UNIVERSITI MALAYSIA PAHANG

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JUDUL: **ROPE CLIMBING ROBOT**

SESI PENGAJIAN: **2009/2010**

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ROPE CLIMBING ROBOT

NOOR JURAIZAH BINTI MOHD JINAL

A Dissertation Submitted To the Faculty of Electrical & Electronic Engineering in Partial Fulfillment of the Requirements for the Award of The Degree Of

Bachelor of Electrical Engineering (Electronic)

Faculty of Electrical & Electronic Engineering

Universiti Malaysia Pahang

NOVEMBER 2009

"I hereby declare that I have read this thesis and in my own opinion the scope and quality of this thesis is qualified for the award of the Bachelor of Electrical Engineering (Electronic)"

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Date : 23 NOVEMBER 2009

DEDICATION

Specially dedication to my beloved and important persons in my life:
My beloved mother, Mrs. Isanah Binti Ismail; Father, Mr. Mohd Jinal Bin Hamid;
Supervisor, Mr.Mohamad Fadhil Bin Abas
And to the others who have been dedicate their love, support and understanding in my study.

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ROPE CIMBING ROBOT

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ABSTRACT

The objective of this project is to build a hardware and software of a Rope Climbing Robot and to study the motion of a robot that can climb rope. The robot can climb up via the rope. The robot weight must be not too heavy because it has to climb up via a rope to get the target. The research of the project has been done using a Peripheral Interface Connection (PIC) software. The programming about the motion of the robot has been built using the software developed. PicBASIC Pro-compiler and MicroCode studio from Microchip has been used to design a programming and compile the program. The PIC 18F4550 has been used as a microcontroller of the robot. The robot has a gripper at the top, in the middle and at the bottom of the robot's body which sequentially alternate between gripping and releasing the pole while moving upwards. Type HITEC HD7150 M DC Servo Motor from Cytron Technologies Sdn. Bhd has been choose as a gear to move each pair of robot arms.

ABSTRAK

Projek tersebut bertujuan membina rupa bentuk dan program bagi Robot Pemanjat Tali dan bertujuan mengkaji pergerakan robot melalui tali. Robot yang dibina mempunyai keupayaan untuk bergerak melalui tali secara menaik. Berat badan robot tersebut hendaklah kurang bagi menampung berat badan semasa memanjat tali. Kajian tentang projek tersebut telah disuaipadankan dengan penggunaan perisian Peripheral Interface Connection (PIC). Penggunaan perisian PicBASIC Pro-Compiler dan MicroCode Studio dari Microchip Corp. telah digunapakai bagi merekabentuk dan menyusun program bersesuaian dengan robot yang dibina. PIC18F4550 telah digunapakai sebagai pengawal utama kepada pergerakan robot tersebut. Robot tersebut mempunyai pencengkam di bahagian atas, tengah dan bawah badan robot bagi mencengkam tali semasa robot bergerak. Jenis HITEC HD7150 M DC Motor Servo keluaran Cytron Technologies Sdn. Bhd telah digunapakai sebagai gear bagi menggerakkan setiap pencengkam pada robot.

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θ	robot angle
ρ	Density
M	Mach number
ε	Epsilon
ω	Omega
DC	Direct Current

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

The project was named as a Rope Climbing Robot because the application of the robot is to climb across the rope line. The design of the robot use a Mechatronic design which is the design is a combination of electrical and mechanical engineering studies by applying the application. The robots use a movement and the control of the motion technique to move through the rope. For the Rope Climbing Robot, the voltage and current will be given to the DC Servo Motor to move the robot by gripping the rope. As an output device, the DC Servo Motor was used. The motor was used to move the robot. The PIC18F4550 was used as a microcontroller and the PICBASIC Pro-Compiler or MicroCode studio from Microchip Corp. has been used for the robot programming and as a compiler. After the program was and has been burned on the PIC18F4550 using a PIC2Kit burner, the compiler is needed to open the programming. Lastly, the program will be run and the robot will be move as we need.

According to Karel Capec who was introduced a robot is one of a basic study in Mechatronic Engineering field at 1920's that play *Rossum Universal Robot.* Karel Capec is one of the Czech playright. According to him, a word robot comes from the word robota which is means simply work. A robot was designed to help human in the world to have an easier job in a life. A robot was introduced to help human to get some object that cannot be pick by hand such as at the hot place, at the top and so on. Robot also can be used in a life days to help a housewife to keep clean their house without waste their energy and strength. A robot has no feeling like a human so that the robot will not tired when doing some work without rest. A robot can do the job for a whole day as long as human want. Practically, a robot is distinguished from electromechanical motion equipment by their dexterious manipulation capability in that robot can work, position and move tools and other objects with far greater dexterity than other machines found in the factory.

According to Ben- Zion Sandler in his book entitled *Robotics, Designing The Mechanism For Automated Machinery*, 1999, an industrial robot is defined as "a programmable mechanical manipulator, capable of moving along several directions, equipped at its end with a work device called the end effectors (or tool) and capable of performing factory work ordinarily done by human beings. The term robot is used for a manipulator that has a built-in control system and is capable of stand-alone operation. According to the Robotics International Division of the Society of Manufacturing Engineers, a robot is a reprogrammable multifunctional manipulator designed to move materials, parts, tools, or specialized devices through variable programmed motions for the performance of a variety of tasks by the definition.

1.2 OBJECTIVE:

In the rope climbing robot project, there is a few of main objective that would like to achieve. The main objective is to build hardware of Rope Climbing Robot and to test a Rope Climbing Robot.

1.3 SCOPE OF PROJECT

The scope of this project is to investigate the robot application by using a software and hardware development. The main focus or scope in this research project may include the aspects of hardware building for a rope climbing robot, a firm use for climbing robot and to test a motion of the robot via a rope track.

1.4 EXPECTED OUTCOMES

As an expected outcome, the project research would like to expect a prototype of a rope climbing robot at the end.

1.5 SIGNIFICANCE OF THE STUDY

The studies of the Rope Climbing Robot is significant to have a quality product of a climbing robot that will help us in life such as save cost in daily life. The robot also can save more time that we have to finish.

1.6 PROBLEM STATEMENT

While designing the Rope Climbing Robot, there were a few problems has faced. The problem is to choose what the type motion of the robot. The type of robot's motion is very important in the research so that the result will be fulfilled the design. Then, it is very important thing to understand what is suitable material that we will be use to build the robot. The material used also known as hardware of the robot. The PIC microcontroller also should be to study and to understand because the robot programming will use a PIC18F4550 microcontroller and programming. At last, the project must to make sure that a programming using PICBASIC Pro-Compiler and MicroCode Studio is suitable to move the robot properly

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

According to the N. Ranasinghe et al, 2000, when the robots tied horizontally, the design known as "horizontal rope climber", while a gait for climbing rope tied vertically known as "vertical rope climber". A few modules of the robot needed for the horizontal line climb to perform a twisting action at each end. For the vertical rope case, a different attachment is required. There is only two modules are necessary since we no longer require the twisting action. The tension of the rope also varies in the climbing method and is a function of the location of the robot along the length of the rope. If the robot is low on the rope, the tension it experiences is low but if the robot is high on the rope, the tension is higher because the entire weight of the rope below it is exerting a force. Further, the weight of the robot adds tension as well. If the top attachment is gripping the rope, the bottom attachment will not experience the tension created by the robot weight. However, if the bottom attachment is gripping the rope, the top attachment will still experience the tension caused by the robot weight. In addition, by creating the friction further distorts the rope by locally, the twisting of one pipe is needed. The twisting one rope also needed for create unwanted friction on the other pipe that is supposed to be loose.

According to Jong-Hoon Kim from B.E., Seoul National University of Technology in Seoul, South Korea, 2005, December 2008, the caterpillar tracks used to help the robot to distribute its weight evenly over a larger surface of the track, when compared to the wheel-based robot. The ability used to be the tracked robot moves forward the segment which is used for the track is laid out flat on the ground at the front and picked up again at the back. So this feature of the caterpillar track helps the robot to handle the uneven surfaces much efficiently. To take up the additional load of the robot, the rollers was used at the front and back of the robot. The complete rolling track of the robot will help the robot in handling the movement smoothly in loose areas, where the wheel-based robot of the same potential would fail to do the job.

According to Wei Wang, Kun Wang and Hauxiang Xiang from a Robotics Institute, School Of Mechanical Engineering and Automation in their journal, according to the gaits of their model, Crawling gaitz realization of the mini-modular climbing caterpillar robot, the gait of a caterpillar robot engages a changing kinematic chain, open chain-closed chain-open chain, while the inchworm robot only moves in an open-chain state. According to their journal, the other characteristic of their model, when the caterpillar robot climbing, it will transmit a wave along its body, and the middle joints will repeat similar control rules with certain phase differences, there is no wave transmitting along the body of inchworm robot, and the control rules of its three joint are diferrent.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

In this chapter, we will introduce about a hardware design that was designed after all to build the robot. In the hardware design, a mechanical design will be constructed start from a head to tail of the robot. In designing the hardware, the head, body, tail and gripper is an important part for the robot. At the head of the robot, the linear actuator 1 will be connected to the head while the other one of the linear actuator will be connected to the tail of the robot. A gripper will be constructed, one at the head of robot that state in front of the linear actuator, while the second one at the body of robot and the last gripper will be connected to the tail of robot. The second linear actuator will be connected to the tail of robot. The linear actuator function is to forward and reverse the gripper before the robot will grip the rope. The DC servo motor was used in designing the robot. The motor that connect with the gripper use to control the angle of the gripper want to go.

