RANCANG BANGUN ALAT MONITORING ARUS LISTRIK *DC (DIRECT CURRENT)* BERBASIS SENSOR ARUS ACS712ELC- 30 A, MIKROKONTROLER ARDUINO UNO DAN *SECURE DIGITAL CARD*

SKRIPSI

Untuk memenuhi sebagian persyaratan mencapai derajat Sarjana S- 1

Program Studi Fisika

Diajukan oleh

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Kepada

PROGRAM STUDI FISIKA

FAKULTAS SAINS DAN TEKNOLOGI

UNIVERSITAS ISLAM NEGERI SUNAN KALIJAGA

YOGYAKARTA

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PENGESAHAN SKRIPSI/TUGAS AKHIR

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Skripsi/Tugas Akhir dengan judul : Rancang Bangun Alat Monitoring Arus Listrik DC (Direct Current) Berbasis Sensor Arus ACS712 ELC-30 A, Miikrokontroler Arduino Uno dan Secure Digital Card

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Assalamu'alaikum wr. wb.

Setelah membaca, meneliti, memberikan petunjuk dan mengoreksi serta mengadakan perbaikan seperlunya, maka kami selaku pembimbing berpendapat bahwa skripsi Saudara:

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sudah dapat diajukan kembali kepada Program Studi Fisika Fakultas Sains dan Teknologi UIN Sunan Kalijaga Yogyakarta sebagai salah satu syarat untuk memperoleh gelar Sarjana Strata Satu dalam Jurusan Fisika

Dengan ini kami mengharap agar skripsi/tugas akhir Saudara tersebut di atas dapat segera dimunaqsyahkan. Atas perhatiannya kami ucapkan terima kasih.

Wassalamu'alaikum wr. wb.
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Dengan ini saya menyatakan bahwa skripsi yang berjudul : Rancang Bangun Alat Monitoring Arus Listrik DC *(Direct Current)* Berbasis Sensor Arus ACS712ELC-30 A, Mikrokontroler Arduino Uno dan *Secure Digital Card* adalah benar-benar karya saya sendiri. Sepanjang pengetahuan saya tidak terdapat karya atau pendapat yang ditulis atau diterbitkan orang lain kecuali sebagai acuan atau kutipan dengan tata penulisan yang lazim.

Yogyakarta, 12 Juni 2017

Yang menyatakan

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MOTTO

بسم الله الرّحمن الرحيم

انّ الله لا يغيّر ما بقوم حتّى يغيّروا ما بأنفسهم

" Sesungguhnya Allah tidak akan mengubah apa yang ada pada suatu kaum sehingga mereka mengubah apa yang ada pada diri mereka sendiri"

(Al-Ra'du 13: 11)

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Karya ini kupersembahkan untuk:

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- **Kakakku Nafika Suciani dan Purnomo serta adikku Imron NW**
- **Seluruh mahasiswa Fisika Fakultas Sains dan Teknologi UIN Sunan Kalijaga**
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- **Almamaterku tercinta**

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بسم الله الرحمن الرحيم

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Skripsi ini disusun dalam rangka memenuhi syarat untuk memperoleh gelar sarjana strata satu Fisika di Universitas Islam Negeri Sunan Kalijaga Yogyakarta. Dalam penyusunan laporan ini banyak kendala-kendala yang harus dialami oleh penulis, namun kendala-kendala tersebut bisa diatasi atas saran, bimbingan, dan motivasi dari berbagai pihak. Oleh karena itu penulis ingin menyampaikan ucapan terima kasih kepada :

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RANCANG BANGUN ALAT MONITORING ARUS LISTRIK DC *(DIRECT CURRENT)* BERBASIS SENSOR ARUS ACS712ELC-30 A, MIKROKONTROLER ARDUINO UNO DAN *SECURE DIGITAL CARD*

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ABSTRAK

Penelitian rancang bangun alat monitoring arus listrik DC *(direct current)* telah selesai dilakukan dengan menggunakan sensor arus ACS712ELC-30 A, mikrokontroler arduino uno dan *secure digital card*. Tujuan penelitian ini adalah mengetahui karakterisasi sensor arus ACS712ELC-30 A, membuat alat monitoring arus listrik DC dan mengkarakterisasi alat monitoring arus listrik DC. Penelitian ini dilakukan melalui tiga tahapan: karakterisasi sensor arus ACS712ELC-30 A, pembuatan alat monitoring arus listrik DC dan karakterisasi alat monitoring arus listrik DC. Hasil karakterisasi sensor arus ACS712ELC-30 A pada penelitian ini menunjukkan fungsi transfer, V= 0,0668I + 2,4926 dengan hubungan input-outputnya sebesar 0,9995; sensitivitas sensor 66,8 mV/A; dan ripitabilitas 99,84%. Hasil karakterisasi alat monitoring arus listrik DC meliputi efisiensi 98,11%; akurasi 99,99%; dan presisi 99,54%.

Kata kunci : monitoring, sensor arus ACS712ELC-30 A, mikrokontroler arduino uno, *secure digital card*

THE DESIGN OF DIRECT CURRENT MONITORING INSTRUMENT BASSED ON ACS712ELC-30 A CURRENT SENSOR, MICROCONTROLLER ARDUINO UNO AND SECURE DIGITAL CARD

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ABSTRACT

The research on design of direct current monitoring instrument has been done using ACS712ELC-30 A current sensor, microcontroller arduino uno and secure digital card. This monitoring instrument is measurement device of electric current bassed on ACS712ELC-30 A current sensor which work on hall effect principle. The purpose of this research was to know ACS712ELC-30 A current sensor characteristic, to make the direct current electric monitoring instrument and characterize the direct current electric monitoring tool. This research was conducted in three phases: characterization of ACS712ELC-30 A current sensor, manufacturing of direct current monitoring instrument and characterization of direct current monitoring instrument. The result of ACS712ELC-30 A current sensor characterization in the research showed transfer function, V = 0,0668 I + 2,4926 with input-output relation 0,9995; sensor sensitivity 66,8 mV/A; and repeatability 99,84%. The result of characterization of direct current monitoring instrument covers efficiency 98,11% ; accuracy 99,99%; and precision 99,54%.

Keywords : monitoring, ACS712ELC-30 A current sensor, microcontroller arduino uno, secure digital card

BAB I

PENDAHULUAN

1.1 Latar Belakang

Perkembangan zaman yang semakin cepat dan dinamis menuntut manusia untuk hidup serba cepat dan efisen, terutama dalam hal pemenuhan kebutuhan sehari-hari. Alat-alat yang serba modern pun digunakan agar semua kebutuhan terpenuhi, seperti halnya mesin cuci, kulkas, seterika, kompor listrik, oven, dan lain sebagainya. Alat-alat modern tersebut tentunya membutuhkan energi listrik.

Di Indonesia, saat ini sebagian besar energi listrik berasal dari pembangkit listrik berbahan bakar fosil yang menyebabkan emisi karbondioksida yang menjadi salah satu penyumbang terjadinya pemanasan global dan perubahan iklim. Energi terbarukan merupakan solusi tepat untuk mengurangi emisi sehingga menghambat laju perubahan iklim. Energi terbarukan juga menjadi sumber energi tidak terbatas dan mempunyai potensi yang besar di Indonesia.

Kondisi wilayah Indonesia yang terletak di sepanjang garis khatulistiwa, memiliki intensitas sinar matahari tinggi dan ada di sepanjang tahun. Belum lagi wilayah Indonesia terletak diantara dua benua yaitu benua Australia dan benua Asia, sehingga angin laut dan angin daratnya pun sangat memadai, dan untuk memanfaatkan keadaan tersebut didirikan PLTH

(Pembangkit Listrik Tenaga Hybrid). Pembangunan PLTH ini merupakan bukti bahwa energi terbarukan bisa diterapkan dengan optimal.

Salah satu PLTH yang masih aktif sampai sekarang yaitu PLTH yang berada di daerah Pandansimo, Srandakan, Bantul, Yogyakarta tepatnya di pantai Baru Yogyakarta. Pembangkit Listrik Tenaga Hybrid (PLTH) di Pandansimo ini merupakan pembangkit listrik gabungan dari tenaga angin dan surya (Apriando, 2014).

Adanya pembangunan Pembangkit Listrik Tenaga Hybrid di Pandansimo, Srandakan, Bantul ini tentunya tidak terlepas dari pengukuran arus listriknya, baik arus listrik yang dihasilkan oleh kincir angin maupun panel surya. Karena kondisi lingkungan yang berubah-ubah setiap waktu menyebabkan arus keluaran dari panel surya juga ikut berfluktuasi (Fachri dkk, 2015), sedangkan besar arus listrik yang digunakan pada berbagai piranti elektronik tidak selalu sama. Apabila arus listrik yang digunakan terlalu besar atau melebihi batas maksimum yang diperbolehkan, maka piranti tersebut bisa jadi akan mengalami kerusakan. Sebaliknya, jika arus listrik yang digunakan terlalu kecil atau kurang dari nilai minimum yang diperlukan, maka piranti tersebut tidak dapat berfungsi secara optimal.

Secara konvensional, pengukuran arus di dalam suatu rangkaian listrik mengharuskan pencatatan secara manual, maka dibutuhkan perangkat pengukuran arus berbasis *embedded system* menggunakan sensor arus. Salah satu sensor arus yang kompleksitas rangkaiannya lebih sederhana yaitu sensor arus ACS712ELC- 30 A.

Sensor arus ACS712ELC-30 A menggunakan prinsip Efek Hall. Sensor ini mampu mendeteksi arus dari -30 Ampere hingga 30 Ampere. Sensor ini membutuhkan mikrokontroler yang berfungsi sebagai pengolah data. Mikrokontoler yang dipilih adalah mikrokontroler arduino uno. Arduino uno merupakan board mikrokontroler berbasis ATmega328, papan ini berisi semua yang diperlukan untuk mendukung mikrokontroler (Abdillah dkk, 2015). Dari paparan di atas, maka dilakukan penelitian tentang Rancang Bangun Alat Monitoring Arus Listrik DC *(direct current)* Berbasis Sensor Arus ACS712ELC- 30 A, Mikrokontroler Arduino Uno dan *Secure Digital Card*. *Secure digital card* digunakan untuk menyimpan hasil monitoring arus listrik DC *(direct current)* secara *real time*.

1.2 Rumusan Masalah

Berdasarkan uraian latar belakang di atas, maka dibuat suatu rumusan masalah sebagai berikut:

1. Bagaimana karakteristik sensor arus ACS712ELC- 30 A ?
2. Bagaimana membuat alat monitoring arus listrik *DC (direct current)* berbasis sensor arus ACS712ELC- 30 A, mikrokontroler arduino uno dan *secure digital card* ?

3. Bagaimana hasil karakterisasi alat monitoring arus listrik *DC (direct current)* berbasis sensor arus ACS712ELC- 30 A, mikrokontroler arduino uno dan *secure digital card* ?

1.3 Tujuan Penelitian

Penelitian ini bertujuan untuk:

1. Mengkarakterisasi sensor arus ACS712ELC- 30 A.
2. Membuat alat monitoring arus listrik *DC (direct current)* berbasis sensor arus ACS712ELC- 30 A, mikrokontroler arduino uno dan *secure digital card*.
3. Mengkarakterisasi alat monitoring arus listrik *DC (direct current)* berbasis sensor arus ACS712ELC- 30 A, mikrokontroler arduino uno dan *secure digital card*.

1.4 Batasan Penelitian

Batasan penelitian ini sebagai berikut:

1. Tidak mempertimbangkan pengaruh suhu terhadap tegangan *output* sensor.
2. Pengambilan data percobaan hanya sampai < 15 ampere DC
3. Pengujian hanya dilakukan pada skala laboratorium
4. Pengujian yang dilakukan meliputi efisiensi, akurasi dan presisi.

1.5 Manfaat Penelitian

1. Untuk Pembangkit Listrik Tenaga Hybrid (PLTH)

   Alat dapat digunakan untuk memonitoring arus listrik DC *(direct current)* keluaran dari panel surya secara *real time* dan dapat dijadikan sebagai bahan inventarisasi energi pada PLTH.

2. Untuk Ilmu Pengetahuan

   Penelitian ini dapat digunakan sebagai penerapan konsep ilmu fisika di bidang instrumentasi dan menambah wawasan khususnya tentang arus listrik.

3. Untuk Masyarakat dan Lingkungan

   Alat ini dapat dimanfaatkan oleh masyarakat untuk memonitoring atau mengukur arus listrik secara *real time*.

BAB V

PENUTUP

5.1 Kesimpulan

Berdasarkan hasil penelitian dan pembahasan dapat disimpulkan bahwa:

1. Sensor arus ACS712ELC-30 A yang digunakan pada penelitian ini memiliki karakteristik fungsi transfer, V = 0,0668 I + 2,4926 dengan hubungan *input-output* sebesar 0,9995 ; sensitivitas sebesar 66,8 mV/A ; dan ripitabilitas sebesar 99,76%.
2. Alat monitoring arus listrik DC telah berhasil dibuat menggunakan sensor arus ACS712ELC-30 A, mikrokontroler arduino uno dan *secure digital card*.
3. Hasil karakterisasi alat monitoring arus listrik DC diperoleh karakteristik: efisiensi sebesar 98,11%, akurasi sebesar 99,99% dan presisi sebesar 99,54%.

