CALIFORNIA STATE UNIVERSITY SACRAMENTO

CHILD SAFETY: PROJECT DOCUMENTATION

PROJECT GUARDIAN

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CHILD SAFETY: Project Documentation

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Abstract—One of the hardest, and sometimes scariest, things for a parent to do is let their child walk out that door alone to be gone for the next eight to sixteen hours. Sure theyre more than likely at school or out with close family friends but there are those times in between, en route, where anything can happen. A child can get lost, run away, or worse yet get kidnapped! These are some of things parents take into consideration when allowing or not allowing their child to go out on their own. Parents and guardians want assurance that their child is safe at their destination and will return home safe and sound. Team Child Safety wants to give these parents peace of mind while their children are not within their grasp. We are doing this by creating a mobile application for the parent to interface with their child who will wear our wearable device that will provide the childs location, capture heart rate data, and allow the child and parent/guardian to communicate via text messaging and voice communication. It will be as if the child is always within reach. This paper will go into more detail as to how our device will operate along with provide the reader with some statistics regarding child safety gathered through research.

Keywords—*Wearable, child, safety, kidnapping, missing, apps, mobile, gps, iot.*

I. Introduction

The Laboratory prototype documentation will cover the following portions: Problem statement, Design idea with punch list, work breakdown structure and time line (year-long portions), as well as photographic documentation from work completed. Along with an additional portion going over the teams participation in the competition, The Pitch, no other team in the senior design class was part of. The report contains executive summaries that contains a synopsis of all the sections, written specifically by the members that have completed work in that specific area. The document will also contain a user guide to help the user understand both the application and device. Along with the proper documentation, the report will also accommodate preliminary testing results.

II. Societal Problem

Research conducted by Team Child Safety during the Fall semester of 2015 displayed that there is a societal need for a device to help reduce the amount of children that are reported missing each year and to help track children that become lost or kidnapped. From the research, the team conducted, it became evident, that this truly was a very serious problem in today's society. In the United States alone, there were at least 466,949 children reported missing by the National Crime Information Center (NCIC). In 2013, this number was at least 462,567. [1]

As the statics show, the number of children reported missing is steadily increasing.

Many predators use social media sites such as Facebook to contact underage children and trick them into meeting them. Youtuber, Coby Persin, set out to perform a social experiment which revealed how easy it can be for someone to kidnap a child using Facebook. [2] YouTuber Coby Persin carried out a child predator test with the agreement of the families of three children one who was 14, another who was 13 and a third who was just 12. Mikayla, 13, started chatting with Coby via a fake Facebook profile for a 15-year-old boy called Jason Biazzo. Just four days later she not only gave him her mobile phone number but she agreed to meet him in her local park.But after arriving she is shocked to find her father there waiting for her instead and he is not happy at all."You realise how scary this could have been?", he tells her. [2] Next up is a 12-year-old girl called Julianna, who agrees with "Jason" that he can come to her house after her father had fallen asleep. Julianna, who also offered up her telephone number without a second thought, texted him saying: "LOL. I would have to wait until my dad falls asleep if you want to chill cos I cant have boys over." Again, Julianna invited him inside and her father (who was not asleep) was not happy at all."Whats wrong with you?" he said. You could have been raped or murdered. I love you. Dont you ever do this again. The third youngster was called Jenna a 14-year-old who again handed over her phone number. This time the parents allowed Cory to pretend to kidnap her in a van to demonstrate the dangers of chatting to strangers online. [2]

All three of these innocent girls did not understand how dangerous the world can be and learned valuable lessons that day. The outcome may have been much worse. This is something that occurs every day. Predators finding new methods to contact underage children and tricking them into meeting them.

III. Design Idea

With the information Team Child Safety has gathered from researching, a consensus was reach on how the team should approach the societal issue. Team Child Safety wants to create a device which will provide location data to enhance the search efforts of missing minors. By allowing parents to track the position of their children through a app on a smart phone, the parents are given more comfort of where their children truly are. Team Child Safety will cover S.W.A.T (Smart Wearable Adolescence Tracker) in more detail throughout this report.

The design has three major focal points. The wearable device, a smart phone application and a central data processing

center. The goal is to keep this wearable as light, user friendly and comfortable as possible while sending vital information to the paired smart phone. The smart phone app will receive information from the wearable such as location. The central data processing center will be used to process the information from the watch to the app.

The design helps to solve the societal problem, by giving children who are in need, a device that can be used to contact for help. Children will be able contact for help, at will, when they are in a frightening situation. Parents will also be able to track their children through the mobile phone application. Giving the users a sense of security and comfort. With such a device implemented, Team Child Safety will give children that are in need of help, a way to inform their guardian. For example if a child is kidnapped, being followed or lost, the device will have GPS, voice communication and a panic button, all of which can be used to contact for help or be found.

A. Feature: Voice Communication

Voice communication is a key aspect for a parent or guardian to have with their child. This feature allows the user, namely the child. the parent or guardian, to communicate with one another verbally. The reasoning behind this, is to keep the child in a calm state of mind. Talking with ones parent or guardian, in a time where one is panicking, can tremendously help. A addition to this feature is to allow communication with more than one parental figure or guardian. Only a select number are allowed to communicate with the child.

For this feature to be enabled on the device, some hardware is required. Team Child Safety has chosen an add-on module for the Intel Edison Platform. This module is the same one that was chosen for Global Positioning System Tracking and GSM Mobile communication.

"The Diymall SIM808 GPS GSM GPRS Module for Arduino" was chosen as the add on module. [3]. In addition to this add on module, Team Child Safety will be required to integrate an antenna for the signal to transmit and receive data on.

The software behind this feature will include the use of some predefined libraries along with custom hand coded functions and classes. [4] The coding for this feature will be done in C/C++ programming language since Arduino supports only these two langauges. The code will include a basic functionality for calling and texting such as make and receive phone calls, send and receive text messages, call disconnect, etc. To code for this platform. Team Child Safety have chosen to use a mixture of IDE's from Jet Brains, namely the IntelliJ IDEA. [5]

It is absolutely crucial for this feature to work 100% of the time. If this feature does not work properly many issues may arise, as this is a feature can be used in a very emotional period of time. One of the instances that this feature could not work properly or could eventually fail is when the wearable device is in the basement of the building or it is in the area where there is poor reception.

To validate voice communication, testing must be done on the data being sent in and out. All vocal transmissions must be tested manually by two parties to confirm, what is being said on the transmission is actually being received on the receiver.

The tests that will be conducted, include, but are not solely limited to the following.

Also, the constant communication of the wearable device with the android application which will show the location of the child through GPS.

To determine if Voice communication is complete, all tests listed above need to completed. Along with the tests, field testing needs to be done.

B. Feature: Mobile GSM Network Connection

The back end of communication with the mechanism and a data communicating server is all achieved with a Mobile GSM Network, GSM, or Global System for Mobile Communications. The Mobile GSM Network, is a definitive developed by the European Telecommunications Standards Institute (ETSI) to construe protocols for second-generation (2G) digital cellular networks used by mobile phones, first deployed in Finland in July 1991. [6] For Team Child safety, this results in being a key feature for the device to work properly. This feature allows the device to transmit data wireless to the central data processing center. Basically, this is the gateway between transmitting and receiving data between a parent/guardian and his or her child. This feature is crucial for the entire unit to work properly. If no data is being transmitted for received, then there is no tracking.

To validate Mobile GSM Network Connection, testing must be done on the data being sent in and out. All data that is sent in and out of the device must be validated. A CRC Check must be performed to determine the integrity of the data at hand.

C. Feature: Global Position System Tracking

Global Position System Tracking is another key feature for a parent to have with their child. This feature allows the user, namely the parent, to track their child. The reasoning behind this, is to allow the parent to know about his or her child's whereabouts. This can come in crucial if the child is lost or even, in a worst case scenario, the child is kidnapped. This can tremendously help the proper authorities locate and retrieve a child, or even the parent if the child is lost.

For this feature to be enabled on the device, some hardware is required. Team Child Safety has chosen an add on module for the Intel Edison Platform. This module is the same one that was chosen for Voice Communication and GSM Mobile communication. "The Diymall SIM808 GPS GSM GPRS Module for Arduino" was chosen as the add on module. [3]. In addition to this add on module, Team Child Safety will be required to integrate an antenna for the signal to transmit and receive data on.

The software behind this feature will include the use of some predefined libraries along with custom hand coded functions

and classes. [4] To code for this platform. Team Child Safety have chosen to use a mixture of IDE's from Jet Brains, namely the IntelliJ IDEA. [5]

It is absolutely crucial for this feature to work 100% of the time. If this feature does not work properly many issues may arise, as this is a feature can be used in a very emotional period of time. The tests that will be conducted, include, but are not solely limited to the following.

To determine if Global Positioning System Tracking is complete, all tests listed above need to completed. Along with the tests, field testing needs to be done.

This feature in general may take a few weeks to complete. It is a key feature, that is required to allow the device to function correctly.

D. Feature: Parental Control Application

A Parental Control Application is required for this device. For a parent to be able to communicate and locate his or her child, some type of mechanism is required. This is were the Parental Control Application comes in. This is the central hub for a parent to use any functionality that the device the child wears will offer. This feature is crucial for the entire unit to work properly. If there is no way for the parent to communicate or locate his or her child then there is no clear purpose for the device, generally speaking. With out this application, major functionality is disabled.

For this feature to be enabled, the parent must have an Android smart phone. This hardware is not provided by Team Child Safety. Team Child safety will provide an application that is downloadable to the smart phone.

The software behind this feature will be hand coded in its entirety using Android Studio as the IDE. This IDE is based upon the IntelliJ platform that Jet Brains offers. [7]

It is absolutely crucial for this feature to work 100% of the time. If this feature does not work properly many issues may arise, as this is a feature can be used in a very emotional period of time. The tests that will be conducted, include, but are not solely limited to the following:

To determine if Parental Control Application is complete, all tests listed above need to completed. Along with the tests, field testing needs to be done.

This feature in general will be an on going process. Estimation for it's complete is not readily available. There are too many variables in determining the length of time that will be taken. It is a key feature that allows the parent to view viable and usable data.

E. Feature: Electrocardiogram

There are particular vitals that need to be watched on a child. One of the imperative vitals is the child's pulse which will result in the child's heart rate. Contemporary heart rate monitors usually comprise two elements: a transmitter and a receiver, though, later units have used conductive smart fabric

with built-in microprocessors that inspects the Electrocardiogram signal to determine heart rate. [8] This results in the Electrocardiogram, EKG becoming an essential feature for this device. With an EKG enabled on this device, a parent is able to view quite a few vitals on his or her child. Some vitals include the child's pulse and if the device is attached to the child. When this data is transmitted, it is first sent to the central processing center to be processed. The data is then refined and permeated on the central processing center and then the processed and filtered data is transmitted to the parental control application. The data given isn't just a number, but instead a level. The heart rate is then displayed in a friendly user interface, or UI. This UI will either display the heart rate in three forms. One, if the heart rate is within an acceptable range. Two, if it is starting to climb. Three, if the heart rate is in a dangerously high range. There is also an option available to display the data as a numerical amount instead. This level indicates if the child's pulse is within reasonable values. If it is not then the parental application alerts the parent of this change. If the device is found to not be connected on the child this is also a good indicator that the child's location may not be 100% valid. This feature is essential in providing useful feedback and metrics for the parent. Without this feature being implemented, the devices functionality can be limited.

For this feature to be enabled, device requires a series of components. A series Operational Amplifier, capacitors, resistors, along with some electrodes are required to complete this feature.

The software behind this feature will be entirely hand coded with a number of functions and classes. [4] To code for this platform. Team Child Safety have chosen to use a mixture of IDE's from Jet Brains, namely the IntelliJ IDEA. [5]

It is important for this feature to work. If this feature does not work properly, many of the metrics being sent to the parental application will not be enabled. The tests that will be conducted, include, but are not solely limited to the following.

To determine if Electrocardiogram is complete, all tests listed above need to completed. Along with the tests, field testing needs to be done.

This feature in general will take a few weeks to complete. It is a key feature that allows the parent to receive viable metrics data on his or her child's vitals.

F. Feature: Panic Button

If the situation ever occurs, where a child is being kidnapped or in danger for instance, the child is able to press the panic button on his or her watch. Briefly speaking, a panic button is an electronic component designed to assist in alerting an individual in emergency situations where a threat to persons or property exists. [9] Which is exactly what a child in a dire situation needs.

This feature is essential in providing useful feedback and metrics for the parent. Without this feature being implemented, the devices functionality can be limited.

For this feature to be incorporated on this device, there are a few components required. A button and resistors are required

for this feature.

The software behind this feature will be entirely hand coded with a number of functions and classes. [4] To code for this platform. Team Child Safety has chosen to use a mixture of IDE's from Jet Brains, namely the IntelliJ IDEA. [5]

It is important for this feature to work. If this feature does not work properly, the child could press the panic button and the parent may never get a notification for this.

To determine if the Panic Button is complete, all tests listed above need to completed. Along with the tests, field testing needs to be done.

This feature in general will take a few weeks to complete. It is a key feature that allows the parent to receives critical information on his or her child.

G. *Feature: Compass*

When locating a child, GPS is not always readily available for use. Backup forms of locating are necessary to add as fail safes for the overall system.

This feature is useful in providing secondary localization data. Without this feature being implemented, the device will not have a fail safe back up when GPS does not function properly or is not readily available for use.

For this feature to be incorporated on this device, there are a few components required. A Triple-axis Accelerometer+Magnetometer (Compass) Board - LSM303 [10], is required to complete this feature.

The software behind this feature will be entirely hand coded with a number of functions and classes. [4] To code for this platform. Team Child Safety has chosen to use a mixture of IDE's from Jet Brains, namely the IntelliJ IDEA. [5]

It is important for this feature to work. If this feature does not work properly, then there is no fail safe system in place.

To determine if Compass is complete, all tests listed above need to completed. Along with the tests, field testing needs to be done.

This feature in general will take a few weeks to complete. It is a key feature that allows the parent to receives a secondary source of information on his or her child.

H. *Feature: Pedometer*

When locating a child, GPS is not always readily available for use. A portable electronic device, that counts each step a person takes by detecting the motion of the person's hips and hands can provide crucial pieces of information that can be used to determine the number of steps that the child in parallel with the direction they are moving with a compass. [11] Backup forms of locating are necessary to add as fail safes for the overall system.

This feature is useful in providing secondary localization data. Without this feature being implemented, the device will not have a fail safe back up when GPS does not function properly or is not readily available for use.

For this feature to be incorporated on this device, there are a few components required. A Triple-axis Accelerometer+Magnetometer (Compass) Board - LSM303 [10], is required to complete this feature.

The software behind this feature will be entirely hand coded with a number of functions and classes. [4] To code for this platform. Team Child Safety has chosen to use a mixture of IDE's from Jet Brains, namely the IntelliJ IDEA. [5]

It is important for this feature to work. If this feature does not work properly, then there is no fail safe system in place.

To determine if Pedometer is complete, all tests listed above need to completed. Along with the tests, field testing needs to be done.

This feature in general will take a few weeks to complete. It is a key feature that allows the parent to receives a secondary source of information on his or her child.

I. *Feature: Wireless Network Usage*

Taking in consideration, the situation where a child may be lost or kidnapped, for instance, GPS and GSM are not always available in certain locations. There is the backup fail safe of a compass/pedometer feature, but this can only go so far. There needs to be another alternative, this is where wireless network usage comes into play. Everywhere around us, there are a growing number of wireless networks, such as Wifi. It would only make sense for this device to connect to them, as well, as another source of data connection. Along with being another source of data connection, wireless networks have identifiers, that identify which network they are. This piece of information can be used in locating a child. This information will be stored and then sent to the Central data processing center for further storage and usage.

This feature is useful in providing additional localization data and an alternative source of data connection.

Without this feature being implemented, the device will be more limited in certain scenarios.

For this feature to be incorporated on this device, there are a few components required. The Intel Edison Platform, will be used, as it has built in wifi and bluetooth radios. [12]

The software behind this feature will use a mixture of predefined libraries along many hand coded functions and classes. [4] To code for this platform. Team Child Safety have chosen to use a mixture of IDE's from Jet Brains, namely the IntelliJ IDEA. [5]

It is important for this feature to work. If this feature does not work properly, then there is no fail safe system in place.

1) Data Reliability
   - Verification of wireless networks being present.
   - Verification of wireless networks names being stored.

To determine if Wireless Network Usage is complete, all tests listed above need to completed. Along with the tests, field testing needs to be done.

This feature in general will take a few weeks to complete. It is a key feature that allows the parent to receives additional

information on his or her child along with the device being able to connect to an alternative data connection.

Data Transmission

When transmitting data, Team Child Safety will begin with series of common steps for each feature which includes cyclic redundancy check, states are coded into the system. An error detection is done through this code. Also, the verification of bit rate for data transfer between CPU and add on module. Team Child Safety will also perform waveform test bench verification that all bits are being transferred correctly based on the clock cycle.

Testing

To determine if each feature set is complete, a series of test will be conducted. Along with the tests, field testing needs to be done.

IV. FUNDING: "THE PITCH"

The pitch is a competition hosted by the Center of Entrepreneurship at Sacramento State along with the Association of Collegiate Entrepreneurs. This competition is designed to help participants turn their solution to a problem in to a business. This event was closed to Sacramento State students, the winners from this even would be able to attend the Future Four competition. Team Child Safety decided that this competition would be a good way to get reimbursed and also provide funding for Project Guardian. The prizes for winning were the following: First Place $700, Second Place $500, and Third Place $300. It was the first time presenting Project Guardian outside of the classroom, and to the team it seemed like a great success. Unfortunately, Team Child Safety was unable to place in the qualifying round, it did not discourage the team at all. The team considered this a valuable learning experience, and will continue to participate in any competitions, and strive for greatness.

V. PLANNING FOR THE SPRING 2016 SEMESTER

As the first half of our senior design winds down we are able to look back and take note of our successes while also looking into the future to the additional features to be added to make our system great. We have been able to get the following systems working: GSM communication, GPS localization, Heart rate sensor data, user verification, data streaming, and our mobile application along with our website. Taking a closer look into next semester, we plan to implement the following features: Panic Button, Battery and charging mechanism, design of band, clock, pedometer, improving our mobile application, and a feature which detects and stores other phones wireless ids. The previously stated additional features to be implemented during the spring semester are fairly self-explanatory except for the last feature which I will explain in more detail. In the event that a child is kidnapped, although there will be our GPS module, law enforcement and especially the parent/guardian would benefit from knowing who they are dealing with. To assist in this manner we plan to implement a feature that detects and stores surrounding phone wi-fi IDs as well as the time and length of time in which the phones were within range of the users wearable device. We believe this will potentially identify the kidnapper and make retrieving the child a success. Along with our new features, we still plan on continuously improving our current features and focusing on the actual build of the wearable. We are currently utilizing Arduinos but plan to implement all of our features on the Intel Edison to improve and enhance processing as well as decrease in the size of the band to make it more aesthetically pleasing to the user.

VI. WORK BREAKDOWN STRUCTURE

TABLE I: Work Breakdown Structure

Feature	Subtask	Activity
Localization	Voice Communication	Interface GSM Radio with Intel Edison Kit/Arduino UNO
		Validation of feature with overall system
	Mobile GSM Network Connection	Interface GSM Radio with Intel Edison Kit/Arduino UNO
		Validation of feature with overall system
	Global Positioning System Tracking Set	Interface GSM Radio with Intel Edison Kit/Arduino UNO
		Validation of feature with overall system
	Compass	Interface Compass with Intel Edison Kit/Arduino UNO
		Validation of feature with overall system
	Pedometer	Interface Pedometer with Intel Edison Kit/Arduino UNO
		Validation of feature with overall system
	Wireless Network Usage	Interface WiFi Radio with Intel Edison Kit/Arduino UNO
		Validation of feature with overall system
	Central Data Processing Center	Interface Central Processing Center with Intel Edison Kit/Arduino UNO
		Interface Central Processing Center with the Intel Edison Kit/Arduino UNO
		Validation of feature with overall system
Application	Clock	Implement Clock Interface in the Application
		User Verification with the Application
	User Verification	User Verification with the Application
		Debug feature for any bugs encountered in Validation
	Real Time Location	Implement Real Time Location in the Application
	Locking Mechanism	Implement Locking Mechanism in the Application
	Threat Level	Implement Threat Level in the Application
Vitals	Electrocardiogram	Implement Electrocardiogram in the Application
		Interface Electrocardiogram,with the Intel Edison Kit/Arduino UNO
		Validation of feature with overall system
Wearable Device	Panic Button	Interface the Panic Button with the Intel Edison Kit/Arduino UNO
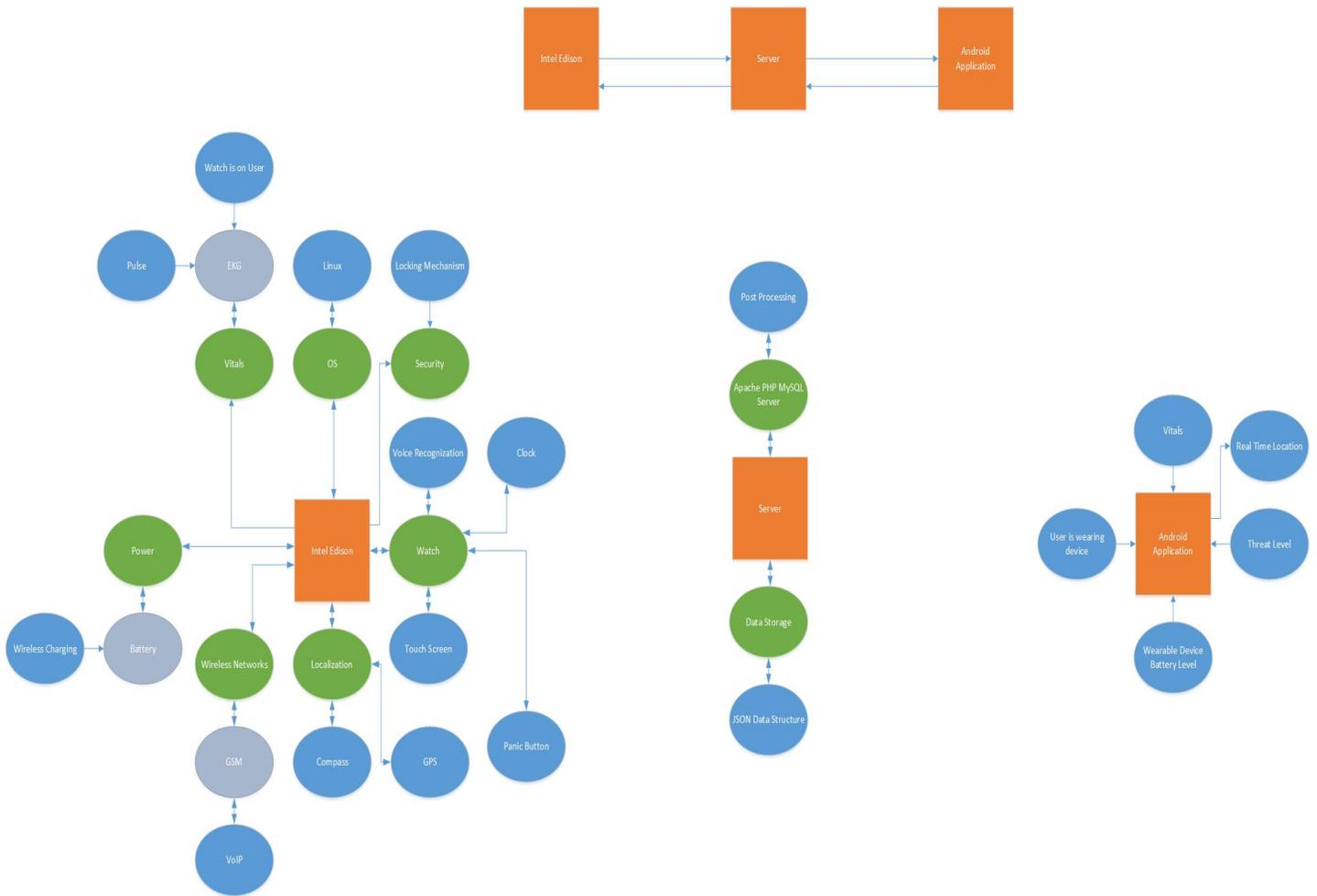
Fig. 1: Work Breakdown Structure Diagram

VII. PROJECT TIME LINE

TABLE II: Project Time Line

Tasks	Due Date
Develop Working Prototype	12/04/15
Continue improving Working Prototype	04/25/16
Problem Statement Report	09/14/15
Design Idea Contract	09/28/15
Work Breakdown Structure	09/28/15
Project Timeline	10/12/14
Risk Assessment Report	12/26/15
End of Term Documentation	12/11/15
Revised Problem Statement	01/22/16
Device Test Plan Report	02/01/16
Market Review	02/29/16
Mid Term Review	3/14/16
Deploy-able Prototype Presentation	4/18/16
End of Project Presentation	5/19/16
Android Application	4/1/16
Voice Communication	11/27/15
Global Positioning Date	11/27/15
Server	11/27/15
Vitals	11/27/15
User Verification	11/27/15
Panic Button	1/11/16
Wireless Network Monitoring	1/11/16
Touch Screen Display	11/27/15
Compass/Pedometer	1/11/16
Battery	2/12/16
Wireless Charging	4/1/16
Integrating all components together	4/1/16

VIII. RISK ASSESSMENT AND MITIGATION'S

As Team Child Safety is working to develop a wearable device for children that will be synced to a mobile app in which their parents will be able to view the status of their safety, health, and whereabouts, there are many risks to take in consideration. The four main features that pose as the four main risk, if execution fails, are localization, voice communication, the mobile application, and user verification.

