://medium.com/@arifwicaksanaa/pengertian-use-case-a7e576e1b6bf.

[3] C. Sültrop, "Vehicle control unit for drivetrains exclusively from power electronics technology demonstrators," *Veh. Control unit drivetrains Exclus. from power Electron. Technol. Demonstr*.

[4] C. Sültrop, "Vehicle control unit for drivetrains exclusively from power electronics technology demonstrators," *2015 IEEE Transp. Electrif. Conf. Expo, ITEC 2015*, no. September, 2015, doi: 10.1109/ITEC.2015.7165825.

[5] A. Łebkowski, "Electric Motorcycle Design," no. September, pp. 1–16, 2017.

[6] L. Wu, H. Wang, D. Pi, E. Wang, and X. Wang, "Hill-Start of Distributed Drive Electric Vehicle Based on Pneumatic Electronic Parking Brake System," *IEEE Access*, vol. 8, pp. 64382–64398, 2020, doi: 10.1109/ACCESS.2020.2984679.

[7] J. Seo, B. Kim, and K. Yi, "Design and Evaluation of a Driving Mode Decision Algorithm for Automated Driving Vehicle on a Motorway," *IFAC-PapersOnLine*, vol. 49, pp. 115–120, Jan. 2016, doi: 10.1016/j.ifacol.2016.08.018.

[8] C. K. Chau, K. Elbassioni, and C. M. Tseng, "Drive Mode Optimization and Path Planning for Plug-In Hybrid Electric Vehicles," *IEEE Trans. Intell. Transp. Syst.*, vol. 18, no. 12, pp. 3421–3432, 2017, doi: 10.1109/TITS.2017.2691606.

[9] A. Dwivedi, M. Mohan, and A. N. Tiwari, "A Review of Speed Control of BLDC Motor with Different Controllers Hysteresis current control View project A Review of Speed Control of BLDC Motor with Different Controllers 1," no. May 2013, 2013, [Online]. Available: https://www.researchgate.net/publication/321911922.

[10] X. Wen and Z. Q. Li, "Brushless DC motor speed control strategy of simulation research," *MATEC Web Conf.*, vol. 139, 2017, doi: 10.1051/matecconf/201713900172.

[11] A. A. Krishnan, P. R. Ajith, K. Ashwin, S. Deepak, and N. S. Pillai, "Sensorless operation of brushless DC motor drive designed for air conditioners," *Proc. IEEE Int. Conf. Innov. Electr. Electron. Instrum. Media Technol. ICIEEIMT 2017*, vol. 2017-January, no. February 2017, pp. 71–74, 2017, doi: 10.1109/ICIEEIMT.2017.8116808.

[12] P. Devendra, M. Tvvs, K. A. Mary, and C. Saibabu, "Microcontroller Based Control of Three Phase Bldc Motor," *J. Eng. Res. Stud.*, vol. II, no. IV, pp. 68–71, 2011.

[13] A. N. Patel, "PIC32MZ Milliseconds and Microseconds Delay Routines," vol. 9, no. 2, pp. 41–44, 2019, doi: 10.5923/j.eee.20190902.03.

[14] Pjrc, "Teensy 4.0," [Online]. Available: https://www.pjrc.com/teensy/.

Appendix A Datasheet

ALLEGRO microsystems

ACS758xCB

Thermally Enhanced, Fully Integrated, Hall-Effect-Based Linear Current Sensor IC with 100 μΩ Current Conductor

FEATURES AND BENEFITS

- Industry-leading noise performance through proprietary amplifier and filter design techniques
- Integrated shield greatly reduces capacitive coupling from current conductor to die due to high dV/dt signals, and prevents offset drift in high-side, high-voltage applications
- Total output error improvement through gain and offset trim over temperature
- Small package size, with easy mounting capability
- Monolithic Hall IC for high reliability
- Ultralow power loss: 100 μΩ internal conductor resistance
- Galvanic isolation allows use in economical, high-side current sensing in high-voltage systems
- AEC-Q100 qualified

Continued on the next page…

TÜV America Certificate Number: U8V 15 05 54214 037 UL Certified File No.: US-29755-UL

PACKAGE: 5-Pin CB Package

DESCRIPTION

The Allegro™ ACS758 family of current sensor ICs provides economical and precise solutions for AC or DC current sensing. Typical applications include motor control, load detection and management, power supply and DC-to-DC converter control, inverter control, and overcurrent fault detection.

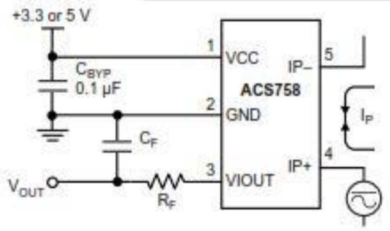
The device consists of a precision, low-offset linear Hall circuit with a copper conduction path located near the die. Applied current flowing through this copper conduction path generates a magnetic field which the Hall IC converts into a proportional voltage. Device accuracy is optimized through the close proximity of the magnetic signal to the Hall transducer. A precise, proportional output voltage is provided by the low-offset, chopper-stabilized BiCMOS Hall IC, which is programmed for accuracy at the factory.

High-level immunity to current conductor dV/dt and stray electric fields, offered by Allegro proprietary integrated shield technology, provides low output voltage ripple and low offset drift in high-side, high-voltage applications.

The output of the device has a positive slope ($>V_{CC}/2$) when an increasing current flows through the primary copper conduction path (from terminal 4 to terminal 5), which is the path used for current sampling. The internal resistance of this conductive path is 100 μΩ typical, providing low power loss.

The thickness of the copper conductor allows survival of the device at high overcurrent conditions. The terminals of the conductive path are electrically isolated from the signal leads

Continued on the next page…



Application 1: The ACS758 outputs an analog signal, V_{OUT}, that varies linearly with the uni- or bi-directional AC or DC primary sampled current, I_P, within the range specified. C_F is for optimal noise management, with values that depend on the application.

