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DAFTAR LAMPIRAN

Lampiran 1. Cara penggunaan dan pengujian alat

INSTRUKSI KERJA

PENGGUNAAN ALAT UJI IMPAK DWIT DENGAN LOAD CELL

1. TUJUAN

Tujuan dibuatnya Instruksi Kerja ini untuk membantu dan memudahkan Mahasiswa dalam melakukan pengujian impak dengan alat DWIT menggunakan load cell.

2. RUANG LINGKUP

Instruksi Kerja ini digunakan pada alat DWIT yang berada pada Laboratorium Mesin President University, yang sudah dimodifikasi dengan menambahkan load cell untuk pengukuran beban dengan menggunakan perangkat elektronik dan program Arduino 1.8.13

3. PERALATAN

Peralatan yang digunakan dalam pengujian impak ini adalah:

a. Alat Impak DWIT
b. Load cell
c. Voltage regulator
d. Perangkat Mikro controller (ADC,Amplifier dan ESP32)
e. Multimeter
f. Spesiment

4. KEAMANAN

Dalam melakukan pengujian alat ini ada beberapa hal yang perlu diperhatikan keamanannya yaitu:

a. Terjepit – alat ini masih dijatuhkan manual sehingga jika tidak hati-hati tangan bisa terjepit
b. Kebisingan – pada saat impactor dijatuhkan akan ada suara benturan yang keras untuk itu disarankan menggunakan earplug
c. Terkena serpihan spesiment – hati-hati jika menggunakan spesiment yang getas atau mudah pecah.

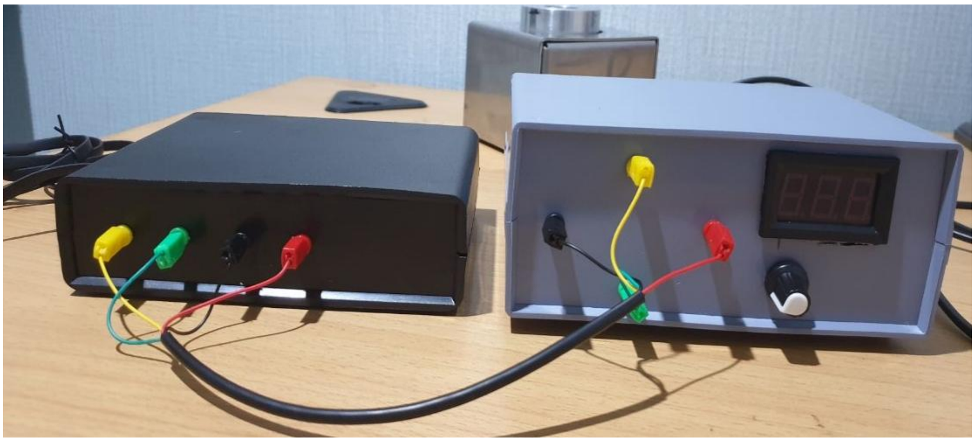
5. PROSEDUR KERJA

A. Perakitan Komponen Elektronik

1. Pasang load cell pada alat DWIT, seperti pada gambar 1 dibawah ini.

Gambar 1 : Pemasangan Load cell

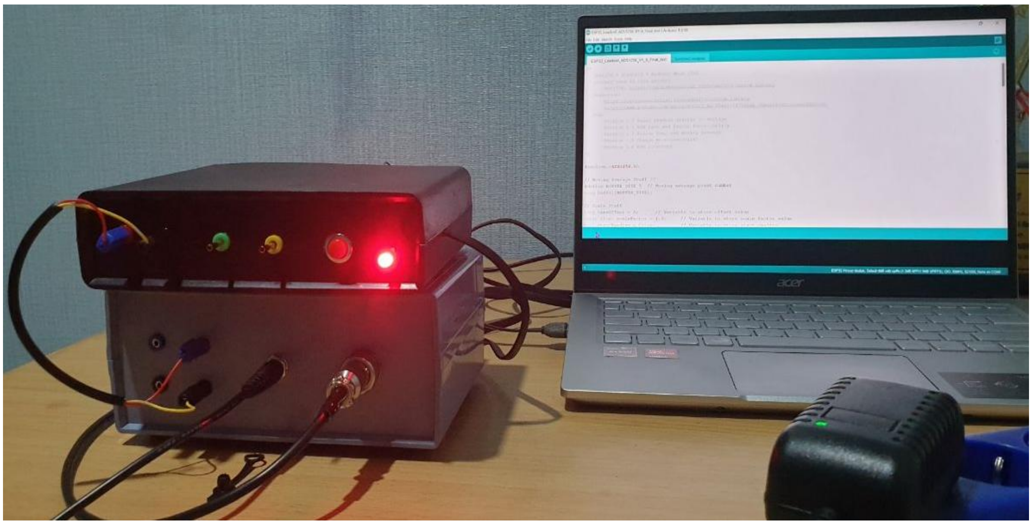
2. Yakinkan baut pengikat pada bagian bawah load cell sudah terpasang dengan kuat.
3. Pasangkan kabel dari strain gauge ke box Voltage regulator.
4. Hubungkan terminal tegangan input dan output dari load cell pada box Mikro kontroler, yakinkan warna kabel sesuai dengan masing-masing terminalnya seperti pada gambar 2 dan gambar 3 dibawah ini:



Gambar 2: Pemasangan kabel Wheatstone Bridge

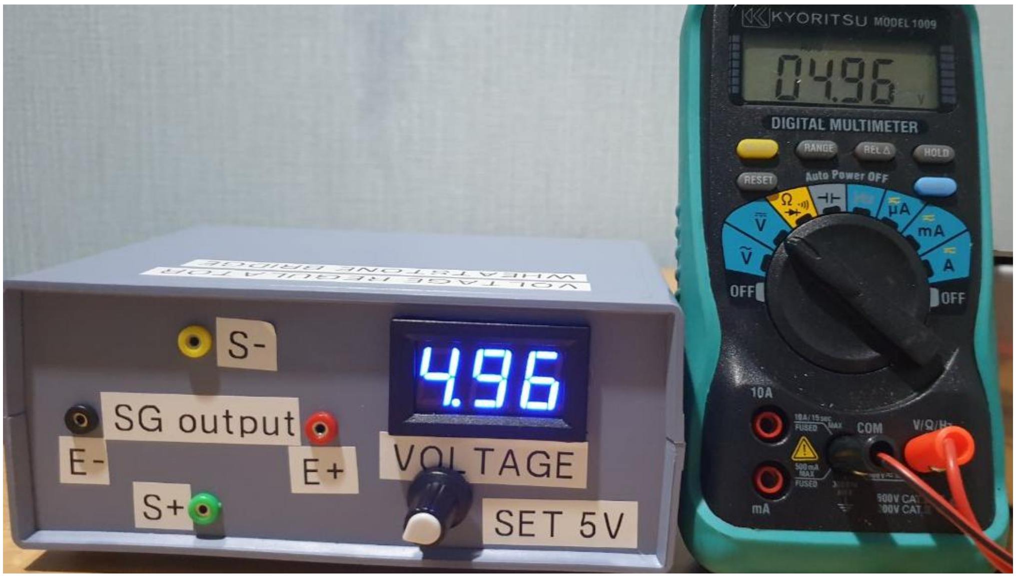
Gambar 3: Pemasangan kabel tegangan

5. Pasangkan input power supply untuk Voltage Regulator
6. Pasangkan input power supply micro controller ke laptop
7. Nyalakan kedua power supply hingga lampu indikator menyala seperti pada gambar 4 dibawah ini :



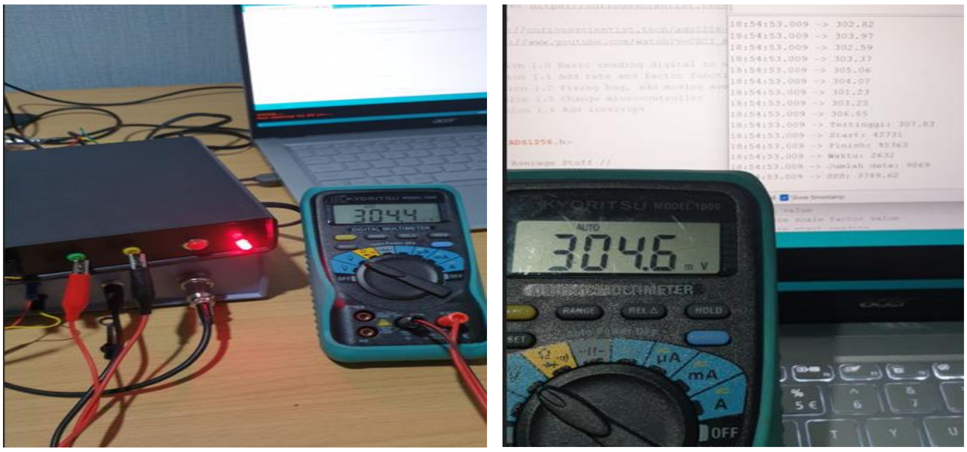
Gambar 4: Lampu indikator tegangan

8. Setting tegangan dari Voltage Regulator dengan standar nilai tegangan di 5V seperti pada gambar 5 dibawah ini:



Gambar 5: Nilai tegangan power supply

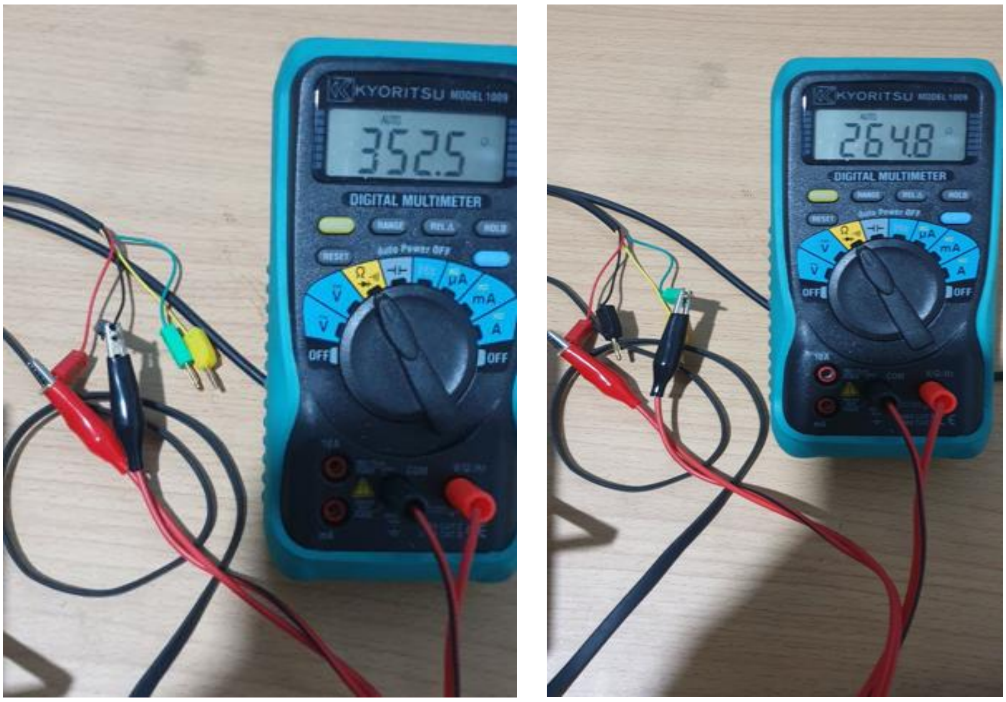
9. Upload program Arduino kedalam mikro kontroler dan yakinkan nilai tegangan (mV) yang terbaca pada Arduino kurang lebih sama dengan tegangan yang terbaca pada Multimeter seperti pada gambar 6 dibawah ini:



Gambar 6: Nilai tegangan output Wheatstone Bridge

10. Jika nilai tegangannya sudah sama lakukan pengujian impak dengan mengatur ketinggian impactor
11. Setting nilai PGA dan Speed, dimana di percobaan sebelumnya menggunakan setting PGA 32 dan speed 3750SPS.
12. Setelah Impaktor disiapkan pada ketinggian tertentu ketik “r” pada serial monitor kemudian enter, jatuhkan impactor ketik “s” setelah impactor berbenturan dengan speciment.

13. Pindahkan data hasil pengukuran pada serial monitor ke excel untuk di analisa besarnya beban yang terukur.
14. Apabila ada kendala dalam proses pengujian, lakukan pengukuran nilai hambatan pada load cell seperti pada gambar 7 dibawah ini:



Gambar 7: Nilai tahanan strain gauge

15. Yakinkan besarnya nilai tahanan pada strain gauge adalah 350 Ohm, dan tahanan kabel berkisar 2 Ohm sehingga besarnya nilai tahanan pada terminal E+ dan E- sama dengan S+ dan S- yaitu ± 352,5 Ohm. Sedangkan besaran nilai tahanan antara E dan S adalah sebesar ± 264,8 Ohm. Apabila nilainya berbeda dari kedua pengukuran tersebut periksa strain gauge dari kemungkinan kabel putus atau rusak.
16. Apabila nilainya tidak stabil periksa Amplifier lakukan setting gain dan ganti jika rusak.

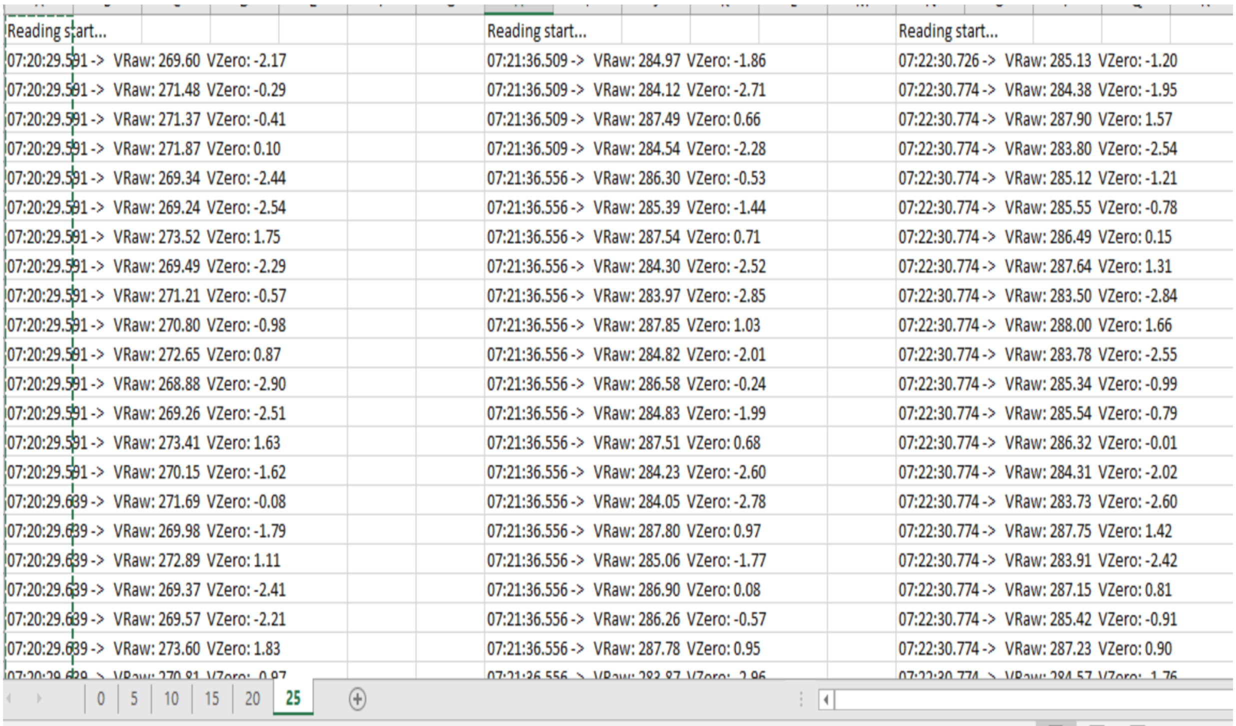
6 PENUTUP

Setelah pengujian selesai dilakukan matikan power supply dan lepas kembali kabel dan rapikan peralatan.