Localization is critical in our design as it allows the parent/guardian the ability to view their child's location as the child wears the wearable which contains a GPRS and GSM module. The GPRS module is what enables the localization but cannot work properly unless paired with the GSM module which provides it the ability to send the location data to the mobile application for the parent/guardian to view. One of the goals of this product is to provide the parent/guardian with the ability to view their child's whereabouts and if our GPRS/GSM module fails then the entire product fails. We currently have this feature up and running and our goal for next semester is to incorporate a fail safe feature in case this fails which will incorporate an inertial measurement unit which will provide back up localization data. In conjunction with our localization feature, we are providing the ability for the child to communicate with the parent/guardian directly via voice communication and text messaging. We currently do not have any back up communication services if this feature were to completely fail but in the event that this feature were to fail, the parent/guardian will be notified via the mobile app and the wearable device.

The mobile application is one of the cornerstones of our wearable device as it provides the parent/guardian with the necessary data on their child. In the event that this feature fails to execute, our device will then begin to send the pertinent data via text messaging directly to the parents device. One of our biggest fears is our device ending up in the wrong hands and being manipulated by a thief, which could potentially alter and provide false data to the parent/guardian. To combat this we will be utilizing a user verification method which requires the user to input a password in order to register, utilize, and view data on the device. With our combined efforts we hope to provide the user and parent/guardian with an extra pair of eyes that is with their child even when their child is not within their sight.

IX. TASK'S ASSIGNED

Each member of the group was assigned certain features of this project depending on skill set, what they wanted to work on and the work load of each feature.

Below is a table with shows the tasks Zohaib Arshad worked on this semester.

TABLE III: Zohaib's Assignments

Task	Hours
Problem Statement Report	20 Hours
Design Idea Report	25 Hours
Work Breakdown Report	32 Hours
Project Time line	10 Hours
Risk Assessment Report	3 Hours
Heart Rate Sensor	12 Hours
Android Application	2 Hours
Localization Feature	10 Hours
Voice Communication Feature	29 Hours
Shield Debugging	7 Hours
Global Positioning System Feature	10 Hours
Setting up Intel Edison	5 Hours
Implement GPS/GSM Shield with Intel Edison	10 Hours
The Pitch Competition	8 Hours
Laboratory Prototype Documentation	10 Hours
Total	**193 Hours**

Below is a table with shows the tasks Jashanjit Badwal worked on this semester.

TABLE IV: Jashanjit's Assignments

Task	Hours
Problem Statement Report	20 Hours
Design Idea Report	25 Hours
Work Breakdown Report	32 Hours
Project Timeline	10 Hours
Risk Assessment Report	3 Hours
Heart Rate Sensor	4 Hours
Android Application	5 Hours
Localization Feature	8 Hours
Voice Communication	59 Hours
Laboratory Prototype Documentation	15 Hours
Total	**181 Hours**

Below is a table with shows the tasks Leonardo Jacobo worked on this semester.

TABLE V: Leonardo's Assignments

Task	Hours
Problem Statement Report	20 Hours
Design Idea Report	25 Hours
Work Breakdown Report	32 Hours
Project Time line	10 Hours
Risk Assessment Report	3 Hours
Android Application Development	73 Hours
Repository	2 Hours
The Pitch Competition	8 Hours
Python Refresher	4 Hours
Laboratory Prototype Documentation	12 Hours
Total	**189 Hours**

Below is a table with shows the tasks Didier Mponte worked on this semester.

TABLE VI: Didier's Assignments

Task	Hours
Risk Assessment Report	10 Hours
Heart Rate Sensor	38 Hours
Risk Assessment Presentation	1 Hours
User Verification	10 Hours
Data Transfer to Server	20 Hours
Access Code and Security	10 Hours
Laboratory Prototype Documentation	3 Hours
Total	**92 Hours**

Below is a table with shows the tasks Harpreet Sidhu worked on this semester.

TABLE VII: Harpreet's Assignments

Task	Hours
Problem Statement Report	20 Hours
Design Idea Report	25 Hours
Work Breakdown Report	32 Hours
Project Time Line	10 Hours
Risk Assessment Report	3 Hours
Heart Rate Sensor	2 Hours
Android Application Development	69 Hours
Repository	5 Hours
Touch screen	10 Hours
Server Development	20 Hours
Back end Code Development	36 Hours
Data Retrieval API Development	10 Hours
Authentication API Development	10 Hours
The Pitch Competition	8 Hours
Synchronization API	10 Hours
Data Management	4 Hours
User Authentication API	3 Hours
Laboratory Prototype Documentation	10 Hours
Total	287 Hours

TABLE VIII: Hours Per Assignment

Task	Zohaib	Jashanjit	Leonardo	Didier	Harpreet	Total
Problem Statement Report	20	20	20	0	20	80
Design Idea Report	25	25	25	0	25	100
Work Breakdown Report	32	32	32	0	32	128
Project Time Line	10	10	10	0	10	40
Risk Assessment Report	3	3	3	10	3	22
Voice Communication	29	59	0	0	0	88
Localization	10	8	0	0	0	18
Android Application	2	5	75	0	74	156
Touch Screen	0	0	0	0	10	10
Global Positioning System	10	0	0	0	0	10
User Verfication	0	0	0	10	0	10
Server	0	0	0	0	93	93
Heart Rate Sensor	12	0	0	38	2	52
Laboratory Prototype	10	15	12	3	10	50

X.   User Manual

The project has two essential features the user will need to understand how to use. The first is the wearable device which the parent of guardian will use to communicate with the wearable device. The second is the wearable device, the child will wear, which gives essential information to the parent or guardian.

A. Android Application

Team Child Safety has designed an application to work hand in hand with the device the user will be wearing. The purpose of the application is to prove the guardian of the user a feasible way to keep track of the whereabouts and important information regarding the user. The team decided that the best way to make an application was to keep it simple. The application highlights key features like Overview of the user, communication, and Miscellaneous. Within those features are subsections that will contain specific controls that will be available to the guardian.

As stated before the application is split into three portions. First is the overview, the overview will contain the basic information about the wearer. The two options currently available are vitals, and /GPS location. Communication is split into the

Fig. 2: Application Overview

following portions, calling and texting. If you select the calling function, the application will automatically call the wearer, The Miscellaneous option will have any options the team feels
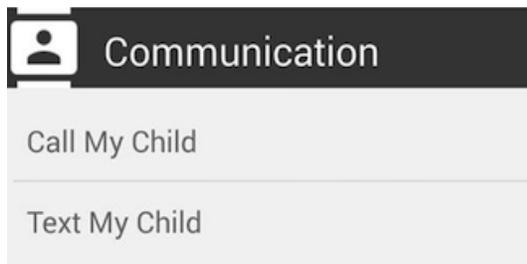
Fig. 3: Application Communication

will be necessary, for example, the contacts available on the device that the user can access. Most of these features are simple to use, basically you select the option you want and the application will do the rest. The way it's set up, makes it
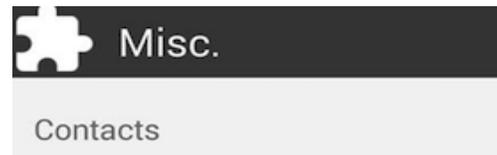
Fig. 4: Application Miscellaneous

so that the user wont have to input anything. Team Child Safety figured that the best approach would be a fast and simple one, the application will recognize the device and display the information needed when selected.

B. Wearable Device

As of right now, all usage of the wearable device must be done through a serial monitor application. The recommended application is the Arduino software's serial monitor, which is available at http://www.arduino.cc/ A text based user interface is provided as of now. Through this interface a user is able to make calls, send and receive text messages, transmit and receive synchronous data from the central data storage center.

XI.   Design Documentation

For our project to work as expected, a combination of both hardware and software is required. The details for the hardware equipment and software we used are given in detail below.

A. Hardware

For the hardware, the team relied primarily on the Arduino Uno as the main micro controller this semester. Eventually the team plans to transition to the Intel Edison, a microprocessor which is stronger, and much smaller then the Aduino Uno. For the GSM/GPRS/GPS shield, the team had to make various changes. The first shield we used, The Quadband GSM/GPRS/GPS shield stopped functioning, and after hours of debugging, the team decided to buy new component. The team needed to eventually replace this component as it was very big and would not suite a wearable device. To keep the project moving, the team purchased a GPRS shield for voice communication and texting. The team later bought a Lonet - GSM/GPRS/GPS Breakout, which included all of the essential features we needed. This component was very small and light, a excellent replacement for the Quadband GSM/GPRS/GPS. The team also bought spare components if any of the equipment stopped functioning.

B. Software

Software for this project has been coded from the ground up. Multiple integrated development environments, or IDE for short, are used in the development of the software. The Jetbrains software suite is widely used ranging from code that is done within Android XML, Android Java, C, C++, PHP, Python, and SQL. The different parts of this software suite There is a need to have a complier for the microcontrollers and

microprocessors that are used. The software for these include Intel's XDK software, and Arduino's very own IDE. All data transactions are ran through the UART protocol. UART, universal asynchronous receiver/transmitter, is a protocol that allows data to transfer from one location to another over high speeds. Calling, texting and locating can be verified using the code provided.

XII. INTEGRATION PLANS

The team conducted many tests to check if the device is working correctly.This was done regularly to determine if each feature is working correctly. For example, to test out the Voice Communication Feature, the team would make calls from and to the GSM/GPRS shield. This was done for all features including the android application, global positioning system, and heart rate sensor. This also provided us feedback for which members needed help and which features required more assistance.

From this the team was able to determine how to integrate the features together. The team did encounter situations where some of the hardware was not compatible with other hardware or software. Only after confirming each part would work together, we would purchase the item. Only after each member had their feature working correctly with the hardware or software, the team would try to integrate the components together. So far, the team has run into minor errors but the major components still need to be integrated into the project. The team plans to dedicate this week to that.

XIII. PHOTOGRAPHIC DOCUMENTATION

Below is the GPRS/GSM/GPS module that team child safety will be using for voice communciation and GPS location.

Fig. 5: GSM/GPRS/GPS

Below is the Intel Edison microprocessor that team child safety will be using for integrating all the features together.

Fig. 6: Intel Edison Chip

Below is the Intel Edison Board that team child safety will be using for integrating all the features together.

Fig. 7: Intel Edison Board

Below is the working prototype of GPRS/GSM/GPS using Arduino UNO board.
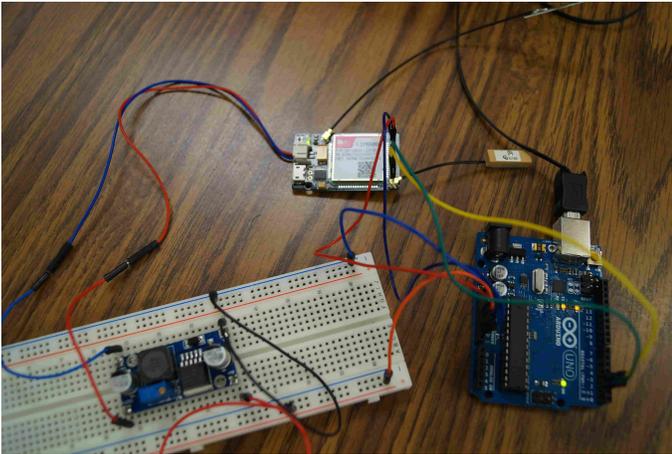
Fig. 8: GSM/GPRS/GPS Working Prototype

XIV.   CONCLUSION

This document has described our development towards a wearable device that will provide parents and guardians peace of mind as their children are out and about throughout the day by providing their location, status of their health, and a medium to communicate (via voice and text messaging). We believe that users of our product will benefit from the wealth of data our device captures and stores. As members of the engineering community it is our responsibility to utilize our skillsets and knowledge obtained to better society. Children have and will always be the key to our future as bred amongst them will be our next great leaders and inventors and we believe it is our duty to protect them and ensure their safety. With our combined engineering skillsets we believe our system will accomplish this task while also providing parents and guardians with peace of mind.

APPENDIX

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GLOSSARY

CAD
       Computer-Aided Design.

CPU
       Central Processing Unit.

CRC
       Cyclic Redundancy Check.

EKG
       Electrocardiogram.

ETSI
       European Telecommunications Standards Institute.

GPRS
       General Packet Radio Service.

GPS
       Global Positioning System.

GSM
       Global System for Mobile Communications.

IDE
       Integrated Development Environment.

IMU
       Inertial Measurement Unit.

IoT
       Internet of Things.

MCSM
       Mobile Children Security Monitoring.

NCIC
       National Crime Information Center.

NCMC
       National Center for Missing Children.

NCMEC
       National Center for Missing and Exploited Children.

PCB
       Printed Circuit Board.

UI
       User Interface.

ACKNOWLEDGMENT

Intel® Edison Development Platform

Introduction

The Intel® Edison development platform is designed to lower the barriers to entry for a range of inventors, entrepreneurs, and consumer product designers to rapidly prototype and produce "Internet of Things" (IoT) and wearable computing products.

Intel® Edison Board for Arduino*

Supports Arduino Sketch, Linux, Wi-Fi, and Bluetooth.

Board I/O: Compatible with Arduino Uno (except 4 PWM instead of 6 PWM):

- 20 digital input/output pins, including 4 pins as PWM outputs.
- 6 analog inputs.
- 1 UART (Rx/Tx).
- 1 I²C.
- 1 ICSP 6-pin header (SPI).
- Micro USB device connector OR (via mechanical switch) dedicated standard size USB host Type-A connector.
- Micro USB device (connected to UART).
- SD card connector.
- DC power jack (7 to15 VDC input).

Intel® Edison Breakout Board

Slightly larger than the Intel® Edison module, the Intel® Edison Breakout Board has a minimal set of features:

- Exposes native 1.8 V I/O of the Edison module.
- 0.1 inch grid I/O array of through-hole solder points.
- USB OTG with USB Micro Type-AB connector.
- USB OTG power switch.
- Battery charger.
- USB to device UART bridge with USB micro Type-B connector.
- DC power supply jack (7 to 15 VDC input).

Intel® IoT Analytics Platform

- Provides seamless Device-to-Device and Device-to-Cloud communication.
- Ability to run rules on your data stream that trigger alerts based on advanced analytics.
- Foundational tools for collecting, storing, and processing data in the cloud.
- Free for limited and noncommercial use.
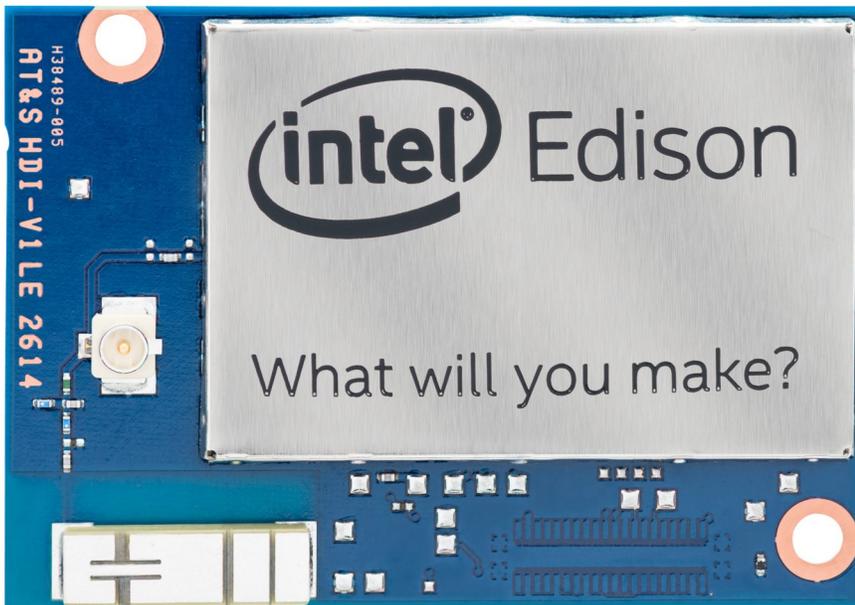
Intel® Edison Development Platform

PHYSICAL	
Form factor	Board with 70-pin connector
Dimensions	35.5 × 25.0 × 3.9 mm (1.4 × 1.0 × 0.15 inches) max
C/M/F	Blue PCB with shields / No enclosure
Connector	Hirose DF40 Series (1.5, 2.0, or 3.0 mm stack height)
Operating temperature	32 to 104°F (0 to 40°C)

EXTERNAL INTERFACES	
Total of 40 GPIOs, which can be configured as:	
SD card	1 interface
UART	2 controllers (1 full flow control, 1 Rx/Tx)
I2C	2 controllers
SPI	1 controller with 2 chip selects
I2S	1 controller
GPIO	Additional 12 (with 4 capable of PWM)
USB 2.0	1 OTG controller
Clock output	32 kHz, 19.2 MHz

MAJOR EDISON COMPONENTS	
SoC	22 nm Intel® SoC that includes a dual-core, dual-threaded Intel® Atom™ CPU at 500 MHz and a 32-bit Intel® Quark™ microcontroller at 100 MHz
RAM	1 GB LPDDR3 POP memory (2 channel 32bits @ 800MT/sec)
Flash storage	4 GB eMMC (v4.51 spec)
WiFi	Broadcom* 43340 802.11 a/b/g/n; Dual-band (2.4 and 5 GHz) Onboard antenna or external antenna (SKU configurations)
Bluetooth	Bluetooth 4.0

POWER	
Input	3.3 to 4.5 V
Output	100 ma @3.3 V and 100 ma @ 1.8 V
Power	Standby (No radios): 13 mW Standby (Bluetooth 4.0): 21.5 mW (BTLE in Q4-14) Standby (Wi-Fi): 35 mW

FIRMWARE + SOFTWARE	
CPU OS	Yocto Linux* v1.6
Development environments	Arduino* IDE Eclipse supporting: C, C++, and Python Intel XDK supporting: Node.JS and HTML5
MCU OS	RTOS
Development environments	MCU SDK and IDE

Intel® Edison for Arduino®
Sept/2014

IOREF Jumper selects 3.3V or 5V Shield Operation

ICSP

IO12	1	2	5V
IO13	3	4	~IO11
RESET	5	6	GND

7V to 15V Brick Power Supply

POWER
1
IOREF 2
RESET 3
3.3V 4
5V 5
GND 6
GND 7
VIN 8

3.3V
5V
VIN (7V to 15V)

ANALOG IN
A0 1
A1 2
A2 3
A3 4
A4 5
A5 6

MUX

Level Shifter

6

6   GPIO

I2C

5

ADC   SPI0

SEL &PULL UP

Port Expander

Port Expander

DIR

I2C

Intel® Edison

SPI1   2
SPI1   MUX

Level Shifter

GPIO

PWM   4

JUMPER SELECTION

3

3

Level Shifter

GPIO

2   UART 1

DIGITAL (PWM~)

10   SCL
9   SDA
8   AREF
7   GND
6   IO13
5   IO12
4   ~IO11
3   ~IO10
2   IO9
1   IO8

8   IO7
7   ~IO6
6   ~IO5
5   IO4
4   ~IO3
3   IO2
2   TX →
1   RX ←

DIR &PULL UP

3.3V <-> 5V Level Translation provided on board between all Edison I/O and Shield Headers

USB OTG

Micro SD Connector

SD

UART 2

USB MUX

UART = USB FTDI

Port Expander

Port Expander

I2C

Host USB Full size Type-A

Client USB Micro Type-B

Client USB Micro Type-B

EDISON FOR ARDUINO® BOARD

Title   Title page

Size   B   Document Number   H40485   Rev   5

Date: Tuesday, August 26, 2014   Sheet   1   of   11

MICRO USB INTERFACE

J4
GND   P5*5   GND
S2 GND ID   P4
S1 GND DP   P3
        DM   P2
        VCC P1   VBUS
MICRO-SMD

2   2   VBUS
1   1   GND
J3

SIMCARD SLOT

J1
        VCC   SIM_VDD
6   VPP   SIM_DATA
5   I/O   SIM_CLK
        GND   CLK   SIM_RST
               RST

ESDA6V1SC5
D1

ANTENNA

L1 22pH   R4   22   VDD_EXT
ANT1   GPS_RF
Only used for active GPS antenna

ANT2   GSM_RF

SIM808

GND 68
GND 67
GND 66   GSM_RF
     65
GND 64
GND 63
     62
     61
     60   COL0
     59   COL1
     58   COL2
     57   COL3
     56   ROW0
     55   ROW1
     54   ROW2
     53   ROW3
     52   ANT_BT   GND

GND 1   GND   GND   51   GND
GND 2   GND   NETLIGHT 50 NETLIGHT
GND 3   GND   STATUS   49 STATUS
     4   VBAT   PCM_OUT   48
VBAT 5   VBAT   PCM_IN   47
     6   VBAT   PCM_CLK   46
VDD_EXT 7 VDD_EXT   PCM_SYNC 45
PWRKEY 8 PWRKEY   GPIO6   44
DTR 9   DTR   GPIO5   43
RI   10 RI   PWM1   42
     11 DCD   PWM2   41
     12 CTS   GND   40   GND
     13 RTS   SCL   39
TXD 14 TXD   SDA   38
RXD 15 RXD   1PPS   37
RESET 16 RESET   GND   36   GND
VRTC 17 VRTC   GPS_RF_IN 35   GPS_RF

C18 100uF

RTC BATTERY

GND 18
MICIN 19
MICIP 20
SPKIN 21
SPKIP 22
ADC1 23
ADC2 24
VBUS 25
USB_DP 26
USB_DM 27
GND 28
SIM_VDD 29
SIM_DATA 30
SIM_CLK 31
SIM_RST 32
SIM_PWR 33
GND 34

LEVEL CONVERTING

VDD_EXT   H_VIO
            1   14
VDD_EXT 8 OE   VCCA VCCB
DTR 2   A1   B1   13 H_DTR
RI   3   A2   B2   12 H_RI
TXD 4   A3   B3   11 H_TXD
RXD 5   A4   B4   10 H_RXD
         1.2-3.6V 1.65-5.5V
U1   7   TXB0104PWR   GND

INDICATOR

D4 red   R14 100R
NETLIGHT

D5 green R15 100R
STATUS

Connectors

VBAT 9
GND 8
H_VIO 7
H_DTR 6
PWRKEY   H_PWR 5
D2 1N4148   H_RI 4
             H_TXD 3
RESET   H_RXD 2
D3 1N4148   H_RST 1
J2

POWER SUPPLY

JST-2.0
1P*1 VBAT   C2 10pF
2N*1 GND   D6 PZ3D4V2H
CN2   C1 33pF
                 C4 470uF   GND

POWER SWITCH

K1
A0   A0 A1   A1
B0   B0 B1   B1   PWRKEY

TITLE: SIM808B

Design by: Deray

REV:

Date: ?????

Sheet: 1/1

SIM808_Hardware Design_V1.00

Development Kit

Hardware Design

Reference Design
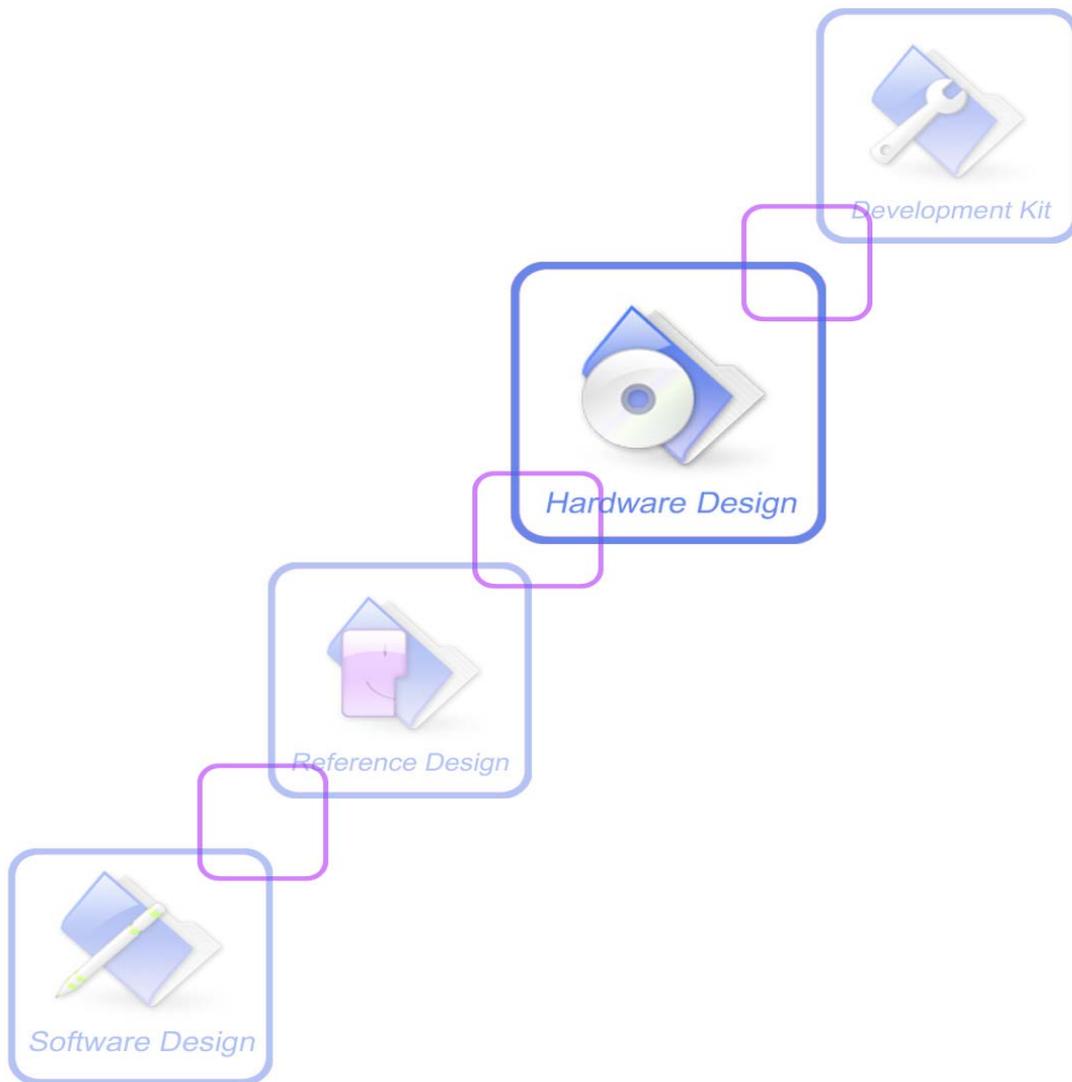
Software Design

Document Title	SIM808_Hardware_Design_V1.00
Version	1.00
Date	2014-03-27
Status	Release
Document Control ID	SIM808_Hardware Design

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Contents

Table Index

<h1 align="center">Figure Index</h1>

Version History

Date	Version	Description of change	Author
2014-03-27	1.00	Origin	ShengWu.Sun Xuegang.Wang

1 Introduction

This document describes SIM808 hardware interface in great detail. This document can help user to quickly understand SIM808 interface specifications, electrical and mechanical details. With the help of this document and other SIM808 application notes, user guide, users can use SIM808 to design various applications quickly.