Typical Application

ACS758-DS, Rev. 18
MCO-0000203 May 16, 2022

ACS758xCB

Thermally Enhanced, Fully Integrated, Hall-Effect-Based Linear Current Sensor IC with 100 μΩ Current Conductor

FEATURES AND BENEFITS (CONTINUED)

- 3.0 to 5.5 V, single supply operation
- 120 kHz typical bandwidth
- 3 μs output rise time in response to step input current
- Output voltage proportional to AC or DC currents
- Factory-trimmed for accuracy
- Extremely stable output offset voltage
- Nearly zero magnetic hysteresis

DESCRIPTION (CONTINUED)

(pins 1 through 3). This allows the ACS758 family of sensor ICs to be used in applications requiring electrical isolation without the use of opto-isolators or other costly isolation techniques.

The device is fully calibrated prior to shipment from the factory. The ACS758 family is lead (Pb) free. All leads are plated with 100% matte tin, and there is no Pb inside the package. The heavy gauge leadframe is made of oxygen-free copper.

Selection Guide

Part Number [1]	Package		Primary Sampled Current, I_P (A)	Sensitivity Sens (Typ.) (mV/A)	Current Directionality	T_{OP} (°C)	Packing
	Terminals	Signal Pins					
ACS758LCB-050B-PFF-T	Formed	Formed	±50	40	Bidirectional	–40 to 150	34 pieces per tube
ACS758LCB-050U-PFF-T	Formed	Formed	50	60	Unidirectional		
ACS758LCB-100B-PFF-T	Formed	Formed	±100	20	Bidirectional		
ACS758LCB-100B-PSF-T	Straight	Formed	±100	20	Bidirectional		
ACS758LCB-100U-PFF-T	Formed	Formed	100	40	Unidirectional		
ACS758KCB-150B-PFF-T	Formed	Formed	±150	13.3	Bidirectional	–40 to 125	
ACS758KCB-150B-PSF-T	Straight	Formed	±150	13.3	Bidirectional		
ACS758KCB-150B-PSS-T	Straight	Straight	±150	13.3	Bidirectional		
ACS758KCB-150U-PFF-T	Formed	Formed	150	26.7	Unidirectional		
ACS758KCB-150U-PSF-T	Straight	Formed	150	26.7	Unidirectional		
ACS758ECB-200B-PFF-T	Formed	Formed	±200	10	Bidirectional	–40 to 85	
ACS758ECB-200B-PSF-T	Straight	Formed	±200	10	Bidirectional		
ACS758ECB-200B-PSS-T	Straight	Straight	±200	10	Bidirectional		
ACS758ECB-200U-PFF-T	Formed	Formed	200	20	Unidirectional		
ACS758ECB-200U-PSF-T	Straight	Formed	200	20	Unidirectional		

[1] Additional leadform options available for qualified volumes.

2

Allegro MicroSystems
955 Perimeter Road
Manchester, NH 03103-3353 U.S.A.
www.allegromicro.com

Product Folder | Order Now | Technical Documents | Tools & Software | Support & Community

TEXAS INSTRUMENTS

ADS1113, ADS1114, ADS1115

SBAS444D – MAY 2009 – REVISED JANUARY 2016

ADS111x Ultra-Small, Low-Power, I²C-Compatible, 860-SPS, 16-Bit ADCs With Internal Reference, Oscillator, and Programmable Comparator

1 Features

- Ultra-Small X2QFN Package: 2 mm × 1.5 mm × 0.4 mm
- Wide Supply Range: 2.0 V to 5.5 V
- Low Current Consumption: 150 µA (Continuous-Conversion Mode)
- Programmable Data Rate: 8 SPS to 860 SPS
- Single-Cycle Settling
- Internal Low-Drift Voltage Reference
- Internal Oscillator
- I²C Interface: Four Pin-Selectable Addresses
- Four Single-Ended or Two Differential Inputs (ADS1115)
- Programmable Comparator (ADS1114 and ADS1115)
- Operating Temperature Range: –40°C to +125°C

2 Applications

- Portable Instrumentation
- Battery Voltage and Current Monitoring
- Temperature Measurement Systems
- Consumer Electronics
- Factory Automation and Process Control

3 Description

The ADS1113, ADS1114, and ADS1115 devices (ADS111x) are precision, low-power, 16-bit, I²C-compatible, analog-to-digital converters (ADCs) offered in an ultra-small, leadless, X2QFN-10 package, and a VSSOP-10 package. The ADS111x devices incorporate a low-drift voltage reference and an oscillator. The ADS1114 and ADS1115 also incorporate a programmable gain amplifier (PGA) and a digital comparator. These features, along with a wide operating supply range, make the ADS111x well suited for power- and space-constrained, sensor measurement applications.

The ADS111x perform conversions at data rates up to 860 samples per second (SPS). The PGA offers input ranges from ±256 mV to ±6.144 V, allowing precise large- and small-signal measurements. The ADS1115 features an input multiplexer (MUX) that allows two differential or four single-ended input measurements. Use the digital comparator in the ADS1114 and ADS1115 for under- and overvoltage detection.

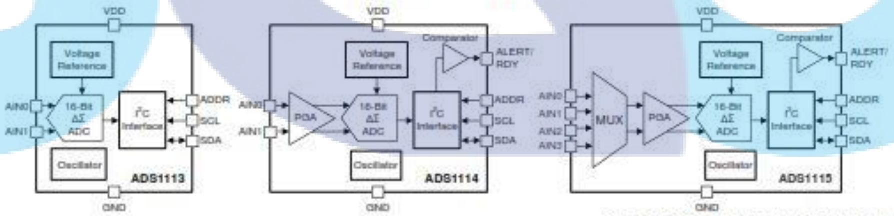
The ADS111x operate in either continuous-conversion mode or single-shot mode. The devices are automatically powered down after one conversion in single-shot mode; therefore, power consumption is significantly reduced during idle periods.

Device Information[(1)]

PART NUMBER	PACKAGE	BODY SIZE (NOM)
ADS111x	X2QFN (10)	1.50 mm × 2.00 mm
	VSSOP (10)	3.00 mm × 3.00 mm

(1) For all available packages, see the package option addendum at the end of the data sheet.

Simplified Block Diagrams



An IMPORTANT NOTICE at the end of this data sheet addresses availability, warranty, changes, use in safety-critical applications, intellectual property matters and other important disclaimers. PRODUCTION DATA.