5.2 Saran

Berdasarkan hasil penelitian yang dilakukan maka untuk penyempurnaannya disampaikan sebagai berikut:

1. Pengambilan data tidak hanya dilakukan pada skala laboratorium.
2. Penyimpanan data secara *real time* tidak hanya pada SD Card yang dipasang pada alat monitoring melainkan bisa dikembangkan lagi penyimpanan data secara *online* yang bisa diakses pada *website*.

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LAMPIRAN

Lampiran 1

Data Karakterisasi Sensor Arus ACS712ELC- 30 A

Tabel 1. Data Karakterisasi Sensor Arus ACS712ELC- 30 A

A input (Ampere)	V1 (Volt)	V2 (Volt)	V3 (Volt)	V4 (Volt)	V5 (Volt)	V6 (Volt)	V7 (Volt)	V8 (Volt)
0.165	2.5	2.501	2.501	2.501	2.501	2.501	2.501	2.501
0.299	2.512	2.513	2.513	2.513	2.513	2.513	2.513	2.513
0.41	2.523	2.522	2.522	2.522	2.523	2.523	2.523	2.523
0.575	2.528	2.529	2.53	2.529	2.53	2.529	2.531	2.531
0.64	2.533	2.536	2.537	2.537	2.537	2.537	2.538	2.539
0.786	2.542	2.544	2.544	2.544	2.544	2.544	2.545	2.546
0.87	2.551	2.55	2.55	2.55	2.55	2.55	2.552	2.552
0.902	2.552	2.555	2.556	2.556	2.557	2.556	2.557	2.558
1.022	2.558	2.56	2.56	2.559	2.56	2.56	2.56	2.562
1.1	2.563	2.562	2.564	2.564	2.564	2.564	2.565	2.565

Tabel 1. Data Karakterisasi Sensor Arus ACS712ELC-30 A

V9 (Volt)	V10 (Volt)	V (Volt)	Vmax	Vmin	Vmax-Vmin
2.501	2.501	2.5009	2.501	2.5	0.001
2.513	2.513	2.5129	2.513	2.512	0.001
2.522	2.523	2.5226	2.523	2.522	0.001
2.531	2.531	2.5299	2.531	2.528	0.003
2.537	2.538	2.5369	2.539	2.533	0.006
2.544	2.544	2.5441	2.546	2.542	0.004
2.55	2.551	2.5506	2.552	2.55	0.002
2.556	2.558	2.5561	2.558	2.552	0.006
2.56	2.56	2.5599	2.562	2.558	0.004
2.564	2.564	2.5639	2.565	2.562	0.003

Lampiran 2

Perhitungan Mencari Nilai b dan Ripitabilitas

1. Mencari nilai b *(slope)*

$$b = \frac{n\sum x_i y_i - \sum x_i \sum y_i}{n\sum x_i^2 - \left(\sum x_i\right)^2} = \frac{10x17,23737 - 6,769x25,3778}{10x5,467735 - (6,769)^2}$$

$$= \frac{172,3737 - 171,7823}{54,67735 - 45,81936}$$

$$= \frac{0,591372}{8,857989}$$

$$= 0,0668$$

2. Menentukan presentase error Ripitabilitas

$$\delta = \frac{\Delta}{FS} \times 100\%$$

$$\delta = \frac{0,006}{2,565} \times 100\%$$

$$\delta = 0,2339\%$$

3. Menentukan Presentase Ripitabilitas

$$Ripitabilitas = 100\% - error\ Ripitabilitas\ (\delta)$$

$$Ripitabilitas = 100\% - 0,2339\%$$

$$Ripitabilitas = 99,766\%$$

Lampiran 3

Data Uji Coba Alat Monitoring Arus Listrik DC Berbasis Sensor Arus ACS712ELC-30 A, Mikrokontroler Arduino Uno dan *Secure Digital Card*

Tabel 2. Data uji coba efisiensi

No	V_{in} (V)	V_{out} (V)	I_{in} (A)	I_{out} (A)	P_{in} (W)	P_{out} (W)	η (%)
1	6.06	6.06	1.35	1.35	8.18	8.18	100
2	6.06	6.03	2.52	2.5	15.27	15.07	98.71
3	6.06	6	3.6	3.6	21.81	21.6	99.01
4	6.05	5.98	4.84	4.8	29.28	28.70	98.03
5	6.04	5.95	5.96	5.96	35.9984	35.46	98.51
6	6.03	5.93	6.98	6.89	42.09	40.86	97.07
7	6.02	5.9	7.9	7.85	47.56	46.3	97.38
8	6.01	5.89	8.77	8.7	52.71	51.24	97.22
9	6	5.86	9.52	9.53	57.12	55.84	97.77
10	6	5.84	10.3	10.31	61.8	60.21	97.43
						Rata-rata	98.11

Lampiran 4

Tabel 3. Data uji coba akurasi

No.	**Alat Standar (Clamp meter)**										**Jumlah**	**$I_{rata-rata}$(A)**
	I_1 (A)	**I_2 (A)**	**I_3 (A)**	**I_4 (A)**	**I_5 (A)**	**I_6 (A)**	**I_7 (A)**	**I_8 (A)**	**I_9 (A)**	**I_{10} (A)**		
1	1.33	1.34	1.33	1.33	1.33	1.33	1.33	1.36	1.37	1.37	13.42	1.342
2	2.52	2.59	2.51	2.51	2.51	2.54	2.51	2.52	2.58	2.55	25.34	2.534
3	3.71	3.73	3.67	3.67	3.65	3.68	3.65	3.69	3.69	3.71	36.85	3.685
4	4.93	4.95	4.88	4.9	4.9	4.9	4.9	4.92	4.9	4.92	49.1	4.91
5	6.04	6.14	6.01	6.02	6	6	6.02	6.02	6.04	6.1	60.39	6.039
6	7.08	7.12	7.08	7.08	7	7.01	7.02	7.12	7.02	7.12	70.65	7.065
7	8.05	8.02	8	8	7.93	7.93	7.97	7.95	8.02	8.03	79.9	7.99
8	8.98	8.89	8.9	8.91	8.75	8.83	8.82	8.83	8.9	9.02	88.83	8.883
9	9.82	9.84	9.82	9.79	9.59	9.84	9.62	9.62	9.72	9.8	97.46	9.746
10	10.59	10.62	10.5	10.57	10.28	10.6	10.54	10.88	10.5	10.6	105.68	10.568
												62.762

Tabel 3. Data uji coba akurasi

Alat Uji											
I_1 (A)	I_2 (A)	I_3 (A)	I_4 (A)	I_5 (A)	I_6 (A)	I_7 (A)	I_8 (A)	I_9 (A)	I_{10} (A)	jumlah	$I_{rata-rata}$ (A)
1.31	1.34	1.28	1.17	1.33	1.33	1.34	1.36	1.34	1.33	13.13	1.313
2.5	2.59	2.5	2.36	2.51	2.51	2.52	2.55	2.51	2.52	25.07	2.507
3.66	3.72	3.66	3.53	3.66	3.65	3.68	3.71	3.67	3.68	36.62	3.662
4.87	4.93	4.88	4.76	4.86	4.85	4.87	4.91	4.9	4.9	48.73	4.873
6.01	6.12	6.01	5.9	5.97	5.97	6.01	6.05	6.02	6.03	60.09	6.009
7.03	7.12	7.02	7	6.98	6.92	7.01	7.04	7.03	7.05	70.2	7.02
8	8.01	8	7.9	7.89	7.85	7.97	7.96	8.01	8	79.59	7.959
8.89	8.88	8.9	8.81	8.76	8.77	8.82	8.85	8.88	8.95	88.51	8.851
9.73	9.81	9.72	9.75	9.56	9.77	9.59	9.64	9.72	9.75	97.04	9.704
10.5	10.59	10.44	10.42	10.22	10.54	10.49	10.42	10.44	10.5	104.56	10.456
											62.354

Tabel 3. Data uji coba akurasi

x^2	y^2	Xy
1.723969	1.800964	1.762046
6.285049	6.421156	6.352738
13.41024	13.57923	13.49447
23.74613	24.1081	23.92643
36.10808	36.46952	36.28835
49.2804	49.91423	49.5963
63.34568	63.8401	63.59241
78.3402	78.90769	78.62343
94.16762	94.98452	94.57518
109.3279	111.6826	110.499
475.7353	481.7081	478.7104

$$r_{xy} = \frac{n\sum xy - \sum x \sum y}{\sqrt{n\sum x^2 - (\sum x)^2}\sqrt{n\sum y^2 - (\sum y)^2}}$$

$$r_{xy} = \frac{10(478,7104) - (62,354)(62,762)}{\sqrt{10(475,7353) - (62,354)^2}\sqrt{10(481,7081) - (62,762)^2}}$$

$$r_{xy} = \frac{873,64195}{(29,484432)(29,631277)}$$

$$r_{xy} = \frac{873,64195}{873,66137}$$

$$r_{xy} = 0,9999778$$

$$Akurasi = r \times 100\% = 0,9999778 \times 100\% = 99,99\%$$

Lampiran 5

Tabel 4. Data uji coba presisi

No.	Alat Standar	Alat Uji									
		I_1 (A)	I_2 (A)	I_3 (A)	I_4 (A)	I_5 (A)	I_6 (A)	I_7 (A)	I_8 (A)	I_9 (A)	I_{10} (A)
1	1.342	1.31	1.34	1.28	1.17	1.33	1.33	1.34	1.36	1.34	1.33
2	2.534	2.5	2.59	2.5	2.36	2.51	2.51	2.52	2.55	2.51	2.52
3	3.685	3.66	3.72	3.66	3.53	3.66	3.65	3.68	3.71	3.67	3.68
4	4.91	4.87	4.93	4.88	4.76	4.86	4.85	4.87	4.91	4.9	4.9
5	6.039	6.01	6.12	6.01	5.9	5.97	5.97	6.01	6.05	6.02	6.03
6	7.065	7.03	7.12	7.02	7	6.98	6.92	7.01	7.04	7.03	7.05
7	7.99	8	8.01	8	7.9	7.89	7.85	7.97	7.96	8.01	8
8	8.883	8.89	8.88	8.9	8.81	8.76	8.77	8.82	8.85	8.88	8.95
9	9.746	9.73	9.81	9.72	9.75	9.56	9.77	9.59	9.64	9.72	9.75
10	10.568	10.5	10.59	10.44	10.42	10.22	10.54	10.49	10.42	10.44	10.5

Tabel 4. Data uji coba presisi

Jumlah	$\bar{x}$ (rata-rata)	$x_i - \bar{x}$									
		δx1	**δx2**	**δx3**	**δx4**	**δx5**	**δx6**	**δx7**	**δx8**	**δx9**	**δx10**
13.13	1.313	-0.003	0.027	-0.033	-0.143	0.017	0.017	0.027	0.047	0.027	0.017
25.07	2.507	-0.007	0.083	-0.007	-0.147	0.003	0.003	0.013	0.043	0.003	0.013
36.62	3.662	-0.002	0.058	-0.002	-0.132	-0.002	-0.012	0.018	0.048	0.008	0.018
48.73	4.873	-0.003	0.057	0.007	-0.113	-0.013	-0.023	-0.003	0.037	0.027	0.027
60.09	6.009	0.001	0.111	0.001	-0.109	-0.039	-0.039	0.001	0.041	0.011	0.021
70.2	7.02	0.01	0.1	0	-0.02	-0.04	-0.1	-0.01	0.02	0.01	0.03
79.59	7.959	0.041	0.051	0.041	-0.059	-0.069	-0.109	0.011	0.001	0.051	0.041
88.51	8.851	0.039	0.029	0.049	-0.041	-0.091	-0.081	-0.031	-0.001	0.029	0.099
97.04	9.704	0.026	0.106	0.016	0.046	-0.144	0.066	-0.114	-0.064	0.016	0.046
104.56	10.456	0.044	0.134	-0.016	-0.036	-0.236	0.084	0.034	-0.036	-0.016	0.044

