

PIC16F1825 I2C PWM Servo Control and Current Measurement Guide

MK-44149

December 26, 2014

IONOTRONICS Corporation

<http://www.ionotronics.com>

Copyright (C) 2014 IONOTRONICS

Permission is granted to copy, distribute and/or modify this document under the terms of the GNU Free Documentation License, Version 1.3 or any later version published by the Free Software Foundation; with no Invariant Sections, no Front-Cover Texts, and no Back-Cover Texts. A copy of the license is included in the section entitled "GNU Free Documentation License".

Table of Contents

1	Introduction	5
2	Changing I2C Address.....	8
3	Commands.....	8
3.1	Set the PWM (0xA1).....	8
4	Set PWM Time (0xA3)	9
5	Read Current (ADC) Value (0xA2).....	9
6	Read Mean Current (ADC) Value (0xA5)	12
7	Set ADC Sample Period (A6)	12
8	Connections and Selected Circuits	13
9	Applications	15
9.1	AL5A Robot Arm Control	15
10	Hirose DF11 Series Connector	22
11	GNU Free Documentation License	24

List of Figures

Figure 1 MK-44149 PIC16F1825 Based I2C Slave for PWM and Current Measurement	5
Figure 2 MK-44149 Top View	6
Figure 3 MK-44149 Bottom Showing PIC16F1825 and Clock XTAL	7
Figure 4 Board Dimensions	8
Figure 5 Measured Value versus Current	10
Figure 6 PyroRaptor Graphical User Interface for I2C Control Device Address is 0x68	11
Figure 7 10 AMP Current Meter	11
Figure 8 Pin RA4 Used for Onboard LED (Green)	13
Figure 9 6 Pin Molex Connector for I2C, 6V High Current to Servos and Interrupt and Inhibit Support	13
Figure 10 3 Wire Servo Interface. Signal, 6V and Ground.	13
Figure 11 Current Measurement with ACS714. RC3 is Connected to ADC in PIC16F1825	14
Figure 12 Power Supply Regulator (LDO) with Inhibit. 12-6V to 5V	14
Figure 13 AL5A Lynxmotion Controlled with 5 x MK-44149 I2C PWM Slaves with Current Measurement for Each Individual Servo	16
Figure 14 Closeup Showing 6.0 Volt Ni-MH 2800mAh Battery Pack, 5Amper Meter, Bar Voltage Indicator, High Current Terminals and PowerPoles	17
Figure 15 Arm Control wit 5x MK-44149	18
Figure 16 High Current I2C Bus with 6 Pin Molex Connector for 5x MK-44149 I2C PWM/Current Slaves and Connection to PyroRaptor (USB/I2C Bus). Unmounted for Illustration Purposes.	19
Figure 17 Showing Interface of I2C Arm Control to PyroRaptor USB/I2C Bridge	20
Figure 18 PyroRaptor Java Graphical Interface I2C Bus Scan Results Showing I2C devices (5x MK-44149)	21
Figure 19 Guide to the Hirose DF11 series connector	22

1 Introduction

This is a guide to using the PIC16F1825 as an I2C device for PWM control of Servos (e.g. HiTech) and current measurement. The PIC16F1825 is pre-programmed. Users can also program the 16F1825 using the CCS C Compiler or C Compiler from MicroChip for their own applications.

The I2C interface allows for the I2C address to be changed in the field using the IONOTRONICS PyroRaptor and IONOTRONICS Pyroraptor Java Graphical User Interface.