7 Specifications

7.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)(1)

		MIN	MAX	UNIT
Power-supply voltage	VDD to GND	–0.3	7	V
Analog input voltage	AIN0, AIN1, AIN2, AIN3	GND – 0.3	VDD + 0.3	V
Digital input voltage	SDA, SCL, ADDR, ALERT/RDY	GND – 0.3	5.5	V
Input current, continuous	Any pin except power supply pins	–10	10	mA
Temperature	Operating ambient, T_A	–40	125	°C
	Junction, T_J	–40	150	
	Storage, T_{stg}	–60	150	

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

7.2 ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001(1)	±2000	V
		Charged-device model (CDM), per JEDEC specification JESD22-C101(2)	±500	

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

7.3 Recommended Operating Conditions

		MIN	NOM	MAX	UNIT
POWER SUPPLY					
	Power supply (VDD to GND)	2		5.5	V
ANALOG INPUTS(1)					
FSR	Full-scale input voltage range(2) ($V_{IN} = V_{(AINP)} – V_{(AINN)}$)	±0.256		±6.144	V
$V_{(AINx)}$	Absolute input voltage	GND		VDD	V
DIGITAL INPUTS					
V_{DIG}	Digital input voltage	GND		5.5	V
TEMPERATURE					
T_A	Operating ambient temperature	–40		125	°C

(1) AINP and AINN denote the selected positive and negative inputs. AINx denotes one of the four available analog inputs.
(2) This parameter expresses the full-scale range of the ADC scaling. No more than VDD + 0.3 V must be applied to the analog inputs of the device. See Table 3 more information.

7.4 Thermal Information

THERMAL METRIC(1)		ADS111x DGS (VSSOP) 10 PINS	ADS111x RUG (X2QFN) 10 PINS	UNIT
$R_{\theta JA}$	Junction-to-ambient thermal resistance	182.7	245.2	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	67.2	69.3	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	103.8	172.0	°C/W
ψ_{JT}	Junction-to-top characterization parameter	10.2	8.2	°C/W
ψ_{JB}	Junction-to-board characterization parameter	102.1	170.8	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	N/A	N/A	°C/W

(1) For more information about traditional and new thermal metrics, see the *Semiconductor and IC Package Thermal Metrics* application report.

Advanced Monolithic Systems

AMS1117

800mA LOW DROPOUT VOLTAGE REGULATOR

FEATURES

- **Three Terminal Adjustable or Fixed Voltages***
  1.5V, 1.8V, 2.5V, 2.85V, 3.3V and 5.0V
- **Output Current of 800mA**
- **Operates Down to 1V Dropout**
- **Line Regulation: 0.2% Max.**
- **Load Regulation: 0.4% Max.**
- **SOT-223 and TO-252 package available**

APPLICATIONS

- **High Efficiency Linear Regulators**
- **Post Regulators for Switching Supplies**
- **5V to 3.3V Linear Regulator**
- **Battery Chargers**
- **Active SCSI Terminators**
- **Power Management for Notebook**
- **Battery Powered Instrumentation**

GENERAL DESCRIPTION

The AMS1117 series of adjustable and fixed voltage regulators are designed to provide 800mA output current and to operate down to 1V input-to-output differential. The dropout voltage of the device is guaranteed maximum 1.3V at maximum output current, decreasing at lower load currents.

On-chip trimming adjusts the reference voltage to 1%. Current limit is also trimmed, minimizing the stress under overload conditions on both the regulator and power source circuitry.

The AMS1117 devices are pin compatible with other three-terminal SCSI regulators and are offered in the low profile surface mount SOT-223 package and in the TO-252 (DPAK) plastic package.

ORDERING INFORMATION:

PACKAGE TYPE		OPERATING JUNCTION TEMPERATURE RANGE
TO-252	SOT-223	
AMS1117CD	AMS1117	0 to 125° C
AMS1117CD-1.5	AMS1117-1.5	0 to 125° C
AMS1117CD-1.8	AMS1117-1.8	0 to 125° C
AMS1117CD-2.5	AMS1117-2.5	0 to 125° C
AMS1117CD-2.85	AMS1117-2.85	0 to 125° C
AMS1117CD-3.3	AMS1117-3.3	0 to 125° C
AMS1117CD-5.0	AMS1117-5.0	0 to 125° C

*For additional available fixed voltages contact factory.

SOT-223 Top View

PIN CONNECTIONS

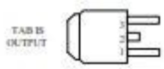
FIXED VERSION

1- Ground
2- V_{OUT}
3- V_{IN}

ADJUSTABLE VERSION

1- Adjust
2- V_{OUT}
3- V_{IN}

TO-252 FRONT VIEW



Advanced Monolithic Systems, Inc. 6680B Sierra Lane, Dublin, CA 94568 Phone (925) 556-9090 Fax (925) 556-9140

AMS1117

ABSOLUTE MAXIMUM RATINGS (Note 1)

Power Dissipation	Internally limited
Input Voltage	15V
Operating Junction Temperature	
Control Section	0°C to 125°C
Power Transistor	0°C to 150°C
Storage temperature	- 65°C to +150°C

Soldering information	
Lead Temperature (10 sec)	300°C
Thermal Resistance	
TO-252 package	φ_{JA} = 80°C/W
SOT-223 package	φ_{JA} = 90°C/W*

* With package soldering to copper area over backside ground plane or internal power plane φ_{JA} can vary from 46°C/W to >90°C/W depending on mounting technique and the size of the copper area.

ELECTRICAL CHARACTERISTICS

Electrical Characteristics at I_{OUT} = 0 mA, and T_J = +25°C unless otherwise specified.