3.2 HARDWARE DESIGN

3.2.1 Mechanical Design

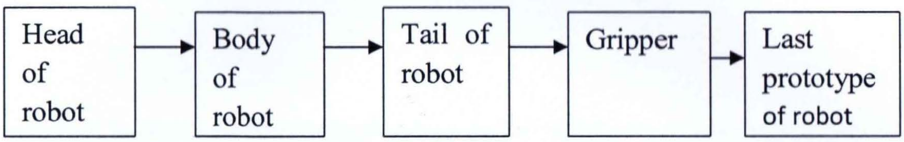


Figure 3.2.1.1: Head of the Robot

Figure 3.2.1.2: In The Middle Of Robot

Figure 3.2.1.3: Tail of the Robot

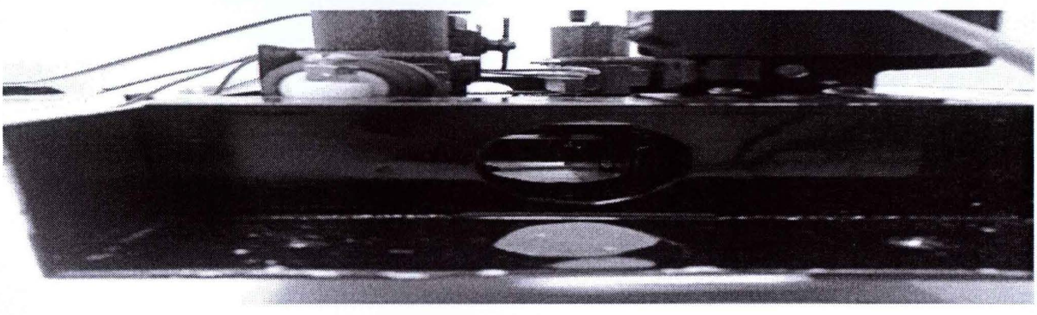


Figure 3.2.1.4: Hole for Rope Enter

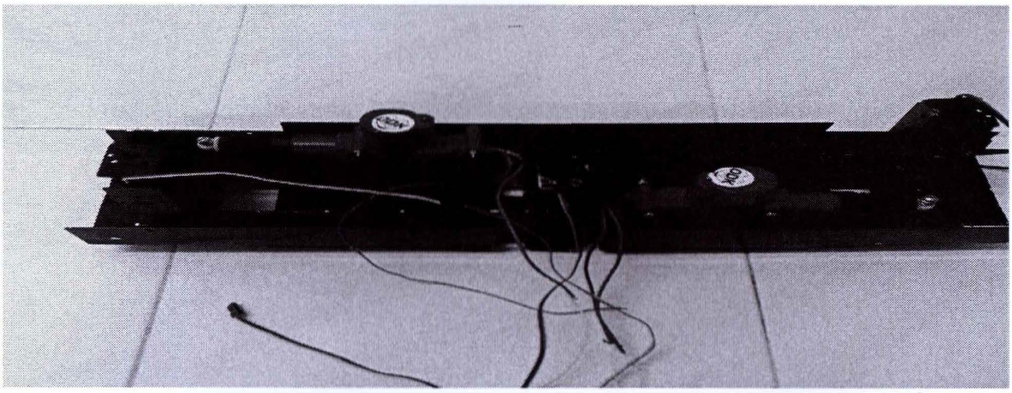


Figure 3.2.1.5: Last Prototype of Robot

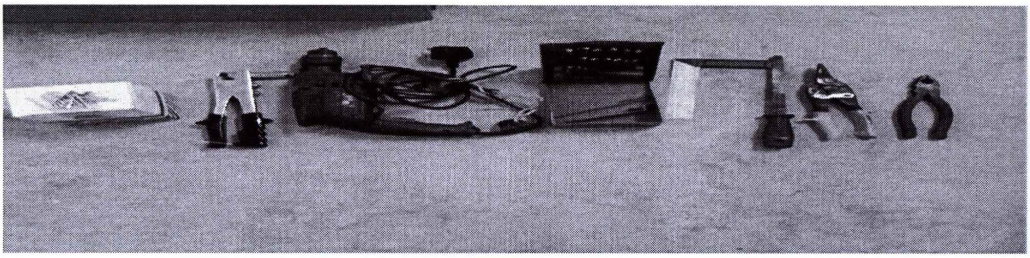


Figure 3.2.1.6: Tool using to cut aluminium

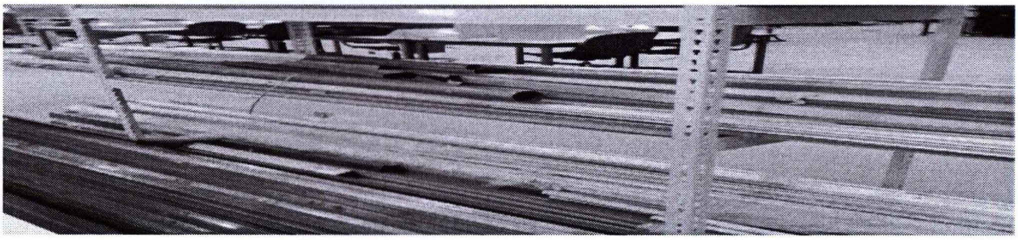


Figure 3.2.1.7: Aluminium trunk

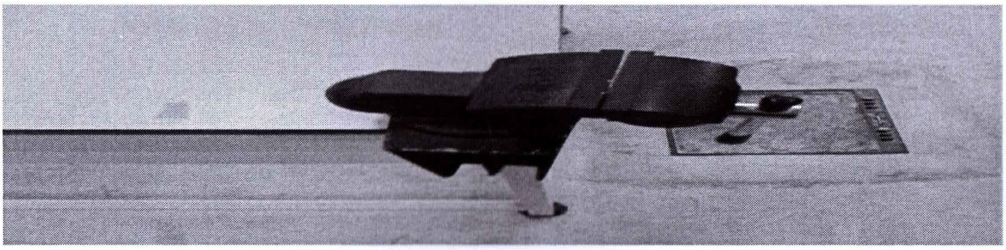


Figure 3.2.1.8: G-clamp

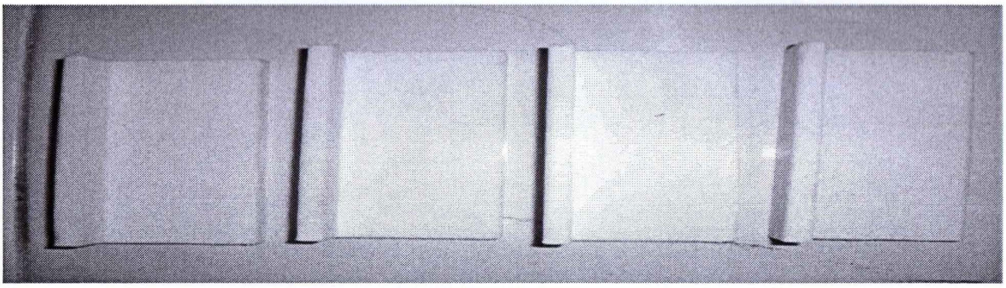


Figure 3.2.1.9: Teflon from the top view

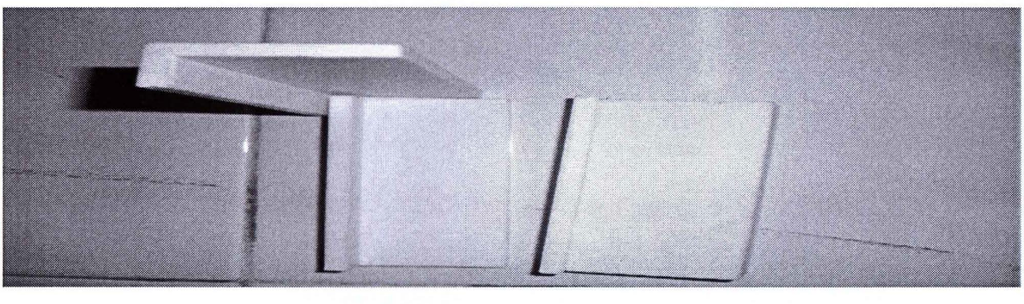
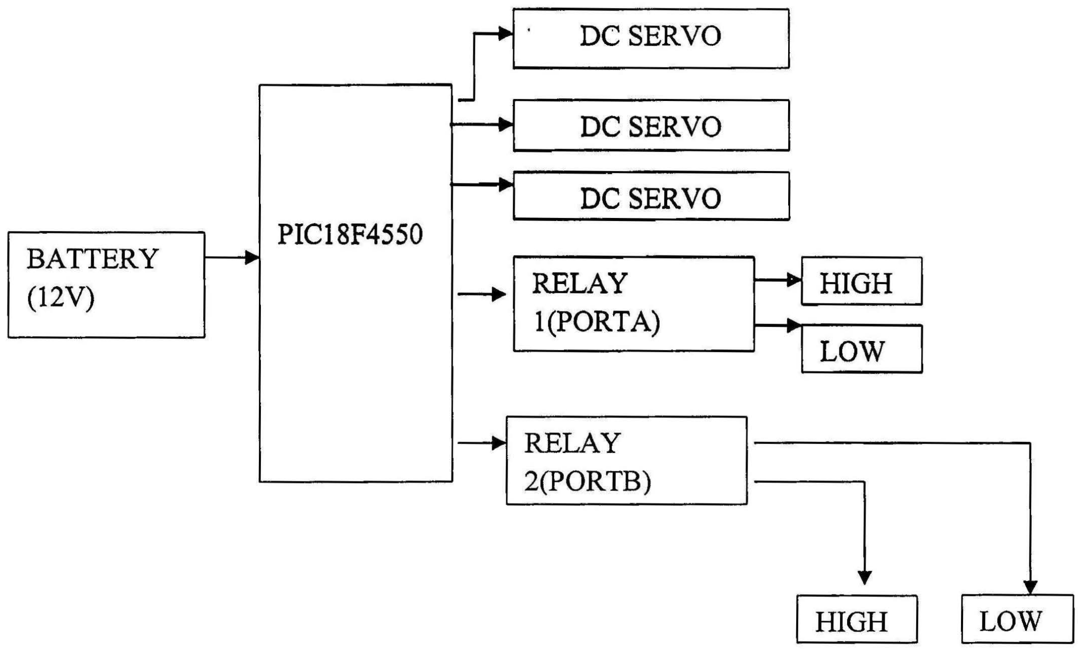


Figure 3.2.1.10: Teflon from the top view and side view

3.2.2 Electrical & Electronic Design



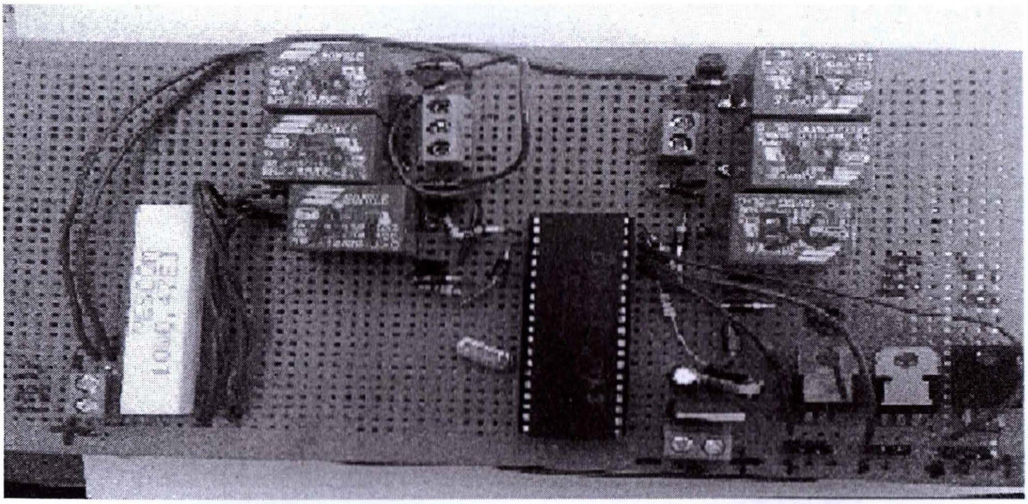


Figure 3.2.2.1: Circuit Board

Circuit operation

A battery 12VDC has been used to give a power supply to the circuit. A relay 1 will be connected to the PIC18F4550 at port A0 and the one of relay that connected to port A0 also will be connected to linear actuator 1 for the reverse (LOW digital input at the programming declaration) function. The relay 3 that connected to the port A1 connected to the PIC18F4550 for the forward (HIGH digital input at the programming declaration) function. It's same as for the relay 1, 2 and 3 at the port B. one of the relay at Port B7 declared the forward while port B6 declared as reverse function. The servos motor connected to the pin RB3, RB4 and RB5 at the PIC18F4550. A 12VDC power supply from the battery will be given to the servos motor so that it can function. A voltage regulator has been used in the circuit operation to

PIC18F4550

The Microchip PIC18F4550 is the mother of the board. The robot will not function if the PIC18F4550 is not connected to the board because the main function of the robot's motion was interfaced onto the PIC.

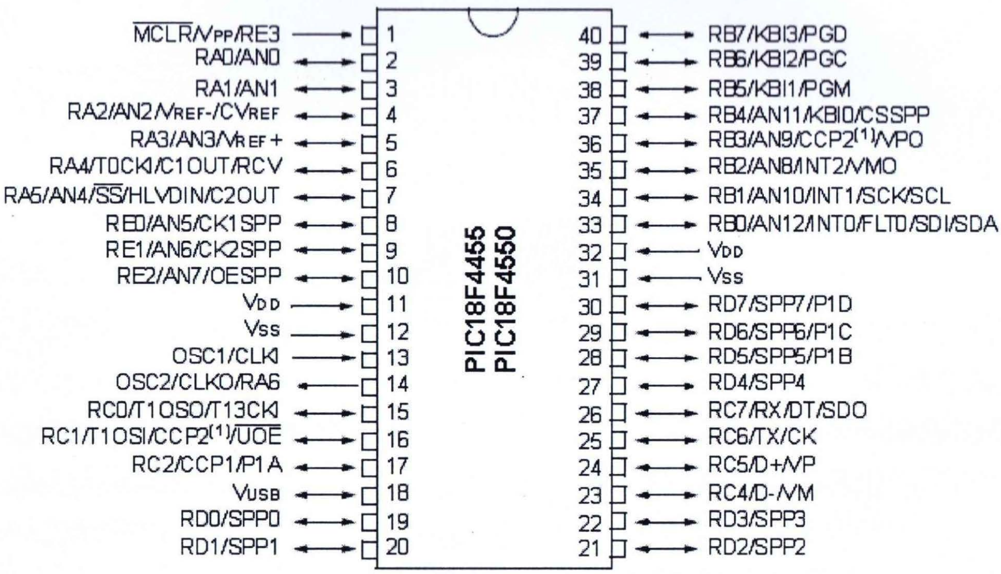


Figure 3.2.2.2: PIC18F4550

REGULATOR IC 7805

Based on the commercial IC7805 voltage regulator, the +5V was supplied to the circuit. The voltage regulator accepts any input voltage between 8 to 18 volts that contains all circuitry needed. It is also produce a steady +5 volt output, accurate to within 5% (0.25 volt). To protect the IC from damaged in case of excessive load current by reduce its output, the circuit need to contain a current-limiting circuitry and thermal overload protection.

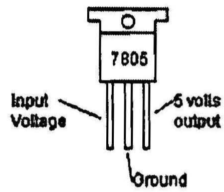


Figure 3.2.2.3: 7805 Pin out

CRYSTAL OSCILLATOR

According to Aleena Emmanual et al, a crystal oscillator is used to provide the clock for the PIC that has a very stable Q equivalently to RLC circuit. The crystal provides 8 MHz clock oscillates at its resonating frequency to the PIC. It requires resistors and capacitors and oscillates properly.

DC SERVO MOTOR

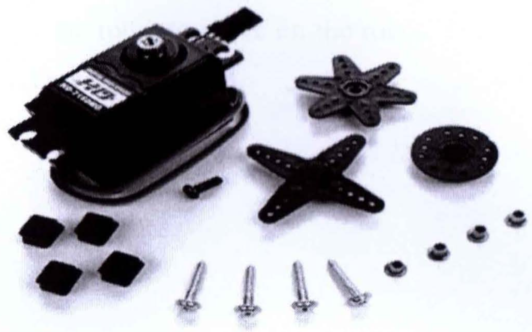


Figure 3.2.2.4: HD-7150MG

Servos motor are commonly use in a robotics especially in build small robots. The advantage of having servo motors is that a separate speed controller would not be needed. These motors operate through the use of pulse width modulation by receiving certain frequencies of pulses to position the shaft. Conversely, since full travel of these motors is typically 180°, they would have to be modified in order for continuous travel. Also, these motors are generally slower and less powerful than a DC motor.

The DC servo motor that used for the robot motion is type HD-7150MG. The model can be use when the supply voltage is between 4.5v to 6v. Speed of the DC servo motor in each second per 60 degrees is 0.19 second. The torque produce from the DC motor is 7.2 kilogram per centimeter and the bearing of the motor is 2BB. The gears use is a metal and the weight of the motor is 49 gram and the size of the motor is 40x20x37mm.

ACTUATOR

The actuator used in the Rope Climbing Robot is a linear DC actuator which will be used as an actuator of the robot to move on the robot. The actuator connected to the relay for the forward and reverse function.

RELAY

The circuit connection will use a relay SPDT 12VDC. The relay use to control the actuator either forward or reverse motion. The relay will be a reverse function when it is given LOW (0) input and function as a forward when the input given is HIGH (1) inputs.

CURRENT LIMITER

A current limiter use to limit the current that through the actuator so that the actuator will not blows initially. The limiter current need to limit the current when it reach 2A of current on the circuit so that the actuator and the PIC circuit board and the actuator will not be damaged.

COMPILER

In the research study, the compiler using in the research is PicBASIC Pro Compiler or MicroCode Studio. The PicBASIC Pro Compiler designed suitable for PIC18F4550 microcontroller.

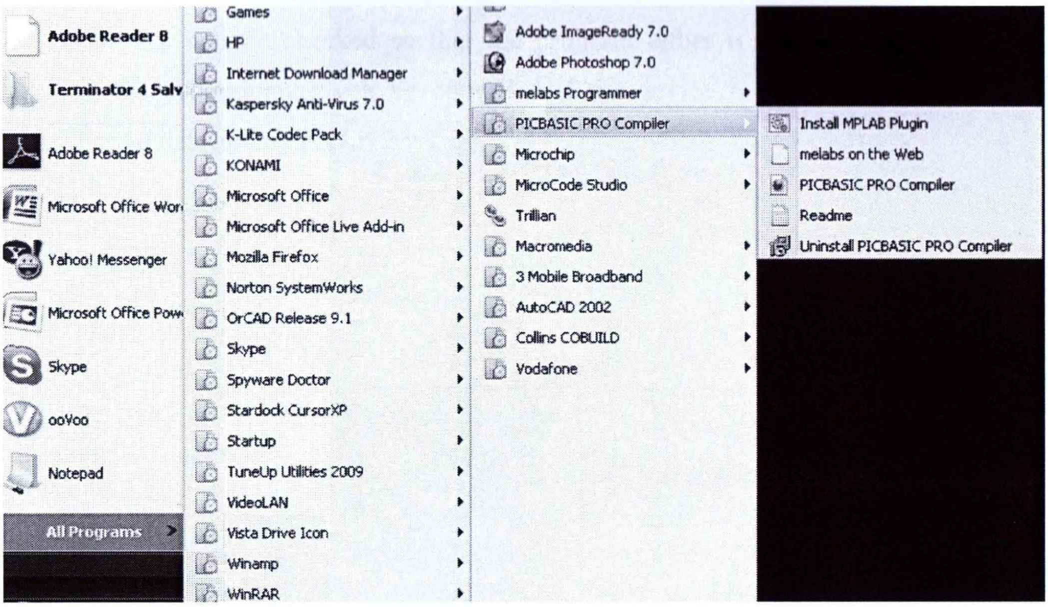
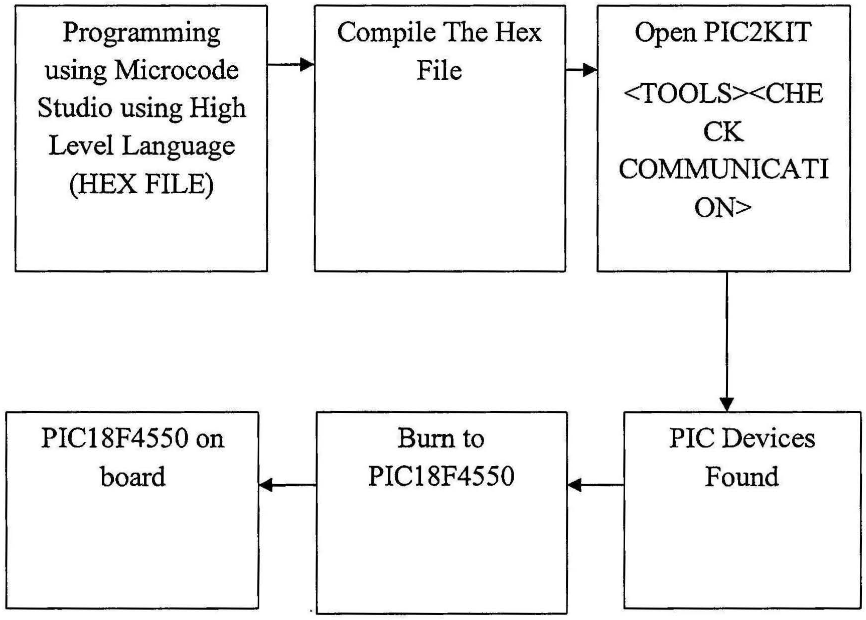


Figure 3.2.2.5: Opening PICbasic PRO Compiler

3.2.3 Software Design

Programming will be use to control the function of circuit through the PIC. Before that circuit can be use y itself, the programming will be burned into PIC using such a compiler. After the compiling file, the connection between the devices (PIC18F4550) will be checked so that the program either it can be compile or not. Usually, the programming can be compiled if the device is in good condition (the PIC18F4550 detected by PICkit 2 v.255).