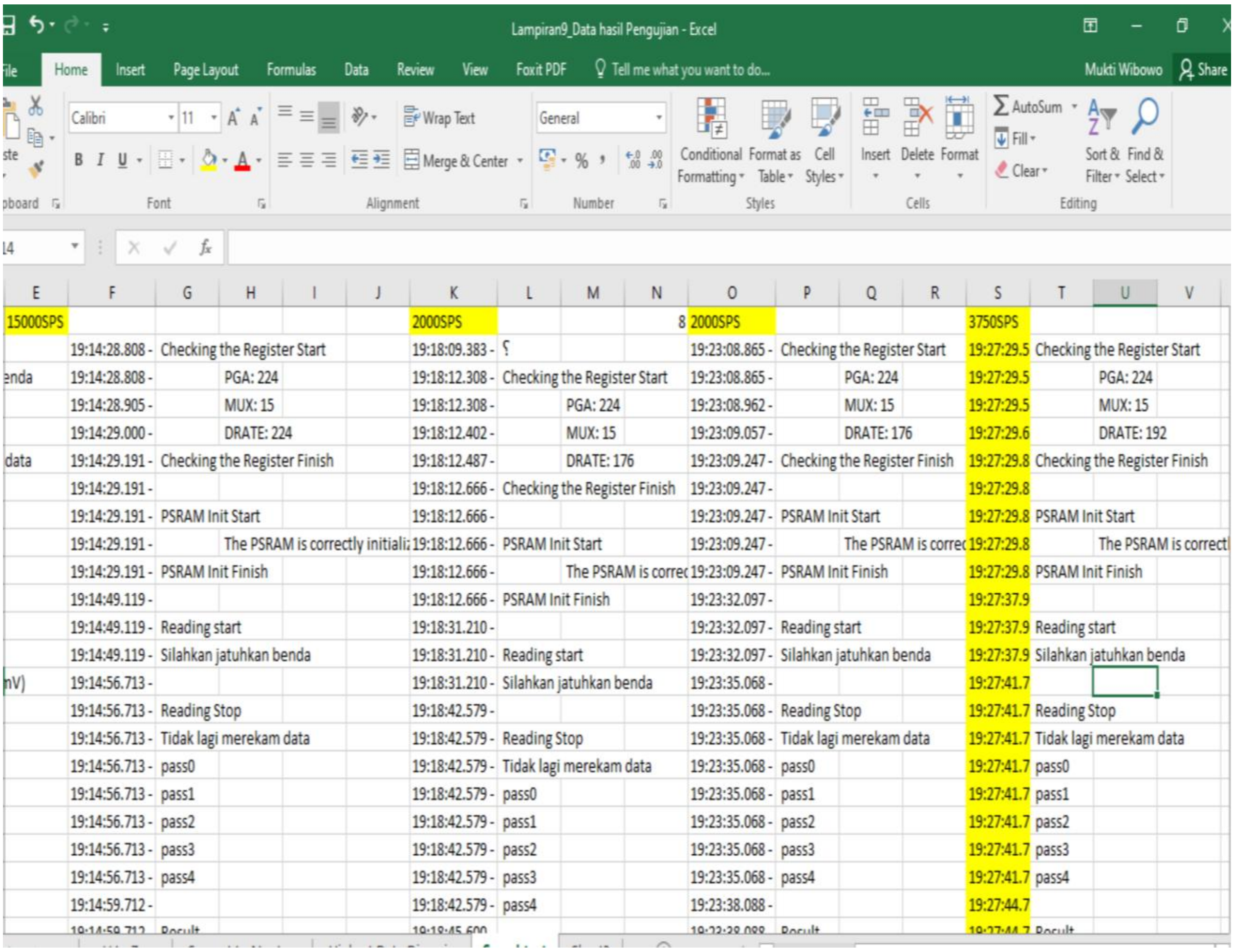
Buat pelaporan hasil pengujian yang meliputi bentuk speciment setelah terkena impak dan nilai gaya reaksi yang bekerja.

Lampiran 2. Data hasil Pengujian

Contoh raw data



Reading start...	Reading start...	Reading start...
07:20:29.591 -> VRaw: 269.60 VZero: -2.17	07:21:36.509 -> VRaw: 284.97 VZero: -1.86	07:22:30.726 -> VRaw: 285.13 VZero: -1.20
07:20:29.591 -> VRaw: 271.48 VZero: -0.29	07:21:36.509 -> VRaw: 284.12 VZero: -2.71	07:22:30.774 -> VRaw: 284.38 VZero: -1.95
07:20:29.591 -> VRaw: 271.37 VZero: -0.41	07:21:36.509 -> VRaw: 287.49 VZero: 0.66	07:22:30.774 -> VRaw: 287.90 VZero: 1.57
07:20:29.591 -> VRaw: 271.87 VZero: 0.10	07:21:36.509 -> VRaw: 284.54 VZero: -2.28	07:22:30.774 -> VRaw: 283.80 VZero: -2.54
07:20:29.591 -> VRaw: 269.34 VZero: -2.44	07:21:36.556 -> VRaw: 286.30 VZero: -0.53	07:22:30.774 -> VRaw: 285.12 VZero: -1.21
07:20:29.591 -> VRaw: 269.24 VZero: -2.54	07:21:36.556 -> VRaw: 285.39 VZero: -1.44	07:22:30.774 -> VRaw: 285.55 VZero: -0.78
07:20:29.591 -> VRaw: 273.52 VZero: 1.75	07:21:36.556 -> VRaw: 287.54 VZero: 0.71	07:22:30.774 -> VRaw: 286.49 VZero: 0.15
07:20:29.591 -> VRaw: 269.49 VZero: -2.29	07:21:36.556 -> VRaw: 284.30 VZero: -2.52	07:22:30.774 -> VRaw: 287.64 VZero: 1.31
07:20:29.591 -> VRaw: 271.21 VZero: -0.57	07:21:36.556 -> VRaw: 283.97 VZero: -2.85	07:22:30.774 -> VRaw: 283.50 VZero: -2.84
07:20:29.591 -> VRaw: 270.80 VZero: -0.98	07:21:36.556 -> VRaw: 287.85 VZero: 1.03	07:22:30.774 -> VRaw: 288.00 VZero: 1.66
07:20:29.591 -> VRaw: 272.65 VZero: 0.87	07:21:36.556 -> VRaw: 284.82 VZero: -2.01	07:22:30.774 -> VRaw: 283.78 VZero: -2.55
07:20:29.591 -> VRaw: 268.88 VZero: -2.90	07:21:36.556 -> VRaw: 286.58 VZero: -0.24	07:22:30.774 -> VRaw: 285.34 VZero: -0.99
07:20:29.591 -> VRaw: 269.26 VZero: -2.51	07:21:36.556 -> VRaw: 284.83 VZero: -1.99	07:22:30.774 -> VRaw: 285.54 VZero: -0.79
07:20:29.591 -> VRaw: 273.41 VZero: 1.63	07:21:36.556 -> VRaw: 287.51 VZero: 0.68	07:22:30.774 -> VRaw: 286.32 VZero: -0.01
07:20:29.591 -> VRaw: 270.15 VZero: -1.62	07:21:36.556 -> VRaw: 284.23 VZero: -2.60	07:22:30.774 -> VRaw: 284.31 VZero: -2.02
07:20:29.639 -> VRaw: 271.69 VZero: -0.08	07:21:36.556 -> VRaw: 284.05 VZero: -2.78	07:22:30.774 -> VRaw: 283.73 VZero: -2.60
07:20:29.639 -> VRaw: 269.98 VZero: -1.79	07:21:36.556 -> VRaw: 287.80 VZero: 0.97	07:22:30.774 -> VRaw: 287.75 VZero: 1.42
07:20:29.639 -> VRaw: 272.89 VZero: 1.11	07:21:36.556 -> VRaw: 285.06 VZero: -1.77	07:22:30.774 -> VRaw: 283.91 VZero: -2.42
07:20:29.639 -> VRaw: 269.37 VZero: -2.41	07:21:36.556 -> VRaw: 286.90 VZero: 0.08	07:22:30.774 -> VRaw: 287.15 VZero: 0.81
07:20:29.639 -> VRaw: 269.57 VZero: -2.21	07:21:36.556 -> VRaw: 286.26 VZero: -0.57	07:22:30.774 -> VRaw: 285.42 VZero: -0.91
07:20:29.639 -> VRaw: 273.60 VZero: 1.83	07:21:36.556 -> VRaw: 287.78 VZero: 0.95	07:22:30.774 -> VRaw: 287.23 VZero: 0.90



E	F	G	H	K	L	M	N	O	P	Q	S	T	U
15000SPS				2000SPS			8	2000SPS			3750SPS		
	19:14:28.808 -	Checking the Register Start		19:18:09.383 -	ʕ			19:23:08.865 -	Checking the Register Start		19:27:29.5	Checking the Register Start	
enda	19:14:28.808 -		PGA: 224	19:18:12.308 -	Checking the Register Start			19:23:08.865 -		PGA: 224	19:27:29.5		PGA: 224
	19:14:28.905 -		MUX: 15	19:18:12.308 -		PGA: 224		19:23:08.962 -		MUX: 15	19:27:29.5		MUX: 15
	19:14:29.000 -		DRATE: 224	19:18:12.402 -		MUX: 15		19:23:09.057 -		DRATE: 176	19:27:29.6		DRATE: 192
data	19:14:29.191 -	Checking the Register Finish		19:18:12.487 -		DRATE: 176		19:23:09.247 -	Checking the Register Finish		19:27:29.8	Checking the Register Finish	
	19:14:29.191 -			19:18:12.666 -	Checking the Register Finish			19:23:09.247 -			19:27:29.8		
	19:14:29.191 -	PSRAM Init Start		19:18:12.666 -				19:23:09.247 -	PSRAM Init Start		19:27:29.8	PSRAM Init Start	
	19:14:29.191 -		The PSRAM is correctly initiali	19:18:12.666 -	PSRAM Init Start			19:23:09.247 -		The PSRAM is correc	19:27:29.8		The PSRAM is correct
	19:14:29.191 -	PSRAM Init Finish		19:18:12.666 -		The PSRAM is correc		19:23:09.247 -	PSRAM Init Finish		19:27:29.8	PSRAM Init Finish	
	19:14:49.119 -			19:18:12.666 -	PSRAM Init Finish			19:23:32.097 -			19:27:37.9		
	19:14:49.119 -	Reading start		19:18:31.210 -				19:23:32.097 -	Reading start		19:27:37.9	Reading start	
	19:14:49.119 -	Silahkan jatuhkan benda		19:18:31.210 -	Reading start			19:23:32.097 -	Silahkan jatuhkan benda		19:27:37.9	Silahkan jatuhkan benda	
nV)	19:14:56.713 -			19:18:31.210 -	Silahkan jatuhkan benda			19:23:35.068 -			19:27:41.7		
	19:14:56.713 -	Reading Stop		19:18:42.579 -				19:23:35.068 -	Reading Stop		19:27:41.7	Reading Stop	
	19:14:56.713 -	Tidak lagi merekam data		19:18:42.579 -	Reading Stop			19:23:35.068 -	Tidak lagi merekam data		19:27:41.7	Tidak lagi merekam data	
	19:14:56.713 -	pass0		19:18:42.579 -	Tidak lagi merekam data			19:23:35.068 -	pass0		19:27:41.7	pass0	
	19:14:56.713 -	pass1		19:18:42.579 -	pass0			19:23:35.068 -	pass1		19:27:41.7	pass1	
	19:14:56.713 -	pass2		19:18:42.579 -	pass1			19:23:35.068 -	pass2		19:27:41.7	pass2	
	19:14:56.713 -	pass3		19:18:42.579 -	pass2			19:23:35.068 -	pass3		19:27:41.7	pass3	
	19:14:56.713 -	pass4		19:18:42.579 -	pass3			19:23:35.068 -	pass4		19:27:41.7	pass4	
	19:14:59.712 -			19:18:42.579 -	pass4			19:23:38.088 -			19:27:44.7		

Lampiran 3. Data sheet_ESP32

1 Module Overview

Note:

Check the link or the QR code to make sure that you use the latest version of this document:
https://www.espressif.com/documentation/esp32-s3-wroom-1_wroom-1u_datasheet_en.pdf

1.1 Features

CPU and On-Chip Memory

- ESP32-S3 series of SoCs embedded, Xtensa® dual-core 32-bit LX7 microprocessor, up to 240 MHz
- 384 KB ROM
- 512 KB SRAM
- 16 KB SRAM in RTC
- Up to 8 MB PSRAM

Wi-Fi

- 802.11 b/g/n
- Bit rate: 802.11n up to 150 Mbps
- A-MPDU and A-MSDU aggregation
- 0.4 μs guard interval support
- Center frequency range of operating channel: 2412 ~ 2484 MHz

Bluetooth

- Bluetooth LE: Bluetooth 5, Bluetooth mesh
- Speed: 125 Kbps, 500 Kbps, 1 Mbps, 2 Mbps
- Advertising extensions
- Multiple advertisement sets
- Channel selection algorithm #2
- Internal co-existence mechanism between Wi-Fi and Bluetooth to share the same antenna

Peripherals

- GPIO, SPI, LCD interface, Camera interface, UART, I2C, I2S, remote control, pulse counter, LED PWM, USB 1.1 OTG, USB Serial/JTAG controller, MCPWM, SDIO host, GDMA, TWAI® controller (compatible with ISO 11898-1), ADC, touch sensor, temperature sensor, timers and watchdogs

Note:
* Please refer to *ESP32-S3 Series Datasheet* for detailed information about the module peripherals.

Integrated Components on Module

- 40 MHz crystal oscillator
- Up to 16 MB Quad SPI flash

Antenna Options

- On-board PCB antenna (ESP32-S3-WROOM-1)
- External antenna via a connector (ESP32-S3-WROOM-1U)

Operating Conditions

- Operating voltage/Power supply: 3.0 ~ 3.6 V
- Operating ambient temperature:
  - 65 °C version: –40 ~ 65 °C
  - 85 °C version: –40 ~ 85 °C
  - 105 °C version: –40 ~ 105 °C

Certification

- RF certification: See certificates
- Green certification: RoHS/REACH

Test

- HTOL/HTSL/uHAST/TCT/ESD

1.2 Description

ESP32-S3-WROOM-1 and ESP32-S3-WROOM-1U are two powerful, generic Wi-Fi + Bluetooth LE MCU modules that are built around the ESP32-S3 series of SoCs. On top of a rich set of peripherals, the acceleration for neural network computing and signal processing workloads provided by the SoC make the modules an ideal choice for a wide variety of application scenarios related to AI and Artificial Intelligence of Things (AIoT), such as wake word detection, speech commands recognition, face detection and recognition, smart home, smart appliances, smart control panel, smart speaker, etc.

ESP32-S3-WROOM-1 comes with a PCB antenna. ESP32-S3-WROOM-1U comes with an external antenna connector. A wide selection of module variants are available for customers as shown in Table 1 and 2. Among the module variants, those embed ESP32-S3R8 operate at –40 ~ 65 °C ambient temperature, ESP32-S3-WROOM-1-H4 and ESP32-S3-WROOM-1U-H4 operate at –40 ~ 105 °C ambient temperature, and other module variants operate at –40 ~ 85 °C ambient temperature. Please note that for R8 series modules (8-line PSRAM embedded), if the PSRAM ECC function is enabled, the maximum ambient temperature can be improved to 85 °C, while the usable size of PSRAM will be reduced by 1/16.

Table 1: ESP32-S3-WROOM-1 Series Comparison[1]

Ordering Code	Flash	PSRAM[2]	Ambient Temp.[3] (°C)	Size[4] (mm)
ESP32-S3-WROOM-1-N4	4 MB (Quad SPI)	-	–40 ~ 85	18.0 × 25.5 × 3.1
ESP32-S3-WROOM-1-N8	8 MB (Quad SPI)	-	–40 ~ 85	
ESP32-S3-WROOM-1-N16	16 MB (Quad SPI)	-	–40 ~ 85	
ESP32-S3-WROOM-1-H4	4 MB (Quad SPI)	-	–40 ~ 105	
ESP32-S3-WROOM-1-N4R2	4 MB (Quad SPI)	2 MB (Quad SPI)	–40 ~ 85	
ESP32-S3-WROOM-1-N8R2	8 MB (Quad SPI)	2 MB (Quad SPI)	–40 ~ 85	
ESP32-S3-WROOM-1-N16R2	16 MB (Quad SPI)	2 MB (Quad SPI)	–40 ~ 85	
ESP32-S3-WROOM-1-N4R8	4 MB (Quad SPI)	8 MB (Octal SPI)	–40 ~ 65	
ESP32-S3-WROOM-1-N8R8	8 MB (Quad SPI)	8 MB (Octal SPI)	–40 ~ 65	
ESP32-S3-WROOM-1-N16R8	16 MB (Quad SPI)	8 MB (Octal SPI)	–40 ~ 65	

[1] This table shares the same notes presented in Table 2 below.

Table 2: ESP32-S3-WROOM-1U Series Comparison

Ordering Code	Flash[2]	PSRAM	Ambient Temp.[3] (°C)	Size[4] (mm)
ESP32-S3-WROOM-1U-N4	4 MB (Quad SPI)	-	–40 ~ 85	18.0 × 19.2 × 3.2
ESP32-S3-WROOM-1U-N8	8 MB (Quad SPI)	-	–40 ~ 85	
ESP32-S3-WROOM-1U-N16	16 MB (Quad SPI)	-	–40 ~ 85	
ESP32-S3-WROOM-1U-H4	4 MB (Quad SPI)	-	–40 ~ 105	
ESP32-S3-WROOM-1U-N4R2	4 MB (Quad SPI)	2 MB (Quad SPI)	–40 ~ 85	
ESP32-S3-WROOM-1U-N8R2	8 MB (Quad SPI)	2 MB (Quad SPI)	–40 ~ 85	
ESP32-S3-WROOM-1U-N16R2	16 MB (Quad SPI)	2 MB (Quad SPI)	–40 ~ 85	
ESP32-S3-WROOM-1U-N4R8	4 MB (Quad SPI)	8 MB (Octal SPI)	–40 ~ 65	
ESP32-S3-WROOM-1U-N8R8	8 MB (Quad SPI)	8 MB (Octal SPI)	–40 ~ 65	
ESP32-S3-WROOM-1U-N16R8	16 MB (Quad SPI)	8 MB (Octal SPI)	–40 ~ 65	

[2] The modules use PSRAM integrated in the chip's package.
[3] Ambient temperature specifies the recommended temperature range of the environment immediately outside the Espressif module.
[4] For details, refer to Section 7.1 *Physical Dimensions*.

At the core of the modules is an ESP32-S3 series of SoC *, an Xtensa® 32-bit LX7 CPU that operates at up to 240 MHz. You can power off the CPU and make use of the low-power co-processor to constantly monitor the peripherals for changes or crossing of thresholds.

ESP32-S3 integrates a rich set of peripherals including SPI, LCD, Camera interface, UART, I2C, I2S, remote control, pulse counter, LED PWM, USB Serial/JTAG controller, MCPWM, SDIO host, GDMA, TWAI® controller (compatible with ISO 11898-1), ADC, touch sensor, temperature sensor, timers and watchdogs, as well as up to 45 GPIOs. It also includes a full-speed USB 2.0 On-The-Go (OTG) interface to enable USB communication.

