GSM-BASED HOME INTRUSION DETECTION DEVICE USING SMS MESSAGING IN REPORTING INTRUSIONS TO SECURITY ADMINISTRATOR

by

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Approval Sheet

Mapua Institute of Technology
School of EECE

This is to certify that I have supervised the preparation of and read the design report prepared by **John Nicohlus R. Cañeba** entitled **GSM-BASED HOME INTRUSION DETECTION DEVICE USING SMS MESSAGING IN REPORTING INTRUSIONS TO SECURITY ADMINISTRATOR** and that the said report has been submitted for final examination by the Oral Examination Committee.

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As members of the Oral Examination Committee, we certify that we have examined this design report, presented before the committee on **September 3, 2011**, and hereby recommended that it be accepted in fulfilment of the design requirements for the degree in Bachelor of Science in Computer Engineering.

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ABSTRACT

The GSM-Based Home Intrusion Detection Device is a security device that sends a text message to the owner's mobile number in case of home intrusion. This is to warn and notify the owner of an impending attack. It is used when the owner is outside the house, or even when asleep. The device uses a GSM modem which requires a SIM card to send SMS messages. The device is activated once the door or window is opened and it automatically sends a text message to the security administrator. The device improves the effectiveness to which possible incidents of intrusion and robbery are reported to security administrators when he is away from home through long distance communication using GSM technology. It bridges the gap between the security device and its administrator when the latter is away.

Keywords: intrusion, long distance communication, GSM, SMS

Chapter 1

DESIGN BACKGROUND AND INTRODUCTION

Background

The GSM-Based Home Intrusion Detection Device is a security device that sends a text message to the owner's mobile number in case of home intrusion. This is to warn and notify the owner of an impending attack. It is useful when the owner is outside the house, or even when asleep. It is pre-programmed to store the owner's mobile number in which the device would send a text message notifying the receiver of an intrusion. The device uses a GSM modem which requires a SIM card to send text messages. The device is to be placed adjacent to possible entries of intrusion, such as doors and windows. The device is activated once the door or window is opened and it automatically sends a text message which is also pre-programmed.

Statement of the Problem

In today's world where crime is increasing, home intrusion becomes a major issue. However, technology has provided us ways to prevent and protect our property from intruders and thieves. These "security devices" alert and notify its security administrators of a possible intrusion and robbery. However, the security administrator is informed of a possible incident by these devices only when he is at home where he can be easily notified. The author of this design believes that an intrusion is more probable when the owner is not around. When the security administrator is not at home, possible incidents of intrusion are not reported.

Objectives of the Design

The main objective of this design was to integrate long distance communication with home security in reporting possible incidents of intrusion and robbery to the security administrator when he is away from home through the use of GSM technology.

Specifically, this included:

1. Creating a device that triggers when doors and windows are forcibly opened;
2. Using GSM technology in sending notifications to the security administrator's mobile number notifying him of a possible intruder to home;
3. Measuring the time it takes before the intrusion notification is received by the security administrator relative to the normal sending of SMS messages using a mobile phone.

Impact of the Design

Security systems become useless and ineffective when it is activated but no necessary countermeasures are made. This happens when the system detects an intrusion but nobody knows about it. A possible reason to this is that the security administrator may be outside (work, school, etc.) or is considerably remote from the security system. This design fills in the gap between the security system and its administrator; the gap being the distance between the two when the latter is away from home. It is important that the security administrator is always notified when the security of the house or property is compromised.

This intrusion detection system impacts the safety in the house regardless of the security administrator's location. It guarantees the safety of the house even when the administrator is away.

Design Constraints

The GSM-Based Home Intrusion Detection Device can be manufactured with relative ease at minimum cost and maximum reliability. However, it has its own limitations. Its reliability is highly dependent on GSM technology. It may fail to send the owner a text message if its SIM card does not have sufficient balance to send a text message (in case of pre-paid SIM cards). It may also fail if the network used by the device is down or experiencing delay. Since this is a security device, it must always be connected to a power source. The device cannot detect intrusion once the method of intrusion used does not involve opening of the door or window, but other methods such as breaking into (in case of glass doors or windows).

Definition of Terms

Intrusion – is an illegal act of entering, seizing, or taking possession of another's property.

Intrusion Detection System – is a device or software application that monitors network and/or system activities for malicious activities or policy violations and produces reports to a Management Station.

Alert or Alarm – is a signal suggesting that a system has been or is being compromised.

Attacker or Intruder – is an individual who tries to find a way to gain unauthorized access to information, inflict harm or engage in other malicious activities.

GSM – is a standard set developed by the European Telecommunications Standards Institute (ETSI) to describe technologies for second generation (or "2G") digital cellular networks. Developed as a replacement for first generation analog cellular networks, the GSM standard originally described a digital, circuit switched network optimized for full duplex voice telephony.

GSM Modem – is a wireless modem that uses GSM mobile telephone system.

SIM – or Subscriber Identification Module is an integrated circuit that securely stores the service-subscriber key (IMSI) used to identify a subscriber on mobile telephony devices (such as mobile phones and computers). It is protected by a four-digit Personal Identification Number (PIN).

SMS – or Short Message Service is the text communication service component of phone, web, or mobile communication systems, using standardized communications protocols that allow the exchange of short text messages between fixed line or mobile phone devices.

Microswitch – or miniature snap-action switch is an electric switch that is actuated by very little physical force, through the use of a tipping-point mechanism, sometimes called an "over-center" mechanism.

Chapter 2

REVIEW OF RELATED DESIGN LITERATURES AND STUDIES

The purpose of this design was to create a home security device that can communicate with its security administrator regardless of the latter's location. This chapter presents the review of research related to the conceptual model of this design. These literatures served as reference to the development of this design.

Stefan Axelsson of Ericsson Mobile Data Design AB wrote in "ACM Transactions on Information and System Security" that there are many demands that can be made of an intrusion detection system. His work may be related to computer and network security and not home security; nevertheless, security is always a general concept. In network security, network administrators protect important and private information inside their network. For example, companies do not usually allow its employees to send and receive e-mail attachments out of the company's local network. This is to prevent leakage of sensitive information. The companies also have firewalls to protect their network from hackers. Similarly, home security protects the house from burglars and other criminals. In short, his assertions about intrusion detection systems used in information and system security may also be applied in home intrusion detection systems.

Axelsson presented the demands of an intrusion detection system such as: effectiveness, efficiency, ease of use, security, interoperability, transparency, and so on.

The author of this design focused on the effectiveness parameter on an intrusion detection system. He tried to answer questions such as: How effective is a security system when its administrator is away from it? Would it still be as effective? Considering the common security systems today (alarms, surveillance cameras, etc.), they require constant monitoring, if not, close supervision from its administrators.

In 2008, the Social Weather Stations conducted a survey on common crime victimization. It was found out that 7.8% of families lost property to pickpockets, burglars or carnappers, and 1.6% suffered physical violence. The survey found 3.6% of families were victimized by burglary.

Comparing these data with the previous SWS survey of 2007, families victimized by pickpockets and carnapping declined from 8.6% and 1.9%, respectively, but families victimized by burglary and physical violence rose from 3.0% and 1.3%. As in most SWS surveys, Metro Manila was found to have the highest rates of victimization by property crimes.

Families who suffered break-ins rose in most areas. It went up from 5.0% to 7.0% in Metro Manila, from 1.7% to 3.7% in the Visayas, and from 2.3% to 4.0% in Mindanao. It went from 3.3% to 2.3% in Luzon.

Based from these data, it is evident that intrusion and burglary is rampant and there is an increasing demand for security systems for home usage.

To protect the household from these possible incidents of intrusion, several studies were made to develop home security systems for the occupants' convenience and safety especially during the day.

Yanbo Zhao and Zhaohui Ye of the Dept. of Automation of Tsinghua University in Beijing developed a low cost GSM/GPRS based wireless home security system. The system is a wireless home network which contains a GSM/GPRS gateway and three kinds of wireless security sensor nodes that are door security nodes, infrared security nodes and fire alarm nodes. The nodes are easy installing. The system can response rapidly to alarm incidents and has a friendly user interface including a LCD (liquid crystal display) and a capacitive sensor keyboard. The wireless communication protocol between the gateway and the nodes is also suitable for other home appliances.

This study used wireless technology to interconnect the components of the system. It is low cost and easy to use. However, this study does not answer the problem stated in Chapter 1. The system becomes ineffective when there is no one to alarm or notify about an incident. The author decided not to integrate wireless technology in connecting the design components, but in communicating with the security administrator himself.

Dechuan Chen and Meifang Wang from Hangzhou Dianzi University in China introduced an experimental home security monitoring and alarming system based on Zigbee technology, which is capable of monitoring door and window magnetic contact, smoke, gas leak, water flooding, providing simple controls such as turning off the valves, and sending the alarms to the residential area security network etc. The system used a control key fob for activating and de-activating the alarm easily, supports Web interface so that user can access the system remotely to control, search or review the history record, and offers a LCD panel for simple configuration. The experimental system had been designed and its wireless communication test result showed that the Zigbee wireless network can improve the home security with low power and easy to implement solution.

Similar to the aforementioned study, students from the College of Information Science & Engineering, North-eastern University in Shenyang researched an intelligent home security surveillance system based on ZigBee. In their study, they implemented real-time surveillance of the home security; the intelligent remote monitoring system was developed for home security based on ZigBee technology and GSM / GPRS network. The system can send abnormal images and warning messages through MMS and SMS; receive remote instruction, and remote monitor household appliances. Meanwhile, the introduction of a variety of sensors guaranteed that the intelligent remote monitoring system can be responsible for home security. The results of their experiment showed that the system can attain remote surveillance of intelligent home safety with high availability and reliability.

Their studies primarily focused on home security monitoring, real-time surveillance and monitoring of household appliances. However, these systems could be very expensive since they are highly intelligent. The former uses Web interface to allow the user to control the system remotely. This may be complicated for typical household occupants and may require several computing resources. The latter can actually process images taken from its surveillance cameras and decide whether these images are normal or not. It may also consume a lot of power for it uses several cameras and a variety of sensors. Also, this system has to utilize several computing resources, and a considerable amount of storage for its images.

Considering Axelsson's demands of an intrusion detection system, this may seem to be impractical for a home security system. Ishiguro, K. and Runhe Huang of Hosei University in Japan describes in the "Implementation of a Wireless Communication Technologies-based Home Security System" a light weighted home security system that exploits the common use of wireless communication technology like mobile phone, Bluetooth communication, wireless sensors, etc. The paper discussed that the system scale must be small and the cost must be low, which is more suitable for the smaller scope of a home and a general civilian family.

Thus, the latter’s use of GSM technology and the former’s capability of monitoring door and window contact were used as bases for the development of the author’s conceptual model of a simpler, low-cost home intrusion detection system which is capable of reporting incidents to its security administrator using SMS messaging.

Chapter 3

DESIGN PROCEDURES

The GSM-Based Home Intrusion Detection Device is made up of a control circuit, an LCD monitor, a numeric keypad, and a GSM module. Its microcontroller stores the owner's mobile number which the user inputs using the numeric keypad. The device would send a text message to this number notifying the receiver of an intrusion. The device uses a GSM modem which requires a SIM card to send text messages. The device is placed adjacent to possible entries of intrusion, such as doors and windows. A microswitch is used to detect intrusion once the door or window is opened and it immediately sends a text message. Here are the step-by-step procedures in constructing the design:

1. Gather all necessary data and information needed for the design of the system. This includes information about the problem to be solved, the solution to the problem, the concept of the design, the software needed, the components to be used, etc.
2. Purchase all the materials needed for the assembly of the design.
3. Create the circuit design and PCB design.
4. Code the software. The source code is found at Appendix C. Compile.
5. Burn the PIC16F877A with the generated hex file.

6. Connect all the necessary components to the microcontroller such as resistors, capacitors, microswitches, keypad, LCD monitor, crystal oscillator, and the GSM module.
7. Test all parts of the design. Conduct troubleshooting to verify the output of the design.
8. Construct the final casing of the design.

Hardware Development

This section covers the hardware development of the design. It shows in detail the materials and components used in constructing the device, how the components are connected to one another, what each component does, and the decomposition of all components.

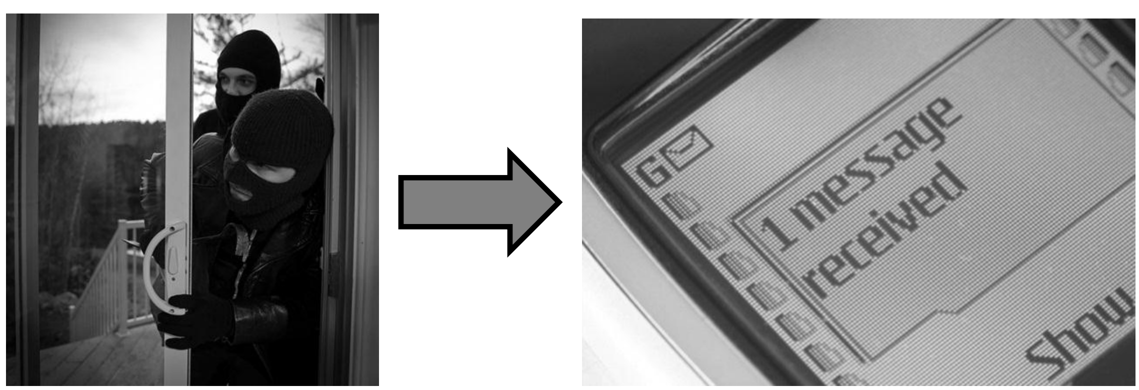

Figure 3.1 Conceptual Diagram

The figure above shows the Conceptual Diagram of the design. It shows the theoretical set-up of the design. The diagram has two images. The first image on the diagram shows a representation of an intrusion – two intruders (i.e. burglars) entering through a door. The image then points to the other image which is a representation of a mobile phone receiving a text message. This image is actually the output or the result of the first image as represented by the arrow pointing to the right.

Based on this diagram, one can infer that the device is triggered once the door (or window) where the device is placed adjacent to is intruded. It immediately sends a notification to the security administrator through an SMS message sent to his mobile number.

To trigger the device once there is an intrusion, it requires a mechanism to indicate such event. When actuated by the opening of the door (or window), it must send a signal to the control circuit indicating an intrusion. The control circuit must then immediately notify the security administrator of an impending attack using GSM technology.

The figure below shows the device in blocks. Each block connects to another depending on which block sends and/or receives a signal. These signals are represented through the direction of the arrows that connect the blocks.

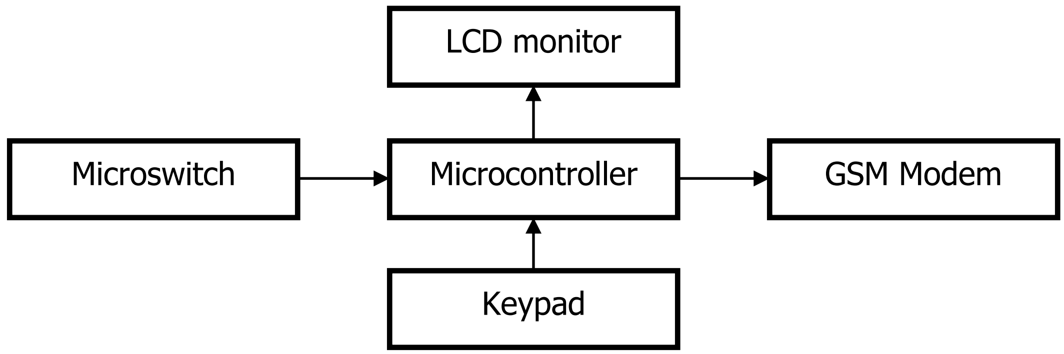

Figure 3.2 Block Diagram

The device accepts the security administrator's 11-digit mobile number (e.g. 09123456789) through a numeric keypad. He is guided through instructions which are displayed using the LCD monitor. The mechanism used to trigger the device is a microswitch. It serves as the main input of the design where its state is dependent on the door (or window) where the device is adjacent to. When the door (or window) is opened, this switch is triggered and the microcontroller sends instructions to the GSM modem where it would send an SMS message to the stored mobile number.

To complete the hardware design of this project, all components must be connected to one another to form one functional circuit. The Block Diagram (Figure 3.2) connects the main parts of the design. However, these parts cannot be connected to one another directly. It also needs voltage regulation, resistors for limiting current and voltages, oscillator, capacitors, etc.