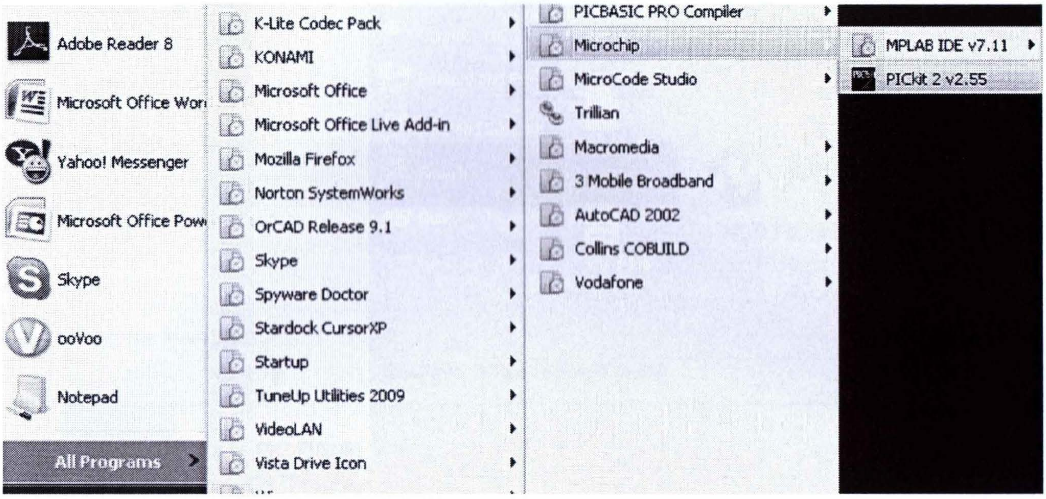


Figure 3.2.3.1: Opening PICkit 2 v.255

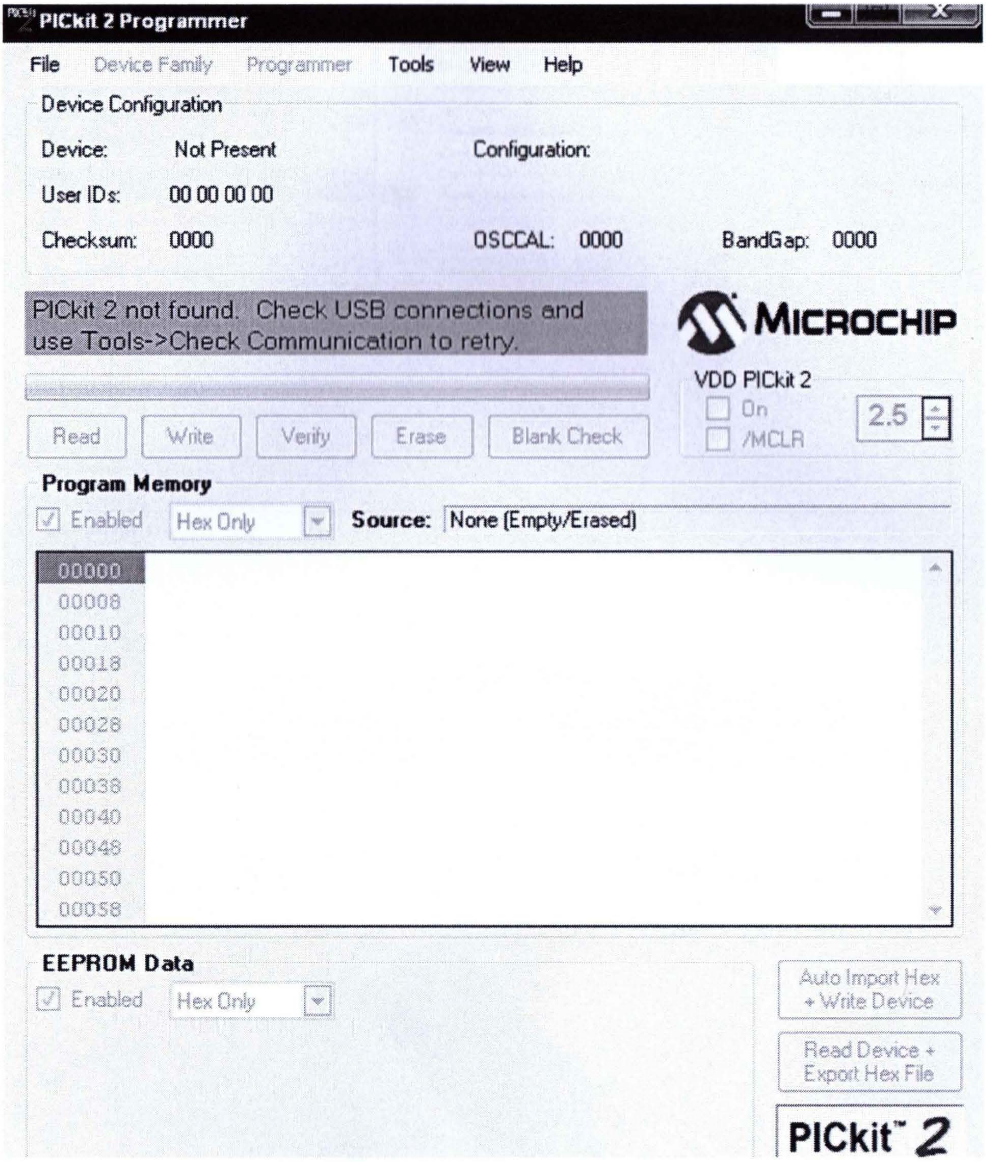


Figure 3.2.3.2: PICkit 2 v.255 programmer

Figure 3.2.3.3: Check Communication Between Pickit 2 V.255

and the devices PIC18F4550

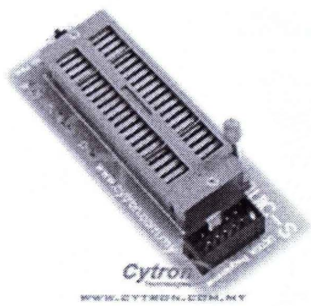


Figure 3.2.3.4: PIC USB Port

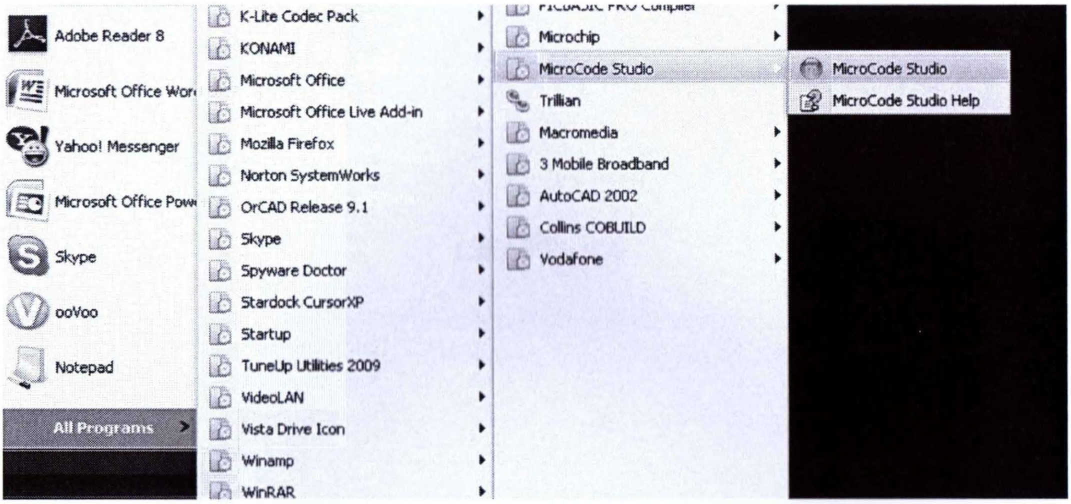


Figure 3.2.3.5: Opening Microcode Studio

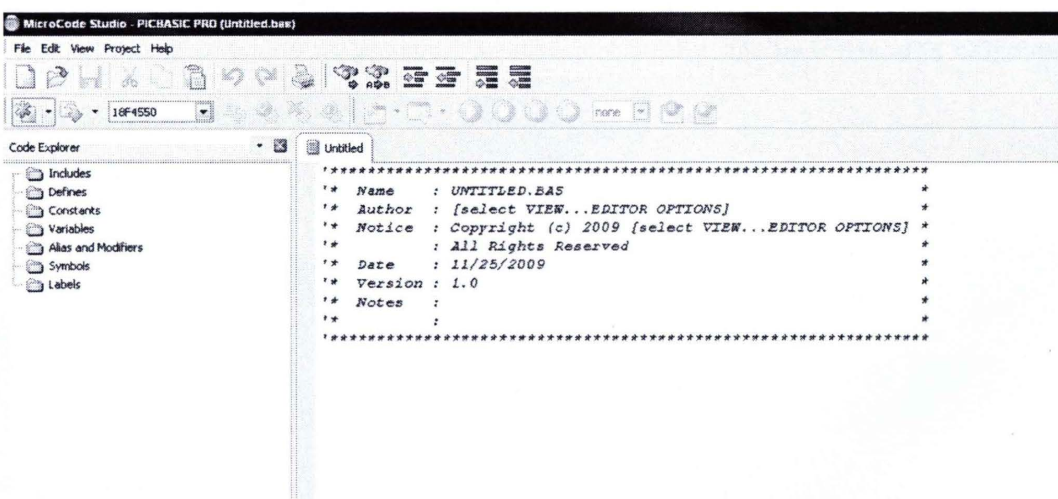


Figure 3.2.3.6: Opening new page on Microcode Studio

CHAPTER 4

RESULT AND DISCUSSION

As a result, the robot climbs up via a vertical rope when the robot through a vertical line of rope and the robot walk horizontally when the rope line is in horizontal line.

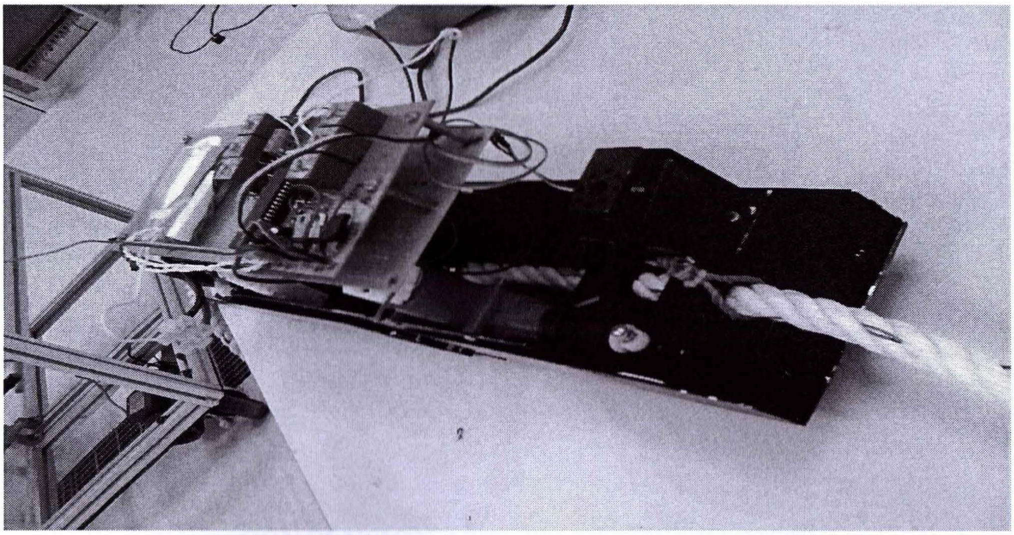


Figure 4.1: Robot Climb the Rope Horizontally

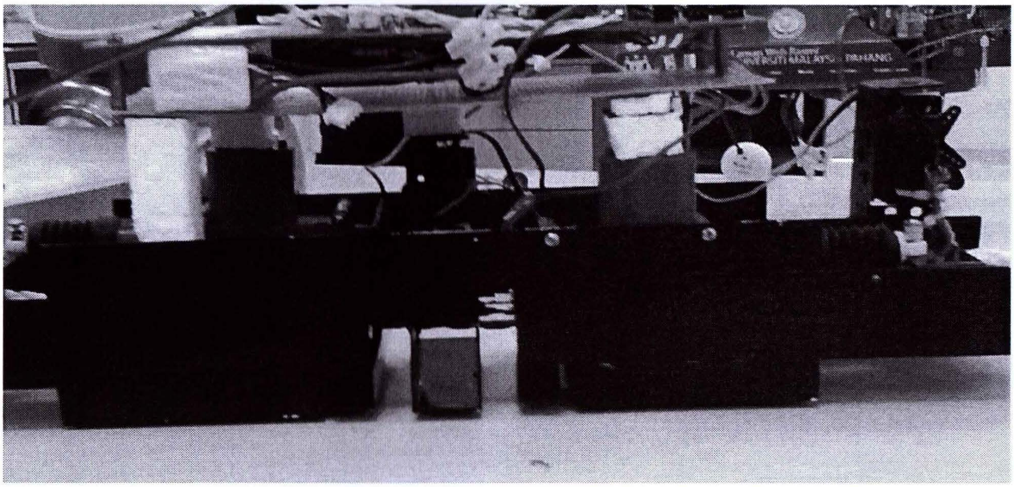


Figure 4.2: Robot Last Prototype

CHAPTER 5

CONCLUSION AND RECOMMENDATION

At the end of the project, a Rope Climbing Robot has been built and the robots overalls function. The objective of the project has been achieved that to build a hardware of Rope Climbing Robot and to test a Rope Climbing Robot. Based on this project, some modification are required in order to improve and to get more efficient and smooth motion of the robot. All criteria should be considered to build a robot so that the robot can move via a rope track without any problem.

APPENDIX

APPENDIX A

PROJECT SCHEDULE

PSM 1 GANTT CHART

Week	1	2	3	4	5	6	7	8	9	10	11	12		
Task														
Taklimat psm 1		■												
Proposal submition				■										
Seminar 1					■	■								
Final report+ log book							■	■	■	■				