Tabel 4. Data uji coba presisi

$(x_i - \bar{x})^2$										
δx1^2	**δx2^2**	**δx3^2**	**δx4^2**	**δx5^2**	**δx6^2**	**δx7^2**	**δx8^2**	**δx9^2**	**δx10^2**	**Jumlah**
-0.006	0.000729	0.001089	0.020449	0.000289	0.000289	0.000729	0.002209	0.000729	0.000289	0.020801
-0.014	0.006889	4.9E-05	0.021609	9E-06	9E-06	0.000169	0.001849	9E-06	0.000169	0.016761
-0.004	0.003364	4E-06	0.017424	4E-06	0.000144	0.000324	0.002304	6.4E-05	0.000324	0.019956
-0.006	0.003249	4.9E-05	0.012769	0.000169	0.000529	9E-06	0.001369	0.000729	0.000729	0.013601
0.002	0.012321	1E-06	0.011881	0.001521	0.001521	1E-06	0.001681	0.000121	0.000441	0.031489
0.02	0.01	0	0.0004	0.0016	0.01	0.0001	0.0004	1E-04	0.0009	0.0435
0.082	0.002601	0.001681	0.003481	0.004761	0.011881	0.000121	1E-06	0.002601	0.001681	0.110809
0.078	0.000841	0.002401	0.001681	0.008281	0.006561	0.000961	1E-06	0.000841	0.009801	0.109369
0.052	0.011236	0.000256	0.002116	0.020736	0.004356	0.012996	0.004096	0.000256	0.002116	0.110164
0.088	0.017956	0.000256	0.001296	0.055696	0.007056	0.001156	0.001296	0.000256	0.001936	0.174904

Tabel 4. Data uji coba presisi

Δx	% error	Presisi
0.015203	1.15786	98.84214
0.013647	0.544345	99.45565
0.014891	0.406628	99.59337
0.012293	0.252271	99.74773
0.018705	0.311283	99.68872
0.021985	0.313174	99.68683
0.035089	0.440867	99.55913
0.03486	0.393852	99.60615
0.034986	0.360535	99.63946
0.044084	0.421612	99.57839
		99.53976

Keterangan

$$\bar{x} = \frac{\sum_i^n x_i}{n}$$

$$\delta x_i = x_i - \bar{x}$$

$$\Delta x = \sqrt{\frac{\sum_i^n (\delta x_i)}{n(n-1)}} = \sqrt{\frac{\sum_i^n (x_i - \bar{x})^2}{n(n-1)}}$$

$$\%error = \frac{\Delta x}{x} \times 100\% = ...\%$$

$$presisi = 100\% - \%error$$

Lampiran 6

List Program Arduino IDE

```
#include <SPI.h>
#include <SD.h>
#include <Wire.h>
#include "RTClib.h"
#include <LiquidCrystal.h>
RTC_DS3231 rtc;
LiquidCrystal lcd(7, 6, 5, 4, 3, 2 );
const int chipSelect = 10;
int sensorV;
float teg[20];
float tegavg;
int sensorA;
float arus[20];
float arusavg;
String dataString, dataString1;

void setup (){
 #ifndef ESP8266
  while (!Serial); // for Leonardo/Micro/Zero
#endif
  Serial.begin(9600);
  lcd.begin(16,2);
  delay(1000);

  if (! rtc.begin()) {
    Serial.println("Couldn't find RTC");
    while (1);
  }
  if (rtc.lostPower()) {
    Serial.println("RTC lost power, lets set the time!");
    rtc.adjust(DateTime(F(__DATE__), F(__TIME__)));
   }

  pinMode (8,INPUT);
  digitalWrite(8,HIGH);
```

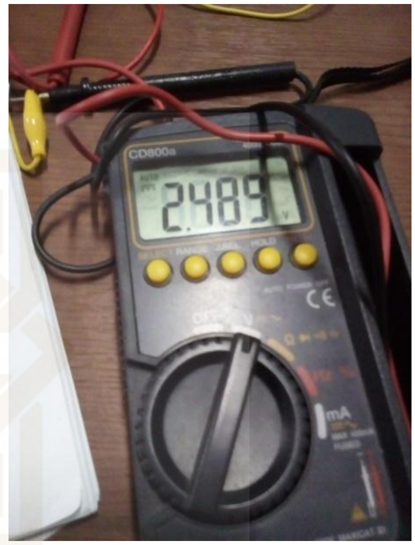
```
  lcd.print("Initializing SD card...");
  while (!Serial) { ;
    }
   Serial.print("Initializing SD card...");
   pinMode(10, OUTPUT);
   if (!SD.begin(chipSelect)) {
    Serial.println("Card failed, or not present");
        return;
  }
  Serial.println("card initialized.");
  dataString1 = "";
  dataString1 += "tanggal waktu tegangan arus daya energi";

  File dataFile1 = SD.open("plth.xls", FILE_WRITE);
  if (dataFile1) {
    dataFile1.println(dataString1);
    dataFile1.close();
    Serial.println(dataString1);
  }
  else {
    Serial.println("error opening plth.xls");
  }
}

void loop(){
  for (int i=1; i<=600; i++){
  dataString = "";
  delay (1000);
  DateTime now = rtc.now();
  DateTime future (now + TimeSpan(0,3,19,40));
  int hari = future.day();
  int bulan = future.month();
  int tahun = future.year();
  int jam = future.hour();
  int menit = future.minute();
  int detik = future.second();
```

```
  dataString += String(hari);
  dataString += "/";
  dataString += String(bulan);
  dataString += "/";
  dataString += String(tahun);
  dataString += " ";
  dataString += String(jam);
  dataString += ":";
  dataString += String(menit);
  dataString += ":";
  dataString += String(detik);
  dataString += " ";

  for (int i=1; i<=20; i++){
  int sensorA = analogRead(A0);
  arus[i]=((sensorA*0.00490)-2.4926)/0.06680;
  int sensorV = analogRead(A1);
  teg[i] = sensorV*50.0/929.0;
  }

  tegavg                                                                 =
(teg[1]+teg[2]+teg[3]+teg[4]+teg[5]+teg[6]+teg[7]+teg[8]+teg[9]+teg[10]
+teg[11]+teg[12]+teg[13]+teg[14]+teg[15]+teg[16]+teg[17]+teg[18]+teg[19
]+teg[20])/20;
  arusavg                                                                =
(arus[1]+arus[2]+arus[3]+arus[4]+arus[5]+arus[6]+arus[7]+arus[8]+arus[9]
+arus[10]+arus[11]+arus[12]+arus[13]+arus[14]+arus[15]+arus[16]+arus[17]
+arus[18]+arus[19]+arus[20])/20;
  dataString += String(tegavg);
  dataString += " ";
  dataString += String(arusavg);
  dataString += " ";

  float daya = arusavg * tegavg;
  dataString += String(daya);
  dataString += " ";
```

```
lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print(tegavg);
  lcd.print(" V");

  lcd.setCursor(0, 1);
  lcd.print(arusavg);
  lcd.print(" A");

  lcd.setCursor(8, 0);
  lcd.print(daya);
  lcd.print(" W");


  File dataFile = SD.open("plth.xls", FILE_WRITE);
  if (dataFile) {
    dataFile.println(dataString);
    dataFile.close();
    Serial.println(dataString);
  }
  else {
    Serial.println("error opening plth.xls");
  }
  }
}
```

Lampiran 7

Proses Pembuatan Alat Monitoring Arus Listrik DC



Pengambilan data karakterisasi

Proses pengeboran dan packaging alat monitoring

Rangkaian pengambilan data percobaan

Proses pengambilan data uji coba alat monitoring arus listrik DC

Hasil pembacaan awal alat monitoring arus listrik DC ketika tidak ada beban

Hasil pembacaan awal alat monitoring arus listrik DC ketika tidak ada beban

Lampiran 8

Data Hasil Monitoring Arus Listrik DC pada Beban Lampu Motor secara *Real Time*

tanggal	waktu	tegangan	arus	daya
23-05-17	14:07:46	0	-0.02	0
23-05-17	14:07:47	0	-0.03	0
23-05-17	14:07:48	0	-0.05	0
23-05-17	14:07:49	0	-0.02	0
23-05-17	14:07:50	0	-0.03	0
23-05-17	14:07:51	0	-0.04	0
23-05-17	14:07:52	0	-0.03	0
23-05-17	14:07:53	0	-0.03	0
23-05-17	14:07:54	0	-0.04	0
23-05-17	14:07:56	0	-0.04	0
23-05-17	14:07:57	0	-0.04	0
23-05-17	14:07:58	0	-0.04	0
23-05-17	14:07:59	0	-0.05	0
23-05-17	14:08:00	0	-0.04	0
23-05-17	14:08:01	0	-0.04	0
23-05-17	14:08:02	0	-0.03	0
23-05-17	14:08:03	0	-0.03	0
23-05-17	14:08:04	0	-0.03	0
23-05-17	14:08:05	0	-0.02	0
23-05-17	14:08:06	0	-0.03	0
23-05-17	14:08:07	0	-0.05	0
23-05-17	14:08:08	0	-0.03	0
23-05-17	14:08:09	0	-0.02	0
23-05-17	14:08:10	0	-0.04	0
23-05-17	14:08:11	0	-0.04	0
23-05-17	14:08:12	0	-0.03	0
23-05-17	14:08:13	0	-0.04	0
23-05-17	14:08:14	0	-0.03	0
23-05-17	14:08:15	0	-0.03	0
23-05-17	14:08:16	0	-0.05	0
23-05-17	14:08:17	0	-0.04	0
23-05-17	14:08:18	0	-0.03	0
23-05-17	14:08:19	0	-0.03	0
23-05-17	14:08:20	0	-0.04	0

23-05-17	14:08:21	0	-0.04	0
23-05-17	14:08:22	0	-0.03	0
23-05-17	14:08:23	0	-0.03	0
23-05-17	14:08:24	0	-0.04	0
23-05-17	14:08:25	0	-0.04	0
23-05-17	14:08:27	0	-0.03	0
23-05-17	14:08:28	0	-0.04	0
23-05-17	14:08:29	0	-0.04	0
23-05-17	14:08:30	0	-0.03	0
23-05-17	14:08:31	0	-0.04	0
23-05-17	14:08:32	0	-0.03	0
23-05-17	14:08:33	0	-0.04	0
23-05-17	14:08:34	0	-0.02	0
23-05-17	14:08:35	0	-0.04	0
23-05-17	14:08:36	0	-0.05	0
23-05-17	14:08:37	0	-0.04	0
23-05-17	14:08:38	0	-0.03	0
23-05-17	14:08:39	0	-0.02	0
23-05-17	14:08:40	0	-0.03	0
23-05-17	14:08:41	0	-0.04	0
23-05-17	14:08:42	0	-0.03	0
23-05-17	14:08:43	0	-0.04	0
23-05-17	14:08:44	0	-0.04	0
23-05-17	14:08:45	0	-0.05	0
23-05-17	14:08:46	0	-0.03	0
23-05-17	14:08:47	0	-0.04	0
23-05-17	14:08:48	0	-0.04	0
23-05-17	14:08:49	0	-0.04	0
23-05-17	14:08:50	0	-0.04	0
23-05-17	14:08:51	0	-0.03	0
23-05-17	14:08:52	0	-0.03	0
23-05-17	14:08:53	0	-0.04	0
23-05-17	14:08:54	0	-0.03	0
23-05-17	14:08:55	0	-0.03	0
23-05-17	14:08:56	0	-0.03	0
23-05-17	14:08:57	6.12	-0.03	-0.16
23-05-17	14:08:58	6.12	-0.02	-0.12
23-05-17	14:09:00	6.13	-0.04	-0.23
23-05-17	14:09:01	6.12	-0.03	-0.21

23-05-17	14:09:02	6.12	-0.03	-0.16
23-05-17	14:09:03	6.12	-0.03	-0.21
23-05-17	14:09:04	6.12	-0.03	-0.18
23-05-17	14:09:05	6.12	-0.03	-0.16
23-05-17	14:09:06	6.12	-0.03	-0.16
23-05-17	14:09:07	6.08	1.53	9.3
23-05-17	14:09:08	6.08	1.33	8.07
23-05-17	14:09:09	6.08	1.33	8.07
23-05-17	14:09:10	6.08	1.32	8.03
23-05-17	14:09:11	6.08	1.32	8.04
23-05-17	14:09:12	6.08	1.32	8
23-05-17	14:09:13	6.08	1.31	7.98
23-05-17	14:09:14	6.08	1.31	7.94
23-05-17	14:09:15	6.08	1.31	7.96
23-05-17	14:09:16	6.09	1.32	8.03
23-05-17	14:09:17	6.08	1.3	7.91
23-05-17	14:09:18	6.08	1.32	8.03
23-05-17	14:09:19	6.08	1.32	8.03
23-05-17	14:09:20	6.09	1.31	8
23-05-17	14:09:21	6.08	1.31	7.96
23-05-17	14:09:22	6.08	1.31	7.98
23-05-17	14:09:23	6.08	1.3	7.9
23-05-17	14:09:24	6.08	1.32	8.03
23-05-17	14:09:25	6.08	2.52	15.31
23-05-17	14:09:26	6.08	2.52	15.31
23-05-17	14:09:27	6.08	2.51	15.25
23-05-17	14:09:28	6.08	2.5	15.22
23-05-17	14:09:29	6.08	2.5	15.2
23-05-17	14:09:31	6.07	2.5	15.18
23-05-17	14:09:32	6.08	2.5	15.2
23-05-17	14:09:33	6.08	2.51	15.26
23-05-17	14:09:34	6.08	2.5	15.2
23-05-17	14:09:35	6.08	2.5	15.17
23-05-17	14:09:36	6.07	2.5	15.17
23-05-17	14:09:37	6.08	2.5	15.18
23-05-17	14:09:38	6.08	2.5	15.17
23-05-17	14:09:39	6.08	2.5	15.19
23-05-17	14:09:40	6.08	2.5	15.19
23-05-17	14:09:41	6.08	2.5	15.19