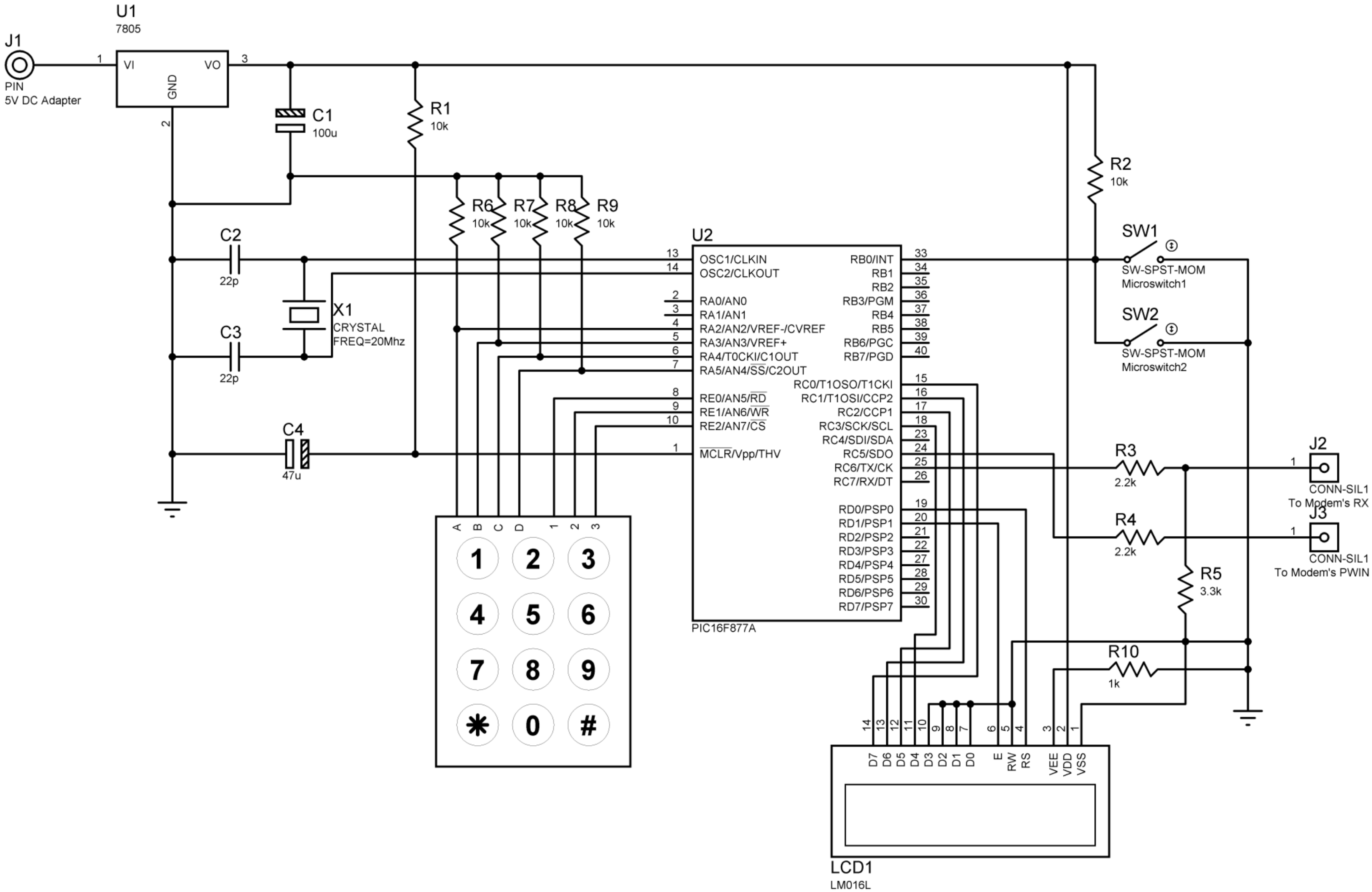

Figure 3.3 Schematic Diagram

The figure above shows the complete schematic diagram of the design.

Software Development

The design needs software since it uses a microcontroller as discussed in the previous section. The device will not work with hardware alone. It must be embedded with instructions to follow and execute to accomplish what it is expected to do. The software that the design requires is illustrated in the figure below.

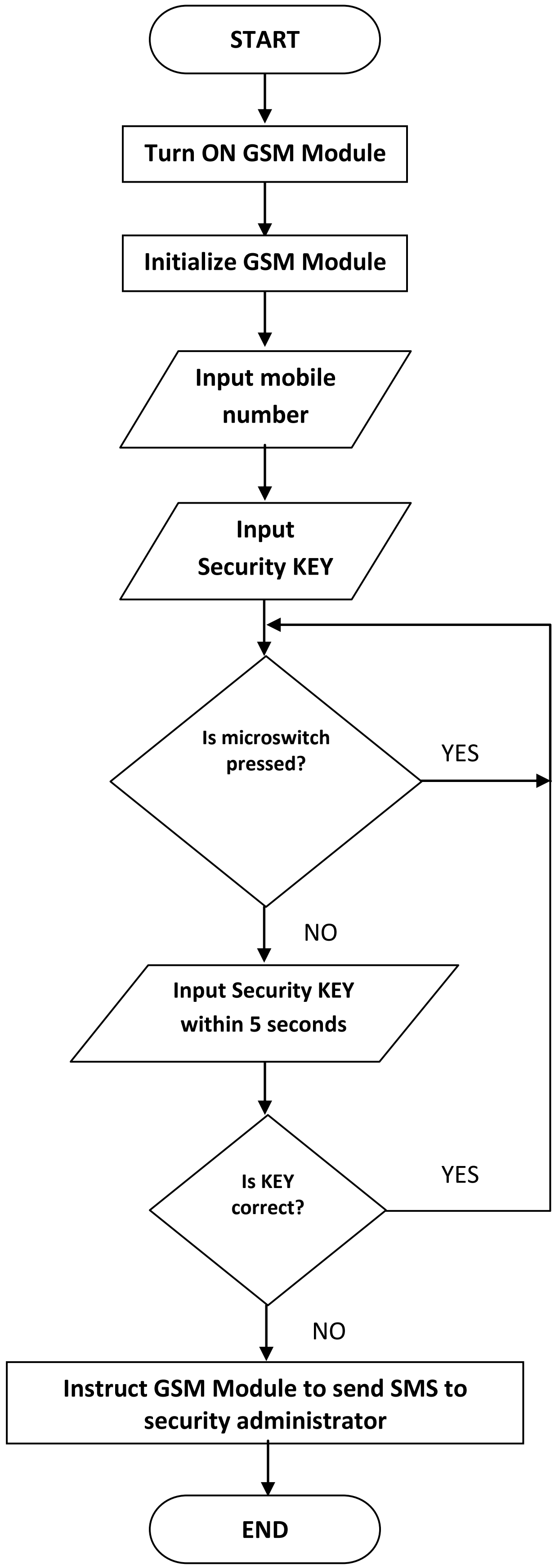

Figure 3.4 System Flowchart of the Design Software

Figure 3.4 shows the system flowchart of the design. When the device is powered on, it turns the GSM module ON. The GSM module has a PWON pin. It must be connected to the microcontroller. Any input/output bit in the microcontroller configured as OUTPUT should work except the USART port which is needed for the GSM module connection. In this design, the author used bit 5 of Port C. To turn the module on, the microcontroller should send a 1- to 2-second pulse to the PWON pin. This can be done by sending a HIGH signal to the specified bit, insert a 1- or 2-second delay, and then send a LOW signal to the same bit. If PWON is successful, the GSM module should turn on. Its status light indicator should turn on.

Then, the GSM module boots up. This is indicated by the status light indicator blinking. After booting which can take up to 15 seconds, the status light indicator should be blinking slower than earlier. This is a sign that the GSM module is ready to receive commands.

The GSM module has a specific set of commands or instructions that it can understand. These commands are called AT Commands. These commands are sent from the TX pin of the microcontroller to the RX pin of the GSM module.

The syntax used for AT Commands must have "AT" or "at" prefix at the beginning of each command line. To terminate a Command line enter <CR>. Here are the types of commands and their syntax.

Type	Syntax	Description
Test Command	AT+<x>=?	The mobile equipment returns the list of parameters and value ranges set with the corresponding Write Command or by internal processes.
Read Command	AT+<x>?	This command returns the currently set value of the parameter or parameters.
Write Command	AT+<x>=<…>	This command sets the user-definable parameter values.
Execution Command	AT+<x>	The execution command reads non-variable parameters affected by internal processes in the GSM engine

Table 3.1 Types of AT Commands

There are several AT Commands. Among these commands, only a few are to be used for this design. These commands are for sending SMS messages. The table below summarizes the commands to be used in this design.

Command	Description/Parameters
AT+CFUN=<fun>, [<rst>]	Sets phone functionality
	<fun> 0: minimum functionality 1: full functionality (Default) 4 disable phone both transmit and receive RF circuits <rst> 0: Set the ME to <fun> power level immediately. This is the default when <rst> is not given. 1: Set the ME to <fun> power level after the ME been reset.
AT+CMGF=[<mode>]	Select SMS Message Format
	<mode> 0: PDU mode 1: text mode
AT+CMGS=<da>[,<toda>]<CR> *text is entered* <ctrl-Z/ESC> ESC quits without sending	Send SMS Message
	<da> Address-Value field in string format; BCD numbers (or GSM default alphabet characters); type of address given by <toda> <toda> Type-of-Address octet in integer format (when first character of <da> is + (IRA 43) default is 145, otherwise default is 129) <length> integer type value indicating in the text mode (+CMGF=1) the length of the message body <data> (or <cdata>) in characters; or in PDU mode (+CMGF=0), the length of the actual data unit in octets

Table 3.2 SMS Commands

Before sending an SMS message, the GSM module must first be initialized to text mode.

AT+CFUN = 1

AT+CMGF = 1

Based on Table 3.2, the first line will set the module to phone functionality. It has a value of 1 by default so this line may be omitted. But in order to make sure the module is set to phone functionality, the author included this line in the code. The next line will set the module to text mode. The GSM module is now set to send text messages.

Once the GSM module is set to text mode, the device should ask the user to input his mobile number. Note that this number is the receiver's number not the sender. He is instructed by the LCD monitor to do this. The device should then receive the user's 11-digit mobile number by using the keypad. The keypad should only recognize 11 presses. Once the user is done, the device stores this 11-digit number as string to the AT command AT+CMGS. Every time the device sends a text message, it uses the number keyed in by the user.

Then, the device asks the user to input a security key. The security key allows the device to determine whether it is the security administrator who is entering the house.

After the input, the device now enters a decision. It checks whether the microswitch is pressed or not. To do this, the microswitch is configured normally open.

Based on the Schematic Diagram (Figure 3.3), bit 0 of Port B (pin 33) to which the microswitches are connected is normally HIGH. When a switch is pressed, it becomes LOW. The test becomes if bit 0 of Port B is HIGH or LOW. If it is LOW, then the switch is pressed. It loops back to the decision. If it is HIGH, the switch is depressed.

When bit 0 of Port B goes HIGH, the device asks for the security key within 5 seconds. The user has a 5-second window to input his security key to instruct the device that he is not an intruder. When the key is incorrect, or when the 5-second interval has lapsed, the device instructs the GSM module to alert the security administrator of a possible intrusion through AT Commands. Using the mobile number stored earlier, the microcontroller sends the following commands to the GSM module to send a text message:

AT+CMGS = "[mobile number string]"

[Message]

CTRL + Z

The mobile number is enclosed inside quotation marks. This is easily done using string manipulation. The message is also a string which says "Your house is under attack!” Finally, a CTRL + Z must be transmitted to send the message. There is no specific command to send a CTRL + Z. However, the equivalent hex value of a CTRL + Z can be used. This is done by sending a char value of 0x1A. This is the same as CTRL + Z.

Once the message is sent, the LCD monitor displays a notification that the message is sent.

The following figure shows the program flowchart of the software.

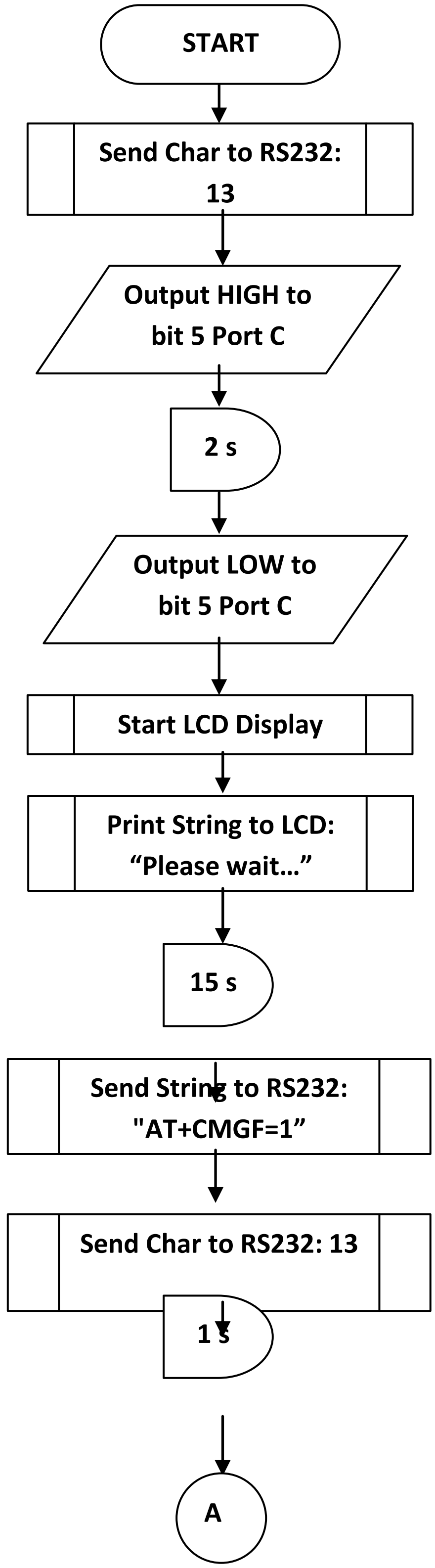

Figure 3.5.1 Main Program Flowchart of the Design Software

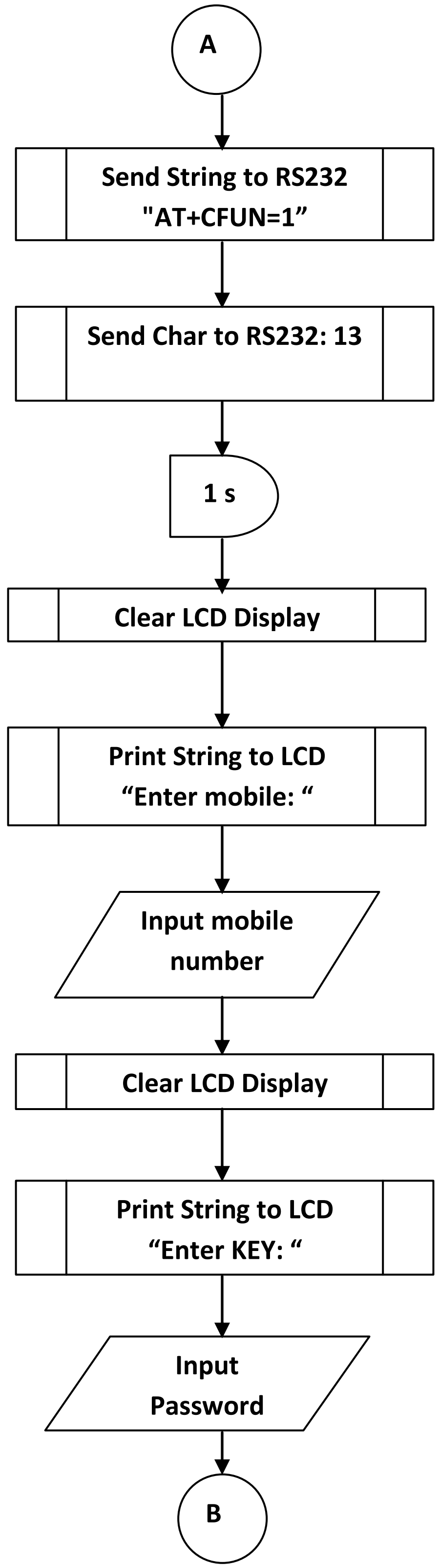

Figure 3.5.2 Main Program Flowchart of the Design Software (cont’d)

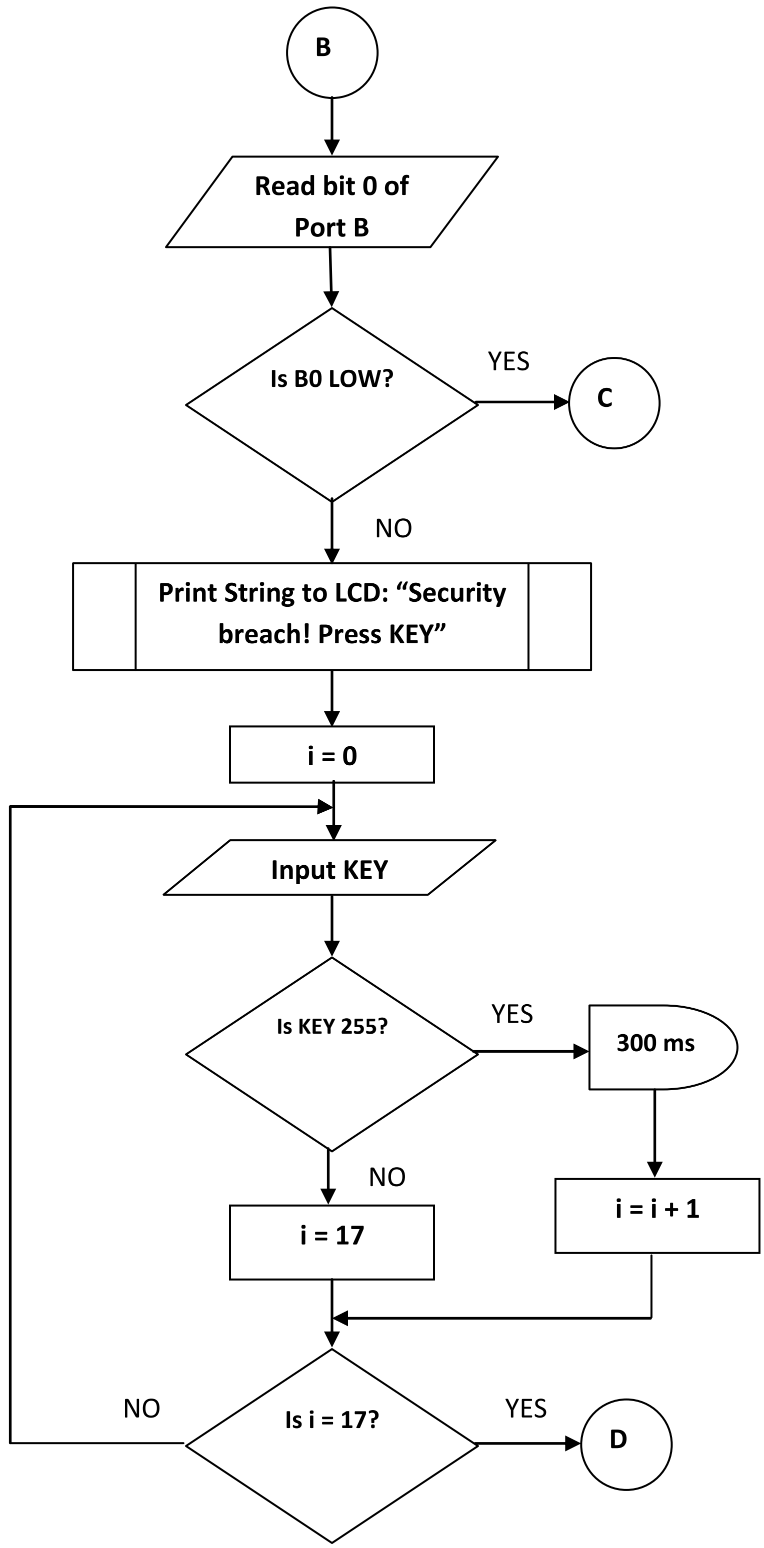

Figure 3.5.3 Main Program Flowchart of the Design Software (cont'd)