Note:
* For more information on ESP32-S3 series of SoCs, please refer to *ESP32-S3 Series Datasheet*.

1.3 Applications

- Generic Low-power IoT Sensor Hub
- Generic Low-power IoT Data Loggers
- Cameras for Video Streaming
- Over-the-top (OTT) Devices
- USB Devices
- Speech Recognition
- Image Recognition
- Mesh Network
- Home Automation
- Smart Building
- Industrial Automation
- Smart Agriculture
- Audio Applications
- Health Care Applications
- Wi-Fi-enabled Toys
- Wearable Electronics
- Retail & Catering Applications

2 Block Diagram

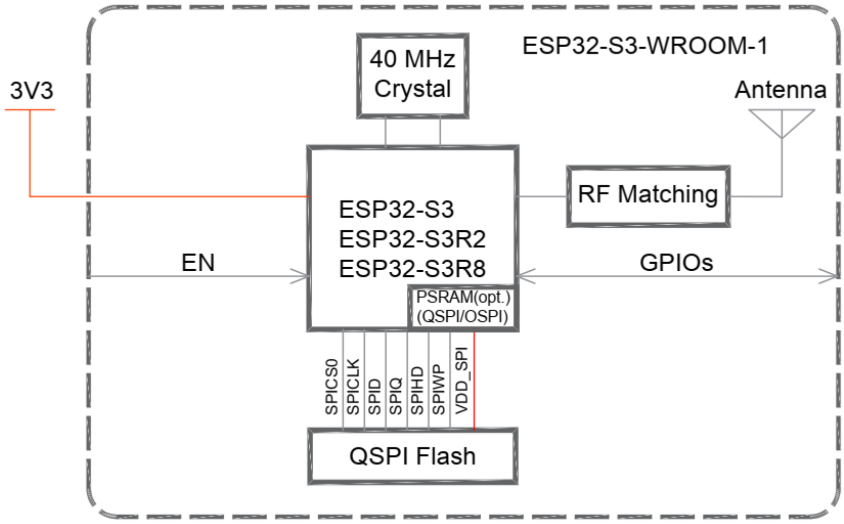


Figure 1: ESP32-S3-WROOM-1 Block Diagram

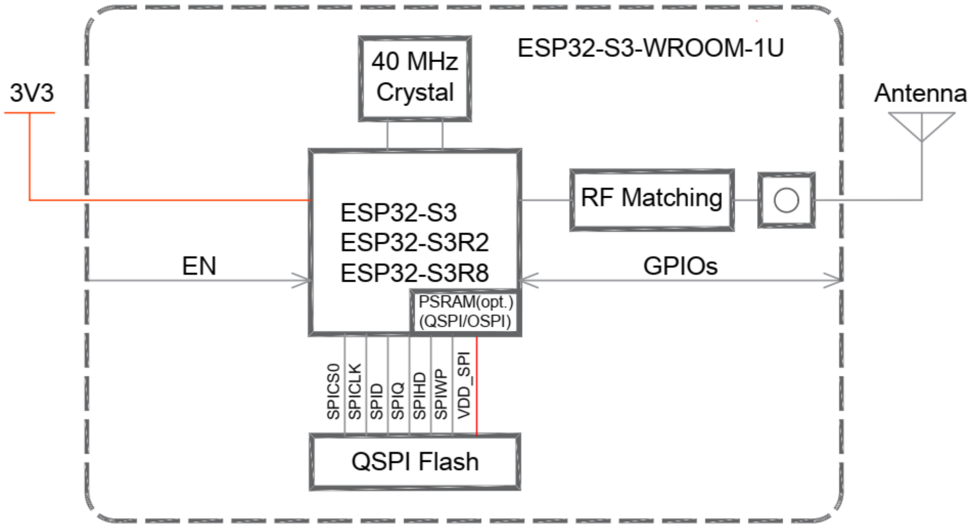


Figure 2: ESP32-S3-WROOM-1U Block Diagram

Lampiran 4. Data sheet ADC ADS1256

TEXAS INSTRUMENTS

ADS1255
ADS1256

SBAS288K – JUNE 2003 – REVISED SEPTEMBER 2013

Very Low Noise, 24-Bit Analog-to-Digital Converter

FEATURES

- 24 Bits, No Missing Codes
  - All Data Rates and PGA Settings
- Up to 23 Bits Noise-Free Resolution
- ±0.0010% Nonlinearity (max)
- Data Output Rates to 30kSPS
- Fast Channel Cycling
  - 18.6 Bits Noise-Free (21.3 Effective Bits) at 1.45kHz
- One-Shot Conversions with Single-Cycle Settling
- Flexible Input Multiplexer with Sensor Detect
  - Four Differential Inputs (ADS1256 only)
  - Eight Single-Ended Inputs (ADS1256 only)
- Chopper-Stabilized Input Buffer
- Low-Noise PGA: 27nV Input-Referred Noise
- Self and System Calibration for All PGA Settings
- 5V Tolerant SPI™-Compatible Serial Interface
- Analog Supply: 5V
- Digital Supply: 1.8V to 3.6V
- Power Dissipation
  - As Low as 38mW in Normal Mode
  - 0.4mW in Standby Mode

APPLICATIONS

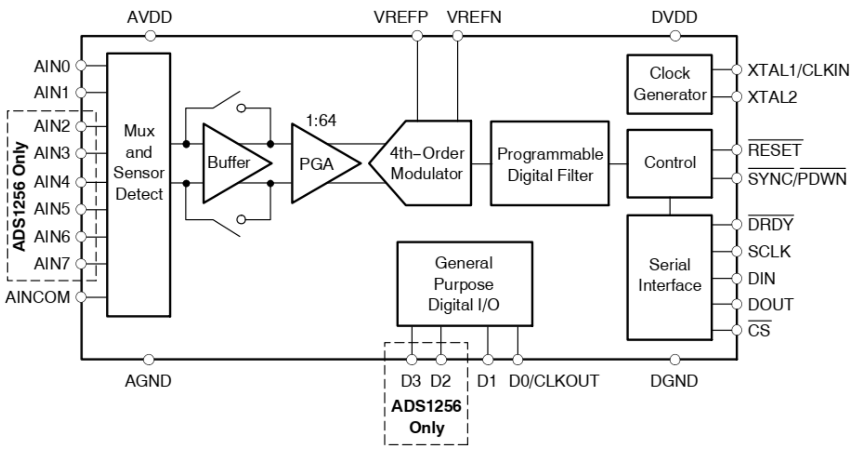
- Scientific Instrumentation
- Industrial Process Control
- Medical Equipment
- Test and Measurement
- Weigh Scales

DESCRIPTION

The ADS1255 and ADS1256 are extremely low-noise, 24-bit analog-to-digital (A/D) converters. They provide complete high-resolution measurement solutions for the most demanding applications.

The converter is comprised of a 4th-order, delta-sigma (ΔΣ) modulator followed by a programmable digital filter. A flexible input multiplexer handles differential or single-ended signals and includes circuitry to verify the integrity of the external sensor connected to the inputs. The selectable input buffer greatly increases the input impedance and the low-noise programmable gain amplifier (PGA) provides gains from 1 to 64 in binary steps. The programmable filter allows the user to optimize between a resolution of up to 23 bits noise-free and a data rate of up to 30k samples per second (SPS). The converters offer fast channel cycling for measuring multiplexed inputs and can also perform one-shot conversions that settle in just a single cycle.

Communication is handled over an SPI-compatible serial interface that can operate with a 2-wire connection. Onboard calibration supports both self and system correction of offset and gain errors for all the PGA settings. Bidirectional digital I/Os and a programmable clock output driver are provided for general use. The ADS1255 is packaged in an SSOP-20, and the ADS1256 in an SSOP-28.



ORDERING INFORMATION

For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI web site at www.ti.com.

ABSOLUTE MAXIMUM RATINGS

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

<table>
<tr><th colspan="2"></th><th>ADS1255, ADS1256</th><th>UNIT</th></tr>
<tr><td colspan="2">AVDD to AGND</td><td>−0.3 to +6</td><td>V</td></tr>
<tr><td colspan="2">DVDD to DGND</td><td>−0.3 to +3.6</td><td>V</td></tr>
<tr><td colspan="2">AGND to DGND</td><td>−0.3 to +0.3</td><td>V</td></tr>
<tr><td colspan="2" rowspan="2">Input Current</td><td>100, Momentary</td><td>mA</td></tr>
<tr><td>10, Continuous</td><td>mA</td></tr>
<tr><td colspan="2">Analog inputs to AGND</td><td>−0.3 to AVDD + 0.3</td><td>V</td></tr>
<tr><td rowspan="2">Digital inputs</td><td>DIN, SCLK, $\overline{CS}$, $\overline{RESET}$, $\overline{SYNC}/\overline{PDWN}$, XTAL1/CLKIN to DGND</td><td>−0.3 to +6</td><td>V</td></tr>
<tr><td>D0/CLKOUT, D1, D2, D3 to DGND</td><td>−0.3 to DVDD + 0.3</td><td>V</td></tr>
<tr><td colspan="2">Maximum Junction Temperature</td><td>+150</td><td>°C</td></tr>
<tr><td colspan="2">Operating Temperature Range</td><td>−40 to +105</td><td>°C</td></tr>
<tr><td colspan="2">Storage Temperature Range</td><td>−60 to +150</td><td>°C</td></tr>
<tr><td colspan="2">Lead Temperature (soldering, 10s)</td><td>+300</td><td>°C</td></tr>
</table>

(1) Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the device. Exposure to absolute maximum conditions for extended periods may degrade device reliability. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those specified is not implied.

This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

ELECTRICAL CHARACTERISTICS

All specifications at –40°C to +85°C, AVDD = +5V, DVDD = +1.8V, f_{CLKIN} = 7.68MHz, PGA = 1, and V_{REF} = +2.5V, unless otherwise noted.

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Analog Inputs					
Full-scale input voltage (AIN_P – AIN_N)			±2V_{REF}/PGA		V
Absolute input voltage (AIN0-7, AINCOM to AGND)	Buffer off	AGND – 0.1		AVDD + 0.1	V
	Buffer on	AGND		AVDD – 2.0	V
Programmable gain amplifier		1		64	
Differential input impedance	Buffer off, PGA = 1, 2, 4, 8, 16		150/PGA		kΩ
	Buffer off, PGA = 32, 64		4.7		kΩ
	Buffer on, f_{DATA} ≤ 50Hz(1)		80		MΩ
Sensor detect current sources	SDCS[1:0] = 01		0.5		µA
	SDCS[1:0] = 10		2		µA
	SDCS[1:0] = 11		10		µA
System Performance					
Resolution		24			Bit
No missing codes	All data rates and PGA settings	24			Bit
Data rate (f_{DATA})	f_{CLKIN} = 7.68MHz	2.5		30,000	SPS(2)
Integral nonlinearity	Differential input, PGA = 1		±0.0003	±0.0010	%FSR(3)
	Differential input, PGA = 64		±0.0007		%FSR
Offset error	After calibration		On the level of the noise		
Offset drift	PGA = 1		±100		nV/°C
	PGA = 64		±4		nV/°C
Gain error	After calibration, PGA = 1, Buffer on		±0.005		%
	After calibration, PGA = 64, Buffer on		±0.03		%
Gain drift	PGA = 1		±0.8		ppm/°C
	PGA = 64		±0.8		ppm/°C
Common-mode rejection	f_{CM}(4) = 60Hz, f_{DATA} = 30kSPS(5)	95	110		dB
Noise			See Noise Performance Tables		
AVDD power-supply rejection	±5% Δ in AVDD	60	70		dB
DVDD power-supply rejection	±10% Δ in DVDD		100		dB
Voltage Reference Inputs					
Reference input voltage (V_{REF})	V_{REF} ≡ VREFP – VREFN	0.5	2.5	2.6	V
Negative reference input (VREFN)	Buffer off	AGND – 0.1		VREFP – 0.5	V
	Buffer on(6)	AGND		VREFP – 0.5	V
Positive reference input (VREFP)	Buffer off	VREFN + 0.5		AVDD + 0.1	V
	Buffer on(6)	VREFN + 0.5		AVDD – 2.0	V
Voltage reference impedance	f_{CLKIN} = 7.68MHz		18.5		kΩ
Digital Input/Output					
V_{IH}	DIN, SCLK, XTAL1/CLKIN, $\overline{SYNC}/\overline{PDWN}$, $\overline{CS}$, $\overline{RESET}$	0.8 DVDD		5.25	V
	D0/CLKOUT, D1, D2, D3	0.8 DVDD		DVDD	V
V_{IL}		DGND		0.2 DVDD	V
V_{OH}	I_{OH} = 5mA	0.8 DVDD			V
V_{OL}	I_{OL} = 5mA			0.2 DVDD	V
Input hysteresis			0.5		V
Input leakage	0 < $V_{DIGITAL\ INPUT}$ < DVDD			±10	µA
Master clock rate	External crystal between XTAL1 and XTAL2	2	7.68	10	MHz
	External oscillator driving CLKIN	0.1	7.68	10	MHz

ELECTRICAL CHARACTERISTICS (continued)

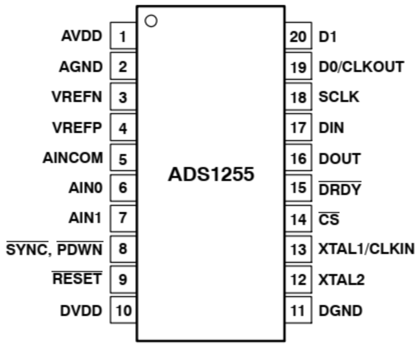
All specifications at –40°C to +85°C, AVDD = +5V, DVDD = +1.8V, f_{CLKIN} = 7.68MHz, PGA = 1, and V_{REF} = +2.5V, unless otherwise noted.

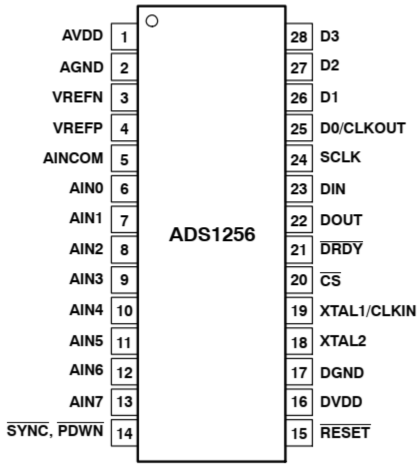
PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Power-Supply					
AVDD		4.75		5.25	V
DVDD		1.8		3.6	V
AVDD current	Power-down mode			2	μA
	Standby mode		20		μA
	Normal mode, PGA = 1, Buffer off		7	10	mA
	Normal mode, PGA = 64, Buffer off		16	22	mA
	Normal mode, PGA = 1, Buffer on		13	19	mA
	Normal mode, PGA = 64, Buffer on		36	50	mA
DVDD current	Power-down mode			2	μA
	Standby mode, CLKOUT off, DVDD = 3.3V		95		μA
	Normal mode, CLKOUT off, DVDD = 3.3V		0.9	2	mA
Power dissipation	Normal mode, PGA = 1, Buffer off, DVDD = 3.3V		38	57	mW
	Standby mode, DVDD = 3.3V		0.4		mW
Temperature Range					
Specified		–40		+85	°C
Operating		–40		+105	°C
Storage		–60		+150	°C

(1) See text for more information on input impedance.
(2) SPS = samples per second.
(3) FSR = full-scale range = $4V_{REF}$/PGA.
(4) f_{CM} is the frequency of the common-mode input signal.
(5) Placing a notch of the digital filter at 60Hz (setting f_{DATA} = 60SPS, 30SPS, 15SPS, 10SPS, 5SPS, or 2.5SPS) will further improve the common-mode rejection of this frequency.
(6) The reference input range with Buffer on is restricted only if self-calibration or gain self-calibration is to be used. If using system calibration or writing calibration values directly to the registers, the entire Buffer off range can be used.