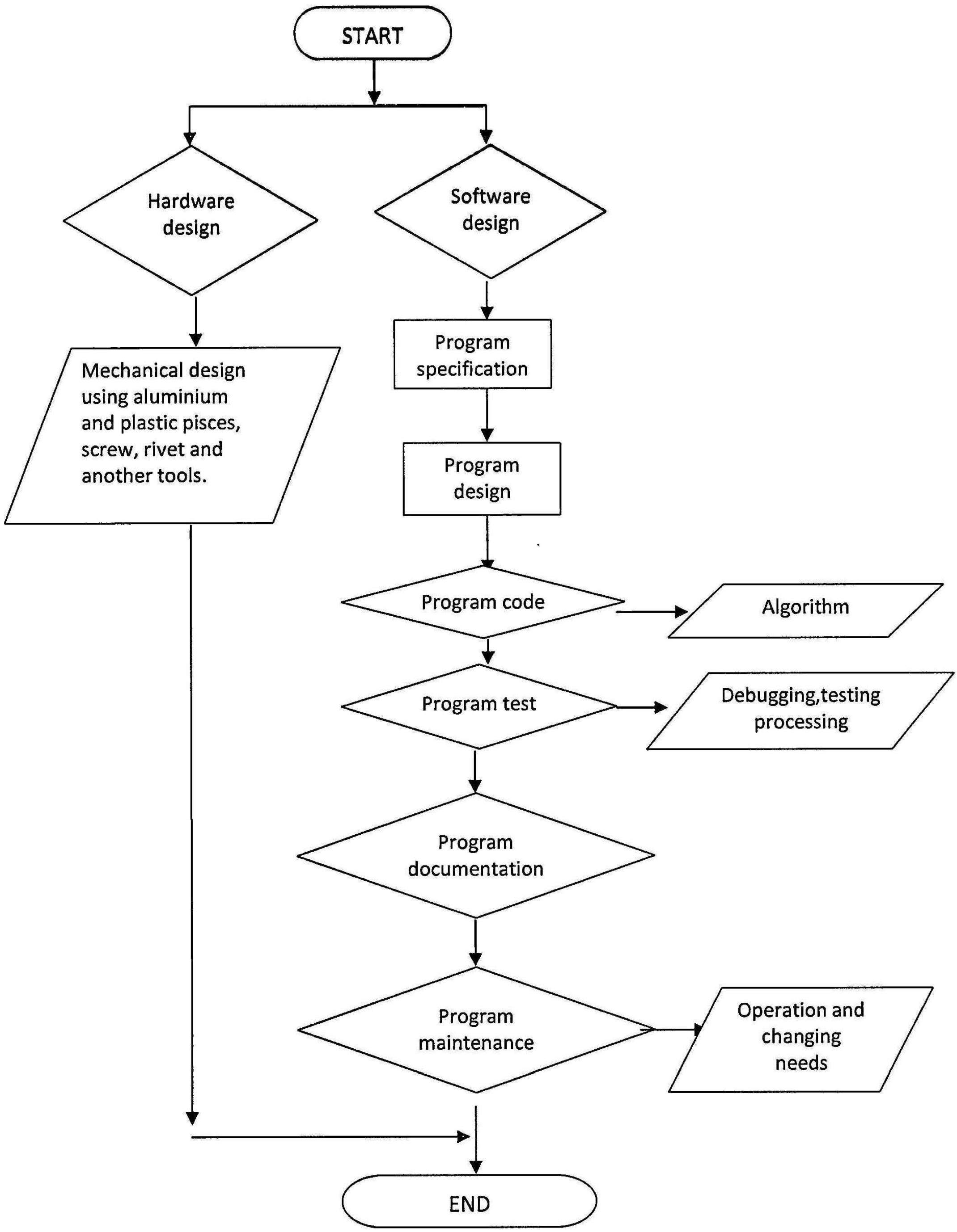
APPENDIX A

PSM 2 GANTT CHART

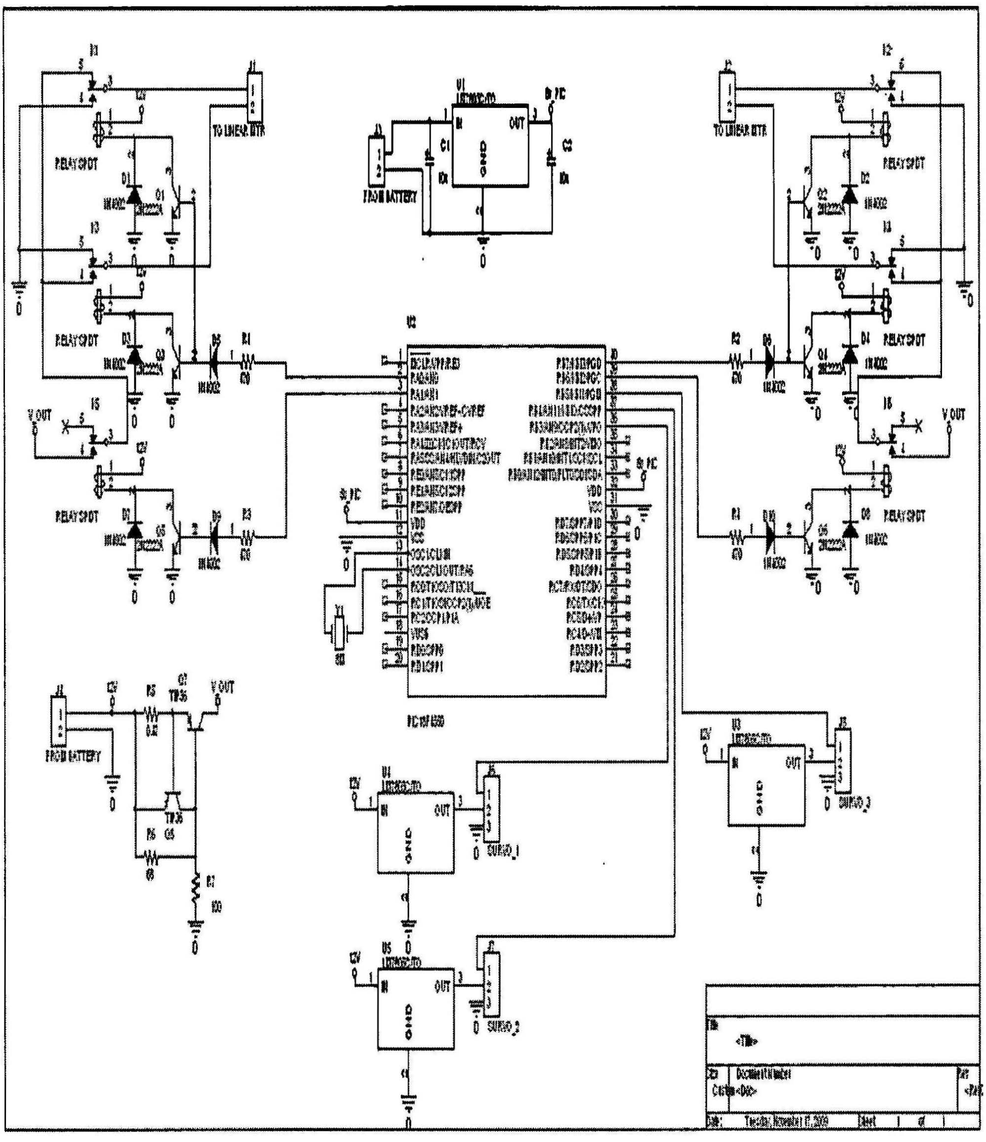
Week Project task	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
PIC18F4550 Software studies	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
Draf 1								■								
Draf 2											■					
Psm 2 Briefing								■								
Hardware design	■	■	■	■	■	■	■	■	■	■						
Software design							■	■	■	■	■	■	■	■		
Interfacing hardware and software										■	■	■	■	■		
Fully abstract submition												■	■			
Seminar 2											■					
Final thesis draft														■		
presentation													■	■		
Thesis(fully)	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

APPENDIX B

FLOWCHART



APPENDIX C



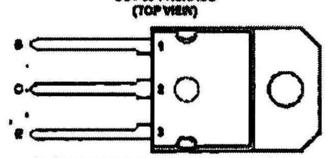
APPENDIX D

TIP36, TIP36A, TIP36B, TIP36C
PNP SILICON POWER TRANSISTORS

JULY 1968 - REVISED MARCH 1997

- **Designed for Complementary Use with the TIP35 Series**
- **125 W at 25°C Case Temperature**
- **25 A Continuous Collector Current**
- **40 A Peak Collector Current**
- **Customer-Specified Selections Available**

SOT-93 PACKAGE (TOP VIEW)



Pin 2 is in electrical contact with the mounting base.

MDTRAA

absolute maximum ratings at 25°C case temperature (unless otherwise noted)

RATING		SYMBOL	VALUE	UNIT
Collector-base voltage (I_E = 0)	TIP36	V_{CBO}	-80	V
	TIP36A		-100	
	TIP36B		-120	
	TIP36C		-140	
Collector-emitter voltage (I_B = 0)	TIP36	V_{CEO}	-40	V
	TIP36A		-60	
	TIP36B		-80	
	TIP36C		-100	
Emitter-base voltage		V_{EBO}	-5	V
Continuous collector current		I_C	-25	A
Peak collector current (see Note 1)		I_{CM}	-40	A
Continuous base current		I_B	-5	A
Continuous device dissipation at (or below) 25°C case temperature (see Note 2)		P_{tot}	125	W
Continuous device dissipation at (or below) 25°C free air temperature (see Note 3)		P_{tot}	3.5	W
Unclamped inductive load energy (see Note 4)		$½LI_C^2$	90	mJ
Operating junction temperature range		T_j	-65 to +150	°C
Storage temperature range		T_{stg}	-65 to +150	°C
Lead temperature 3.2 mm from case for 10 seconds		T_L	250	°C

NOTES:
1. This value applies for $t_p \leq 0.3$ ms, duty cycle ≤ 10%.
2. Derate linearly to 150°C case temperature at the rate of 1 W/°C.
3. Derate linearly to 150°C free air temperature at the rate of 28 mW/°C.
4. This rating is based on the capability of the transistor to operate safely in a circuit of: L = 20 mH, $I_{B(on)}$ = -0.4 A, R_{BE} = 100 Ω, $V_{BE(off)}$ = 0, R_S = 0.1 Ω, V_{CC} = -20 V.

APPENDIX D

TIP36, TIP36A, TIP36B, TIP36C
PNP SILICON POWER TRANSISTORS

JULY 1968 - REVISED MARCH 1997

electrical characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS			MIN	TYP	MAX	UNIT
$V_{(BR)CEO}$	Collector-emitter breakdown voltage	I_C = -30 mA (see Note 5)	I_B = 0	TIP36 TIP36A TIP36B TIP36C	-40 -60 -80 -100			V
I_{CES}	Collector-emitter cut-off current	V_{CE} = -80 V V_{CE} = -100 V V_{CE} = -120 V V_{CE} = -140 V	V_{BE} = 0 V_{BE} = 0 V_{BE} = 0 V_{BE} = 0	TIP36 TIP36A TIP36B TIP36C			-0.7 -0.7 -0.7 -0.7	mA
I_{CEO}	Collector cut-off current	V_{CE} = -30 V V_{CE} = -60 V	I_B = 0 I_B = 0	TIP36/36A TIP36B/36C			-1 -1	mA
I_{EBO}	Emitter cut-off current	V_{EB} = -5 V	I_C = 0				-1	mA
h_{FE}	Forward current transfer ratio	V_{CE} = -4 V V_{CE} = -4 V	I_C = -1.5 A I_C = -15 A	(see Notes 5 and 6)	25 10		 50	
$V_{CE(sat)}$	Collector-emitter saturation voltage	I_B = -1.5 A I_B = -5 A	I_C = -15 A I_C = -25 A	(see Notes 5 and 6)			-1.8 -4	V
V_{BE}	Base-emitter voltage	V_{CE} = -4 V V_{CE} = -4 V	I_C = -15 A I_C = -25 A	(see Notes 5 and 6)			-2 -4	V
h_{fe}	Small signal forward current transfer ratio	V_{CE} = -10 V	I_C = -1 A	f = 1 kHz	25			
$\|h_{fe}\|$	Small signal forward current transfer ratio	V_{CE} = -10 V	I_C = -1 A	f = 1 MHz	3			

NOTES: 5. These parameters must be measured using pulse techniques, t_p = 300 µs, duty cycle ≤ 2%.
6. These parameters must be measured using voltage-sensing contacts, separate from the current carrying contacts.

thermal characteristics

PARAMETER		MIN	TYP	MAX	UNIT
$R_{θJC}$	Junction to case thermal resistance			1	°C/W
$R_{θJA}$	Junction to free air thermal resistance			35.7	°C/W

resistive-load-switching characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS †			MIN	TYP	MAX	UNIT
t_{on}	Turn-on time	I_C = -25 A	$I_{B(on)}$ = -1.5 A	$I_{B(off)}$ = 1.5 A		1.1		µs
t_{off}	Turn-off time	$V_{BE(off)}$ = 4.15 V	R_L = 2 Ω	t_p = 20 µs, dc ≤ 2%		0.6		µs

† Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

APPENDIX D

TYPICAL CHARACTERISTICS

TYPICAL DC CURRENT GAIN vs COLLECTOR CURRENT

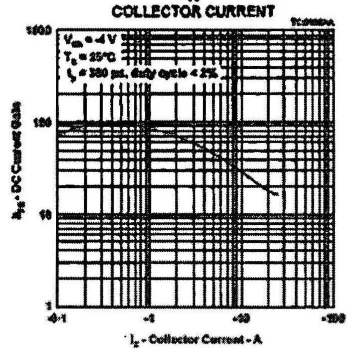


Figure 1.

COLLECTOR-EMITTER SATURATION VOLTAGE vs BASE CURRENT

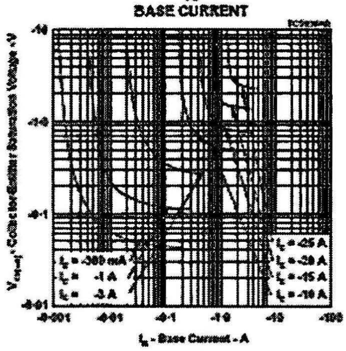


Figure 2.

BASE-EMITTER VOLTAGE vs COLLECTOR CURRENT

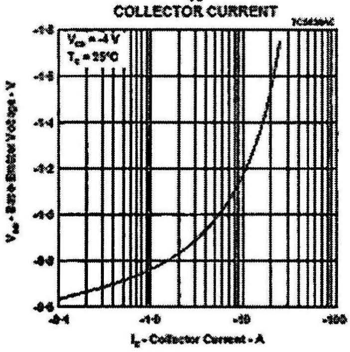


Figure 3.

APPENDIX D

TIP36, TIP36A, TIP36B, TIP36C
PNP SILICON POWER TRANSISTORS

JULY 1968 - REVISED MARCH 1997

MAXIMUM SAFE OPERATING REGIONS

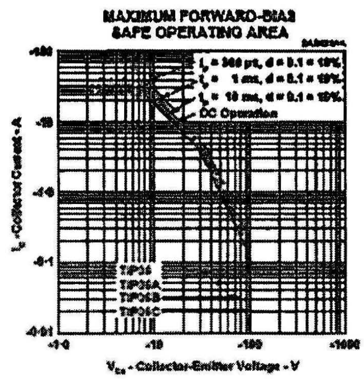


Figure 4.

THERMAL INFORMATION

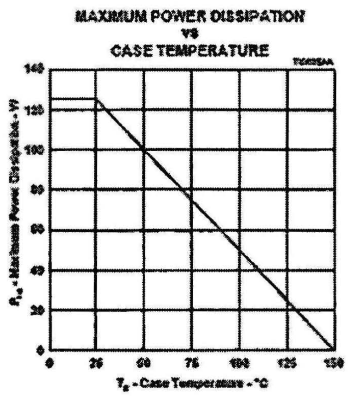


Figure 5.

APPENDIX D

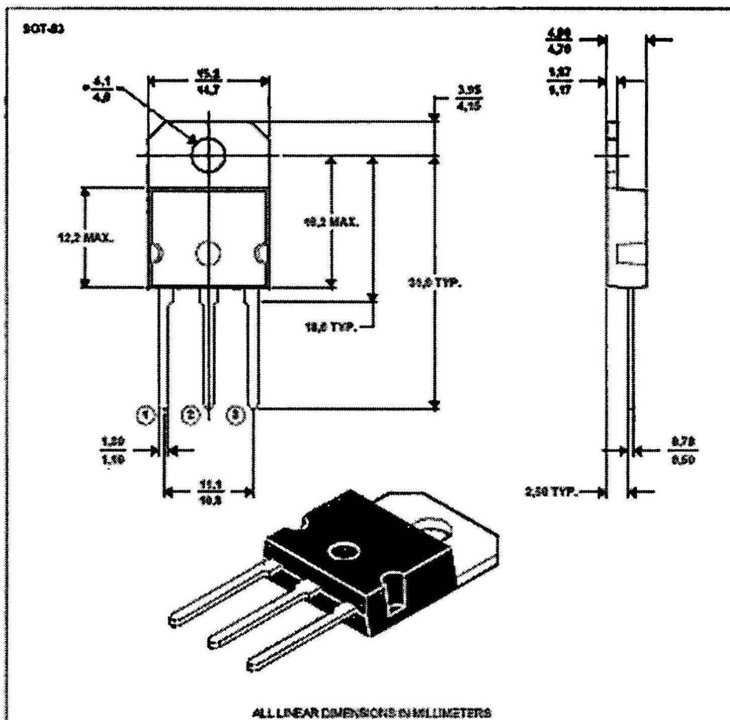
TIP36, TIP36A, TIP36B, TIP36C
PNP SILICON POWER TRANSISTORS

JULY 1968 - REVISED MARCH 1997

MECHANICAL DATA

SOT-93
3-pin plastic flange-mount package

This single-in-line package consists of a circuit mounted on a lead frame and encapsulated within a plastic compound. The compound will withstand soldering temperature with no deformation, and circuit performance characteristics will remain stable when operated in high humidity conditions. Leads require no additional cleaning or processing when used in soldered assembly.



NOTE A: The centre pin is in electrical contact with the mounting tab.

MDXXAW

APPENDIX D

TIP36, TIP36A, TIP36B, TIP36C
PNP SILICON POWER TRANSISTORS

JULY 1968 - REVISED MARCH 1997

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APPENDIX E

FAIRCHILD SEMICONDUCTOR

March 2003

LM78XX/LM78XXA 3-Terminal 1A Positive Voltage Regulator

Features

- Output Current up to 1A
- Output Voltages of 5, 6, 8, 9, 10, 12, 15, 18, 24
- Thermal Overload Protection
- Short Circuit Protection
- Output Transistor Safe Operating Area Protection

General Description

The LM78XX series of three terminal positive regulators are available in the TO-220 package and with several fixed output voltages, making them useful in a wide range of applications. Each type employs internal current limiting, thermal shut down and safe operating area protection, making it essentially indestructible. If adequate heat sinking is provided, they can deliver over 1A output current. Although designed primarily as fixed voltage regulators, these devices can be used with external components to obtain adjustable voltages and currents.

Ordering Information

Product Number	Output Voltage Tolerance	Package	Operating Temperature
LM7805CT	±4%	TO-220	-40°C to +125°C
LM7806CT			
LM7808CT			
LM7809CT			
LM7810CT			
LM7812CT			
LM7815CT			
LM7818CT			
LM7824CT			
LM7805ACT	±2%		0°C to +125°C
LM7806ACT			
LM7808ACT			
LM7809ACT			
LM7810ACT			
LM7812ACT			
LM7815ACT			
LM7818ACT			
LM7824ACT			

APPENDIX E

Block Diagram

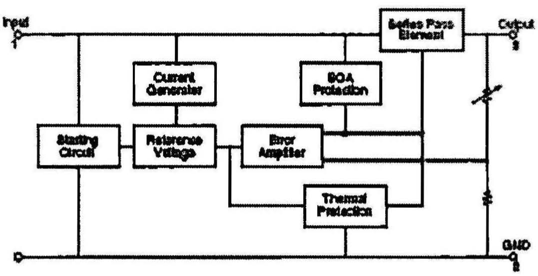

Figure 1.

Pin Assignment

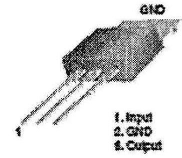

Figure 2.

Absolute Maximum Ratings

Absolute maximum ratings are those values beyond which damage to the device may occur. The datasheet specifications should be met, without exception, to ensure that the system design is reliable over its power supply, temperature, and output/input loading variables. Fairchild does not recommend operation outside datasheet specifications.

Symbol	Parameter		Value	Unit
V_I	Input Voltage	V_O = 5V to 18V	35	V
		V_O = 24V	40	V
$R_{\theta JC}$	Thermal Resistance Junction-Cases (TO-220)		5	°C/W
$R_{\theta JA}$	Thermal Resistance Junction-Air (TO-220)		65	°C/W
T_{OPR}	Operating Temperature Range	LM78xx	-40 to +125	°C
		LM78xxA	0 to +125	
T_{STG}	Storage Temperature Range		-65 to +150	°C

APPENDIX E

Electrical Characteristics (LM7805)

Refer to the test circuits. $-40°C < T_J < 125°C$, $I_O = 500mA$, $V_I = 10V$, $C_I = 0.1\mu F$, unless otherwise specified.