23-05-17	14:09:42	6.08	2.5	15.19
23-05-17	14:09:43	6.08	2.49	15.16
23-05-17	14:09:44	6.08	2.5	15.2
23-05-17	14:09:45	6.08	2.49	15.16
23-05-17	14:09:46	6.07	2.48	15.07
23-05-17	14:09:47	6.08	2.49	15.15
23-05-17	14:09:48	6.08	2.49	15.13
23-05-17	14:09:49	6.08	2.49	15.16
23-05-17	14:09:50	6.08	2.5	15.17
23-05-17	14:09:51	6.07	2.49	15.12
23-05-17	14:09:52	6.08	2.49	15.16
23-05-17	14:09:53	6.08	2.49	15.16
23-05-17	14:09:54	6.08	2.5	15.19
23-05-17	14:09:55	6.07	2.49	15.1
23-05-17	14:09:56	6.05	3.67	22.2
23-05-17	14:09:57	6.05	3.67	22.21
23-05-17	14:09:58	6.05	3.68	22.25
23-05-17	14:09:59	6.05	3.67	22.25
23-05-17	14:10:00	6.05	3.67	22.22
23-05-17	14:10:01	6.04	3.67	22.18
23-05-17	14:10:03	6.05	3.67	22.21
23-05-17	14:10:04	6.05	3.67	22.21
23-05-17	14:10:05	6.04	3.67	22.16
23-05-17	14:10:06	6.04	3.67	22.18
23-05-17	14:10:07	6.05	3.66	22.16
23-05-17	14:10:08	6.05	3.67	22.17
23-05-17	14:10:09	6.04	3.66	22.12
23-05-17	14:10:10	6.05	3.66	22.17
23-05-17	14:10:11	6.04	3.66	22.11
23-05-17	14:10:12	6.03	4.9	29.53
23-05-17	14:10:13	6.02	4.91	29.54
23-05-17	14:10:14	6.02	4.9	29.51
23-05-17	14:10:15	6.03	4.89	29.48
23-05-17	14:10:16	6.03	4.89	29.45
23-05-17	14:10:17	6.03	4.88	29.39
23-05-17	14:10:18	6.03	4.88	29.41
23-05-17	14:10:19	6.02	4.88	29.37
23-05-17	14:10:20	6.03	4.87	29.38
23-05-17	14:10:21	6.03	4.88	29.42

23-05-17	14:10:22	6.03	4.87	29.37
23-05-17	14:10:23	6.03	4.85	29.25
23-05-17	14:10:24	6.03	4.88	29.42
23-05-17	14:10:25	6.03	4.86	29.3
23-05-17	14:10:26	6.03	4.85	29.25
23-05-17	14:10:27	6.03	4.87	29.36
23-05-17	14:10:28	6.03	4.85	29.25
23-05-17	14:10:29	6.03	4.87	29.37
23-05-17	14:10:30	6.03	4.87	29.35
23-05-17	14:10:31	6.03	4.85	29.26
23-05-17	14:10:32	6.03	4.86	29.3
23-05-17	14:10:34	6.03	4.86	29.28
23-05-17	14:10:35	6	6.37	38.21
23-05-17	14:10:36	6.01	6.04	36.29
23-05-17	14:10:37	6.01	6.04	36.26
23-05-17	14:10:38	6.01	6.02	36.22
23-05-17	14:10:39	6.01	6.02	36.18
23-05-17	14:10:40	6.01	6.01	36.12
23-05-17	14:10:41	6	6.02	36.14
23-05-17	14:10:42	6.01	6.02	36.18
23-05-17	14:10:43	6	6.02	36.13
23-05-17	14:10:44	6	6.02	36.15
23-05-17	14:10:45	6.01	6.01	36.1
23-05-17	14:10:46	6	6	35.98
23-05-17	14:10:47	6	6.01	36.08
23-05-17	14:10:48	6.01	6.01	36.12
23-05-17	14:10:49	6.01	6.01	36.12
23-05-17	14:10:50	6.01	6.01	36.17
23-05-17	14:10:51	6.01	6.02	36.18
23-05-17	14:10:52	6.01	6.01	36.1
23-05-17	14:10:53	6.01	6.01	36.1
23-05-17	14:10:54	6.01	6	36.06
23-05-17	14:10:55	6.01	6.02	36.15
23-05-17	14:10:56	6.01	6.02	36.2
23-05-17	14:10:57	5.97	7.04	42.09
23-05-17	14:10:58	5.98	7.04	42.1
23-05-17	14:10:59	5.98	7.05	42.17
23-05-17	14:11:00	5.98	7.04	42.13
23-05-17	14:11:01	5.98	7.04	42.1

23-05-17	14:11:02	5.97	7.04	42.07
23-05-17	14:11:03	5.98	7.04	42.06
23-05-17	14:11:04	5.97	7.04	42.07
23-05-17	14:11:06	5.98	7.04	42.13
23-05-17	14:11:07	5.98	7.03	42.08
23-05-17	14:11:08	5.98	7.04	42.11
23-05-17	14:11:09	5.97	7.04	42.09
23-05-17	14:11:10	5.97	7.04	42.07
23-05-17	14:11:11	5.98	7.03	42.04
23-05-17	14:11:12	5.98	7.03	42.06
23-05-17	14:11:13	5.98	7.03	42.08
23-05-17	14:11:14	5.98	7.04	42.13
23-05-17	14:11:15	5.98	7.04	42.1
23-05-17	14:11:16	5.97	8.02	47.94
23-05-17	14:11:17	5.97	8.01	47.83
23-05-17	14:11:18	5.97	8	47.78
23-05-17	14:11:19	5.97	8.02	47.89
23-05-17	14:11:20	5.97	8	47.76
23-05-17	14:11:21	5.97	8	47.74
23-05-17	14:11:22	5.97	8.01	47.83
23-05-17	14:11:23	5.97	8	47.78
23-05-17	14:11:24	5.97	8	47.78
23-05-17	14:11:25	5.97	8	47.78
23-05-17	14:11:26	5.97	8	47.76
23-05-17	14:11:27	5.97	7.99	47.74
23-05-17	14:11:28	5.96	8	47.7
23-05-17	14:11:29	5.97	7.99	47.72
23-05-17	14:11:30	5.97	7.99	47.74
23-05-17	14:11:31	5.96	8	47.68
23-05-17	14:11:32	5.96	8	47.68
23-05-17	14:11:33	5.97	8	47.78
23-05-17	14:11:34	5.97	7.99	47.76
23-05-17	14:11:35	5.97	7.99	47.74
23-05-17	14:11:37	5.97	8	47.78
23-05-17	14:11:38	5.98	8	47.81
23-05-17	14:11:39	5.97	7.99	47.74
23-05-17	14:11:40	5.94	8.92	52.99
23-05-17	14:11:41	5.94	8.9	52.89
23-05-17	14:11:42	5.94	8.91	52.98

23-05-17	14:11:43	5.96	8.91	53.05
23-05-17	14:11:44	5.94	8.9	52.89
23-05-17	14:11:45	5.95	8.9	52.96
23-05-17	14:11:46	5.94	8.9	52.91
23-05-17	14:11:47	5.94	8.9	52.91
23-05-17	14:11:48	5.94	8.89	52.84
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23-05-17	14:11:50	5.95	8.89	52.85
23-05-17	14:11:51	5.95	8.9	52.94
23-05-17	14:11:52	5.95	8.88	52.87
23-05-17	14:11:53	5.95	8.88	52.78
23-05-17	14:11:54	5.96	8.88	52.85
23-05-17	14:11:55	5.93	9.76	57.88
23-05-17	14:11:56	5.92	9.73	57.62
23-05-17	14:11:57	5.92	9.75	57.73
23-05-17	14:11:58	5.92	9.76	57.73
23-05-17	14:11:59	5.92	9.75	57.76
23-05-17	14:12:00	5.93	9.73	57.63
23-05-17	14:12:01	5.92	9.75	57.74
23-05-17	14:12:02	5.92	9.74	57.69
23-05-17	14:12:03	5.92	9.72	57.59
23-05-17	14:12:04	5.92	9.74	57.69
23-05-17	14:12:05	5.92	9.72	57.53
23-05-17	14:12:06	5.92	9.72	57.54
23-05-17	14:12:07	5.92	9.73	57.63
23-05-17	14:12:09	5.92	9.73	57.61
23-05-17	14:12:10	5.92	9.74	57.66
23-05-17	14:12:11	5.92	9.7	57.46
23-05-17	14:12:12	5.92	9.73	57.58
23-05-17	14:12:13	5.93	9.73	57.63
23-05-17	14:12:14	5.93	9.73	57.63
23-05-17	14:12:15	5.92	9.71	57.52
23-05-17	14:12:16	5.92	9.73	57.6
23-05-17	14:12:17	5.91	10.69	63.26
23-05-17	14:12:18	5.91	10.52	62.21
23-05-17	14:12:19	5.92	10.53	62.29
23-05-17	14:12:20	5.92	10.51	62.18
23-05-17	14:12:21	5.92	10.51	62.23
23-05-17	14:12:22	5.91	10.5	62.1

23-05-17	14:12:23	5.92	10.5	62.16
23-05-17	14:12:24	5.91	10.51	62.14
23-05-17	14:12:25	5.91	10.49	62.06
23-05-17	14:12:26	5.92	10.51	62.23
23-05-17	14:12:27	5.91	10.5	62.1
23-05-17	14:12:28	5.92	10.51	62.2
23-05-17	14:12:29	5.91	10.51	62.12
23-05-17	14:12:30	5.92	10.5	62.16
23-05-17	14:12:31	5.92	10.5	62.13
23-05-17	14:12:32	5.91	10.5	62.08
23-05-17	14:12:33	5.92	10.51	62.21
23-05-17	14:12:34	5.92	10.5	62.11
23-05-17	14:12:35	5.91	10.5	62.11
23-05-17	14:12:36	5.91	10.49	62.03
23-05-17	14:12:37	5.92	10.5	62.11
23-05-17	14:12:39	5.91	10.51	62.15
23-05-17	14:12:40	5.92	10.5	62.16
23-05-17	14:12:41	5.92	10.51	62.21
23-05-17	14:12:42	5.91	10.5	62.11
23-05-17	14:12:43	5.92	10.49	62.09
23-05-17	14:12:44	5.91	10.5	62.11
23-05-17	14:12:45	5.92	10.5	62.11
23-05-17	14:12:46	5.92	10.49	62.12
23-05-17	14:12:47	5.92	10.5	62.14
23-05-17	14:12:48	5.92	10.49	62.12
23-05-17	14:12:49	5.91	10.5	62.08
23-05-17	14:12:50	5.92	10.16	60.17

ACS712

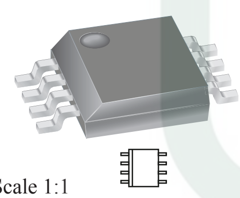
Fully Integrated, Hall Effect-Based Linear Current Sensor IC with 2.1 kVRMS Isolation and a Low-Resistance Current Conductor

Features and Benefits

- Low-noise analog signal path
- Device bandwidth is set via the new FILTER pin
- 5 µs output rise time in response to step input current
- 80 kHz bandwidth
- Total output error 1.5% at T_A = 25°C
- Small footprint, low-profile SOIC8 package
- 1.2 mΩ internal conductor resistance
- 2.1 kVRMS minimum isolation voltage from pins 1-4 to pins 5-8
- 5.0 V, single supply operation
- 66 to 185 mV/A output sensitivity
- Output voltage proportional to AC or DC currents
- Factory-trimmed for accuracy
- Extremely stable output offset voltage
- Nearly zero magnetic hysteresis
- Ratiometric output from supply voltage

TÜV America
Certificate Number:
U8V 06 05 54214 010

Package: 8 Lead SOIC (suffix LC)



Approximate Scale 1:1

Description

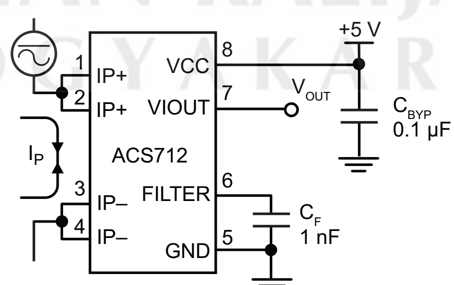
The Allegro™ ACS712 provides economical and precise solutions for AC or DC current sensing in industrial, commercial, and communications systems. The device package allows for easy implementation by the customer. Typical applications include motor control, load detection and management, switch-mode power supplies, and overcurrent fault protection. The device is not intended for automotive applications.