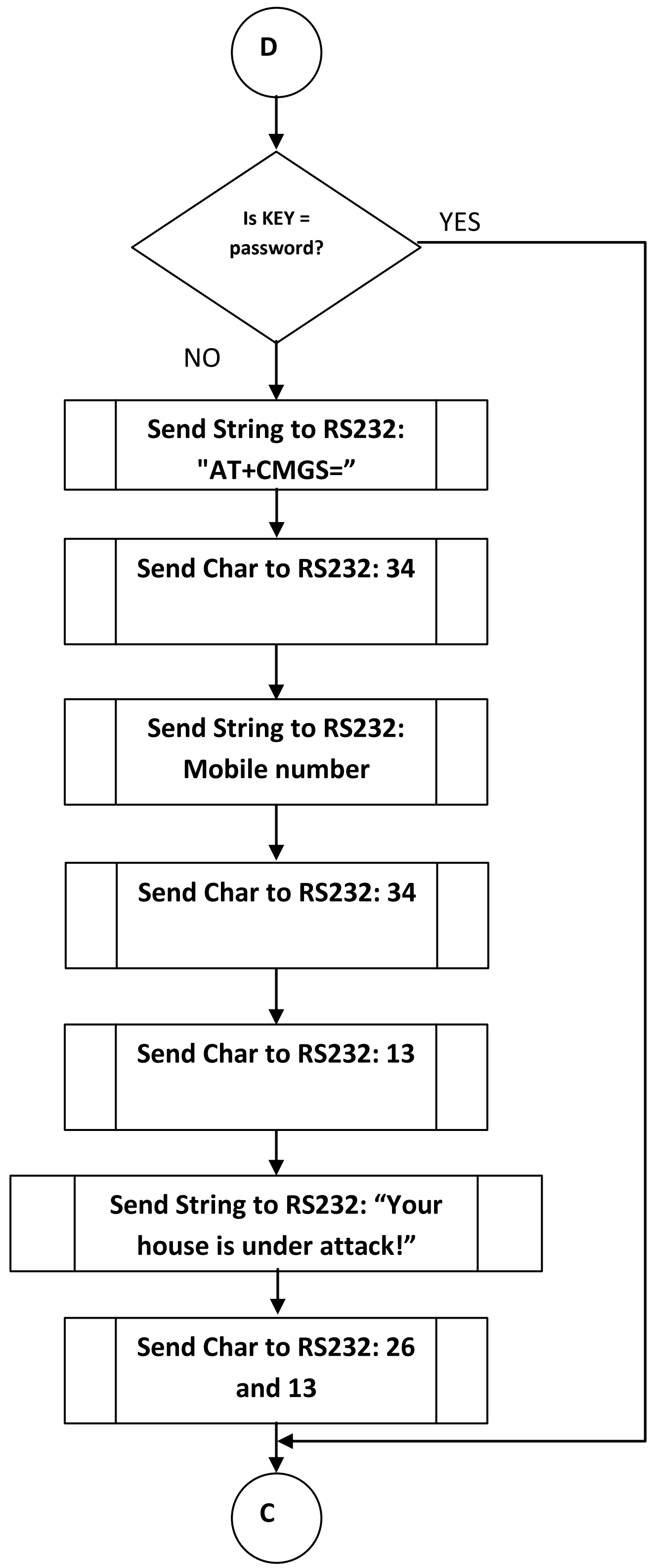

Figure 3.5.4 Main Program Flowchart of the Design Software (cont'd)

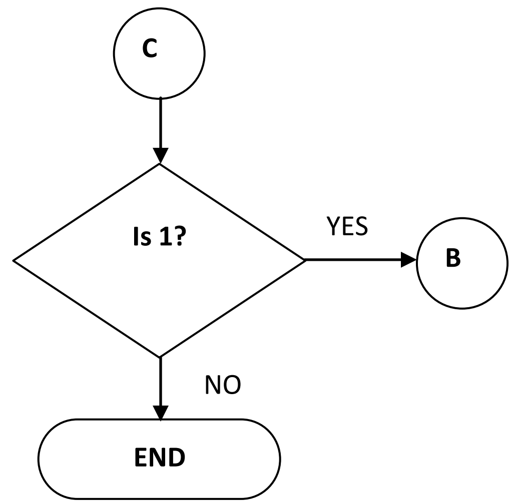

Figure 3.5.5 Main Program Flowchart of the Design Software (cont'd)

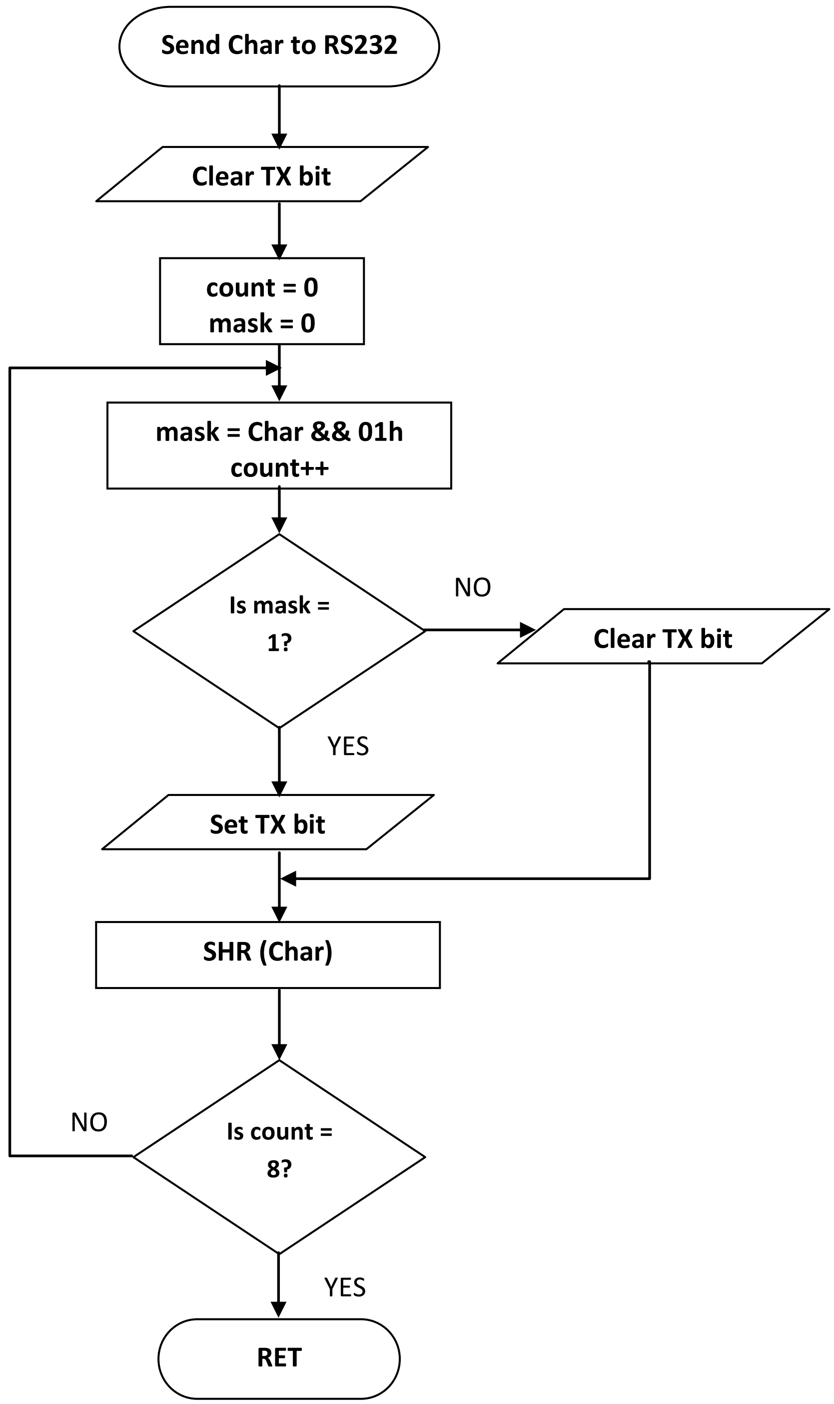

Figure 3.6 Send Char to RS232 Subroutine Flowchart

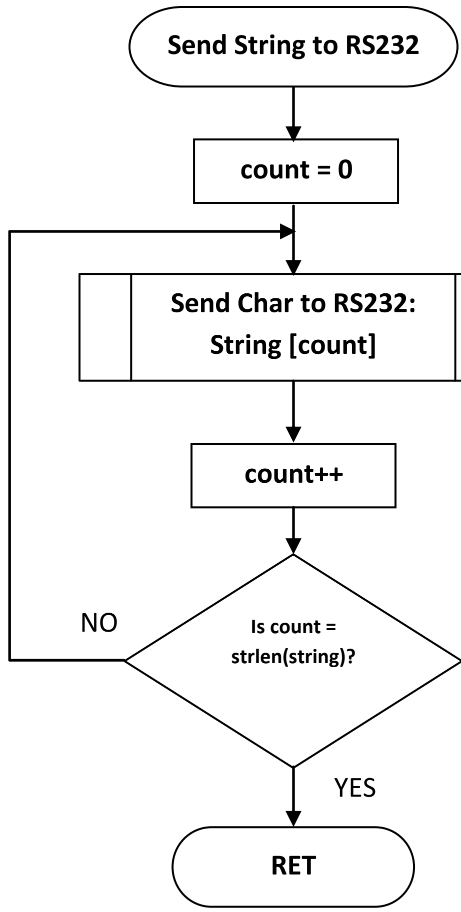

Figure 3.7 Send String to RS232 Subroutine Flowchart

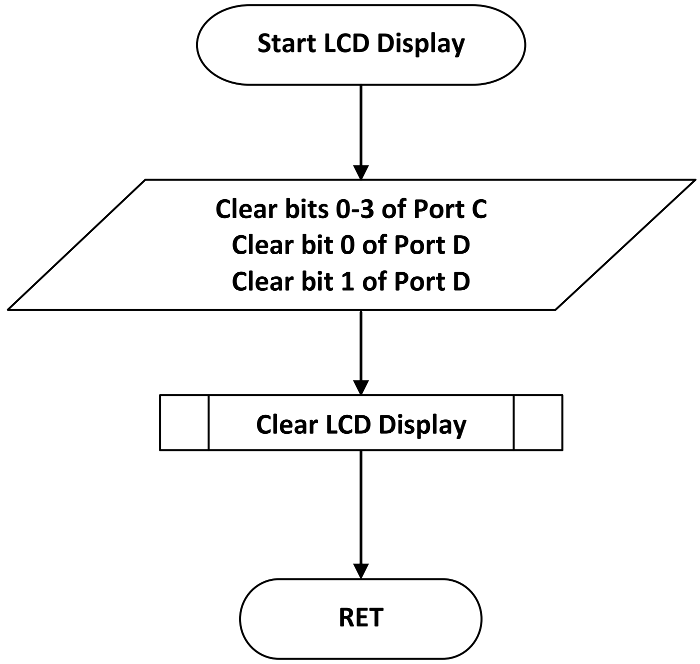

Figure 3.8 Start LCD Display Subroutine Flowchart

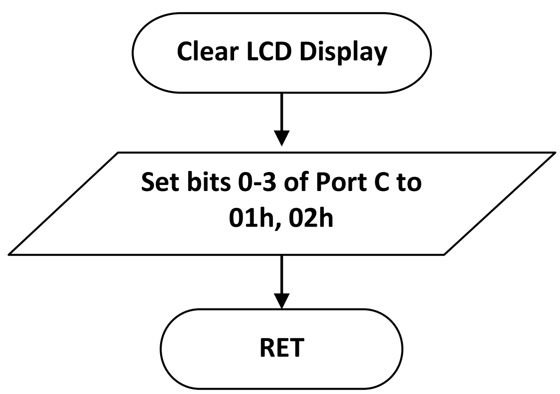

Figure 3.9 Clear LCD Display Subroutine Flowchart

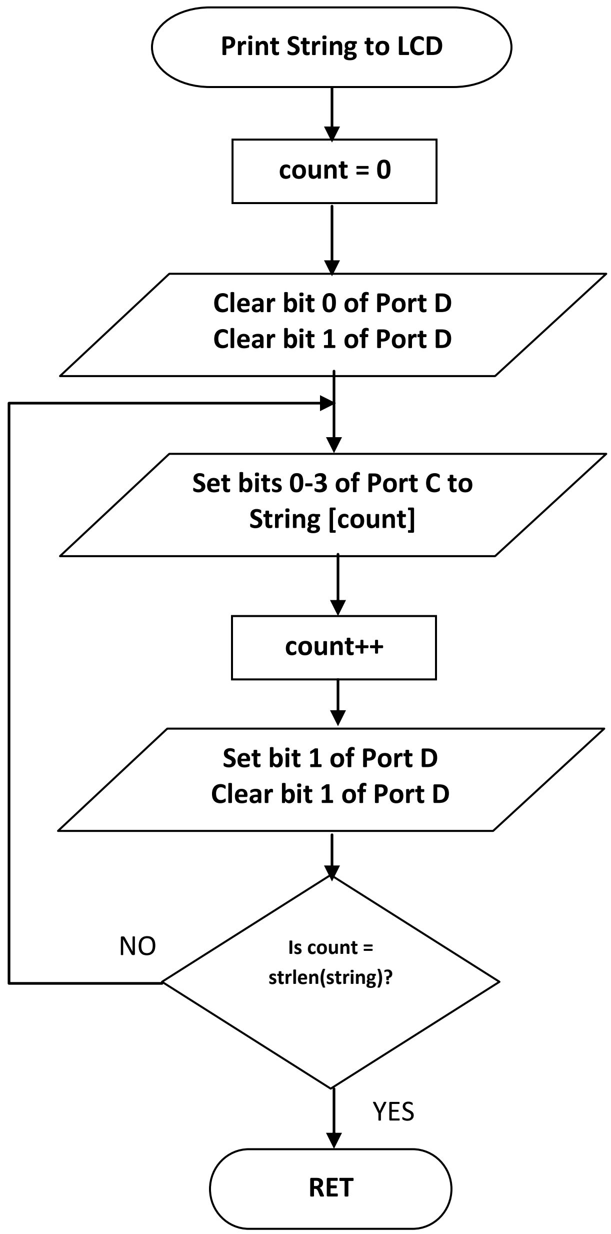

Figure 3.10 Print String to LCD Subroutine Flowchart

Prototype Development

The GSM-Based Home Intrusion Detection Device is composed of two major parts: the control circuit and the GSM module. To interface the device with the user, an LCD monitor displays messages and a keypad accepts input. The control circuit consists of the PIC16F877A microcontroller and the microswitches. The GSM module consists of the SIM900D GSM modem and a SIM card slot.

The following are the main components used in the development of the prototype:

PIC16F877A Microcontroller

PIC16F877A is a PIC microcontroller with 40 I/O pins which is suitable for the design because it comes with a USART port that allows communication with the GSM module, and several ports to connect to the keypad and the LCD display.

Keypad

The keypad allows the user to enter all required information needed by the device, such as the mobile number to use, and the security key.

LCD Display

This 16x2 lines alphanumeric module displays information and messages needed by the user. It gives the instructions and notifications the user needs in using the device.

GSM Module

The GSM module is capable of performing the main functionality of the device which is long distance communication to the security administrator in case of an intrusion. The module is configured to send SMS messages to the mobile number provided by the user.

The table below shows the breakdown of all the components:

Components	Quantity	Unit Price	Total
SIM900D GSM Module	1	3275.00	3275.00
PIC16F877A	1	250.00	250.00
MS1 micro switch	2	15.00	30.00
20 MHz Crystal Oscillator	1	20.00	20.00
LM7805 Voltage Regulator	1	12.00	12.00
¼W Resistors	7	0.25	1.75
100uF/10V Capacitor	1	1.50	1.50
22pF Capacitor	2	0.50	1.00
Connecting wires	1	15.00	15.00
40-pin DIL Socket	1	15.00	15.00
PCB	1	90.00	90.00
16x2 LCD Module	1	350.00	350.00
4x3 Numeric Keypad	1	150.00	150.00
Casing	1	155.00	155.00
TOTAL			4366.25

Table 3.3 Decomposition of Components

Chapter 4

TESTING, PRESENTATION, AND INTERPRETATION OF DATA

This chapter discusses the test conducted in relation to the stated objectives in Chapter 1 to determine the functionality and reliability of the created prototype.

SMS Notification Test

The purpose of this test was to determine whether the device would be triggered once the door or window is opened, and to determine whether, once triggered, an intrusion notification will be received by the security administrator. In doing the test, the device is placed adjacent to a door. When the door is opened, the LCD panel must display “Security Breach! Press KEY”. This is an indication that the device is triggered. To force the device to send an SMS message, no security key is entered within 5 seconds. After which, an SMS message is expected to be received by the security administrator. The next table shows the result of this test.

Event	Expected Output	Actual Output	Result
Door is closed.	The LCD panel of the device must display "GSM-BASED HOME INTRUSION DEVICE"	The LCD panel of the device is displaying "GSM-BASED HOME INTRUSION DEVICE"	The device is not triggered.
Door is opened.	The LCD panel should display "Security Breach! Enter KEY".	The LCD panel displays "Security Breach! Enter KEY".	The device is triggered.
	After 5 seconds, the device sends an SMS message.	After 5 seconds, an SMS message "Your house is under attack!" is received by the security administrator.	The device sends an SMS message when it is triggered.