Symbol	Parameter	Conditions		Min.	Typ.	Max.	Unit
V_O	Output Voltage	$T_J = +25°C$		4.8	5.0	5.2	V
		$5mA \le I_O \le 1A$, $P_O \le 15W$, $V_I = 7V$ to $20V$		4.75	5.0	5.25	
Regline	Line Regulation[1]	$T_J = +25°C$	$V_O = 7V$ to $25V$	-	4.0	100	mV
			$V_I = 8V$ to $12V$	-	1.6	50.0	
Regload	Load Regulation[1]	$T_J = +25°C$	$I_O = 5mA$ to $1.5A$	-	9.0	100	mV
			$I_O = 250mA$ to $750mA$	-	4.0	50.0	
I_Q	Quiescent Current	$T_J = +25°C$		-	5.0	8.0	mA
ΔI_Q	Quiescent Current Change	$I_O = 5mA$ to $1A$		-	0.03	0.5	mA
		$V_I = 7V$ to $25V$		-	0.3	1.3	
$\Delta V_O/\Delta T$	Output Voltage Drift[2]	$I_O = 5mA$		-	-0.8	-	mV/°C
V_N	Output Noise Voltage	$f = 10Hz$ to $100kHz$, $T_A = +25°C$		-	42.0	-	$\mu V/V_O$
RR	Ripple Rejection[2]	$f = 120Hz$, $V_O = 8V$ to $18V$		62.0	73.0	-	dB
V_{DROP}	Dropout Voltage	$I_O = 1A$, $T_J = +25°C$		-	2.0	-	V
r_O	Output Resistance[2]	$f = 1kHz$		-	15.0	-	mΩ
I_{SC}	Short Circuit Current	$V_I = 35V$, $T_A = +25°C$		-	230	-	mA
I_{PK}	Peak Current[2]	$T_J = +25°C$		-	2.2	-	A

Notes:

1. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.
2. These parameters, although guaranteed, are not 100% tested in production.

APPENDIX E

Electrical Characteristics (LM7806) (Continued)

Refer to the test circuits. -40°C < T_J < 125°C, I_O = 500mA, V_I = 11V, C_I = 0.33µF, C_O = 0.1µF, unless otherwise specified.

Symbol	Parameter	Conditions		Min	Typ.	Max.	Unit
V_O	Output Voltage	T_J = +25°C		5.75	6.0	6.25	V
		5mA ≤ I_O ≤ 1A, P_O ≤ 15W, V_I = 8.0V to 21V		5.7	6.0	6.3	
Regline	Line Regulation[3]	T_J = +25°C	V_I = 8V to 25V	–	5.0	120	mV
			V_I = 9V to 13V	–	1.5	60.0	
Regload	Load Regulation[3]	T_J = +25°C	I_O = 5mA to 1.5A	–	9.0	120	mV
			I_O = 250mA to 750mA	–	3.0	60.0	
I_Q	Quiescent Current	T_J = +25°C		–	5.0	8.0	mA
ΔI_Q	Quiescent Current Change	I_O = 5mA to 1A		–	–	0.5	mA
		V_I = 8V to 25V		–	–	1.3	
$\Delta V_O/\Delta T$	Output Voltage Drift[4]	I_O = 5mA		–	-0.8	–	mV/°C
V_N	Output Noise Voltage	f = 10Hz to 100kHz, T_A = +25°C		–	45.0	–	µV/V_O
RR	Ripple Rejection[4]	f = 120Hz, V_O = 8V to 18V		62.0	73.0	–	dB
V_{DROP}	Dropout Voltage	I_O = 1A, T_J = +25°C		–	2.0	–	V
r_O	Output Resistance[4]	f = 1kHz		–	19.0	–	mΩ
I_{SC}	Short Circuit Current	V_I = 35V, T_A = +25°C		–	250	–	mA
I_{PK}	Peak Current[4]	T_J = +25°C		–	2.2	–	A

Notes:

3. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.
4. These parameters, although guaranteed, are not 100% tested in production.

APPENDIX E

Electrical Characteristics (LM7808) (Continued)

Refer to the test circuits. -40°C < T_J < 125°C, I_O = 500mA, V_I = 14V, C_I = 0.33µF, C_O = 0.1µF, unless otherwise specified.

Symbol	Parameter	Conditions		Min.	Typ.	Max.	Unit
V_O	Output Voltage	T_J = +25°C		7.7	8.0	8.3	V
		5mA ≤ I_O ≤ 1A, P_O ≤ 15W, V_I = 10.5V to 23V		7.6	8.0	8.4	
Regline	Line Regulation[5]	T_J = +25°C	V_I = 10.5V to 25V	–	5.0	160	mV
			V_I = 11.5V to 17V	–	2.0	80.0	
Regload	Load Regulation[5]	T_J = +25°C	I_O = 5mA to 1.5A	–	10.0	160	mV
			I_O = 250mA to 750mA	–	5.0	80.0	
I_Q	Quiescent Current	T_J = +25°C		–	5.0	8.0	mA
ΔI_Q	Quiescent Current Change	I_O = 5mA to 1A		–	0.05	0.5	mA
		V_I = 10.5V to 25V		–	0.5	1.0	
$\Delta V_O/\Delta T$	Output Voltage Drift[6]	I_O = 5mA		–	-0.8	–	mV/°C
V_N	Output Noise Voltage	f = 10Hz to 100kHz, T_A = +25°C		–	52.0	–	µV/V_O
RR	Ripple Rejection[6]	f = 120Hz, V_O = 11.5V to 21.5V		56.0	72.0	–	dB
V_{DROP}	Dropout Voltage	I_O = 1A, T_J = +25°C		–	2.0	–	V
r_O	Output Resistance[6]	f = 1kHz		–	17.0	–	mΩ
I_{SC}	Short Circuit Current	V_I = 35V, T_A = +25°C		–	230	–	mA
I_{PK}	Peak Current[6]	T_J = +25°C		–	2.2	–	A

Notes:

5. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.
6. These parameters, although guaranteed, are not 100% tested in production.

APPENDIX E

Electrical Characteristics (LM7809) (Continued)

Refer to the test circuits. -40°C < T_J < 125°C, I_O = 500mA, V_I = 15V, C_I = 0.33μF, C_O = 0.1μF, unless otherwise specified.

Symbol	Parameter	Conditions		Min.	Typ.	Max.	Unit
V_O	Output Voltage	T_J = +25°C		8.65	9.0	9.35	V
		5mA ≤ I_O ≤ 1A, P_O ≤ 15W, V_I = 11.5V to 24V		8.6	9.0	9.4	
Regline	Line Regulation[7]	T_J = +25°C	V_I = 11.5V to 25V	–	6.0	180	mV
			V_I = 12V to 17V	–	2.0	90.0	
Regload	Load Regulation[7]	T_J = +25°C	I_O = 5mA to 1.5A	–	12.0	180	mV
			I_O = 250mA to 750mA	–	4.0	90.0	
I_Q	Quiescent Current	T_J = +25°C		–	6.0	8.0	mA
ΔI_Q	Quiescent Current Change	I_O = 5mA to 1A		–	–	0.5	mA
		V_I = 11.5V to 26V		–	–	1.3	
$\Delta V_O/\Delta T$	Output Voltage Drift[8]	I_O = 5mA		–	-1.0	–	mV/°C
V_N	Output Noise Voltage	f = 10Hz to 100kHz, T_A = +25°C		–	58.0	–	μV/V_O
RR	Ripple Rejection[8]	f = 120Hz, V_O = 13V to 23V		56.0	71.0	–	dB
V_{DROP}	Dropout Voltage	I_O = 1A, T_J = +25°C		–	2.0	–	V
r_O	Output Resistance[8]	f = 1kHz		–	17.0	–	mΩ
I_{SC}	Short Circuit Current	V_I = 35V, T_A = +25°C		–	250	–	mA
I_{PK}	Peak Current[8]	T_J = +25°C		–	2.2	–	A

Notes:

7. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.
8. These parameters, although guaranteed, are not 100% tested in production.

APPENDIX E

Electrical Characteristics (LM7810) (Continued)

Refer to the test circuits. $-40°C < T_J < 125°C$, $I_O = 500mA$, $V_I = 16V$, $C_I = 0.33\mu F$, $C_O = 0.1\mu F$, unless otherwise specified.

Symbol	Parameter	Conditions		Min.	Typ.	Max.	Unit
V_O	Output Voltage	$T_J = +25°C$		9.6	10.0	10.4	V
		$5mA \le I_O \le 1A$, $P_O \le 15W$, $V_I = 12.5V$ to $25V$		9.5	10.0	10.5	
Regline	Line Regulation(9)	$T_J = +25°C$	$V_I = 12.5V$ to $25V$	–	10.0	200	mV
			$V_I = 13V$ to $25V$	–	3.0	100	
Regload	Load Regulation(9)	$T_J = +25°C$	$I_O = 5mA$ to $1.5A$	–	12.0	200	mV
			$I_O = 250mA$ to $750mA$	–	4.0	400	
I_Q	Quiescent Current	$T_J = +25°C$		–	5.1	8.0	mA
ΔI_Q	Quiescent Current Change	$I_O = 5mA$ to $1A$		–	–	0.5	mA
		$V_I = 12.5V$ to $29V$		–	–	1.0	
$\Delta V_O/\Delta T$	Output Voltage Drift(10)	$I_O = 5mA$		–	-1.0	–	mV/°C
V_N	Output Noise Voltage	$f = 10Hz$ to $100kHz$, $T_A = +25°C$		–	58.0	–	$\mu V/V_O$
RR	Ripple Rejection(10)	$f = 120Hz$, $V_O = 13V$ to $23V$		56.0	71.0	–	dB
V_{DROP}	Dropout Voltage	$I_O = 1A$, $T_J = +25°C$		–	2.0	–	V
r_O	Output Resistance(10)	$f = 1kHz$		–	17.0	–	mΩ
I_{SC}	Short Circuit Current	$V_I = 35V$, $T_A = +25°C$		–	250	–	mA
I_{PK}	Peak Current(10)	$T_J = +25°C$		–	2.2	–	A

Notes:

9. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.

10. These parameters, although guaranteed, are not 100% tested in production.

APPENDIX E

LM78XX/LM78XXA 3-Terminal 1A Positive Voltage Regulator

Electrical Characteristics (LM7812) (Continued)

Refer to the test circuits. $-40°C < T_J < 125°C$, $I_O = 500mA$, $V_I = 19V$, $C_I = 0.33\mu F$, $C_O = 0.1\mu F$, unless otherwise specified.

Symbol	Parameter	Conditions		Min.	Typ.	Max.	Unit
V_O	Output Voltage	$T_J = +25°C$		11.5	12.0	12.5	V
		$5mA \le I_O \le 1A$, $P_D \le 15W$, $V_I = 14.5V$ to $27V$		11.4	12.0	12.6	
Regline	Line Regulation[11]	$T_J = +25°C$	$V_I = 14.5V$ to $30V$	–	10.0	240	mV
			$V_I = 16V$ to $22V$	–	3.0	120	
Regload	Load Regulation[11]	$T_J = +25°C$	$I_O = 5mA$ to $1.5A$	–	11.0	240	mV
			$I_O = 250mA$ to $750mA$	–	5.0	120	
I_Q	Quiescent Current	$T_J = +25°C$		–	5.1	8.0	mA
ΔI_Q	Quiescent Current Change	$I_O = 5mA$ to $1A$		–	0.1	0.5	mA
		$V_I = 14.5V$ to $30V$		–	0.5	1.0	
$\Delta V_O/\Delta T$	Output Voltage Drift[12]	$I_O = 5mA$		–	-1.0	–	mV/°C
V_N	Output Noise Voltage	$f = 10Hz$ to $100kHz$, $T_A = +25°C$		–	76.0	–	$\mu V/V_O$
RR	Ripple Rejection[12]	$f = 120Hz$, $V_I = 15V$ to $25V$		55.0	71.0	–	dB
V_{DROP}	Dropout Voltage	$I_O = 1A$, $T_J = +25°C$		–	2.0	–	V
r_O	Output Resistance[12]	$f = 1kHz$		–	18.0	–	mΩ
I_{SC}	Short Circuit Current	$V_I = 35V$, $T_A = +25°C$		–	230	–	mA
I_{PK}	Peak Current[12]	$T_J = +25°C$		–	2.2	–	A

Notes:

11. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account seperately. Pulse testing with low duty is used.
12. These parameters, although guaranteed, are not 100% tested in production.

APPENDIX E

Electrical Characteristics (LM7815) (Continued)

Refer to the test circuits. -40°C < T_J < 125°C, I_O = 500mA, V_I = 23V, C_I = 0.33µF, C_O = 0.1µF, unless otherwise specified.

Symbol	Parameter	Conditions		Min.	Typ.	Max.	Unit
V_O	Output Voltage	T_J = +25°C		14.4	15.0	15.6	V
		5mA ≤ I_O ≤ 1A, P_O ≤ 15W, V_I = 17.5V to 30V		14.25	15.0	15.75	
Regline	Line Regulation[13]	T_J = +25°C	V_I = 17.5V to 30V	–	11.0	300	mV
			V_I = 20V to 26V	–	3.0	150	
Regload	Load Regulation[13]	T_J = +25°C	I_O = 5mA to 1.5A	–	12.0	300	mV
			I_O = 250mA to 750mA	–	4.0	150	
I_Q	Quiescent Current	T_J = +25°C		–	5.2	8.0	mA
ΔI_Q	Quiescent Current Change	I_O = 5mA to 1A		–	–	0.5	mA
		V_I = 17.5V to 30V		–	–	1.0	
$\Delta V_O/\Delta T$	Output Voltage Drift[14]	I_O = 5mA		–	-1.0	–	mV/°C
V_N	Output Noise Voltage	f = 10Hz to 100kHz, T_A = +25°C		–	90.0	–	µV/V_O
RR	Ripple Rejection[14]	f = 120Hz, V_I = 18.5V to 28.5V		54.0	70.0	–	dB
V_{DROP}	Dropout Voltage	I_O = 1A, T_J = +25°C		–	2.0	–	V
r_O	Output Resistance[14]	f = 1kHz		–	19.0	–	mΩ
I_{SC}	Short Circuit Current	V_I = 35V, T_A = +25°C		–	250	–	mA
I_{PK}	Peak Current[14]	T_J = +25°C		–	2.2	–	A

Notes:

13. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.

14. These parameters, although guaranteed, are not 100% tested in production.

APPENDIX E

Electrical Characteristics (LM7818) (Continued)

Refer to the test circuits. $-40°C < T_J < 125°C$, $I_O = 500mA$, $V_I = 27V$, $C_I = 0.33\mu F$, $C_O = 0.1\mu F$, unless otherwise specified.

Symbol	Parameter	Conditions		Min.	Typ.	Max.	Unit
V_O	Output Voltage	$T_J = +25°C$		17.3	18.0	18.7	V
		$5mA \leq I_O \leq 1A$, $P_D \leq 15W$, $V_I = 21V$ to $33V$		17.1	18.0	18.9	
Regline	Line Regulation[15]	$T_J = +25°C$	$V_I = 21V$ to $33V$	–	15.0	360	mV
			$V_I = 24V$ to $30V$	–	5.0	180	
Regload	Load Regulation[15]	$T_J = +25°C$	$I_O = 5mA$ to $1.5A$	–	15.0	360	mV
			$I_O = 250mA$ to $750mA$	–	5.0	180	
I_Q	Quiescent Current	$T_J = +25°C$		–	5.2	8.0	mA
ΔI_Q	Quiescent Current Change	$I_O = 5mA$ to $1A$		–	–	0.5	mA
		$V_I = 21V$ to $33V$		–	–	1.0	
$\Delta V_O/\Delta T$	Output Voltage Drift[16]	$I_O = 5mA$		–	-1.0	–	mV/°C
V_N	Output Noise Voltage	$f = 10Hz$ to $100kHz$, $T_A = +25°C$		–	110	–	$\mu V/V_O$
RR	Ripple Rejection[16]	$f = 120Hz$, $V_I = 22V$ to $32V$		53.0	69.0	–	dB
V_{DROP}	Dropout Voltage	$I_O = 1A$, $T_J = +25°C$		–	2.0	–	V
r_O	Output Resistance[16]	$f = 1kHz$		–	22.0	–	mΩ
I_{SC}	Short Circuit Current	$V_I = 35V$, $T_A = +25°C$		–	250	–	mA
I_{PK}	Peak Current[16]	$T_J = +25°C$		–	2.2	–	A

Notes:

15. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.
16. These parameters, although guaranteed, are not 100% tested in production.

APPENDIX E

Electrical Characteristics (LM7824) (Continued)

Refer to the test circuits. -40°C < T_J < 125°C, I_O = 500mA, V_I = 33V, C_I = 0.33μF, C_O = 0.1μF, unless otherwise specified.