Parameter	Device	Conditions	Min	Typ	Max	Units
Reference Voltage (Note 2)	AMS1117	I_{OUT} = 10 mA 10mA ≤ I_{OUT} ≤ 800mA, 1.5V≤ (V_{IN} - V_{OUT}) ≤ 12V	1.238 **1.225**	1.250 **1.250**	1.262 **1.270**	V V
Output Voltage (Note 2)	AMS1117-1.5	0 ≤ I_{OUT} ≤ 800mA , 3.0V≤ V_{IN} ≤ 12V	1.485 **1.476**	1.500 **1.500**	1.515 **1.524**	V V
	AMS1117-1.8	0 ≤ I_{OUT} ≤ 800mA , 3.3V≤ V_{IN} ≤ 12V	1.782 **1.773**	1.800 **1.800**	1.818 **1.827**	V V
	AMS1117-2.5	0 ≤ I_{OUT} ≤ 800mA , 4.0V≤ V_{IN} ≤ 12V	2.475 **2.460**	2.500 **2.500**	2.525 **2.560**	V V
	AMS1117-2.85	0 ≤ I_{OUT} ≤ 800mA , 4.35V≤ V_{IN} ≤ 12V	2.82 **2.79**	2.850 **2.850**	2.88 **2.91**	V V
	AMS1117-3.3	0 ≤ I_{OUT} ≤ 800mA , 4.75V ≤ V_{IN} ≤ 12V	3.267 **3.235**	3.300 **3.300**	3.333 **3.365**	V V
	AMS1117-5.0	0 ≤ I_{OUT} ≤ 800mA , 6.5V ≤ V_{IN} ≤ 12V	4.950 **4.900**	5.000 **5.000**	5.050 **5.100**	V V
Line Regulation	AMS1117	I_{LOAD} = 10 mA , 1.5V≤ (V_{IN} - V_{OUT}) ≤ 12V		0.015 **0.035**	0.2 **0.2**	% %
	AMS1117-1.5	3.0V≤ V_{IN} ≤ 12V		0.3 **0.6**	5 **6**	mV mV
	AMS1117-1.8	3.3V≤ V_{IN} ≤ 12V		0.3 **0.6**	5 **6**	mV mV
	AMS1117-2.5	4.0V≤ V_{IN} ≤ 12V		0.3 **0.6**	6 **6**	mV mV
	AMS1117-2.85	4.35V≤ V_{IN} ≤ 12V		0.3 **0.6**	6 **6**	mV mV
	AMS1117-3.3	4.75V≤ V_{IN} ≤ 12V		0.5 **1.0**	10 **10**	mV mV
	AMS1117-5.0	6.5V≤ V_{IN} ≤ 12V		0.5 **1.0**	10 **10**	mV mV
Load Regulation (Notes 2, 3)	AMS1117	(V_{IN} - V_{OUT}) =3V, 10mA ≤ I_{OUT} ≤ 800mA		0.1 **0.2**	0.3 **0.4**	% %
	AMS1117-1.5	V_{IN} = 5V, 0 ≤ I_{OUT} ≤ 800mA		3 **6**	10 **20**	mV mV
	AMS1117-1.8	V_{IN} = 5V, 0 ≤ I_{OUT} ≤ 800mA		3 **6**	10 **20**	mV mV
	AMS1117-2.5	V_{IN} = 5V, 0 ≤ I_{OUT} ≤ 800mA		3 **6**	12 **20**	mV mV

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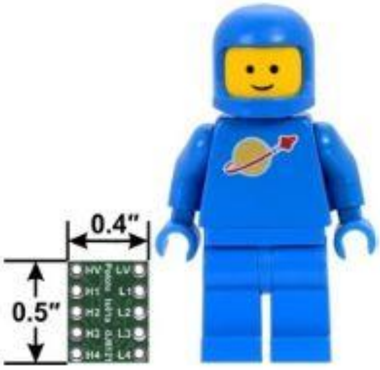
Pololu
Robotics & Electronics

Logic Level Shifter, 4-Channel, Bidirectional



Overview

As digital devices get smaller and faster, once ubiquitous 5 V logic has given way to ever lower-voltage standards like 3.3 V, 2.5 V, and even 1.8 V, leading to an ecosystem of components that need a little help talking to each other. For example, a 5 V part might fail to read a 3.3 V signal as high, and a 3.3 V part might be damaged by a 5 V signal. This level shifter solves these problems by offering bidirectional voltage translation of up to four independent signals, converting between logic levels as low as 1.5 V on the lower-voltage side and as high as 18 V on the higher-voltage side, and its compact size and breadboard-compatible pin spacing make it easy to integrate into projects.

The logic high levels on each side of the shifter are achieved by 10 kΩ pull-up resistors to their respective supplies; these provide quick enough rise times to allow decent conversion of fast mode (400 kHz) I²C signals or other similarly fast digital interfaces (e.g. SPI or asynchronous TTL serial). External pull-ups can be added to speed up the rise time further at the expense of higher current draw. See the schematic diagram below for more information.

Features

- **Dual-supply bus translation:**
  - **Lower-voltage (LV) supply can be 1.5 V to 7 V**
  - **Higher-voltage (HV) supply can be LV to 18 V**
- **Four bidirectional channels**
- **Small size: 0.4″ × 0.5″ × 0.08″ (13 mm × 10 mm × 2 mm)**
- **Breadboard-compatible pin spacing**

Connections

Rev 2; 6/05

DALLAS SEMICONDUCTOR MAXIM

Extremely Accurate I²C-Integrated RTC/TCXO/Crystal

DS3231

General Description

The DS3231 is a low-cost, extremely accurate I²C real-time clock (RTC) with an integrated temperature-compensated crystal oscillator (TCXO) and crystal. The device incorporates a battery input, and maintains accurate timekeeping when main power to the device is interrupted. The integration of the crystal resonator enhances the long-term accuracy of the device as well as reduces the piece-part count in a manufacturing line. The DS3231 is available in commercial and industrial temperature ranges, and is offered in a 16-pin, 300-mil SO package.

The RTC maintains seconds, minutes, hours, day, date, month, and year information. The date at the end of the month is automatically adjusted for months with fewer than 31 days, including corrections for leap year. The clock operates in either the 24-hour or 12-hour format with an AM/PM indicator. Two programmable time-of-day alarms and a programmable square-wave output are provided. Address and data are transferred serially through an I²C bidirectional bus.

A precision temperature-compensated voltage reference and comparator circuit monitors the status of V_{CC} to detect power failures, to provide a reset output, and to automatically switch to the backup supply when necessary. Additionally, the RST pin is monitored as a pushbutton input for generating a reset externally.

Applications

Servers
Utility Power Meters
Telematics
GPS

Pin Configuration appears at end of data sheet.