2 SIM808 Overview

Designed for global market, SIM808 is integrated with a high performance GSM/GPRS engine, a GPS engine and a BT engine. The GSM/GPRS engine is a quad-band GSM/GPRS module that works on frequencies GSM 850MHz, EGSM 900MHz, DCS 1800MHz and PCS 1900MHz. SIM808 features GPRS multi-slot class 12/ class 10 (optional) and supports the GPRS coding schemes CS-1, CS-2, CS-3 and CS-4. The GPS solution offers best-in-class acquisition and tracing sensitivity, Time-To-First-Fix (TTFF) and accuracy.

With a tiny configuration of 24*24*2.6mm, SIM808 can meet almost all the space requirements in user applications, such as M2M, smart phone, PDA, tracker and other mobile devices.

SIM808 has 68 SMT pads, and provides all hardware interfaces between the module and customers' boards.
- Support 4*4*2 keypads.
- One full modem serial port.
- One USB, the USB interfaces can debug, download software.
- Audio channels which include a microphone input and a receiver output.
- One SIM card interface.
- Charging interface.
- Programmable general purpose input and output.
- Support Bluetooth function.
- Support PWM and ADC.
- PCM/SPI/SD card interface, only one function can be accessed synchronously. (Default function is PCM).

SIM808 is designed with power saving technique so that the current consumption is as low as 1mA in sleep mode (GPS engine is powered down).
SIM808 integrates TCP/IP protocol and extended TCP/IP AT commands which are very useful for data transfer applications. For details about TCP/IP applications, please refer to *document [2]*.

2.1 SIM808 Key Features

Table 1: SIM808 GSM/GPRS engine key features

Feature	Implementation
Power supply	3.4V ~ 4.4V
Power saving	Typical power consumption in sleep mode is 1mA (BS-PA-MFRMS=9, GPS engine is powered down)
Charging	Supports charging control for Li-Ion battery
Frequency bands	• SIM808 Quad-band: GSM 850, EGSM 900, DCS 1800, PCS 1900. SIM808

	can search the 4 frequency bands automatically. The frequency bands also can be set by AT command "AT+CBAND". For details, please refer to *document [1].* ● Compliant to GSM Phase 2/2+
Transmitting power	● Class 4 (2W) at GSM 850 and EGSM 900 ● Class 1 (1W) at DCS 1800 and PCS 1900
GPRS connectivity	● GPRS multi-slot class 12（default） ● GPRS multi-slot class 1~12 (optional)
Temperature range	● Normal operation: -40℃ ～ +85℃ ● Storage temperature -45℃~ +90℃
Data GPRS	● GPRS data downlink transfer: max. 85.6 kbps ● GPRS data uplink transfer: max. 85.6 kbps ● Coding scheme: CS-1, CS-2, CS-3 and CS-4 ● PAP protocol for PPP connect ● Integrate the TCP/IP protocol. ● Support Packet Broadcast Control Channel (PBCCH) ● CSD transmission rates：2.4，4.8，9.6，14.4 kbps
CSD	● Support CSD transmission
USSD	● Unstructured Supplementary Services Data (USSD) support
SMS	● MT, MO, CB, Text and PDU mode ● SMS storage: SIM card
SIM interface	Support SIM card: 1.8V, 3V
External antenna	Antenna pad
Audio features	Speech codec modes: ● Half Rate (ETS 06.20) ● Full Rate (ETS 06.10) ● Enhanced Full Rate (ETS 06.50 / 06.60 / 06.80) ● Adaptive multi rate (AMR) ● Echo Cancellation ● Noise Suppression
Serial port and USB interface	**Serial port:** ● Full modem interface with status and control lines, unbalanced, asynchronous. ● 1200bps to 115200bps. ● Can be used for AT commands or data stream. ● Support RTS/CTS hardware handshake and software ON/OFF flow control. ● Multiplex ability according to GSM 07.10 Multiplexer Protocol. ● Autobauding supports baud rate from 1200 bps to 115200bps. **USB interface:** ● Can be used as debugging and firmware upgrading.
Phonebook management	Support phonebook types: SM, FD, LD, RC, ON, MC.
SIM application toolkit	GSM 11.14 Release 99
Real time clock	Support RTC
Alarm function	Can be set by AT command
Physical characteristics	Size: 24*24*2.6mm Weight: 3.5g

Firmware upgrade	Firmware upgrading by USB interface.

Table 2: GPS engine Performance

Parameter	Description	Performance			
		Min	Type	Max	Unit
Horizontal Position Accuracy(1)	Autonomous		<2.5		m
Velocity Accuracy(2)	Without Aid		0.1		m/s
	DGPS		0.05		m/s
Acceleration Accuracy	Without Aid		0.1		m/s^2
	DGPS		0.05		m/s^2
Timing Accuracy			10		nS
Dynamic Performance	Maximum Altitude			18000	m
	Maximum Velocity			515	m/s
	Maximum Acceleration			4	G
Time To First Fix(3)	Hot start		1		s
	Warm start		28		s
	Cold start		30		s
Sensitivity	Autonomous acquisition(cold start)		-147		dBm
	Re-acquisition		-159		dBm
	Tracking		-165		dBm
Receiver	Channels		22/66		
	Update rate			5	Hz
	Tracking L1, CA Code				
	Protocol support NMEA				
Power consumption(4)	Acquisition		42		mA
	Continuous tracking		24		mA

(1) 50% 24hr static, -130dBm

(2) 50% at 30m/s

(3) GPS signal level: -130dBm

(4) Single Power supply 3.8V@-130dBm,GSM IDLE

Table 3: Coding schemes and maximum net data rates over air interface

Coding scheme	1 timeslot	2 timeslot	4 timeslot
CS-1	9.05kbps	18.1kbps	36.2kbps
CS-2	13.4kbps	26.8kbps	53.6kbps
CS-3	15.6kbps	31.2kbps	62.4kbps
CS-4	21.4kbps	42.8kbps	85.6kbps

2.2 Operating Modes

The table below summarizes the various operating modes of SIM808.

Table 4: Overview of operating modes

Mode	Function	
Normal operation	GSM/GPRS SLEEP	Module will automatically go into sleep mode if the conditions of sleep mode are enabling and there is no on air and no hardware interrupt (such as GPIO interrupt or data on serial port). In this case, the current consumption of module will reduce to the minimal level. In sleep mode, the module can still receive paging message and SMS.
	GSM IDLE	Software is active. Module registered to the GSM network, and the module is ready to communicate.
	GSM TALK	Connection between two subscribers is in progress. In this case, the power consumption depends on network settings such as DTX off/on, FR/EFR/HR, hopping sequences, antenna.
	GPRS STANDBY	Module is ready for GPRS data transfer, but no data is currently sent or received. In this case, power consumption depends on network settings and GPRS configuration.
	GPRS DATA	There is GPRS data transfer (PPP or TCP or UDP) in progress. In this case, power consumption is related with network settings (e.g. power control level); uplink/downlink data rates and GPRS configuration (e.g. used multi-slot settings).
	Charge	The mode support charge function (Default is not support).
Power down		Normal power down by sending the AT command "AT+CPOWD=1" or using the PWRKEY. The power management unit shuts down the power supply for the baseband part of the module, and only the power supply for the RTC is remained. Software is not active. The serial port is not accessible. Power supply (connected to VBAT) remains applied.
Minimum functionality mode		AT command "AT+CFUN" can be used to set the module to a minimum functionality mode without removing the power supply. In this mode, the RF part of the module will not work or the SIM card will not be accessible, or both RF part and SIM card will be closed, and the serial port is still accessible. The power consumption in this mode is lower than normal mode.

2.3   SIM808 Functional Diagram

The following figure shows a functional diagram of SIM808:

- The GSM baseband engine
- The GPS engine
- Flash
- The GSM radio frequency part
- The antenna interface
- The other interfaces
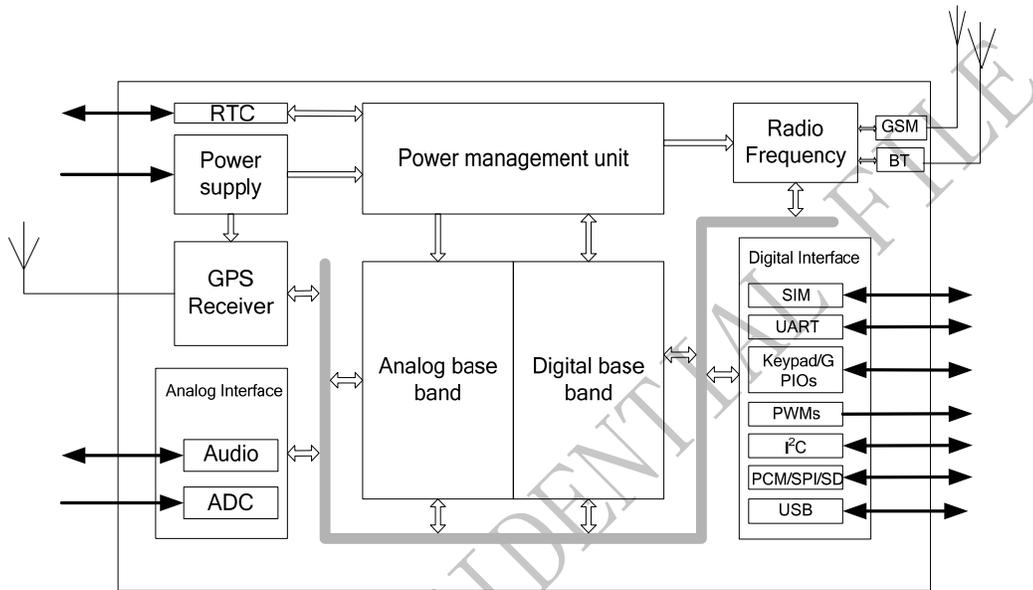
Figure 1: SIM808 functional diagram

# 3 Package Information

3.1 Pin out Diagram
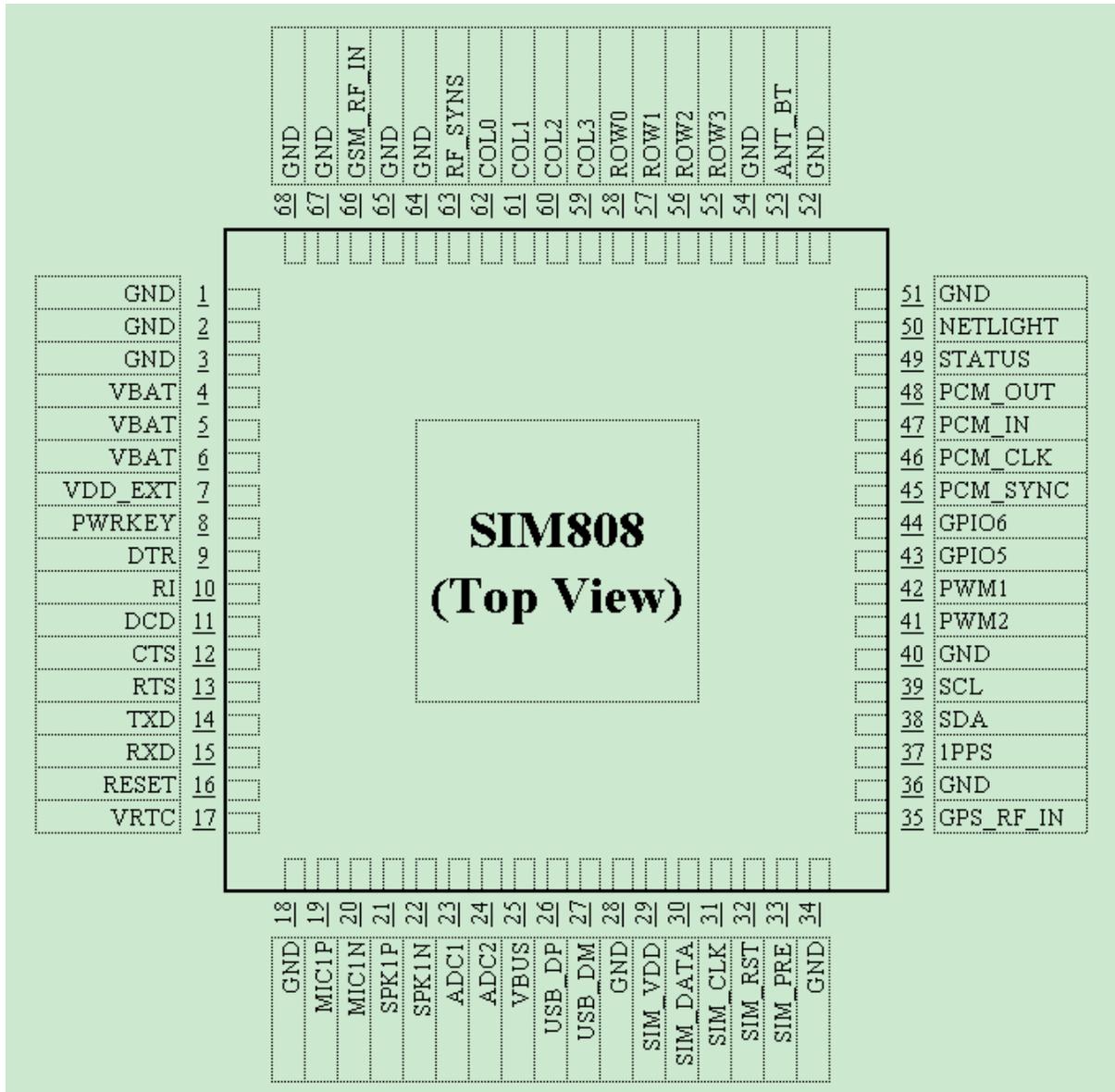
Figure 2: SIM808 pin out diagram (Top view)

3.2 Pin Description

Table 5: Pin description

Pin name	Pin number	I/O	Description	Comment
Power supply				
VBAT	4,5,6	I	SIM808 supplies 3 VBAT pins, and the power range is from 3.4V to 4.4V. Power supply should provide sufficient current so that the module can work normally; the peak current is nearly 2A.	Zener diode is Strongly recommended to anti surge on VBAT.
VRTC	17	I/O	Power supply for RTC	It is recommended to connect VRTC to a battery or a capacitor (e.g. 4.7uF).
VDD_EXT	7	O	2.8V power output	Keep floating if unused.
GND	1,2,3,18,28,34,36,40,51,52,54,64,65,67,68		Ground	Recommend connecting 1,2,3pin to the power GND.
Power on/off				
PWRKEY	8	I	PWRKEY should be pulled low at least 1 second and then released to power on/down the module.	Internally pulled up to VBAT.
Audio interface				
MIC1P	19	I	Differential audio input	Keep floating if unused.
MIC1N	20	I	Differential audio input	Keep floating if unused.
SPK1P	21	O	Differential audio output	Keep floating if unused.
SPK1N	22	O	Differential audio output	Keep floating if unused.
PCM interface				
PCM_OUT	48	O	PCM interface for audio	Keep floating if unused.
PCM_IN	47	I	PCM interface for audio	Keep floating if unused.
PCM_SYNC	45	O	PCM interface for audio	Keep floating if unused.
PCM_CLK	46	I	PCM interface for audio	Keep floating if unused.
Keypad interface				
COL3	59	I	Support up to 32 buttons (4*4*2)	Keep floating if unused. (COL0 can not be pulled down).
COL2	60	I	Support up to 32 buttons (4*4*2)	Keep floating if unused. (COL0 can not be pulled down).
COL1	61	I	Support up to 32 buttons (4*4*2)	Keep floating if unused. (COL0 can not be pulled down).
COL0	62	I	Support up to 32 buttons (4*4*2)	Keep floating if unused. (COL0 can not be pulled down).
ROW3	55	O	Support up to 32 buttons (4*4*2)	Keep floating if unused. (COL0 can not be pulled down).
ROW2	56	O	Support up to 32 buttons (4*4*2)	Keep floating if unused. (COL0 can not be pulled down).
ROW1	57	O	Support up to 32 buttons (4*4*2)	Keep floating if unused. (COL0 can not be pulled down).
ROW0	58	O	Support up to 32 buttons (4*4*2)	Keep floating if unused. (COL0 can not be pulled down).

GPIO				
GPIO5	43	I/O	Programmable general purpose input and output.	
GPIO6	44	I/O		
NETLIGHT	50	O	Network status	Can not multiplex with GPIO function.
STATUS	49	O	Power on status	
Serial port				
DTR	9	I	Data terminal ready	Keep floating if unused.
RI	10	O	Ring indicator	
DCD	11	O	Data carrier detect	
CTS	12	O	Clear to send	
RTS	13	I	Request to send	
TXD	14	O	Transmit data	
RXD	15	I	Receive data	
USB interface				
VBUS	25	I	Debug and firmware upgrading	Keep floating if unused.
USB_DP	26	I/O		
USB_DM	27	I/O		
ADC				
ADC1	23	I	10 bit general analog to digital converter	Keep floating if unused.
ADC2	24			
PWM				
PWM1	42	O	Pulse-width modulation, multiplex with GPIO4.	Keep floating if unused.
PWM2	41	O	Pulse-width modulation, multiplex with GPIO3.	
I2C				
SDA	38	I/O	I2C serial bus data	Internal pulled up to 2.8V via 4.7KΩ
SCL	39	O	I2C serial bus clock	
SIM interface				
SIM_VDD	29	O	Voltage supply for SIM card. Support 1.8V or 3V for SIM card	All signals of SIM interface should be protected against ESD with a TVS diode array.
SIM_DATA	30	I/O	SIM data input/output	
SIM_CLK	31	O	SIM clock	
SIM_RST	32	O	SIM reset	
SIM_PRESENCE	33	I	SIM card detection	
Antenna				
GSM_RF_IN	66	I/O	Connect GSM antenna	Impendence must be controlled to 50Ω.
ANT_BT	53	I/O	Connect Bluetooth antenna	Impendence must be controlled to 50Ω.
GPS_RF_IN	35	I	Connect GPS antenna	Impendence must be controlled to 50Ω.
RF synchronization				
RF_SYNC	63	O	RF burst synchronous signal	Do not pull up

Other signal				
RESET	16	I	Reset input(Active low)	
1PPS	37	I	Time Mark outputs timing pulse related to receiver time	If unused, keep open.

3.3 Package Dimensions
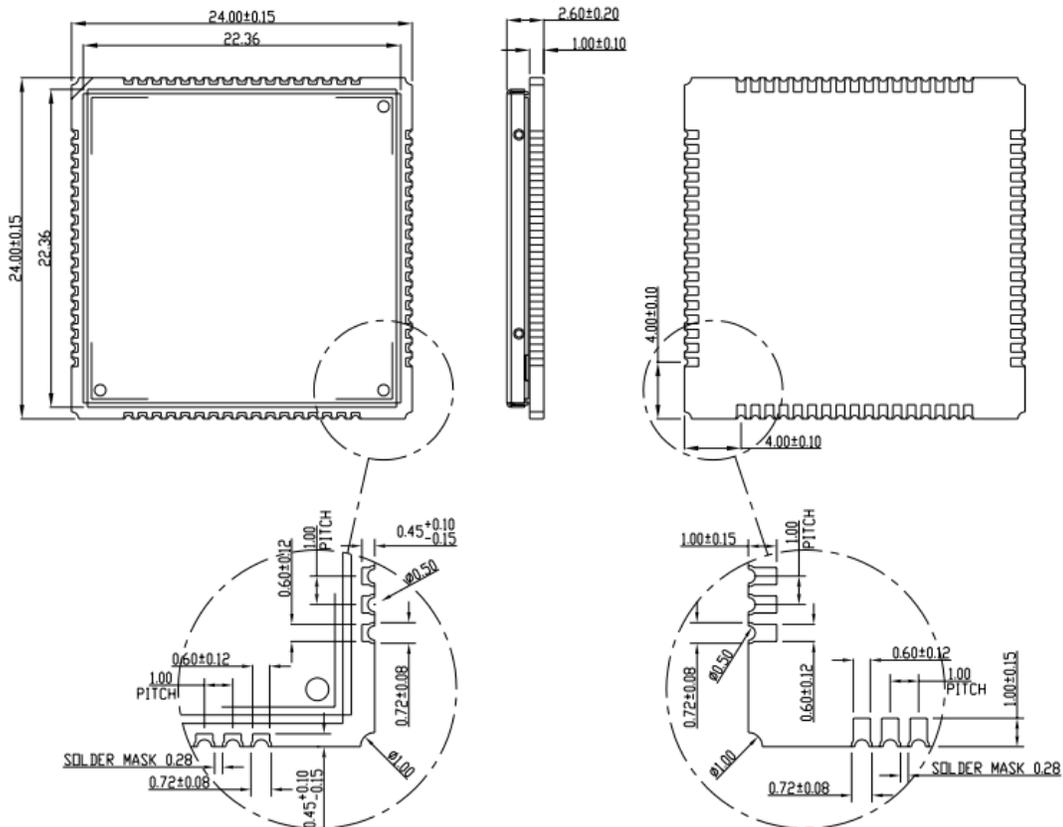
Figure 3: Dimensions of SIM808（Unit: mm）
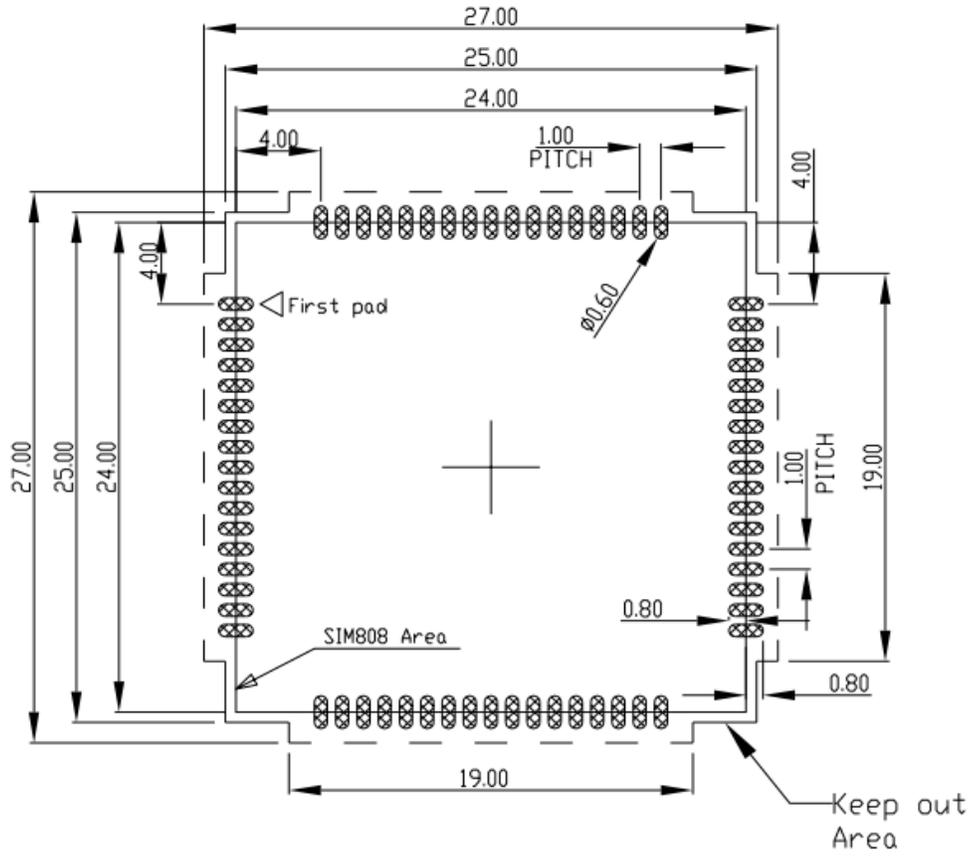
Figure 4: Recommended PCB footprint outline（Unit: mm）

4　GSM Application Interface

4.1　Power Supply

The power supply range of SIM808 is from 3.4V to 4.4V.Recommended voltage is 4.0V.The transmitting burst will cause voltage drop and the power supply must be able to provide sufficient current up to 2A. For the VBAT input, a bypass capacitor (low ESR) such as a 100 µF is strongly recommended.