Symbol	Parameter	Conditions		Min.	Typ.	Max.	Unit
V_O	Output Voltage	T_J = +25°C		23.0	24.0	25.0	V
		5mA ≤ I_O ≤ 1A, P_O ≤ 15W, V_I = 27V to 38V		22.8	24.0	25.25	
Regline	Line Regulation[17]	T_J = +25°C	V_I = 27V to 38V	–	17.0	480	mV
			V_I = 30V to 36V	–	6.0	240	
Regload	Load Regulation[17]	T_J = +25°C	I_O = 5mA to 1.5A	–	15.0	480	mV
			I_O = 250mA to 750mA	–	5.0	240	
I_Q	Quiescent Current	T_J = +25°C		–	5.2	6.0	mA
ΔI_Q	Quiescent Current Change	I_O = 5mA to 1A		–	0.1	0.5	mA
		V_I = 27V to 38V		–	0.5	1.0	
$\Delta V_O/\Delta T$	Output Voltage Drift[18]	I_O = 5mA		–	-1.5	–	mV/°C
V_N	Output Noise Voltage	f = 10Hz to 100kHz, T_A = +25°C		–	60.0	–	μV/V_O
RR	Ripple Rejection[18]	f = 120Hz, V_I = 28V to 38V		50.0	67.0	–	dB
V_{DROP}	Dropout Voltage	I_O = 1A, T_J = +25°C		–	2.0	–	V
rO	Output Resistance[18]	f = 1kHz		–	28.0	–	mΩ
I_{SC}	Short Circuit Current	V_I = 35V, T_A = +25°C		–	230	–	mA
I_{PK}	Peak Current[18]	T_J = +25°C		–	2.2	–	A

Notes:

17. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.
18. These parameters, although guaranteed, are not 100% tested in production.

APPENDIX E

Electrical Characteristics (LM7805A) (Continued)

Refer to the test circuits. 0°C < T_J < 125°C, I_O = 1A, V_I = 10V, C_I = 0.33µF, C_O = 0.1µF, unless otherwise specified.

Symbol	Parameter	Conditions		Min.	Typ.	Max.	Unit
V_O	Output Voltage	T_J = +25°C		4.9	5.0	5.1	V
		I_O = 5mA to 1A, P_O ≤ 15W, V_I = 7.5V to 20V		4.8	5.0	5.2	
Regline	Line Regulation[19]	V_I = 7.5V to 25V, I_O = 500mA		–	5.0	50.0	mV
		V_I = 8V to 12V		–	3.0	50.0	
		T_J = +25°C	V_I = 7.3V to 20V	–	5.0	50.0	
			V_I = 8V to 12V	–	1.5	25.0	
Regload	Load Regulation[19]	T_J = +25°C, I_O = 5mA to 1.5A		–	9.0	100	mV
		I_O = 5mA to 1A		–	9.0	100	
		I_O = 250mA to 750mA		–	4.0	50.0	
I_Q	Quiescent Current	T_J = +25°C		–	5.0	6.0	mA
ΔI_Q	Quiescent Current Change	I_O = 5mA to 1A		–	–	0.5	mA
		V_I = 8V to 25V, I_O = 500mA		–	–	0.8	
		V_I = 7.5V to 20V, T_J = +25°C		–	–	0.8	
$\Delta V_O/\Delta T$	Output Voltage Drift[20]	I_O = 5mA		–	-0.8	–	mV/°C
V_N	Output Noise Voltage	f = 10Hz to 100kHz, T_A = +25°C		–	10.0	–	µV/V_O
RR	Ripple Rejection[20]	f = 120Hz, I_O = 500mA, V_I = 8V to 18V		–	68.0	–	dB
V_{DROP}	Dropout Voltage	I_O = 1A, T_J = +25°C		–	2.0	–	V
r_O	Output Resistance[20]	f = 1kHz		–	17.0	–	mΩ
I_{SC}	Short Circuit Current	V_I = 35V, T_A = +25°C		–	250	–	mA
I_{PK}	Peak Current[20]	T_J = +25°C		–	2.2	–	A

Notes:

19. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.

20. These parameters, although guaranteed, are not 100% tested in production.

APPENDIX E

Electrical Characteristics (LM7806A) (Continued)

Refer to the test circuits. 0°C < T_J < 125°C, I_O = 1A, V_I = 11V, C_I = 0.33µF, C_O = 0.1µF, unless otherwise specified.

Symbol	Parameter	Conditions		Min.	Typ.	Max.	Unit
V_O	Output Voltage	T_J = +25°C		5.88	6.0	6.12	V
		I_O = 5mA to 1A, P_O ≤ 15W, V_I = 8.6V to 21V		5.76	6.0	6.24	
Regline	Line Regulation[21]	V_I = 8.6V to 25V, I_O = 500mA		–	5.0	60.0	mV
		V_I = 9V to 13V		–	3.0	60.0	
		T_J = +25°C	V_I = 8.3V to 21V	–	5.0	60.0	
			V_I = 9V to 13V	–	1.5	30.0	
Regload	Load Regulation[21]	T_J = +25°C, I_O = 5mA to 1.5A		–	9.0	100	mV
		I_O = 5mA to 1A		–	9.0	100	
		I_O = 250mA to 750mA		–	5.0	50.0	
I_Q	Quiescent Current	T_J = +25°C		–	4.3	6.0	mA
ΔI_Q	Quiescent Current Change	I_O = 5mA to 1A		–	–	0.5	mA
		V_I = 9V to 25V, I_O = 500mA		–	–	0.8	
		V_I = 8.5V to 21V, T_J = +25°C		–	–	0.8	
$\Delta V_O/\Delta T$	Output Voltage Drift[22]	I_O = 5mA		–	-0.8	–	mV/°C
V_N	Output Noise Voltage	f = 10Hz to 100kHz, T_A = +25°C		–	10.0	–	µV/V_O
RR	Ripple Rejection[22]	f = 120Hz, I_O = 500mA, V_I = 9V to 19V		–	65.0	–	dB
V_{DROP}	Dropout Voltage	I_O = 1A, T_J = +25°C		–	2.0	–	V
r_O	Output Resistance[22]	f = 1kHz		–	17.0	–	mΩ
I_{SC}	Short Circuit Current	V_I = 35V, T_A = +25°C		–	250	–	mA
I_{PK}	Peak Current[22]	T_J = +25°C		–	2.2	–	A

Notes:

21. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.

22. These parameters, although guaranteed, are not 100% tested in production.

APPENDIX E

Electrical Characteristics (LM7808A) (Continued)

Refer to the test circuits. $0°C < T_J < 125°C$, $I_O = 1A$, $V_I = 14V$, $C_I = 0.33\mu F$, $C_O = 0.1\mu F$, unless otherwise specified.

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
V_O	Output Voltage	$T_J = +25°C$	7.84	8.0	8.16	V
		$I_O = 5mA$ to $1A$, $P_D \leq 15W$, $V_I = 10.6V$ to $23V$	7.7	8.0	8.3	
Regline	Line Regulation[23]	$V_I = 10.6V$ to $25V$, $I_O = 500mA$	–	6.0	80.0	mV
		$V_I = 11V$ to $17V$	–	3.0	80.0	
		$T_J = +25°C$, $V_I = 10.4V$ to $23V$	–	6.0	80.0	
		$T_J = +25°C$, $V_I = 11V$ to $17V$	–	2.0	40.0	
Regload	Load Regulation[23]	$T_J = +25°C$, $I_O = 5mA$ to $1.5A$	–	12.0	100	mV
		$I_O = 5mA$ to $1A$	–	12.0	100	
		$I_O = 250mA$ to $750mA$	–	5.0	50.0	
I_Q	Quiescent Current	$T_J = +25°C$	–	5.0	6.0	mA
ΔI_Q	Quiescent Current Change	$I_O = 5mA$ to $1A$	–	–	0.5	mA
		$V_I = 11V$ to $25V$, $I_O = 500mA$	–	–	0.8	
		$V_I = 10.6V$ to $23V$, $T_J = +25°C$	–	–	0.8	
$\Delta V_O/\Delta T$	Output Voltage Drift[24]	$I_O = 5mA$	–	-0.8	–	mV/°C
V_N	Output Noise Voltage	$f = 10Hz$ to $100kHz$, $T_A = +25°C$	–	10.0	–	$\mu V/V_O$
RR	Ripple Rejection[24]	$f = 120Hz$, $I_O = 500mA$, $V_I = 11.5V$ to $21.5V$	–	62.0	–	dB
V_{DROP}	Dropout Voltage	$I_O = 1A$, $T_J = +25°C$	–	2.0	–	V
r_O	Output Resistance[24]	$f = 1kHz$	–	18.0	–	mΩ
I_{SC}	Short Circuit Current	$V_I = 35V$, $T_A = +25°C$	–	250	–	mA
I_{PK}	Peak Current[24]	$T_J = +25°C$	–	2.2	–	A

Notes:

23. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.

24. These parameters, although guaranteed, are not 100% tested in production.

APPENDIX E

Electrical Characteristics (LM7809A) (Continued)

Refer to the test circuits. $0°C < T_J < 125°C$, $I_O = 1A$, $V_I = 15V$, $C_I = 0.33\mu F$, $C_O = 0.1\mu F$, unless otherwise specified.

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Units
V_O	Output Voltage	$T_J = +25°C$	8.82	9.0	9.16	V
		$I_O = 5mA$ to 1A, $P_D \leq 15W$, $V_I = 11.2V$ to 24V	8.65	9.0	9.35	
Regline	Line Regulation[25]	$V_I = 11.7V$ to 25V, $I_O = 500mA$	–	6.0	90.0	mV
		$V_I = 12.5V$ to 19V	–	4.0	45.0	
		$T_J = +25°C$, $V_I = 11.5V$ to 24V	–	6.0	90.0	
		$T_J = +25°C$, $V_I = 12.5V$ to 19V	–	2.0	45.0	
Regload	Load Regulation[25]	$T_J = +25°C$, $I_O = 5mA$ to 1.5A	–	12.0	100	mV
		$I_O = 5mA$ to 1A	–	12.0	100	
		$I_O = 250mA$ to 750mA	–	5.0	50.0	
I_Q	Quiescent Current	$T_J = +25°C$	–	5.0	6.0	mA
ΔI_Q	Quiescent Current Change	$I_O = 5mA$ to 1A	–	–	0.5	mA
		$V_I = 12V$ to 25V, $I_O = 500mA$	–	–	0.8	
		$V_I = 11.7V$ to 25V, $T_J = +25°C$	–	–	0.8	
$\Delta V_O/\Delta T$	Output Voltage Drift[26]	$I_O = 5mA$	–	-1.0	–	mV/°C
V_N	Output Noise Voltage	f = 10Hz to 100kHz, $T_A = +25°C$	–	10.0	–	µV/Vo
RR	Ripple Rejection[26]	f = 120Hz, $I_O = 500mA$, $V_I = 12V$ to 22V	–	62.0	–	dB
V_{DROP}	Dropout Voltage	$I_O = 1A$, $T_J = +25°C$	–	2.0	–	V
r_O	Output Resistance[26]	f = 1kHz	–	17.0	–	mΩ
I_{SC}	Short Circuit Current	$V_I = 35V$, $T_A = +25°C$	–	250	–	mA
I_{PK}	Peak Current[26]	$T_J = +25°C$	–	2.2	–	A

Notes:

25. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.

26. These parameters, although guaranteed, are not 100% tested in production.

APPENDIX E

Electrical Characteristics (LM7810A) (Continued)

Refer to the test circuits. 0°C < T_J < 125°C, I_O = 1A, V_I = 16V, C_I = 0.33μF, C_O = 0.1μF, unless otherwise specified.

Symbol	Parameter	Conditions		Min.	Typ.	Max.	Units
V_O	Output Voltage	T_J = +25°C		9.8	10.0	10.2	V
		I_O = 5mA to 1A, P_O ≤ 15W, V_I = 12.8V to 25V		9.6	10.0	10.4	
Regline	Line Regulation[27]	V_I = 12.8V to 26V, I_O = 500mA		–	8.0	100	mV
		V_I = 13V to 20V		–	4.0	50.0	
		T_J = +25°C	V_I = 12.8V to 25V	–	8.0	100	
			V_I = 13V to 20V	–	3.0	50.0	
Regload	Load Regulation[27]	T_J = +25°C, I_O = 5mA to 1.5A		–	12.0	100	mV
		I_O = 5mA to 1A		–	12.0	100	
		I_O = 250mA to 750mA		–	5.0	50.0	
I_Q	Quiescent Current	T_J = +25°C		–	5.0	6.0	mA
ΔI_Q	Quiescent Current Change	I_O = 5mA to 1A		–	–	0.5	mA
		V_I = 12.8V to 26V, I_O = 500mA		–	–	0.8	
		V_I = 13V to 26V, T_J = +25°C		–	–	0.5	
$\Delta V_O/\Delta T$	Output Voltage Drift[28]	I_O = 5mA		–	-1.0	–	mV/°C
V_N	Output Noise Voltage	f = 10Hz to 100kHz, T_A = +25°C		–	10.0	–	μV/V_O
RR	Ripple Rejection[28]	f = 120Hz, I_O = 500mA, V_I = 14V to 24V		–	62.0	–	dB
V_{DROP}	Dropout Voltage	I_O = 1A, T_J = +25°C		–	2.0	–	V
r_O	Output Resistance[28]	f = 1kHz		–	17.0	–	mΩ
I_{SC}	Short Circuit Current	V_I = 35V, T_A = +25°C		–	250	–	mA
I_{PK}	Peak Current[28]	T_J = +25°C		–	2.2	–	A

Notes:

27. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.

28. These parameters, although guaranteed, are not 100% tested in production.

APPENDIX E

Electrical Characteristics (LM7812A) (Continued)

Refer to the test circuits. 0°C < T_J < 125°C, I_O = 1A, V_I = 19V, C_I = 0.33μF, C_O = 0.1μF, unless otherwise specified.

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Units
V_O	Output Voltage	T_J = +25°C	11.75	12.0	12.25	V
		I_O = 5mA to 1A, P_O ≤ 15W, V_I = 14.8V to 27V	11.5	12.0	12.5	
Regline	Line Regulation[29]	V_I = 14.8V to 30V, I_O = 500mA	–	10.0	120	mV
		V_I = 16V to 22V	–	4.0	120	
		T_J = +25°C, V_I = 14.5V to 27V	–	10.0	120	
		T_J = +25°C, V_I = 16V to 22V	–	3.0	60.0	
Regload	Load Regulation[29]	T_J = +25°C, I_O = 5mA to 1.5A	–	12.0	100	mV
		I_O = 5mA to 1A	–	12.0	100	
		I_O = 250mA to 750mA	–	5.0	50.0	
I_Q	Quiescent Current	T_J = +25°C	–	5.1	6.0	mA
ΔI_Q	Quiescent Current Change	I_O = 5mA to 1A	–	–	0.5	mA
		V_I = 14V to 27V, I_O = 500mA	–	–	0.8	
		V_I = 15V to 30V, T_J = +25°C	–	–	0.8	
$\Delta V_O/\Delta T$	Output Voltage Drift[30]	I_O = 5mA	–	-1.0	–	mV/°C
V_N	Output Noise Voltage	f = 10Hz to 100kHz, T_A = +25°C	–	10.0	–	μV/V_O
RR	Ripple Rejection[30]	f = 120Hz, I_O = 500mA, V_I = 14V to 24V	–	60.0	–	dB
V_{DROP}	Dropout Voltage	I_O = 1A, T_J = +25°C	–	2.0	–	V
r_O	Output Resistance[30]	f = 1kHz	–	18.0	–	mΩ
I_{SC}	Short Circuit Current	V_I = 35V, T_A = +25°C	–	250	–	mA
I_{PK}	Peak Current[30]	T_J = +25°C	–	2.2	–	A

Note:

29. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.
30. These parameters, although guaranteed, are not 100% tested in production.

APPENDIX E

Electrical Characteristics (LM7815A) (Continued)

Refer to the test circuits. $0°C < T_J < 125°C$, $I_O = 1A$, $V_I = 23V$, $C_I = 0.33\mu F$, $C_O = 0.1\mu F$, unless otherwise specified.