Features

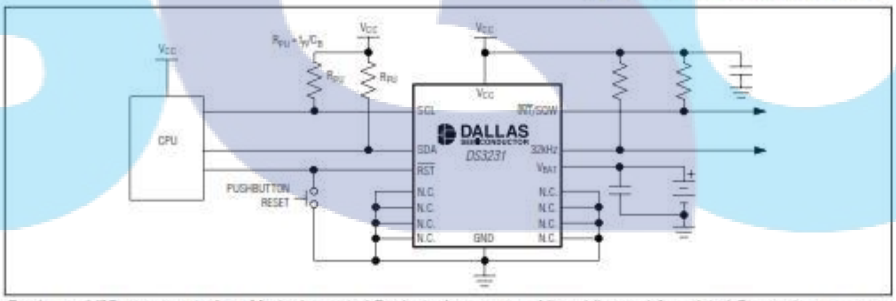
- Accuracy ±2ppm from 0°C to +40°C
- Accuracy ±3.5ppm from -40°C to +85°C
- Battery Backup Input for Continuous Timekeeping
- Operating Temperature Ranges
  - Commercial: 0°C to +70°C
  - Industrial: -40°C to +85°C
- Low-Power Consumption
- Real-Time Clock Counts Seconds, Minutes, Hours, Day, Date, Month, and Year with Leap Year Compensation Valid Up to 2100
- Two Time-of-Day Alarms
- Programmable Square-Wave Output
- Fast (400kHz) I²C Interface
- 3.3V Operation
- Digital Temp Sensor Output: ±3°C Accuracy
- Register for Aging Trim
- RST Input/Output
- UL Recognized

Ordering Information

PART	TEMP RANGE	PIN-PACKAGE	TOP MARK
DS3231S	0°C to +70°C	16 SO	DS3231
DS3231SN	-40°C to +85°C	16 SO	DS3231N
DS3231S+	0°C to +70°C	16 SO	DS3231+
DS3231SN+	-40°C to +85°C	16 SO	DS3231N+

+Denotes lead-free

Typical Operating Circuit



Purchase of I²C components from Maxim Integrated Products, Inc., or one of its sublicensed Associated Companies, conveys a license under the Philips I²C Patent Rights to use these components in an I²C system, provided that the system conforms to the I²C Standard Specification as defined by Philips.

DALLAS SEMICONDUCTOR MAXIM Maxim Integrated Products 1

For pricing, delivery, and ordering information, please contact Maxim/Dallas Direct! at 1-888-629-4642, or visit Maxim's website at www.maxim-ic.com.

Extremely Accurate I^2C-Integrated RTC/TCXO/Crystal

DS3231

ABSOLUTE MAXIMUM RATINGS

Voltage Range on V_{CC}, V_{BAT}, 32kHz, SCL, SDA, $\overline{\text{RST}}$, $\overline{\text{INT}}$/SQW Relative to Ground....-0.3V to +6.0V
Operating Temperature Range (noncondensing)....-40°C to +85°C
Junction Temperature....+125°C
Storage Temperature Range....-40°C to +85°C
Lead Temperature (Soldering, 10s)....+260°C/10s
Soldering Temperature....See the *Handling, PC Board Layout, and Assembly* section.

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

RECOMMENDED DC OPERATING CONDITIONS

($T_A = T_{MIN}$ to T_{MAX}, unless otherwise noted.) (Notes 1, 2)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Supply Voltage	V_{CC}		2.3	3.3	5.5	V
	V_{BAT}		2.3	3.0	5.5	V
Logic 1 Input SDA, SCL	V_{IH}		0.7 x V_{CC}		V_{CC} + 0.3	V
Logic 0 Input SDA, SCL	V_{IL}		-0.3		+0.3 x V_{CC}	V
Pullup Voltage (SDA, SCL, 32kHz, $\overline{\text{INT}}$/SQW)	V_{PU}	V_{CC} = 0V			5.5V	V

ELECTRICAL CHARACTERISTICS

(V_{CC} = 2.3V to 5.5V, $V_{CC} > V_{BAT}$, $T_A = T_{MIN}$ to T_{MAX}, unless otherwise noted.) (Typical values are at V_{CC} = 3.3V, V_{BAT} = 3.0V, and T_A = +25°C, unless otherwise noted.) (Notes 1, 2)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Active Supply Current	I_{CCA}	(Notes 3, 4)	V_{CC} = 3.63V			200	µA
			V_{CC} = 5.5V			300	
Standby Supply Current	I_{CCS}	I^2C bus inactive, 32kHz output on, SQW output off (Note 4)	V_{CC} = 3.63V			110	µA
			V_{CC} = 5.5V			170	
Temperature Conversion Current	$I_{CCSCONV}$	I^2C bus inactive, 32kHz output on, SQW output off	V_{CC} = 3.63V			575	µA
			V_{CC} = 5.5V			650	
Power-Fail Voltage	V_{PF}			2.45	2.575	2.70	V
Logic 0 Output, 32kHz, $\overline{\text{INT}}$/SQW, SDA	V_{OL}	I_{OL} = 3mA				0.4	V
Logic 0 Output, $\overline{\text{RST}}$	V_{OL}	I_{OL} = 1mA				0.4	V
Output Leakage Current 32kHz, $\overline{\text{INT}}$/SQW, SDA	I_{LO}	Output high impedance		-1	0	+1	µA
Input Leakage SCL	I_{LI}			-1		+1	µA
$\overline{\text{RST}}$ Pin I/O Leakage	I_{OL}	$\overline{\text{RST}}$ high impedance (Note 5)		-200		+10	µA
V_{BAT} Leakage Current (V_{CC} Active)	I_{BATLKG}				25	100	nA

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LM2596 Series

3A / 150kHz Step-Down DC-DC Converter

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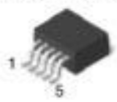
PIN CONFIGURATION

TO-263-5L (D^2PAK)



Pin Definition:

1. Input
2. SW Output
3. Ground
4. Feedback
5. Enable

ABSOLUTE MAXIMUM RATINGS

PARAMETER	SYMBOL	LIMIT	UNIT
Maximum Supply Voltage	V_{CC}	+45	V
Recommend Operating Supply Voltage	V_{OP}	+4.5 to +40	V
SW, EN Pin Input Voltage	V_{SW}, V_{EN}	-0.3 to +40	V
Feedback Pin Voltage	V_{FB}	-0.3 to +12	V
Power Dissipation	P_D	Internally Limited	W
Output Voltage to Ground	V_{OUT}	-1	V
Storage Temperature Range	T_{ST}	-65 ~ +150	°C
Operating Temperature Range	T_{OP}	-40 ~ +125	°C
ESD Susceptibility (HBM)		2	kV

THERMAL INFORMATION

PARAMETER	SYMBOL	LIMIT	UNIT
Junction to Case Thermal Resistance	$R_{θJC}$	2	°C/W
Junction to Ambient Thermal Resistance	$R_{θJA}$	50	°C/W

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LM2596 Series

3A / 150kHz Step-Down DC-DC Converter

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GENERAL DESCRIPTION

The LM2596 Series are step-down switching regulator s with all required active functions. It is capable of driving 3A load with excellent line and load regulations. These devices are available in fixed output voltages of 3.3V, 5V, and an adjustable output version.