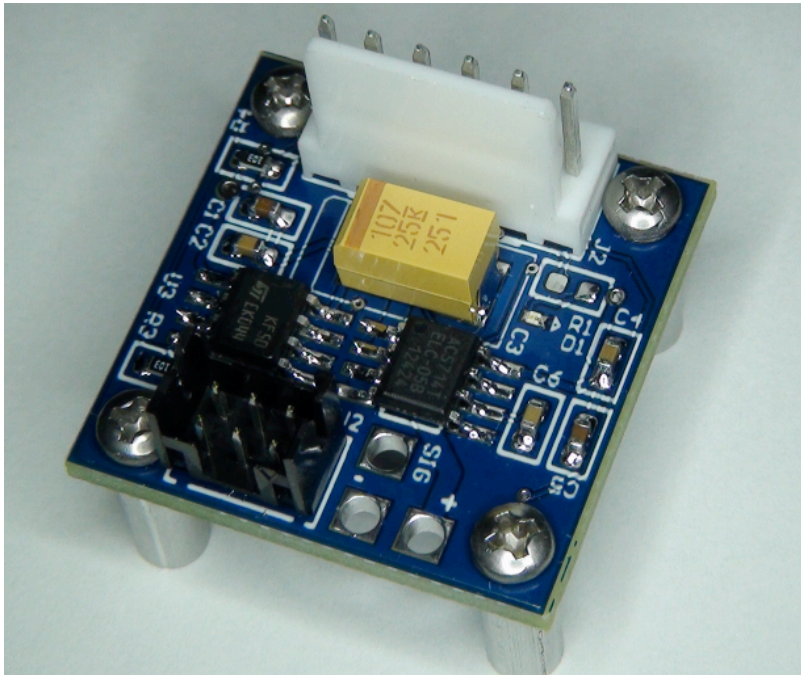


Figure 1 MK-44149 PIC16F1825 Based I2C Slave for PWM and Current Measurement

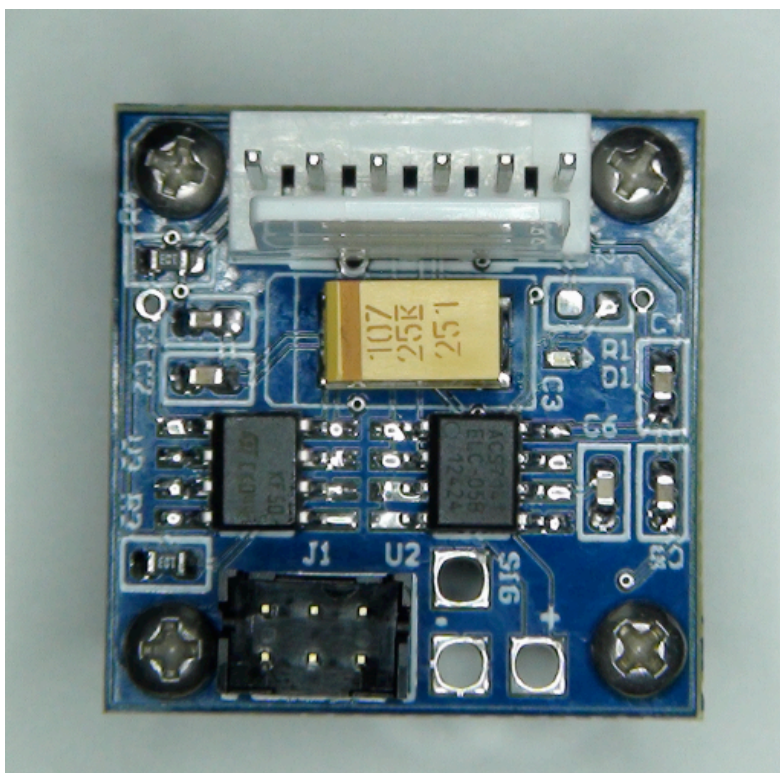


Figure 2 MK-44149 Top View

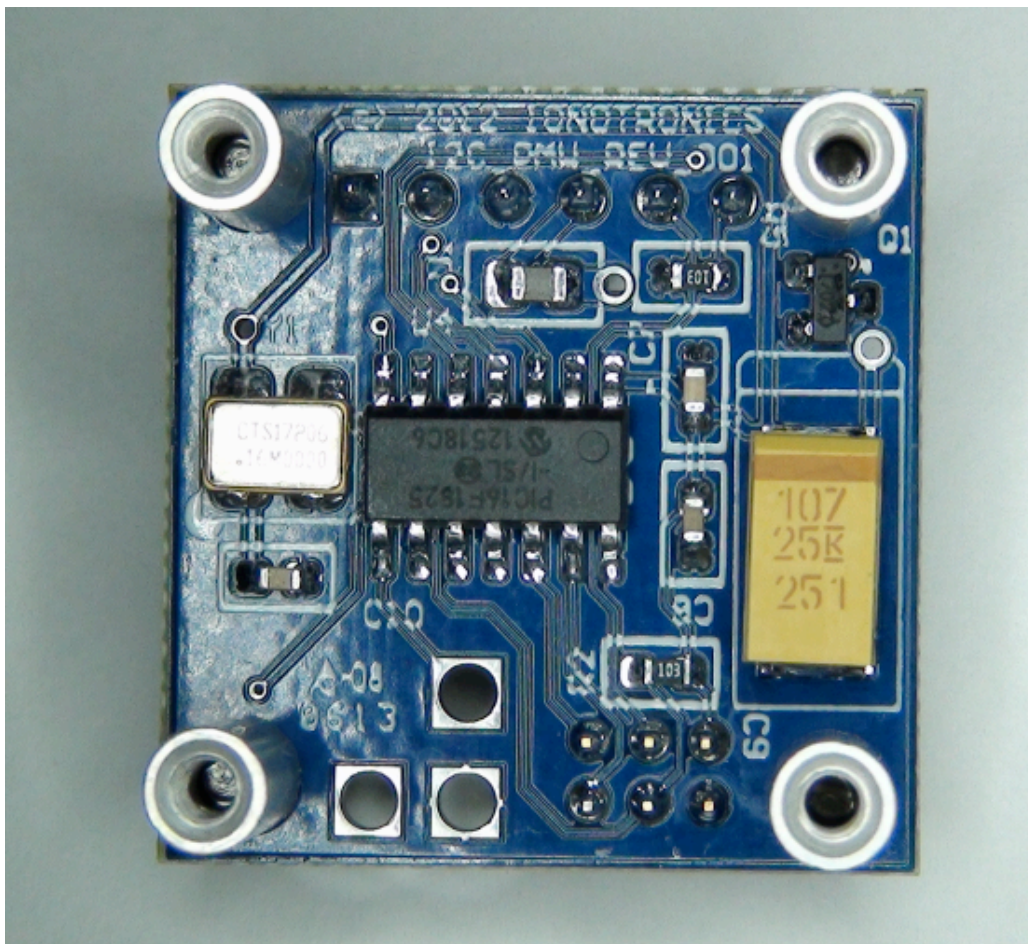


Figure 3 MK-44149 Bottom Showing PIC16F1825 and Clock XTAL

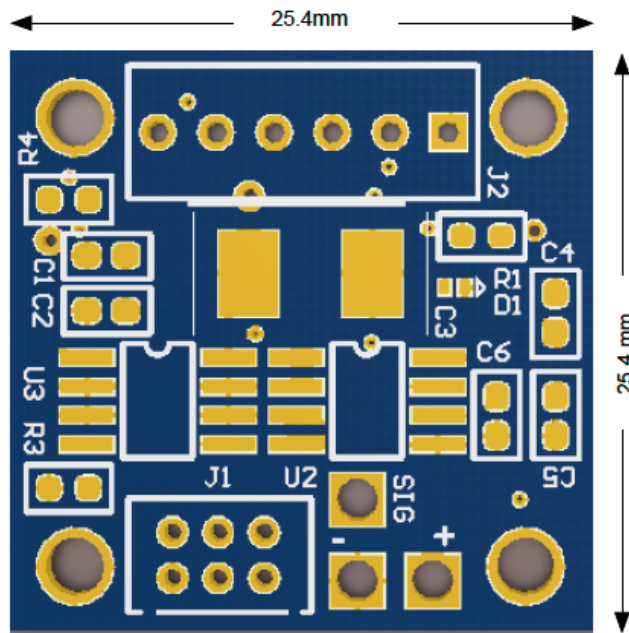


Figure 4 Board Dimensions

2 Changing I2C Address

To change the default I2C address (0x3A) send the command 0xFE to the I2C device. Next send the new I2C address (twice the actual address). Note these are two separate commands. That is send the command then start a new I2C transaction and send the address. For example to set the I2C address to 0x4e send 0x9C.

3 Commands

3.1 Set the PWM (0xA1)

Step 1: Write the command value 0xA1 to the device(PIC16F1825).

Step 2: Write the Most Significant Byte (MSB)to the I2C device.

Step 2: Write the Least Significant Byte (LSB) to the I2C device.

The device will set the PWM value as:

$\text{pwm value} = \text{MSB} * 256 + \text{LSB}$.

Note that if a Time Interval has been set, the pwm will start from the current value and ramp up or down to the pwm value specified. If the time interval is 0 then the pwm value is immediately updated.

4 Set PWM Time (0xA3)

Step 1: Write the command value 0xA3 to the device(PIC16F1825).

Setp 2: Write time duration byte to the device.

The total time is:

$\text{time} = \text{timeByte} * 20 \text{ ms}$

So the step value is 20ms.

The maximum time is $255 * 20 = 5100 \text{ms}$ or 5.1s

This is an important parameter. Controlling the rate at which the present PWM (location) approaches the final PWM (location) is important for precision and over shoot avoidance as well as for example Robot stability.

5 Read Current (ADC) Value (0xA2)

Step 1: Write the command value 0xA2 to the device(PIC16F1825).

Step2 : Read the measured current as a Byte (this is ADC value).

The Table below shows the measured current value versus the actual current (using AMP Meter).

Table 1 Measured Value (I2C) versus Actual Current

Current	Measured Value	Hex
4	148	94
2.6	86	56
1.4	50	32
1.2	42	2A
0.75	26	1A
0.5	18	12

The plot of the table values is shown in the Figure below.

Current Measured (Value from 1825 ADC)

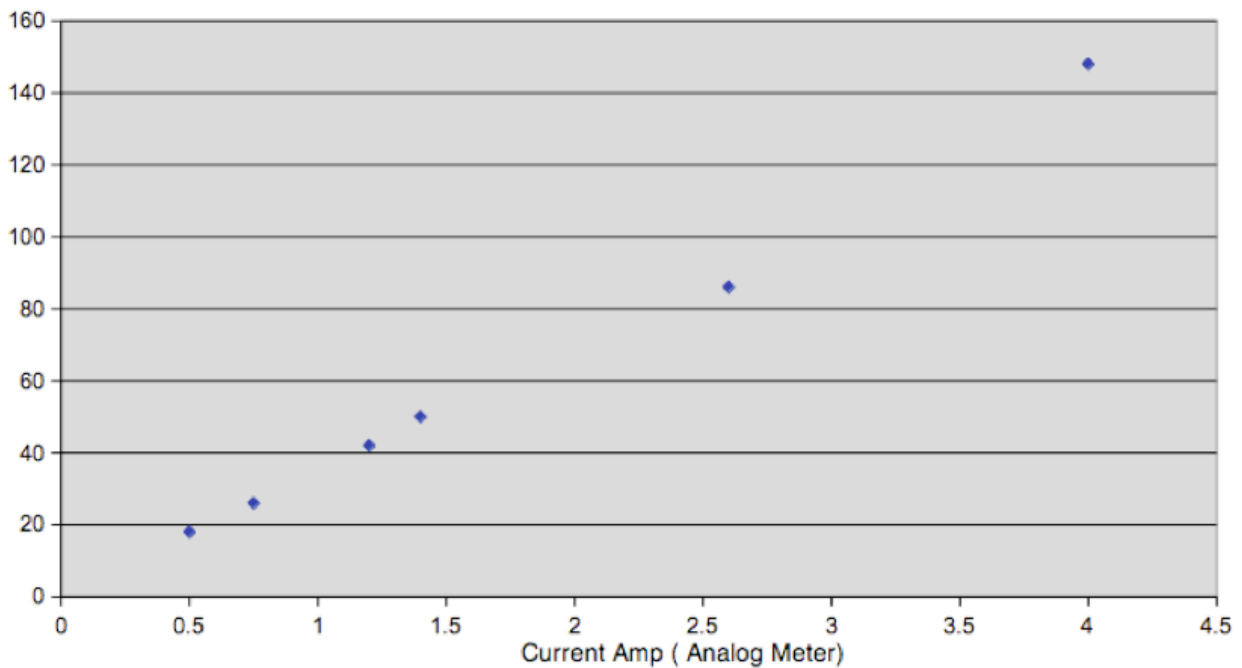


Figure 5 Measured Value versus Current

The Figure below shows the measured value obtained using PyroRaptor and the Graphical User Interface. Note the command 0xA2. The measured value was 0x1A and the load was 10 Ohms.

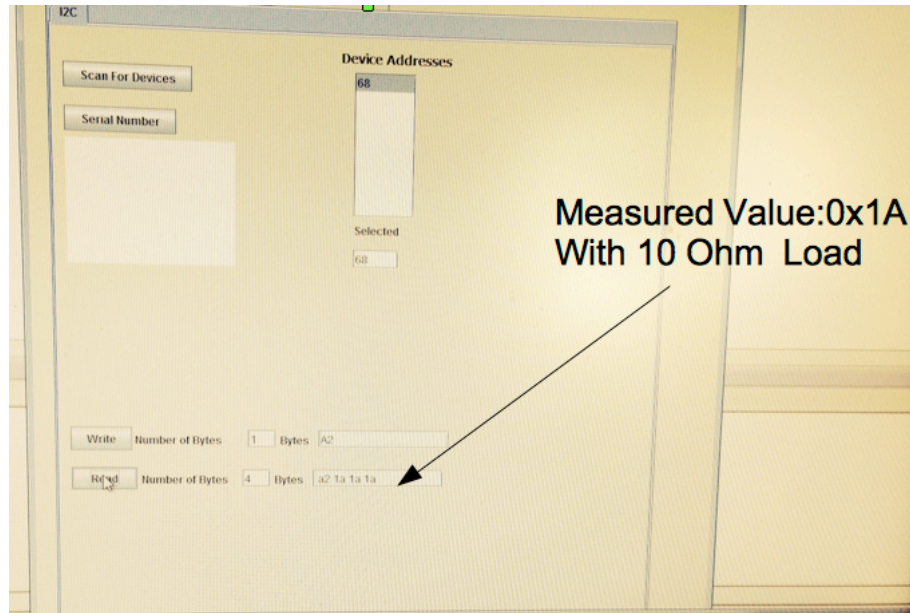


Figure 6 PyroRaptor Graphical User Interface for I2C Control Device Address is 0x68

The 10 AMP Analog Current Meter is shown below.