Increase the 33PF and 10PF capacitors can effectively eliminate the high frequency interference. A 5.1V/500mW Zener diode is strongly recommended, the diode can prevent chip from damaging by the voltage surge. These capacitors and Zener diode should be placed as close as possible to SIM808 VBAT pins.
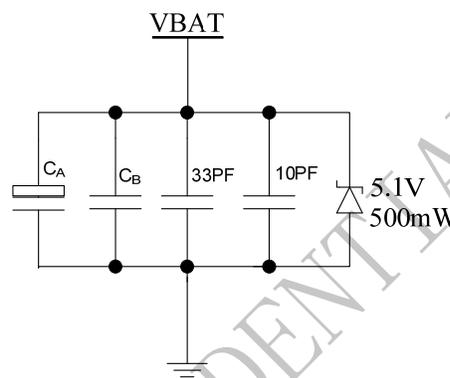
Figure 5: Reference circuit of the VBAT input

Table 6: Recommended Zener diode

	Vendor	Part number	Power(watts)	Packages
1	On semi	MMSZ5231BT1G	500mW	SOD123
2	Prisemi	PZ3D4V2H	500mW	SOD323
3	Prisemi	PZ5D4V2H	500mW	SOD523
4	Vishay	MMSZ4689-V	500mW	SOD123
5	Crownpo	CDZ55C5V1SM	500mW	0805

The following figure is the reference design of +5V input power supply. The designed output for the power supply is 4.1V, thus a linear regulator can be used.
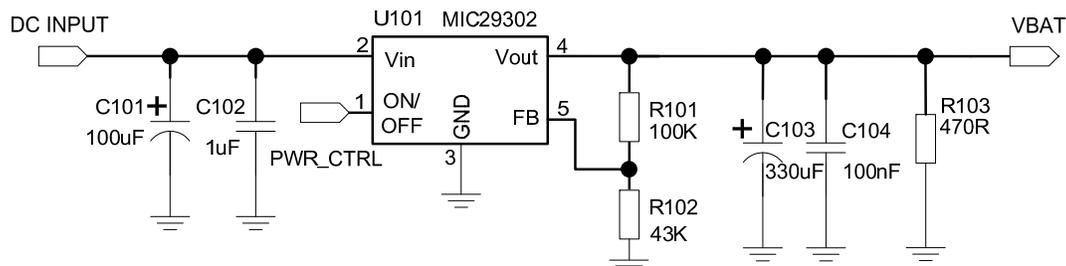
Figure 6: Reference circuit of the LDO power supply

If there is a high drop-out between the input and the desired output (VBAT), a DC-DC power supply will be preferable because of its better efficiency especially with the 2A peak current in burst mode of the module. The following figure is the reference circuit.
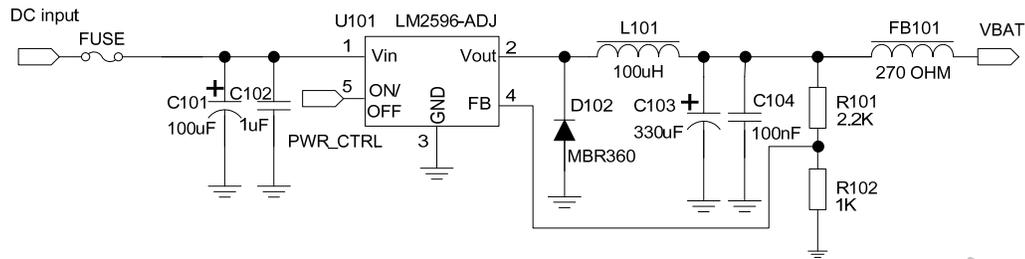
Figure 7: Reference circuit of the DC-DC power supply

The single 3.7V Li-ion cell battery can be connected to SIM808 VBAT pins directly. But the Ni-Cd or Ni-MH battery must be used carefully, since their maximum voltage can rise over the absolute maximum voltage of the module and damage it.

Notes：The module do not support for charging Ni-Cd or Ni-MH battery.

When battery is used, the total impedance between battery and VBAT pins should be less than 150mΩ.
The following figure shows the VBAT voltage drop at the maximum power transmit phase, and the test condition is as following:

VBAT=4.0V,
A VBAT bypass capacitor C_A=100µF tantalum capacitor (ESR=0.7Ω),
Another VBAT bypass capacitor C_B=1µF.
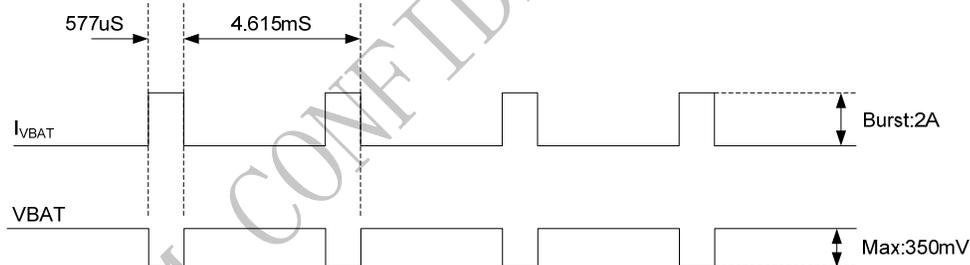
Figure 8: VBAT voltage drop during transmit burst

4.1.1　Power Supply Pin

The 3 VBAT pins are used for power input, and pin 4, 5, 6 should be connected to the power GND. VRTC pin is power supply of the RTC circuit in the module. VDD_EXT will output 2.8V when module powered up.

When designing the power supply in user's application, pay special attention to power losses. Ensure that the input voltage never drop below 3.0V even when current consumption rises to 2A in the transmit burst. If the power voltage drops below 3.0V, the module may be shut down automatically. The PCB traces from the VBAT pins to the power supply must be wide enough (at least 60mil) to decrease voltage drops in the transmit burst. The power IC and the bypass capacitor should be placed to the module as close as possible.

VBAT

MIN:3.0V
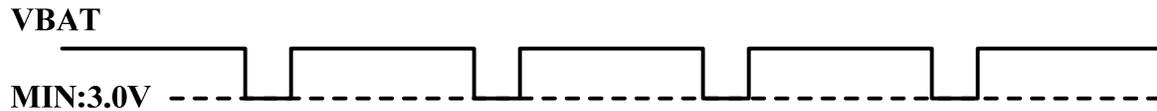
<div align="center">Figure 9: The minimal VBAT voltage requirement at VBAT drop</div>

4.1.2   Monitoring Power Supply

The AT command "AT+CBC" can be used to monitor the VBAT voltage. For detail, please refer to *document [1].*

4.2   Power on/down SIM808

4.2.1   Power on SIM808

4.2.1.1   Turn on SIM808 Using the PWRKEY Pin (Power on)

User can power on SIM808 by pulling down the PWRKEY pin for at least 1 second and release. This pin is already pulled up to VBAT in the module internal, so external pull up is not necessary. Reference circuit is shown as below.
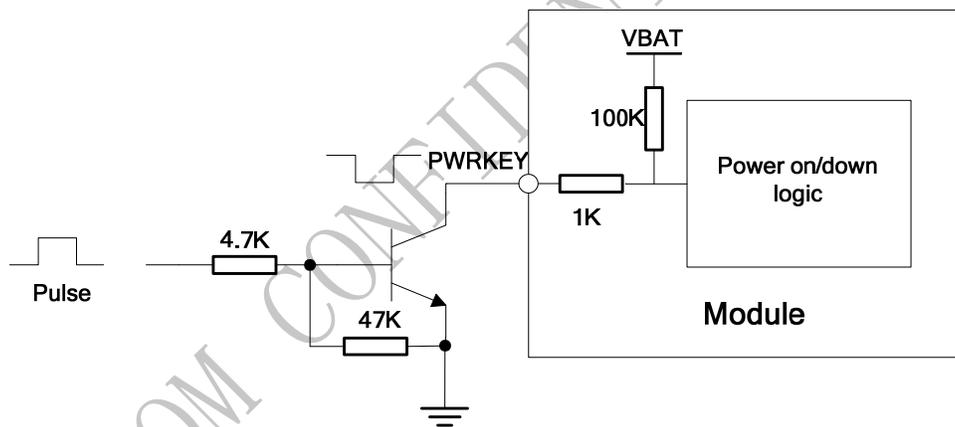
<div align="center">Figure 10: Powered on/down module using transistor</div>
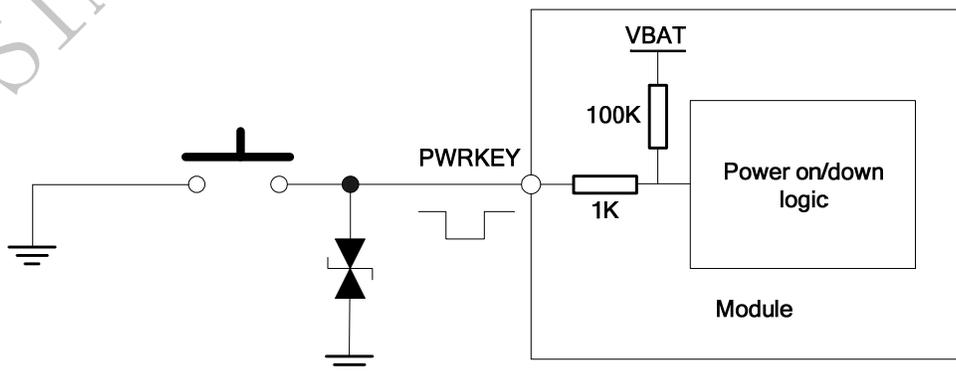
<div align="center">Figure 11: Powered on/down module using button</div>

The power on scenarios is illustrated as following figure.
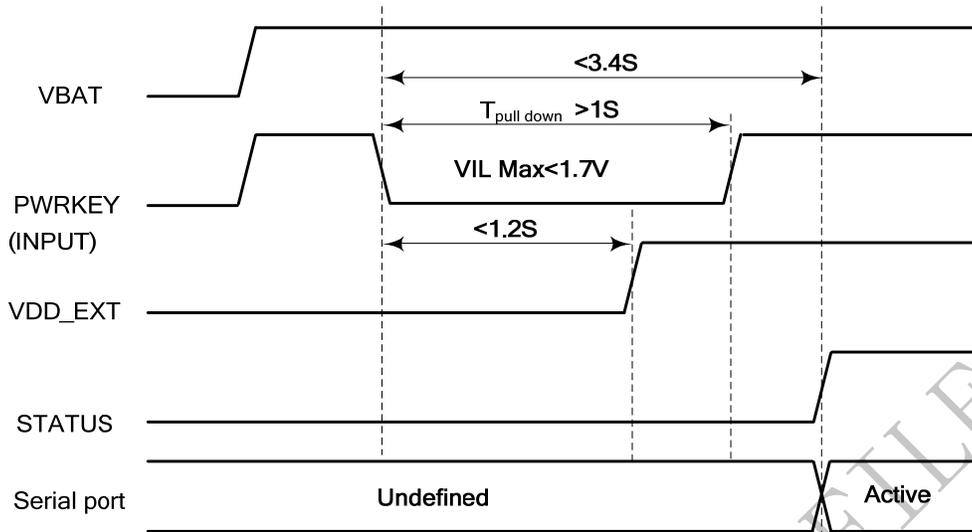
Figure 12: Timing of power on module

When power on procedure is completed, SIM808 will send following URC to indicate that the module is ready to operate at fixed baud rate.

RDY

This URC does not appear when autobauding function is active.

Note: User can use AT command "AT+IPR=x" to set a fixed baud rate and save the configuration to non-volatile flash memory. After the configuration is saved as fixed baud rate, the Code "RDY" should be received from the serial port every time when SIM808 is powered on. For details, please refer to the chapter "AT+IPR" in document [1].

4.2.1.2   Turn on the SIM808 using the VBUS Signal

The SIM808 will be automatically turned on when a charger is connected to VBUS pin, the switched-off SIM808 of which VBAT pin voltage is greater than 3.4V. SIM808 will power up.
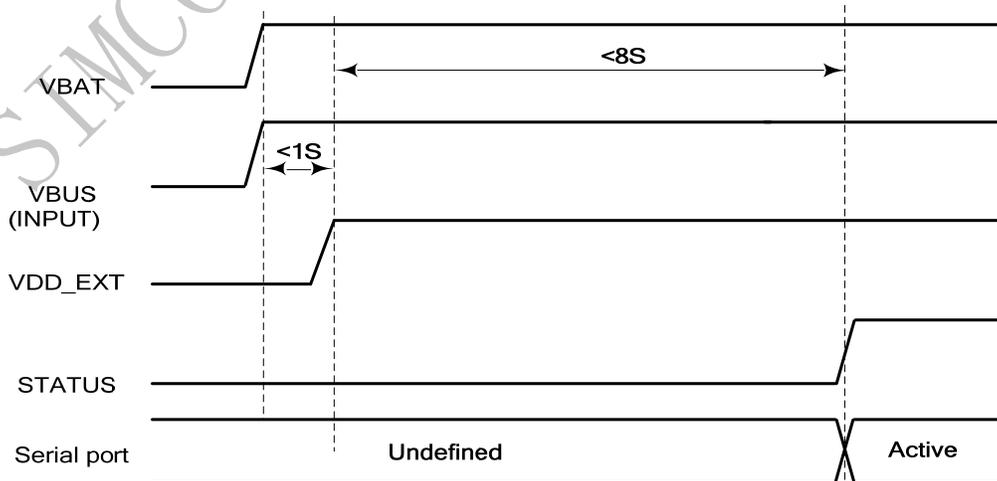
Figure 13: Timing of power on module

4.2.2 Power down SIM808

SIM808 will be powered down in the following situations：
- Normal power down procedure: power down SIM808 by the PWRKEY pin.
- Normal power down procedure: power down SIM808 by AT command "AT+CPOWD=1".
- Abnormal power down: over-voltage or under-voltage automatic power down.
- Abnormal power down: over-temperature or under-temperature automatic power down.

NOTE：The VBUS pin should not be charged, otherwise ,the module will not be powered down.

4.2.2.1 Power down SIM808 by the PWRKEY Pin

User can power down SIM808 by pulling down the PWRKEY pin for at least 1 second and release. Please refer to the power on circuit. The power down scenario is illustrated in following figure.
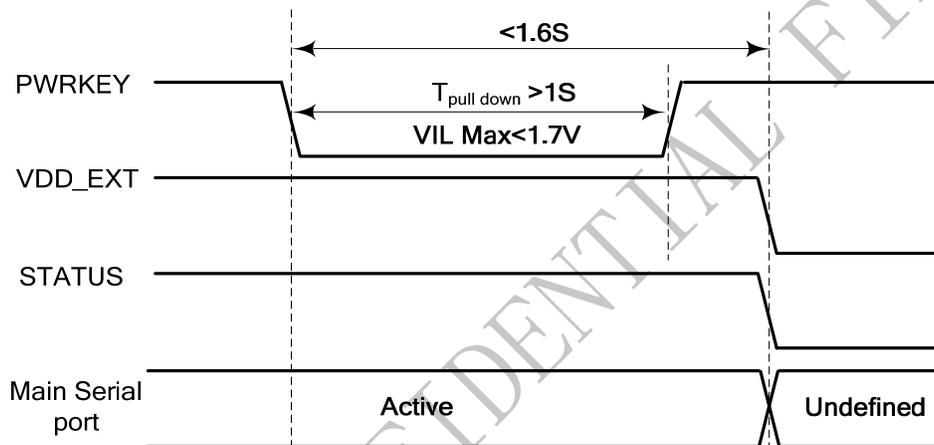
Figure 14: Timing of power down SIM808 by PWRKEY

This procedure makes the module log off from the network and allows the software to enter into a secure state to save data before completely shut down.

Before the completion of the power down procedure, the module will send URC:
  NORMAL POWER DOWN
At this moment, AT commands can not be executed any more, and only the RTC is still active. Power down mode can also be indicated by STATUS pin, which is at low level at this time.

4.2.2.2 Power down SIM808 by AT Command

SIM808 can be powered down by AT command "AT+CPOWD=1". This procedure makes the module log off from the network and allows the software to enter into a secure state to save data before completely shut down.

Before the completion of the power down procedure, the module will send URC:
  NORMAL POWER DOWN
At this moment, AT commands can not be executed any more, and only the RTC is still active. Power down mode can also be indicated by STATUS pin, which is at low level at this time.

For detail about the AT command "AT+CPOWD", please refer to *document [1]*

4.2.2.3   Over-voltage or Under-voltage Power down

The module software monitors the VBAT voltage constantly.

If the voltage ≤ 3.5V, the following URC will be reported:

　　UNDER-VOLTAGE WARNNING

If the voltage ≥ 4.3V, the following URC will be reported:

　　OVER-VOLTAGE WARNNING

If the voltage < 3.4V, the following URC will be reported, and the module will be automatically powered down.

　　UNDER-VOLTAGE POWER DOWN

If the voltage > 4.4V, the following URC will be reported, and the module will be automatically powered down.

　　OVER-VOLTAGE POWER DOWN

At this moment, AT commands can not be executed any more, and only the RTC is still active. Power down mode can also be indicated by STATUS pin, which is at low level at this time.

4.2.2.4   Over-temperature or Under-temperature Power down

The module will constantly monitor the temperature of the module,

If the temperature > +80℃, the following URC will be reported:

　+CMTE: 1

If the temperature < -30℃, the following URC will be reported:

　+CMTE:-1

If the temperature > +85℃, the following URC will be reported, and the module will be automatically powered down.

　+CMTE: 2

If the temperature < -40℃, the following URC will be reported, and the module will be automatically powered down.

　+CMTE:-2

At this moment, AT commands can not be executed any more, and only the RTC is still active. Power down mode can also be indicated by STATUS pin, which is at low level at this time.

The AT command "AT+CMTE" could be used to read the temperature when the module is running.

For details please refer to *document [1]*.

4.2.3   Reset Function

SIM808 also has a RESET pin (pin 16) used to reset the module. This function is used as an emergency reset only when AT command "AT+CPOWD=1" and the POWER_ON pin has no effect. User can pull the RESET pin to ground, then the module will reset.

This pin is already isolated in the module, so the external isolation is not necessary. Following figure is internal circuit of the RESET pin.
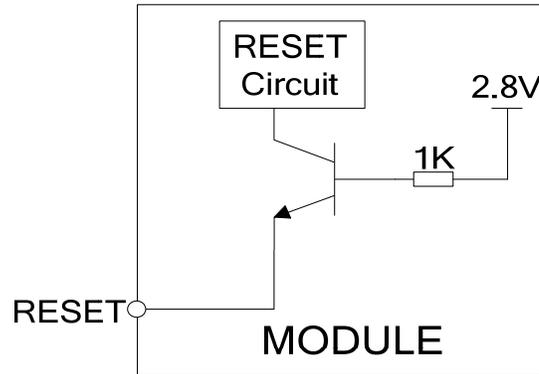
Figure 15: Reset Circuit

The typical value of RESET pin high level is 2.8V, so for the 3V or 3.3V, customer could use MCU's GPIO to driver this pin directly, resistor in serial the RESET signal could enhance the ESD performance but the value should not be too high, otherwise the level of RESET could be lower than threshold value; RESET hardware parameters can refer to the following table.

Table 7: Electronic characteristic of the RESET Pin

Pin name	Symbol	Min	Typ	Max	Unit
RESET	V_{IH}	2.7	2.8	2.9	V
	V_{IL}	-	-	0.6	V
	$T_{pull\ down}$	105		-	mS

The reset scenarios are illustrated in the following figures.
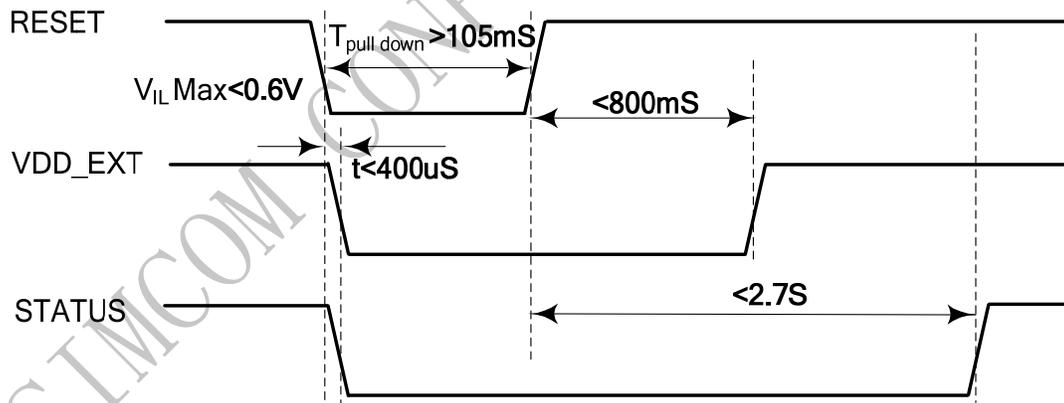
Figure 16: Reset timing sequence

4.3   Power Saving Mode

User can control SIM808 module to enter or exit the sleep mode (AT+CSCLK=1) by DTR signal. When DTR is in high level and without interrupt (on air and hardware such as GPIO interrupt or data in serial port), SIM808 will enter sleep mode automatically. In this mode, SIM808 can still receive paging or SMS from network but the serial port is not accessible.

Note: Customer must shut off the power supply of GPS, and then the AT commands about the power saving mode can be executed correctly, and the current consumption will be lower.

4.3.1   Function Mode

There are three functionality modes, which could be set by the AT command "AT+CFUN=<fun>". The command provides the choice of the functionality levels <fun>=0, 1, 4.

- AT+CFUN=0: minimum functionality.
- AT+CFUN=1: full functionality (default).
- AT+CFUN=4: flight mode (disable RF function).

Table 8: The current consumption of function modes (BS-PA-MFRMS=5)

<Fun>	Current consumption(uA) (CSCLK=1)
0	869.5
1	1400
4	922.5

Minimum functionality mode minimizes the current consumption to the lowest level. If SIM808 is set to minimum functionality by "AT+CFUN=0", the RF function and SIM card function will be disabled. In this case, the serial port is still accessible, but all AT commands correlative with RF function and SIM card function will not be accessible.

For detailed information about the AT Command "AT+CFUN=<fun>", please refer to *document [1]*.

4.3.2   Sleep Mode (AT+CSCLK=1)

When the GPS function is shut off, user can control SIM808 module to enter or exit the sleep mode (AT+CSCLK=1) by DTR signal. When DTR is in high level and without interrupt (on air and hardware such as GPIO interrupt or data in serial port), SIM808 will enter sleep mode automatically. In this mode, SIM808 can still receive paging or SMS from network but the serial port is not accessible.

Note: For SIM808, it requests to set AT command "AT+CSCLK=1" and ensure DTR at high level to enable the sleep mode ; the default value is 0, which can not make the module to enter sleep mode. For more details please refer to document [1].

4.3.3   Wake Up SIM808 from Sleep Mode (AT+CSCLK=1)

When SIM808 is in sleep mode (AT+CSCLK=1), the following methods can wake up the module:
- Pull down DTR pin.
  The serial port will be active after DTR pin is pulled to low level for about 50ms.
- Receive a voice or data call from network.
- Receive a SMS from network.
- Receive external interrupt
- Charge VBUS pin

4.4 Charging Interface

SIM808 has integrated a charging circuit inside the module for Li-Ion batteries charging control, which make it very convenient for user's applications that support battery charging. A common connection is shown in the following figure:
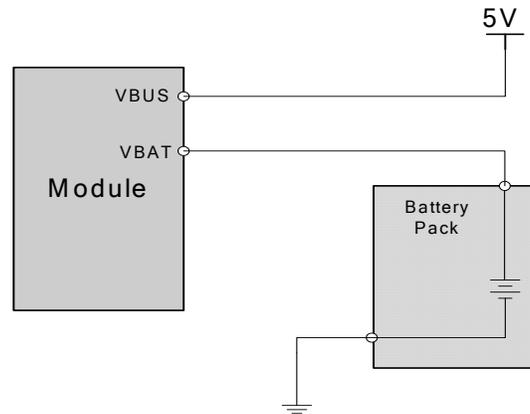
Figure 17: SIM808 with battery charger and pack connection

4.4.1 Battery Pack Characteristics

SIM808 has optimized the charging algorithm for the Li-Ion battery that meets the characteristics listed below.

- The maximum charging voltage of the Li-Ion battery pack is 4.2V and the recommended capacity is 1100mAh. The Battery packs with more than 1100 mAh capacity will take more time for charging.
- The battery pack should have a protection circuit to avoid overcharging, deep discharging and over-current, and the circuit should be insensitive to pulsed current.
- The internal resistance of the battery pack including protection circuit should be as low as possible. Its recommended value does not exceed 150mΩ.
- The battery pack must be protected from reverse pole connection.

On the SIM808, the build-in circuit of the power management chipset monitors the supply voltage constantly. Once the Under-voltage is detected, the SIM808 will be powered down automatically.

4.4.2 Recommended Battery Pack

Following is the specification of recommended battery pack:

Table 9: Specification of recommended battery pack

Items	Description
Battery type	Li-ion
Manufacturer	Jiade Energy Technology
Normal voltage	3.7V
Capacity	NORMAL 1100mAh
Charge Voltage	4.200±0.050V

Max Charge Current	1.0C
Charge Method	CC / CV (Constant Current / Constant Voltage)
Max Discharge Current	1.0C (for continuous discharging mode)
Discharge Cut-off Voltage	3.0V/ cell
Internal resistance	Initial≤150mΩ

4.4.3 Implemented Charging Technique

SIM808 has battery charging function, but default function is not support for charging, the customer should input AT command to enable charging function. There are two pins related to the battery charging function: there are VBUS, VBAT and pins. The VBUS Pin is driven by an external voltage (AC adapter or USB host), system can use this Pin to detect a charger supply and provide most charging current through SIM808 module to battery when charging is in fast charge state. VBAT pin gives charging current to external battery from SIM808 module.

It is very simple to implement charging function, user just needs to connect the charger to the VBUS Pin and connect the battery to the VBAT Pin.
SIM808 battery charging happens after detecting charger supply and the presence of battery. If there is no charger supply or no battery present, charging function will not be enabled.

Normally, there are three states in the whole charging procedure.
- DDLO charge (Pull-up mode) and UVLO charge (Pre-charge mode);
- Constant current mode (CC);
- Constant voltage mode and over-voltage protection(OV)

DDLO charge and UVLO charge:
DDLO is the state of battery when its voltage is under 2.2V. And UVLO means the battery voltage is less than 3.3V and more than 2.2V. The battery is not suitable for fast charging when its condition is DDLO or UVLO. The SIM808 provides a small constant current to the battery when the battery is between DDLO and UVLO. In DDLO charging state, SIM808 gives out pulse 70mA current to the battery. And in UVLO charging state, SIM808 provides about 200mA (AC<7V) or 70mA (USB mode) current to the battery.

DDLO charging terminates when the battery voltage reaches 2.2V. UVLO charging terminates when the battery voltage is up to 3.4V. Both DDLO and UVLO charge are controlled by the SIM808 hardware only.