The LM2596 series operates at a switching frequency of 150kHz thus allowing smaller sized filter components than what would be needed with lower frequency switching regulators. It substantially not only reduces the area of board size but also the size of heat sink, and in some cases no heat sink is required. The ±4% tolerance on output voltage within specified input voltages and output load conditions is guaranteed. Also, the oscillator frequency accuracy is within ±10%. External shutdown is included. Featuring 100μA (typical) standby current. The output switch includes cycle-by-cycle current limiting, as well as thermal shutdown for full protection under fault conditions.

Features

- Output voltage: 3.3V, 5V & adjustable version
- Adjustable output voltage range 1.23V~38.5V
- 150kHz fixed switching frequency
- Voltage mode Non-synchronous PWM control
- Thermal shutdown and current limit protection
- ON/OFF shutdown control input
- Short circuit protect (SCP)
- Operating voltage can be up to 40V
- Output load current 3A

Applications

- Simple High-efficiency Step down Regulator
- On-Card Switching Regulators
- Positive to Negative Converter

TYPICAL APPLICATION

OUTPUT VOLTAGE	PART NO.	PACKAGE	PACKING
3.3V	LM2596SX-3.3	TO-263-5L (D^2PAK)	500pcs / 13" Reel
5.0V	LM2596SX-5.0	TO-263-5L (D^2PAK)	500pcs / 13" Reel
ADJ	LM2596SX-ADJ	TO-263-5L (D^2PAK)	500pcs / 13" Reel

Marking:

LM2596SX-3.3

TECH PUBLIC
LM2596S
-3.3 P+

LM2596SX-5.0

TECH PUBLIC
LM2596S
-5.0 P+

LM2596SX-ADJ

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LM2596S
-ADJ P+

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InvenSense	MPU-6000/MPU-6050 Product Specification	Document Number: PS-MPU-6000A-00 Revision: 3.3 Release Date: 5/16/2012

6 Electrical Characteristics

6.1 Gyroscope Specifications

VDD = 2.375V-3.46V, VLOGIC (MPU-6050 only) = 1.8V±5% or VDD, T_A = 25°C

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS	NOTES
GYROSCOPE SENSITIVITY						
Full-Scale Range	FS_SEL=0		±250		°/s	
	FS_SEL=1		±500		°/s	
	FS_SEL=2		±1000		°/s	
	FS_SEL=3		±2000		°/s	
Gyroscope ADC Word Length			16		bits	
Sensitivity Scale Factor	FS_SEL=0		131		LSB/(°/s)	
	FS_SEL=1		65.5		LSB/(°/s)	
	FS_SEL=2		32.8		LSB/(°/s)	
	FS_SEL=3		16.4		LSB/(°/s)	
Sensitivity Scale Factor Tolerance	25°C	-3		+3	%	
Sensitivity Scale Factor Variation Over Temperature			±2		%	
Nonlinearity	Best fit straight line; 25°C		0.2		%	
Cross-Axis Sensitivity			±2		%	
GYROSCOPE ZERO-RATE OUTPUT (ZRO)						
Initial ZRO Tolerance	25°C		±20		°/s	
ZRO Variation Over Temperature	-40°C to +85°C		±20		°/s	
Power-Supply Sensitivity (1-10Hz)	Sine wave, 100mVpp; VDD=2.5V		0.2		°/s	
Power-Supply Sensitivity (10 - 250Hz)	Sine wave, 100mVpp; VDD=2.5V		0.2		°/s	
Power-Supply Sensitivity (250Hz - 100kHz)	Sine wave, 100mVpp; VDD=2.5V		4		°/s	
Linear Acceleration Sensitivity	Static		0.1		°/s/g	
SELF-TEST RESPONSE						
Relative	Change from factory trim	-14		14	%	1
GYROSCOPE NOISE PERFORMANCE	**FS_SEL=0**					
Total RMS Noise	DLPFCFG=2 (100Hz)		0.05		°/s-rms	
Low-frequency RMS noise	Bandwidth 1Hz to10Hz		0.033		°/s-rms	
Rate Noise Spectral Density	At 10Hz		0.005		°/s/ √Hz	
GYROSCOPE MECHANICAL FREQUENCIES						
X-Axis		30	33	36	kHz	
Y-Axis		27	30	33	kHz	
Z-Axis		24	27	30	kHz	
LOW PASS FILTER RESPONSE						
	Programmable Range	5		256	Hz	
OUTPUT DATA RATE						
	Programmable	4		8,000	Hz	
GYROSCOPE START-UP TIME	**DLPFCFG=0**					
ZRO Settling (from power-on)	to ±1°/s of Final		30		ms	

1. Please refer to the following document for further information on Self-Test: *MPU-6000/MPU-6050 Register Map and Descriptions*

InvenSense	MPU-6000/MPU-6050 Product Specification	Document Number: PS-MPU-6000A-00 Revision: 3.3 Release Date: 5/16/2012