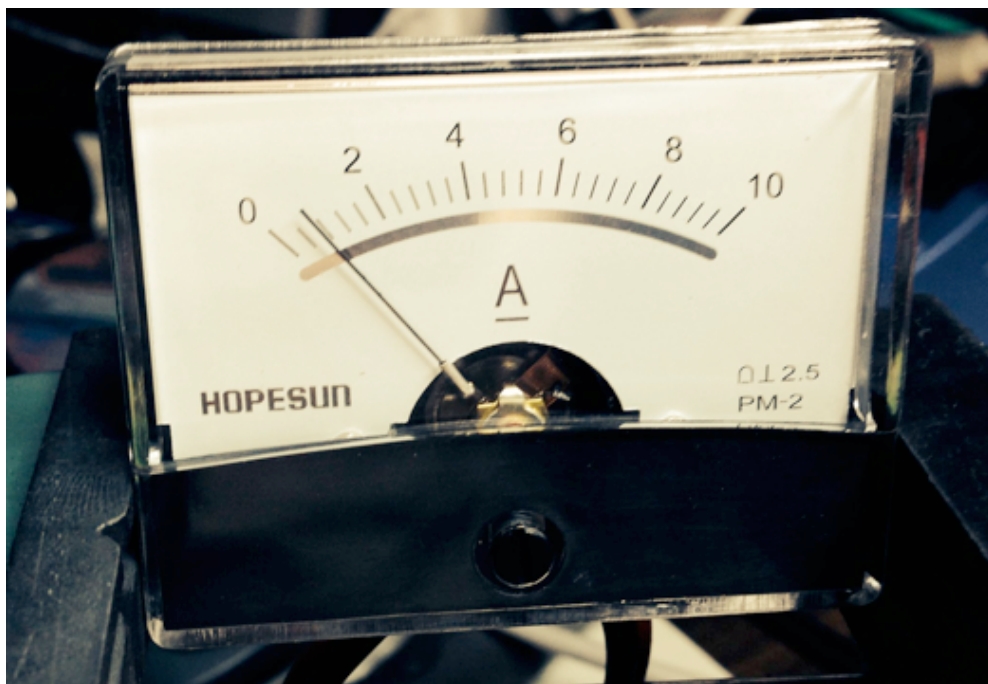


Figure 7 10 AMP Current Meter

6 Read Mean Current (ADC) Value (0xA5)

Step 1: Write the command value 0xA5 to the device(PIC16F1825).

Step2 : Read the measured mean current as a Byte (this is ADC value).

7 Set ADC Sample Period (A6)

Step 1: Write the command value 0xA6 to the device(PIC16F1825).

Step2 : Write the ADC Sample Period Byte to the device.

The ADC sampling interval for measuring the current is the value (8 bit) multiplied by 100us.

So $\text{adcSamplingInterval} = \text{value} * 100 \text{ us}$.

Example: $\text{value} = 100$ (0x64) then interval is $100 * 100\text{us} = 10\text{ms}$.

The mean value is computed using 10000 samples.

A 2 Amp change is a change of mean of 5.

8 Connections and Selected Circuits

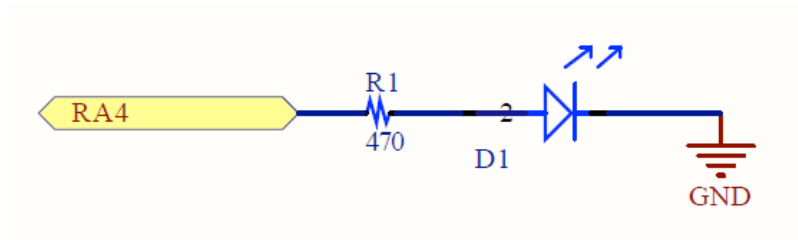


Figure 8 Pin RA4 Used for Onboard LED (Green)

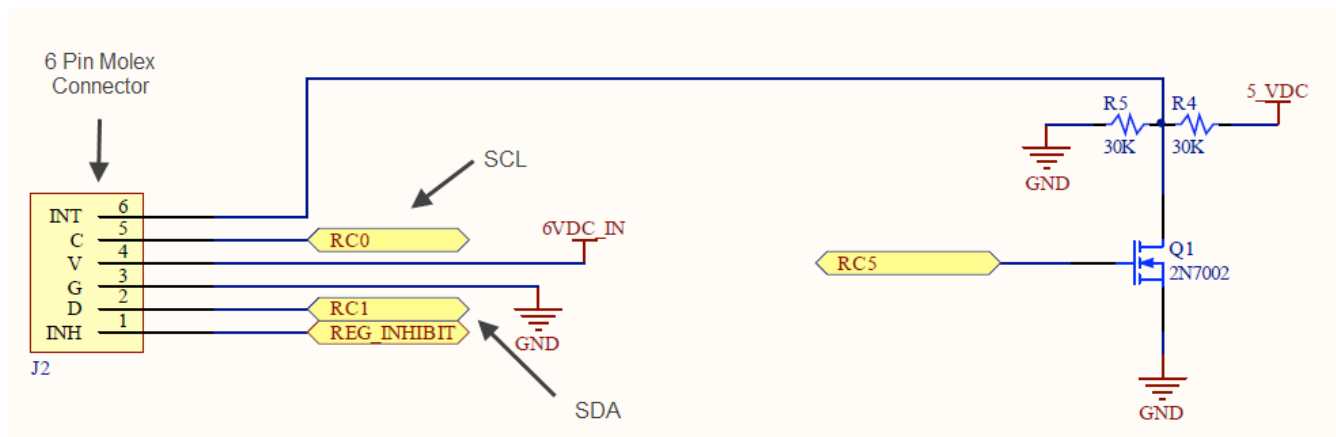


Figure 9 6 Pin Molex Connector for I2C, 6V High Current to Servos and Interrupt and Inhibit Support

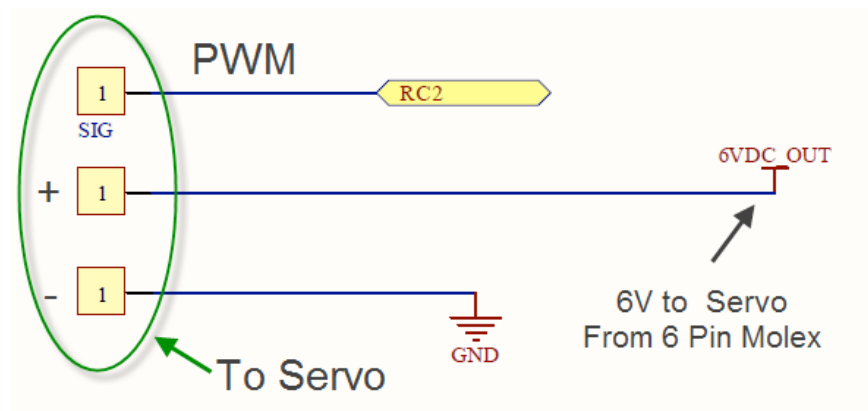


Figure 10 3 Wire Servo Interface. Signal, 6V and Ground.