Constant current mode (CC):
As the battery voltage is charged up and over3.4V, the SIM808 will enter CC mode. The CC mode charging current can be set from 70 to 800mA by the software.
Constant voltage mode (CV) and over-voltage protection (OV):
As the battery is charged up and over 4.05V, the SIM808 will enter CV mode. While the batter voltage actually reaches 4.2V, the charging current is gradually decreased step by step until stop charging.

4.4.4 Operating Modes during Charging

The battery can be charged during various operating mode. That means that charging can be in progress while SIM808 is in Normal mode (SLEEP, IDLE, TALK, GPRS IDLE or GPRS DATA mode). In this case the voltage supply should be sufficient. Here Charging in Normal mode is named as Charge mode.

If the charger is connected to the module's VBUS Pin and the valid battery is connected to the VBAT Pin while SIM808 is in POWER DOWN mode, SIM808 will auto power up.

4.4.5   Charger Requirements

Following is the requirements of charger for SIM808:

● Simple transformer power plug

● Output voltage: 5.0V~7V

● Minimum supply current: 800mA

● A 10V peak voltage is allowed for maximum 1ms when charging current is switched off.

● A 1.6A peak current is allowed for maximum 1ms when charging current is switched on.

4.5   RTC Backup

Current input for RTC when the VBAT is not supplied for the system. Current output for backup battery when the VBAT power supply is in present and the backup battery is in low voltage state. The RTC power supply of module can be provided by an external capacitor or a battery (non-chargeable or rechargeable) through the VRTC. The following figures show various reference circuits for RTC back up.

● **External capacitor for RTC**
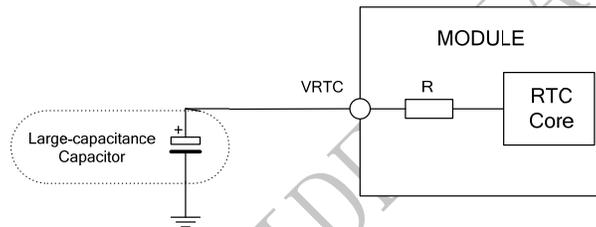
Figure 18: RTC supply from capacitor

● **Non-chargeable battery for RTC**
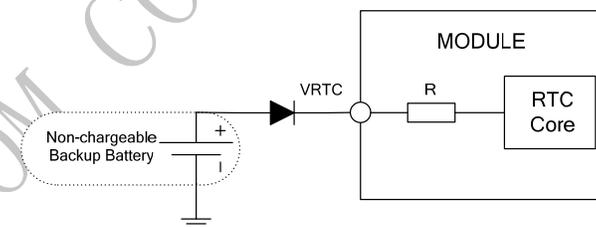
Figure 19: RTC supply from non-chargeable battery

● **Rechargeable battery for RTC**
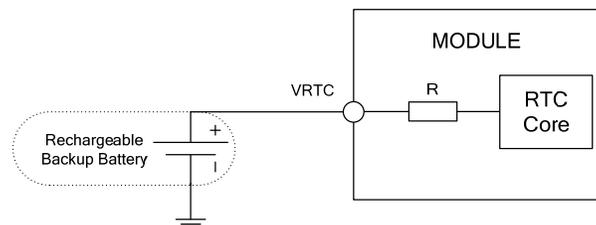
Figure 20: RTC supply from rechargeable battery

Coin-type rechargeable battery is recommended, such as XH414H-IV01E from Seiko can be used.

Typical charge-discharge curves for this battery are shown in the following figure.
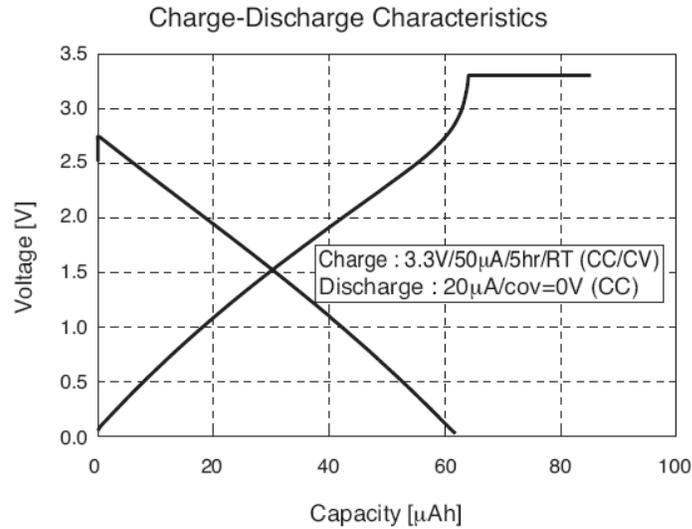
Figure 21: Seiko XH414H-IV01E charge-discharge characteristic

4.6   Serial Port and USB Interface

SIM808 provides one unbalanced asynchronous serial port. The module is designed as a DCE (Data Communication Equipment). The following figure shows the connection between module and client (DTE).

Table 10: Serial port and USB pin definition

	Name	Pin number	Function
Serial port	DTR	9	Data terminal ready
	RI	10	Ring indicator
	DCD	11	Data carrier detect
	CTS	12	Clear to send
	RTS	13	Request to send
	TXD	14	Transmit data
	RXD	15	Receive data
USB interface	VBUS	25	USB power supply
	USB_DP	26	USB data line plus
	USB_DM	27	USB data line minus

Note: Hardware flow control is disabled by default. The AT command "AT+IFC=2,2" can enable hardware flow control .The AT command "AT+IFC=0,0"can disable hardware flow control. For more details, please refer to document [1].

Table 11: Serial port characteristics

Symbol	Min	Max	Unit
V_{IL}	0	0.3	V
V_{IH}	2.5	2.8	V
V_{OL}	0	0.1	V
V_{OH}	2.7	2.8	V

4.6.1　Function of Serial Port

Serial port:

● Full modem device.

● Contains data lines TXD and RXD, hardware flow control lines RTS and CTS, status lines DTR, DCD and RI.

● Serial port can be used for CSD FAX, GPRS service and AT communication..

● Serial port supports the following baud rates:
1200, 2400, 4800, 9600, 19200, 38400, 57600 and 115200bps

● Autobauding only supports the following baud rates:
1200, 2400, 4800, 9600, 19200, 38400, 57600 and 115200bps

● The default setting is autobauding.

Autobauding allows SIM808 to automatically detect the baud rate of the host device. Pay more attention to the following requirements:

● **Synchronization between DTE and DCE:**
When DCE powers on with autobauding enabled, firstly, user must send character "A" or "a" to synchronize the baud rate. It is recommended to send "AT" until DTE receives the "OK" response, which means DTE and DCE are correctly synchronized. For more information please refer to the AT command "AT+IPR".

● **Restrictions of autobauding operation:**
The DTE serial port must be set at 8 data bits, no parity and 1 stop bit.
The URC such as "RDY", "+CFUN: 1" and "+CPIN: READY" will not be reported.

Note: User can use AT command "AT+IPR=x" to set a fixed baud rate and the setting will be saved to non-volatile flash memory automatically. After the configuration is set as fixed baud rate, the URC such as "RDY", "+CFUN: 1" and "+CPIN: READY" will be reported when SIM808 is powered on.

4.6.2　Serial Port

The following figure shows the connection between module and client (DTE).
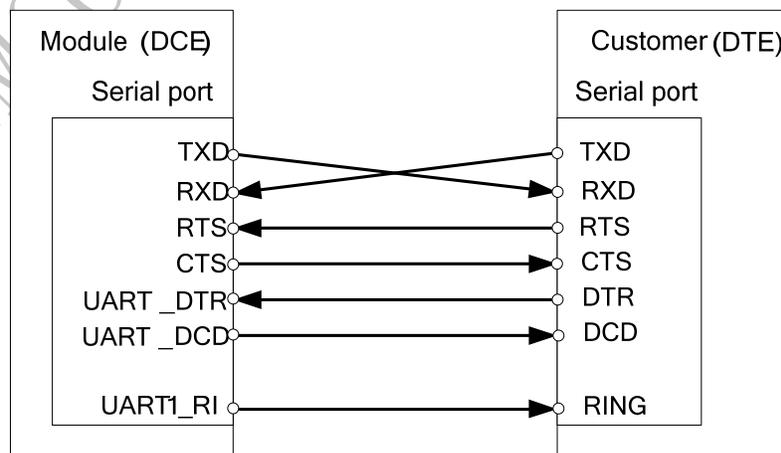
Figure 22: Connection of the serial port

If the voltage of UART is 3.3V, the following reference circuits are recommended. If the voltage is 3.0V, please

change the resistors in the following figure from 5.6K to 14K.
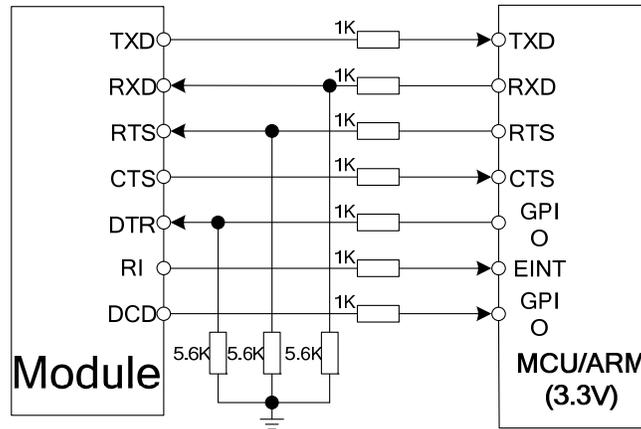
Figure 23: Level converting by resistor

If the voltage of UART is 3V or3.3V, user also can use following reference circuits:
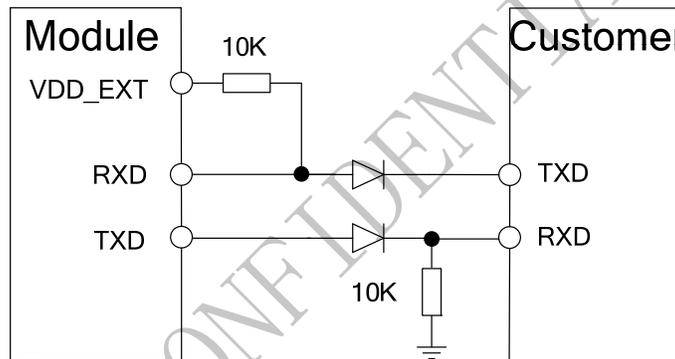
Figure 24: Isolation circuit by diodes

Note: when a diode used to isolate voltage cross, customer should notice that there's voltage drop on the diode. And the signal's voltage level should meet the customer's electrical character. The recommend diode is Schottky diode e.g. RB551V-30TE-17 and SDM20U40.

If the voltage of UART is 5V on customer side, customer can use the following reference circuits :
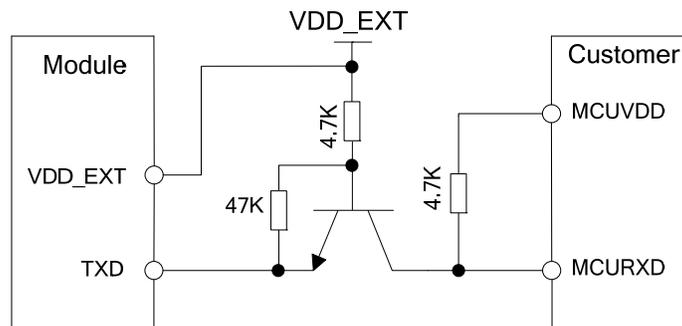
Figure 25: TX level converting by transistor
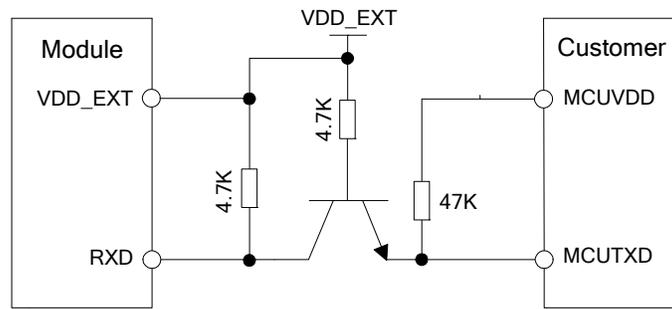
Figure 26: RX level converting by transistor

Note: The recommend Transistors' part numbers are 2SC4617TLR and PBHV8115Z. when update firmware via the TXD/RXD circuit as figure 25 and figure 26 shows, customer should make sure the VDD_EXT has voltage output, or a external LDO should be added to power VDD_EXT.

4.6.3 USB Interface

USB interface supports software debug function. When power on the module, connect VBUS, USB_DP, USB_DM and GND to PC, then install the driver successfully, a UART port could be recognized by the PC, customer could achieve the software Debug purpose with this UART port.

The following diagram is recommended:
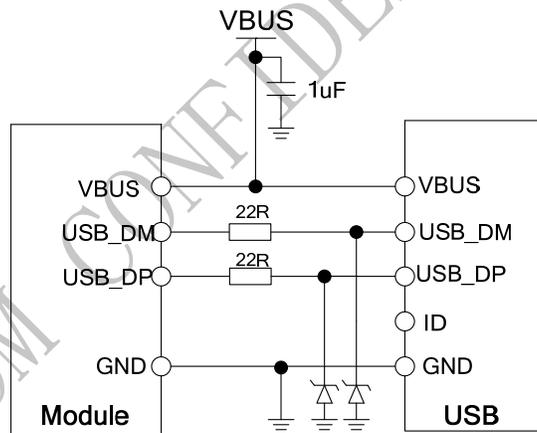
Figure 27: USB reference circuit

The maximum allowable cap load of TVS on USB data line should be less than 5pF (e.g. ESD9L5.0ST5G and ESD9M5.0ST5G). The USB_DP and USB_DM should be routed in differential traces.

Note: please reserve the USB interface or test point for debug.

Table 12: Serial port characteristics

Pin	Min	Typ	Max	Unit
VBUS	4.3	5	7	V

4.6.4 Software Upgrade and Debug

Only USB and interface can be used for firmware upgrade.

If customer upgrading firmware via the USB port, SIM808 must be powered first, then connect VBUS, USB_DP, USB_DM and GND to PC. There is no need to operate PWRKEY pin in the whole procedure, when SIM808 detects VBUS and could communicate normally by USB_DP and USB_DM, module will enter USB download mode automatically.

Note: When only USB_DP and USB_DM connected, no VBUS, customer need to pull down COL0 before power on the module, then press the PWRKEY button, the module will enter download mode;

The serial port and the debug port support the CMOS level. If user connects the module to the computer, the level shifter should be added between the DCE and DTE.
For details about software upgrading, please refer to *document [4]*.

4.7 RI Behaviors

Table 13: RI Behaviors

State	RI response
Standby	High
Voice call	The pin is changed to low. When any of the following events occur, the pin will be changed to high: (1)Establish the call (2)Hang up the call
Data call	The pin is changed to low. When any of the following events occur, the pin will be changed to high: (1)Establish the call (2)Hang up the call
SMS	The pin is changed to low, and kept low for 120ms when a SMS is received. Then it is changed to high.
URC	The pin is changed to low, and kept low for 120ms when some URCs are reported. Then it is changed to high. For more details, please refer to *document [10]*.

The behavior of the RI pin is shown in the following figure when the module is used as a receiver.
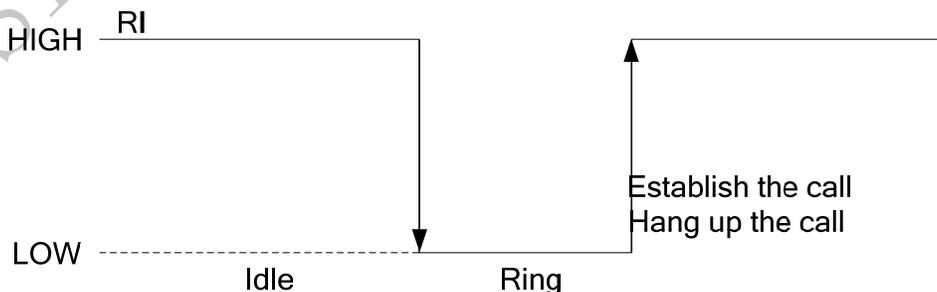
Figure 28: RI behaviour of voice calling as a receiver
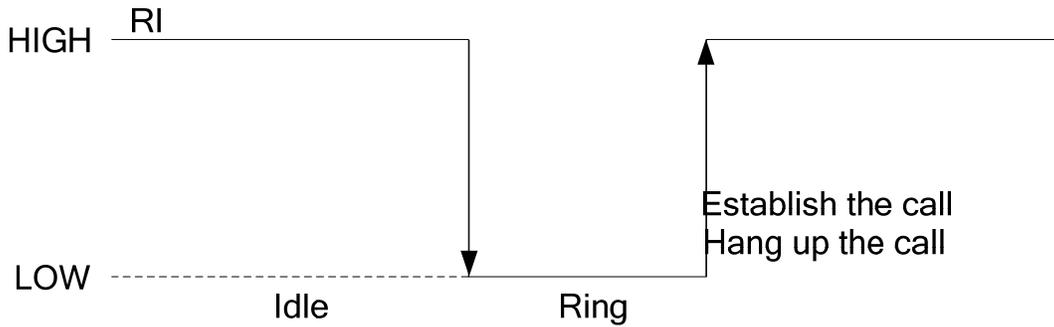
Figure 29: RI behaviour of data calling as a receiver
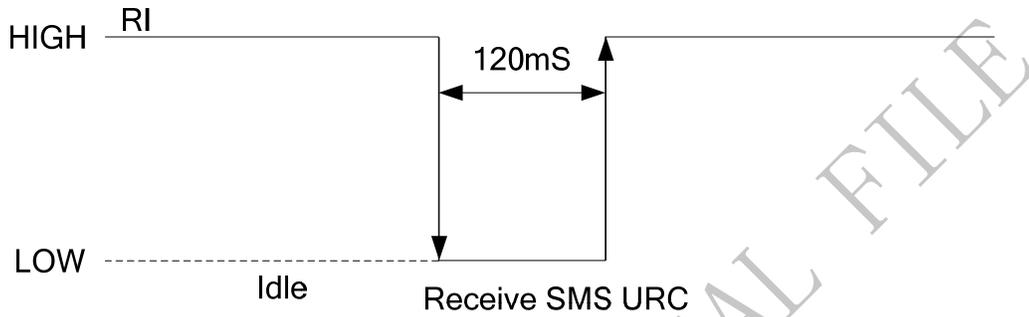
Figure 30: RI behaviour of URC or receive SMS

However, if the module is used as caller, the RI will remain high. Please refer to the following figure.
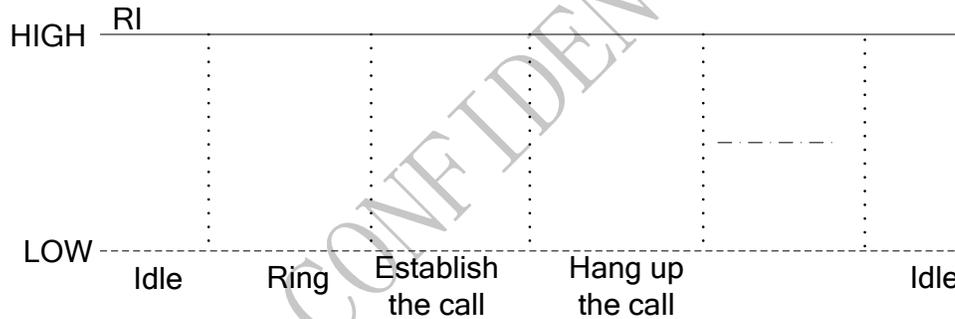
Figure 31: RI behaviour as a caller

4.8 Audio Interfaces

SIM808 provides one analog input, which could be used for electret microphone. The module also provides one analog output. The output can directly drive 32Ω receiver.

Table 14: Audio interface definition

	Pin name	Pin number	Function
Audio channel	MIC1P	19	Main Audio input positive
	MIC1N	20	Main Audio input negative
	SPK1P	21	Main Audio output positive
	SPK1N	22	Main Audio output negative

"AT+CMIC" is used to adjust the input gain level of microphone. "AT+SIDET" is used to set the side-tone level. In addition, "AT+CLVL" is used to adjust the output gain level. For more details, please refer to *document [1]*

In order to improve audio performance, the following reference circuits are recommended. The audio signals have to be layout according to differential signal layout rules as shown in following figures.

4.8.1 Speaker Interface Configuration
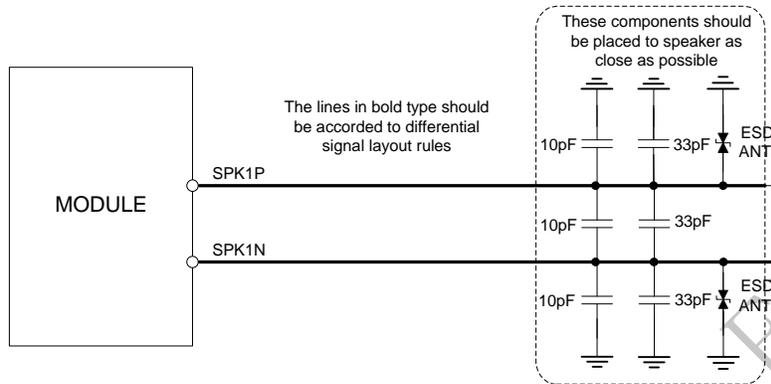
Figure 32: Speaker reference circuit
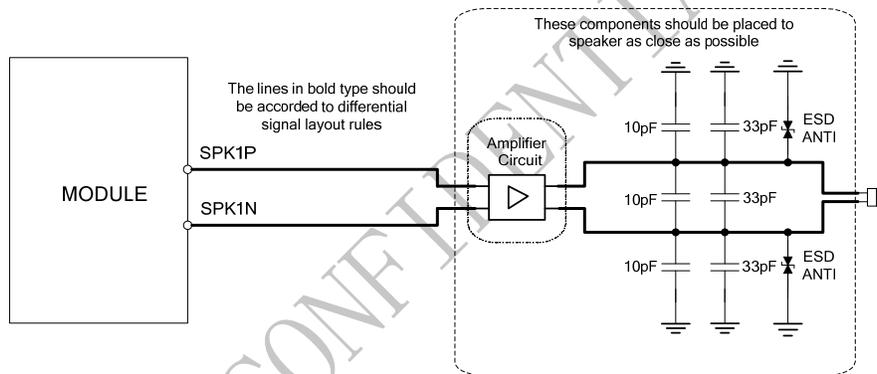
Figure 33: Speaker with amplifier reference circuit

4.8.2 Microphone Interfaces Configuration
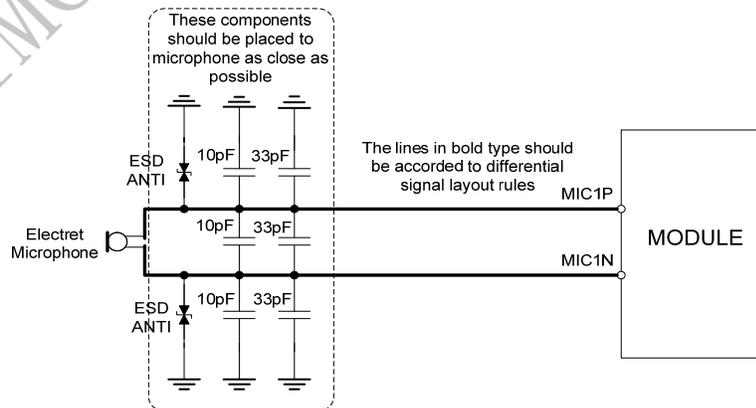
Figure 34 : Microphone reference circuit

4.8.3   Audio Electronic Characteristics

Table 15: Microphone input characteristics

Parameter		Min	Typ	Max	Unit
Mic biasing voltage			1.9	2.2	V
Working Current				2	mA
Input impedance(differential)		13	20	27	KΩ
Idle channel noise				-67	dBm
SINAD	Input level:-40dBm0	29			dB
	Input level:0dBm0		69		dB

Table 16: Audio output characteristics

parameter	Conditions	Min	Typ	Max	Unit
Normal output	R_L=32 Ω receiver	-	90	-	mW

4.8.4   TDD

GSM signal could interfere audio by coupling or conducting. Coupling noise could be filtered by adding 33 pF and 10pF capacitor over audio lines.33pF capacitor could eliminate noise from GSM900MHz, while 10pF capacitor could eliminate noise from DCS1800MHz frequency. Coupling noise has great relatives with PCB layout. Under some scenarios, TDD noise from GSM 900MHz frequency affects heavily, but some different story is from GSM1800MHz fervency, so customer should develop this filter solution according to field test result.

GSM antenna is the key coupling interfering source of TDD noise.   Pay attention to the layout of audio lines which should be far away from RF cable & antenna and VBAT pin. The bypass capacitor for filtering should be placed near module and another group placed near to connector.

Conducting noise is mainly caused by the VBAT drop. If Audio PA was powered by VBAT directly, then there will be some cheep noise from SPK output easily. So, it's better to put big capacitor and ferrite bead near audio PA input.

TDD noise has something to do with GND signal surely. If GND signal issued not good, lots of high-frequency noise will interfere MIC and speaker over bypass capacitor. So, take care of GND well during PCB layout.

4.9   Bluetooth

SIM808 supports Bluetooth function, customer only needs to design the Bluetooth antenna, and then customer can operate Bluetooth conveniently by AT commands. For the detail commands about Bluetooth please refer to *document [1]*

- Fully compliant with Bluetooth specification3.0 + EDR
- Support operation with GPS and GSM/GPRS worldwide radio systems
- Fully integrated PA provides 10dbm output power
- Up to 4 simultaneous active ACL links
- Support sniff mode

Support PCM interface and built-in programmable transcoders for liner voice with transmission.