PIN ASSIGNMENTS

SSOP PACKAGE
(TOP VIEW)





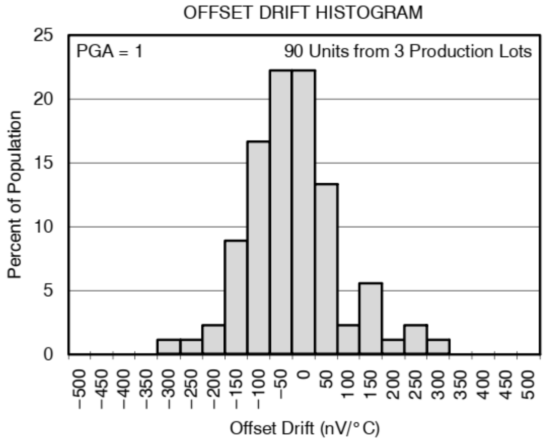
Terminal Functions

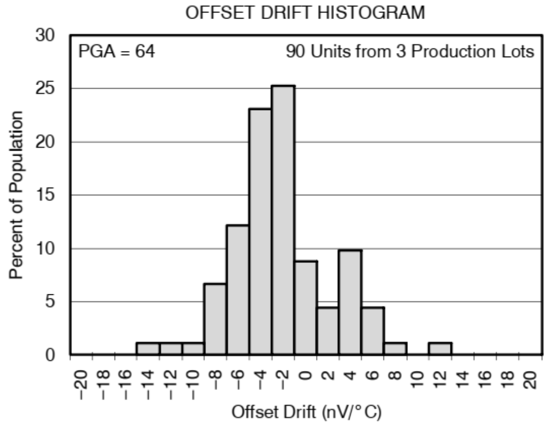
	TERMINAL NO.			
NAME	ADS1255	ADS1256	ANALOG/DIGITAL INPUT/OUTPUT	DESCRIPTION
AVDD	1	1	Analog	Analog power supply
AGND	2	2	Analog	Analog ground
VREFN	3	3	Analog input	Negative reference input
VREFP	4	4	Analog input	Positive reference input
AINCOM	5	5	Analog input	Analog input common
AIN0	6	6	Analog input	Analog input 0
AIN1	7	7	Analog input	Analog input 1
AIN2	—	8	Analog input	Analog input 2
AIN3	—	9	Analog input	Analog input 3
AIN4	—	10	Analog input	Analog input 4
AIN5	—	11	Analog input	Analog input 5
AIN6	—	12	Analog input	Analog input 6
AIN7	—	13	Analog input	Analog input 7
$\overline{\text{SYNC}}$/$\overline{\text{PDWN}}$	8	14	Digital input[1][2]: active low	Synchronization / power down input
$\overline{\text{RESET}}$	9	15	Digital input[1][2]: active low	Reset input
DVDD	10	16	Digital	Digital power supply
DGND	11	17	Digital	Digital ground
XTAL2	12	18	Digital[3]	Crystal oscillator connection
XTAL1/CLKIN	13	19	Digital/Digital input[2]	Crystal oscillator connection / external clock input
$\overline{\text{CS}}$	14	20	Digital input[1][2]: active low	Chip select
$\overline{\text{DRDY}}$	15	21	Digital output: active low	Data ready output
DOUT	16	22	Digital output	Serial data output
DIN	17	23	Digital input[1][2]	Serial data input
SCLK	18	24	Digital input[1][2]	Serial clock input
D0/CLKOUT	19	25	Digital IO[4]	Digital I/O 0 / clock output
D1	20	26	Digital IO[4]	Digital I/O 1
D2	—	27	Digital IO[4]	Digital I/O 2
D3	—	28	Digital IO[4]	Digital I/O 3

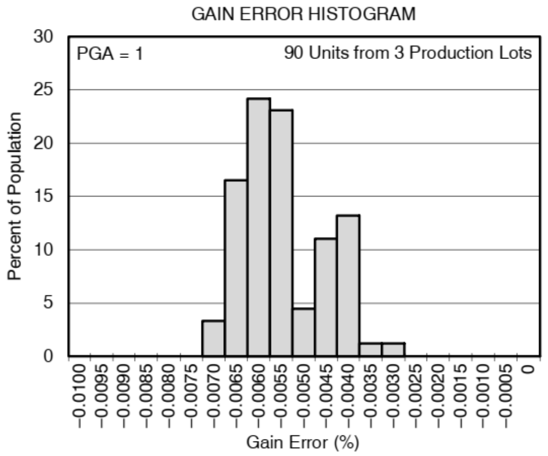
(1) Schmitt-Trigger digital input.
(2) 5V tolerant digital input.
(3) Leave disconnected if external clock input is applied to XTAL1/CLKIN.
(4) Schmitt-Trigger digital input when the digital I/O is configured as an input.

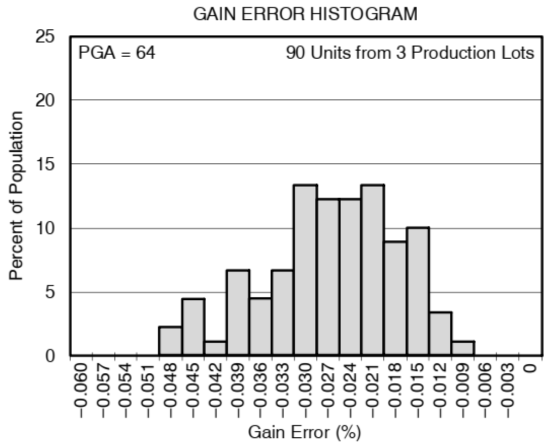
TYPICAL CHARACTERISTICS

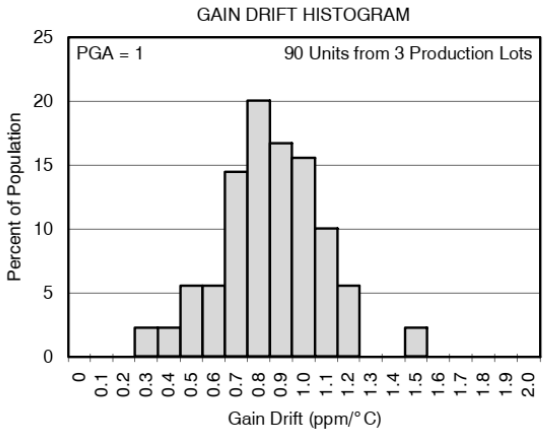
T_A = +25°C, AVDD = 5V, DVDD = 1.8V, f_{CLKIN} = 7.68MHz, PGA = 1, and V_{REF} = 2.5V, unless otherwise noted.

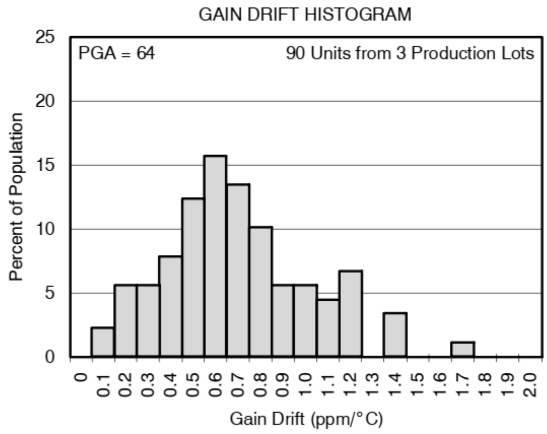






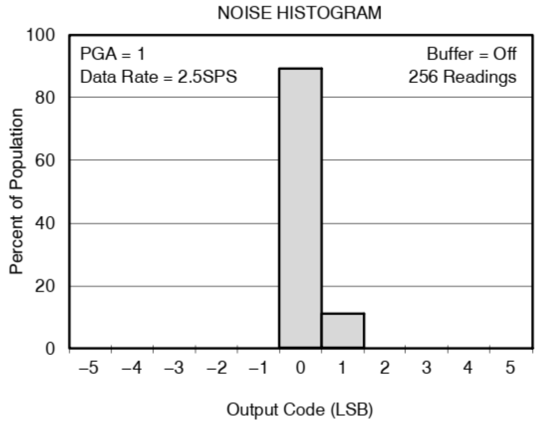


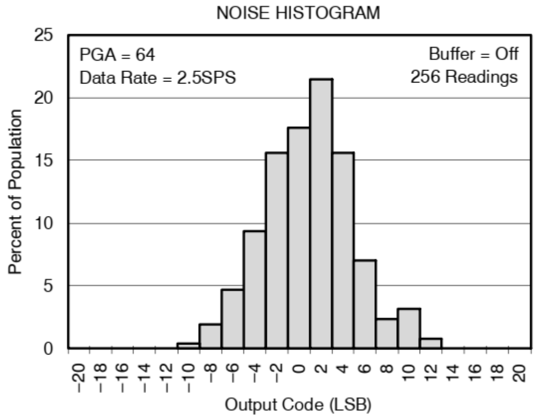


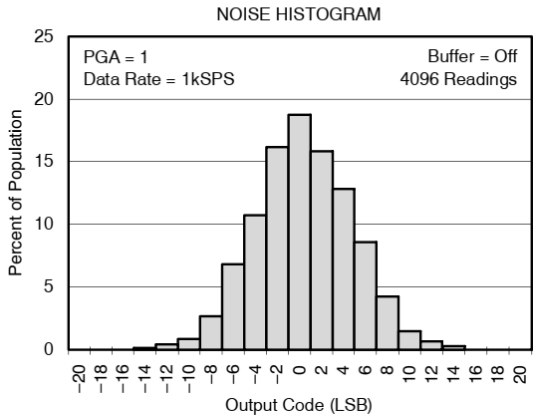


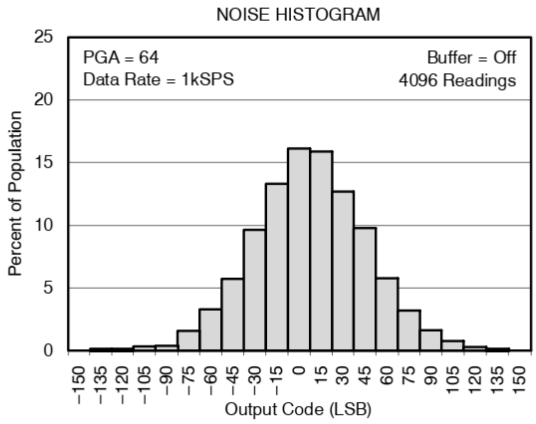
TYPICAL CHARACTERISTICS (continued)

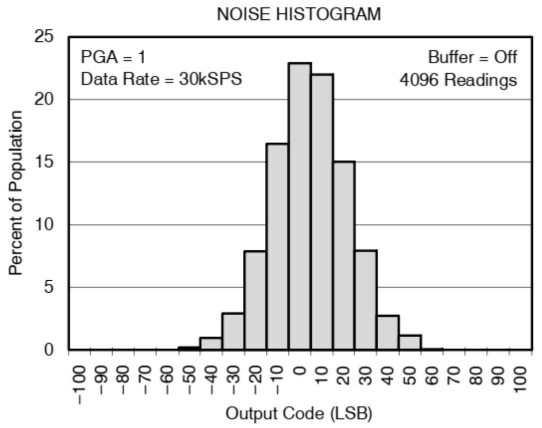
T_A = +25°C, AVDD = 5V, DVDD = 1.8V, f_{CLKIN} = 7.68MHz, PGA = 1, and V_{REF} = 2.5V, unless otherwise noted.

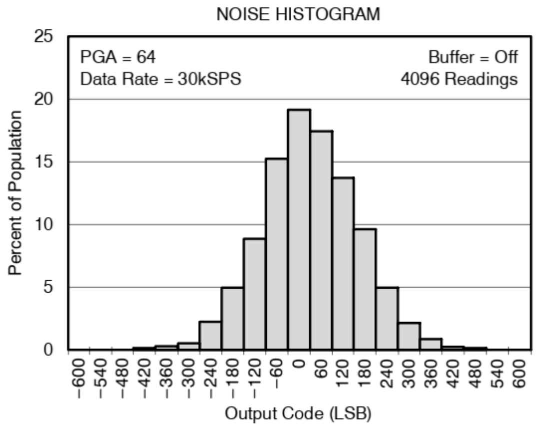












Lampiran 5. Amplifier AD620

ANALOG DEVICES

Low Cost Low Power Instrumentation Amplifier

AD620

FEATURES

Easy to use
- **Gain set with one external resistor**
  - **(Gain range 1 to 10,000)**
- **Wide power supply range (±2.3 V to ±18 V)**
- **Higher performance than 3 op amp IA designs**
- **Available in 8-lead DIP and SOIC packaging**
- **Low power, 1.3 mA max supply current**

Excellent dc performance (B grade)
- **50 μV max, input offset voltage**
- **0.6 μV/°C max, input offset drift**
- **1.0 nA max, input bias current**
- **100 dB min common-mode rejection ratio (G = 10)**

Low noise
- **9 nV/√Hz @ 1 kHz, input voltage noise**
- **0.28 μV p-p noise (0.1 Hz to 10 Hz)**

Excellent ac specifications
- **120 kHz bandwidth (G = 100)**
- **15 μs settling time to 0.01%**

APPLICATIONS

Weigh scales
ECG and medical instrumentation
Transducer interface
Data acquisition systems
Industrial process controls
Battery-powered and portable equipment

Table 1. Next Generation Upgrades for AD620

Part	Comment
AD8221	Better specs at lower price
AD8222	Dual channel or differential out
AD8226	Low power, wide input range
AD8220	JFET input
AD8228	Best gain accuracy
AD8295	+2 precision op amps or differential out
AD8429	Ultra low noise

CONNECTION DIAGRAM

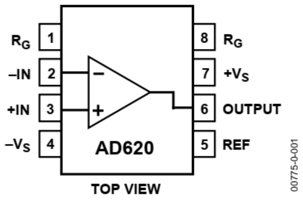


Figure 1. 8-Lead PDIP (N), CERDIP (Q), and SOIC (R) Packages

PRODUCT DESCRIPTION

The AD620 is a low cost, high accuracy instrumentation amplifier that requires only one external resistor to set gains of 1 to 10,000. Furthermore, the AD620 features 8-lead SOIC and DIP packaging that is smaller than discrete designs and offers lower power (only 1.3 mA max supply current), making it a good fit for battery-powered, portable (or remote) applications.

The AD620, with its high accuracy of 40 ppm maximum nonlinearity, low offset voltage of 50 μV max, and offset drift of 0.6 μV/°C max, is ideal for use in precision data acquisition systems, such as weigh scales and transducer interfaces. Furthermore, the low noise, low input bias current, and low power of the AD620 make it well suited for medical applications, such as ECG and noninvasive blood pressure monitors.

The low input bias current of 1.0 nA max is made possible with the use of Superϐeta processing in the input stage. The AD620 works well as a preamplifier due to its low input voltage noise of 9 nV/√Hz at 1 kHz, 0.28 μV p-p in the 0.1 Hz to 10 Hz band, and 0.1 pA/√Hz input current noise. Also, the AD620 is well suited for multiplexed applications with its settling time of 15 μs to 0.01%, and its cost is low enough to enable designs with one in-amp per channel.

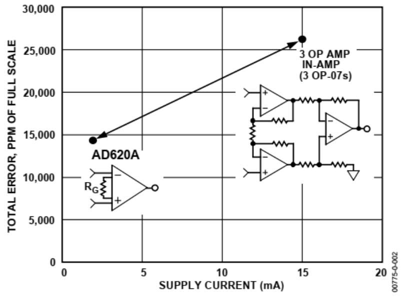


Figure 2. Three Op Amp IA Designs vs. AD620

Rev. H

One Technology Way, P.O. Box 9106, Norwood, MA 02062-9106, U.S.A.
Tel: 781.329.4700 www.analog.com
Fax: 781.326.8703

SPECIFICATIONS

Typical @ 25°C, V_S = ±15 V, and R_L = 2 kΩ, unless otherwise noted.

Table 2.

		AD620A			AD620B			AD620S[1]			
Parameter	**Conditions**	**Min**	**Typ**	**Max**	**Min**	**Typ**	**Max**	**Min**	**Typ**	**Max**	**Unit**
GAIN	G = 1 + (49.4 kΩ/R_G)										
Gain Range		1		10,000	1		10,000	1		10,000	
Gain Error[2]	V_{OUT} = ±10 V										
G = 1			0.03	0.10		0.01	0.02		0.03	0.10	%
G = 10			0.15	0.30		0.10	0.15		0.15	0.30	%
G = 100			0.15	0.30		0.10	0.15		0.15	0.30	%
G = 1000			0.40	0.70		0.35	0.50		0.40	0.70	%
Nonlinearity	V_{OUT} = −10 V to +10 V										
G = 1–1000	R_L = 10 kΩ		10	40		10	40		10	40	ppm
G = 1–100	R_L = 2 kΩ		10	95		10	95		10	95	ppm
Gain vs. Temperature											
	G = 1			10			10			10	ppm/°C
	Gain >1[2]			−50			−50			−50	ppm/°C
VOLTAGE OFFSET	(Total RTI Error = V_{OSI} + V_{OSO}/G)										
Input Offset, V_{OSI}	V_S = ±5 V to ± 15 V		30	125		15	50		30	125	μV
Overtemperature	V_S = ±5 V to ± 15 V			185			85			225	μV
Average TC	V_S = ±5 V to ± 15 V		0.3	1.0		0.1	0.6		0.3	1.0	μV/°C
Output Offset, V_{OSO}	V_S = ±15 V		400	1000		200	500		400	1000	μV
	V_S = ± 5 V			1500			750			1500	μV
Overtemperature	V_S = ±5 V to ± 15 V			2000			1000			2000	μV
Average TC	V_S = ±5 V to ± 15 V		5.0	15		2.5	7.0		5.0	15	μV/°C
Offset Referred to the Input vs. Supply (PSR)	V_S = ±2.3 V to ±18 V										
G = 1		80	100		80	100		80	100		dB
G = 10		95	120		100	120		95	120		dB
G = 100		110	140		120	140		110	140		dB
G = 1000		110	140		120	140		110	140		dB
INPUT CURRENT											
Input Bias Current			0.5	2.0		0.5	1.0		0.5	2	nA
Overtemperature				2.5			1.5			4	nA
Average TC			3.0			3.0			8.0		pA/°C
Input Offset Current			0.3	1.0		0.3	0.5		0.3	1.0	nA
Overtemperature				1.5			0.75			2.0	nA
Average TC			1.5			1.5			8.0		pA/°C
INPUT											
Input Impedance											
Differential			$10\|2$			$10\|2$			$10\|2$		GΩ_pF
Common-Mode			$10\|2$			$10\|2$			$10\|2$		GΩ_pF
Input Voltage Range[3]	V_S = ±2.3 V to ±5 V	$-V_S + 1.9$		$+V_S - 1.2$	$-V_S + 1.9$		$+V_S - 1.2$	$-V_S + 1.9$		$+V_S - 1.2$	V
Overtemperature		$-V_S + 2.1$		$+V_S - 1.3$	$-V_S + 2.1$		$+V_S - 1.3$	$-V_S + 2.1$		$+V_S - 1.3$	V
	V_S = ± 5 V to ±18 V	$-V_S + 1.9$		$+V_S - 1.4$	$-V_S + 1.9$		$+V_S - 1.4$	$-V_S + 1.9$		$+V_S - 1.4$	V
Overtemperature		$-V_S + 2.1$		$+V_S - 1.4$	$-V_S + 2.1$		$+V_S + 2.1$	$-V_S + 2.3$		$+V_S - 1.4$	V

ABSOLUTE MAXIMUM RATINGS

Table 3.