The device consists of a precise, low-offset, linear Hall circuit with a copper conduction path located near the surface of 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 voltage is provided by the low-offset, chopper-stabilized BiCMOS Hall IC, which is programmed for accuracy after packaging.

The output of the device has a positive slope (>$V_{IOUT(Q)}$) when an increasing current flows through the primary copper conduction path (from pins 1 and 2, to pins 3 and 4), which is the path used for current sampling. The internal resistance of this conductive path is 1.2 mΩ typical, providing low power loss. The thickness of the copper conductor allows survival of

Continued on the next page…

Typical Application



Application 1. The ACS712 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 recommended for noise management, with values that depend on the application.

Description (continued)

the device at up to 5× overcurrent conditions. The terminals of the conductive path are electrically isolated from the signal leads (pins 5 through 8). This allows the ACS712 to be used in applications requiring electrical isolation without the use of opto-isolators or other costly isolation techniques.

The ACS712 is provided in a small, surface mount SOIC8 package. The leadframe is plated with 100% matte tin, which is compatible with standard lead (Pb) free printed circuit board assembly processes. Internally, the device is Pb-free, except for flip-chip high-temperature Pb-based solder balls, currently exempt from RoHS. The device is fully calibrated prior to shipment from the factory.

Selection Guide

Part Number	Packing*	T_A (°C)	Optimized Range, I_P (A)	Sensitivity, Sens (Typ) (mV/A)
ACS712ELCTR-05B-T	Tape and reel, 3000 pieces/reel	–40 to 85	±5	185
ACS712ELCTR-20A-T	Tape and reel, 3000 pieces/reel	–40 to 85	±20	100
ACS712ELCTR-30A-T	Tape and reel, 3000 pieces/reel	–40 to 85	±30	66

*Contact Allegro for additional packing options.

Absolute Maximum Ratings

Characteristic	Symbol	Notes	Rating	Units
Supply Voltage	V_{CC}		8	V
Reverse Supply Voltage	V_{RCC}		–0.1	V
Output Voltage	V_{IOUT}		8	V
Reverse Output Voltage	V_{RIOUT}		–0.1	V
Output Current Source	$I_{IOUT(Source)}$		3	mA
Output Current Sink	$I_{IOUT(Sink)}$		10	mA
Overcurrent Transient Tolerance	I_P	1 pulse, 100 ms	100	A
Nominal Operating Ambient Temperature	T_A	Range E	–40 to 85	ºC
Maximum Junction Temperature	T_J(max)		165	ºC
Storage Temperature	T_{stg}		–65 to 170	ºC

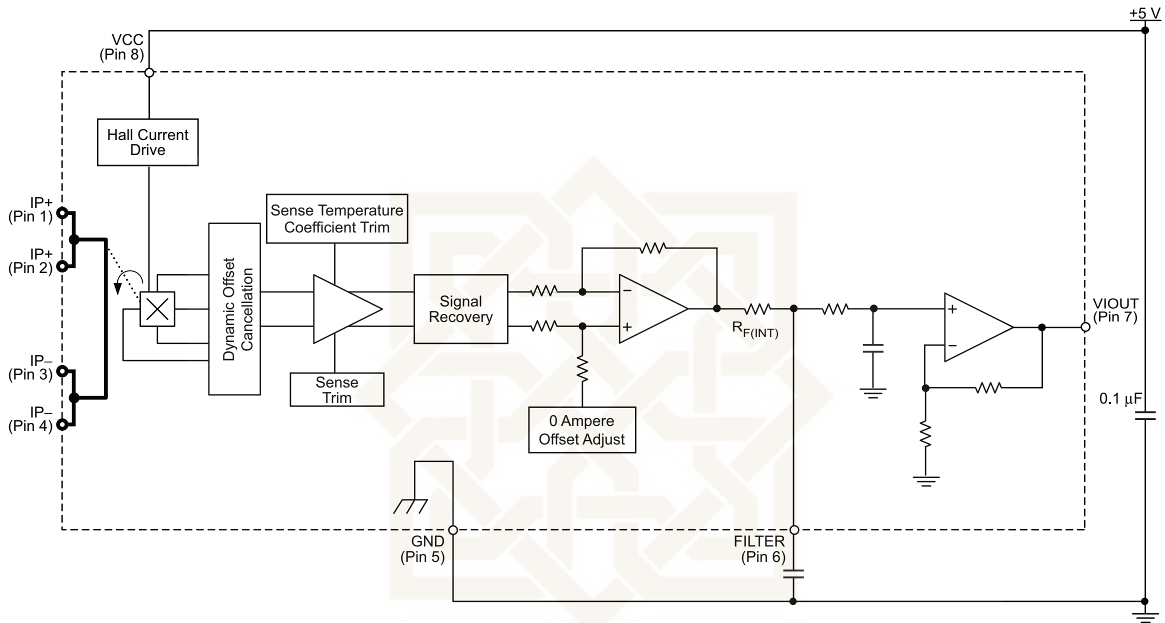
Isolation Characteristics

Characteristic	Symbol	Notes	Rating	Unit
Dielectric Strength Test Voltage*	V_{ISO}	Agency type-tested for 60 seconds per UL standard 60950-1, 1st Edition	2100	VAC
Working Voltage for Basic Isolation	V_{WFSI}	For basic (single) isolation per UL standard 60950-1, 1st Edition	354	VDC or V_{pk}
Working Voltage for Reinforced Isolation	V_{WFRI}	For reinforced (double) isolation per UL standard 60950-1, 1st Edition	184	VDC or V_{pk}

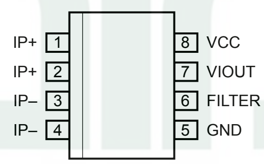
* Allegro does not conduct 60-second testing. It is done only during the UL certification process.

Parameter	Specification
Fire and Electric Shock	CAN/CSA-C22.2 No. 60950-1-03 UL 60950-1:2003 EN 60950-1:2001

Functional Block Diagram



Pin-out Diagram



Terminal List Table

Number	Name	Description
1 and 2	IP+	Terminals for current being sampled; fused internally
3 and 4	IP–	Terminals for current being sampled; fused internally
5	GND	Signal ground terminal
6	FILTER	Terminal for external capacitor that sets bandwidth
7	VIOUT	Analog output signal
8	VCC	Device power supply terminal

COMMON OPERATING CHARACTERISTICS[1] over full range of T_A, C_F = 1 nF, and V_{CC} = 5 V, unless otherwise specified

Characteristic	Symbol	Test Conditions	Min.	Typ.	Max.	Units
ELECTRICAL CHARACTERISTICS						
Supply Voltage	V_{CC}		4.5	5.0	5.5	V
Supply Current	I_{CC}	V_{CC} = 5.0 V, output open	–	10	13	mA
Output Capacitance Load	C_{LOAD}	VIOUT to GND	–	–	10	nF
Output Resistive Load	R_{LOAD}	VIOUT to GND	4.7	–	–	kΩ
Primary Conductor Resistance	$R_{PRIMARY}$	T_A = 25°C	–	1.2	–	mΩ
Rise Time	t_r	I_P = I_P(max), T_A = 25°C, C_{OUT} = open	–	3.5	–	μs
Frequency Bandwidth	f	–3 dB, T_A = 25°C; I_P is 10 A peak-to-peak	–	80	–	kHz
Nonlinearity	E_{LIN}	Over full range of I_P	–	1.5	–	%
Symmetry	E_{SYM}	Over full range of I_P	98	100	102	%
Zero Current Output Voltage	$V_{IOUT(Q)}$	Bidirectional; I_P = 0 A, T_A = 25°C	–	V_{CC} × 0.5	–	V
Power-On Time	t_{PO}	Output reaches 90% of steady-state level, T_J = 25°C, 20 A present on leadframe	–	35	–	μs
Magnetic Coupling[2]			–	12	–	G/A
Internal Filter Resistance[3]	$R_{F(INT)}$			1.7		kΩ

[1]Device may be operated at higher primary current levels, I_P, and ambient, T_A, and internal leadframe temperatures, T_A, provided that the Maximum Junction Temperature, T_J(max), is not exceeded.

[2]1G = 0.1 mT.

[3]$R_{F(INT)}$ forms an RC circuit via the FILTER pin.

COMMON THERMAL CHARACTERISTICS[1]

			Min.	Typ.	Max.	Units
Operating Internal Leadframe Temperature	T_A	E range	–40	–	85	°C
					Value	Units
Junction-to-Lead Thermal Resistance[2]	$R_{\theta JL}$	Mounted on the Allegro ASEK 712 evaluation board			5	°C/W
Junction-to-Ambient Thermal Resistance	$R_{\theta JA}$	Mounted on the Allegro 85-0322 evaluation board, includes the power consumed by the board			23	°C/W

[1]Additional thermal information is available on the Allegro website.

[2]The Allegro evaluation board has 1500 mm² of 2 oz. copper on each side, connected to pins 1 and 2, and to pins 3 and 4, with thermal vias connecting the layers. Performance values include the power consumed by the PCB. Further details on the board are available from the Frequently Asked Questions document on our website. Further information about board design and thermal performance also can be found in the Applications Information section of this datasheet.

x05B PERFORMANCE CHARACTERISTICS[1] T_A = –40°C to 85°C, C_F = 1 nF, and V_{CC} = 5 V, unless otherwise specified

Characteristic	Symbol	Test Conditions	Min.	Typ.	Max.	Units
Optimized Accuracy Range	I_P		–5	–	5	A
Sensitivity	Sens	Over full range of I_P, T_A = 25°C	180	185	190	mV/A
Noise	$V_{NOISE(PP)}$	Peak-to-peak, T_A = 25°C, 185 mV/A programmed Sensitivity, C_F = 47 nF, C_{OUT} = open, 2 kHz bandwidth	–	21	–	mV
Zero Current Output Slope	$\Delta V_{OUT(Q)}$	T_A = –40°C to 25°C	–	–0.26	–	mV/°C
		T_A = 25°C to 150°C	–	–0.08	–	mV/°C
Sensitivity Slope	ΔSens	T_A = –40°C to 25°C	–	0.054	–	mV/A/°C
		T_A = 25°C to 150°C	–	–0.008	–	mV/A/°C
Total Output Error[2]	E_{TOT}	I_P = ±5 A, T_A = 25°C	–	±1.5	–	%

[1]Device may be operated at higher primary current levels, I_P, and ambient temperatures, T_A, provided that the Maximum Junction Temperature, $T_{J(max)}$, is not exceeded.

[2]Percentage of I_P, with I_P = 5 A. Output filtered.

x20A PERFORMANCE CHARACTERISTICS[1] T_A = –40°C to 85°C, C_F = 1 nF, and V_{CC} = 5 V, unless otherwise specified

Characteristic	Symbol	Test Conditions	Min.	Typ.	Max.	Units
Optimized Accuracy Range	I_P		–20	–	20	A
Sensitivity	Sens	Over full range of I_P, T_A = 25°C	96	100	104	mV/A
Noise	$V_{NOISE(PP)}$	Peak-to-peak, T_A = 25°C, 100 mV/A programmed Sensitivity, C_F = 47 nF, C_{OUT} = open, 2 kHz bandwidth	–	11	–	mV
Zero Current Output Slope	$\Delta V_{OUT(Q)}$	T_A = –40°C to 25°C	–	–0.34	–	mV/°C
		T_A = 25°C to 150°C	–	–0.07	–	mV/°C
Sensitivity Slope	ΔSens	T_A = –40°C to 25°C	–	0.017	–	mV/A/°C
		T_A = 25°C to 150°C	–	–0.004	–	mV/A/°C
Total Output Error[2]	E_{TOT}	I_P = ±20 A, T_A = 25°C	–	±1.5	–	%

[1]Device may be operated at higher primary current levels, I_P, and ambient temperatures, T_A, provided that the Maximum Junction Temperature, T_J(max), is not exceeded.

[2]Percentage of I_P, with I_P = 20 A. Output filtered.

x30A PERFORMANCE CHARACTERISTICS[1] T_A = –40°C to 85°C, C_F = 1 nF, and V_{CC} = 5 V, unless otherwise specified

Characteristic	Symbol	Test Conditions	Min.	Typ.	Max.	Units
Optimized Accuracy Range	I_P		–30	–	30	A
Sensitivity	Sens	Over full range of I_P, T_A = 25°C	63	66	69	mV/A
Noise	$V_{NOISE(PP)}$	Peak-to-peak, T_A = 25°C, 66 mV/A programmed Sensitivity, C_F = 47 nF, C_{OUT} = open, 2 kHz bandwidth	–	7	–	mV
Zero Current Output Slope	$\Delta V_{OUT(Q)}$	T_A = –40°C to 25°C	–	–0.35	–	mV/°C
		T_A = 25°C to 150°C	–	–0.08	–	mV/°C
Sensitivity Slope	ΔSens	T_A = –40°C to 25°C	–	0.007	–	mV/A/°C
		T_A = 25°C to 150°C	–	–0.002	–	mV/A/°C
Total Output Error[2]	E_{TOT}	I_P = ±30 A, T_A = 25°C	–	±1.5	–	%

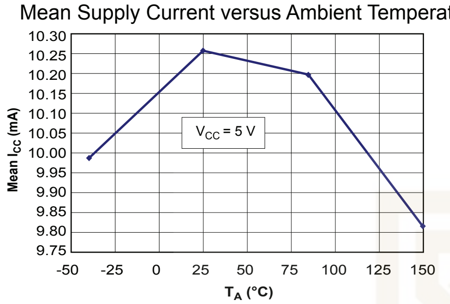
[1]Device may be operated at higher primary current levels, I_P, and ambient temperatures, T_A, provided that the Maximum Junction Temperature, T_J(max), is not exceeded.