6.2 Accelerometer Specifications

VDD = 2.375V-3.46V, VLOGIC (MPU-6050 only) = 1.8V±5% or VDD, T_A = 25°C

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS	NOTES
ACCELEROMETER SENSITIVITY						
Full-Scale Range	AFS_SEL=0		±2		*g*	
	AFS_SEL=1		±4		*g*	
	AFS_SEL=2		±8		*g*	
	AFS_SEL=3		±16		*g*	
ADC Word Length	Output in two's complement format		16		bits	
Sensitivity Scale Factor	AFS_SEL=0		16,384		LSB/*g*	
	AFS_SEL=1		8,192		LSB/*g*	
	AFS_SEL=2		4,096		LSB/*g*	
	AFS_SEL=3		2,048		LSB/*g*	
Initial Calibration Tolerance			±3		%	
Sensitivity Change vs. Temperature	AFS_SEL=0, -40°C to +85°C		±0.02		%/°C	
Nonlinearity	Best Fit Straight Line		0.5		%	
Cross-Axis Sensitivity			±2		%	
ZERO-G OUTPUT						
Initial Calibration Tolerance	X and Y axes		±50		m*g*	1
	Z axis		±80		m*g*	
Zero-G Level Change vs. Temperature	X and Y axes, 0°C to +70°C		±35			
	Z axis, 0°C to +70°C		±60		m*g*	
SELF TEST RESPONSE						
Relative	Change from factory trim	-14		14	%	2
NOISE PERFORMANCE						
Power Spectral Density	@10Hz, AFS_SEL=0 & ODR=1kHz		400		μg/ √Hz	
LOW PASS FILTER RESPONSE	Programmable Range	5		260	Hz	
OUTPUT DATA RATE	Programmable Range	4		1,000	Hz	
INTELLIGENCE FUNCTION INCREMENT			32		mg/LSB	

1. Typical zero-g initial calibration tolerance value after MSL3 preconditioning
2. Please refer to the following document for further information on Self-Test: *MPU-6000/MPU-6050 Register Map and Descriptions*

Appendix B Program Codes

Main Program:

```
#include <DS3231.h>
#include <SPI.h>
#include <SD.h>
#include<ADS1115_WE.h>
#include <MPU6050_light.h>
#include<Wire.h>


#define I2C_ADDRESS 0x48
#define slave_addr 5

File Datalog_File; // name file
RTClib myRTC; // name RTC

MPU6050 mpu(Wire);
float angle_avg;
float angle_tot;
float angle_y ;

ADS1115_WE adc = ADS1115_WE(I2C_ADDRESS); //parameter ads
float current_ratio = 20;
float voltage_tot=0;
float voltage = 0.0;

//speed calc parameter

int counter = 0;
float pole_pairs = 26;
double rpm,rps;

// Output motor parameter
int pwm_motor;
int p_inc=0;//increment
int p_dec=0;
unsigned long timer = 0;
int modeFlag;

int ledRed = 2;
int ledBlue= 4;
int ledGreen=3;
```

```
void setup() {
Wire.begin();
Serial.begin(115200);

  byte status = mpu.begin();
  Serial.print(F("MPU6050 status: "));
  Serial.println(status);
  while(status!=0){ }

  Serial.println(F("Calculating offsets, do not move MPU6050"));
  delay(1000);
  mpu.calcOffsets();
  Serial.println("Done!\n");

if (!adc.init()) {
    Serial.println("ADS1115 not connected!");
  }
  adc.setVoltageRange_mV(ADS1115_RANGE_6144);
  adc.setMeasureMode(ADS1115_CONTINUOUS);

//Initialation SD card
  Serial.print("Initializing SD card...");
  if (!SD.begin(10)) {
  Serial.println("initialization failed!");
  while (1);
  }
  Serial.println("initialization done.");

  //Hall sensor input
pinMode (14,INPUT);

pinMode(7,INPUT_PULLUP);
pinMode(8,INPUT_PULLUP);
pinMode(5,INPUT_PULLUP);
pinMode(6,INPUT_PULLUP);

pinMode(15,OUTPUT);
pinMode(ledRed,OUTPUT);
pinMode(ledGreen,OUTPUT);
pinMode(ledBlue,OUTPUT);

pwm_motor=0;
//PWM Resolution
analogWriteResolution(15);

}

void  loop() {
  //Name pin
```

```
int s1 = digitalRead(7);
int s2 = digitalRead(8);
int s3 = digitalRead(5);
int s4 = digitalRead(6);

DateTime now = myRTC.now();

mpu.update();

for (int i=0; i<10; i++ )
{
angle_y = mpu.getAngleY();
angle_tot = angle_tot + angle_y;
}
 angle_avg= angle_tot/10;


//Mode selector

if (s1 !=1)
{
modeFlag=0;
}

if (s2!=1)
{
modeFlag=1;
}

if (s3!=1)
{
modeFlag=2;
}

if (s4!=1)
{
modeFlag=3;
}

switch(modeFlag)
{
  case 0:
  p_inc=500;
  p_dec=1000;
  digitalWrite(ledRed,LOW);
  digitalWrite(ledGreen,HIGH);
  digitalWrite(ledBlue,LOW);
//  Serial.println("mode: ECO ");
  break;
```

```
  case 1:
  p_inc=1000;
  p_dec=1000;
  digitalWrite(ledRed,HIGH);
  digitalWrite(ledGreen,HIGH);
  digitalWrite(ledBlue,LOW);
//  Serial.println("mode: Sport");
  break;


  case 2:
  Hill_Start();
  digitalWrite(ledRed,LOW);
  digitalWrite(ledGreen,LOW);
  digitalWrite(ledBlue,HIGH);
//  Serial.println("mode: hill start ");
  break;

  case 3:
  p_inc=0;
  pwm_motor=13500;
  digitalWrite(ledRed,HIGH);
  digitalWrite(ledGreen,LOW);
  digitalWrite(ledBlue,LOW);
//  Serial.println("mode: brake ");
  break;
}


//motor output
motor_control();
analogWrite(15,pwm_motor);


for (int i=0; i<10; i++ )
{
  voltage = readChannel(ADS1115_COMP_3_GND);
  voltage_tot = voltage_tot + voltage;
}
float current_avg= voltage_tot/10;
float current = (voltage - current_avg) / current_ratio;


//rpm_calculation;
counter = read_counter(slave_addr);
 rps = counter/pole_pairs;
 rpm = rps * 60 *2;
```

```
//datalog
Datalog_File = SD.open("Datalog_Measuement.txt", FILE_WRITE);

if (Datalog_File) {

  Datalog_File.print(now.hour(), DEC);
  Datalog_File.print('/');
  Datalog_File.print(now.minute(), DEC);
  Datalog_File.print('/');
  Datalog_File.print(now.second(), DEC);
  Datalog_File.print(",");
  Datalog_File.print(current);
  Datalog_File.print(",");
  Datalog_File.print(rpm);
  Datalog_File.print(",");
  Datalog_File.print(pwm_motor);
  Datalog_File.print(",");
  Datalog_File.println(mpu.getAngleY());

  Serial.print("time: ");
  Serial.print(now.hour(), DEC);
  Serial.print(';');
  Serial.print(now.minute(), DEC);
  Serial.print(';');
  Serial.print(now.second(), DEC);
  Serial.print(", ");
  Serial.print("Current= ");
  Serial.print(current);
  Serial.print(" PWM= ");
  Serial.print(pwm_motor);
  Serial.print(" RPM= ");
  Serial.print(rpm);
  Serial.print(" angleY= ,");
  Serial.println(mpu.getAngleY());

  voltage_tot=0;
  angle_tot=0;

  Datalog_File.close();

//  Serial.println("  measurement done");
}
}


float readChannel(ADS1115_MUX channel) {
  float voltage = 0.0;
```

```
  adc.setCompareChannels(channel);
  voltage = adc.getResult_mV(); // alternative: getResult_mV for Millivolt
  return voltage;
}

int read_counter(int address) {
  int counter;
  Wire.requestFrom(address,1 );
 while(Wire.available() == 1 ) counter = Wire.read();
  return counter;
}



void Hill_Start()
{
  if(angle_avg >= 10)
  {
   pwm_motor=16000;
   p_inc=0;
   p_dec=0;
  }
  else
  {
   modeFlag = 0;
  }

}

void motor_control()
{
float throttle = 0.0;
//  Serial.print(" Input Throttle : ");
  throttle = readChannel(ADS1115_COMP_1_GND);
//  Serial.println(throttle);
 int throttle_signal=map(throttle,855,3620,14000,32000);

    if(throttle_signal>pwm_motor)
  {
  pwm_motor=pwm_motor+p_inc;
//  Serial.println(" test+ ");
  }
  else if (throttle_signal<pwm_motor)
  {
  pwm_motor=pwm_motor-p_dec;
//    Serial.println(" test- ");
  }
  else if (throttle_signal==pwm_motor)
  {
```

```
    pwm_motor=pwm_motor;
//      Serial.println(" test= ");
  }
  if(pwm_motor>=32000)
  {
    pwm_motor=32000;
  }
}
```