Parameter	Rating
Supply Voltage	±18 V
Internal Power Dissipation[1]	650 mW
Input Voltage (Common-Mode)	$\pm V_S$
Differential Input Voltage	25 V
Output Short-Circuit Duration	Indefinite
Storage Temperature Range (Q)	−65°C to +150°C
Storage Temperature Range (N, R)	−65°C to +125°C
Operating Temperature Range	
AD620 (A, B)	−40°C to +85°C
AD620 (S)	−55°C to +125°C
Lead Temperature Range	
(Soldering 10 seconds)	300°C

[1] Specification is for device in free air:
8-Lead Plastic Package: θ_{JA} = 95°C
8-Lead CERDIP Package: θ_{JA} = 110°C
8-Lead SOIC Package: θ_{JA} = 155°C

Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only; functional operation of the device at these or any other condition s above those indicated in the operational section of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ESD CAUTION

ESD (electrostatic discharge) sensitive device. Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

TYPICAL PERFORMANCE CHARACTERISTICS

(@ 25°C, V_S = ±15 V, R_L = 2 kΩ, unless otherwise noted.)

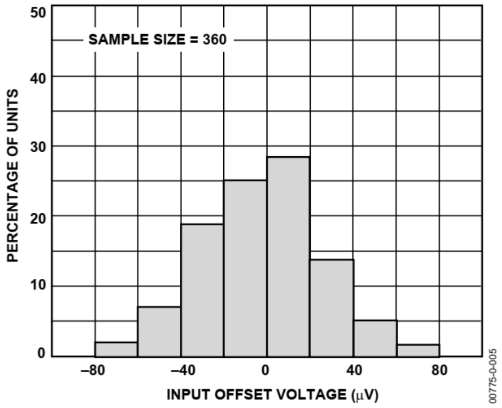


Figure 3. Typical Distribution of Input Offset Voltage

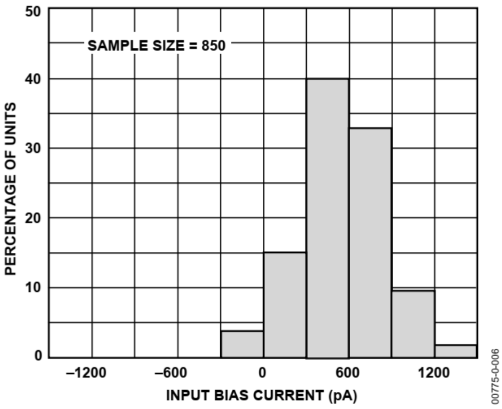


Figure 4. Typical Distribution of Input Bias Current

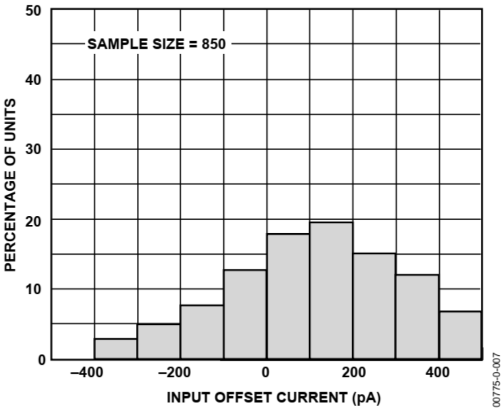


Figure 5. Typical Distribution of Input Offset Current

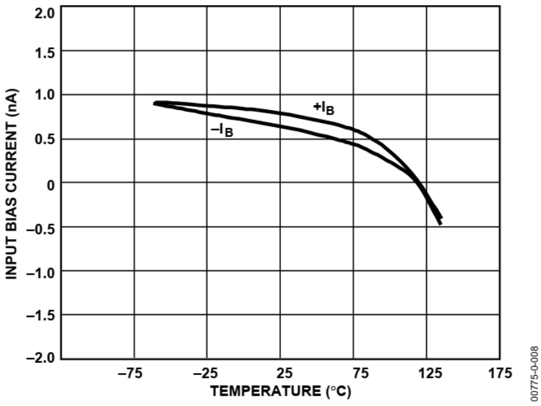


Figure 6. Input Bias Current vs. Temperature

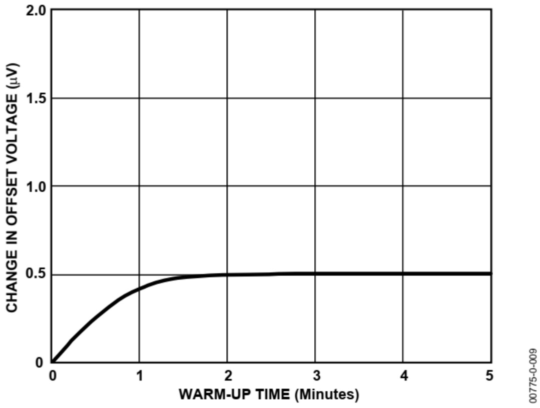


Figure 7. Change in Input Offset Voltage vs. Warm-Up Time

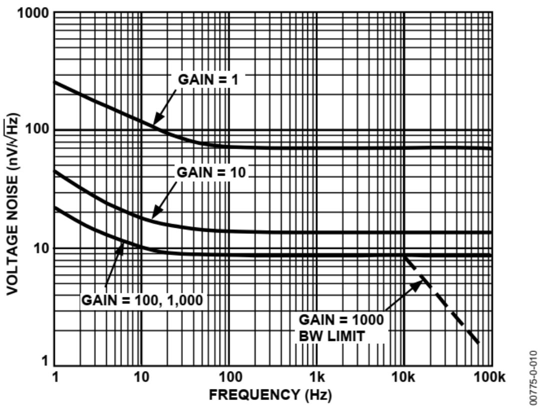


Figure 8. Voltage Noise Spectral Density vs. Frequency (G = 1−1000)

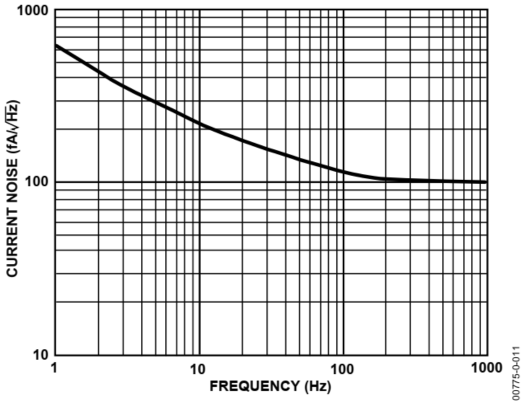


Figure 9. Current Noise Spectral Density vs. Frequency

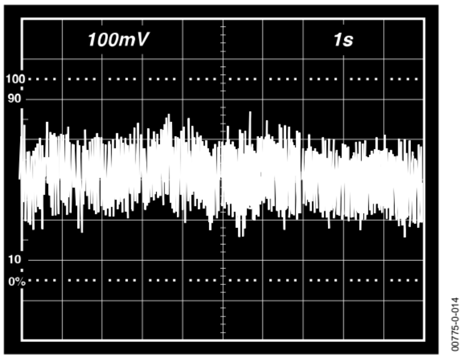


Figure 12. 0.1 Hz to 10 Hz Current Noise, 5 pA/Div

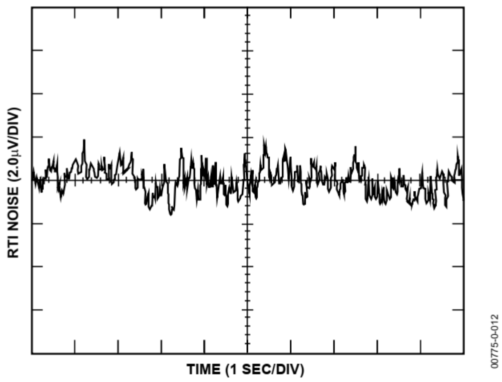


Figure 10. 0.1 Hz to 10 Hz RTI Voltage Noise (G = 1)

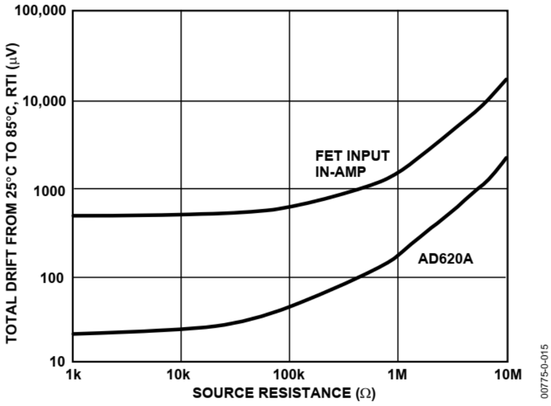


Figure 13. Total Drift vs. Source Resistance

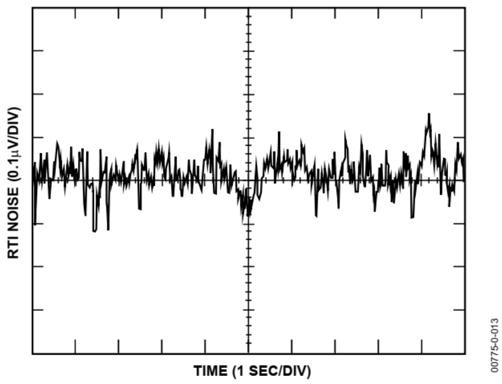


Figure 11. 0.1 Hz to 10 Hz RTI Voltage Noise (G = 1000)

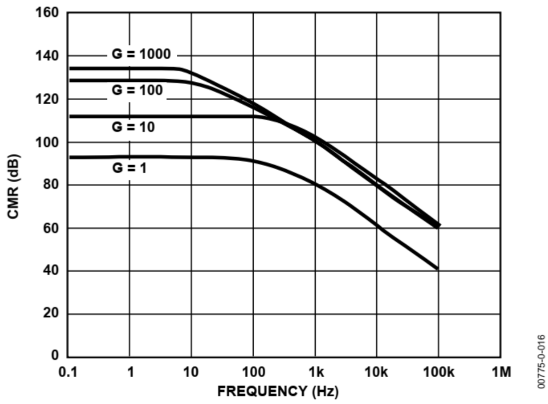


Figure 14. Typical CMR vs. Frequency, RTI, Zero to 1 kΩ Source Imbalance

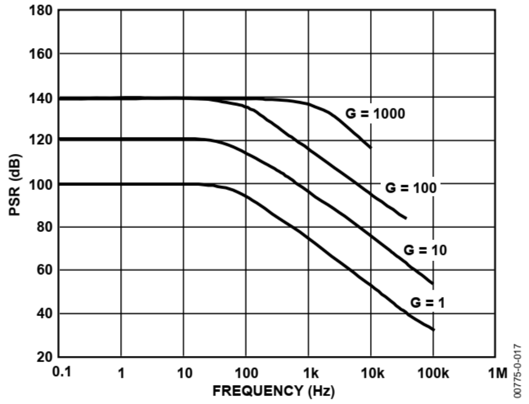


Figure 15. Positive PSR vs. Frequency, RTI (G = 1–1000)

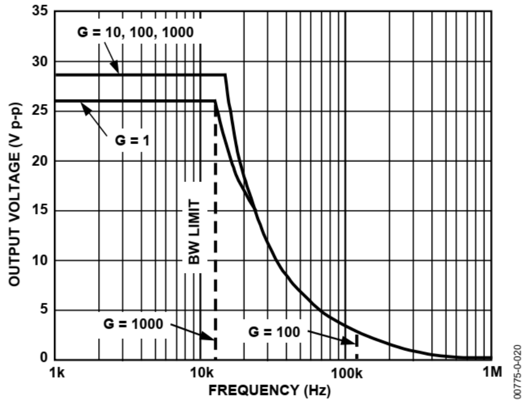


Figure 18. Large Signal Frequency Response

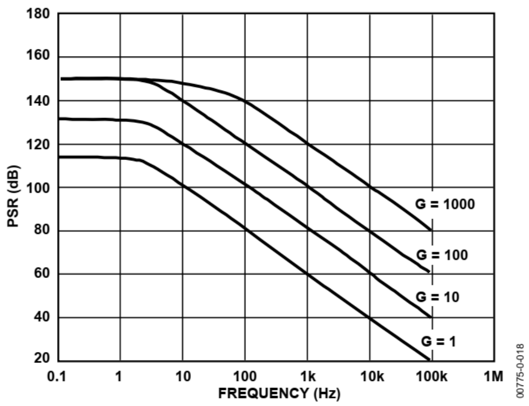


Figure 16. Negative PSR vs. Frequency, RTI (G = 1–1000)

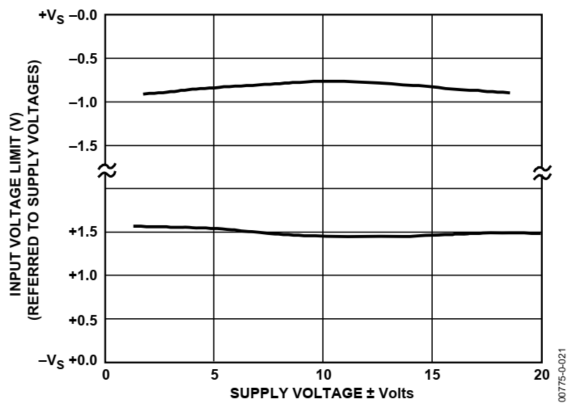


Figure 19. Input Voltage Range vs. Supply Voltage, G = 1

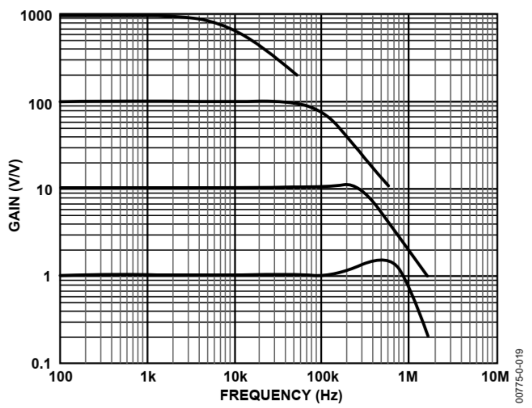


Figure 17. Gain vs. Frequency

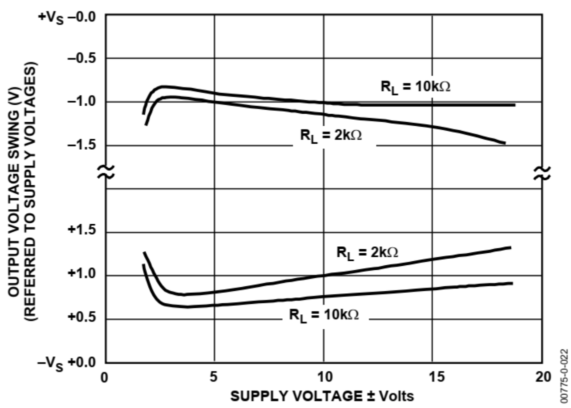


Figure 20. Output Voltage Swing vs. Supply Voltage, G = 10

THEORY OF OPERATION

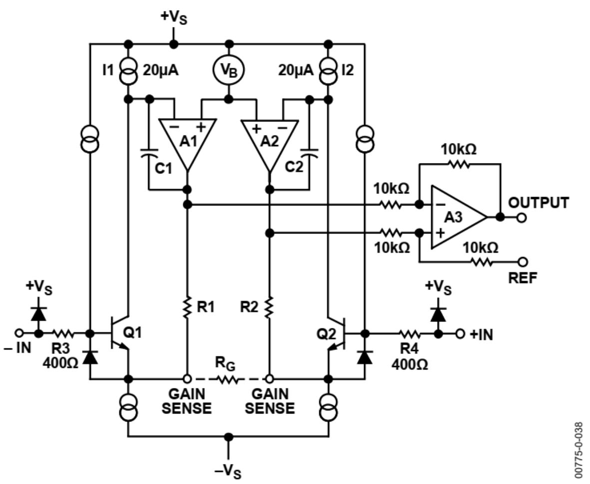


Figure 36. Simplified Schematic of AD620

The AD620 is a monolithic instrumentation amplifier based on a modification of the classic three op amp approach. Absolute value trimming allows the user to program gain *accurately* (to 0.15% at G = 100) with only one resistor. Monolithic construction and laser wafer trimming allow the tight matching and tracking of circuit components, thus ensuring the high level of performance inherent in this circuit.

The input transistors Q1 and Q2 provide a single differential-pair bipolar input for high precision (Figure 36), yet offer 10× lower input bias current thanks to Superβeta processing. Feedback through the Q1-A1-R1 loop and the Q2-A2-R2 loop maintains constant collector current of the input devices Q1 and Q2, thereby impressing the input voltage across the external gain setting resistor R_G. This creates a differential gain from the inputs to the A1/A2 outputs given by $G = (R1 + R2)/R_G + 1$. The unity-gain subtractor, A3, removes any common-mode signal, yielding a single-ended output referred to the REF pin potential.

The value of R_G also determines the transconductance of the preamp stage. As R_G is reduced for larger gains, the transconductance increases asymptotically to that of the input transistors. This has three important advantages: (a) Open-loop gain is boosted for increasing programmed gain, thus reducing gain related errors. (b) The gain-bandwidth product (determined by C1 and C2 and the preamp transconductance) increases with programmed gain, thus optimizing frequency response. (c) The input voltage noise is reduced to a value of 9 nV/√Hz, determined mainly by the collector current and base resistance of the input devices.

The internal gain resistors, R1 and R2, are trimmed to an absolute value of 24.7 kΩ, allowing the gain to be programmed accurately with a single external resistor.

The gain equation is then

$$G = \frac{49.4k\Omega}{R_G} + 1$$

$$R_G = \frac{49.4k\Omega}{G-1}$$

Make vs. Buy: a Typical Bridge Application Error Budget

The AD620 offers improved performance over "homebrew" three op amp IA designs, along with smaller size, fewer components, and 10× lower supply current. In the typical application, shown in Figure 37, a gain of 100 is required to amplify a bridge output of 20 mV full-scale over the industrial temperature range of −40°C to +85°C. Table 4 shows how to calculate the effect various error sources have on circuit accuracy.