Table 4.1 SMS Notification Test Results

Success Rate Test

The purpose of this test was to determine the fraction or percentage of the prototype being able to successfully do its functionality among a number of intrusion attempts. In conducting the test, the prototype was forced to detect an intrusion by triggering one of the microswitches. This was done in a number of attempts. In each attempt, the prototype was expected to send an SMS notification to the security administrator. The result of each attempt may be a success or a failure. Success was indicated when the security administrator receives the SMS notification immediately after the intrusion. Otherwise, it is a failure. The number of times an SMS message was received by the security administrator was counted and the success rate was computed.

Number of Attempts Conducted	10
Number of times an SMS message is received by the Security Administrator	10

Table 4.2 Success Rate Table

Upon obtaining the result of each attempt, the success rate was computed. Success rate was defined by:

$$Success\ Rate = \frac{No.of\ times\ message\ is\ received}{No.of\ Attempts} \times 100\%$$

Using the formula above, the success rate is equal to the total number of Success divided by the total number of attempts. From Table 4.1, of the 10 attempts observed, 10 were denoted Success. Substituting these values to the equation:

$$Success\ Rate = \frac{10}{10} \times 100\%$$

$$Success\ Rate = 100\%$$

From the computation above, a 100% success rate was achieved. This means the prototype performed its functionality successfully in all the intrusion attempts made. The result of this test signifies that the prototype is working functionally and reliably.

SMS Message Delivery Time

The purpose of this test was to determine the time it takes before the intrusion notification is received by the security administrator and compared it to the usual time it takes for an SMS message to be received while using a mobile phone. In doing the test, the device was forced to send an SMS notification for a number of attempts (10) by triggering the device and not entering the security key within the five-second interval. Once triggered, the device entered a five-second interval then sent the SMS message. The time from triggering until receiving of the SMS message was recorded for each attempt. Each time recorded was subtracted with 5 which is the five-second interval. Within this interval, the device was yet to send an SMS message. In doing the test, it was assumed that there were no network problems.

Attempts	Time (s)
1st	6.89
2nd	7.23
3rd	6.16
4th	5.10
5th	5.74
6th	5.39
7th	6.13
8th	6.54
9th	5.39
10th	6.28

Table 4.3 Delivery Time using Device

Attempts	Time (s)
1st	6.11
2nd	5.98
3rd	7.32
4th	6.46
5th	6.43
6th	6.58
7th	5.65
8th	5.89
9th	6.57
10th	5.25

Table 4.4 Delivery Time using Mobile Phone

From the data obtained, the average SMS delivery time while using the device and the SMS delivery time using a mobile phone are computed using the following formula:

$$Delivery\ Time = \frac{t_1 + t_2 + \cdots + t_n}{n}$$

Where:

t = time for each attempt

n = number of attempts

$$Delivery\ Time\ (Device) = \frac{t_1 + t_2 + \cdots + t_n}{n}$$

$$= \frac{6.89 + 7.23 + 6.16 + 5.10 + 5.74 + 5.39 + 6.13 + 6.54 + 5.39 + 6.28}{10}$$

$$= \frac{6.89 + 7.23 + 6.16 + 5.10 + 5.74 + 5.39 + 6.13 + 6.54 + 5.39 + 6.28}{10}$$

$$Delivery\ Time\ (Device) = 6.09\ s$$

$$Delivery\ Time\ (Phone) = \frac{t_1 + t_2 + \cdots + t_n}{n}$$

$$= \frac{6.11 + 5.98 + 7.32 + 6.46 + 6.43 + 6.58 + 5.65 + 5.89 + 6.57 + 5.25}{10}$$

$$Delivery\ Time\ (Phone) = 6.22\ s$$

From the results of the above computations, the average delivery time for an SMS message using the device is 6.09 seconds while the average delivery time for an SMS message using a mobile phone is 6.22 seconds. The percentage difference is computed using the formula below:

$$\%\ difference = \frac{difference\ of\ the\ two\ values}{average\ of\ the\ two\ values} x100\%$$

$$\%\ difference = \frac{6.22 - 6.09}{\frac{6.22 + 6.09}{2}} x100\%$$

$$\%\ difference = 2.11\%$$

From the result above, the percentage difference between the average delivery times for an SMS message using the device and using a mobile phone is little or 2.11%. With little percentage difference, the author concluded that the device is capable of sending SMS messages with the same speed as to sending SMS messages on a mobile phone.

Chapter 5

CONCLUSION AND RECOMMENDATION

Conclusion

The GSM-Based Home Intrusion Detection Device integrates long distance communication with home security in reporting possible incidents of intrusion and robbery when the owner is away from home using GSM technology. It bridges the gap between the security device and its administrator in this case the owner, when he is away. This device triggers when possible entries of intrusion and robbery such as doors and windows are entered forcibly or trespassed. It uses GSM technology to send an SMS message to the security administrator's mobile number notifying him of possible intrusion to his home. The device is capable of sending SMS messages with the same speed as sending SMS messages on a mobile phone.

Recommendations

This design can still be improved to enhance its capabilities and functionalities. The device is limited only to one entry of intrusion since it only has two triggering microswitches. However, this number can be increased. One can use more and connect them to a central control system (microcontroller circuit) and still have the same functionality but increased capability. Also, sensors can be used instead of microswitches although they are quite expensive.

The author also recommends the use of uninterrupted power supply for the device in case of power failure.

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APPENDIX A

Operation's Manual

Installing the GSM-Based Home Intrusion Detection Device:

1. Unscrew and open the device cover.
2. Insert a valid SIM card to the GSM modem card slot.
3. Close the device and screw the cover.
4. Attach the device adjacent to possible entries of intrusion such as doors and windows in such a manner that either microswitch is triggered when these entries are opened. The microswitch must be pressed when the door or window is closed and depressed when opened. To do this, attach an angled bar (L-shaped) on the door or window. Screw one side to the door or window with the other side facing the microswitch.

User's Manual – Setting up the device

1. Plug in the device and turn the switch ON.
2. Wait for a few seconds as indicated by the LCD display. The GSM modem is initializing.
3. Input mobile number. This number is the security administrator's 11-digit mobile number. (e.g. 09123456789)
4. Input security key. This key will be used by the security administrator when entering the house.
5. The device is set and ready.

User’s Manual – When entering the house

1. Upon entering the house, the device will be triggered and it enters a 5-second interval for the security administrator to input his security key.
2. Within this duration, enter security key to instruct the device that you are not an intruder.

Troubleshooting Guides when no SMS notifications are received

1. Check whether the mobile number stored is correct. To do this, force the device to send an SMS message. Wait for the screen to display “Message sent to [mobile number]”. The number shown is the number stored by the device. If number is incorrect, reset the device and enter the correct number.
2. Check whether there is a valid SIM card inserted inside the device.
3. For prepaid SIM card users, check whether the SIM card has sufficient balance to send an SMS message. To do this, remove the SIM card from the device and check remaining balance using a mobile phone.

APPENDIX B

Pictures of Prototype

Figure 6.1 Prototype

Figure 6.2 Inside the box

Figure 6.3 Main Components

APPENDIX C

Program Listing

```
#define MX_PIC
//Defines for microcontroller
#define P16F877A
#define MX_EE
#define MX_EE_TYPE2
#define MX_EE_SIZE 256
#define MX_UART
#define MX_UART_C
#define MX_UART_TX 6
#define MX_UART_RX 7

//Functions
#define MX_CLK_SPEED 20000000
#ifdef _BOOSTC
#include <system.h>
#endif
#ifdef HI_TECH_C
#include <pic.h>
#endif

//Configuration data
#ifdef _BOOSTC
#pragma DATA 0x2007, 0x3f3a
#endif
#ifdef HI_TECH_C
__CONFIG(0x3f3a);
#endif

//Internal functions
#include "C:\Program Files (x86)\Matrix Multimedia\Flowcode
V4\FCD\internals.h"

//Macro function declarations
void FCM_SEND_MESSAGE();
void FCM_INPUT_NUMBER();
void FCM_INPUT_PASSWORD();

//Variable declarations
#define FCSZ_NUM 1
```

```
#define FCSZ_STRINGCELLNUMBER 11
#define FCSZ_STRINGMESSAGE 30

char FCV_NUM[FCSZ_NUM];
char FCV_STRINGCELLNUMBER[FCSZ_STRINGCELLNUMBER];
short FCV_I;
char FCV_DIGIT;
char FCV_MICROSWITCH;
char FCV_KEY;
char FCV_STRINGMESSAGE[FCSZ_STRINGMESSAGE];
char FCV_PASSWORD;

//Defines: Macro Substitutions
portc = RTS Port
trisc = RTS Data Direction
portc = CTS Port
trisc = CTS Data Direction
0 = RTS Pin
4 = CTS Pin
1 = UART Selection          (0-SW / 1-UART1 / 2-UART2)
0 = Flow Control            (0-Off / 1-On)
0 = Debug Enable            (0-Off / 1-On)
0 = Echo Enable             (0-Off / 1-On)
4 = UART TXSTA Value
129 = UART SPBRG Value
RS232_462324 = Unique ID
Unused = Bitbanged Receive Port Register
Unused = Bitbanged Receive Data Direction Register
Unused = Bitbanged Receive Pin
Unused = Bitbanged Transmit Pin
120 = Bitbanged BAUD Rate Delay
0 = Timout   Selection      (0-Legacy / 1-MS Timeout)
0 = Data Size                       (0-8 bits / 1-9 bits / 2-7 bits & Only available
on BitBanged components)
0 = Parity Enable           (0-No Parity / 1-Odd Parity / 2-Even Parity)
0 = Legacy Return           (0-Legacy mode return 255 / 1-New mode return MSB
err flags)
Unused = Bitbanged Transmit Port Register
Unused = Bitbanged Transmit Data Direction Register

#define RS232_462324_RTS_PORT                    portc
#define RS232_462324_RTS_TRIS                    trisc
#define RS232_462324_CTS_PORT                    portc
#define RS232_462324_CTS_TRIS                    trisc
```

```
#define RS232_462324_RTS_PIN		0
#define RS232_462324_CTS_PIN		4
#define RS232_462324_UART			1
#define RS232_462324_TOUT		0
#define RS232_462324_DATASIZE			0
#define RS232_462324_PARITY		0
#define RS232_462324_LEGACY_RV			0

#if (0 == 1)
	#define RS232_462324_HARDWARE
#endif

#if (0 == 1)
	#define RS232_462324_DEBUG
#endif

#if (0 == 1)
	#define RS232_462324_ECHO
#endif

#if (RS232_462324_UART == 0)
	#define RS232_462324_RX_PORT			Unused
	#define RS232_462324_RX_TRIS		Unused
	#define RS232_462324_SW_RX		Unused
	#define RS232_462324_SW_TX		Unused
	#define RS232_462324_SW_BAUD			120
	#define RS232_462324_TX_PORT			Unused
	#define RS232_462324_TX_TRIS		Unused
#else
	#define RS232_462324_TXSTA_VAL	4
	#define RS232_462324_SPBRG_VAL	129
	#define RS232_462324_SW_BAUD			0
#endif

#if (RS232_462324_LEGACY_RV == 0)
	#if (RS232_462324_DATASIZE == 1)
		#ifdef _BOOSTC
			#pragma error "Chip does not have second UART capability"
		#endif
		#ifdef HI_TECH_C
			#error "Chip does not have second UART capability"
		#endif
	#endif
#endif
```

```
#define RS232_462324_STATUS_LOOP        0
#define RS232_462324_STATUS_TIMEOUT     1
#define RS232_462324_STATUS_RXBYTE      2

//RS232(0): //Macro function declarations
void FCD_RS2320_SendRS232Char(short nChar);
void FCD_RS2320_SendRS232String(char* String, char MSZ_String);

//Defines: Macro Substitutions
portc = D1 Port
trisc = D1 Data Direction
portc = D2 Port
trisc = D2 Data Direction
portc = D3 Port
trisc = D3 Data Direction
portc = D4 Port
trisc = D4 Data Direction
portd = RS Port
trisd = RS Data Direction
portd = E Port
trisd = E Data Direction
3 = Data 1_Pin
2 = Data 2 Pin
1 = Data 3 Pin
0 = Data 4 Pin
0 = RS Pin
1 = Enable Pin
LCD_135058 = Unique Component Reference Number
2 = Row Count
16 = Column Count

    //component connections
    #define LCD_135058_PORT0    portc
    #define LCD_135058_TRIS0    trisc
    #define LCD_135058_PORT1    portc
    #define LCD_135058_TRIS1    trisc
    #define LCD_135058_PORT2    portc
    #define LCD_135058_TRIS2    trisc
    #define LCD_135058_PORT3    portc
    #define LCD_135058_TRIS3    trisc
    #define LCD_135058_PORT4    portd
    #define LCD_135058_TRIS4    trisd
    #define LCD_135058_PORT5    portd
    #define LCD_135058_TRIS5    trisd
```

```
        #define LCD_135058_BIT0         3
        #define LCD_135058_BIT1         2
        #define LCD_135058_BIT2         1
        #define LCD_135058_BIT3         0
        #define LCD_135058_RS           0
        #define LCD_135058_E            1
        #define LCD_135058_ROWCNT   2
        #define LCD_135058_COLCNT     16

        #ifdef _BOOSTC
          #define LCD_135058_DELAY   delay_10us(10)
        #endif
        #ifdef _C2C_
          #define LCD_135058_DELAY   delay_us(100)
        #endif
        #ifdef HI_TECH_C
          #define LCD_135058_DELAY   __delay_us(120)
        #endif
        #ifndef LCD_135058_DELAY
          #define LCD_135058_DELAY   delay_us(100)
        #endif

//LCDDisplay(0): //Macro function declarations
void FCD_LCDDisplay0_Start();
void FCD_LCDDisplay0_Clear();
void FCD_LCDDisplay0_PrintASCII(char Character);
void FCD_LCDDisplay0_Cursor(char x, char y);
void FCD_LCDDisplay0_PrintString(char* String, char MSZ_String);

//Defines: Macro Substitutions
{'1','4','7','*','2','5','8','0','3','6','9','#'} = Key List (Numbers)
{1,4,7,0,2,5,8,0,3,6,9,0} = Key List (Characters)
trisa = Row Data Direction Register
porta = Row Port Register
3 = Number Of Columns
4 = Number Of Rows
trise = Column Data Direction Register
porte = Column Port Register
1 = Column 1 mask
2 = Column 2 mask
4 = Column 3 mask
4 = Column 4 mask
4 = Row 1 mask
8 = Row 2 mask
```