4.9.1   Bluetooth Antenna Interface

The module provides a Bluetooth antenna interface named ANT_BT. External antenna must be matched properly to achieve best performance, so the matching circuit is necessary, the connection is recommended as the following figure:
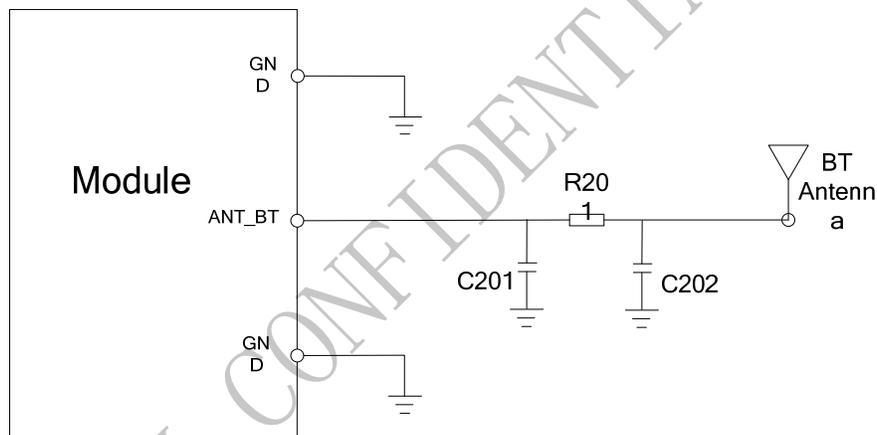
Figure 35: Bluetooth antenna matching circuit

R201, C201, C202 are the matching circuit, the values depend on antenna debug result. Normally R201 is 0Ω, C201 and C202 are not mounted.

4.10   SIM Card Interface

The SIM interface complies with the GSM Phase 1 specification and the new GSM Phase 2+ specification for FAST 64 kbps SIM card. Both 1.8V and 3.0V SIM card are supported. The SIM interface is powered from an internal regulator in the module.

4.10.1 SIM Card Application

Table 17: SIM pin definition

Name	Pin	function
SIM_VDD	29	Voltage supply for SIM card. Support 1.8V or 3V SIM card
SIM_DATA	30	SIM data input/output
SIM_CLK	31	SIM clock
SIM_RST	32	SIM reset
SIM_PRE	33	SIM card detection

It is recommended to use an ESD protection component such as ON (http://onsemi.com) SMF12CT1G. Note that the SIM peripheral circuit should be close to the SIM card socket. The reference circuit of the 8-pin SIM card holder is illustrated in the following figure.
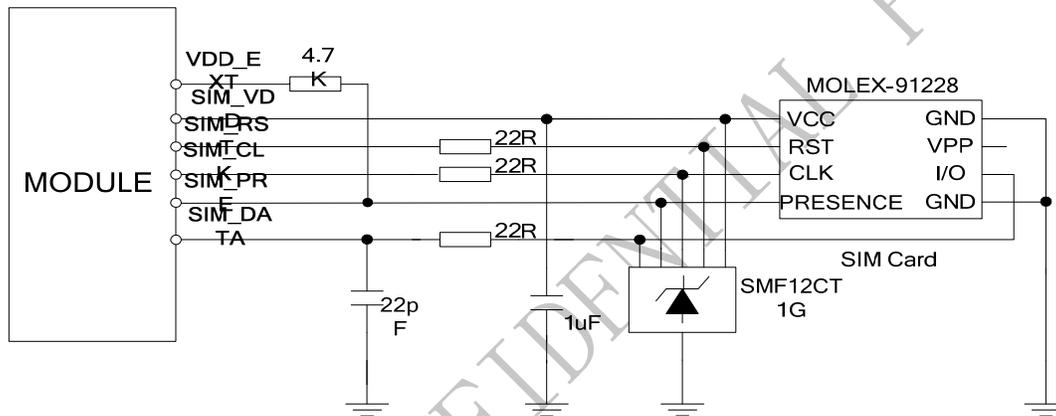
Figure 36: Reference circuit of the 8-pin SIM card holder

The SIM_PRESENCE pin is used for detection of the SIM card hot plug in. User can select the 8-pin SIM card holder to implement SIM card detection function. AT command "AT+CSDT" is used to enable or disable SIM card detection function. For details of this AT command, please refer to *document [1]*.

If the SIM card detection function is not used, user can keep the SIM_PRESENCE pin open. The reference circuit of 6-pin SIM card holder is illustrated in the following figure.
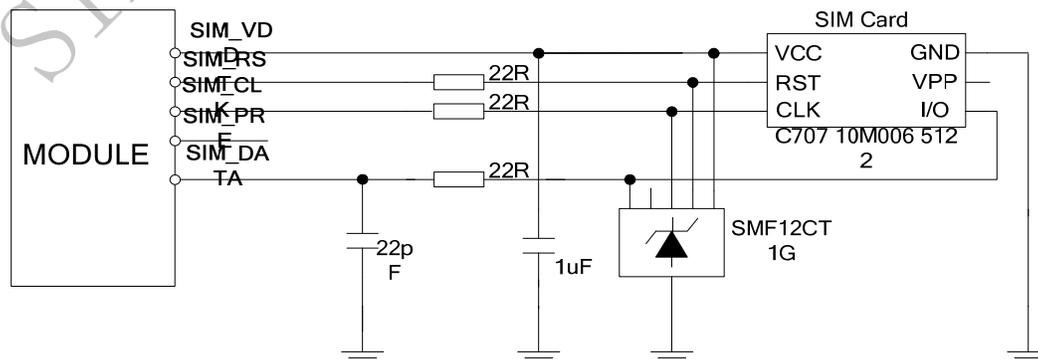
Figure 37: Reference circuit of the 6-pin SIM card holder

4.10.2 SIM Card Design Consideration

SIM card circuit is susceptible to interference, causing the SIM card failures or some other situations, so it is strongly recommended to follow these guidelines while designing:

- Make sure that SIM card holder should far away from GSM antenna while in PCB layout.
- SIM traces should keep away from RF lines, VBAT and high-speed signal lines.
- The traces should be as short as possible.
- Keep SIM holder's GND connect to main ground directly.
- Shielding the SIM card signal by ground well.
- Recommended to place a 1uF capacitor on VSIM line and keep close to the holder.

Add some TVS and the parasitic capacitance should not exceed 50pF, and 22Ω resistor in serials the SIM signal could enhance ESD protection.

4.10.3 Design Considerations for SIM Card Holder

For 8 pins SIM card holder, SIMCom recommends to use Molex 91228.User can visit http://www.molex.com for more information about the holder.
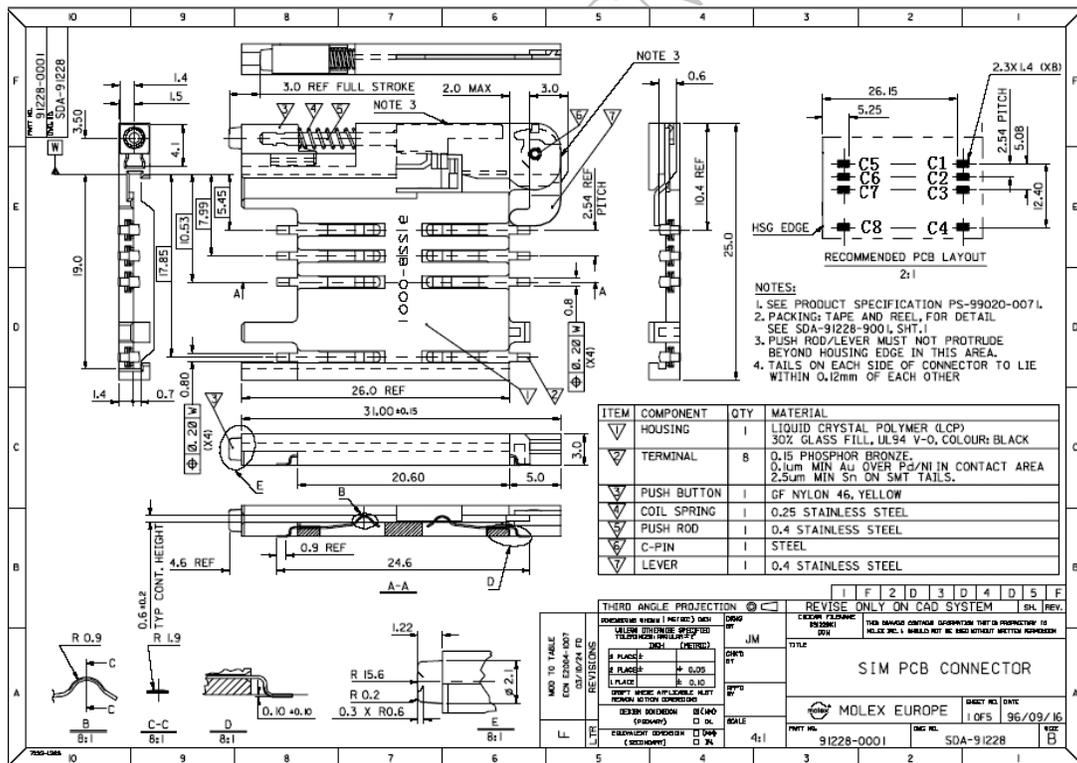
Figure 38: Molex 91228 SIM card holder

Table 18: Pin description (Molex SIM card holder)

Pin name	Signal	Description
C1	SIM_VDD	SIM card power supply
C2	SIM_RST	SIM card reset
C3	SIM_CLK	SIM card clock
C3	GND	Connect to GND
C5	GND	Connect to GND
C6	VPP	Not connect
C7	SIM_DATA	SIM card data I/O
C8	SIM_PRE	Detect SIM card presence

For 6-pin SIM card holder, SIMCom recommends to use Amphenol C707 10M006 5122 .User can visit http://www.amphenol.com for more information about the holder.
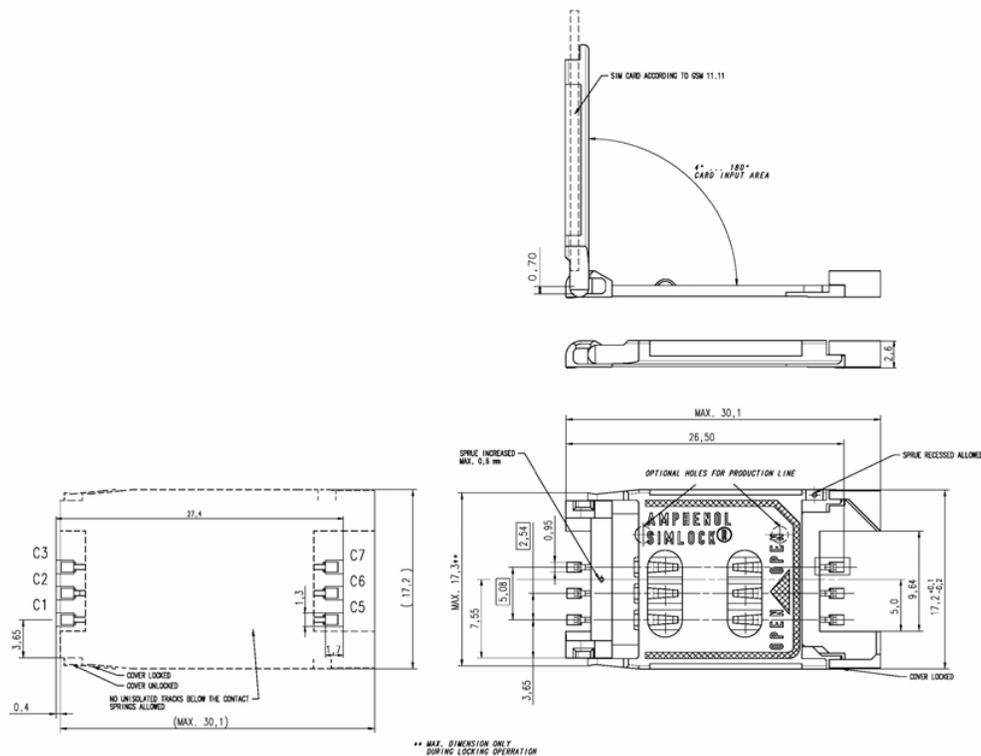
Figure 39: Amphenol C707 10M006 5122 SIM card holder

Table 19: Pin description (Amphenol SIM card holder)

Pin name	Signal	Description
C1	VSIM	SIM card power supply
C2	SIM_RST	SIM card reset
C3	SIM_CLK	SIM card clock
C5	GND	Connect to GND
C6	VPP	Not connect
C7	SIM_DATA	SIM card data I/O

4.11 PCM Interface

SIM808 provides PCM interface.

Table 20: PCM pin definition

Pin name	Pin number	Description
PCM_OUT	48	PCM data output
PCM_IN	47	PCM data input
PCM_SYNC	45	PCM synchrony
PCM_CLK	46	PCM clock

SIM808 PCM interface only supports master mode, data length is 16 bits (linear), and PCM clock rate is 256 KHz.

Table 21: PCM pin specification

Feature	specification
Line Interface Format	Linear(Fixed)
Data length	16bits(Fixed)
PCM Clock/Sync Source	Master Mode(Fixed)
PCM Clock Rate	256Khz(Fixed)
PCM Sync Format	Short sync/Long sync both support
Zero Padding/Sign extension	Default Zero Padding
Data Ordering	MSB/LSB both support

Note: User can use AT command control PCM interface, for details please refer to document [1].

4.11.1 PCM Multiplex Function

With GPIO5 and GPIO6, PCM interface can be configured as SPI or SD interface, the following table shows the detailed multiplex function.

Table 22: PCM Multiplex Function

Name	Pin number	Mode 0(default)	Mode 1	Mode 2	Mode 3
PCM_OUT	48	PCM_OUT	GPIO10	MC3DA3	/
PCM_IN	47	PCM_IN	DISP_DATA	MC3DA2	GPIO9
PCM_SYNC	45	PCM_SYNC	DISP_CS	MC3CK	GPIO7
PCM_CLK	46	PCM_CLK	GPIO8	MC3CM0	GPIO8
GPIO6	44	GPIO6	DISP_CLK	MC3DA1	/
GPIO5	43	GPIO5	DISP_D/C	MC3DA0	/

Note: Multiplex Function need different software version.

4.11.2 PCM Interface

Refer to the following figure for PCM design:
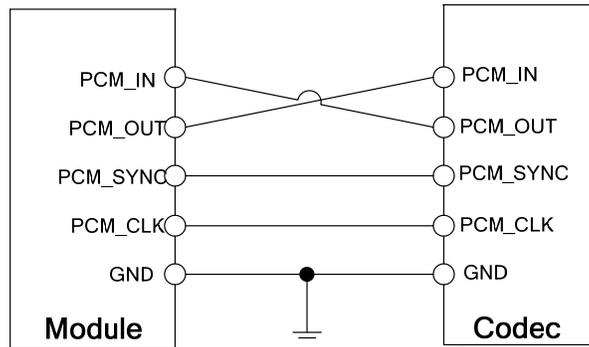
Figure 40: PCM reference circuit

4.11.3 LCD Display/SPI Interface

SIM808 provides a serial interface. It could be used as SPI interface in the embedded AT application. For details about embedded AT application, please refer to *document [1]*.

Refer to the following figure for SPI design:
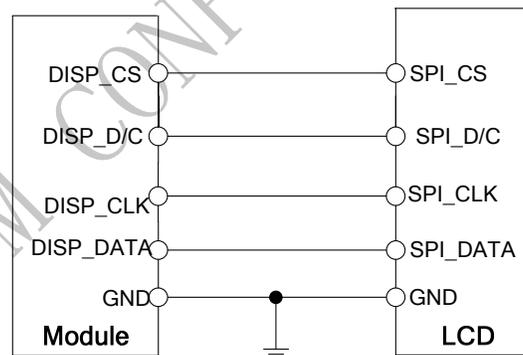
Figure 41: LCD reference circuit

Note: This function is not supported in the standard firmware. If user wants this function, the firmware must be customized. Please contact SIMCom for more details.

4.11.4 SD Card Interface
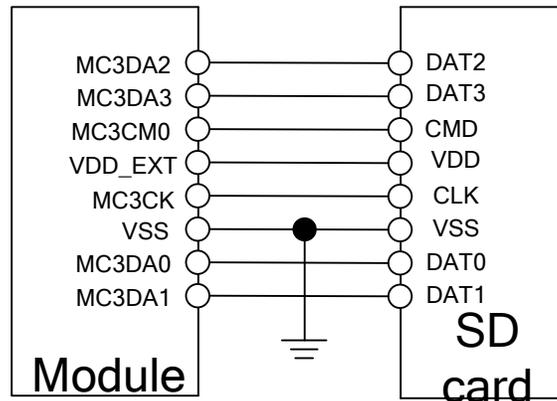
Figure 42: SD reference circuit

If the VDD of SD card is 2.8V, user can use VDD_EXT power the SD card directly. If the VDD is 3.3V, customer should design the power circuit external.

4.12 Keypad Interface

SIM808 consists of 4 keypad column outputs and 4 keypad row inputs, and it can support two kinds of connections, the traditional 4*4 keypad matrix and the extended 4*4*2 keypad matrix.
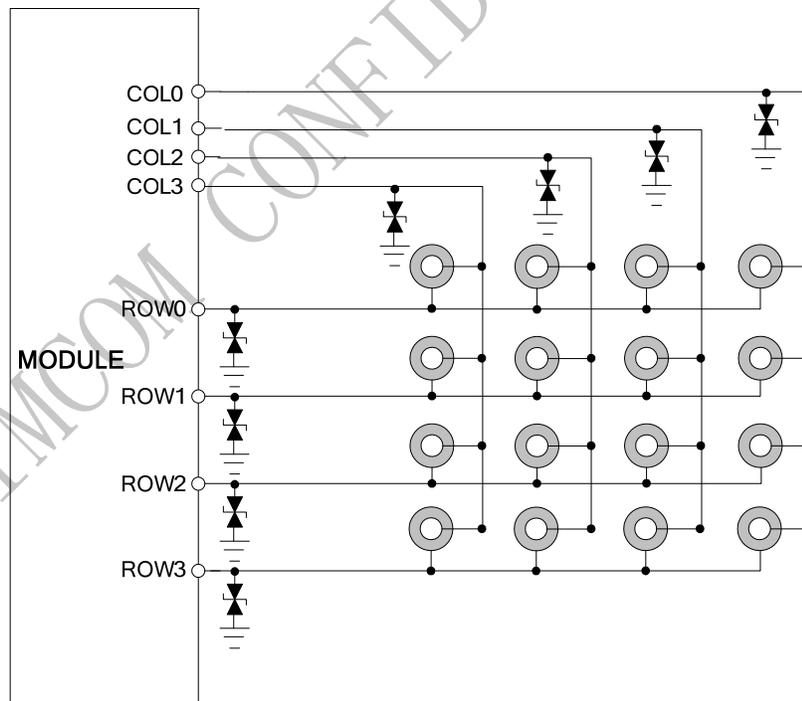
Figure 43: Traditional keypad reference circuit

Note:1、 According to the traditional 4*4 keypad matrix, when there are unused COLs or ROWs, user can execute AT command to define unused COLs and ROWs as GPIO, for details please see the document [1].

2、Press COL0 and ROW0 or pull down COL0 when power-on(PWRKEY, Charging, RTC alarm), power sequence is USB Download.

Module supports a new keypad connection, it can support 4*4*2 amount 32 keypads, meet full keyboard demand, and the connection diagram is as follow:
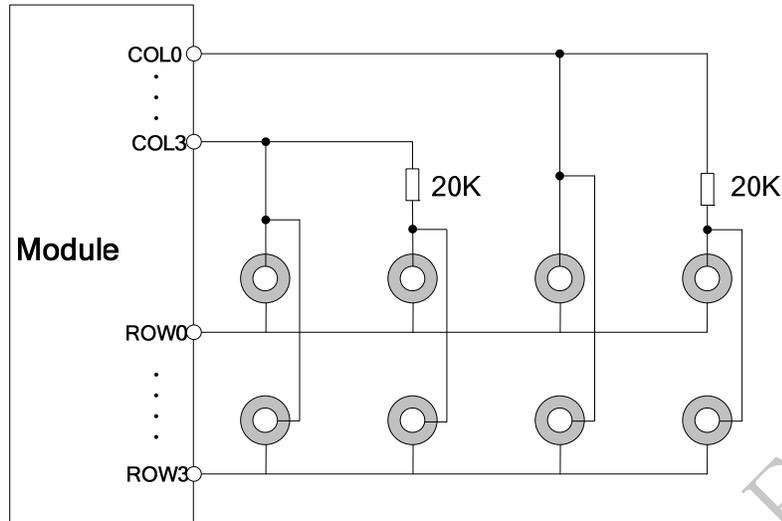
Figure 44: Extended keypad reference circuit

Note: Do not change the 20KΩ resistor in the diagram.

Customer should add a resistor to enhance the ESD performance and the value of resistor should be less than 1KΩ, the connection diagram is shown in follow figure as an example.
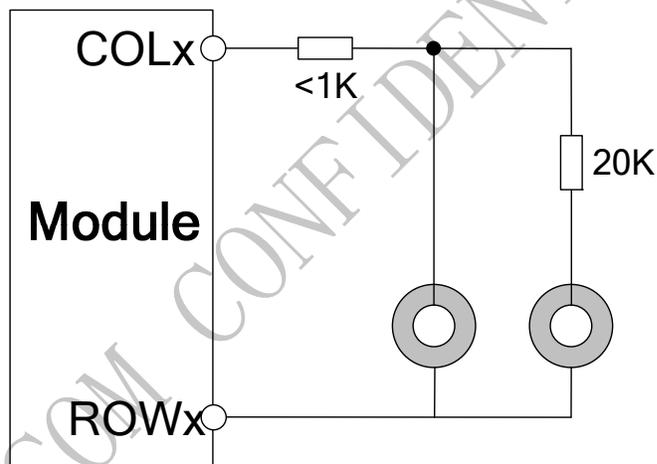
Figure 45: Enhance the ESD performance of keypad circuit

Module can detect two buttons pressed synchronously at both the traditional and extended keypad connection, but customer should notice that, do not assign keys which will be pressed at the same time on same COL and ROW when implement the extended keypad design. The following figure is an example to explain this situation, "CTRL" and "A" can not be recognized if the two buttons were pressed at the same time.
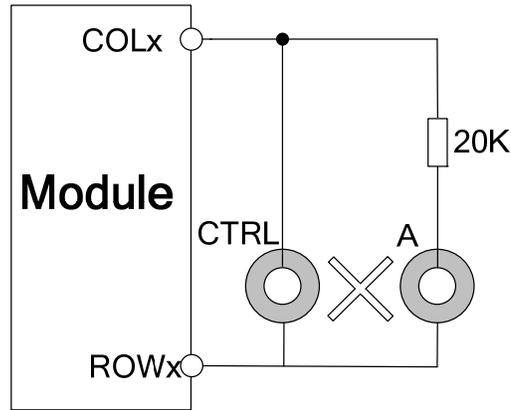
Figure 46: Keypad detected

Table 23: Pin definition of the keypad interface

Name	Pin	Function	Default state
COL0	62	Keypad matrix column	Pull up
COL1	61		Pull down
COL2	60		Pull down
COL3	59		Pull down
ROW0	58	Keypad matrix row	Pull down
ROW1	57		Pull down
ROW2	56		Pull down
ROW3	55		Pull down

Table 24: Keypad multiplex function

Pin name	Pin number	Mode 0(default)	Mode 1
COL0	62	COL0	GPIO18
COL1	61	COL1	GPIO17
COL2	60	COL2	GPIO16
COL3	59	COL3	GPIO15
ROW0	58	ROW0	GPIO14
ROW1	57	ROW1	GPIO13
ROW2	56	ROW2	GPIO12
ROW3	55	ROW3	GPIO11

Note: Multiplex Function need different software version .

4.13 I2C BUS

The SIM808 provides an I2C interface, it can be driven by either the master or slave and conform to the I2C specification. It has the following features:

- Compliant master mode operation

- Adjustable clock speed for LS/FS mode operation
- Support 7-bit/10-bit addressing
- Support high speed mode
- Support slave clock extension
- START/STOP/REPEATED condition
- Manual transfer mode
- Multi-write per transfer (up to 8 data bytes for non-DMA mode)
- Multi-read per transfer (up to 8 data bytes for non-DMA mode)
- Multi-transfer per transaction
- Combined format transfer with length change capability

Active drive/write-and I/O configuration

Table 25: Pin definition of the I2C

Pin name	Pin number	Description
SCL	39	I2C serial bus clock
SDA	38	I2C serial bus data

Note: I2C has been pulled up to 2.8V via 4.7KΩ.

Table 26: I2C multiplex function

Pin name	Pin number	Mode 0(default)	Mode 1
SCL	39	SCL	GPIO2
SDA	38	SDA	GPIO1

4.13.1   General Purpose Input/Output (GPIO)

SIM808 provides 2 GPIO pins. The output voltage level of the GPIO can be set by the AT command "AT+ SGPIO". The input voltage level of the GPIO can also be read by the AT command "AT+ SGPIO". For more details, please refer to *document [1]*.

Table 27: Pin definition of the GPIO

Pin name	Pin number	Reset state
GPIO6	44	Pull down
GPIO5	43	Pull down

4.14 ADC

Table 28: Pin definition of the ADC

Pin name	Pin number	Description
ADC1	23	Analog to Digital Converter
ADC2	24	Analog to Digital Converter

SIM808 provides two auxiliary ADC, which can be used to measure the voltage. User can use AT command

"AT+CADC" to read the voltage value. For details of this AT command, please refer to *document [1]*.

Table 29: ADC specification

Parameter	Min	Typ	Max	Unit
Voltage range	0	-	2.8	V
ADC Resolution	-	10	-	bits
Sampling rate	-	-	1.0833	MHz
ADC precision		10	20	mV

Note: the voltage should less than 2.8V, or the ADC may be damaged.

4.15 PWM

Table 30: Pin definition of the PWM

Pin name	Pin number	Description
PWM1	42	PWM1, multiplex with GPIO4
PWM2	41	PWM2, multiplex with GPIO3

Note: SIM808 can only support 1 PWM synchronously, if customer set PIN 42 as PWM, so PIN41 can only be used as GPIO.