Regardless of the system in which it is being used, the AD620 provides greater accuracy at low power and price. In simple systems, absolute accuracy and drift errors are by far the most significant contributors to error. In more complex systems with an intelligent processor, an autogain/autozero cycle removes all absolute accuracy and drift errors, leaving only the resolution errors of gain, nonlinearity, and noise, thus allowing full 14-bit accuracy.

Note that for the homebrew circuit, the OP07 specifications for input voltage offset and noise have been multiplied by √2. This is because a three op amp type in-amp has two op amps at its inputs, both contributing to the overall input error.

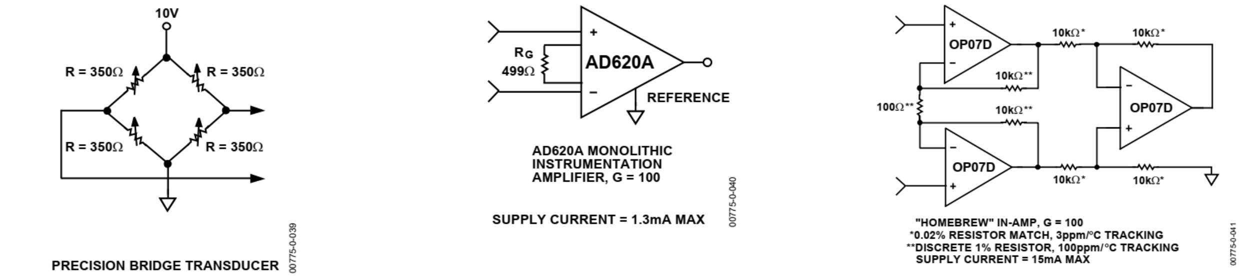


Figure 37. Make vs. Buy

Table 4. Make vs. Buy Error Budget

Error Source	AD620 Circuit Calculation	"Homebrew" Circuit Calculation	Error, ppm of Full Scale AD620	Error, ppm of Full Scale Homebrew
ABSOLUTE ACCURACY at T_A = 25°C				
Input Offset Voltage, µV	125 µV/20 mV	(150 µV × √2)/20 mV	6,250	10,607
Output Offset Voltage, µV	1000 µV/100 mV/20 mV	((150 µV × 2)/100)/20 mV	500	150
Input Offset Current, nA	2 nA ×350 Ω/20 mV	(6 nA ×350 Ω)/20 mV	18	53
CMR, dB	110 dB(3.16 ppm) ×5 V/20 mV	(0.02% Match × 5 V)/20 mV/100	791	500
		Total Absolute Error	7,559	11,310
DRIFT TO 85°C				
Gain Drift, ppm/°C	(50 ppm + 10 ppm) ×60°C	100 ppm/°C Track × 60°C	3,600	6,000
Input Offset Voltage Drift, µV/°C	1 µV/°C × 60°C/20 mV	(2.5 µV/°C × √2 × 60°C)/20 mV	3,000	10,607
Output Offset Voltage Drift, µV/°C	15 µV/°C × 60°C/100 mV/20 mV	(2.5 µV/°C × 2 × 60°C)/100 mV/20 mV	450	150
		Total Drift Error	7,050	16,757
RESOLUTION				
Gain Nonlinearity, ppm of Full Scale	40 ppm	40 ppm	40	40
Typ 0.1 Hz to 10 Hz Voltage Noise, µV p-p	0.28 µV p-p/20 mV	(0.38 µV p-p × √2)/20 mV	14	27
		Total Resolution Error	54	67
		Grand Total Error	14,663	28,134

G = 100, V_S = ±15 V.
(All errors are min/max and referred to input.)

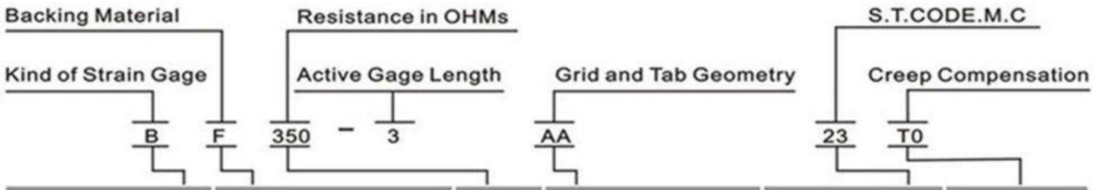
Lampiran 6. Data sheet strain gauge BF350

Introduction

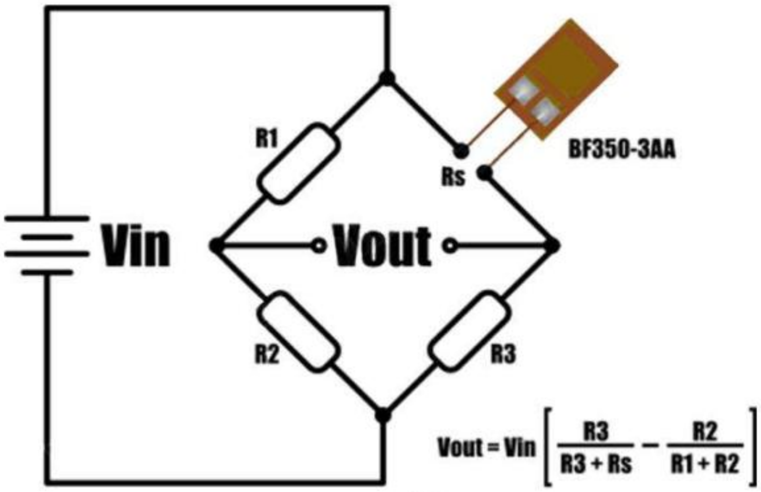
A resistive strain gauge sensor with a 350-ohm nominal resistance which varies when a force is applied. By measuring the change in the sensor's resistance, a measurement of the force applied to it can be obtained. The strain gauges exhibit small changes in resistance. Usually used in general metal materials and other similar elastomers.

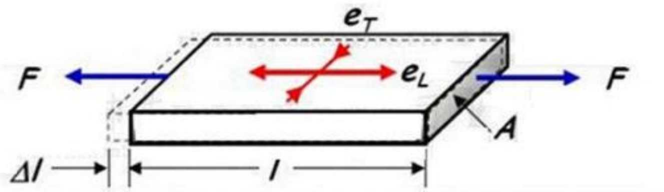
Parameters

Type	BF350-3 AA
Resistance	350 Ω (typ.)
The Basal Material	Epoxy-Modified Phenolic
Basal Material Thickness	32±1(um)
Grid Material	Constantan
Insulation resistance	10000 Ω
Sensitivity Coefficient	2.1
Sensitivity Coefficient Dispersion	⩽±1%
Transverse effect coefficient	0.4%
Strain Limit	2.0%
Fatigue Lifetime	⩾1M
Size	7.1 X 4.5mm/0.28 X 0.18inch(L*W)
Working Temperature	-30~+80℃
Temperature Compensation	Aluminium
Temperature Compensation Coefficient	9,11,16,23,27



B	Foil	F	Phenolices	120 175 350 500 700 1000 1500	AA	Homo taxial	Steel	11	T5 T3 T1 T8 T6 T4 N4 N6 N8 N0 N1 N3 N5 N7 N9 → creep minus → positive
		H X	Epoxy		HA	45° Indented Slice			
T	Specific use	A	Polyimide		GB	Sewmi-bridge Slice	Al	23	
					FG	Full-bridge Slice			
		B	Reinforced Laminated Epoxy		KA	Wafer Slice	Stainless Steel	16	





Material resistivity

$$R = \frac{\rho l}{A}$$

← Element length

← Cross section area

$$\Delta R = \left(\frac{\partial R}{\partial l}\right)\Delta l + \left(\frac{\partial R}{\partial A}\right)\Delta A + \left(\frac{\partial R}{\partial \rho}\right)\Delta$$

Lampiran 7. Data sheet Adhesive Strain gauge CC-33A

IM-G-007d '07.3

CC-33A Adhesive for KYOWA Strain Gages
INSTRUCTION MANUAL

Thank you for purchasing this KYOWA product. Before using it, please read this instruction manual carefully. Also, keep the manual within easy reach so that you can refer to it whenever necessary.

1. Safety precautions

Be sure to observe the following safety precautions when using the adhesive.

[First-aid action]

⚠ If such thing has happened that a finger is bonded to another, softly rub them together in warm water till they get apart. And if the adhesive gets in the eye, immediately wash the eye with water, then see an eye doctor. Never detach bonded fingers forcibly nor rub the eye.

[Safety precautions]

- Maintain proper ventilation while handling the adhesive. Especially when handling for a long time or a large amount of it, wear a protective mask.
- Avoid skin contact with the adhesive because it forms an immediate tenacious bond. Also, wear eyeglasses to keep the adhesive out of the eyes.
- The adhesive falls under Class 3 Petroleum (Danger Class III) in Danger Materials Class 4 provided for by the Fire Laws. Do NOT use the adhesive where there is fire.
- If a large amount of adhesive has soaked into gloves – cloth or leather - and clothing, it may suddenly generate heat to cause a burn. Take care to avoid this harm.
- To store the adhesive, keep it from the direct rays of the sun, moisture and basic materials (such as curing agents and amine).
- For disposal, seal the adhesive hermetically and have a qualified industrial disposal agent to handle as industrial waste (nonflammable).
- Keep the adhesive out of children's reach.
- Do NOT use it for other than bonding.

2. Outline

CC-33A is a cyanoacrylate instantaneous adhesive. It is suitable for bonding general-use strain gages (such as KFG and KFR) for measurement chiefly at normal temperature.

Hardening of the adhesive is complete only by giving finger pressure for a short time (60 seconds or less, normally). As such, the adhesive is very useful where continuous pressing or heating of the gage installation is difficult as with large structures or where it is wanted to measure soon after gage was bonded.

3. How to use

■ Preparing the bonding surface

(1) Using sand paper (#300 to 600, or thereabouts), polish the bonding surface of a measurement object to make it flat and smooth.

(2) Clean the bonding surface of a measurement object by wiping in one direction only with industrial tissue damped with a solvent (acetone, isopropanol, etc.).

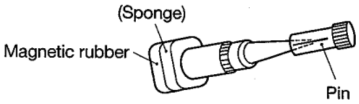
(3) Scribe the gage guidelines on the measuring area, using a lead pencil (whose hardness is 4 to 6H) or the like.

■ Preparing the adhesive

(1) Push the accessory magnetic rubber onto the bottom of the CC-33A container. This will prevent the container from falling.

Precaution: The bottom of the container is a screw cap. Do not turn it strongly, or it may be removed. Also, do not turn the container and magnetic rubber to assemble or disassemble them. Or otherwise, the cap may be loosened, resulting in liquid leakage..

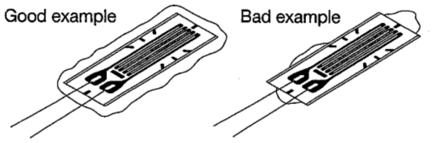
(2) Using a fingertip, flip the liquid staying at the top of container. Then, using the accessory pin, make a hole on the top while taking care not to direct the top to your face. (The liquid may spring out.) After use, insert the pin into the hole as a cap.



(3) Use the accessory micronozzle as required to bond a small base gage, etc.

■ Bonding a strain gage

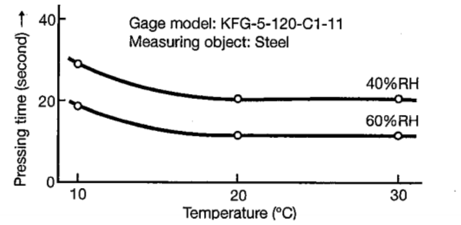
(1) Apply a small amount of CC-33A to the back of the gage. (The proper amount of adhesive applied will overflow the bonded gage base as illustrated in the sketch below.)



(2) Align the gage center mark with the scribed line, cover the gage surface with a polyethylene sheet, and give fingertip pressure to let it adhere to the measurement surface closely. Optimum pressure: 100 to 300kPa (Reference value: app. 1 to 3kgf/cm²).

(3) Required pressing time varies according to temperature and humidity. It is normally 15 to 60 seconds. (See the diagram below.)

CC-33A: Pressing time required for curing



(4) After pressing, leave the gage installation as it is for about 0.5 hours, and it will enable high-stability measurement. But, leave the gage installation as it is for 24 hours at least if high measuring accuracy is desired.

(5) After use, clean the top of the adhesive container with a cloth or the like to prevent the adhesive from fastening at the top, and hermetically seal it. For storage, put the container in an aluminum bag and keep it in a dark and cool (below 10°C) place (except a freezing box).

■ Other cautions

(1) If the temperature at the measuring area is low, give pressure for a longer time. Also, if the temperature is below 10°C, heat the measuring area preliminarily as much as possible, and use S-7 hardening agent together.

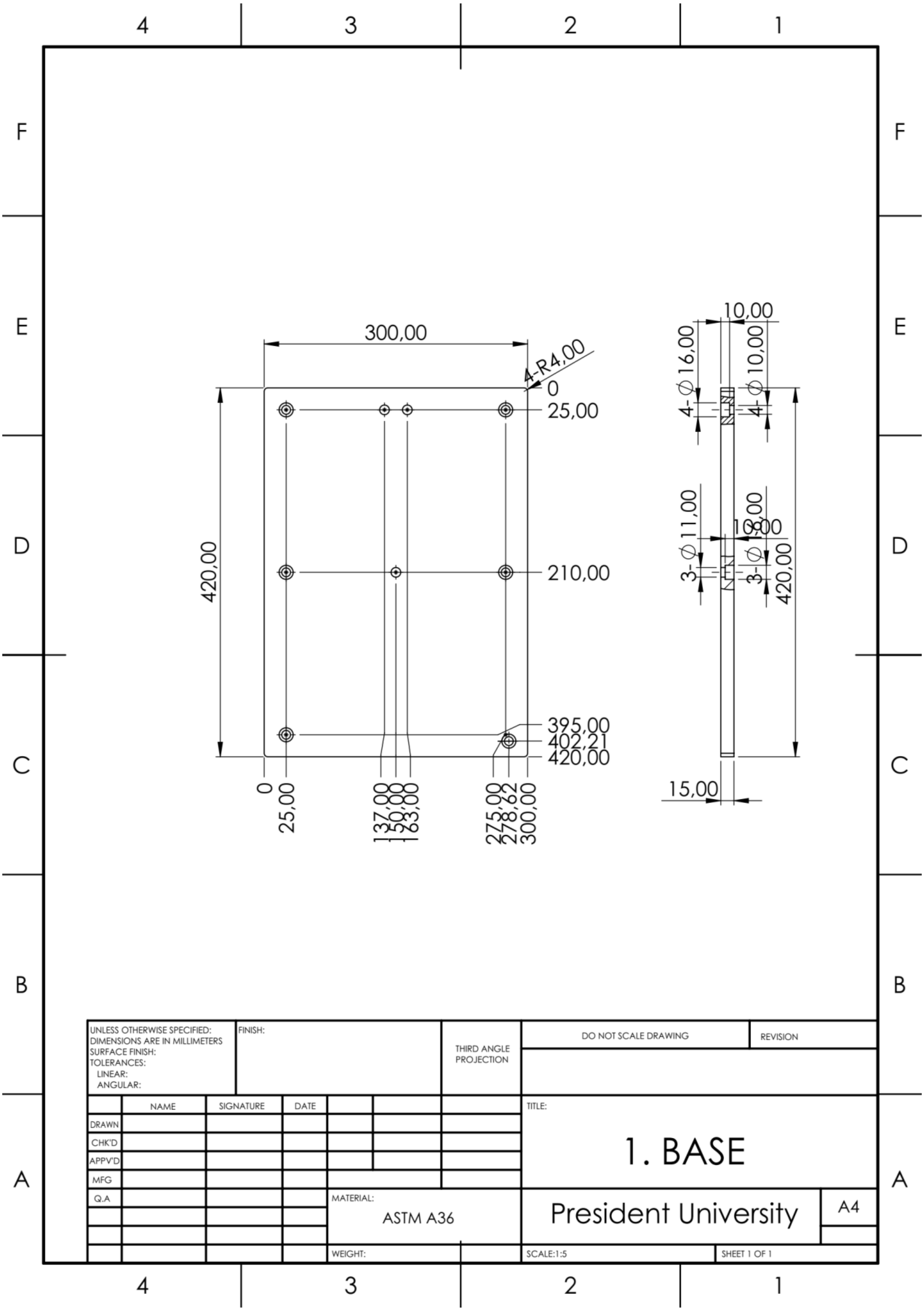
(2) For gage bonding to polyethylene, polypropylene, etc., also use S-9 surface preparation agent.