16 = Row 3 mask
32 = Row 4 mask

```
//KeyPad(0): //Macro function declarations
char FCD_KeyPad0_GetKeypadNumber();
char FCD_KeyPad0_GetKeypadAscii();

//RS232(0): //Macro implementations
void FCD_RS2320_SendRS232Char(short nChar)
{
	#if (RS232_462324_UART == 0)
		char dMask;
		char idx;
		char count = 8;
		#ifdef RS232_462324_HARDWARE
			//wait until CTS is low
			while (( RS232_462324_CTS_PORT & (1 <<
RS232_462324_CTS_PIN) ) != 0);
		#endif
		#if(RS232_462324_DATASIZE == 1)
			count = 9;
		#endif
		#if(RS232_462324_DATASIZE == 2)
			count = 7;
		#endif
		clear_bit( RS232_462324_TX_PORT, RS232_462324_SW_TX);
		// Send Start bit
		FCD_RS2320_RS232_Delay(0);
		for (idx = 0; idx < count; idx++)
		{
			dMask = nChar & 0x01;			// Mask off data bit
			if (dMask)
				set_bit( RS232_462324_TX_PORT,
RS232_462324_SW_TX);
			else
				clear_bit( RS232_462324_TX_PORT,
RS232_462324_SW_TX);
			FCD_RS2320_RS232_Delay(0);
			nChar = nChar >> 1;		// Move to next data bit
		}
		set_bit( RS232_462324_TX_PORT, RS232_462324_SW_TX);
		// Send Stop bit
		FCD_RS2320_RS232_Delay(0);
	#endif
```

```
	#if (RS232_462324_UART == 1)
		#ifndef MX_UART
			#ifdef _BOOSTC
				#pragma error "Chip does not have second UART
capability"
			#endif

			#ifdef HI_TECH_C
				#error "Chip does not have second UART capability"
			#endif
		#endif

		st_bit(txsta, TXEN);
		while (ts_bit(pir1, TXIF) == 0);

		#ifdef RS232_462324_HARDWARE
			//wait until CTS is low
			while (( RS232_462324_CTS_PORT & (1 <<
RS232_462324_CTS_PIN) ) != 0);
		#endif

		#if(RS232_462324_DATASIZE == 1)
			if (test_bit(nChar, 8))
				st_bit(txsta, TX9D);
			else
				cr_bit(txsta, TX9D);
		#endif

		txreg = nChar;
	#endif

	#if (RS232_462324_UART == 2)
		#ifndef MX_UART2
			#ifdef _BOOSTC
				#pragma error "Chip does not have second UART
capability"
			#endif
			#ifdef HI_TECH_C
				#error "Chip does not have second UART capability"
			#endif
		#endif

		st_bit(txsta2, TXEN);
		while (ts_bit(pir3, TX2IF) == 0);
```

```
		#ifdef RS232_462324_HARDWARE
			//wait until CTS is low
			while (( RS232_462324_CTS_PORT & (1 <<
RS232_462324_CTS_PIN) ) != 0);
		#endif
		#if( RS232_462324_DATASIZE == 1)
			if (test_bit(nChar, 8))
				st_bit(txsta2, TX9D);
			else
				cr_bit(txsta2, TX9D);
		#endif
		txreg2 = nChar;
	#endif
}

void FCD_RS2320_SendRS232String(char* String, char MSZ_String)
{
		char idx;
		for(idx = 0; idx < MSZ_String; idx++)
		{
			#ifdef _BOOSTC
				if (String[idx] == 0)
					break;
				else FCD_RS2320_SendRS232Char(String[idx]);
			#endif
			#ifdef HI_TECH_
				if (*String == 0)
					break;
				else FCD_RS2320_SendRS232Char(*String);
				String++;
			#endif
		}
}
//LCDDisplay(0): //Macro implementations

void FCD_LCDDisplay0_RawSend(char in, char mask)
{
		unsigned char pt;

		clear_bit(LCD_135058_PORT0, LCD_135058_BIT0);
		clear_bit(LCD_135058_PORT1, LCD_135058_BIT1);
		clear_bit(LCD_135058_PORT2, LCD_135058_BIT2);
		clear_bit(LCD_135058_PORT3, LCD_135058_BIT3);
```

```
        clear_bit(LCD_135058_PORT4, LCD_135058_RS);
        clear_bit(LCD_135058_PORT5, LCD_135058_E);
        pt = ((in >> 4) & 0x0f);
        if (pt & 0x01)
            set_bit(LCD_135058_PORT0, LCD_135058_BIT0);
        if (pt & 0x02)
            set_bit(LCD_135058_PORT1, LCD_135058_BIT1);
        if (pt & 0x04)
            set_bit(LCD_135058_PORT2, LCD_135058_BIT2);
        if (pt & 0x08)
            set_bit(LCD_135058_PORT3, LCD_135058_BIT3);
        if (mask)
            set_bit(LCD_135058_PORT4, LCD_135058_RS);
        LCD_135058_DELAY;
        set_bit (LCD_135058_PORT5, LCD_135058_E);
        LCD_135058_DELAY;
        clear_bit (LCD_135058_PORT5, LCD_135058_E);
        pt = (in & 0x0f);
        LCD_135058_DELAY;
        clear_bit(LCD_135058_PORT0, LCD_135058_BIT0);
        clear_bit(LCD_135058_PORT1, LCD_135058_BIT1);
        clear_bit(LCD_135058_PORT2, LCD_135058_BIT2);
        clear_bit(LCD_135058_PORT3, LCD_135058_BIT3);
        clear_bit(LCD_135058_PORT4, LCD_135058_RS);
        clear_bit(LCD_135058_PORT5, LCD_135058_E);
        if (pt & 0x01)
            set_bit(LCD_135058_PORT0, LCD_135058_BIT0);
        if (pt & 0x02)
            set_bit(LCD_135058_PORT1, LCD_135058_BIT1);
        if (pt & 0x04)
            set_bit(LCD_135058_PORT2, LCD_135058_BIT2);
        if (pt & 0x08)
            set_bit(LCD_135058_PORT3, LCD_135058_BIT3);
        if (mask)
            set_bit(LCD_135058_PORT4, LCD_135058_RS);
        LCD_135058_DELAY;
        set_bit (LCD_135058_PORT5, LCD_135058_E);
        LCD_135058_DELAY;
        clear_bit (LCD_135058_PORT5, LCD_135058_E);
        LCD_135058_DELAY;
}

void FCD_LCDDisplay0_Start()
{
```

```
		clear_bit(LCD_135058_TRIS0, LCD_135058_BIT0);
		clear_bit(LCD_135058_TRIS1, LCD_135058_BIT1);
		clear_bit(LCD_135058_TRIS2, LCD_135058_BIT2);
		clear_bit(LCD_135058_TRIS3, LCD_135058_BIT3);
		clear_bit(LCD_135058_TRIS4, LCD_135058_RS);
		clear_bit(LCD_135058_TRIS5, LCD_135058_E);

		Wdt_Delay_Ms(12);

		FCD_LCDDisplay0_RawSend(0x33, 0);
		Wdt_Delay_Ms(2);
		FCD_LCDDisplay0_RawSend(0x33, 0);
		Wdt_Delay_Ms(2);
		FCD_LCDDisplay0_RawSend(0x32, 0);
		Wdt_Delay_Ms(2);
		FCD_LCDDisplay0_RawSend(0x2c, 0);
		Wdt_Delay_Ms(2);
		FCD_LCDDisplay0_RawSend(0x06, 0);
		Wdt_Delay_Ms(2);
		FCD_LCDDisplay0_RawSend(0x0c, 0);
		Wdt_Delay_Ms(2);

		//clear the display
		FCD_LCDDisplay0_RawSend(0x01, 0);
		Wdt_Delay_Ms(2);
		FCD_LCDDisplay0_RawSend(0x02, 0);
		Wdt_Delay_Ms(2);
}

void FCD_LCDDisplay0_Clear()
{
		FCD_LCDDisplay0_RawSend(0x01, 0);
		Wdt_Delay_Ms(2);
		FCD_LCDDisplay0_RawSend(0x02, 0);
		Wdt_Delay_Ms(2);
}

void FCD_LCDDisplay0_PrintASCII(char Character)
{
		FCD_LCDDisplay0_RawSend(Character, 0x10);
}


void FCD_LCDDisplay0_Cursor(char x, char y)
```

```
{
	#if (LCD_135058_ROWCNT == 1)
	  y=0x80;
	#endif

	#if (LCD_135058_ROWCNT == 2)
		if (y==0)
			y=0x80;
		else
			y=0xc0;
	#endif

	#if (LCD_135058_ROWCNT == 4)
		if (y==0)
			y=0x80;
		else if (y==1)
			y=0xc0;

		#if (LCD_135058_COLCNT == 16)
			else if (y==2)
				y=0x90;
			else
				y=0xd0;
		#endif

		#if (LCD_135058_COLCNT == 20)
			else if (y==2)
				y=0x94;
			else
				y=0xd4;
		#endif
	#endif

		FCD_LCDDisplay0_RawSend(y+x, 0);
		Wdt_Delay_Ms(2);
}

void FCD_LCDDisplay0_PrintString(char* String, char MSZ_String)
{
		char idx = 0;
		for (idx=0; idx<MSZ_String; idx++)
		{
			#ifdef _BOOSTC
				if (String[idx] == 0)
```

```
				{
					break;
				}
				FCD_LCDDisplay0_RawSend(String[idx], 0x10);
			#endif

			#ifdef HI_TECH_C
				if (*String == 0)
				{
					break;
				}
				FCD_LCDDisplay0_RawSend(*String, 0x10);
				String++;
			#endif
		}
}

//KeyPad(0): //Macro implementations
char FCD_KeyPad0_GetKeypadNumber()
{
		//get matrices for rows and columns
		#if (3 == 1)
			#define KPAD_COL_MTX {1}
			#define KPAD_COL_MASK (1)
		#endif
		#if (3 == 2)
			#define KPAD_COL_MTX {1,2}
			#define KPAD_COL_MASK (1|2)
		#endif
		#if (3 == 3)
			#define KPAD_COL_MTX {1,2,4}
			#define KPAD_COL_MASK (1|2|4)
		#endif
		#if (3 == 4)
			#define KPAD_COL_MTX {1,2,4,4}
			#define KPAD_COL_MASK (1|2|4|4)
		#endif
		#if (4 == 1)
			#define KPAD_ROW_MTX {4}
			#define KPAD_ROW_MASK (4)
		#endif
		#if (4 == 2)
			#define KPAD_ROW_MTX {4,8}
			#define KPAD_ROW_MASK (4|8)
```

```
#endif
#if (4 == 3)
	#define KPAD_ROW_MTX {4,8,16}
	#define KPAD_ROW_MASK (4|8|16)
#endif
#if (4 == 4)
	#define KPAD_ROW_MTX {4,8,16,32}
	#define KPAD_ROW_MASK (4|8|16|32)
#endif

#ifndef KPAD_COL_MTX
	#ifdef _BOOSTC
		#pragma error "Keypad error: column count is not 1-
4"
	#endif
	#ifdef HI_TECH_C
		#error Keypad error: column count is not 1-4
	#endif
#endif
#ifndef KPAD_ROW_MTX
	#ifdef _BOOSTC
		#pragma error "Keypad error: row count is not 1-4"
	#endif
	#ifdef HI_TECH_C
		#error Keypad error: row count is not 1-4
	#endif
#endif

//store keys and pin connections into a constant array
#ifdef _BOOSTC
	rom char* mtxKeysAsNumbers = {1,4,7,0,2,5,8,0,3,6,9,0};
	rom char* mtxCols = KPAD_COL_MTX;
	rom char* mtxRows = KPAD_ROW_MTX;
#endif
#ifdef HI_TECH_C
	const char mtxKeysAsNumbers[] = {1,4,7,0,2,5,8,0,3,6,9,0};
	const char mtxCols[] = KPAD_COL_MTX;
	const char mtxRows[] = KPAD_ROW_MTX;
#endif

//set up i/o of port (rows = inputs, columns = outputs)
trisa = (trisa | KPAD_ROW_MASK);
trise = (trise & ~KPAD_COL_MASK);		//BR
```

```
        char iCol;
        char iRow;
        char c_ip;
        for (iCol=0; iCol<3; iCol++)
        {
            //output the appropriate column high
            porte = mtxCols[iCol];

            //delay
            delay_us(10);

            //read the port
            c_ip = porta;

            //check for a hit
            for (iRow=0; iRow<4; iRow++)
            {
                if ((c_ip & mtxRows[iRow]) != 0)
                {
                    //found it!
                    goto found_key;
                }
            }
        }

        //if it gets here, it has not been found...
        return (255);

    found_key:
        return (mtxKeysAsNumbers[(iCol*4) + iRow]);

    #undef KPAD_COL_MTX
    #undef KPAD_ROW_MTX
    #undef KPAD_COL_MASK
    #undef KPAD_ROW_MASK
}

//Macro implementations
void FCM_SEND_MESSAGE()
{
    FCD_RS2320_SendRS232String("AT+CMGS=",8);
    FCD_RS2320_SendRS232Char(34);
    FCV_I = 0;
    while (1)
```

```
	{
		FCD_RS2320_SendRS232Char(FCV_STRINGCELLNUMBER[FCV_I]);
		FCV_I = FCV_I+1;
		if ((FCV_I==11) != 0) break;
	}
	FCD_RS2320_SendRS232Char(34);
	FCD_RS2320_SendRS232Char(13);
	delay_ms(255);
	delay_ms(245);
	FCD_RS2320_SendRS232String(FCV_STRINGMESSAGE,FCSZ_STRINGMES
SAGE);
	FCD_RS2320_SendRS232Char(26);
	FCD_RS2320_SendRS232Char(13);
	delay_s(5);
}

void FCM_INPUT_NUMBER()
{
	FCV_I = 0;
	FCD_LCDDisplay0_Cursor(0, 1);
	while (1)
	{
		FCV_DIGIT = FCD_KeyPad0_GetKeypadNumber();
		if (FCV_DIGIT==255)
		{
		} else {
			FCI_TOSTRING(FCV_DIGIT,FCV_NUM,FCSZ_NUM);
			FCD_LCDDisplay0_PrintString(FCV_NUM,FCSZ_NUM);
			FCV_STRINGCELLNUMBER[FCV_I] = FCV_NUM[0];
			delay_ms(255);
			delay_ms(45);
			FCV_I = FCV_I+1;


		}
		if ((FCV_I==11) != 0) break;
	}
}

void FCM_INPUT_PASSWORD()
{
	FCV_I = 0;
	FCD_LCDDisplay0_Cursor(0, 1);
	while (1)
```

```
	{
		FCV_DIGIT = FCD_KeyPad0_GetKeypadNumber();
		if (FCV_DIGIT==255)
		{
		} else {
			FCV_PASSWORD = FCV_DIGIT;
			FCD_LCDDisplay0_PrintASCII('*');
			delay_ms(255);
			delay_ms(45);
			FCV_I = FCV_I+1;
		}
		if ((FCV_I==1) != 0) break;
	}
	FCD_LCDDisplay0_Cursor(0, 0);
	FCD_LCDDisplay0_Clear();
	FCD_LCDDisplay0_PrintString(" GSM-BASED HOME",15);
	FCD_LCDDisplay0_Cursor(0, 1);
	FCD_LCDDisplay0_PrintString("INTRUSION DEVICE",16);
}

void main()
{
	//Initialisation
	adcon1 = 0x07;

	#if (RS232_462324_UART == 0)
		set_bit(RS232_462324_RX_TRIS, RS232_462324_SW_RX);
		// Receive pin is a input
		clear_bit(RS232_462324_TX_TRIS, RS232_462324_SW_TX);
	// Transmit pin is a output
		set_bit(RS232_462324_TX_PORT, RS232_462324_SW_TX);
		// Transmit pin is default high
	#endif

	#if (RS232_462324_UART == 1)
		txsta = RS232_462324_TXSTA_VAL;
	// 8-bit, async, low speed, off
		spbrg = RS232_462324_SPBRG_VAL;
	// set the baud rate
		rcsta = 0;					// 8-bit, disabled
		if(RS232_462324_DATASIZE == 1)
		{
			st_bit(txsta, TX9);				// 9-bit TX
			st_bit(rcsta, RX9);			// 9-bit RX
```

```
		}
		st_bit(rcsta, SPEN);					// turn on serial
interface
	#endif

	#if (RS232_462324_UART == 2)
		txsta2 = RS232_462324_TXSTA_VAL;
	// 8-bit, async, low speed, off
		spbrg2 = RS232_462324_SPBRG_VAL;
	// set the baud rate
		rcsta2 = 0;						// 8-bit, disabled
		if(RS232_462324_DATASIZE == 1)
		{
			st_bit(txsta2, TX9);					// 9-
bit TX
			st_bit(rcsta2, RX9);			// 9-bit RX
		}
		st_bit(rcsta2, SPEN);					// turn on serial
interface
	#endif

	#ifdef RS232_462324_HARDWARE
		set_bit( RS232_462324_CTS_TRIS, RS232_462324_CTS_PIN);
		//CTS is an input
		clear_bit( RS232_462324_RTS_TRIS, RS232_462324_RTS_PIN);
	//RTS is an output
		set_bit( RS232_462324_RTS_PORT, RS232_462324_RTS_PIN);
		//not ready to accept data
	#endif

	//Interrupt initialisation code
	option_reg = 0xC0;


	FCD_RS2320_SendRS232Char(13);
	//Output: 1 -> C5
	trisc = trisc & 0xdf;
	if (1)
		portc = (portc & 0xdf) | 0x20;
	else
		portc = portc & 0xdf;

	delay_s(2);
```

```
//Output: 0 -> C5
trisc = trisc & 0xdf;
if (0)
	portc = (portc & 0xdf) | 0x20;
else
	portc = portc & 0xdf;

FCD_LCDDisplay0_Start();
FCD_LCDDisplay0_PrintString("Please wait...",14);
delay_s(15);
FCD_RS2320_SendRS232String("AT+CMGF=1",9);
FCD_RS2320_SendRS232Char(13);
delay_s(1);
FCD_RS2320_SendRS232String("AT+CFUN=1",9);
FCD_RS2320_SendRS232Char(13);
delay_s(1);
FCD_LCDDisplay0_Clear();
FCD_LCDDisplay0_PrintString("Enter mobile:",13);
FCM_INPUT_NUMBER();
FCD_LCDDisplay0_Clear();
FCD_LCDDisplay0_PrintString("Enter KEY:",10);
FCM_INPUT_PASSWORD();

while (1)
{
	//Input
	//Input: B0 -> Microswitch
	trisb = trisb | 0x01;
	FCV_MICROSWITCH = ((portb & 0x01) == 0x01);

	if (FCV_MICROSWITCH == 0)
	{
	} else {
		FCD_LCDDisplay0_Clear();
		FCD_LCDDisplay0_PrintString("SECURITY BREACH!",16);
		FCD_LCDDisplay0_Cursor(0, 1);
		FCD_LCDDisplay0_PrintString("Press KEY",9);
		FCV_I = 0;
		while (1)
		{
			FCV_DIGIT = FCD_KeyPad0_GetKeypadNumber();
			if (FCV_DIGIT==255)
			{
				delay_ms(255);
```

```
                                        delay_ms(45);
                                        FCV_I = FCV_I+1;
                                } else {
                                        FCV_I = 17;
                                }
                                if ((FCV_I==17) != 0) break;
                        }

                        if (FCV_DIGIT==FCV_PASSWORD)
                        {
                        } else {
                                FCI_CONCATENATE("Your house is under
attack!",27,"",0,FCV_STRINGMESSAGE,FCSZ_STRINGMESSAGE);
                                FCM_SEND_MESSAGE();
                                FCD_LCDDisplay0_Clear();
                                FCD_LCDDisplay0_PrintString("Message sent to",15);
                                FCD_LCDDisplay0_Cursor(0, 1);
        FCD_LCDDisplay0_PrintString(FCV_STRINGCELLNUMBER,FCSZ_STRINGCE
LLNUMBER);
                                delay_s(2);
                        }

                        FCD_LCDDisplay0_Clear();
                        FCD_LCDDisplay0_PrintString(" GSM-BASED HOME",15);
                        FCD_LCDDisplay0_Cursor(0, 1);
                        FCD_LCDDisplay0_PrintString("INTRUSION DEVICE",16);

                        while (1)
                        {
                                //Input
                                //Input: B0 -> Microswitch
                                trisb = trisb | 0x01;
                                FCV_MICROSWITCH = ((portb & 0x01) == 0x01);

                                //Do nothing
                                if ((FCV_MICROSWITCH == 0) != 0) break;
                        }
                }
        }
        mainendloop: goto mainendloop;
}
```

APPENDIX D

Data Sheets

MICROCHIP

PIC16F87XA Data Sheet

28/40/44-Pin Enhanced Flash Microcontrollers

Note the following details of the code protection feature on Microchip devices:

- Microchip products meet the specification contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is one of the most secure families of its kind on the market today, when used in the intended manner and under normal conditions.
- There are dishonest and possibly illegal methods used to breach the code protection feature. All of these methods, to our knowledge, require using the Microchip products in a manner outside the operating specifications contained in Microchip's Data Sheets. Most likely, the person doing so is engaged in theft of intellectual property.
- Microchip is willing to work with the customer who is concerned about the integrity of their code.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of their code. Code protection does not mean that we are guaranteeing the product as "unbreakable."

Code protection is constantly evolving. We at Microchip are committed to continuously improving the code protection features of our products. Attempts to break microchip's code protection feature may be a violation of the Digital Millennium Copyright Act. If such acts allow unauthorized access to your software or other copyrighted work, you may have a right to sue for relief under that Act.

Microchip received QS-9000 quality system certification for its worldwide headquarters, design and wafer fabrication facilities in Chandler and Tempe, Arizona in July 1999 and Mountain View, California in March 2002. The Company's quality system processes and procedures are QS-9000 compliant for its PICmicro® 8-bit MCUs, KEELOQ® code hopping devices, Serial EEPROMs, microperipherals, non-volatile memory and analog products. In addition, Microchip's quality system for the design and manufacture of development systems is ISO 9001 certified.