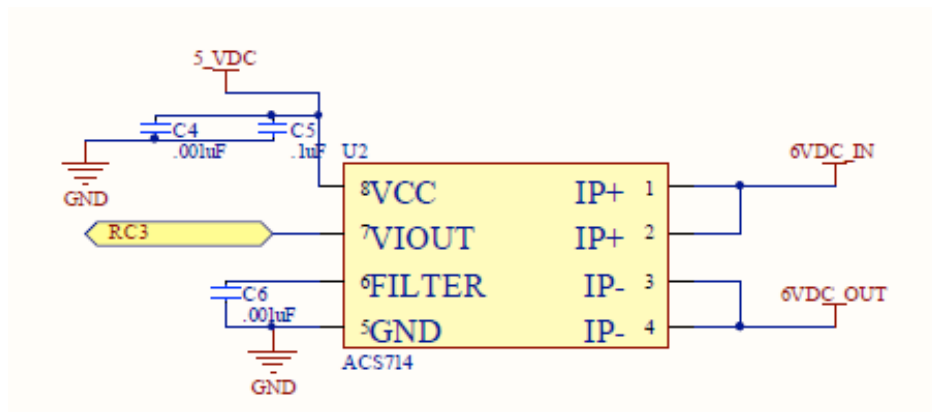


Figure 11 Current Measurement with ACS714. RC3 is Connected to ADC in PIC16F1825

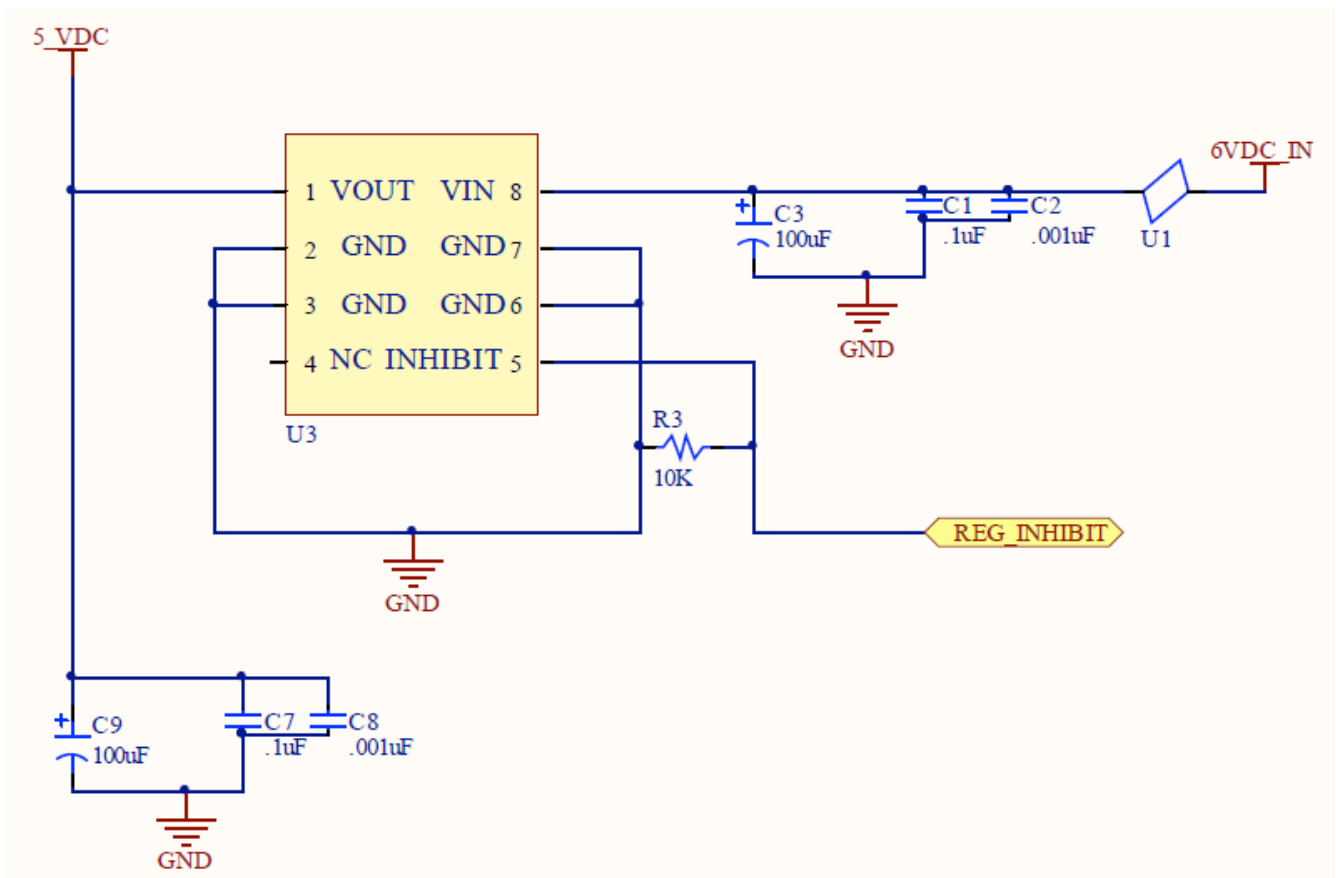


Figure 12 Power Supply Regulator (LDO) with Inhibit. 12-6V to 5V

9 Applications

9.1 AL5A Robot Arm Control

The MK-44149 can be used to control PWM Servos (1500us Neutral). These PWM servos can range from low torque to high torque heavy duty motors. In addition to Servo control, the MK-44149 measures the current through the Servo, This is an important capability on many levels. One can use this capability in Robotic courses to measure current and relate to torque. Also the conversion of electrical to mechanical energy can be investigated. In addition, the current can be measured to set alarms or shut off the motor.

In this application a Lynxmotion AL5A Arm with Hitech Servos will be controlled with 5 MK-44149 devices and the current for each servo can be measured. The control is through an I2C interface. For this purpose, we use the Ionotronics PyroRaptor USB to I2C Bridge and the Ionotronics Java Graphical Interface to the PyroRaptor. See the illustrations below for a complete view of the application. For videos of the AL5A in action visit the Ionotronics Website (<http://www.ionotronics.com>).

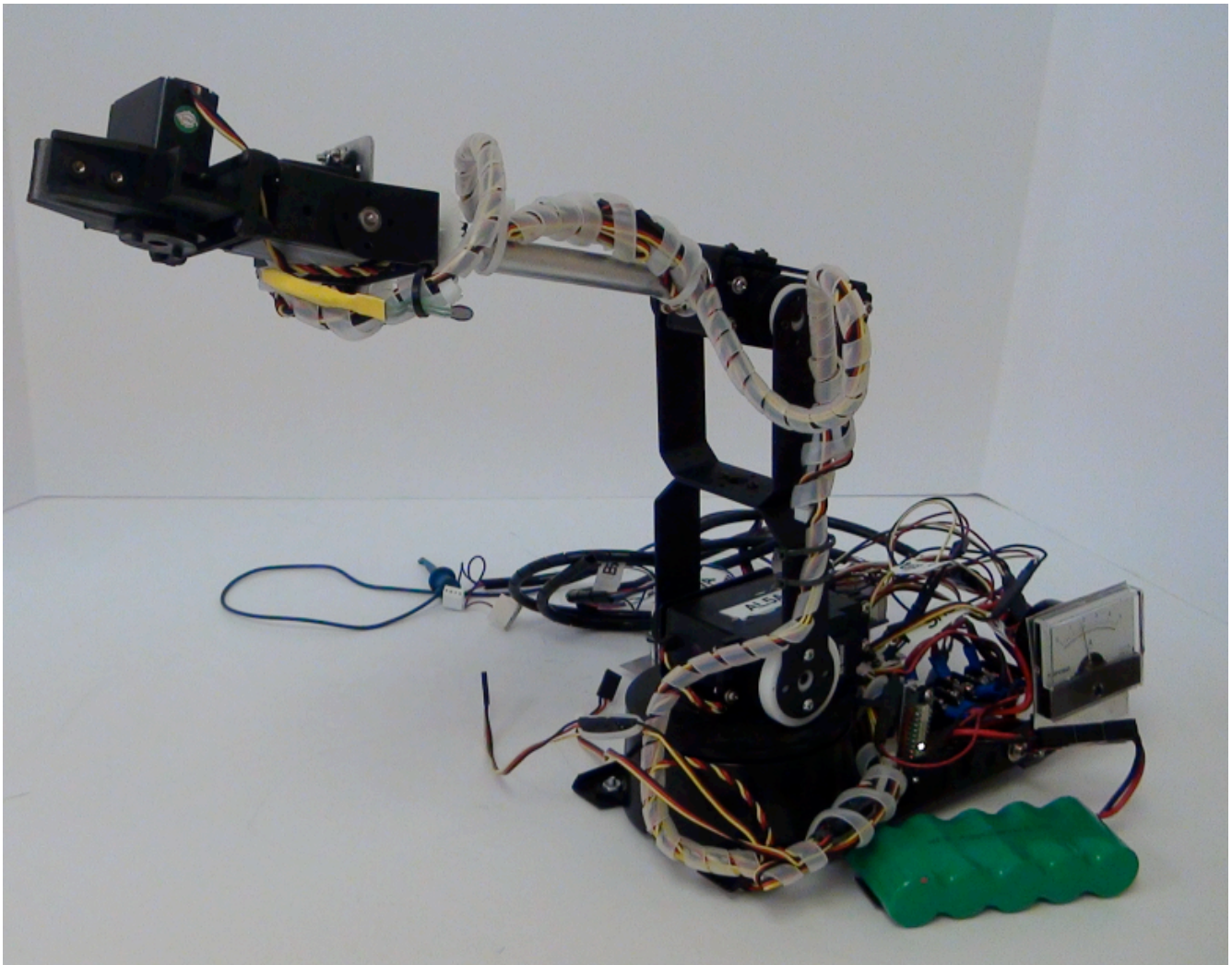


Figure 13 AL5A Lynxmotion Controlled with 5 x MK-44149 I2C PWM Slaves with Current Measurement for Each Individual Servo