Symbol	Parameter	Conditions		Min.	Typ.	Max.	Units
V_O	Output Voltage	$T_J = +25°C$		14.75	15.0	15.3	V
		$I_O = 5mA$ to 1A, $P_D \leq 15W$, $V_I = 17.7V$ to 30V		14.4	15.0	15.6	
Regline	Line Regulation[31]	$V_I = 17.4V$ to 30V, $I_O = 500mA$		–	10.0	150	mV
		$V_I = 20V$ to 26V		–	5.0	150	
		$T_J = +25°C$	$V_I = 17.5V$ to 30V	–	11.0	150	
			$V_I = 20V$ to 26V	–	3.0	75.0	
Regload	Load Regulation[31]	$T_J = +25°C$, $I_O = 5mA$ to 1.5A		–	12.0	100	mV
		$I_O = 5mA$ to 1A		–	12.0	100	
		$I_O = 250mA$ to 750mA		–	5.0	50.0	
I_Q	Quiescent Current	$T_J = +25°C$		–	5.2	6.0	mA
ΔI_Q	Quiescent Current Change	$I_O = 5mA$ to 1A		–	–	0.5	mA
		$V_I = 17.5V$ to 30V, $I_O = 500mA$		–	–	0.8	
		$V_I = 17.5V$ to 30V, $T_J = +25°C$		–	–	0.8	
$\Delta V_O/\Delta T$	Output Voltage Drift[32]	$I_O = 5mA$		–	-1.0	–	mV/°C
V_N	Output Noise Voltage	$f = 10Hz$ to 100kHz, $T_A = +25°C$		–	10.0	–	µV/V_O
RR	Ripple Rejection[32]	$f = 120Hz$, $I_O = 500mA$, $V_I = 18.5V$ to 28.5V		–	58.0	–	dB
V_{DROP}	Dropout Voltage	$I_O = 1A$, $T_J = +25°C$		–	2.0	–	V
r_O	Output Resistance[32]	$f = 1kHz$		–	19.0	–	mΩ
I_{SC}	Short Circuit Current	$V_I = 35V$, $T_A = +25°C$		–	250	–	mA
I_{PK}	Peak Current[32]	$T_J = +25°C$		–	2.2	–	A

Notes:

31. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.

32. These parameters, although guaranteed, are not 100% tested in production.

APPENDIX E

Electrical Characteristics (LM7818A) (Continued)

Refer to the test circuits. $0°C < T_J < 125°C$, $I_O = 1A$, $V_I = 27V$, $C_I = 0.33\mu F$, $C_O = 0.1\mu F$, unless otherwise specified.

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Units
V_O	Output Voltage	$T_J = +25°C$	17.64	18.0	18.36	V
		$I_O = 5mA$ to $1A$, $P_O \leq 15W$, $V_I = 21V$ to $33V$	17.3	18.0	18.7	
Regline	Line Regulation[33]	$V_I = 21V$ to $33V$, $I_O = 500mA$	–	15.0	180	mV
		$V_I = 21V$ to $33V$	–	5.0	180	
		$T_J = +25°C$, $V_I = 20.6V$ to $33V$	–	15.0	180	
		$T_J = +25°C$, $V_I = 24V$ to $30V$	–	5.0	90.0	
Regload	Load Regulation[33]	$T_J = +25°C$, $I_O = 5mA$ to $1.5A$	–	15.0	100	mV
		$I_O = 5mA$ to $1A$	–	15.0	100	
		$I_O = 250mA$ to $750mA$	–	7.0	50.0	
I_Q	Quiescent Current	$T_J = +25°C$	–	5.2	6.0	mA
ΔI_Q	Quiescent Current Change	$I_O = 5mA$ to $1A$	–	–	0.5	mA
		$V_I = 12V$ to $33V$, $I_O = 500mA$	–	–	0.8	
		$V_I = 12V$ to $33V$, $T_J = +25°C$	–	–	0.8	
$\Delta V_O/\Delta T$	Output Voltage Drift[34]	$I_O = 5mA$	–	-1.0	–	mV/°C
V_N	Output Noise Voltage	$f = 10Hz$ to $100kHz$, $T_A = +25°C$	–	10.0	–	$\mu V/V_O$
RR	Ripple Rejection[34]	$f = 120Hz$, $I_O = 500mA$, $V_I = 22V$ to $32V$	–	57.0	–	dB
V_{DROP}	Dropout Voltage	$I_O = 1A$, $T_J = +25°C$	–	2.0	–	V
r_O	Output Resistance[34]	$f = 1kHz$	–	19.0	–	mΩ
I_{SC}	Short Circuit Current	$V_I = 35V$, $T_A = +25°C$	–	250	–	mA
I_{PK}	Peak Current[34]	$T_J = +25°C$	–	2.2	–	A

Notes:

33. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.

34. These parameters, although guaranteed, are not 100% tested in production.

APPENDIX E

Electrical Characteristics (LM7824A) (Continued)

Refer to the test circuits. 0°C < T_J < 125°C, I_O = 1A, V_I = 33V, C_I = 0.33µF, C_O = 0.1µF, unless otherwise specified.

Symbol	Parameter	Conditions		Min.	Typ.	Max.	Units
V_O	Output Voltage	T_J = +25°C		23.5	24.0	24.5	V
		I_O = 5mA to 1A, P_O ≤ 15W, V_I = 27.3V to 38V		23.0	24.0	25.0	
Regline	Line Regulation[35]	V_I = 27V to 38V, I_O = 500mA		–	10.0	240	mV
		V_I = 21V to 33V		–	6.0	240	
		T_J = +25°C	V_I = 26.7V to 38V	–	18.0	240	
			V_I = 30V to 36V	–	6.0	120	
Regload	Load Regulation[35]	T_J = +25°C, I_O = 5mA to 1.5A		–	15.0	100	mV
		I_O = 5mA to 1A		–	15.0	100	
		I_O = 250mA to 750mA		–	7.0	50.0	
I_Q	Quiescent Current	T_J = +25°C		–	6.2	6.0	mA
ΔI_Q	Quiescent Current Change	I_O = 5mA to 1A		–	–	0.5	mA
		V_I = 27.3V to 38V, I_O = 500mA		–	–	0.8	
		V_I = 27.3V to 38V, T_J = +25°C		–	–	0.8	
$\Delta V_O/\Delta T$	Output Voltage Drift[36]	I_O = 5mA		–	-1.5	–	mV/°C
V_N	Output Noise Voltage	f = 10Hz to 100kHz, T_A = +25°C		–	10.0	–	µV/V_O
RR	Ripple Rejection[36]	f = 120Hz, I_O = 500mA, V_I = 28V to 38V		–	64.0	–	dB
V_{DROP}	Dropout Voltage	I_O = 1A, T_J = +25°C		–	2.0	–	V
r_O	Output Resistance[36]	f = 1kHz		–	20.0	–	mΩ
I_{SC}	Short Circuit Current	V_I = 35V, T_A = +25°C		–	250	–	mA
I_{PK}	Peak Current[36]	T_J = +25°C		–	2.2	–	A

Notes:

35. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.
36. These parameters, although guaranteed, are not 100% tested in production.

APPENDIX E

LM78XX/LM78XXA 3-Terminal 1A Positive Voltage Regulator

Typical Performance Characteristics

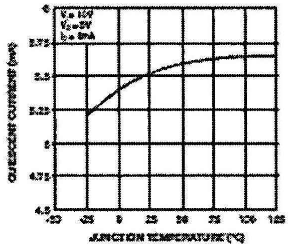

Figure 3. Quiescent Current

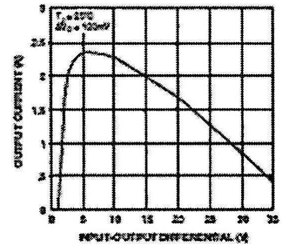

Figure 4. Peak Output Current

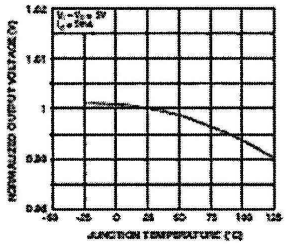

Figure 5. Output Voltage

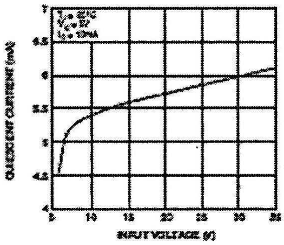

Figure 6. Quiescent Current

APPENDIX E

Typical Applications

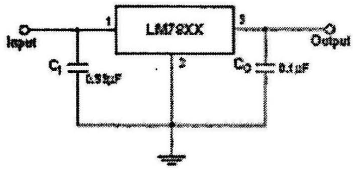

Figure 7. DC Parameters

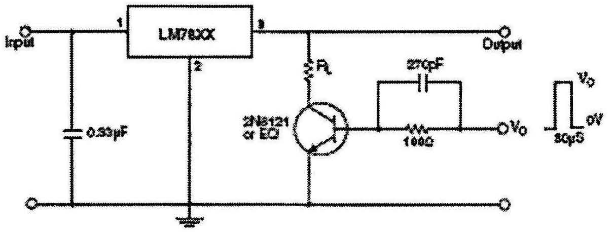

Figure 8. Load Regulation

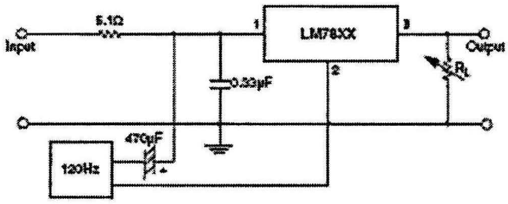

Figure 9. Ripple Rejection

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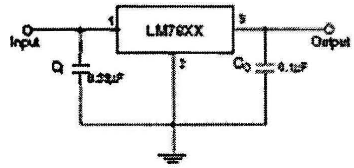
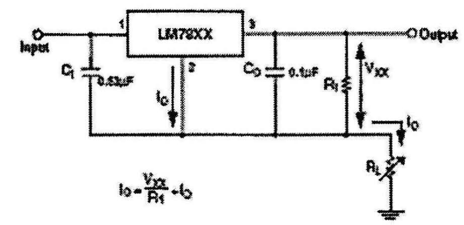


Figure 10. Fixed Output Regulator



Notes:

1. To specify an output voltage, substitute voltage value for "XX." A common ground is required between the input and the output voltage. The input voltage must remain typically 2.0V above the output voltage even during the low point on the input ripple voltage.
2. C_I is required if regulator is located an appreciable distance from power supply filter.
3. C_O improves stability and transient response.

Figure 11.

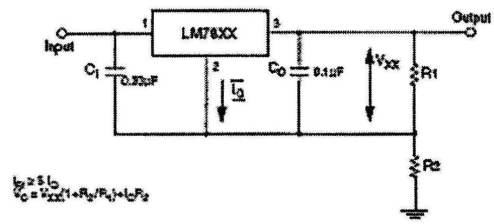


Figure 12. Circuit for Increasing Output Voltage

APPENDIX E

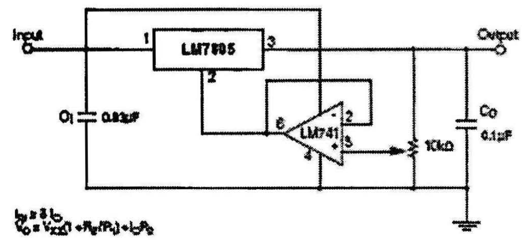


Figure 13. Adjustable Output Regulator (7V to 30V)

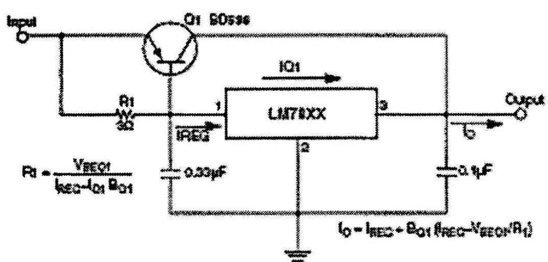


Figure 14. High Current Voltage Regulator

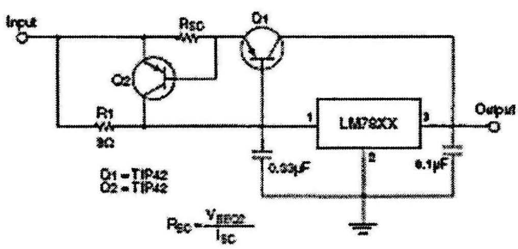


Figure 15. High Output Current with Short Circuit Protection

APPENDIX E

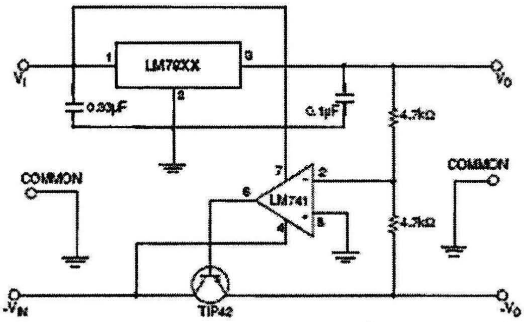


Figure 16. Tracking Voltage Regulator

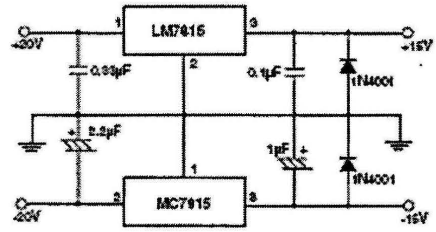


Figure 17. Split Power Supply (±15V – 1A)

LM78XX/LM78XXA 3-Terminal 1A Positive Voltage Regulator

LM78XX/LM78XXA Rev. 1.0

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APPENDIX E

LM78XX/LM78XXA 3-Terminal 1A Positive Voltage Regulator

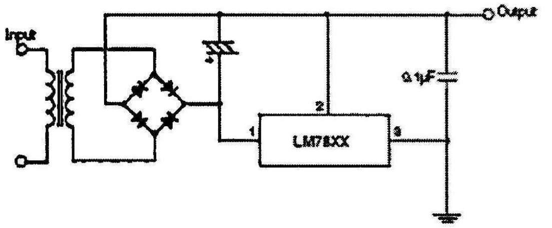


Figure 18. Negative Output Voltage Circuit

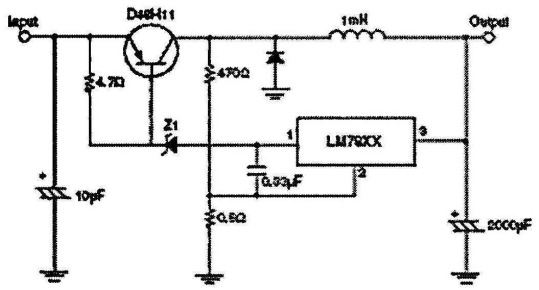
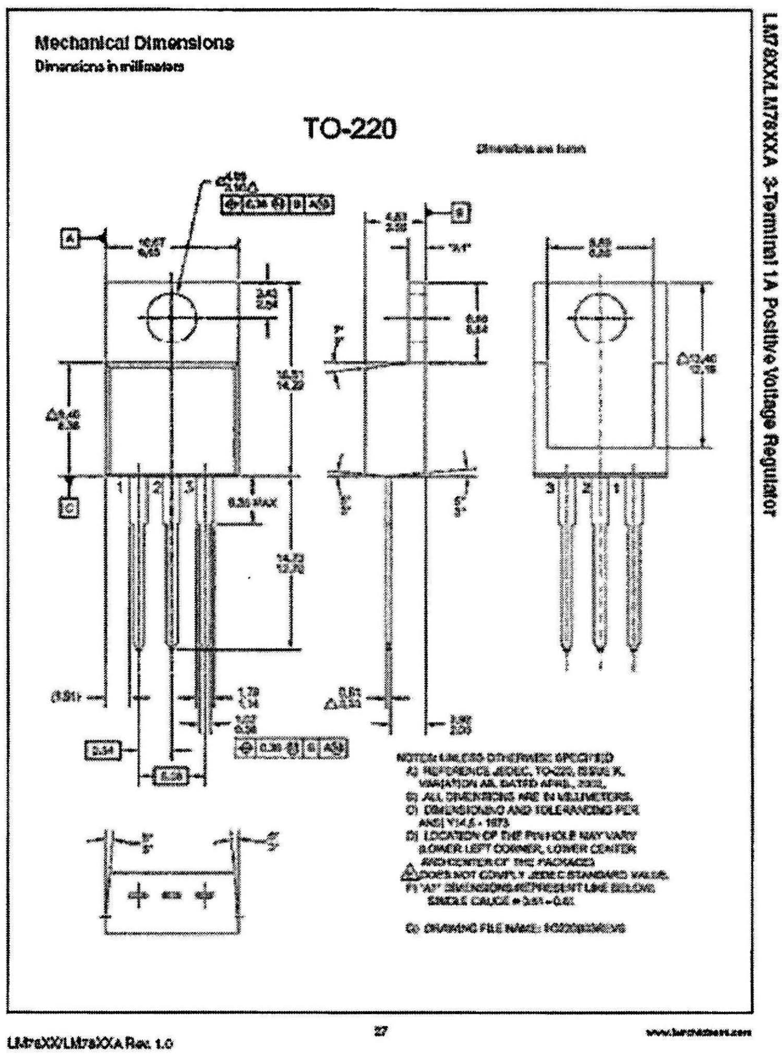


Figure 19. Switching Regulator

LM78XX/LM78XXA Rev. 1.0 25 www.fairchildsemi.com

APPENDIX E


Mechanical Dimensions
Dimensions in millimeters
TO-220
LM78XX/LM78XXA 3-Terminal 1A Positive Voltage Regulator
LM78XX/LM78XXA Rev. 1.0
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APPENDIX E

APPENDIX F

MPS2222, MPS2222A

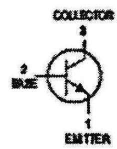
MPS2222A is a Preferred Device

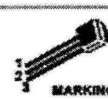
General Purpose Transistors

NPN Silicon

ON Semiconductor™

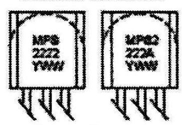
http://onsemi.com





TO–92
CASE 29
STYLE 1

MARKING DIAGRAMS



Y = Year
WW = Work Week

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage MPS2222 / MPS2222A	V_{CEO}	30 / 40	Vdc
Collector–Base Voltage MPS2222 / MPS2222A	V_{CBO}	60 / 75	Vdc
Emitter–Base Voltage MPS2222 / MPS2222A	V_{EBO}	5.0 / 6.0	Vdc
Collector Current – Continuous	I_C	600	mAdc
Total Device Dissipation @ T_A = 25°C; Derate above 25°C	P_D	625; 5.0	mW; mW/°C
Total Device Dissipation @ T_C = 25°C; Derate above 25°C	P_D	1.5; 12	Watts; mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	–55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{θJA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{θJC}$	83.3	°C/W

ORDERING INFORMATION

Device	Package	Shipping
MPS2222	TO–92	5000 Units/Box
MPS2222A	TO–92	5000 Units/Box
MPS2222ARLRA	TO–92	2000/Tape & Reel
MPS2222ARLRM	TO–92	2000/Ammo Pack
MPS2222ARLRP	TO–92	2000/Ammo Pack
MPS2222RLRA	TO–92	2000/Tape & Reel
MPS2222RLRM	TO–92	2000/Ammo Pack
MPS2222RLRP	TO–92	2000/Ammo Pack

Preferred devices are recommended choices for future use and best overall value.