MICROCHIP

PIC16F87XA

28/40/44-Pin Enhanced Flash Microcontrollers

Devices Included in this Data Sheet:

- PIC16F873A
- PIC16F874A
- PIC16F876A
- PIC16F877A

High-Performance RISC CPU:

- Only 35 single-word instructions to learn
- All single-cycle instructions except for program branches, which are two-cycle
- Operating speed: DC – 20 MHz clock input
  DC – 200 ns instruction cycle
- Up to 8K x 14 words of Flash Program Memory, Up to 368 x 8 bytes of Data Memory (RAM), Up to 256 x 8 bytes of EEPROM Data Memory
- Pinout compatible to other 28-pin or 40/44-pin PIC16CXXX and PIC16FXXX microcontrollers

Peripheral Features:

- Timer0: 8-bit timer/counter with 8-bit prescaler
- Timer1: 16-bit timer/counter with prescaler, can be incremented during Sleep via external crystal/clock
- Timer2: 8-bit timer/counter with 8-bit period register, prescaler and postscaler
- Two Capture, Compare, PWM modules
  - Capture is 16-bit, max. resolution is 12.5 ns
  - Compare is 16-bit, max. resolution is 200 ns
  - PWM max. resolution is 10-bit
- Synchronous Serial Port (SSP) with SPI™ (Master mode) and I^2C™ (Master/Slave)
- Universal Synchronous Asynchronous Receiver Transmitter (USART/SCI) with 9-bit address detection
- Parallel Slave Port (PSP) – 8 bits wide with external $\overline{RD}$, $\overline{WR}$ and $\overline{CS}$ controls (40/44-pin only)
- Brown-out detection circuitry for Brown-out Reset (BOR)

Analog Features:

- 10-bit, up to 8-channel Analog-to-Digital Converter (A/D)
- Brown-out Reset (BOR)
- Analog Comparator module with:
  - Two analog comparators
  - Programmable on-chip voltage reference (VREF) module
  - Programmable input multiplexing from device inputs and internal voltage reference
  - Comparator outputs are externally accessible

Special Microcontroller Features:

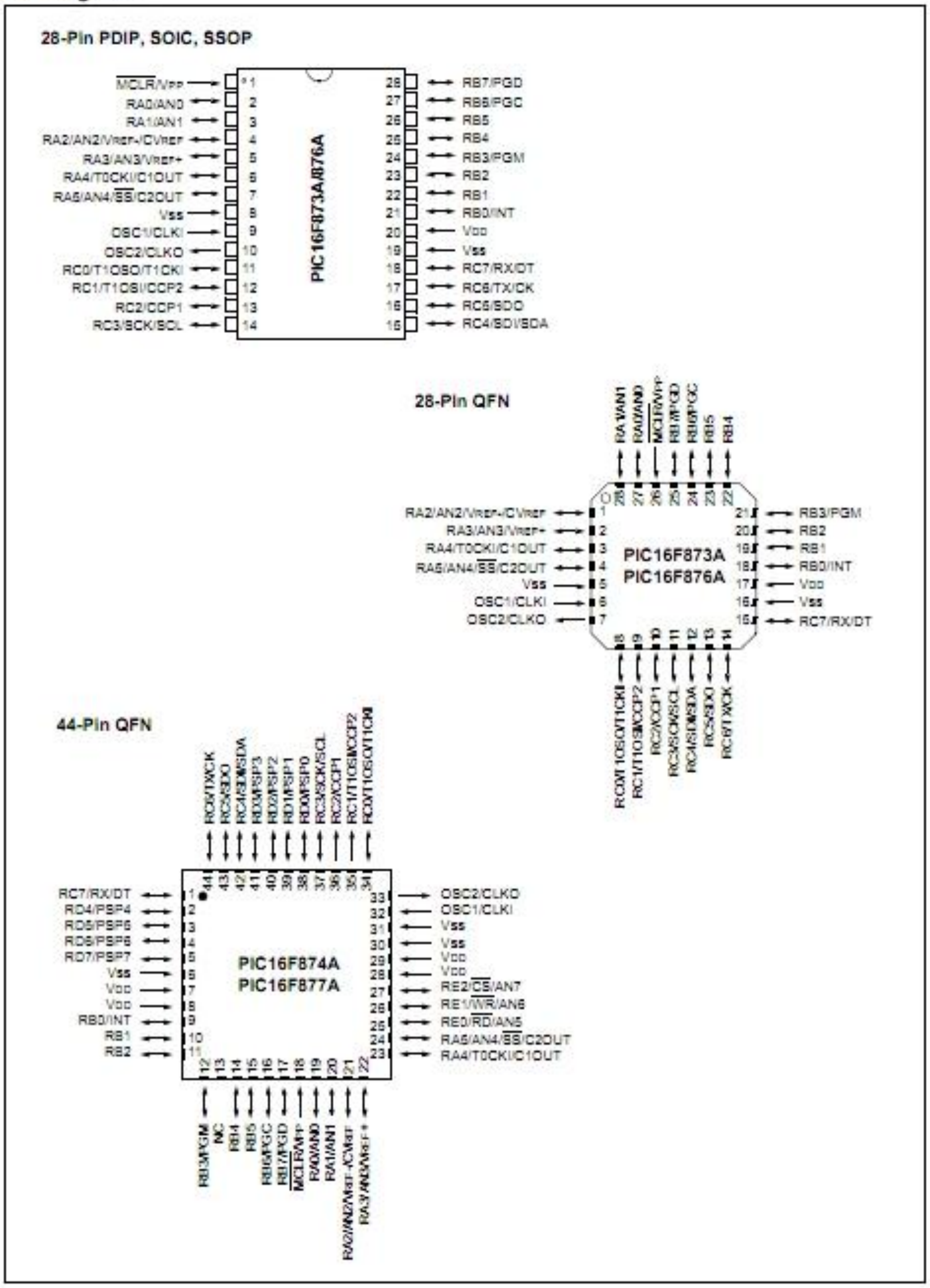
- 100,000 erase/write cycle Enhanced Flash program memory typical
- 1,000,000 erase/write cycle Data EEPROM memory typical
- Data EEPROM Retention > 40 years
- Self-reprogrammable under software control
- In-Circuit Serial Programming™ (ICSP™) via two pins
- Single-supply 5V In-Circuit Serial Programming
- Watchdog Timer (WDT) with its own on-chip RC oscillator for reliable operation
- Programmable code protection
- Power saving Sleep mode
- Selectable oscillator options
- In-Circuit Debug (ICD) via two pins

CMOS Technology:

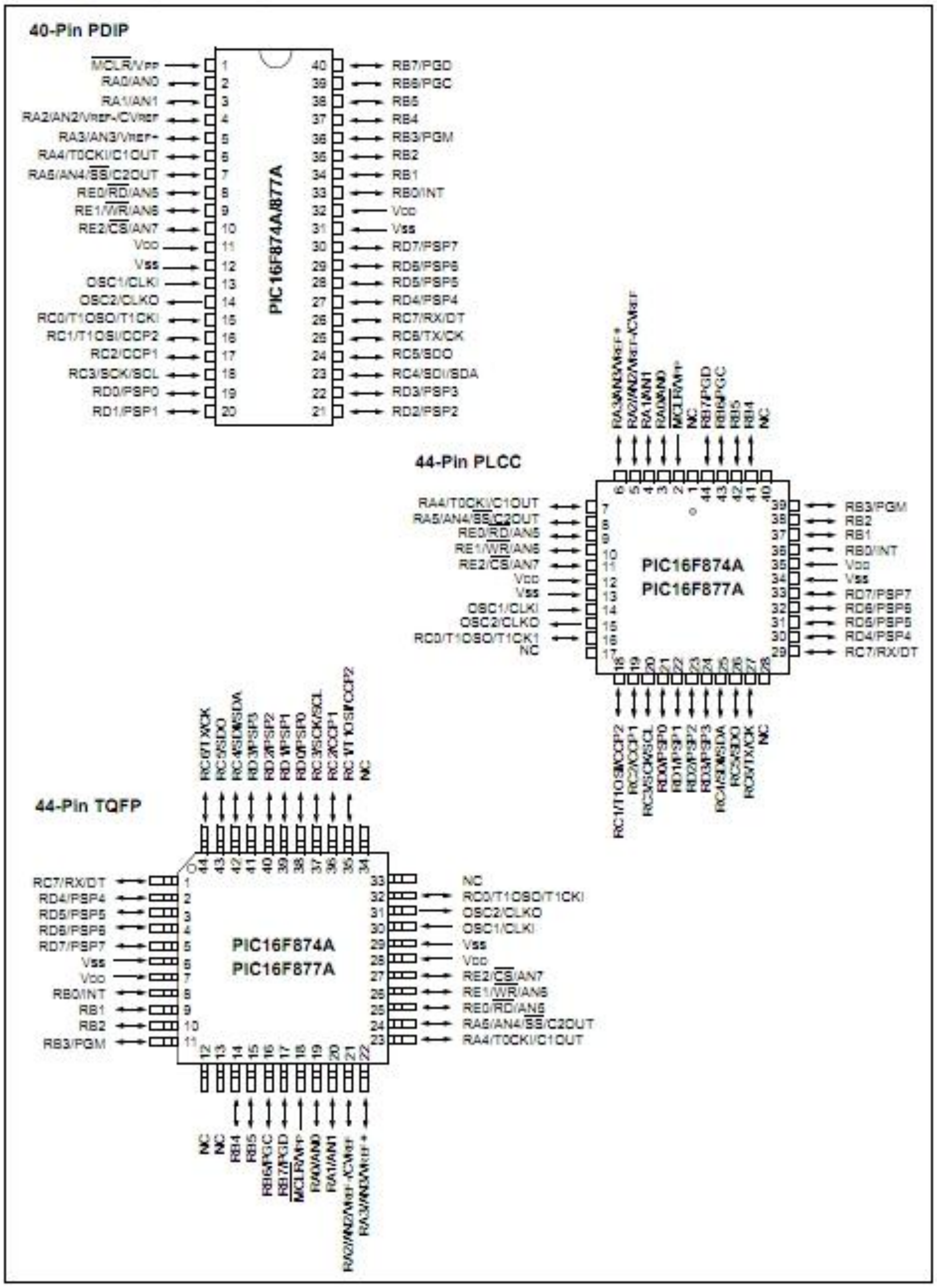
- Low-power, high-speed Flash/EEPROM technology
- Fully static design
- Wide operating voltage range (2.0V to 5.5V)
- Commercial and Industrial temperature ranges
- Low-power consumption

Device	Program Memory		Data SRAM (Bytes)	EEPROM (Bytes)	I/O	10-bit A/D (ch)	CCP (PWM)	MSSP		USART	Timers 8/16-bit	Comparators
	Bytes	# Single Word Instructions						SPI	Master I^2C			
PIC16F873A	7.2K	4096	192	128	22	5	2	Yes	Yes	Yes	2/1	2
PIC16F874A	7.2K	4096	192	128	33	8	2	Yes	Yes	Yes	2/1	2
PIC16F876A	14.3K	8192	368	256	22	5	2	Yes	Yes	Yes	2/1	2
PIC16F877A	14.3K	8192	368	256	33	8	2	Yes	Yes	Yes	2/1	2

Pin Diagrams



Pin Diagrams (Continued)



1.0 DEVICE OVERVIEW

This document contains device specific information about the following devices:

- PIC16F873A
- PIC16F874A
- PIC16F876A
- PIC16F877A

PIC16F873A/876A devices are available only in 28-pin packages, while PIC16F874A/877A devices are available in 40-pin and 44-pin packages. All devices in the PIC16F87XA family share common architecture with the following differences:

- The PIC16F873A and PIC16F874A have one-half of the total on-chip memory of the PIC16F876A and PIC16F877A
- The 28-pin devices have three I/O ports, while the 40/44-pin devices have five
- The 28-pin devices have fourteen interrupts, while the 40/44-pin devices have fifteen
- The 28-pin devices have five A/D input channels, while the 40/44-pin devices have eight
- The Parallel Slave Port is implemented only on the 40/44-pin devices

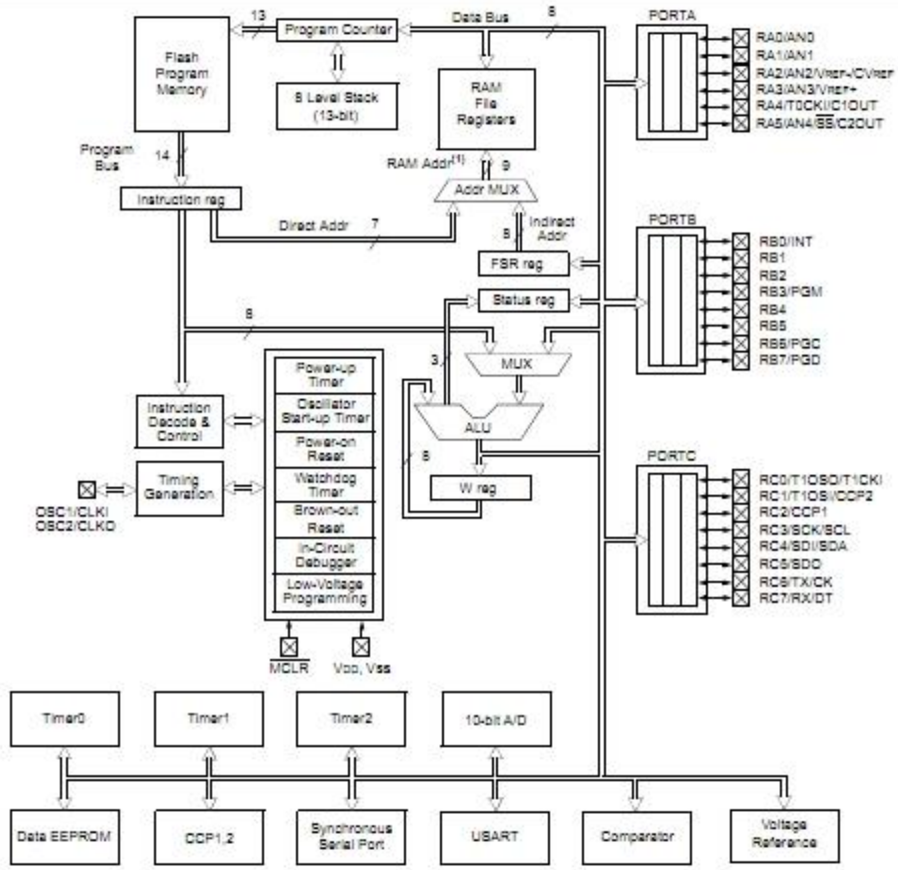
The available features are summarized in Table 1-1. Block diagrams of the PIC16F873A/876A and PIC16F874A/877A devices are provided in Figure 1-1 and Figure 1-2, respectively. The pinouts for these device families are listed in Table 1-2 and Table 1-3.

Additional information may be found in the PICmicro® Mid-Range Reference Manual (DS33023), which may be obtained from your local Microchip Sales Representative or downloaded from the Microchip web site. The Reference Manual should be considered a complementary document to this data sheet and is highly recommended reading for a better understanding of the device architecture and operation of the peripheral modules.

TABLE 1-1: PIC16F87XA DEVICE FEATURES

Key Features	PIC16F873A	PIC16F874A	PIC16F876A	PIC16F877A
Operating Frequency	DC – 20 MHz	DC – 20 MHz	DC – 20 MHz	DC – 20 MHz
Resets (and Delays)	POR, BOR (PWRT, OST)	POR, BOR (PWRT, OST)	POR, BOR (PWRT, OST)	POR, BOR (PWRT, OST)
Flash Program Memory (14-bit words)	4K	4K	8K	8K
Data Memory (bytes)	192	192	368	368
EEPROM Data Memory (bytes)	128	128	256	256
Interrupts	14	15	14	15
I/O Ports	Ports A, B, C	Ports A, B, C, D, E	Ports A, B, C	Ports A, B, C, D, E
Timers	3	3	3	3
Capture/Compare/PWM modules	2	2	2	2
Serial Communications	MSSP, USART	MSSP, USART	MSSP, USART	MSSP, USART
Parallel Communications	—	PSP	—	PSP
10-bit Analog-to-Digital Module	5 input channels	8 input channels	5 input channels	8 input channels
Analog Comparators	2	2	2	2
Instruction Set	35 Instructions	35 Instructions	35 Instructions	35 Instructions
Packages	28-pin PDIP 28-pin SOIC 28-pin SSOP 28-pin QFN	40-pin PDIP 44-pin PLCC 44-pin TQFP 44-pin QFN	28-pin PDIP 28-pin SOIC 28-pin SSOP 28-pin QFN	40-pin PDIP 44-pin PLCC 44-pin TQFP 44-pin QFN

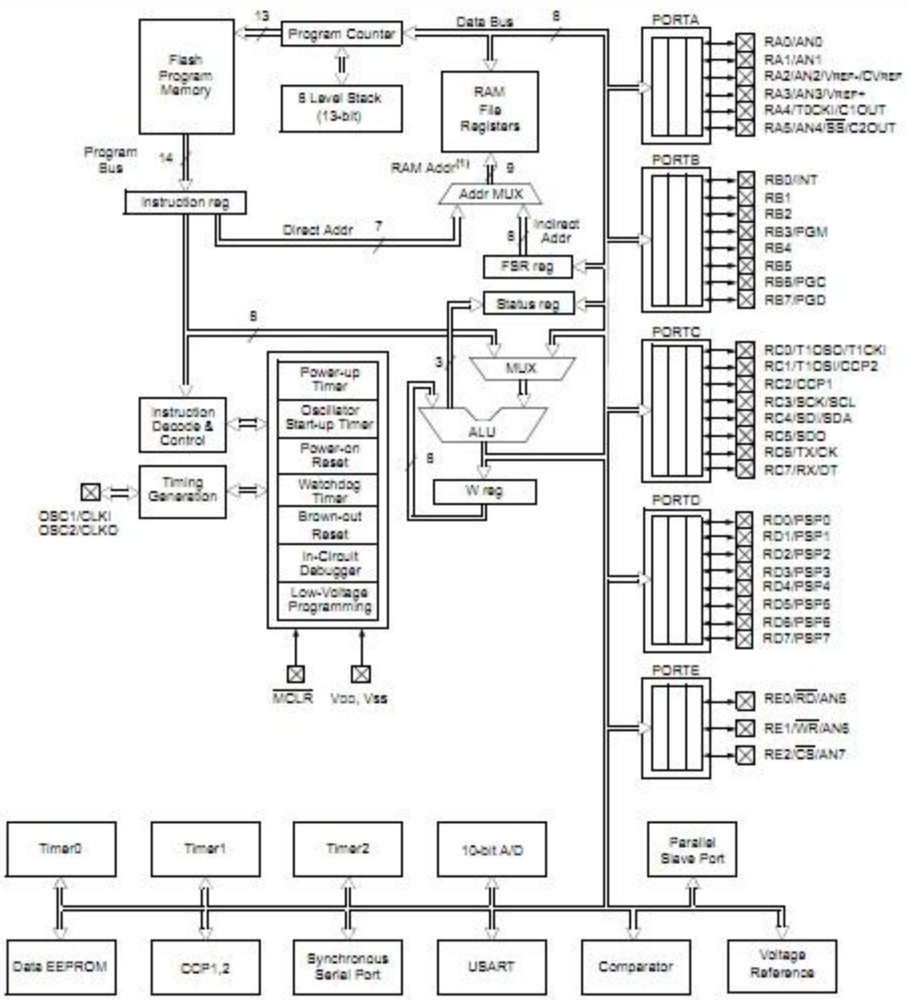
FIGURE 1-1: PIC16F873A/876A BLOCK DIAGRAM



Device	Program Flash	Data Memory	Data EEPROM
PIC16F873A	4K words	192 Bytes	128 Bytes
PIC16F876A	8K words	368 Bytes	256 Bytes

Note 1: Higher order bits are from the Status register.