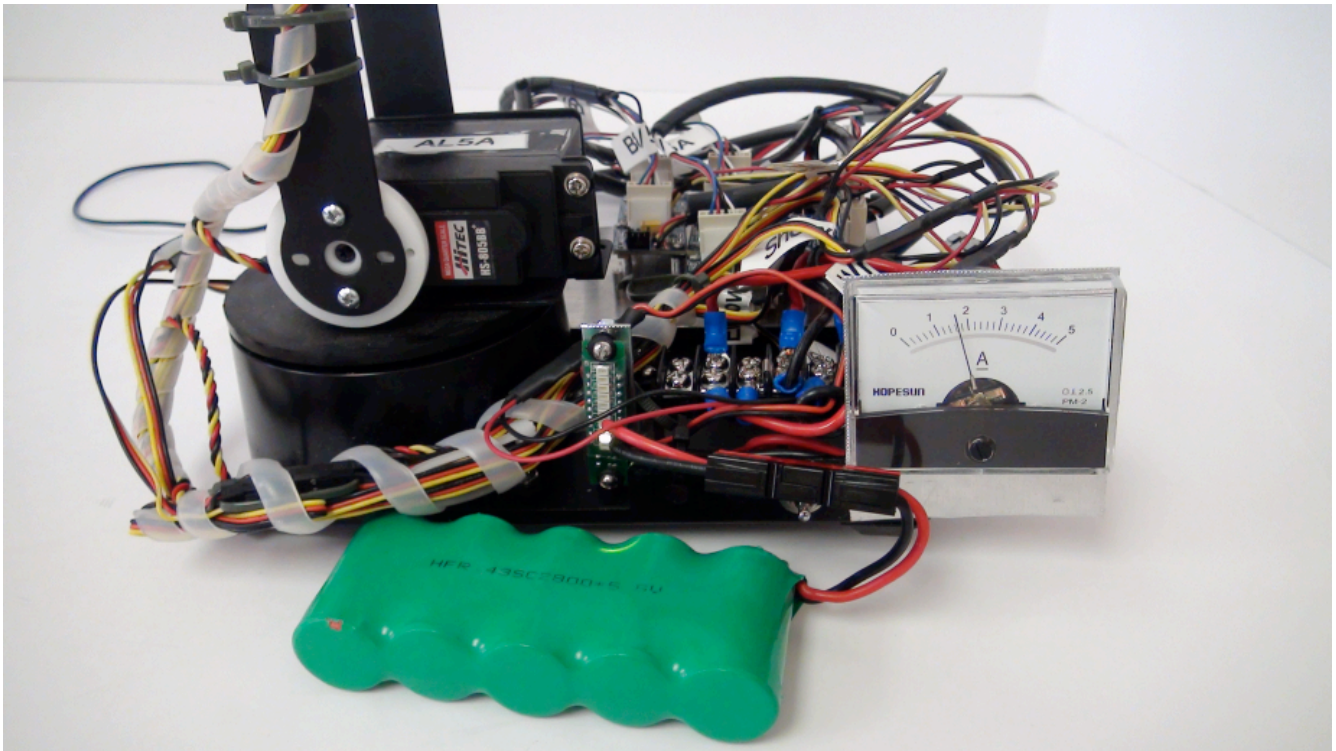


Figure 14 Closeup Showing 6.0 Volt Ni-MH 2800mAh Battery Pack, 5Amper Meter, Bar Voltage Indicator, High Current Terminals and PowerPoles