[2]Percentage of I_P, with I_P = 30 A. Output filtered.

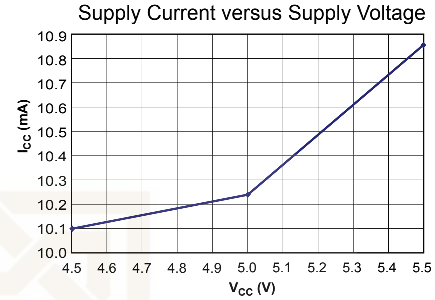
Characteristic Performance

I_P = 5 A, unless otherwise specified

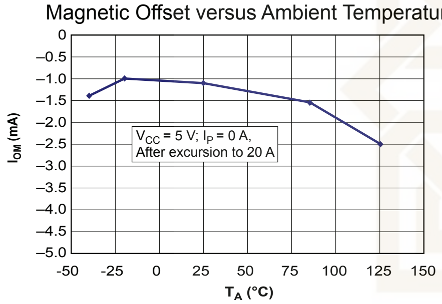
Mean Supply Current versus Ambient Temperature



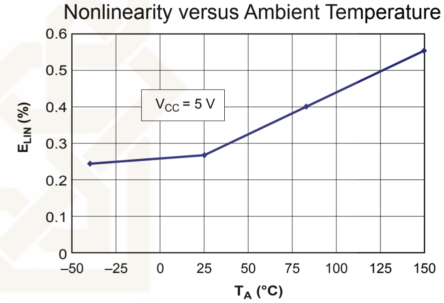
Supply Current versus Supply Voltage



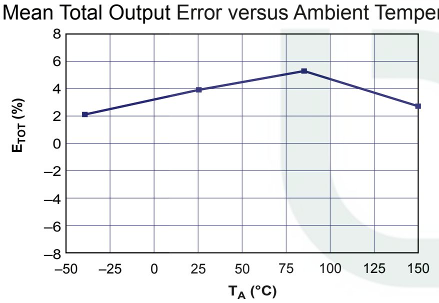
Magnetic Offset versus Ambient Temperature



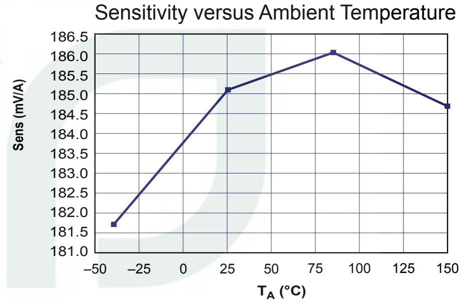
Nonlinearity versus Ambient Temperature



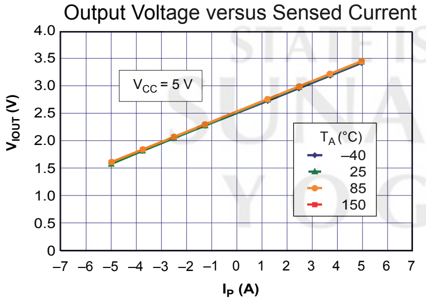
Mean Total Output Error versus Ambient Temperature



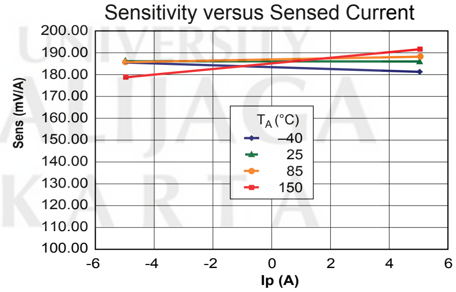
Sensitivity versus Ambient Temperature



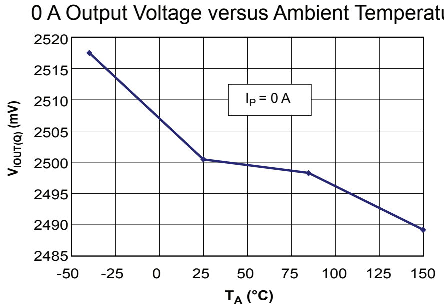
Output Voltage versus Sensed Current



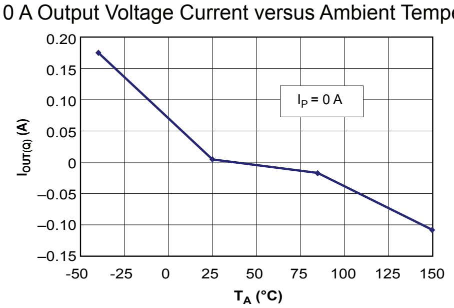
Sensitivity versus Sensed Current



0 A Output Voltage versus Ambient Temperature



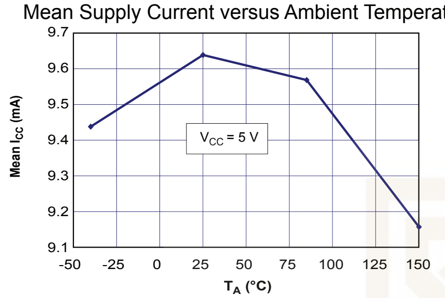
0 A Output Voltage Current versus Ambient Temperature



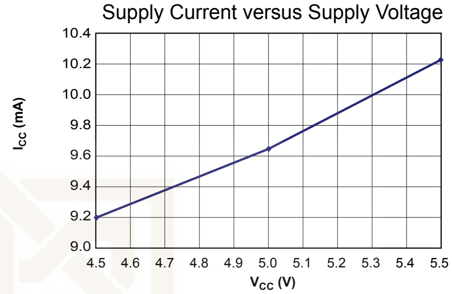
Characteristic Performance

I_P = 20 A, unless otherwise specified

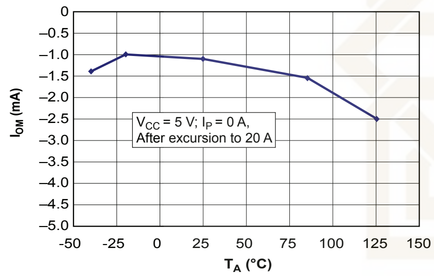
Mean Supply Current versus Ambient Temperature



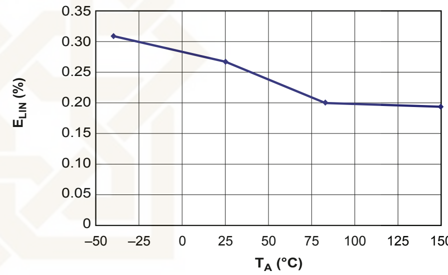
Supply Current versus Supply Voltage



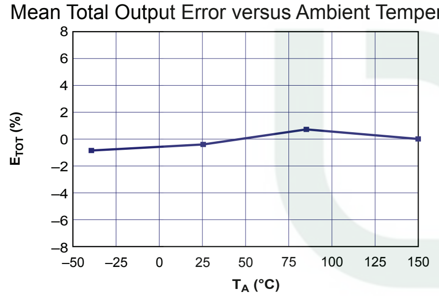
Magnetic Offset versus Ambient Temperature



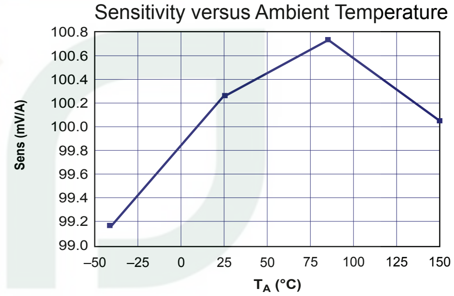
Nonlinearity versus Ambient Temperature



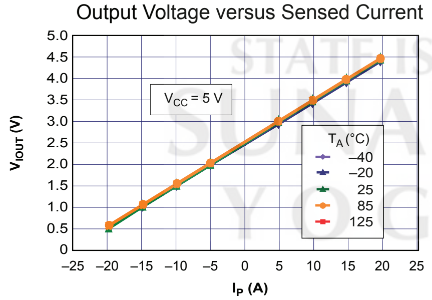
Mean Total Output Error versus Ambient Temperature



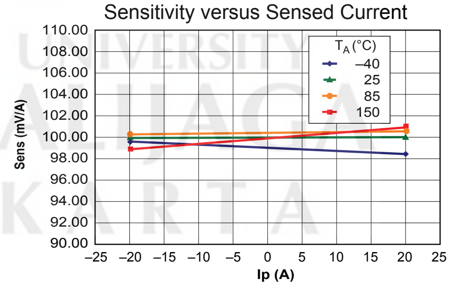
Sensitivity versus Ambient Temperature



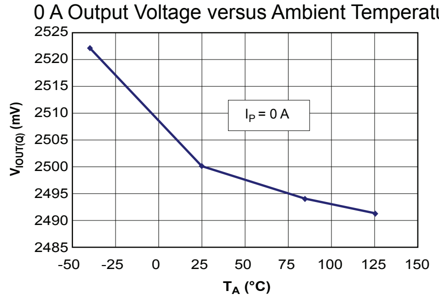
Output Voltage versus Sensed Current



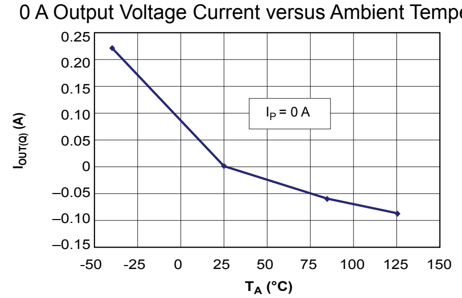
Sensitivity versus Sensed Current



0 A Output Voltage versus Ambient Temperature



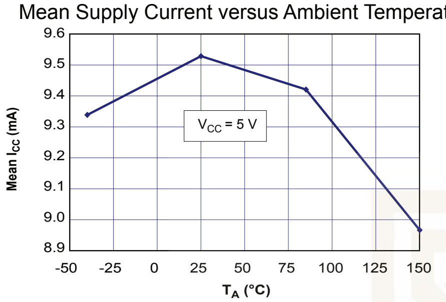
0 A Output Voltage Current versus Ambient Temperature



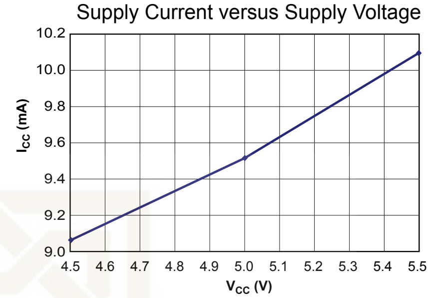
Characteristic Performance

I_P = 30 A, unless otherwise specified

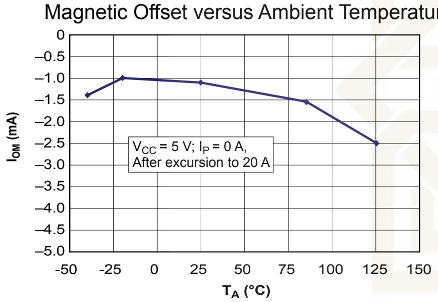
Mean Supply Current versus Ambient Temperature



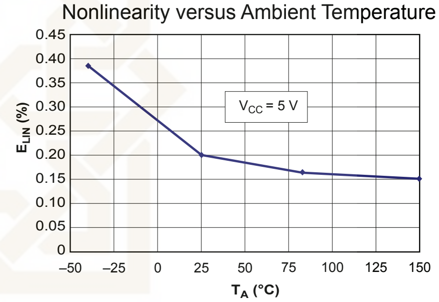
Supply Current versus Supply Voltage



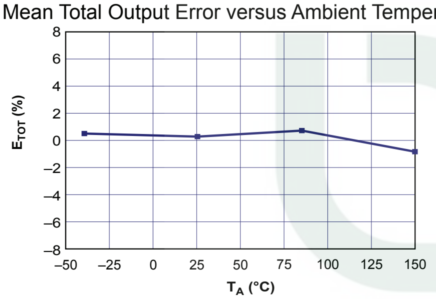
Magnetic Offset versus Ambient Temperature