PWM output frequency varies from 0 to 2KHz.Two 7-bit unsigned binary parameters are used for the output period and for the duty cycle. The AT command "AT + SPWM" is used to set the output period and duty cycle of the PWM. For details, please refer to *document [1]*.

A typical circuit of the PWM drives buzzer is shown in the following figure:
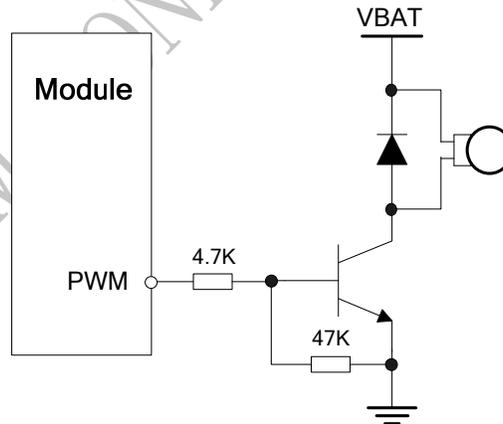
Figure 47: Reference circuit of PWM drive buzzer

Table 31: Buzzer output characteristics

Parameter	Min	Typ	Max	Unit
Working voltage	2.5	2.8	2.9	V
Working current			16	mA

Note: PWM pin must keep low when module in the boot process.

Table 32: PWM multiplex function

Pin name	Pin number	Mode 0(default)	Mode 1
PWM1	42	PWM1	GPIO4
PWM2	41	GPIO3	PWM2

4.16 Network Status Indication

Table 33: Pin definition of the NETLIGHT

Pin name	Pin number	Description
NETLIGHT	50	Network Status Indication

The NETLIGHT pin can be used to drive a network status indication LED. The status of this pin is listed in following table:

Table 34: Status of the NETLIGHT pin

Status	SIM808 behavior
Off	SIM808 is not running
64ms On/ 800ms Off	SIM808 not registered the network
64ms On/ 3000ms Off	SIM808 registered to the network
64ms On/ 300ms Off	PPP GPRS communication is established

A reference circuit is recommended in the following figure:
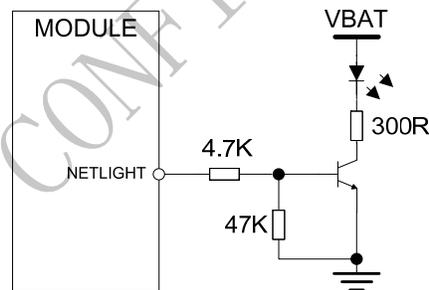
Figure 48: Reference circuit of NETLIGHT

4.17 Operating Status Indication

The STATUS pin indicates the operating status of module. The pin output high when module power on, output is low when module powered off.

Table 35: Pin definition of the STATUS

Pin name	Pin number	Description
STATUS	49	Operating status indication

4.18 RF Synchronization Signal

The synchronization signal serves to indicate growing power consumption during the transmit burst.

Table 36: Definition of the RF_SYNC pin

Pin name	Pin number	Description
RF_SYNC	63	Transmit synchronization signal

Note: Do not pull up RF_SYNC.

The timing of the synchronization signal is shown in the following figure. High level of the RF_SYNC signal indicates increased power consumption during transmission.
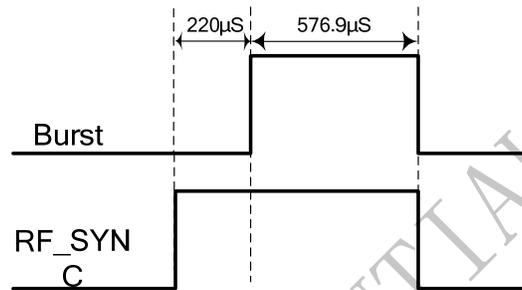
Figure 49: RF_SYNC signal during transmit burst

4.19 GSM antenna Interface

GSM antenna port is named RF_ANT. The impedance should be 50Ω. VSWR should be less than 2. It is recommended that GSM antenna and Bluetooth antenna be placed as far as better to keep the isolations more than 30dB.

The customer's GSM antenna also can be located in the customer's main board and connect to module's GSM_ANT pad through microstrip line or other type RF trace which impendence must be controlled in 50Ω. To facilitate the antenna tuning and certification test, a RF connector and an antenna matching circuit should be added. The following figure is the recommended circuit.
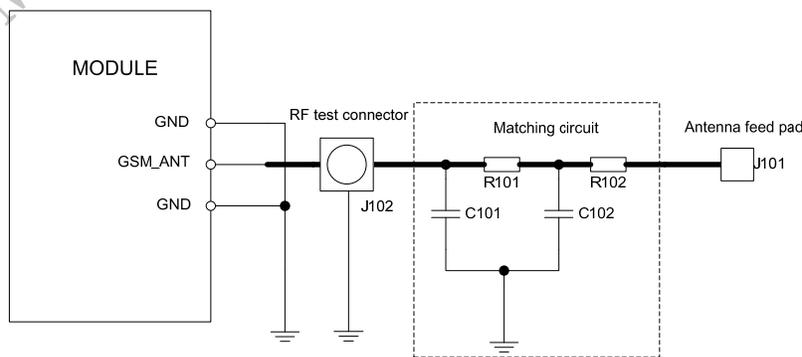
Figure 50: GSM antenna matching circuit

In this figure, the components R101,R102,C101 and C102 is used for antenna matching, the components' value

only can be got after the antenna tuning. Usually, matching components' value is provided by antenna vendor, the default value of R101 and R102 are 0Ω, and reserve the place of C101 and C102 without soldering.

The RF test connector in Figure 50 is used for conducted RF performance test, and should be placed as close as possible to the module's RF_ANT pad. The traces in bold type should be treated as 50Ω impedance controlled line in PCB layout. For details about radio frequency trace layout, please refer to *document [9]*.

5   GPS Application Interface

SIM808 provide a high-performance L1 GPS solution for cellular handset applications. The solution offers best-in-class acquisition and tracking sensitivity, Time-To-First-Fix (TTFF) and accuracy. The GPS engine supports both fully-autonomous operations for use in handheld consumer navigation devices and other standalone navigation systems.
The module supports GPS, QZSS, SBAS ranging (WAAS, EGNOS, GAGAN, MSAS).
The GPS NMEA information is output by serial port. The default baud rate is 115200bps.

The GPS engine is controlled by GSM engine, so when it is necessary to run GPS，the GSM engine must be powered on and not in SLEEP mode.

All the GPS function is controlled by AT command via serial port. The GPS functions of AT commands are listed in the following table.

Table 37: AT Commands for GPS function

Command	Description
AT+CGPSPWR	GPS power control
AT+CGPSRST	GPS mode reset (hot/warm/cold)
AT+CGPSSTATUS	Get current GPS status
AT+CGPSOUT	GPS NMEA data output control
AT+CGPSINF	Get current GPS location info
AT+CGPSIPR	Set GPS NMEA output UART bps

For details of these AT command, please refer to *document [1]*.

5.1   GPS Operating Modes

GPS has two operating modes which can be controlled by AT command.

Active mode: GPS is active as a GPS receiver. The GPS engine will automatically acquire and track GPS satellites.

Power down mode: The GPS engine will be set into this mode by sending AT command "AT+CGPSPWR=0". In this mode the internal power supply for GPS will be shutdown, and the current consumption is very low. The last position, current time and ephemeris data will be stored in the GSM host memory.

5.2 GPS Power on/down Scenarios

5.2.1 Power on GPS engine

User can power on GPS engine by sending AT command "AT+CGPSPWR=1".

5.2.2 Power down GPS engine

User can power down GPS engine by sending AT command "AT+CGPSPWR=0".

5.3 GPS Antenna Interface

5.3.1 GPS Antenna Interface

The customer's GPS antenna also can be located in the customer's main board and connect to module's
GPS_ANT pad through microstrip line or other type RF trace which impendence must be 50Ω.
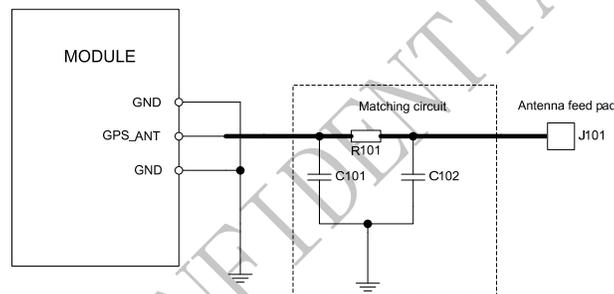
Figure 51: GPS antenna matching circuit

In Figure 51, the components R101, C101 and C102 is used for antenna matching, the components' value only
can be got after the antenna tuning. Usually, matching components' value is provided by antenna vendor, the
default value of R101 is 0Ω, and users need to reserve the place of C101 and C102 without soldering. The traces
in bold type should be treated as 50Ω impedance controlled line in PCB layout.

5.3.2 GPS Antenna Choice Consideration

To obtain excellent GPS reception performance, a good antenna will always be required. The antenna is the most
critical item for successful GPS reception in a weak signal environment. Proper choice and placement of the
antenna will ensure that satellites at all elevations can be seen, and therefore, accurate fix measurements are
obtained.
Most customers contract with antenna design houses to properly measure the radiation pattern of the final
mounted configuration in a plastic housing with associated components near the antenna. Linear antennas are
becoming more popular, and the gain is reasonable, since a smaller ground plane can be used.

User can consider following factors as:

● Choose a linear antenna with a reasonably uniform hemispherical gain pattern of >-4dBi.

● Use of an antenna with lower gain then this will give less than desirable results. Please note that a RHCP

antenna with a gain of 3dBi, equates to a linear polarized antenna of 0dBi.

● Proper ground plane sizing is a critical consideration for small GPS antennas.

● Proper placement of the GPS antenna should always be the FIRST consideration in integrating the SIM808 GPS Module.

If the customer's design will allow for a ceramic RHCP patch antenna with an appropriately sized ground plane, and the patch is normally oriented towards the sky, then that particular solution usually works the best. Note that if the patch antenna ground plane is less than 60x60mm, then compromises to the beam width and gain pattern could result. Usually the gain becomes very directional, and looses several dB of performance. Since results can vary, measuring the antenna radiation pattern in the final housing in an appropriate anechoic chamber is required.

Some customers do not have the size availability to implement a patch antenna approach. In that instance, use of a Linear Polarized (LP) antenna is the next best alternative. There are new ceramic LP antennas on the market that exhibit reasonable gain characteristics once properly mounted in the housing, and when matched to an appropriate sized ground. Generally the ground plane requirements are smaller for a LP antenna when compared to a patch, but once again, proper testing in an anechoic chamber is a mandatory requirement. These ceramic elements will need to be located near the end of the ground plane, and will require several millimeters of clearance between the closest component. It is important to note that use of a LP antenna will result in a minimum of 3dB of gain loss when compared to a RHCP antenna at a defined elevation. This is due to the right hand gain rule of antenna propagation.

Use of PIFA antenna is another LP possibility, but the PIFA usually exhibits a considerable amount of gain nulls, or "holes" in the radiation pattern. This will be undesirable for obtaining a low circular error probability (CEP), since the antenna may not allow the receiver to capture the desired satellite at the ideal orientation due to these noted gain nulls. Once again, careful testing in an appropriate anechoic chamber is required.

If the customer's design is for automotive applications, then an active antenna can be used and located on top of the car in order to achieve the best signal quality. GPS antenna choice should be based on the designing product and other conditions.

For detailed Antenna designing consideration, please refer to related antenna vendor's design recommendation. The antenna vendor will offer further technical support and tune their antenna characteristic to achieve successful GPS reception performance depending on the customer's design.

6 Electrical, Reliability and Radio Characteristics

6.1 Absolute Maximum Ratings

The absolute maximum ratings stated in following table are stress ratings under non-operating conditions. Stresses beyond any of these limits will cause permanent damage to SIM808.

Table 38: Absolute maximum ratings

Symbol	Min	Typ	Max	Unit

VBAT	-	-	4.5	V
Peak Current	0	-	2.0	A
VBUS	-	-	30	V
I_I*	-	-	8	mA
I_O*	-	-	8	mA

* These parameters are for digital interface pins, such as keypad, GPIO, I2C, UART, LCD and PCM..

6.2 Recommended Operating Conditions

Table 39: Recommended operating conditions

Symbol	Parameter	Min	Typ	Max	Unit
VBAT	Power supply voltage	3.4	4.0	4.4	V
T_{OPER}	Operating temperature	-40	+25	+85	℃
T_{STG}	Storage temperature	-45		+90	℃

6.3 Digital Interface Characteristics

Table 40: Digital interface characteristics

Symbol	Parameter	Min	Typ	Max	Unit
I_{IH}	High-level input current	-10	-	10	uA
I_{IL}	Low-level input current	-10	-	10	uA
V_{IH}	High-level input voltage	2.4	-	-	V
V_{IL}	Low-level input voltage	-	-	0.4	V
V_{OH}	High-level output voltage	2.7	-	-	V
V_{OL}	Low-level output voltage	-	-	0.1	V

* These parameters are for digital interface pins, such as keypad, GPIO, I^{2}C, UART, LCD, PWMs and DEBUG.

6.4 SIM Card Interface Characteristics

Table 41: SIM card interface characteristics

Symbol	Parameter	Min	Typ	Max	Unit
I_{IH}	High-level input current	-1	-	1	uA
I_{IL}	Low-level input current	-1	-	1	uA
V_{IH}	High-level input voltage	1.4	-	-	V
		2.4	-	-	V
V_{IL}	Low-level input voltage	-	-	0.27	V
				0.4	V
V_{OH}	High-level output voltage	1.62	-	-	V
		2.7	-	-	V

		-	-	0.36	V
V_{OL}	Low-level output voltage	-	-	0.4	V

6.5 SIM_VDD Characteristics

Table 42: SIM_VDD characteristics

Symbol	Parameter	Min	Typ	Max	Unit
V_O	Output voltage	-	3	-	V
		-	1.80	-	
I_O	Output voltage	-	-	10	mA

6.6 VDD_EXT Characteristics

Table 43: VDD_EXT characteristics

Symbol	Parameter	Min	Typ	Max	Unit
V_O	Output voltage	2.70	2.80	2.95	V
I_O	Output current	-	-	50	mA

6.7 VRTC Characteristics

Table 44: VRTC characteristics

Symbol	Parameter	Min	Typ	Max	Unit
V_{RTC-IN}	VRTC input voltage	-	2.8	-	V
I_{RTC-IN}	VRTC input current	-	3	-	uA
$V_{RTC-OUT}$	VRTC output voltage	-	2.8	-	V
$I_{RTC-OUT}$	VRTC output current	-		2	uA

6.8 Current Consumption (VBAT = 4V, GPS engine is powered down)

Table 45: GSM current consumption*

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
VBAT	Voltage		3.4	4.0	4.4	V
	Power drop	PCL=5			350	mV
	Voltage ripple	PCL=5 @ f<200kHz			50	mV
		@ f>200kHz			2	mV

I$_{VBAT}$	Average current	Power down mode		38	50	uA

		Sleep mode (AT+CFUN=1):
		  (BS-PA-MFRMS=9)
		  (BS-PA-MFRMS=5)
		  (BS-PA-MFRMS=2)
				1.965
				1.7
				1.4
						mA
						mA
						mA

		Idle mode (AT+CFUN=1): EGSM900		22.1		mA

		Voice call (PCL=5):
		  GSM850
		  EGSM900
		  DCS1800
		  PCS1900
				207.63
				202.32
				139.825
				137.805
						mA
						mA

		Data mode GPRS (1Rx,4Tx):
		  GSM850
		  EGSM900
		  DCS1800
		  PCS1900
				445.82
				424.32
				293.62
				279.18
						mA
						mA

		Data mode GPRS (3Rx,2Tx):
		  GSM850
		  EGSM900
		  DCS1800
		  PCS1900
				329.79
				220.62
				223.18
				218.34
						mA
						mA

		Data mode GPRS (4Rx,1Tx):
		  GSM850
		  EGSM900
		  DCS1800
		  PCS1900
				221.25
				220.62
				158.01
				158.62
						mA
						mA

I$_{MAX}$	Peak current	During TX burst		2.0		A

* In above table the current consumption value is the typical one of the module tested in laboratory. In the mass production stage, there may be differences among each individual.

6.9 Electro-Static Discharge

SIM808 is an ESD sensitive component, so more attention should be paid to the procedure of handling and packaging. The ESD test results are shown in the following table.

Table 46: The ESD characteristics (Temperature: 25℃, Humidity: 45 %)

Pin	Contact discharge	Air discharge
VBAT	±5KV	±10KV
GND	±5KV	±10KV
RXD, TXD	±4KV	±8KV
Antenna port	±5KV	±10KV

SPK1P/ SPK1N MIC1P/ MIC1N	±4KV	±8KV
PWRKEY	±4KV	±8KV

Note: It is suggested that customers in serials with 100ohm resistances on UART lines for ESD consideration.

6.10 Radio Characteristics

6.10.1 Module RF Output Power

The following table shows the module conducted output power, it is followed by the 3GPP TS 05.05 technical specification requirement.

Table 47: SIM808 GSM 900 and GSM 850 conducted RF output power

GSM 900 and EGSM 850			
PCL	Nominal output power (dBm)	Tolerance (dB) for conditions	
		Normal	Extreme
0-2	39	±2	±2.5
3	37	±3	±4
4	35	±3	±4
5	33	±3	±4
6	31	±3	±4
7	29	±3	±4
8	27	±3	±4
9	25	±3	±4
10	23	±3	±4
11	21	±3	±4
12	19	±3	±4
13	17	±3	±4
14	15	±3	±4
15	13	±3	±4
16	11	±5	±6
17	9	±5	±6
18	7	±5	±6
19-31	5	±5	±6

Table 48: SIM808 DCS 1800 and PCS 1900 conducted RF output power

DCS 1800 and PCS 1900			
PCL	Nominal output power (dBm)	Tolerance (dB) for conditions	
		Normal	Extreme

29	36	±2	±2.5
30	34	±3	±4
31	32	±3	±4
0	30	±3	±4
1	28	±3	±4
2	26	±3	±4
3	24	±3	±4
4	22	±3	±4
5	20	±3	±4
6	18	±3	±4
7	16	±3	±4
8	14	±3	±4
9	12	±4	±5
10	10	±4	±5
11	8	±4	±5
12	6	±4	±5
13	4	±4	±5
14	2	±5	±6
15-28	0	±5	±6

For the module's output power, the following should be noted:

At GSM900 and GSM850 band, the module is a class 4 device, so the module's output power should not exceed 33dBm, and at the maximum power level, the output power tolerance should not exceed +/-2dB under normal condition and +/-2.5dB under extreme condition.

At DCS1800 and PCS1900 band, the module is a class 1 device, so the module's output power should not exceed 30dBm, and at the maximum power level, the output power tolerance should not exceed +/-2dB under normal condition and +/-2.5dB under extreme condition.

6.10.2   Module RF Receive Sensitivity

The following table shows the module's conducted receive sensitivity, it is tested under static condition.

Table 49: SIM808 conducted RF receive sensitivity

Frequency	Receive sensitivity（Typical）	Receive sensitivity(Max)
GSM850	-109dBm	-107dBm
EGSM900	-109dBm	-107dBm
DCS1800	-109dBm	-107dBm
PCS1900	-109dBm	-107dBm

6.10.3 Module Operating Frequencies

The following table shows the module's operating frequency range; it is followed by the 3GPP TS 05.05 technical specification requirement.

Table 50: SIM808 operating frequencies

Frequency	Receive	Transmit
GSM850	869 ~ 894MHz	824 ~ 849 MHz
EGSM900	925 ~ 960MHz	880 ~ 915MHz
DCS1800	1805 ~ 1880MHz	1710 ~ 1785MHz
PCS1900	1930 ~ 1990MHz	1850 ~ 1910MHz

7 Manufacturing

7.1 Top and Bottom View of SIM808

Figure 52: Top and Bottom View of SIM808

7.2 Typical Solder Reflow Profile
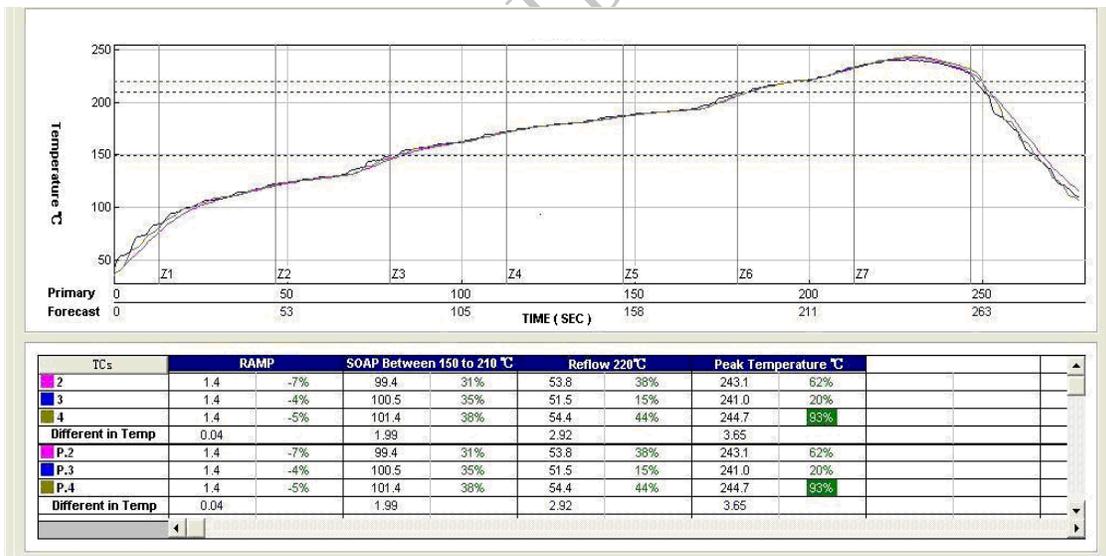
Figure 53: Typical Solder Reflow Profile

Note: Please refer to 《Module secondary-SMT-UGD》 for more information about the module shipping and manufacturing.

7.3　The Moisture Sensitivity Level

The moisture sensitivity level of SIM808 is 3. The module should be mounted within 168 hours after unpacking in the environmental conditions of temperature <30°C and relative humidity of <60% (RH). It is necessary to bake the module if the above conditions are not met:

Table 51: Moisture classification level and floor life

Level	Floor Life (out of bag) at factory ambient≤30°C /60% RH or as stated
1	Unlimited at ≤30°C /85% RH
2	1 year
2a	4 weeks
3	168 hours
4	72 hours
5	48 hours
5a	24 hours
6	Mandatory bake before use. After bake, it must be reflowed within the time limit specified on the label.

NOTES:

1. If the vacuum package is not open for 6 months or longer than the packing date, baking is also recommended before re-flow soldering.

2. For product handling, storage, processing, IPC / JEDEC J-STD-033 must be followed.

7.4　Baking Requirements

Because of its sensitivity to moisture absorption, SIM808 should be baked sufficiently before re-flow soldering. Otherwise SIM808 will be at the risk of permanent damage during re-flow soldering. SIM808 should be baked 192 hours at temperature 40°C +5°C /-0°C and <5% RH for low-temperature device containers, or 72 hours at temperature 80°C±5°C for high-temperature device containers. Care should be taken that the plastic tray is not heat resistant, SIM808 modules should be taken out for baking, and otherwise the tray may be damaged by high-temperature during baking.