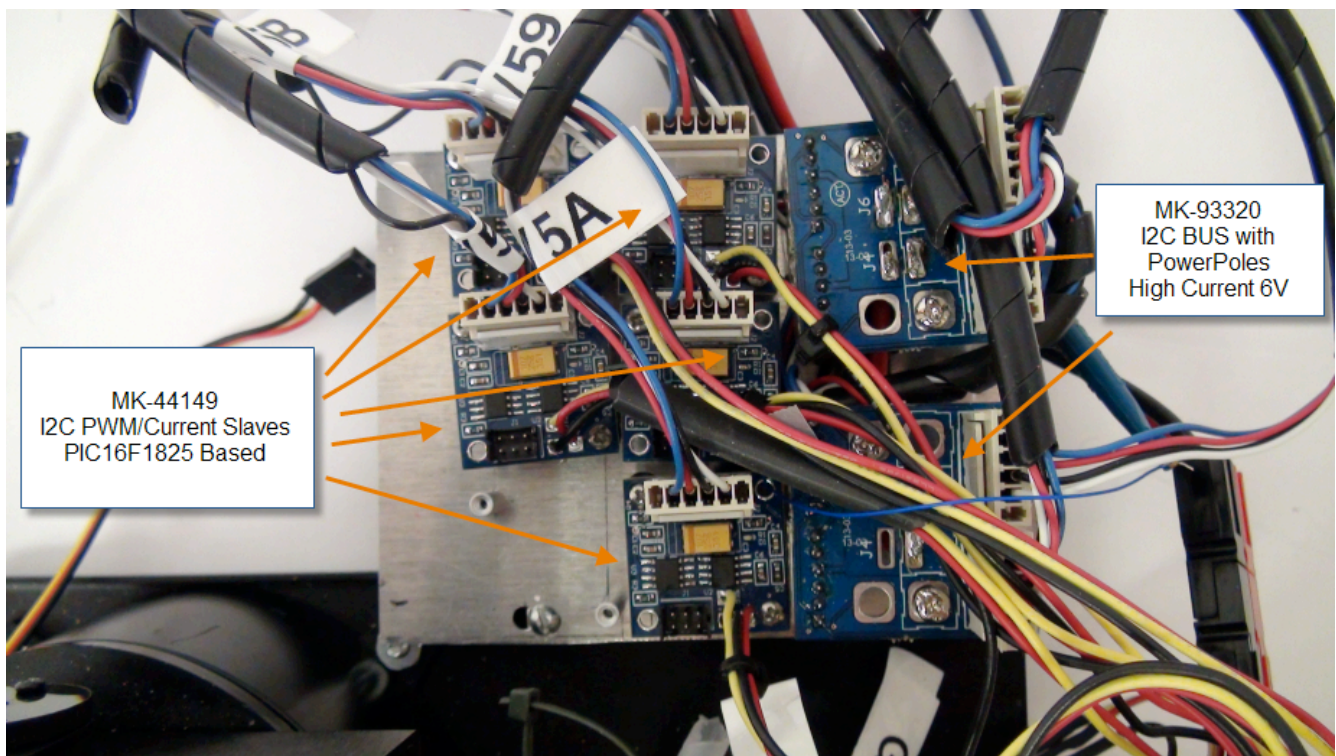


Figure 15 Arm Control wit 5x MK-44149

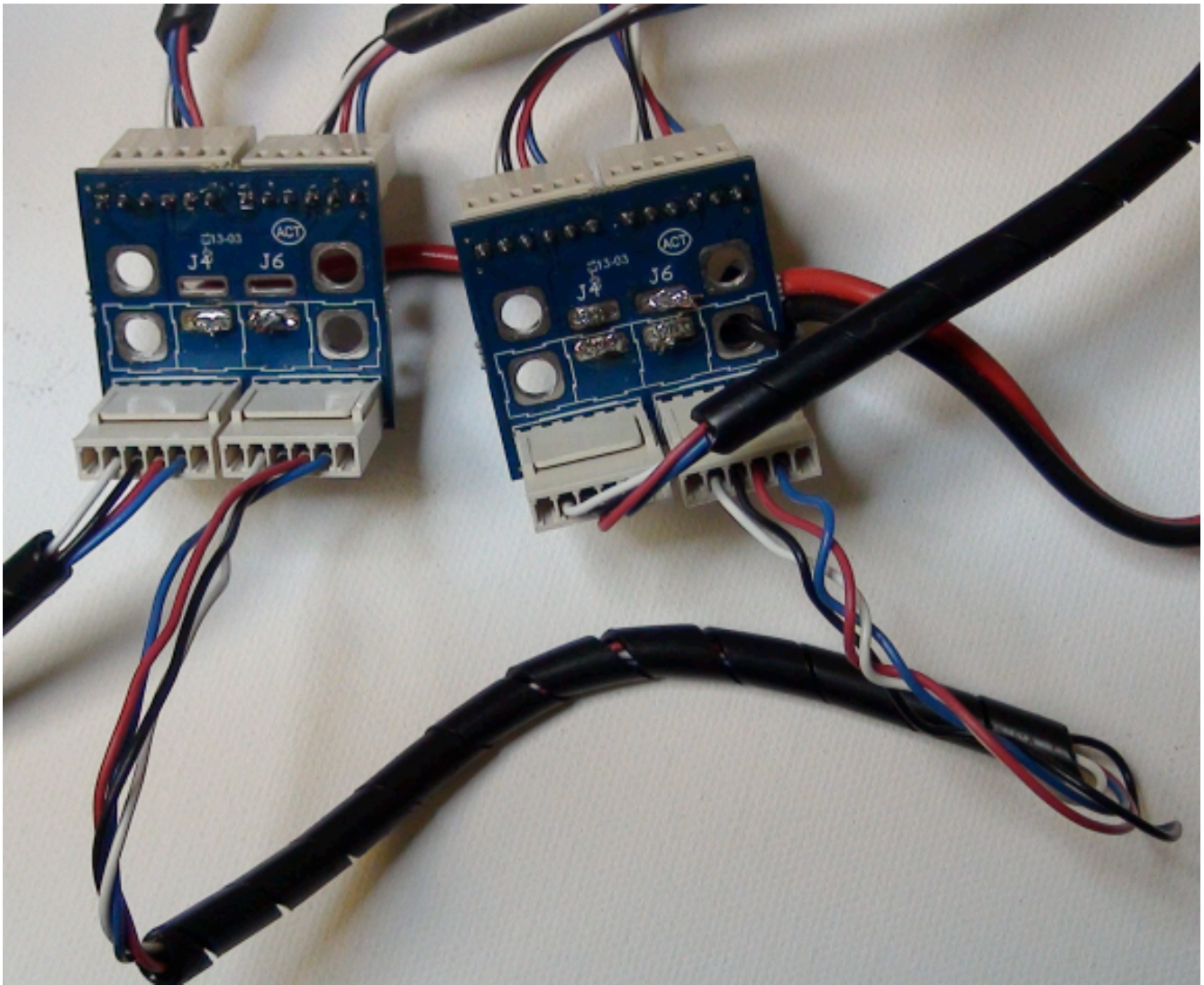


Figure 16 High Current I2C Bus with 6 Pin Molex Connector for 5x MK-44149 I2C PWM/Current Slaves and Connection to PyroRaptor (USB/I2C Bus). Unmounted for Illustration Purposes.

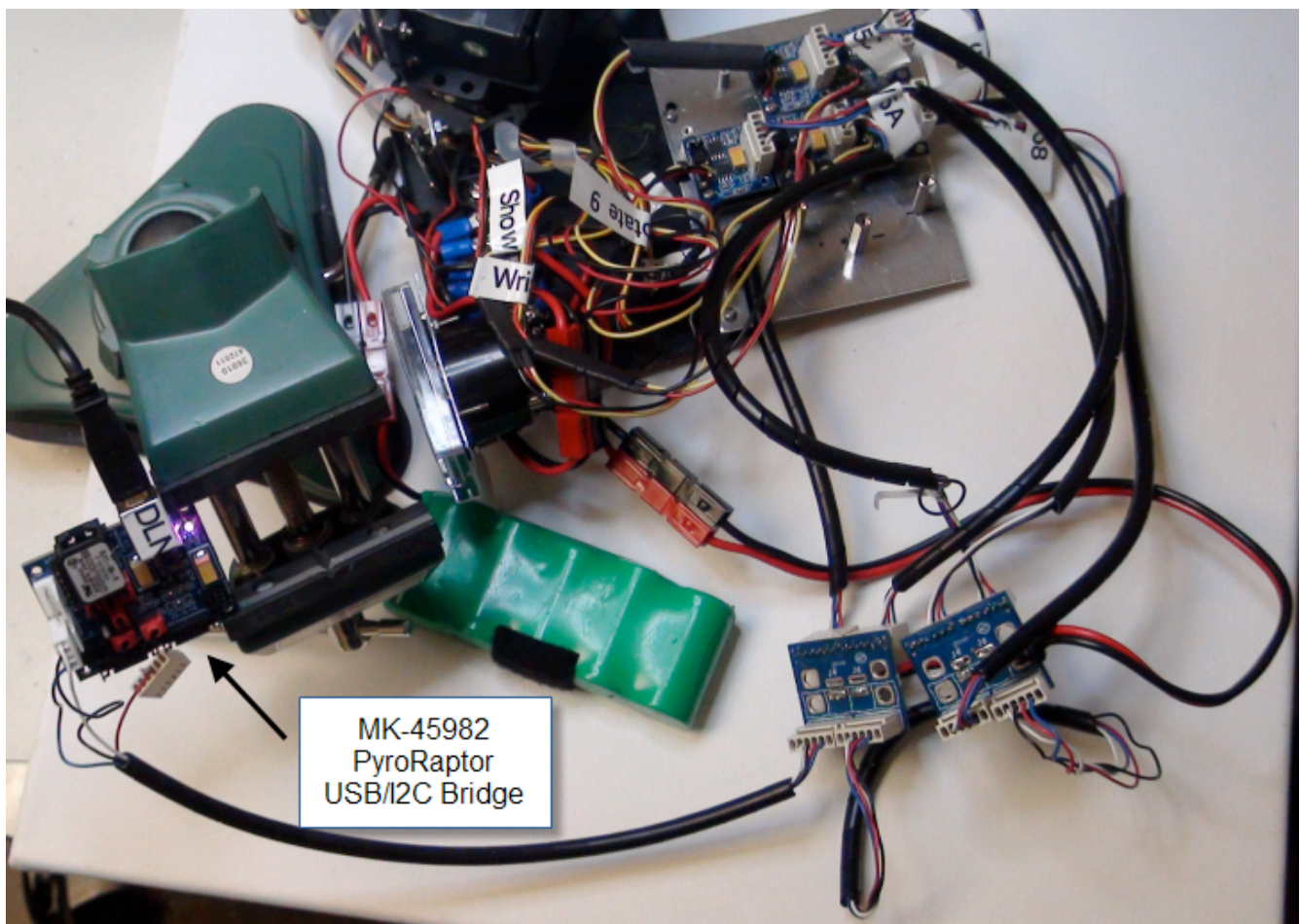


Figure 17 Showing Interface of I2C Arm Control to PyroRaptor USB/I2C Bridge

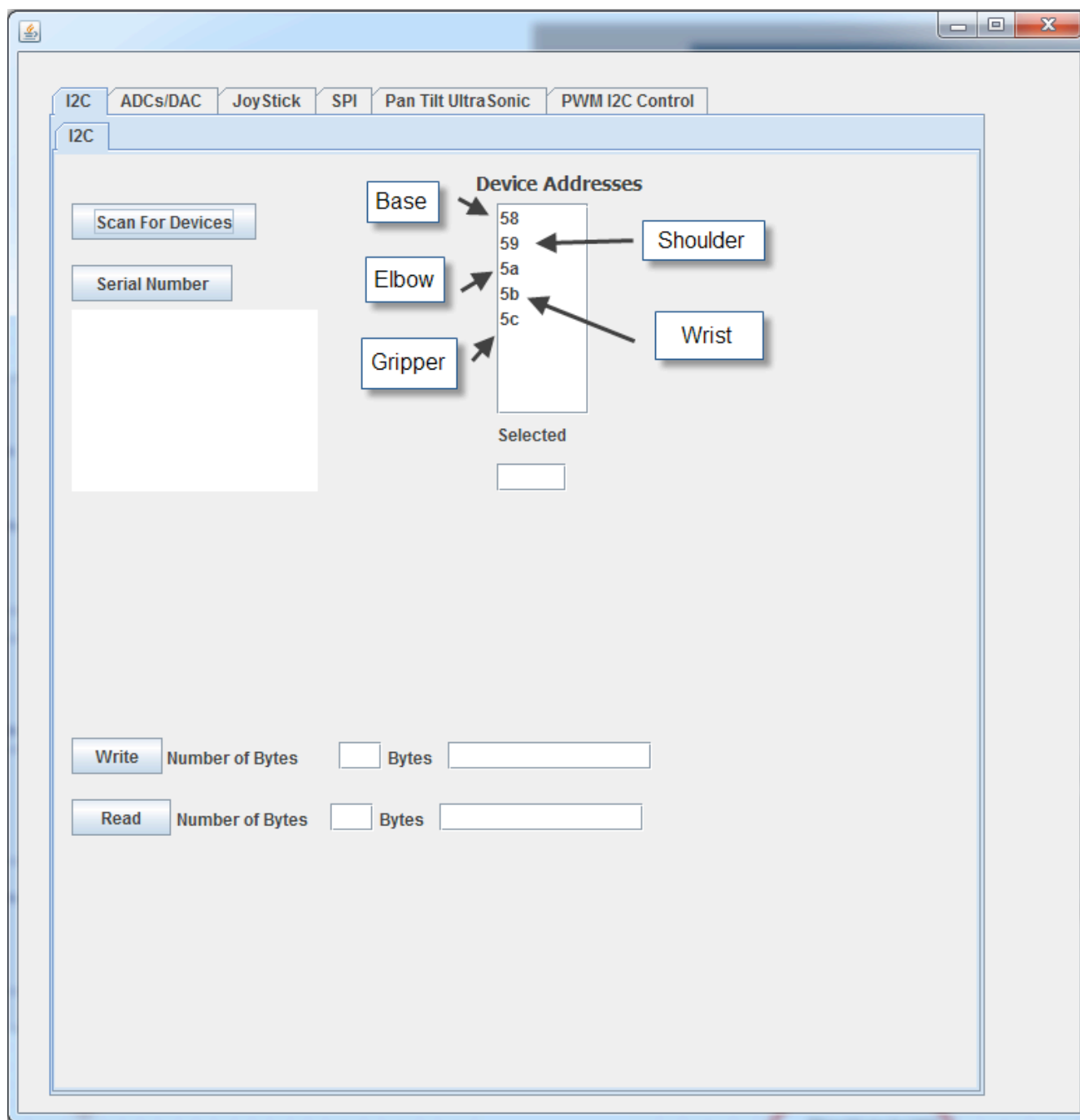


Figure 18 PyroRaptor Java Graphical Interface I2C Bus Scan Results Showing I2C devices (5x MK-44149)