FIGURE 1-2: PIC16F874A/877A BLOCK DIAGRAM



Device	Program Flash	Data Memory	Data EEPROM
PIC16F874A	4K words	192 Bytes	128 Bytes
PIC16F877A	8K words	368 Bytes	256 Bytes

Note 1: Higher order bits are from the Status register.

TABLE 1-2: PIC16F873A/876A PINOUT DESCRIPTION

Pin Name	PDIP, SOIC, SSOP Pin#	QFN Pin#	I/O/P Type	Buffer Type	Description
OSC1/CLKI	9	6		ST/CMOS[3]	Oscillator crystal or external clock input.
OSC1			I		Oscillator crystal input or external clock source input. ST buffer when configured in RC mode; otherwise CMOS.
CLKI			I		External clock source input. Always associated with pin function OSC1 (see OSC1/CLKI, OSC2/CLKO pins).
OSC2/CLKO	10	7		—	Oscillator crystal or clock output.
OSC2			O		Oscillator crystal output. Connects to crystal or resonator in Crystal Oscillator mode.
CLKO			O		In RC mode, OSC2 pin outputs CLKO, which has 1/4 the frequency of OSC1 and denotes the instruction cycle rate.
$\overline{MCLR}$/VPP	1	26		ST	Master Clear (input) or programming voltage (output).
$\overline{MCLR}$			I		Master Clear (Reset) input. This pin is an active low Reset to the device.
VPP			P		Programming voltage input.
					PORTA is a bidirectional I/O port.
RA0/AN0	2	27		TTL	
RA0			I/O		Digital I/O.
AN0			I		Analog input 0.
RA1/AN1	3	28		TTL	
RA1			I/O		Digital I/O.
AN1			I		Analog input 1.
RA2/AN2/VREF-/CVREF	4	1		TTL	
RA2			I/O		Digital I/O.
AN2			I		Analog input 2.
VREF-			I		A/D reference voltage (Low) input.
CVREF			O		Comparator VREF output.
RA3/AN3/VREF+	5	2		TTL	
RA3			I/O		Digital I/O.
AN3			I		Analog input 3.
VREF+			I		A/D reference voltage (High) input.
RA4/T0CKI/C1OUT	6	3		ST	
RA4			I/O		Digital I/O – Open-drain when configured as output.
T0CKI			I		Timer0 external clock input.
C1OUT			O		Comparator 1 output.
RA5/AN4/$\overline{SS}$/C2OUT	7	4		TTL	
RA5			I/O		Digital I/O.
AN4			I		Analog input 4.
$\overline{SS}$			I		SPI slave select input.
C2OUT			O		Comparator 2 output.

Legend: I = input O = output I/O = input/output P = power
— = Not used TTL = TTL input ST = Schmitt Trigger input

Note 1: This buffer is a Schmitt Trigger input when configured as the external interrupt.
2: This buffer is a Schmitt Trigger input when used in Serial Programming mode.
3: This buffer is a Schmitt Trigger input when configured in RC Oscillator mode and a CMOS input otherwise.

TABLE 1-2: PIC16F873A/876A PINOUT DESCRIPTION (CONTINUED)

Pin Name	PDIP, SOIC, SSOP Pin#	QFN Pin#	I/O/P Type	Buffer Type	Description
					PORTB is a bidirectional I/O port. PORTB can be software programmed for internal weak pull-ups on all inputs.
RB0/INT	21	18		TTL/ST[(1)]	
RB0			I/O		Digital I/O.
INT			I		External interrupt.
RB1	22	19	I/O	TTL	Digital I/O.
RB2	23	20	I/O	TTL	Digital I/O.
RB3/PGM	24	21		TTL	
RB3			I/O		Digital I/O.
PGM			I		Low-voltage (single-supply) ICSP programming enable pin.
RB4	25	22	I/O	TTL	Digital I/O.
RB5	26	23	I/O	TTL	Digital I/O.
RB6/PGC	27	24		TTL/ST[(2)]	
RB6			I/O		Digital I/O.
PGC			I		In-circuit debugger and ICSP programming clock.
RB7/PGD	28	25		TTL/ST[(2)]	
RB7			I/O		Digital I/O.
PGD			I/O		In-circuit debugger and ICSP programming data.
					PORTC is a bidirectional I/O port.
RC0/T1OSO/T1CKI	11	8		ST	
RC0			I/O		Digital I/O.
T1OSO			O		Timer1 oscillator output.
T1CKI			I		Timer1 external clock input.
RC1/T1OSI/CCP2	12	9		ST	
RC1			I/O		Digital I/O.
T1OSI			I		Timer1 oscillator input.
CCP2			I/O		Capture2 input, Compare2 output, PWM2 output.
RC2/CCP1	13	10		ST	
RC2			I/O		Digital I/O.
CCP1			I/O		Capture1 input, Compare1 output, PWM1 output.
RC3/SCK/SCL	14	11		ST	
RC3			I/O		Digital I/O.
SCK			I/O		Synchronous serial clock input/output for SPI mode.
SCL			I/O		Synchronous serial clock input/output for I²C mode.
RC4/SDI/SDA	15	12		ST	
RC4			I/O		Digital I/O.
SDI			I		SPI data in.
SDA			I/O		I²C data I/O.
RC5/SDO	16	13		ST	
RC5			I/O		Digital I/O.
SDO			O		SPI data out.
RC6/TX/CK	17	14		ST	
RC6			I/O		Digital I/O.
TX			O		USART asynchronous transmit.
CK			I/O		USART1 synchronous clock.
RC7/RX/DT	18	15		ST	
RC7			I/O		Digital I/O.
RX			I		USART asynchronous receive.
DT			I/O		USART synchronous data.
VSS	8, 19	5, 6	P	—	Ground reference for logic and I/O pins.
VDD	20	17	P	—	Positive supply for logic and I/O pins.

Legend: I = input O = output I/O = input/output P = power
— = Not used TTL = TTL input ST = Schmitt Trigger input

Note 1: This buffer is a Schmitt Trigger input when configured as the external interrupt.
2: This buffer is a Schmitt Trigger input when used in Serial Programming mode.
3: This buffer is a Schmitt Trigger input when configured in RC Oscillator mode and a CMOS input otherwise.

TABLE 1-3: PIC16F874A/877A PINOUT DESCRIPTION

Pin Name	PDIP Pin#	PLCC Pin#	TQFP Pin#	QFN Pin#	I/O/P Type	Buffer Type	Description
OSC1/CLKI	13	14	30	32		ST/CMOS[4]	Oscillator crystal or external clock input.
OSC1					I		Oscillator crystal input or external clock source input. ST buffer when configured in RC mode; otherwise CMOS.
CLKI					I		External clock source input. Always associated with pin function OSC1 (see OSC1/CLKI, OSC2/CLKO pins).
OSC2/CLKO	14	15	31	33		—	Oscillator crystal or clock output.
OSC2					O		Oscillator crystal output. Connects to crystal or resonator in Crystal Oscillator mode.
CLKO					O		In RC mode, OSC2 pin outputs CLKO, which has 1/4 the frequency of OSC1 and denotes the instruction cycle rate.
$\overline{\text{MCLR}}$/VPP	1	2	18	18		ST	Master Clear (input) or programming voltage (output).
$\overline{\text{MCLR}}$					I		Master Clear (Reset) input. This pin is an active low Reset to the device.
VPP					P		Programming voltage input.
							PORTA is a bidirectional I/O port.
RA0/AN0	2	3	19	19		TTL	
RA0					I/O		Digital I/O.
AN0					I		Analog input 0.
RA1/AN1	3	4	20	20		TTL	
RA1					I/O		Digital I/O.
AN1					I		Analog input 1.
RA2/AN2/VREF-/CVREF	4	5	21	21		TTL	
RA2					I/O		Digital I/O.
AN2					I		Analog input 2.
VREF-					I		A/D reference voltage (Low) input.
CVREF					O		Comparator VREF output.
RA3/AN3/VREF+	5	6	22	22		TTL	
RA3					I/O		Digital I/O.
AN3					I		Analog input 3.
VREF+					I		A/D reference voltage (High) input.
RA4/T0CKI/C1OUT	6	7	23	23		ST	
RA4					I/O		Digital I/O – Open-drain when configured as output.
T0CKI					I		Timer0 external clock input.
C1OUT					O		Comparator 1 output.
RA5/AN4/$\overline{\text{SS}}$/C2OUT	7	8	24	24		TTL	
RA5					I/O		Digital I/O.
AN4					I		Analog input 4.
$\overline{\text{SS}}$					I		SPI slave select input.
C2OUT					O		Comparator 2 output.

Legend: I = input O = output I/O = input/output P = power
— = Not used TTL = TTL input ST = Schmitt Trigger input

Note 1: This buffer is a Schmitt Trigger input when configured as the external interrupt.
2: This buffer is a Schmitt Trigger input when used in Serial Programming mode.
3: This buffer is a Schmitt Trigger input when configured in RC Oscillator mode and a CMOS input otherwise.

TABLE 1-3: PIC16F874A/877A PINOUT DESCRIPTION (CONTINUED)

Pin Name	PDIP Pin#	PLCC Pin#	TQFP Pin#	QFN Pin#	I/O/P Type	Buffer Type	Description
							PORTB is a bidirectional I/O port. PORTB can be software programmed for internal weak pull-up on all inputs.
RB0/INT	33	36	8	9		TTL/ST(1)	
RB0					I/O		Digital I/O.
INT					I		External interrupt.
RB1	34	37	9	10	I/O	TTL	Digital I/O.
RB2	35	38	10	11	I/O	TTL	Digital I/O.
RB3/PGM	36	39	11	12		TTL	
RB3					I/O		Digital I/O.
PGM					I		Low-voltage ICSP programming enable pin.
RB4	37	41	14	14	I/O	TTL	Digital I/O.
RB5	38	42	15	15	I/O	TTL	Digital I/O.
RB6/PGC	39	43	16	16		TTL/ST(2)	
RB6					I/O		Digital I/O.
PGC					I		In-circuit debugger and ICSP programming clock.
RB7/PGD	40	44	17	17		TTL/ST(2)	
RB7					I/O		Digital I/O.
PGD					I/O		In-circuit debugger and ICSP programming data.

Legend: I = input O = output I/O = input/output P = power
— = Not used TTL = TTL input ST = Schmitt Trigger input

Note 1: This buffer is a Schmitt Trigger input when configured as the external interrupt.
2: This buffer is a Schmitt Trigger input when used in Serial Programming mode.
3: This buffer is a Schmitt Trigger input when configured in RC Oscillator mode and a CMOS input otherwise.

TABLE 1-3: PIC16F874A/877A PINOUT DESCRIPTION (CONTINUED)

Pin Name	PDIP Pin#	PLCC Pin#	TQFP Pin#	QFN Pin#	I/O/P Type	Buffer Type	Description
							PORTC is a bidirectional I/O port.
RC0/T1OSO/T1CKI	15	16	32	34		ST	
RC0					I/O		Digital I/O.
T1OSO					O		Timer1 oscillator output.
T1CKI					I		Timer1 external clock input.
RC1/T1OSI/CCP2	16	18	35	35		ST	
RC1					I/O		Digital I/O.
T1OSI					I		Timer1 oscillator input.
CCP2					I/O		Capture2 input, Compare2 output, PWM2 output.
RC2/CCP1	17	19	36	36		ST	
RC2					I/O		Digital I/O.
CCP1					I/O		Capture1 input, Compare1 output, PWM1 output.
RC3/SCK/SCL	18	20	37	37		ST	
RC3					I/O		Digital I/O.
SCK					I/O		Synchronous serial clock input/output for SPI mode.
SCL					I/O		Synchronous serial clock input/output for I^{2}C mode.
RC4/SDI/SDA	23	25	42	42		ST	
RC4					I/O		Digital I/O.
SDI					I		SPI data in.
SDA					I/O		I^{2}C data I/O.
RC5/SDO	24	26	43	43		ST	
RC5					I/O		Digital I/O.
SDO					O		SPI data out.
RC6/TX/CK	25	27	44	44		ST	
RC6					I/O		Digital I/O.
TX					O		USART asynchronous transmit.
CK					I/O		USART1 synchronous clock.
RC7/RX/DT	26	29	1	1		ST	
RC7					I/O		Digital I/O.
RX					I		USART asynchronous receive.
DT					I/O		USART synchronous data.

Legend: I = input O = output I/O = input/output P = power
— = Not used TTL = TTL input ST = Schmitt Trigger input

Note 1: This buffer is a Schmitt Trigger input when configured as the external interrupt.
2: This buffer is a Schmitt Trigger input when used in Serial Programming mode.
3: This buffer is a Schmitt Trigger input when configured in RC Oscillator mode and a CMOS input otherwise.

TABLE 1-3: PIC16F874A/877A PINOUT DESCRIPTION (CONTINUED)

Pin Name	PDIP Pin#	PLCC Pin#	TQFP Pin#	QFN Pin#	I/O/P Type	Buffer Type	Description
							PORTD is a bidirectional I/O port or Parallel Slave Port when interfacing to a microprocessor bus.
RD0/PSP0	19	21	38	38		ST/TTL[3]	
RD0					I/O		Digital I/O.
PSP0					I/O		Parallel Slave Port data.
RD1/PSP1	20	22	39	39		ST/TTL[3]	
RD1					I/O		Digital I/O.
PSP1					I/O		Parallel Slave Port data.
RD2/PSP2	21	23	40	40		ST/TTL[3]	
RD2					I/O		Digital I/O.
PSP2					I/O		Parallel Slave Port data.
RD3/PSP3	22	24	41	41		ST/TTL[3]	
RD3					I/O		Digital I/O.
PSP3					I/O		Parallel Slave Port data.
RD4/PSP4	27	30	2	2		ST/TTL[3]	
RD4					I/O		Digital I/O.
PSP4					I/O		Parallel Slave Port data.
RD5/PSP5	28	31	3	3		ST/TTL[3]	
RD5					I/O		Digital I/O.
PSP5					I/O		Parallel Slave Port data.
RD6/PSP6	29	32	4	4		ST/TTL[3]	
RD6					I/O		Digital I/O.
PSP6					I/O		Parallel Slave Port data.
RD7/PSP7	30	33	5	5		ST/TTL[3]	
RD7					I/O		Digital I/O.
PSP7					I/O		Parallel Slave Port data.
							PORTE is a bidirectional I/O port.
RE0/$\overline{RD}$/AN5	8	9	25	25		ST/TTL[3]	
RE0					I/O		Digital I/O.
$\overline{RD}$					I		Read control for Parallel Slave Port.
AN5					I		Analog input 5.
RE1/$\overline{WR}$/AN6	9	10	26	26		ST/TTL[3]	
RE1					I/O		Digital I/O.
$\overline{WR}$					I		Write control for Parallel Slave Port.
AN6					I		Analog input 6.
RE2/$\overline{CS}$/AN7	10	11	27	27		ST/TTL[3]	
RE2					I/O		Digital I/O.
$\overline{CS}$					I		Chip select control for Parallel Slave Port.
AN7					I		Analog input 7.
VSS	12, 31	13, 34	6, 29	6, 30, 31	P	—	Ground reference for logic and I/O pins.
VDD	11, 32	12, 35	7, 28	7, 8, 28, 29	P	—	Positive supply for logic and I/O pins.
NC	—	1, 17, 28, 40	12,13, 33, 34	13	—	—	These pins are not internally connected. These pins should be left unconnected.

Legend: I = input O = output I/O = input/output P = power
— = Not used TTL = TTL input ST = Schmitt Trigger input

Note 1: This buffer is a Schmitt Trigger input when configured as the external interrupt.
2: This buffer is a Schmitt Trigger input when used in Serial Programming mode.
3: This buffer is a Schmitt Trigger input when configured in RC Oscillator mode and a CMOS input otherwise.