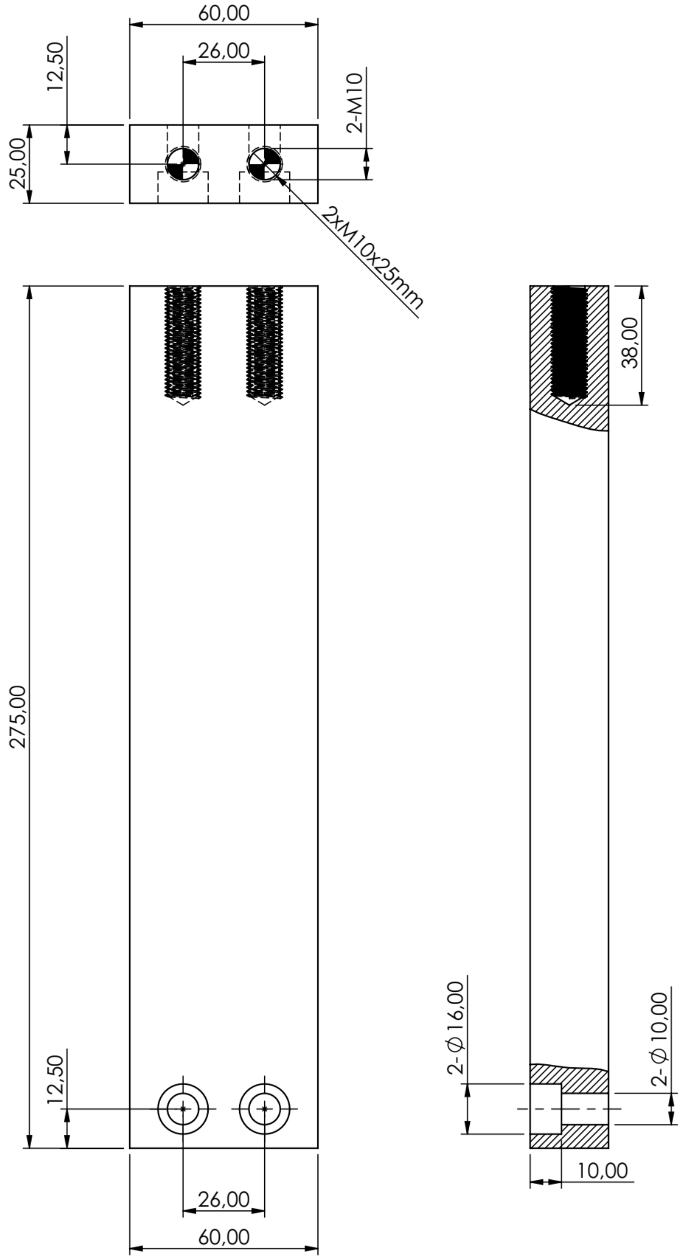
4. General characteristics of CC-33A

Ingredients:	2-Ethyl cyanoacrylate
Appearance, etc.:	Colorless, transparent liquid w/stimulative smell
Operating temperature range after curing:	–196 to 120°C
Dilution agent:	N/A (Exfoliation agent after curing: acetone)

KYOWA
KYOWA ELECTRONIC INSTRUMENTS CO., LTD.
Overseas Department:
Address: 1-22-14, Toranomon, Minato-ku, Tokyo 105-0001 Phone: 03-3502-3553 Fax: 03-3502-3678

Lampiran 8. Gambar komponen DWT (Drop Weight Test)





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TOLERANCES:
LINEAR:
ANGULAR:

FINISH:

THIRD ANGLE PROJECTION

DO NOT SCALE DRAWING

REVISION

	NAME	SIGNATURE	DATE
DRAWN			
CHK'D			
APPV'D			
MFG			
Q.A			

TITLE:

2. FRAME 1

MATERIAL: ASTM A29

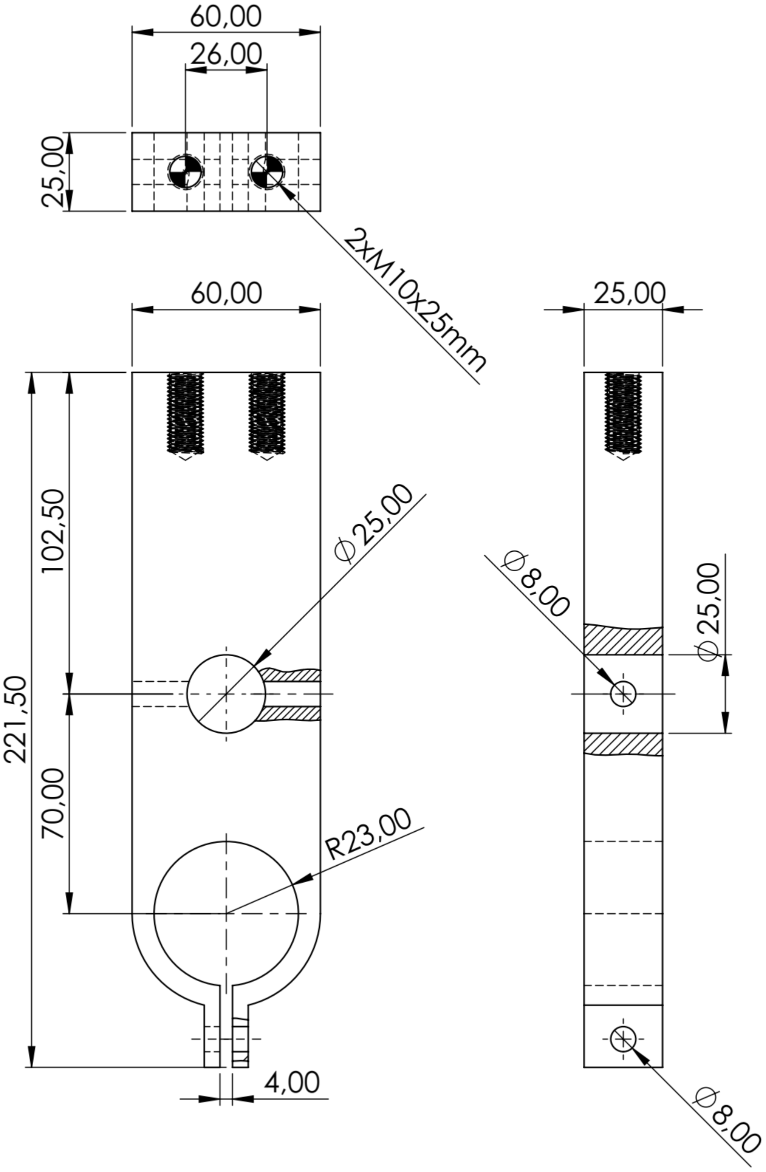
DWG NO. President University

A4

WEIGHT:

SCALE:1:2

SHEET 2 OF 3



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3. FRAME 2

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ASTM A29

President University

A4

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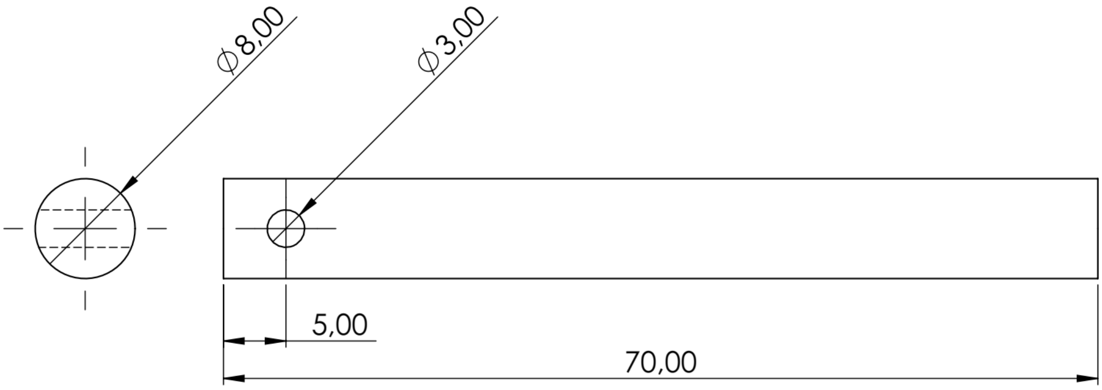
SCALE:1:2

SHEET 1 OF 1



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APPV'D			
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TITLE:

4. Pin

MATERIAL: ASTM A29

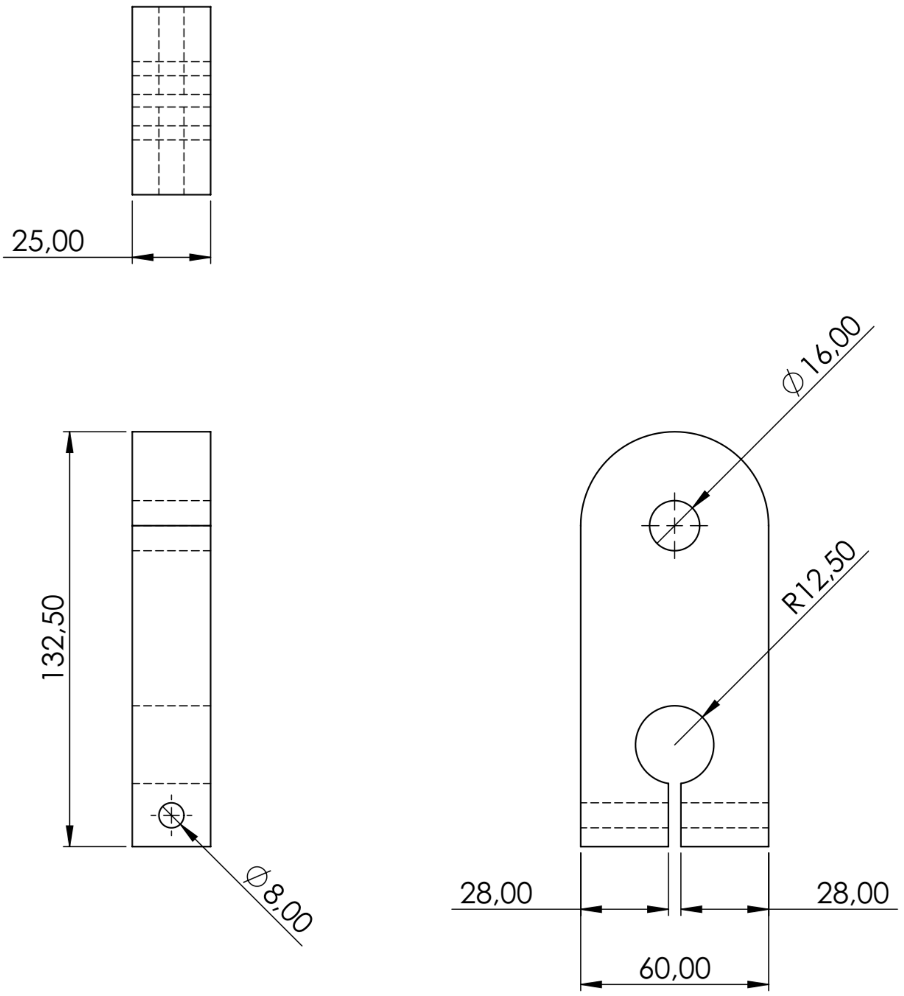
President University

A4

WEIGHT:

SCALE:2:1

SHEET 1 OF 1



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TITLE:

5. Guide Arm

MATERIAL:
ASTM A29

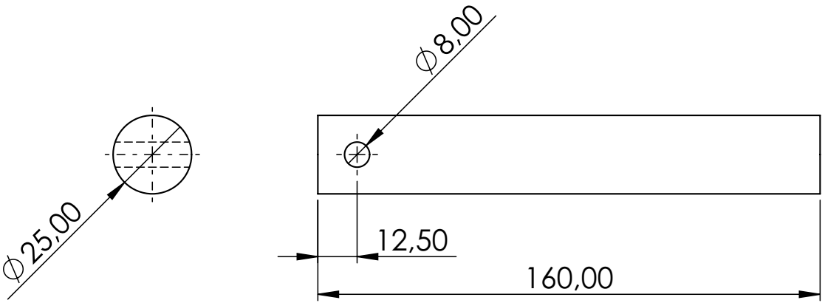
President University

A4

WEIGHT:

SCALE:1:2

SHEET 1 OF 1



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DO NOT SCALE DRAWING

REVISION

	NAME	SIGNATURE	DATE
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CHK'D			
APPV'D			
MFG			
Q.A			

TITLE:

6. Axis

MATERIAL:
ASTM A29

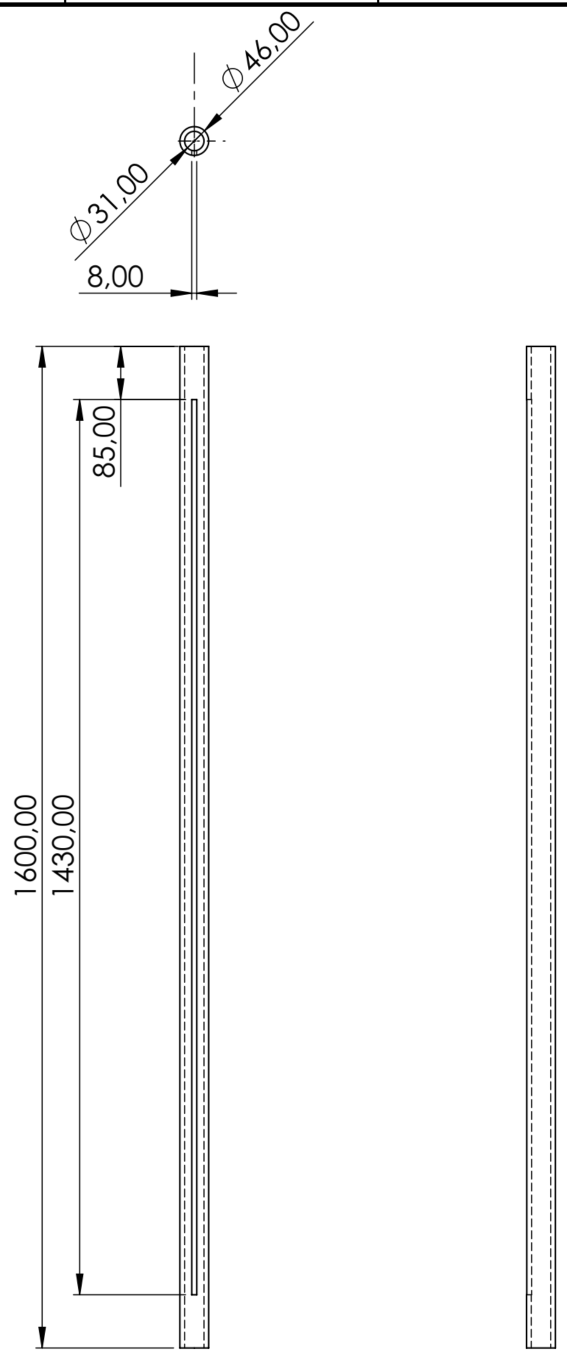
President University

A4

WEIGHT:

SCALE:1:2

SHEET 1 OF 1



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CHK'D			
APPV'D			
MFG			
Q.A			

TITLE:

7. Pipe for Mass

MATERIAL: Aluminium

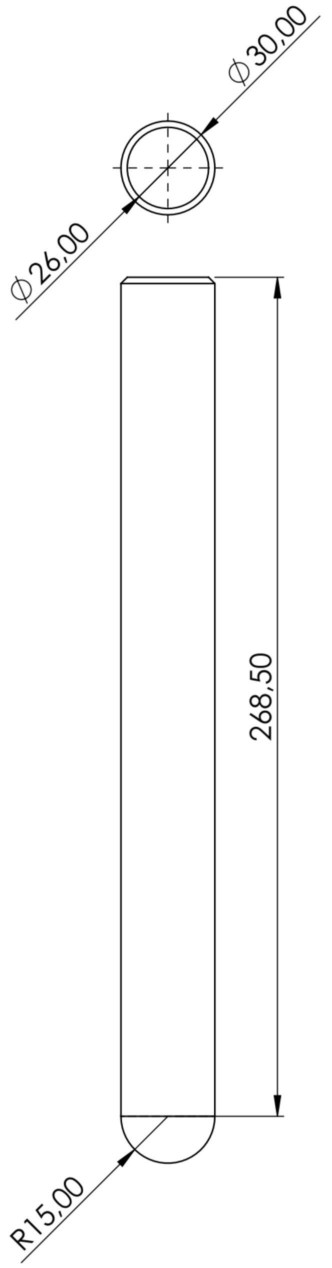
President University

A4

WEIGHT:

SCALE:1:10

SHEET 1 OF 1



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CHK'D			
APPV'D			
MFG			
Q.A			

TITLE:

8. Mass

MATERIAL: ASTM A29

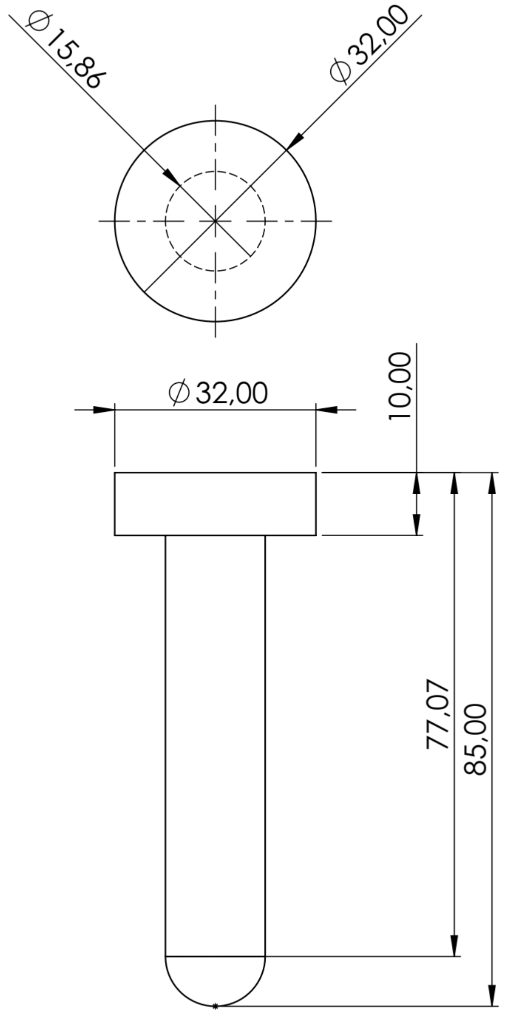
President University

A4

WEIGHT:

SCALE:1:2

SHEET 1 OF 1



UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MILLIMETERS
SURFACE FINISH:
TOLERANCES:
LINEAR:
ANGULAR:

FINISH:

THIRD ANGLE PROJECTION

DO NOT SCALE DRAWING

REVISION

	NAME	SIGNATURE	DATE
DRAWN			
CHK'D			
APPV'D			
MFG			
Q.A			

TITLE:

9. Striker

MATERIAL: ASTM A29

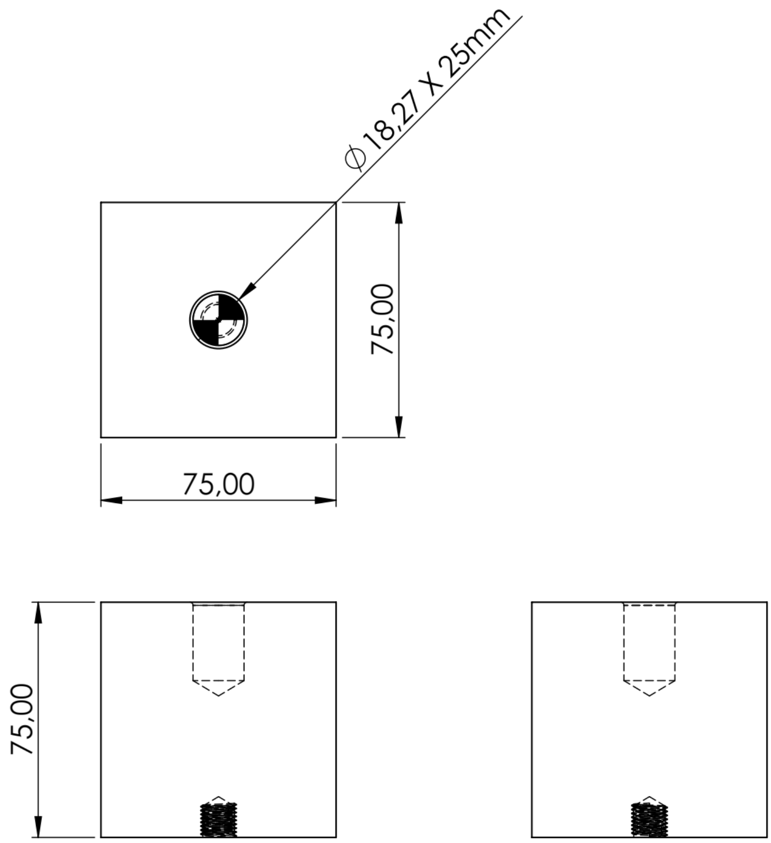
DWG NO. President University

A4

WEIGHT:

SCALE:1:1

SHEET 1 OF 1



UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MILLIMETERS
SURFACE FINISH:
TOLERANCES:
LINEAR:
ANGULAR:

FINISH:

THIRD ANGLE PROJECTION

DO NOT SCALE DRAWING

REVISION

	NAME	SIGNATURE	DATE
DRAWN			
CHK'D			
APPV'D			
MFG			
Q.A			

TITLE:

10. Speciment Support Anvil

MATERIAL: ASTM A29

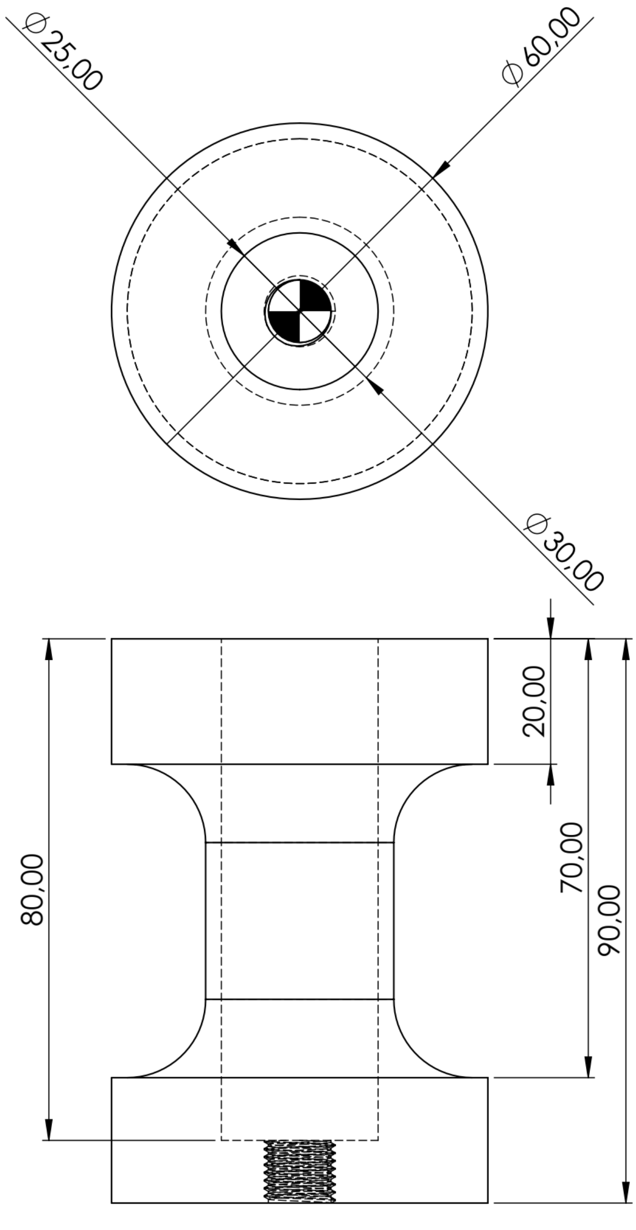
DWG NO. President University

A4

WEIGHT:

SCALE:1:2

SHEET 1 OF 1



UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MILLIMETERS
SURFACE FINISH:
TOLERANCES:
LINEAR:
ANGULAR:

FINISH:

THIRD ANGLE PROJECTION

DO NOT SCALE DRAWING

REVISION

	NAME	SIGNATURE	DATE
DRAWN			
CHK'D			
APPV'D			
MFG			
Q.A			

TITLE:

11. LoadCell

MATERIAL:
ASTM A29

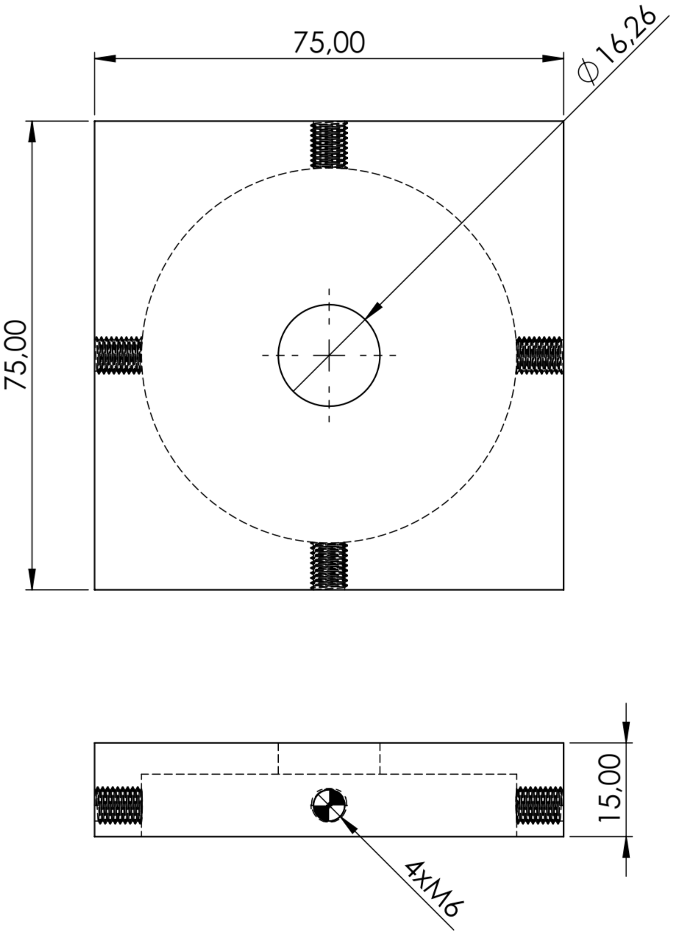
President University

A4

WEIGHT:

SCALE:1:1

SHEET 1 OF 1



UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MILLIMETERS
SURFACE FINISH:
TOLERANCES:
LINEAR:
ANGULAR:

FINISH:

THIRD ANGLE PROJECTION

DO NOT SCALE DRAWING

REVISION

	NAME	SIGNATURE	DATE
DRAWN			
CHK'D			
APPV'D			
MFG			
Q.A			

TITLE:

12. Cap Load Cell

MATERIAL:
ASTM A29

President University

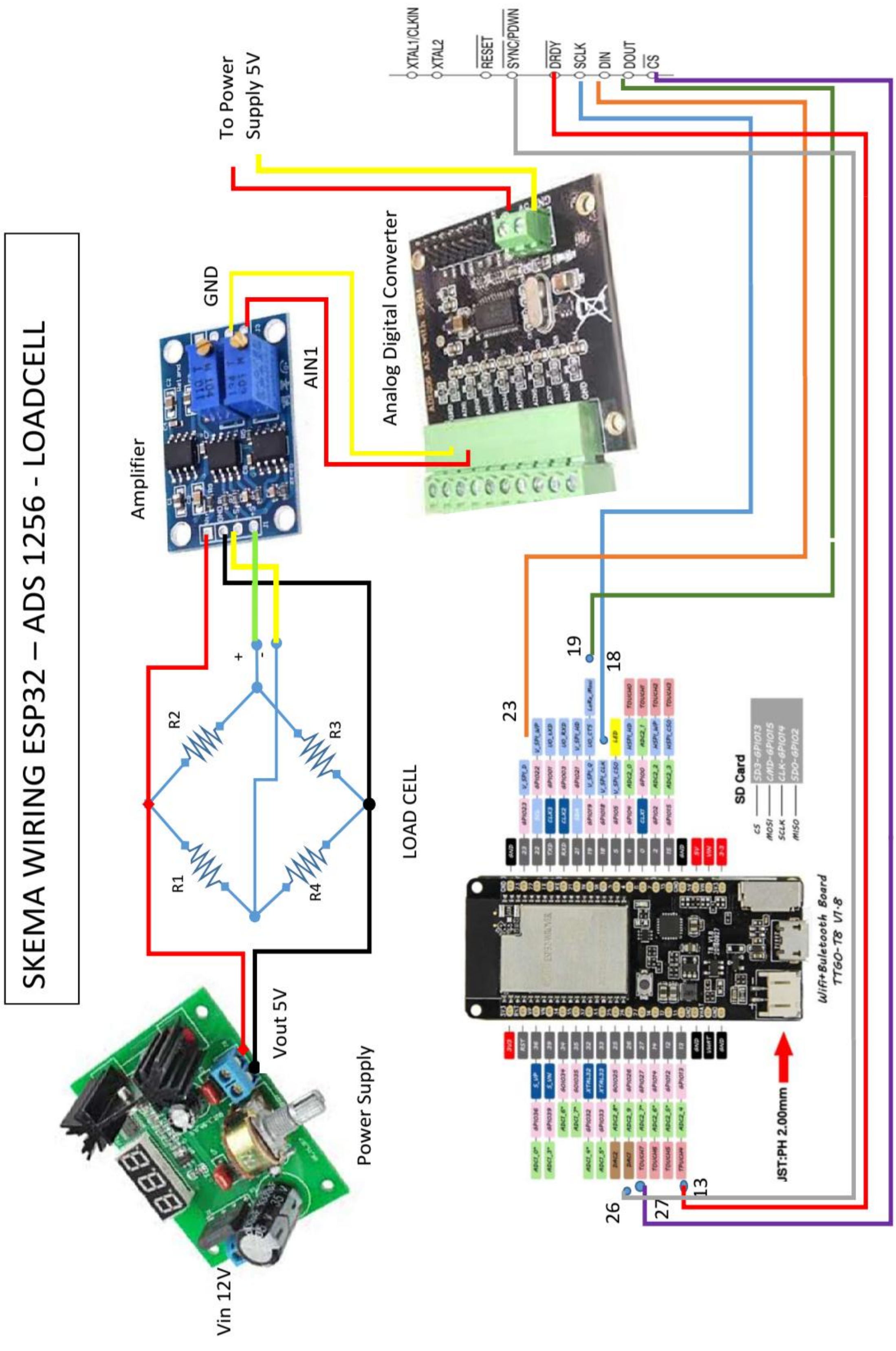
A4

WEIGHT:

SCALE:1:1

SHEET 1 OF 1

Lampiran 9. Rangkaian Arduino ADS1256



Lampiran 10. Program Arduino

```
/*
    ADS1256 + Loadcell + ESP32
    Library used in this projet:
        -ADS1256: https://curiousscientist.tech/ads1256-custom-library Reference:
        -https://curiousscientist.tech/ads1256-custom-library

-https://www.youtube.com/watch?v=CSCI_Au-TRw&t=1475s&ab_channel=CuriousScientist      Log:
        -Version 1.0 Basic reading digital to voltage
        -Version 1.1 Add rate and factor functionality
        -Version 1.2 Fixing bug, add moving average
        -Version 1.5 Change microcontroller
        -Version 1.6 Add interrupt
*/

#include <ADS1256.h>

// Moving Average Stuff //
#define BUFFER_SIZE 5  // Moving average point number long
buffer[BUFFER_SIZE];

// Scale Stuff
long tareOffset = 0;                    // Variable to store offset value
const float scaleFactor = 1.0;                  // Variable to store scale factor value bool
startReading = false;                           // Variable to store start reading volatile bool
ADSIsReady = false;  // Variable to store status of DRDY pin

// ADS 1256 Stuff
#define DRDY_PIN 13  // DRDY Pin (LOW if data is ready) #define
RESET_PIN 0  // 0 = Not use
#define SYNC_PIN 26  // SYNC or PWDN
#define CS_PIN 27          // Chip Select Pin
#define VREF 2.500         // Voltage reference

ADS1256 A(DRDY_PIN,  //DRDY, RESET, SYNC(PDWN), CS, VREF(float).
          RESET_PIN,
          SYNC_PIN,
          CS_PIN,
          VREF);

// Button pin
const byte buttonStart = 31; const
byte buttonStop = 32;

// Buffer memory for logging
const unsigned long logBufferSize = 30000UL * 10UL;  // 3 Detik unsigned long
logBufferIndex = 0;
long* logBuffer;

void IRAM_ATTR ADSStatus() {
  ADSIsReady = true;
}
```

```
void setup() {
  // Button mode
  pinMode(buttonStart, INPUT_PULLUP);
  pinMode(buttonStop, INPUT_PULLUP);

  // Start Serial
  Serial.begin(1000000);

  // Start ADS1256
  ADS1256Begin();
  //attachInterrupt(digitalPinToInterrupt(DRDY_PIN),   ADSStatus,   FALLING);

  // Read back the above 3 values to check if the writing was successful checkRegister();

  // Finding the offset if (true)
  {
  }

  // Store 0 for each buffer index
  for (int i = 0; i < BUFFER_SIZE; i++) { buffer[i] = 0;
  }

  // PSRAM Initialisation PSRAMInitialisation();

  // Buffer initialisation
  logBuffer = (long*)ps_malloc(logBufferSize * sizeof(long));

  if (logBuffer == NULL) {
    // Gagal mengalokasikan memori
    Serial.println("\nGagal mengalokasikan memori untuk logBuffer"); while (1)
      ;  // Jangan lanjutkan eksekusi program jika gagal mengalokasikan memori
  }
}

float terbesar_Vraw = 0; float
terbesar_Bar = 0;

void loop() {
  if (digitalRead(buttonStart) == LOW) {  // Button pressed
    //readingStart();
  }

  if (digitalRead(buttonStop) == LOW) {  // Button pressed
    //readingStop();
  }

  if (startReading && true) {
    logBuffer[logBufferIndex] = A.readSingleContinuous();  // Read raw ADC
    logBufferIndex++;                                       // Move to the next index
    //Serial.println(logBufferIndex);
```

```
        ADSIsReady = false;
        if (logBufferIndex >= logBufferSize) {
            readingStop();
        }
        // Perform necessary operations with ADCRaw
    }

    // Run command serial
    runCommandSerial();
}
unsigned long startTime;
unsigned long finishTime;

void readingStart() {
    for(unsigned long i = 0; i < logBufferSize; i++){
        logBuffer[i] = 0;
    }
    startTime = millis();
    Serial.println("\nReading start \nSilahkan jatuhkan benda"); logBufferIndex = 0;
    terbesar_Vraw =
    0; startReading =
    true;
}

void readingStop() {
    finishTime = millis();
    Serial.println("\nReading Stop \nTidak lagi merekam data"); startReading =
    false;
    A.stopConversion
    (); delay(3000);
    recordFinish();
    //A.stopConversion();

}

void recordFinish() { Serial.println(F("\nResult"));
    Serial.println(F("Raw ADC, Voltage (mV)"));

    for (unsigned long i = 0; i < logBufferIndex; i++) { long
        ADCRaw = logBuffer[i];
        float voltageRaw =
A.convertToVoltage(ADCRaw);

// Convert raw digital value to voltage
        Serial.println(voltageRaw * 1000.0);

        if (voltageRaw * 1000 > terbesar_Vraw) { terbesar_Vraw
            = voltageRaw * 1000;
        }
    }
    Serial.println("Tertinggi: " + String(terbesar_Vraw)); Serial.println("Start: "
```

```
    + String(startTime)); Serial.println("Finish: " + String(finishTime));
    Serial.println("Waktu: " + String(finishTime - startTime));

    Serial.println("Jumlah data: " + String(logBufferIndex)); Serial.println("SPS: " +
    String(logBufferIndex / (finishTime / 1000.0 -
startTime / 1000.0)));
}
```