10 Hirose DF11 Series Connector

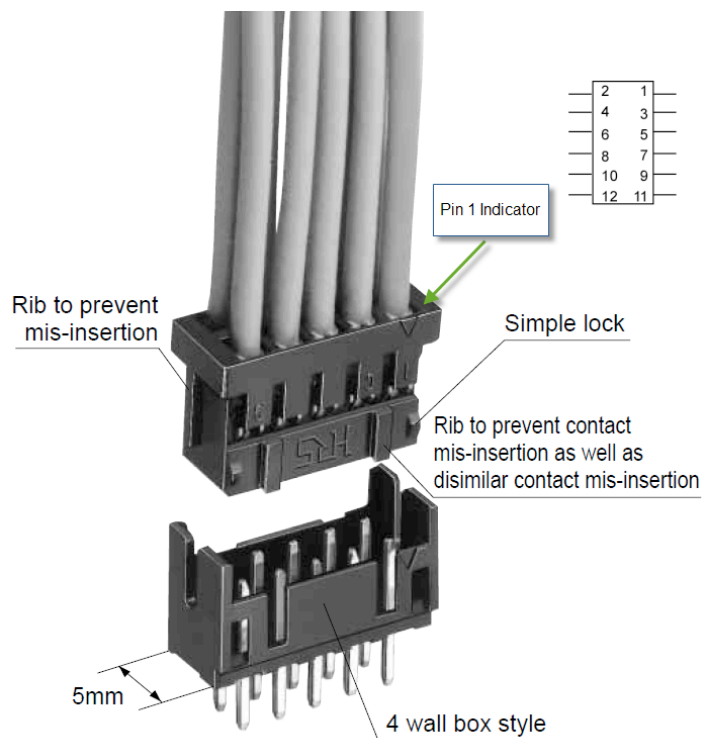


Figure 19 Guide to the Hirose DF11 series connector

11 GNU Free Documentation License

Version 1.3, 3 November 2008

Copyright © 2000, 2001, 2002, 2007, 2008 Free Software Foundation, Inc. <<http://fsf.org/>>

Everyone is permitted to copy and distribute verbatim copies of this license document, but changing it is not allowed.

0. PREAMBLE

The purpose of this License is to make a manual, textbook, or other functional and useful document "free" in the sense of freedom: to assure everyone the effective freedom to copy and redistribute it, with or without modifying it, either commercially or noncommercially. Secondly, this License preserves for the author and publisher a way to get credit for their work, while not being considered responsible for modifications made by others.

This License is a kind of "copyleft", which means that derivative works of the document must themselves be free in the same sense. It complements the GNU General Public License, which is a copyleft license designed for free software.

We have designed this License in order to use it for manuals for free software, because free software needs free documentation: a free program should come with manuals providing the same freedoms that the software does. But this License is not limited to software manuals; it can be used for any textual work, regardless of subject matter or whether it is published as a printed book. We recommend this License principally for works whose purpose is instruction or reference.

1. APPLICABILITY AND DEFINITIONS

This License applies to any manual or other work, in any medium, that contains a notice placed by the copyright holder saying it can be distributed under the terms of this License. Such a notice grants a world-wide, royalty-free license, unlimited in duration, to use that work under the conditions stated herein. The "Document", below, refers to any such manual or work. Any member of the public is a licensee, and is addressed as "you". You accept the license if you copy, modify or distribute the work in a way requiring permission under copyright law.

A "Modified Version" of the Document means any work containing the Document or a portion of it, either copied verbatim, or with modifications and/or translated into another language.

A "Secondary Section" is a named appendix or a front-matter section of the Document that deals exclusively with the relationship of the publishers or authors of the Document to the Document's overall subject (or to related matters) and contains nothing that could fall directly within that overall subject. (Thus, if the Document is in part a textbook of mathematics, a Secondary Section may not explain any mathematics.) The relationship could be a matter of historical connection with the subject or with related matters, or of legal, commercial, philosophical, ethical or political position regarding them.

The "Invariant Sections" are certain Secondary Sections whose titles are designated, as being those of

Invariant Sections, in the notice that says that the Document is released under this License. If a section does not fit the above definition of Secondary then it is not allowed to be designated as Invariant. The Document may contain zero Invariant Sections. If the Document does not identify any Invariant Sections then there are none.

The "Cover Texts" are certain short passages of text that are listed, as Front-Cover Texts or Back-Cover Texts, in the notice that says that the Document is released under this License. A Front-Cover Text may be at most 5 words, and a Back-Cover Text may be at most 25 words.

A "Transparent" copy of the Document means a machine-readable copy, represented in a format whose specification is available to the general public, that is suitable for revising the document straightforwardly with generic text editors or (for images composed of pixels) generic paint programs or (for drawings) some widely available drawing editor, and that is suitable for input to text formatters or for automatic translation to a variety of formats suitable for input to text formatters. A copy made in an otherwise Transparent file format whose markup, or absence of markup, has been arranged to thwart or discourage subsequent modification by readers is not Transparent. An image format is not Transparent if used for any substantial amount of text. A copy that is not "Transparent" is called "Opaque".

Examples of suitable formats for Transparent copies include plain ASCII without markup, Texinfo input format, LaTeX input format, SGML or XML using a publicly available DTD, and standard-conforming simple HTML, PostScript or PDF designed for human modification. Examples of transparent image formats include PNG, XCF and JPG. Opaque formats include proprietary formats that can be read and edited only by proprietary word processors, SGML or XML for which the DTD and/or processing tools are not generally available, and the machine-generated HTML, PostScript or PDF produced by some word processors for output purposes only.

The "Title Page" means, for a printed book, the title page itself, plus such following pages as are needed to hold, legibly, the material this License requires to appear in the title page. For works in formats which do not have any title page as such, "Title Page" means the text near the most prominent appearance of the work's title, preceding the beginning of the body of the text.

The "publisher" means any person or entity that distributes copies of the Document to the public.

A section "Entitled XYZ" means a named subunit of the Document whose title either is precisely XYZ or contains XYZ in parentheses following text that translates XYZ in another language. (Here XYZ stands for a specific section name mentioned below, such as "Acknowledgements", "Dedications", "Endorsements", or "History".) To "Preserve the Title" of such a section when you modify the Document means that it remains a section "Entitled XYZ" according to this definition.

The Document may include Warranty Disclaimers next to the notice which states that this License applies to the Document. These Warranty Disclaimers are considered to be included by reference in this License, but only as regards disclaiming warranties: any other implication that these Warranty Disclaimers may have is void and has no effect on the meaning of this License.

2. VERBATIM COPYING

You may copy and distribute the Document in any medium, either commercially or noncommercially, provided that this License, the copyright notices, and the license notice saying this License applies to the Document are reproduced in all copies, and that you add no other conditions whatsoever to those of

this License. You may not use technical measures to obstruct or control the reading or further copying of the copies you make or distribute. However, you may accept compensation in exchange for copies. If you distribute a large enough number of copies you must also follow the conditions in section 3.

You may also lend copies, under the same conditions stated above, and you may publicly display copies.

3. COPYING IN QUANTITY

If you publish printed copies (or copies in media that commonly have printed covers) of the Document, numbering more than 100, and the Document's license notice requires Cover Texts, you must enclose the copies in covers that carry, clearly and legibly, all these Cover Texts: Front-Cover Texts on the front cover, and Back-Cover Texts on the back cover. Both covers must also clearly and legibly identify you as the publisher of these copies. The front cover must present the full title with all words of the title equally prominent and visible. You may add other material on the covers in addition. Copying with changes limited to the covers, as long as they preserve the title of the Document and satisfy these conditions, can be treated as verbatim copying in other respects.

If the required texts for either cover are too voluminous to fit legibly, you should put the first ones listed (as many as fit reasonably) on the actual cover, and continue the rest onto adjacent pages.

If you publish or distribute Opaque copies of the Document numbering more than 100, you must either include a machine-readable Transparent copy along with each Opaque copy, or state in or with each Opaque copy a computer-network location from which the general network-using public has access to download using public-standard network protocols a complete Transparent copy of the Document, free of added material. If you use the latter option, you must take reasonably prudent steps, when you begin distribution of Opaque copies in quantity, to ensure that this Transparent copy will remain thus accessible at the stated location until at least one year after the last time you distribute an Opaque copy (directly or through your agents or retailers) of that edition to the public.

It is requested, but not required, that you contact the authors of the Document well before redistributing any large number of copies, to give them a chance to provide you with an updated version of the Document.