October, 2001 – Rev. 1
1
Publication Order Number:
MPS2222/D

APPENDIX F

MPS2222, MPS2222A

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted) (Continued)

Characteristic		Symbol	Min	Max	Unit
SMALL–SIGNAL CHARACTERISTICS					
Current–Gain – Bandwidth Product (Note 2.) (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	MPS2222 MPS2222A	f_T	250 300	– –	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	–	8.0	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	MPS2222 MPS2222A	C_{ibo}	– –	30 25	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz) (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MPS2222A MPS2222A	h_{ie}	2.0 0.25	8.0 1.25	kΩ
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz) (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MPS2222A MPS2222A	h_{re}	– –	8.0 4.0	X 10^{-4}
Small–Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz) (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MPS2222A MPS2222A	h_{fe}	50 75	300 375	–
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz) (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MPS2222A MPS2222A	h_{oe}	5.0 25	35 200	μmhos
Collector Base Time Constant (I_E = 20 mAdc, V_{CB} = 20 Vdc, f = 31.8 MHz)	MPS2222A	$rb'C_c$	–	150	ps
Noise Figure (I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 1.0 kΩ, f = 1.0 kHz)	MPS2222A	NF	–	4.0	dB

SWITCHING CHARACTERISTICS MPS2222A only

Characteristic	Conditions	Symbol	Min	Max	Unit
Delay Time	(V_{CC} = 30 Vdc, $V_{BE(off)}$ = –0.5 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc) (Figure 1)	t_d	–	10	ns
Rise Time		t_r	–	25	ns
Storage Time	(V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc) (Figure 2)	t_s	–	225	ns
Fall Time		t_f	–	60	ns

2. f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

SWITCHING TIME EQUIVALENT TEST CIRCUITS

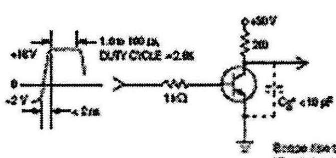
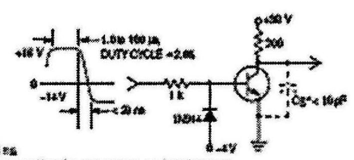


Figure 1. Turn–On Time



Scope rise time < 4 ns
*Total shunt capacitance of test jig, connectors, and oscilloscope.

Figure 2. Turn–Off Time

APPENDIX F

MPS2222, MPS2222A

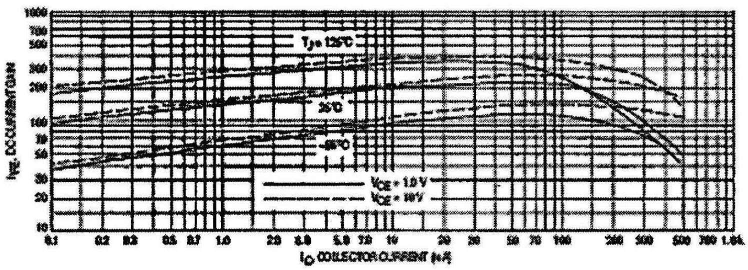


Figure 3. DC Current Gain

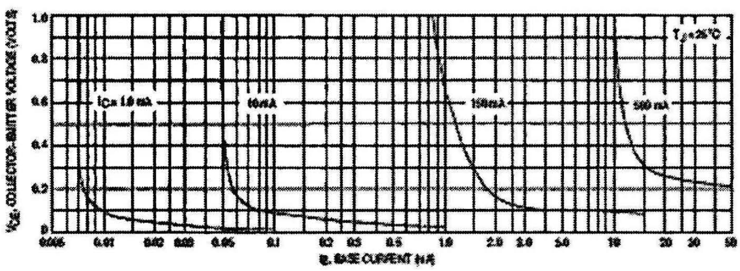


Figure 4. Collector Saturation Region

APPENDIX F

MPS2222, MPS2222A

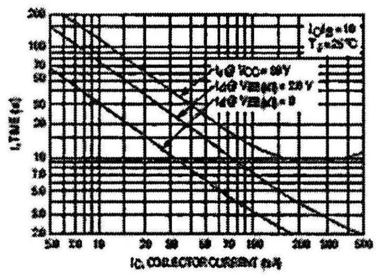


Figure 5. Turn–On Time

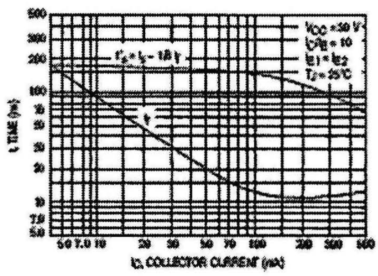


Figure 6. Turn–Off Time

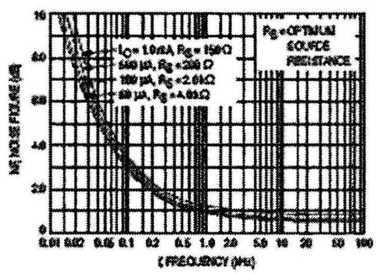


Figure 7. Frequency Effects

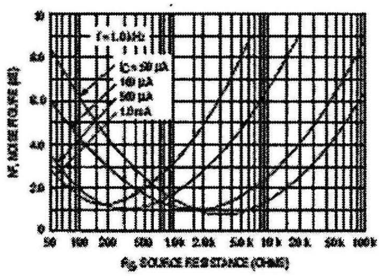


Figure 8. Source Resistance Effects

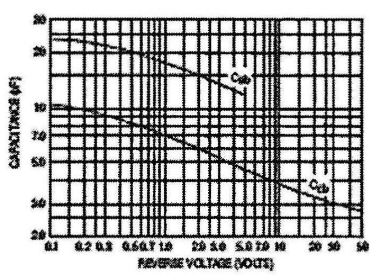


Figure 9. Capacitances

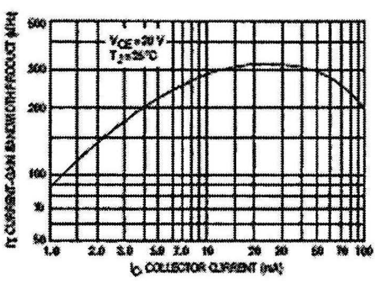


Figure 10. Current–Gain Bandwidth Product

APPENDIX F

MPS2222, MPS2222A

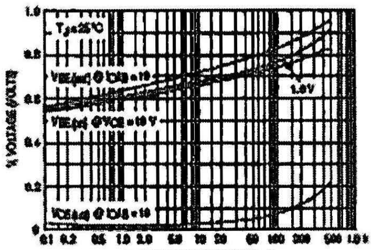


Figure 11. "On" Voltages

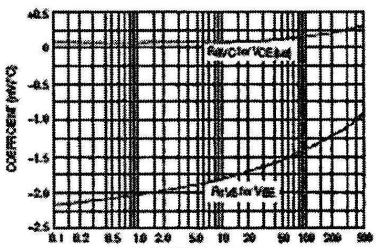


Figure 12. Temperature Coefficients

APPENDIX F

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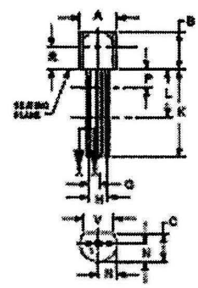
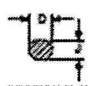
PACKAGE DIMENSIONS

TO–92
TO–226AA
CASE 29–11
ISSUE AL





SECTION X–X

NOTES:
1. [illegible]
2. [illegible]
3. [illegible]
4. [illegible]

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	[illegible]	[illegible]	[illegible]	[illegible]
B	[illegible]	[illegible]	[illegible]	[illegible]
C	[illegible]	[illegible]	[illegible]	[illegible]
D	[illegible]	[illegible]	[illegible]	[illegible]
G	[illegible]	[illegible]	[illegible]	[illegible]
H	[illegible]	[illegible]	[illegible]	[illegible]
J	[illegible]	[illegible]	[illegible]	[illegible]
K	[illegible]	---	[illegible]	---
L	[illegible]	---	[illegible]	---
N	[illegible]	[illegible]	[illegible]	[illegible]
P	---	[illegible]	---	[illegible]
R	[illegible]	---	[illegible]	---
V	[illegible]	---	[illegible]	---

STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

STYLE [illegible]:
PIN 1. EMITTER
2. COLLECTOR
3. BASE

APPENDIX F

MPS2222, MPS2222A

PUBLICATION ORDERING INFORMATION

Literature Fulfillment: [illegible]

N. American Technical Support: [illegible]

JAPAN: ON Semiconductor, Japan Customer Focus Center [illegible]

ON Semiconductor Website: [illegible]

For additional information, please contact your local Sales Representative.

MPS2222/D

```
'.'****************************************************************
'*  Name     : UNTITLED.BAS                                       *
'*  Author   : [select VIEW...EDITOR OPTIONS]                     *
'*  Notice   : Copyright (c) 2009 [select VIEW...EDITOR OPTIONS]  *
'*           : All Rights Reserved                                *
'*  Date     : 11/22/2009                                         *
'*  Version  : 1.0                                                *
'*  Notes    :                                                    *
'*           :                                                    *
'****************************************************************
DEFINE OSC 8               ; oscillator 8mhz
adcon1=%00000111

SER1 VAR PORTB.3           ; port B3 as servo motor 1
SER2 VAR PORTB.4           ; port B4 as servo motor 2
SER3 VAR PORTB.5           ; port B5 as servo motor 3


I VAR WORD                 ; I as word [0-255]

TRISB.3=0                  ; port B3 as output
TRISB.4=0                  ; port B4 as output
TRISB.5=0                  ; port B5 as output


act1_A VAR porta.0
TRISA.0=0
act1_B VAR porta.1
TRISA.1=0

act2_A VAR portb.7
TRISB.7=0
act2_B VAR portb.6
TRISB.6=0

MAIN:

    FOR I=0 TO 50          ; count I from 0 to 50 [total loop 51 times]
        LOW act1_A          ; low at actuator 1
        LOW act2_A          ; low at actuator 2
        HIGH SER1           ; high at servo motor 1
        HIGH SER2           ; high at servo motor 2
        HIGH SER3           ; high at servo motor 3
        PAUSEUS 1384
        LOW SER3            ; low servo motor 1
        PAUSEUS 596
        LOW SER1            ; low servo motor 1
        LOW SER2            ; low servo motor 2
        PAUSEUS 18020       ;
    NEXT I                  ; total delay 20ms then goto next count


    FOR I=0 TO 50           ; count I from 0 to 50 [total loop 51 times]
```

```
        HIGH SER1           ; low at servo motor 1
        HIGH SER2           ; high at servo motor 2
        HIGH SER3           ; high at servo motor 3
        PAUSEUS 800
        LOW SER1            ; low servo motor 1
        PAUSEUS 584         ;
        LOW SER3            ; low servo motor 1
        PAUSEUS 596         ;
        LOW SER1            ; low servo motor 1
        PAUSEUS 18020
    NEXT I                  ; total delay 20ms then goto next count

    FOR I=0 TO 50           ; count I from 0 to 50 [total loop 51 times]

        HIGH act1_B           ; high actuator 1
        LOW  act2_A           ; low actuator 2
        HIGH SER1           ; high at servo motor 1
        HIGH SER2           ; high at servo motor 2
        HIGH SER3           ; high at servo motor 3
        PAUSEUS 1390
        LOW SER3            ; low servo motor 1
        PAUSEUS 590
        LOW SER1            ; low servo motor 1
        LOW SER2            ; low servo motor 1
        PAUSEUS 18020

      NEXT I                  ; total delay 20ms then goto next count


      FOR I=0 TO 150          ; count I from 0 to 150 [total loop 151 times]

        LOW act1_A          ; low at actuator 1
        LOW act2_A          ; low at actuator 2
        HIGH SER1           ; high at servo motor 1
        HIGH SER2           ; high at servo motor 2
        HIGH SER3           ; high at servo motor 3
        PAUSEUS 1384
        LOW SER3            ; low servo motor 1
        PAUSEUS 596
        LOW SER1            ; low servo motor 1
        LOW SER2            ; low servo motor 2
        PAUSEUS 18020       ;
    NEXT I                  ; total delay 20ms then goto next count

    FOR I=0 TO 50           ; count I from 0 to 50 [total loop  51 times]

        HIGH SER1           ; low at servo motor 1
        HIGH SER2           ; high at servo motor 2
        HIGH SER3           ; high at servo motor 3
        PAUSEUS 1891
        LOW SER3            ; low servo motor 1
```

```
    PAUSEUS 596         ;
    HIGH SER1            ; high servo motor 1
    HIGH SER2            ; high servo motor 2
    PAUSEUS 17513
NEXT I                  ; total delay 20ms then goto next count


  FOR I=0 TO 50          ; count I from 0 to 50 [total loop 51 times]
    HIGH act2_B          ; high at actuator 2
    HIGH act1_B          ; high at actuator 1
    HIGH SER1           ; high at servo motor 1
    HIGH SER2           ; high at servo motor 2
    HIGH SER3           ; high at servo motor 3
    PAUSEUS 1384
    LOW SER3            ; low servo motor 3
    PAUSEUS 596
    LOW SER1            ; low servo motor 1
    LOW SER2            ; low servo motor 2
    PAUSEUS 18020       ;
NEXT I                  ; total delay 20ms then goto next count


GOTO MAIN
```

List of Table

Table 1:Standard ASCII Character Set [from *PicBasic Pro Compiler*, microEngineering Lab, Inc.

Decimal	Hex	Display/ Key	Decimal	Hex	Display/ Key	Decimal	Hex	Display /Key
32	20	Space	64	40	@	96	60	`
33	21	!	65	41	A	97	61	a
34	22	"	66	42	B	98	62	b
35	23	#	67	43	C	99	63	c
36	24	$	68	44	D	100	64	d
37	25	%	69	45	E	101	65	e
38	26	&	70	46	F	102	66	f
39	27	'	71	47	G	103	67	g
40	28	{	72	48	H	104	68	h
41	29	}	73	49	I	105	69	i
42	2A	*	74	4A	J	106	6A	j
43	2B	+	75	4B	K	107	6B	k
44	2C	,	76	4C	L	108	6C	l
45	2D	-	77	4D	M	109	6D	m
46	2E	.	78	4E	N	110	6E	n
47	2F	/	79	4F	O	111	6F	o
48	30	0	80	50	P	112	70	p
49	31	1	81	51	Q	113	71	q
50	32	2	82	52	R	114	72	r
51	33	3	83	53	S	115	73	s
52	34	4	84	54	T	116	74	1
53	35	5	85	55	U	117	75	u
54	36	6	86	56	V	118	76	v
55	37	7	87	57	W	119	77	w

56	38	8	88	58	X	120	78	x
57	39	9	89	59	Y	121	79	y
58	3A	:	90	5A	Z	122	7A	z
59	3B	;	91	5B	[	123	7B	{
60	3C	<	92	5C	\	124	7C	|
61	3D	=	93	5D	]	125	7D	}
62	3E	>	94	5E	^	126	7E	~
63	3F	?	95	5F	_	127	7F	DEL

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