Angular velocity Program:

```
#include <Wire.h>

// Define Slave I2C Address
#define slave_addr 5

#define interval_500ms 500

int hall_sensor = 2;
float pole_pairs = 26;

int hall_counter = 0;
int counter;
unsigned long time_1 = 0;
int hall_state = 0;
int last_hall_state = 0;
float rpm,rps;

void setup() {
  // put your setup code here, to run once:
Serial.begin (115200);
pinMode (hall_sensor,INPUT);
Serial.begin (115200);
pinMode (hall_sensor,INPUT);

  // Initialize I2C communications as Slave
  Wire.begin(slave_addr);

   // Function to run when data requested from master
  Wire.onRequest(requestEvent);

}

void requestEvent() {

  // Define a byte to hold data
  // Send response back to Master
  Wire.write(counter);

}

void loop() {
  // put your main code here, to run repeatedly:
  hall_state = digitalRead(hall_sensor);

  if (hall_state != last_hall_state)
  {
```

```
  if (hall_state == HIGH)
  {
   hall_counter++ ;

  }
 }
 last_hall_state = hall_state;

 delay(1);

 if ( millis() >= time_1 + interval_500ms )
 {
  time_1 += interval_500ms;
  rpm_calculation();
 }

}

void rpm_calculation()
{
 counter=hall_counter;
 rps = hall_counter/pole_pairs;
 rpm = rps * 60 * 2;
// float Vel = rps
//Serial.print (hall_counter);
//Serial.print ("round , ");
Serial.print (counter);
Serial.print ("    ");
Serial.println (rpm);

//Serial.println (" rpm");

hall_counter = 0;

}
```

Appendix C Bill of Materials

No	Component	Quantity	Price	Total Price
1	ADS1115	1	IDR 68,000.00	IDR 68,000.00
2	Cable 22 AWG 6M	1	IDR 38,000.00	IDR 38,000.00
3	RGB LED	2	IDR 1,400.00	IDR 2,800.00
4	PCB 9x15cm	1	IDR 18,550.00	IDR 18,550.00
5	DS3231	1	IDR 72,000.00	IDR 72,000.00
6	Bi-directional Logic Converter	1	IDR 14,000.00	IDR 14,000.00
7	Teensy 4.0	1	IDR 610,000.00	IDR 610,000.00
8	SD to SPI	1	IDR 6,000.00	IDR 6,000.00
9	resistor 100 ohm	3	IDR 330.00	IDR 990.00
10	resistor 220 ohm	3	IDR 200.00	IDR 600.00
11	resistor 220 ohm	2	IDR 330.00	IDR 660.00
12	LM2596	1	IDR 7,700.00	IDR 7,700.00
13	AMS1117	1	IDR 3,000.00	IDR 3,000.00
14	MPU6050	1	IDR 30,000.00	IDR 30,000.00
15	KF connector	4	IDR 1,800.00	IDR 7,200.00
16	JST connector	5	IDR 1,000.00	IDR 5,000.00
17	ACS 758	1	IDR 160,000.00	IDR 160,000.00
18	Black box	1	IDR 14,000.00	IDR 14,000.00
19	Bluno nano	1	IDR 300,000.00	IDR 300,000.00
Grand Total				IDR 1,358,500.00

CURRICULUM VITAE

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Education

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2013 - 2015	SMAK 7 BPK Penabur, Jakarta
2016 – Present	Swiss German University, Indonesia Study: Mechatronic

Internship

December 2017 – March 2018 Training machining and benchwork at ATMI Cikarang.

September 2017 - November 2017 Internship in Mercedes-Benz Bogor inEPC (Engineer Passenger Car) division in production plan.

Skills and Knowledge

language: - English

- Indonesian

Skills: Qt(C++) , CNC Simulation, PLC(TIA Portal,CX-Programmer,Beckhoff TwinCAT), Inventor, PCB, AutoCAD, Arduino, SolidWorks, Microsoft Office.

Hobbies

Playing computer, Mountain biking, Robotic(Arduino) ,Repairing electrical appliances