4. MODIFICATIONS

You may copy and distribute a Modified Version of the Document under the conditions of sections 2 and 3 above, provided that you release the Modified Version under precisely this License, with the Modified Version filling the role of the Document, thus licensing distribution and modification of the Modified Version to whoever possesses a copy of it. In addition, you must do these things in the Modified Version:

- A. Use in the Title Page (and on the covers, if any) a title distinct from that of the Document, and from those of previous versions (which should, if there were any, be listed in the History section of the Document). You may use the same title as a previous version if the original publisher of that version gives permission.
- B. List on the Title Page, as authors, one or more persons or entities responsible for authorship of the modifications in the Modified Version, together with at least five of the principal authors of the Document (all of its principal authors, if it has fewer than five), unless they release you

from this requirement.

- C. State on the Title page the name of the publisher of the Modified Version, as the publisher.
- D. Preserve all the copyright notices of the Document.
- E. Add an appropriate copyright notice for your modifications adjacent to the other copyright notices.
- F. Include, immediately after the copyright notices, a license notice giving the public permission to use the Modified Version under the terms of this License, in the form shown in the Addendum below.
- G. Preserve in that license notice the full lists of Invariant Sections and required Cover Texts given in the Document's license notice.
- H. Include an unaltered copy of this License.
- I. Preserve the section Entitled "History", Preserve its Title, and add to it an item stating at least the title, year, new authors, and publisher of the Modified Version as given on the Title Page. If there is no section Entitled "History" in the Document, create one stating the title, year, authors, and publisher of the Document as given on its Title Page, then add an item describing the Modified Version as stated in the previous sentence.
- J. Preserve the network location, if any, given in the Document for public access to a Transparent copy of the Document, and likewise the network locations given in the Document for previous versions it was based on. These may be placed in the "History" section. You may omit a network location for a work that was published at least four years before the Document itself, or if the original publisher of the version it refers to gives permission.
- K. For any section Entitled "Acknowledgements" or "Dedications", Preserve the Title of the section, and preserve in the section all the substance and tone of each of the contributor acknowledgements and/or dedications given therein.
- L. Preserve all the Invariant Sections of the Document, unaltered in their text and in their titles. Section numbers or the equivalent are not considered part of the section titles.
- M. Delete any section Entitled "Endorsements". Such a section may not be included in the Modified Version.
- N. Do not retitle any existing section to be Entitled "Endorsements" or to conflict in title with any Invariant Section.
- O. Preserve any Warranty Disclaimers.

If the Modified Version includes new front-matter sections or appendices that qualify as Secondary Sections and contain no material copied from the Document, you may at your option designate some or all of these sections as invariant. To do this, add their titles to the list of Invariant Sections in the Modified Version's license notice. These titles must be distinct from any other section titles.

You may add a section Entitled "Endorsements", provided it contains nothing but endorsements of your Modified Version by various parties—for example, statements of peer review or that the text has been approved by an organization as the authoritative definition of a standard.

You may add a passage of up to five words as a Front-Cover Text, and a passage of up to 25 words as a Back-Cover Text, to the end of the list of Cover Texts in the Modified Version. Only one passage of Front-Cover Text and one of Back-Cover Text may be added by (or through arrangements made by) any one entity. If the Document already includes a cover text for the same cover, previously added by you or by arrangement made by the same entity you are acting on behalf of, you may not add another; but you may replace the old one, on explicit permission from the previous publisher that added the old

one.

The author(s) and publisher(s) of the Document do not by this License give permission to use their names for publicity for or to assert or imply endorsement of any Modified Version.

5. COMBINING DOCUMENTS

You may combine the Document with other documents released under this License, under the terms defined in section 4 above for modified versions, provided that you include in the combination all of the Invariant Sections of all of the original documents, unmodified, and list them all as Invariant Sections of your combined work in its license notice, and that you preserve all their Warranty Disclaimers.

The combined work need only contain one copy of this License, and multiple identical Invariant Sections may be replaced with a single copy. If there are multiple Invariant Sections with the same name but different contents, make the title of each such section unique by adding at the end of it, in parentheses, the name of the original author or publisher of that section if known, or else a unique number. Make the same adjustment to the section titles in the list of Invariant Sections in the license notice of the combined work.

In the combination, you must combine any sections Entitled "History" in the various original documents, forming one section Entitled "History"; likewise combine any sections Entitled "Acknowledgements", and any sections Entitled "Dedications". You must delete all sections Entitled "Endorsements".

6. COLLECTIONS OF DOCUMENTS

You may make a collection consisting of the Document and other documents released under this License, and replace the individual copies of this License in the various documents with a single copy that is included in the collection, provided that you follow the rules of this License for verbatim copying of each of the documents in all other respects.

You may extract a single document from such a collection, and distribute it individually under this License, provided you insert a copy of this License into the extracted document, and follow this License in all other respects regarding verbatim copying of that document.

7. AGGREGATION WITH INDEPENDENT WORKS

A compilation of the Document or its derivatives with other separate and independent documents or works, in or on a volume of a storage or distribution medium, is called an "aggregate" if the copyright resulting from the compilation is not used to limit the legal rights of the compilation's users beyond what the individual works permit. When the Document is included in an aggregate, this License does not apply to the other works in the aggregate which are not themselves derivative works of the Document.

If the Cover Text requirement of section 3 is applicable to these copies of the Document, then if the Document is less than one half of the entire aggregate, the Document's Cover Texts may be placed on covers that bracket the Document within the aggregate, or the electronic equivalent of covers if the Document is in electronic form. Otherwise they must appear on printed covers that bracket the whole

aggregate.

8. TRANSLATION

Translation is considered a kind of modification, so you may distribute translations of the Document under the terms of section 4. Replacing Invariant Sections with translations requires special permission from their copyright holders, but you may include translations of some or all Invariant Sections in addition to the original versions of these Invariant Sections. You may include a translation of this License, and all the license notices in the Document, and any Warranty Disclaimers, provided that you also include the original English version of this License and the original versions of those notices and disclaimers. In case of a disagreement between the translation and the original version of this License or a notice or disclaimer, the original version will prevail.

If a section in the Document is Entitled "Acknowledgements", "Dedications", or "History", the requirement (section 4) to Preserve its Title (section 1) will typically require changing the actual title.

9. TERMINATION

You may not copy, modify, sublicense, or distribute the Document except as expressly provided under this License. Any attempt otherwise to copy, modify, sublicense, or distribute it is void, and will automatically terminate your rights under this License.

However, if you cease all violation of this License, then your license from a particular copyright holder is reinstated (a) provisionally, unless and until the copyright holder explicitly and finally terminates your license, and (b) permanently, if the copyright holder fails to notify you of the violation by some reasonable means prior to 60 days after the cessation.

Moreover, your license from a particular copyright holder is reinstated permanently if the copyright holder notifies you of the violation by some reasonable means, this is the first time you have received notice of violation of this License (for any work) from that copyright holder, and you cure the violation prior to 30 days after your receipt of the notice.

Termination of your rights under this section does not terminate the licenses of parties who have received copies or rights from you under this License. If your rights have been terminated and not permanently reinstated, receipt of a copy of some or all of the same material does not give you any rights to use it.

10. FUTURE REVISIONS OF THIS LICENSE

The Free Software Foundation may publish new, revised versions of the GNU Free Documentation License from time to time. Such new versions will be similar in spirit to the present version, but may differ in detail to address new problems or concerns. See <http://www.gnu.org/copyleft/>.

Each version of the License is given a distinguishing version number. If the Document specifies that a particular numbered version of this License "or any later version" applies to it, you have the option of following the terms and conditions either of that specified version or of any later version that has been published (not as a draft) by the Free Software Foundation. If the Document does not specify a version number of this License, you may choose any version ever published (not as a draft) by the Free Software Foundation. If the Document specifies that a proxy can decide which future versions of this License can be used, that proxy's public statement of acceptance of a version permanently authorizes

you to choose that version for the Document.

11. RELICENSING

"Massive Multiauthor Collaboration Site" (or "MMC Site") means any World Wide Web server that publishes copyrightable works and also provides prominent facilities for anybody to edit those works. A public wiki that anybody can edit is an example of such a server. A "Massive Multiauthor Collaboration" (or "MMC") contained in the site means any set of copyrightable works thus published on the MMC site.

"CC-BY-SA" means the Creative Commons Attribution-Share Alike 3.0 license published by Creative Commons Corporation, a not-for-profit corporation with a principal place of business in San Francisco, California, as well as future copyleft versions of that license published by that same organization.

"Incorporate" means to publish or republish a Document, in whole or in part, as part of another Document.

An MMC is "eligible for relicensing" if it is licensed under this License, and if all works that were first published under this License somewhere other than this MMC, and subsequently incorporated in whole or in part into the MMC, (1) had no cover texts or invariant sections, and (2) were thus incorporated prior to November 1, 2008.

The operator of an MMC Site may republish an MMC contained in the site under CC-BY-SA on the same site at any time before August 1, 2009, provided the MMC is eligible for relicensing.