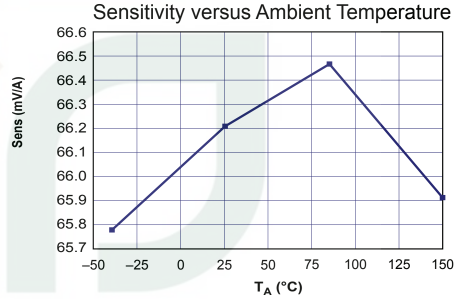
Nonlinearity versus Ambient Temperature



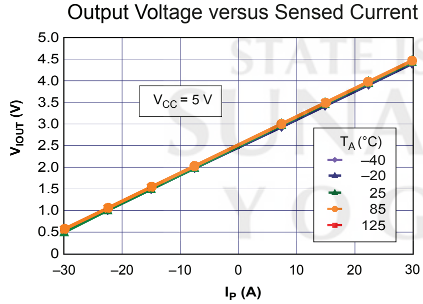
Mean Total Output Error versus Ambient Temperature



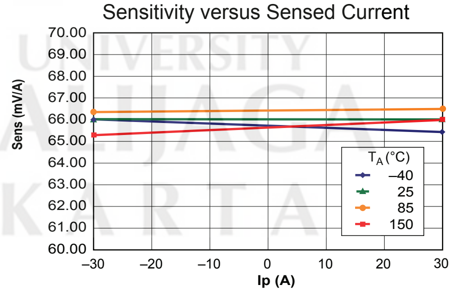
Sensitivity versus Ambient Temperature



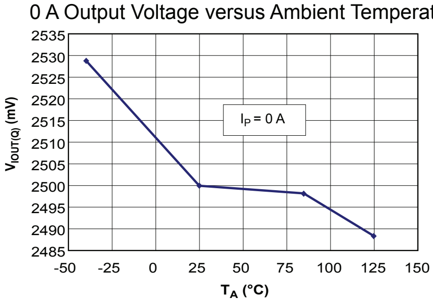
Output Voltage versus Sensed Current



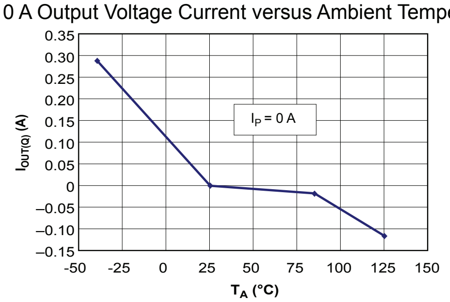
Sensitivity versus Sensed Current



0 A Output Voltage versus Ambient Temperature



0 A Output Voltage Current versus Ambient Temperature



Definitions of Accuracy Characteristics

Sensitivity (Sens). The change in device output in response to a 1 A change through the primary conductor. The sensitivity is the product of the magnetic circuit sensitivity (G/A) and the linear IC amplifier gain (mV/G). The linear IC amplifier gain is programmed at the factory to optimize the sensitivity (mV/A) for the full-scale current of the device.

Noise (V_{NOISE}). The product of the linear IC amplifier gain (mV/G) and the noise floor for the Allegro Hall effect linear IC (≈1 G). The noise floor is derived from the thermal and shot noise observed in Hall elements. Dividing the noise (mV) by the sensitivity (mV/A) provides the smallest current that the device is able to resolve.

Linearity (E_{LIN}). The degree to which the voltage output from the IC varies in direct proportion to the primary current through its full-scale amplitude. Nonlinearity in the output can be attributed to the saturation of the flux concentrator approaching the full-scale current. The following equation is used to derive the linearity:

$$100\left\{1-\left[\frac{\Delta\text{ gain}\times\%\text{ sat }(V_{IOUT\_full\text{-}scale\ amperes}-V_{IOUT(Q)})}{2\,(V_{IOUT\_half\text{-}scale\ amperes}-V_{IOUT(Q)})}\right]\right\}$$

where $V_{IOUT\_full\text{-}scale\ amperes}$ = the output voltage (V) when the sampled current approximates full-scale $\pm I_P$.

Symmetry (E_{SYM}). The degree to which the absolute voltage output from the IC varies in proportion to either a positive or negative full-scale primary current. The following formula is used to derive symmetry:

$$100\left(\frac{V_{IOUT\_+\ full\text{-}scale\ amperes}-V_{IOUT(Q)}}{V_{IOUT(Q)}-V_{IOUT\_-full\text{-}scale\ amperes}}\right)$$

Quiescent output voltage ($V_{IOUT(Q)}$). The output of the device when the primary current is zero. For a unipolar supply voltage, it nominally remains at $V_{CC}/2$. Thus, V_{CC} = 5 V translates into $V_{IOUT(Q)}$ = 2.5 V. Variation in $V_{IOUT(Q)}$ can be attributed to the resolution of the Allegro linear IC quiescent voltage trim and thermal drift.

Electrical offset voltage (V_{OE}). The deviation of the device output from its ideal quiescent value of $V_{CC}/2$ due to nonmagnetic causes. To convert this voltage to amperes, divide by the device sensitivity, Sens.

Accuracy (E_{TOT}). The accuracy represents the maximum deviation of the actual output from its ideal value. This is also known as the total output error. The accuracy is illustrated graphically in the output voltage versus current chart at right.

Accuracy is divided into four areas:

- **0 A at 25°C.** Accuracy at the zero current flow at 25°C, without the effects of temperature.
- **0 A over Δ temperature.** Accuracy at the zero current flow including temperature effects.
- **Full-scale current at 25°C.** Accuracy at the the full-scale current at 25°C, without the effects of temperature.
- **Full-scale current over Δ temperature.** Accuracy at the full-scale current flow including temperature effects.

Ratiometry. The ratiometric feature means that its 0 A output, $V_{IOUT(Q)}$, (nominally equal to $V_{CC}/2$) and sensitivity, Sens, are proportional to its supply voltage, V_{CC}. The following formula is used to derive the ratiometric change in 0 A output voltage, $\Delta V_{IOUT(Q)RAT}$ (%).

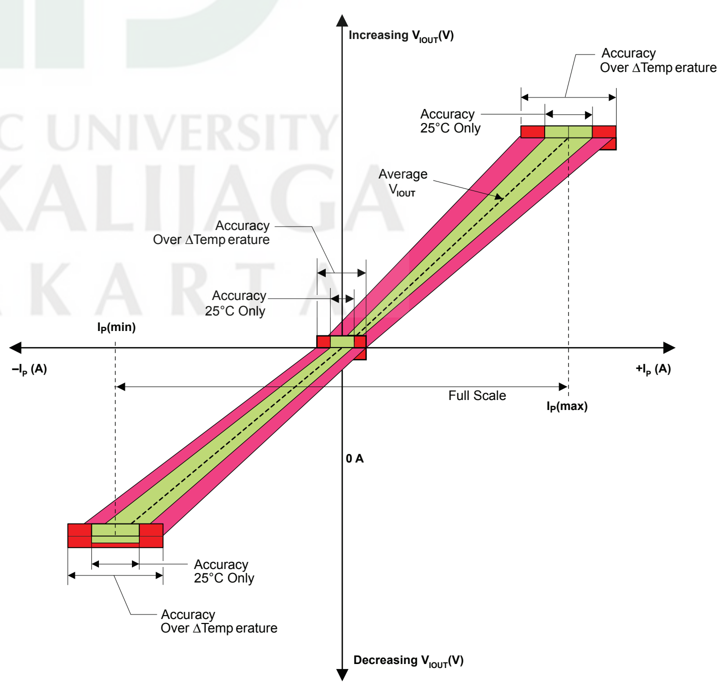
$$100\left(\frac{V_{IOUT(Q)VCC}\,/\,V_{IOUT(Q)5V}}{V_{CC}\,/\,5\text{ V}}\right)$$

The ratiometric change in sensitivity, $\Delta Sens_{RAT}$ (%), is defined as:

$$100\left(\frac{Sens_{VCC}\,/\,Sens_{5V}}{V_{CC}\,/\,5\text{ V}}\right)$$

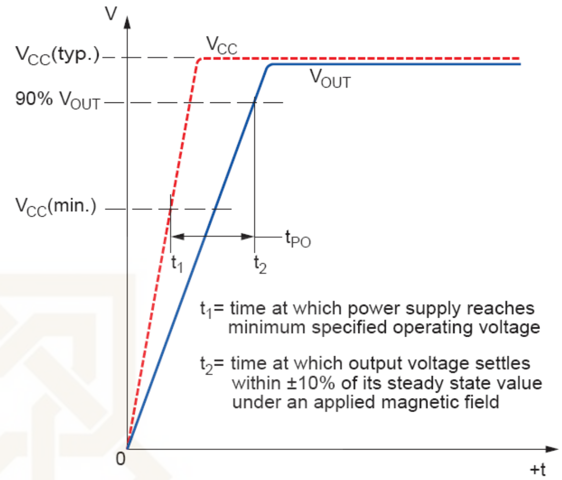
Output Voltage versus Sampled Current

Accuracy at 0 A and at Full-Scale Current

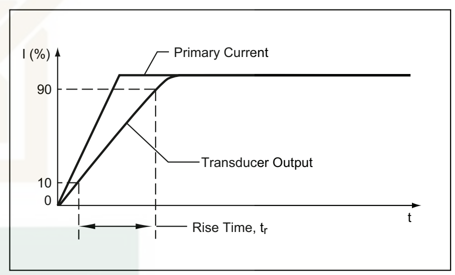


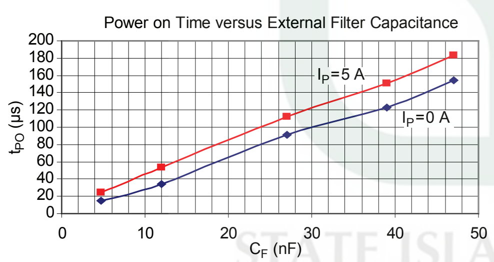
Definitions of Dynamic Response Characteristics

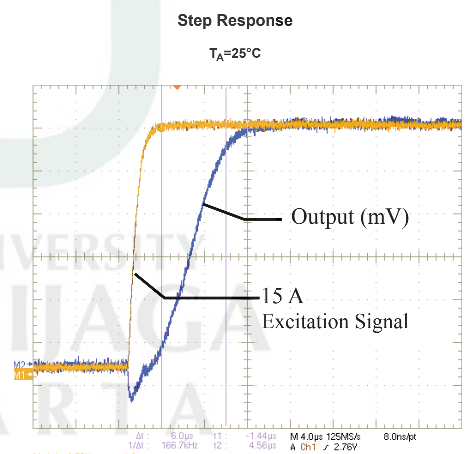
Power-On Time (t_{PO}). When the supply is ramped to its operating voltage, the device requires a finite time to power its internal components before responding to an input magnetic field. Power-On Time, t_{PO} , is defined as the time it takes for the output voltage to settle within ±10% of its steady state value under an applied magnetic field, after the power supply has reached its minimum specified operating voltage, V_{CC}(min), as shown in the chart at right.

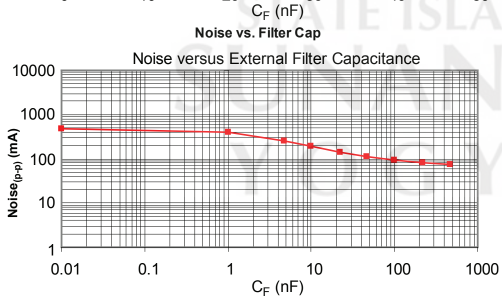


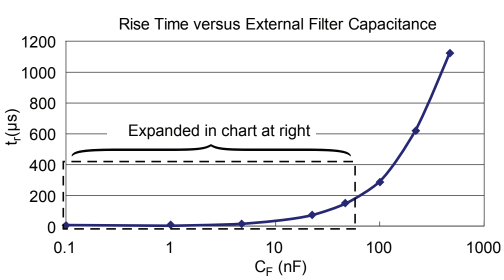
Rise time (t_r). The time interval between a) when the device reaches 10% of its full scale value, and b) when it reaches 90% of its full scale value. The rise time to a step response is used to derive the bandwidth of the device, in which $f(-3\text{ dB}) = 0.35/t_r$. Both t_r and $t_{RESPONSE}$ are detrimentally affected by eddy current losses observed in the conductive IC ground plane.