FAIRCHILD
SEMICONDUCTOR®

April 2010

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			

Block Diagram

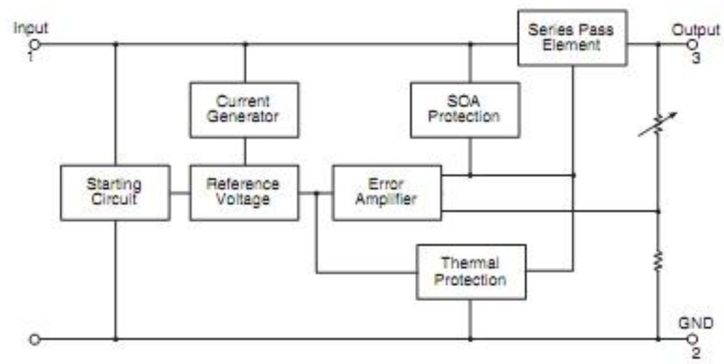


Figure 1.

Pin Assignment

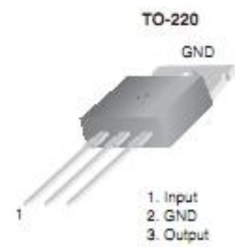


Figure 2.

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

Electrical Characteristics (LM7805)

Refer to the test circuits. -40°C < T_J < 125°C, I_O = 500mA, V_I = 10V, C_I = 0.1µF, 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 ≤ I_O ≤ 1A, P_O ≤ 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	–	µV/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.

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.

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	73.0	–	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.

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		–	5.0	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.

Electrical Characteristics (LM7810) (Continued)

Refer to the test circuits. -40°C < T_J < 125°C, I_O = 500mA, V_I = 16V, 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		9.6	10.0	10.4	V
		5mA ≤ I_O ≤ 1A, P_O ≤ 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	–	µV/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.

Electrical Characteristics (LM7812) (Continued)

Refer to the test circuits. -40°C < T_J < 125°C, I_O = 500mA, V_I = 19V, 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		11.5	12.0	12.5	V
		5mA ≤ I_O ≤ 1A, P_D ≤ 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	–	µV/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 separately. Pulse testing with low duty is used.

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

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.

Electrical Characteristics (LM7818) (Continued)

Refer to the test circuits. -40°C < T_J < 125°C, I_O = 500mA, V_I = 27V, 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		17.3	18.0	18.7	V
		5mA ≤ I_O ≤ 1A, P_O ≤ 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	–	µV/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.

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	8.0	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.

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.

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		5.58	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 = 19V 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.

Electrical Characteristics (LM7808A) (Continued)

Refer to the test circuits. 0°C < T_J < 125°C, I_O = 1A, 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		7.84	8.0	8.16	V
		I_O = 5mA to 1A, P_O ≤ 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	
			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	–	µV/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.

Electrical Characteristics (LM7809A) (Continued)

Refer to the test circuits. 0°C < T_J < 125°C, I_O = 1A, V_I = 15V, 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	8.82	9.0	9.16	V
		I_O = 5mA to 1A, P_O ≤ 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/V_O
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.

Electrical Characteristics (LM7810A) (Continued)

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

Symbol	Parameter	Conditions		Min.	Typ.	Max.	Units
V_O	Output Voltage	$T_J = +25°C$		9.8	10.0	10.2	V
		$I_O = 5mA$ to $1A$, $P_O \leq 15W$, $V_I = 12.8V$ 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	
		$T_J = +25°C$	$V_I = 12.5V$ 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 $25V$, $I_O = 500mA$		–	–	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	–	$\mu V/V_O$
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.

Electrical Characteristics (LM7812A) (Continued)

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

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Units
V_O	Output Voltage	$T_J = +25°C$	11.75	12.0	12.25	V
		$I_O = 5mA$ to $1A$, $P_O \le 15W$, $V_I = 14.8V$ 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	–	$\mu V/V_O$
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.

Electrical Characteristics (LM7815A) (Continued)

Refer to the test circuits. 0°C < T_J < 125°C, I_O = 1A, V_I = 23V, 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		14.75	15.0	15.3	V
		I_O = 5mA to 1A, P_O ≤ 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.

Electrical Characteristics (LM7818A) (Continued)

Refer to the test circuits. 0°C < T_J < 125°C, I_O = 1A, V_I = 27V, 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		17.64	18.0	18.36	V
		I_O = 5mA to 1A, P_O ≤ 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	
			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	–	µV/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.

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		–	18.0	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		–	5.2	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		–	54.0	–	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.

Typical Performance Characteristics

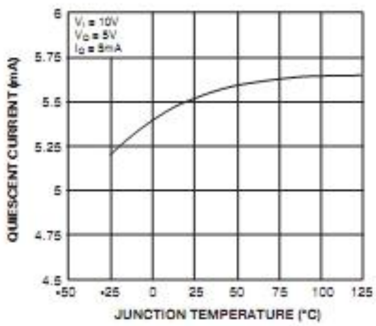


Figure 3. Quiescent Current

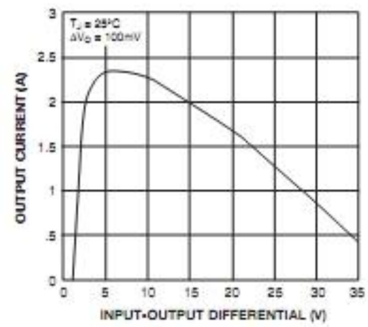


Figure 4. Peak Output Current

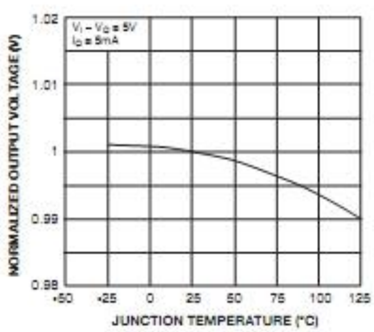


Figure 5. Output Voltage

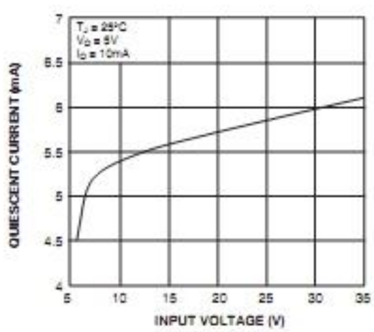


Figure 6. Quiescent Current

Typical Applications

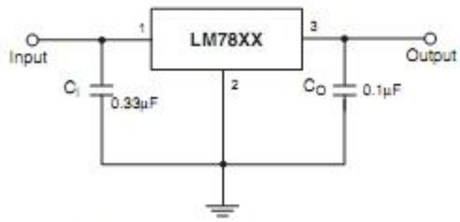


Figure 7. DC Parameters

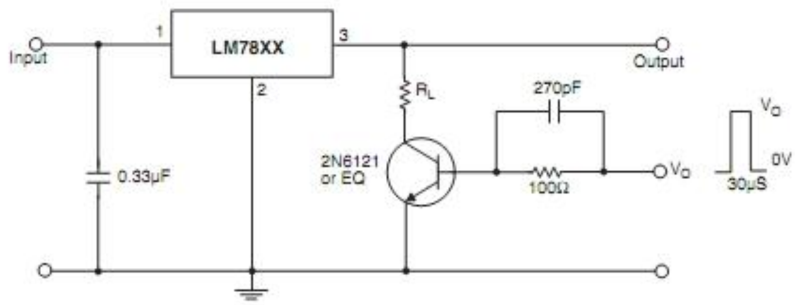


Figure 8. Load Regulation

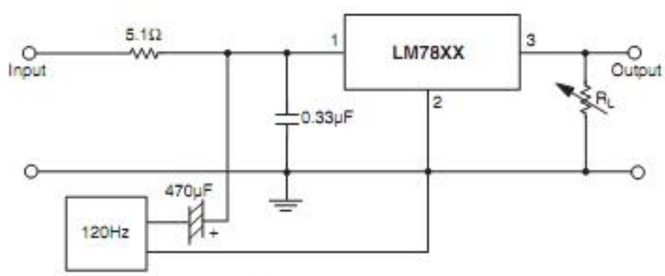


Figure 9. Ripple Rejection

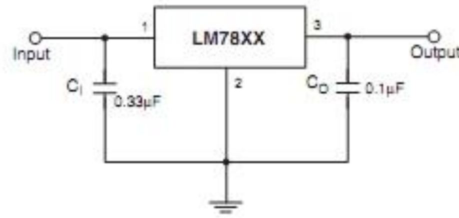
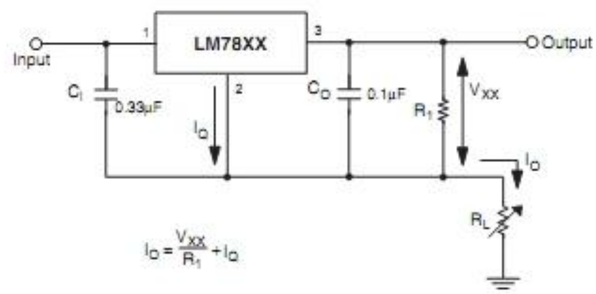


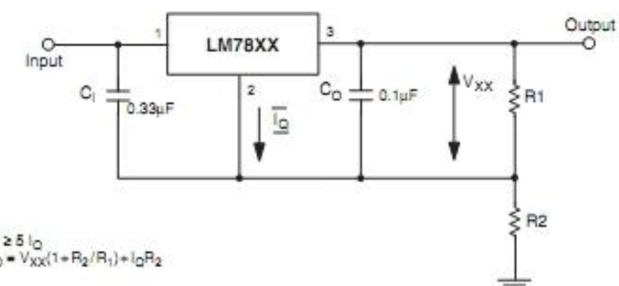
Figure 10. Fixed Output Regulator



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.



$I_{RI} \geq 5\ I_Q$
$V_O = V_{XX}(1 + R_2/R_1) + I_Q R_2$

Figure 12. Circuit for Increasing Output Voltage

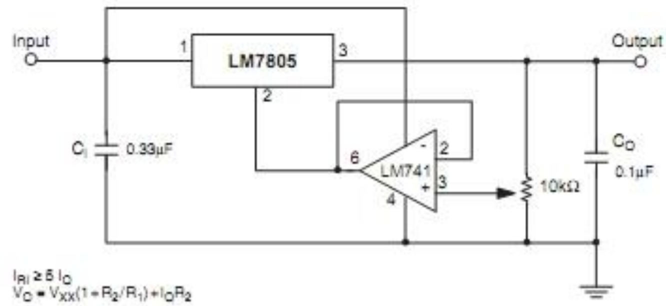


Figure 13. Adjustable Output Regulator (7V to 30V)

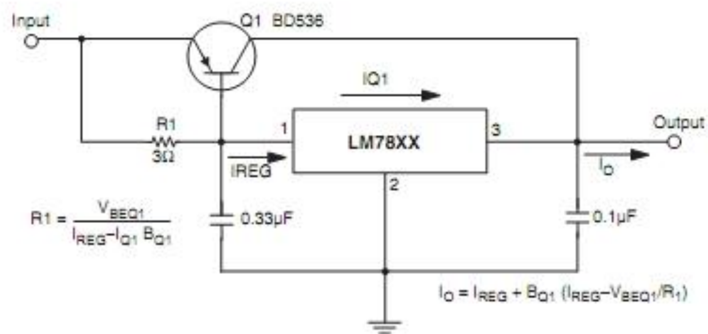


Figure 14. High Current Voltage Regulator

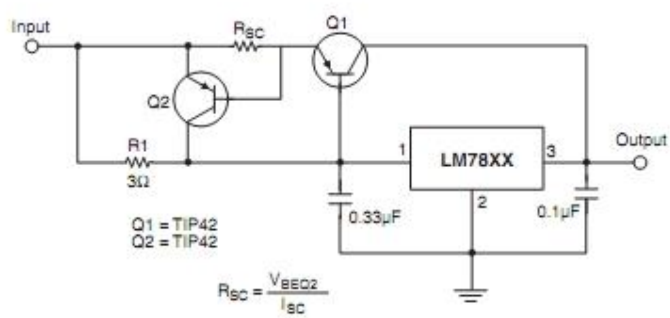


Figure 15. High Output Current with Short Circuit Protection

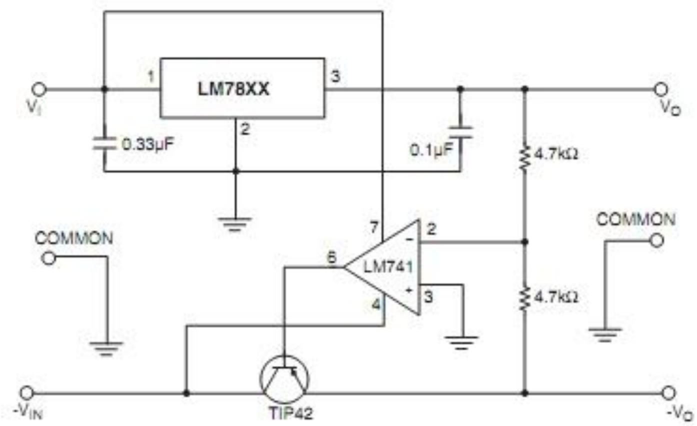


Figure 16. Tracking Voltage Regulator

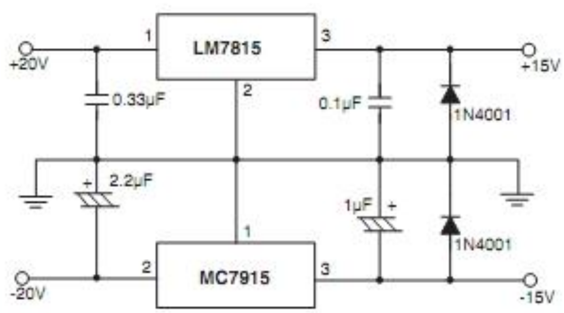


Figure 17. Split Power Supply (±15V – 1A)

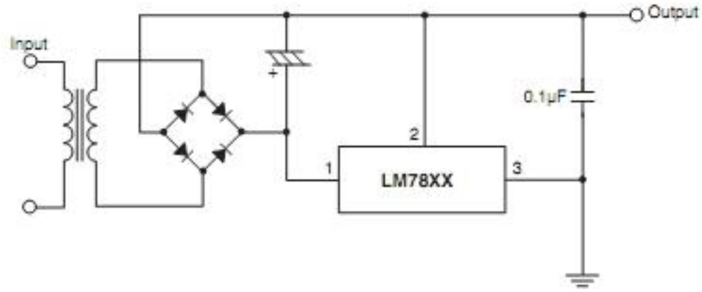


Figure 18. Negative Output Voltage Circuit

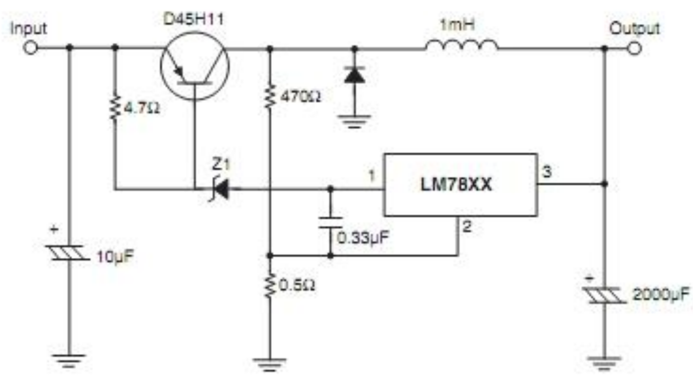
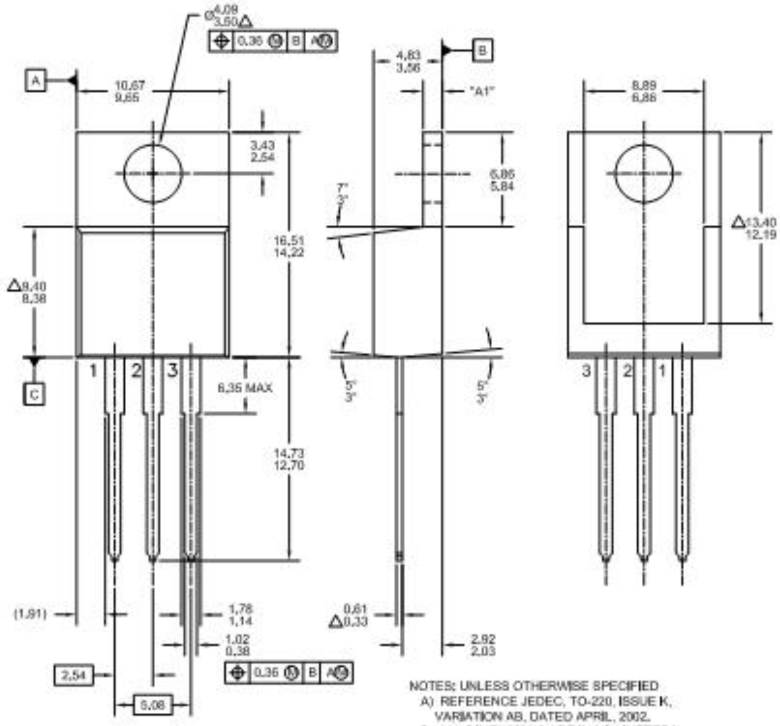


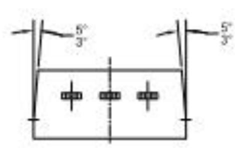
Figure 19. Switching Regulator

Mechanical Dimensions

Dimensions in millimeters

TO-220 [SINGLE GAUGE]





NOTES: UNLESS OTHERWISE SPECIFIED

A) REFERENCE JEDEC, TO-220, ISSUE K, VARIATION AB, DATED APRIL, 2002.

B) ALL DIMENSIONS ARE IN MILLIMETERS.

C) DIMENSIONING AND TOLERANCING PER ANSI Y14.5 - 1973

D) LOCATION OF THE PIN HOLE MAY VARY (LOWER LEFT CORNER, LOWER CENTER AND CENTER OF THE PACKAGE)

E) DOES NOT COMPLY JEDEC STANDARD VALUE.

F) "A1" DIMENSIONS REPRESENT LIKE BELOW:
SINGLE GAUGE = 0,51 - 0,61
DUAL GAUGE = 1,14 - 1,40

G) DRAWING FILE NAME: TO220B03REV6

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Preliminary	First Production	Datasheet contains preliminary data; supplementary data will be published at a later date. Fairchild Semiconductor reserves the right to make changes at any time without notice to improve design.
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