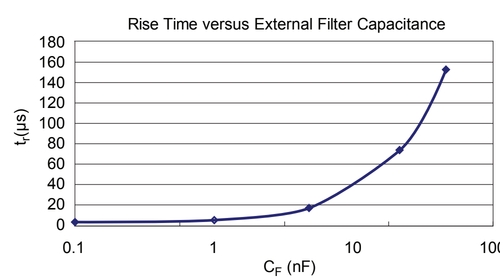








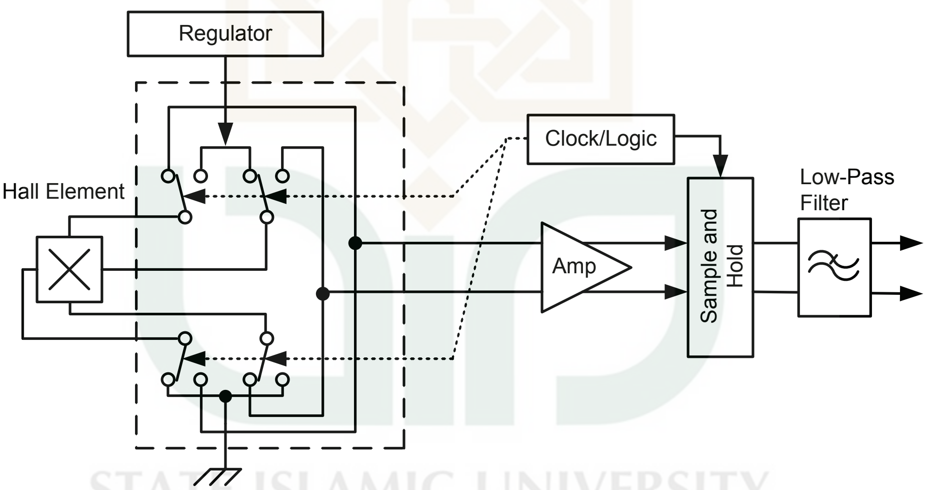
C_F (nF)	t_r (µs)
Open	3.5
1	5.8
4.7	17.5
22	73.5
47	88.2
100	291.3
220	623
470	1120



Chopper Stabilization Technique

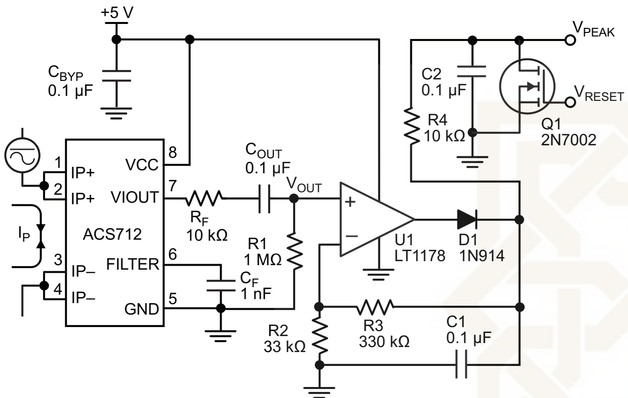
Chopper Stabilization is an innovative circuit technique that is used to minimize the offset voltage of a Hall element and an associated on-chip amplifier. Allegro has a Chopper Stabilization technique that nearly eliminates Hall IC output drift induced by temperature or package stress effects. This offset reduction technique is based on a signal modulation-demodulation process. Modulation is used to separate the undesired DC offset signal from the magnetically induced signal in the frequency domain. Then, using a low-pass filter, the modulated DC offset is suppressed while the magnetically induced signal passes through the filter. As a result of this chopper stabilization approach, the output voltage from the Hall IC is desensitized to the effects of temperature and mechanical stress. This technique produces devices that have an extremely stable Electrical Offset Voltage, are immune to thermal stress, and have precise recoverability after temperature cycling.

This technique is made possible through the use of a BiCMOS process that allows the use of low-offset and low-noise amplifiers in combination with high-density logic integration and sample and hold circuits.

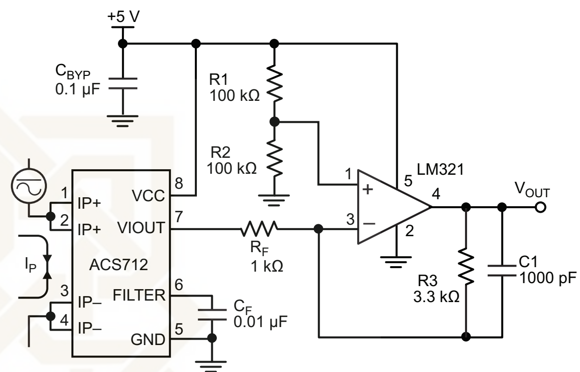


Concept of Chopper Stabilization Technique

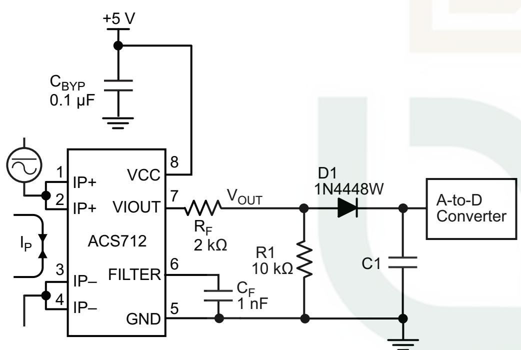
Typical Applications



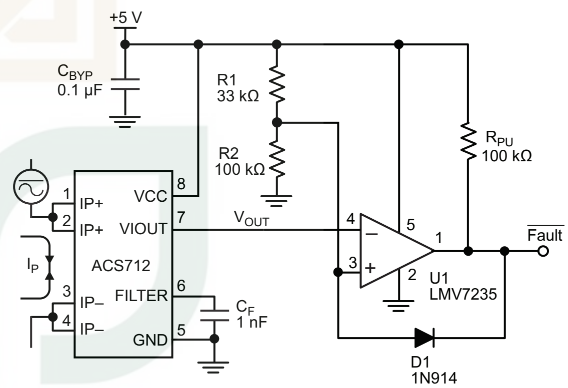
Application 2. Peak Detecting Circuit



Application 3. This configuration increases gain to 610 mV/A (tested using the ACS712ELC-05A).



Application 4. Rectified Output. 3.3 V scaling and rectification application for A-to-D converters. Replaces current transformer solutions with simpler ACS circuit. C1 is a function of the load resistance and filtering desired. R1 can be omitted if the full range is desired.



Application 5. 10 A Overcurrent Fault Latch. Fault threshold set by R1 and R2. This circuit latches an overcurrent fault and holds it until the 5 V rail is powered down.

Improving Sensing System Accuracy Using the FILTER Pin

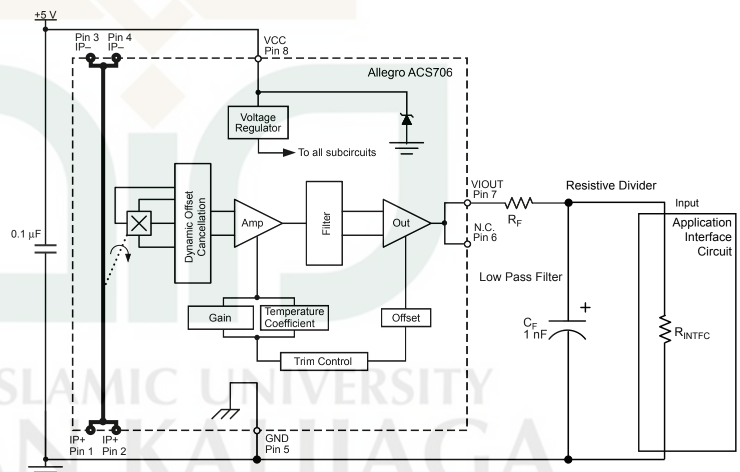
In low-frequency sensing applications, it is often advantageous to add a simple RC filter to the output of the device. Such a low-pass filter improves the signal-to-noise ratio, and therefore the resolution, of the device output signal. However, the addition of an RC filter to the output of a sensor IC can result in undesirable device output attenuation — even for DC signals.

Signal attenuation, ΔV_{ATT}, is a result of the resistive divider effect between the resistance of the external filter, R_F (see Application 6), and the input impedance and resistance of the customer interface circuit, R_{INTFC}. The transfer function of this resistive divider is given by:

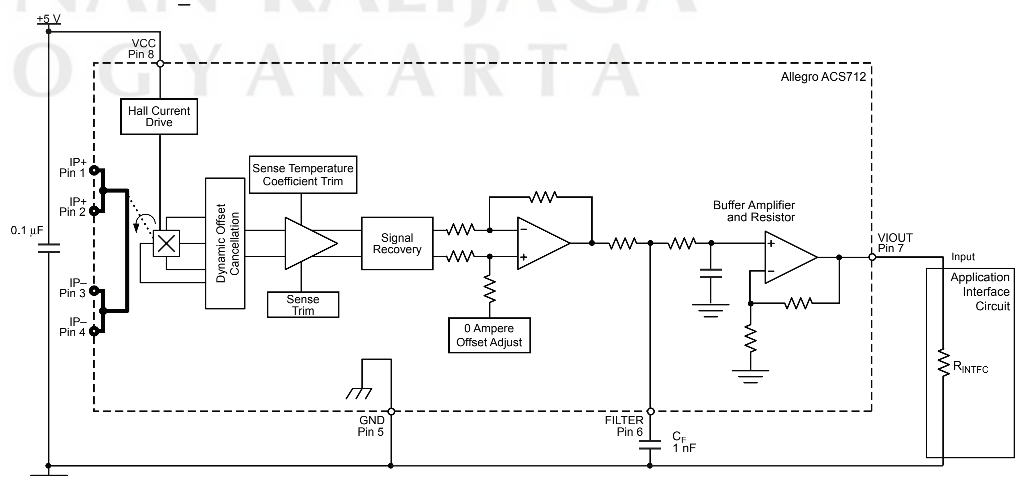
$$\Delta V_{\mathrm{ATT}} = V_{\mathrm{IOUT}}\left(\frac{R_{\mathrm{INTFC}}}{R_{\mathrm{F}} + R_{\mathrm{INTFC}}}\right) .$$

Even if R_F and R_{INTFC} are designed to match, the two individual resistance values will most likely drift by different amounts over temperature. Therefore, signal attenuation will vary as a function of temperature. Note that, in many cases, the input impedance, R_{INTFC}, of a typical analog-to-digital converter (ADC) can be as low as 10 kΩ.

The ACS712 contains an internal resistor, a FILTER pin connection to the printed circuit board, and an internal buffer amplifier. With this circuit architecture, users can implement a simple RC filter via the addition of a capacitor, C_F (see Application 7) from the FILTER pin to ground. The buffer amplifier inside of the ACS712 (located after the internal resistor and FILTER pin connection) eliminates the attenuation caused by the resistive divider effect described in the equation for ΔV_{ATT}. Therefore, the ACS712 device is ideal for use in high-accuracy applications that cannot afford the signal attenuation associated with the use of an external RC low-pass filter.

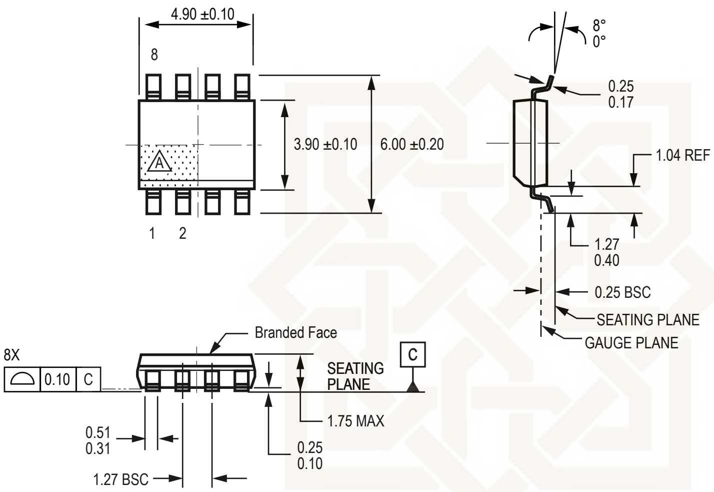


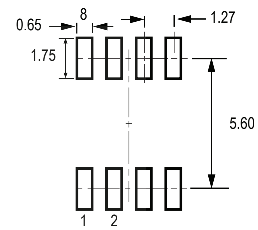
Application 6. When a low pass filter is constructed externally to a standard Hall effect device, a resistive divider may exist between the filter resistor, R_F, and the resistance of the customer interface circuit, R_{INTFC}. This resistive divider will cause excessive attenuation, as given by the transfer function for ΔV_{ATT}.



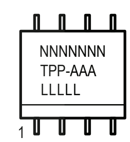
Application 7. Using the FILTER pin provided on the ACS712 eliminates the attenuation effects of the resistor divider between R_F and R_{INTFC}, shown in Application 6.

Package LC, 8-pin SOIC





C PCB Layout Reference View



B Standard Branding Reference View

N = Device part number
T = Device temperature range
P = Package Designator
A = Amperage
L = Lot number
Belly Brand = Country of Origin

For Reference Only; not for tooling use (reference MS-012AA)
Dimensions in millimeters
Dimensions exclusive of mold flash, gate burrs, and dambar protrusions
Exact case and lead configuration at supplier discretion within limits shown

A Terminal #1 mark area
B Branding scale and appearance at supplier discretion
C Reference land pattern layout (reference IPC7351
D SOIC127P600X175-8M); all pads a minimum of 0.20 mm from all adjacent pads; adjust as necessary to meet application process requirements and PCB layout tolerances

Revision History

Revision	Revision Date	Description of Revision
Rev. 15	November 16, 2012	Update rise time and isolation, I_{OUT} reference data, patents

The products described herein are protected by U.S. patents: 5,621,319; 7,598,601; and 7,709,754.

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