Table 52: Baking requirements

Baking temperature	Moisture	Time
40°C±5°C	<5%	192 hours
120°C±5°C	<5%	4 hours

Appendix

A. Related Documents

Table 53: Related documents

SN	Document name	Remark
[1]	SIM800_AT Command Manual	SIM800 AT Command Manual
[2]	AN_SIM900_TCPIP	TCP/IP Applications User Manual
[3]	SIM900_Multiplexer User Manual_Application Note	SIM808 Multiplexer User Manual Application Note
[4]	AN_SIM900 Series_Update Tool_UGD	SIM808 Series Update Tool User Guide
[5]	AN_SIM900_AUDIO	Applications Note About SIM808 Audio
[6]	AN_SIM900_Audio LINE-IN input	Applications Note About SIM808 LINE-IN Input
[7]	SIM900_Embedded AT Application Note	SIM808 Embedded AT Application Note
[8]	AN_Serial Port	Application Note About Serial Port
[9]	AN_SIM900-TE PCB Layout & Schematic for Reference	Application Note About SIM808-TE PCB Layout & Schematic
[10]	Module secondary-SMT-UGD	Module secondary SMT User Guide
[11]	ITU-T Draft new recommendation V.25ter:	Serial asynchronous automatic dialing and control
[12]	GSM 07.07:	Digital cellular telecommunications (Phase 2+); AT command set for GSM Mobile Equipment (ME)
[13]	GSM 07.10:	Support GSM 07.10 multiplexing protocol
[14]	GSM 07.05:	Digital cellular telecommunications (Phase 2+); Use of Data Terminal Equipment – Data Circuit terminating Equipment (DTE – DCE) interface for Short Message Service (SMS) and Cell Broadcast Service (CBS)
[15]	GSM 11.14:	Digital cellular telecommunications system (Phase 2+); Specification of the SIM Application Toolkit for the Subscriber Identity Module – Mobile Equipment (SIM – ME) interface
[16]	GSM 11.11:	Digital cellular telecommunications system (Phase 2+); Specification of the Subscriber Identity Module – Mobile Equipment (SIM – ME) interface
[17]	GSM 03.38:	Digital cellular telecommunications system (Phase 2+); Alphabets and language-specific information
[18]	GSM 11.10	Digital cellular telecommunications system (Phase 2)； Mobile Station (MS) conformance specification； Part 1: Conformance specification

B. Terms and Abbreviations

Table 54: Terms and Abbreviations

Abbreviation	Description
ADC	Analog-to-Digital Converter
AMR	Adaptive Multi-Rate
CS	Coding Scheme
CSD	Circuit Switched Data
CTS	Clear to Send
CEP	Circular Error Probable
DTE	Data Terminal Equipment (typically computer, terminal, printer)
DTR	Data Terminal Ready
DTX	Discontinuous Transmission
EFR	Enhanced Full Rate
EGSM	Enhanced GSM
EGNOS	European Geostationary Navigation Overlay Service
ESD	Electrostatic Discharge
ETS	European Telecommunication Standard
FR	Full Rate
GPRS	General Packet Radio Service
GSM	Global Standard for Mobile Communications
GPS	Global Positioning System
GAGAN	The GPS Aided Geo Augmented Navigation
HR	Half Rate
IMEI	International Mobile Equipment Identity
Li-ion	Lithium-Ion
MO	Mobile Originated
MS	Mobile Station (GSM engine), also referred to as TE
MT	Mobile Terminated
MSAS	Multi-Functional Satellite Augmentation System
NMEA	National Marine Electronics Association
PAP	Password Authentication Protocol
PBCCH	Packet Broadcast Control Channel
PCB	Printed Circuit Board
PCL	Power Control Level
PCS	Personal Communication System, also referred to as GSM 1900
PDU	Protocol Data Unit
PPP	Point-to-point protocol
QZSS	Quasi-Zenith Satellites System
RF	Radio Frequency
RMS	Root Mean Square (value)

RTC	Real Time Clock
RX	Receive Direction
SIM	Subscriber Identification Module
SBAS	Satellite Based Augmentation Systems
SMS	Short Message Service
TE	Terminal Equipment, also referred to as DTE
TX	Transmit Direction
UART	Universal Asynchronous Receiver & Transmitter
URC	Unsolicited Result Code
USSD	Unstructured Supplementary Service Data
WAAS	Wide Area Augmentation System
Phonebook abbreviations	
FD	SIM fix dialing phonebook
LD	SIM last dialing phonebook (list of numbers most recently dialed)
MC	Mobile Equipment list of unanswered MT calls (missed calls)
ON	SIM (or ME) own numbers (MSISDNs) list
RC	Mobile Equipment list of received calls
SM	SIM phonebook
NC	Not connect

C. Safety Caution

Table 55: Safety caution

Marks	Requirements
♥	When in a hospital or other health care facility, observe the restrictions about the use of mobiles. Switch the cellular terminal or mobile off, medical equipment may be sensitive to not operate normally for RF energy interference.
✈	Switch off the cellular terminal or mobile before boarding an aircraft. Make sure it is switched off. The operation of wireless appliances in an aircraft is forbidden to prevent interference with communication systems. Forget to think much of these instructions may lead to the flight safety or offend against local legal action, or both.
🔥	Do not operate the cellular terminal or mobile in the presence of flammable gases or fumes. Switch off the cellular terminal when you are near petrol stations, fuel depots, chemical plants or where blasting operations are in progress. Operation of any electrical equipment in potentially explosive atmospheres can constitute a safety hazard.
	Your cellular terminal or mobile receives and transmits radio frequency energy while switched on. RF interference can occur if it is used close to TV sets, radios, computers or other electric equipment.
🚗	Road safety comes first! Do not use a hand-held cellular terminal or mobile when driving a vehicle, unless it is securely mounted in a holder for hands free operation. Before making a call with a hand-held terminal or mobile, park the vehicle.

GSM cellular terminals or mobiles operate over radio frequency signals and cellular networks and cannot be guaranteed to connect in all conditions, for example no mobile fee or a invalid SIM card. While you are in this condition and need emergent help, please remember using emergency calls. In order to make or receive calls, the cellular terminal or mobile must be switched on and in a service area with adequate cellular signal strength.

Some networks do not allow for emergency call if certain network services or phone features are in use (e.g. lock functions, fixed dialing etc.). You may have to deactivate those features before you can make an emergency call.

Also, some networks require that a valid SIM card be properly inserted in the cellular terminal or mobile.

4D SYSTEMS
TURNING TECHNOLOGY INTO ART

2.4" *micro*LCD PICASO Display
uLCD-24PTU

DATASHEET

Document Date: 22nd June 2015
Document Revision: 1.8

Overview

The **uLCD-24PTU** is a compact and cost effective Intelligent Display Module packed with plenty of features, ready to become the GUI for your target application. It is the perfect choice for many applications that require a front end smart graphics interface.

Embedded at the heart of the design is the **PICASO** processor, which is driven by a highly optimised virtual core engine called **EVE** (Extensible Virtual Engine). An extensive range of hardware and software peripherals have been integrated into the design, to give the user freedom to adapt the module to suit almost any application.

The display module is an elegant combination of a 2.4" (240x320) LCD Screen, audio amplifier and speaker, micro-SD card connector, Lithium Ion and Polymer battery support, along with a group of general purpose input/output pins (GPIO's), including I^{2}C and serial communications.

This module serves as a perfect solution to be deployed at the forefront of any product design, requiring a brilliance of colour, animation or images on any application. This **PICASO** driven Intelligent Display Module is a perfect example of where art meets technology.
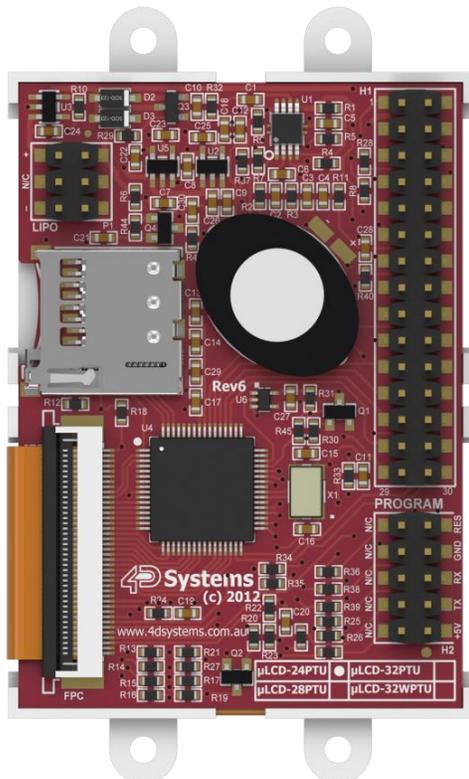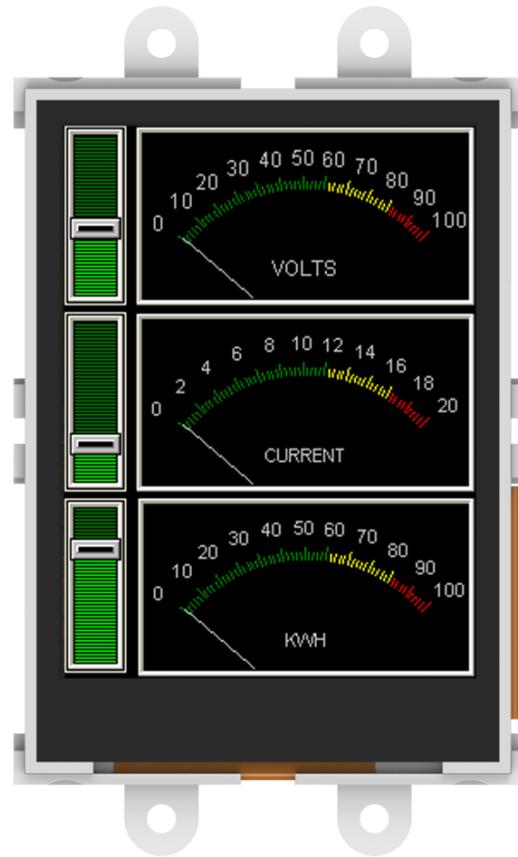
The **uLCD-24PTU** has a **2.4''** TFT LCD display at the forefront of the design that showcases the power and capabilities of the PICASO processor. Combining a resolution of **240x320** pixels with **65K** True to Life colours, this module is perfect for animations, slideshows and other multimedia presentations.

Audio support provided on the display module is supplied by the **PICASO** processor, an on-board audio amplifier and 8Ω speaker. A simple instruction enables the user to play audio files while continuing the execution of the Users code, such as display updates, touch recognition, communications and much more.

The **micro-SD** card slot provides the user with expandable memory space suitable for multimedia file retrieval, including images, animations and movie clips, as well as data logging applications.

The module can be programmed in its native 4DGL language (similar to C), using the Workshop4 IDE software tool suite, or it can be configured as a serial slave device to use with your favourite host controller. The freedom is at your fingertips with this 2.4" intelligent microLCD module.

Contents

microLCD PICASO DISPLAY

microLCD PICASO DISPLAY

1. Description

The uLCD-24PTU module demonstrates class and finesse in the microLCD range, featuring a 2.4'' 240x320 screen resolution that is the ideal size for displaying detailed graphics for many interactive touch applications.

Driving the display and peripherals is the PICASO processor, a very capable and powerful chip which enables stand-alone functionality, programmed using the 4D Systems Workshop 4 IDE Software. The Workshop IDE enables graphic solutions to be constructed rapidly and with ease due to its design being solely for 4D's graphics processors.

The module has an array of features including PWM for Sound, Touch Detection, micro-SD memory storage, Lithium battery support, general purpose I/O, serial communications, an I2C interface and multiple millisecond resolution timers, amongst many more features.

2. Features

- Low-cost 2.4" LCD-TFT display graphics user interface solution.

- 240 x 320 VGA resolution, RGB 65K true to life colours, TFT screen with Integrated 4-Wire Resistive Touch Panel.

- Easy 5 pin interface to any host device:
  VCC, TX, RX, GND, RESET

- Powered by the 4D-Labs PICASO processor (also available as separate OEM IC)

- 14KB of flash memory for user code storage and 14KB of SRAM for user variables, or 14KB shared user code and program variables.

- 2 x Asynchronous hardware serial ports (COM0, COM1), TTL interface, with 300 to 600K baud.

- 1 x I^{2}C interface (Master).

- 8 x 16 bit timers with 1 millisecond resolution.

- 13 x General Purpose I/O pins. Supports fast 8-bit parallel data transfer through Upper 8 bits.

- On-board micro-SD memory card adaptor for multimedia storage and data logging purposes. HC memory card support is also available for cards larger than 4GB.

- DOS compatible file access (FAT16 format) as well as low level access to card memory.

- Lithium battery support, with built in battery charger and automatic change-over.

- Dedicated PWM Audio pin driven by WAV files from micro-SD card.

- On-board audio amplifier with a tiny 8Ω speaker for sound generation and WAV file playback.

- Built in extensive 4DGL graphics and system library functions.

- Display full colour images, animations, icons and video clips.

- Supports all available Windows fonts.

- A 30 pin header for I/O expansion and future plug-in daughter boards.

- 4.0V to 5.5V range operation (single supply).

- Module dimensions: 44.7 x 74.75 x 15.9mm (including corner plates). Weighing ~ 34g.

- Display Viewing Area: 36.72 x 48.96mm

- 4 x corner plates with 2.7mm holes for mechanical mounting.

- RoHS Compliant.

3. Pin Configuration and Summary

P1 – Lithium Battery Header

H1 – I/O Expansion Header

H2 – Programming Header

H1

H2

P1
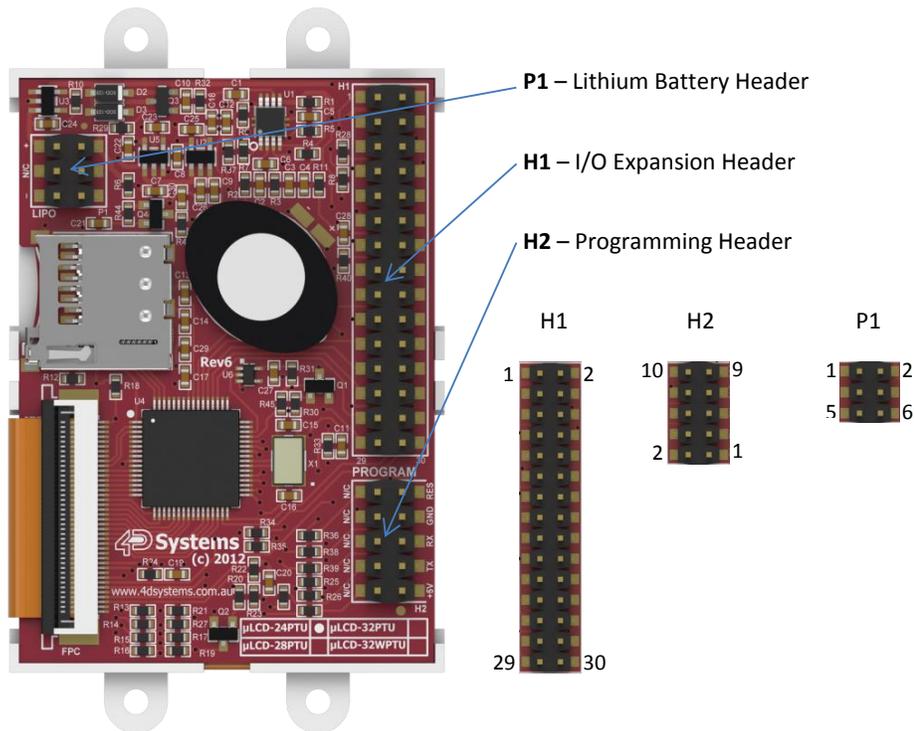
H2 Pin Outs (Programming Header)			
Pin	**Symbol**	**I/O**	**Description**
1	+5V	P	Main Voltage Supply +ve input pin. Reverse polarity protected. Range is 4.0V to
2	+5V	P	5.5V, nominal 5.0V.
3	TX	O	Asynchronous Serial Transmit pin, TTL level. Connect this pin to the Receive (Rx)
4	TX	O	signal of other serial devices. Used in conjunction with the RX pin for programming this microLCD. This pin is tolerant up to 5.0V levels.
5	RX	I	Asynchronous Serial Receive pin, TTL level. Connect this pin to the Transmit (Tx)
6	RX	I	signal of other serial devices. Used in conjunction with the TX pin for programming this microLCD. This pin is tolerant up to 5.0V levels.
7	GND	P	Supply Ground
8	GND	P	
9	RES	I	Master Reset signal. Internally pulled up to 3.3V via a 10K resistor. An active Low
10	RES	I	pulse greater than 2 micro-seconds will reset the module. If the module needs to be reset externally, only use open collector type circuits. This pin is not driven low by any internal conditions. The host should control this pin via one of its port pins using an open collector/drain arrangement.

I = Input, O = Output, P = Power

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H1 Pin Outs (I/O Expansion Header)			
Pin	Symbol	I/O	Description
1	IO1	I/O	General Purpose Input Output 1 Pin (alternatively used as Frame Mark pin when SB2 is closed)
2	SPK-	O	Speaker Output –ve, for external Speaker
3	IO2	I/O	General Purpose Input Output 2 Pin (alternatively used as Battery Status pin pin when SB3 is closed)
4	SPK+	O	Speaker Output +ve, for external Speaker
5	IO3	I/O	General Purpose Input Output 3 Pin (alternatively used as Peripheral Supply pin when SB1 is closed)
6	SCL	O	I^2C Clock Output
7	IO4	I/O	General Purpose Input Output 4 Pin
8	SDA	I/O	I^2C Bidirectional Data
9	IO5	I/O	General Purpose Input Output 5 Pin
10	N/C	-	Not connected
11	GND	P	Supply Ground
12	N/C	-	Not connected
13	GND	P	Supply Ground
14	+5V	P	Supply Input +ve, 4.0V to 5.5V, 5.0V Nominal
15	BUS7	I/O	IO Bus (BUS0..7) bit 7
16	AUDIO	I/O	Audio Input or Output, TTL Line level
17	BUS6	I/O	IO Bus (BUS0..7) bit 6
18	AUDENB	I	Audio Amplified Enable, Active High (5V)
19	BUS5	I/O	IO Bus (BUS0..7) bit 5
20	RES	I	Master Reset, Active Low (GND) (Refer H2 Pinout)
21	BUS4	I/O	IO Bus (BUS0..7) bit 4
22	3.3V OUT	P	3.3V Output, 20mA Max supply
23	BUS3	I/O	IO Bus (BUS0..7) bit 3
24	RX0	I	Asynchronous serial port 0 receive pin. COM0 (same as the RX pin on the H2 Programming Header)
25	BUS2	I/O	IO Bus (BUS0..7) bit 2
26	TX0	O	Asynchronous serial port 0 transmit pin. COM0 (same as the TX pin on the H2 Programming Header)
27	BUS1	I/O	IO Bus (BUS0..7) bit 1
28	TX1	O	Asynchronous serial port 1 transmit pin. COM1
29	BUS0	I/O	IO Bus (BUS0..7) bit 0
30	RX1	I	Asynchronous serial port 1 receive pin. COM1

I = Input, O = Output, P = Power

P1 Pin Outs (Lithium Battery Header)			
Pin	Symbol	I/O	Description
1	+	P	Lithium Ion or Polymer 3.7V Battery +ve Terminal
2	+	P	Lithium Ion or Polymer 3.7V Battery +ve Terminal
3	N/C	-	Not connected
4	N/C	-	Not connected
5	-	P	Lithium Ion or Polymer 3.7V Battery -ve Terminal
6	-	P	Lithium Ion or Polymer 3.7V Battery -ve Terminal

Please refer to section 6.4 prior to using the Lithium Battery Header

I = Input, O = Output, P = Power

4. Hardware Interface - Pins

The uLCD-24PTU provides both a hardware and software interface. This section describes in detail the hardware interface pins of the device.

4.1. Serial Ports - COM0, COM1 UARTS

The uLCD-24PTU has two dedicated hardware Asynchronous Serial ports that can communicate with external serial devices. These are referred to as the COM0 and the COM1 serial ports.

The primary features are:

- Full-Duplex 8 bit data transmission and reception.
- Data format: 8 bits, No Parity, 1 Stop bit.
- Independent Baud rates from 300 baud up to 600K baud.
- Single byte transmits and receives or a fully buffered service. The buffered service feature runs in the background capturing and buffering serial data without the user application having to constantly poll any of the serial ports. This frees up the application to service other tasks.
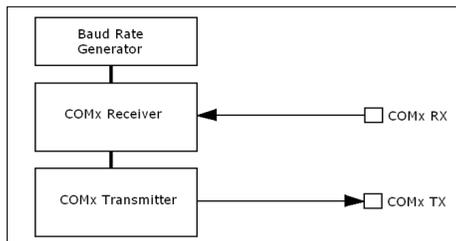
A single byte serial transmission consists of the start bit, 8-bits of data followed by the stop bit. The start bit is always 0, while a stop bit is always 1. The LSB (Least Significant Bit, Bit 0) is sent out first following the start bit. Figure below shows a single byte transmission timing diagram.
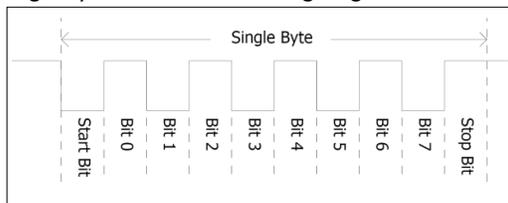
COM0 is also the primary interface for 4DGL user program downloads and chip configuration (PmmC programming). Once the compiled 4DGL application program (EVE byte-code) is downloaded and the user code starts executing, the serial port is then available to the user application. Refer to Section 5. 'Firmware / PmmC Programming' for more details on this subject.

TX0 pin (Serial Transmit COM0):
Asynchronous Serial port COM0 transmit pin, TX0. Connect this pin to external serial device receive (Rx) signal. This pin is 5.0V tolerant.

RX0 pin (Serial Receive COM0):
Asynchronous Serial port COM0 receive pin, RX0. Connect this pin to external serial device transmit (Tx) signal. This pin is 5.0V tolerant.

TX1 pin (Serial Transmit COM1):
Asynchronous Serial port COM1 transmit pin, TX1. Connect this pin to external serial device receive (Rx) signal. This pin is 5.0V tolerant.

RX1 pin (Serial Receive COM1):
Asynchronous Serial port COM1 receive pin, RX1. Connect this pin to external serial device transmit (Tx) signal. This pin is 5.0V tolerant.

4.2. General Purpose I/O

There are 13 general purpose Input/Output (GPIO) pins available to the user. These are grouped as IO1..IO5 (Note for IO1, IO2 and IO3 below) and BUS0..BUS7. Power-Up Reset default is all INPUTS.

The 5 I/O pins (IO1..IO5), provide flexibility of individual bit operations while the 8 pins (BUS0..BUS7), known as GPIO BUS, serve collectively for byte wise operations. The IO4 and IO5 also act as strobing signals to control the GPIO Bus. GPIO Bus can be read or written by strobing a low pulse (50ns duration or greater) the IO4/BUS_RD or IO5/BUS_WR for read or write respectively. For detailed usage refer to the separate document titled:
"*PICASO-4DGL-Internal-Functions.pdf*"

IO1-IO5 pins:
General purpose I/O pins. Each pin can be individually set for INPUT or an OUTPUT.
IO1-IO3 have also optional functionality when its dedicated Solder Jumper is closed. Please read below for more information.

IO1 pin (Frame Mark pin):
The IO1 pin has 2 functions. It can be used as a GPIO pin (Default on HW >= 13.0 onward) but can also be used to detect the start of a Frame (Default on HW < 13.0). When used as a Frame Mark pin, simply solder it´s dedicated solder jumper SB2. When using IO1 for Frame Mark read the status of IO1 as an Input.

IO2 pin (Lithium Battery Status pin):
The IO2 pin has 2 functions. It can be used as a

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GPIO pin (Default on HW >= 13.0) but can also be used to tell when the Lithium battery has reached a low level (3.7V) and needs to be charged (Default on HW < 13.0). When used as a Lithium Battery Status pin, simply solder it´s dedicated solder jumper SB3. When using IO2 for Battery Status read the status of IO2 as an Input. (See 6.4. 'Lithium Batteries' for more information).

IO3 pin (Peripheral Supply pin):
The IO3 pin has 2 functions. It can be used as a GPIO pin (Default HW >= 13.0) but can also be used as Peripheral Supply pin (Default HW < 13.0) when it´s dedicated solder jumper SB1 is closed.
IO3 set as Peripheral Supply pin is controllable via the processor, or via the H2 Interface pin driven by an external circuit. If IO3 is set as OUTPUT and driven HIGH the uSD card and Display are enabled, and disabled when driven LO. Set as INPUT to use an external circuit to drive this pin.

IO4/BUS_RD pin (GPIO IO4 or BUS_RD pin):
General Purpose IO4 pin. Also used for BUS_RD signal to read and latch the data in to the parallel GPIO BUS0..BUS7.

IO5/BUS_WR pin (GPIO IO5 or BUS_WR pin):
General Purpose IO5 pin. Also used for BUS_WR signal to write and latch the data to the parallel GPIO BUS0..BUS7.

BUS0-BUS7 pins (GPIO 8-Bit Bus):
8-bit parallel General purpose I/O Bus.

> **Note:** All GPIO pins are 5.0V tolerant.

4.3. System Pins

+5V (Module Voltage Input)
H1 pin 14, H2 pin 1 and 2:
Module supply voltage input pin. This pin must be connected to a regulated supply voltage in the range of 4.0 Volts* to 5.5 Volts DC. Nominal operating voltage is 5.0 Volts.

3.3V Out (3.3V Regulated Output)
H1 pin 22:
External circuitry that requires a regulated 3.3V supply can be powered up via this pin. Maximum available current is 150mA. Attempting to draw more can result in peripherals such as the microSD card, not working correctly.

GND (Module Ground)
H1 pin 11/13, H2 pin 7 and 8:
Device ground pins. These pins must be connected to ground.

RESET (Module Master Reset)
H1 pin 20, H2 pin 9 and 10:
Module Master Reset pin. An active low pulse of greater than 2µs will reset the module. Internally pulled up to 3.3V via a 10K resistor. Only use open collector type circuits to reset the device if an external reset is required.

SPK-/SPK+ (External Speaker Outputs)
H1 pin 2/4 respectively:
External Speaker Outputs, designed to drive an 8Ω speaker to a maximum of 1.2W. These are connected in Parallel with the on board speaker.

AUDENB (Audio Enable Output)
H1 pin 18:
Output dedicated to enable or disable an external amplifier if the on-board amplifier is not desirable to use. Controlled by the PICASO processor. When AUDENB is low, the on-board Amplifier is Enabled. When AUDENB is high, the on-board Amplifier is Disabled.

AUDIO (Audio Line Level Input/Output)
H1 pin 16:
Universal Input or Output specifically for Audio. This pin connects directly into the on-board amplifier, but also with the filtered PWM output from the PICASO Processor. This pin can be used to input a signal into the on-board amplifier to play audio from an external device using the on-board amplifier, or as a line-level output to drive an external amplifier with PICASO generated Audio. Note that AUDENB must be enabled (low) in PICASO for any input signal to be heard.

+/- (Lithium Battery Terminals)
P1 pins 1/2(+ve), 5/6(-ve):
These are the terminals of the Lithium Battery connector. These are to be connected **only** to a Lithium Ion or Polymer 3.7V Battery else the uLCD-24PTU may be damaged. See Section 6.4

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5. PmmC/Firmware Programming

The PICASO processor used in the uLCD-24PTU module is a custom graphics processor. All functionality including the high level commands are built into the chip. This chip level configuration is available as a Firmware/PmmC (Personality-module-micro-Code) file.

A PmmC file contains all of the low level micro-code information (analogy of that of a soft silicon) which define the characteristics and functionality of the device. The ability of programming the device with a PmmC file provides an extremely flexible method of customising as well as upgrading it with future enhancements.

A PmmC file can only be programmed into the device via its COM0 serial port. Figure below provides a typical implementation for the PmmC programming interface.

The PmmC file is programmed into the device with the aid of Workshop 4, the 4D Systems IDE software (See Section 11). To provide a link between the PC and the ICSP interface, a specific 4D Programming Cable is required and is available from 4D Systems.

Using a non-4D programming interface could damage your display, and **void your Warranty.**

Please refer to section 8.1 for more information on 4D programming interfaces.
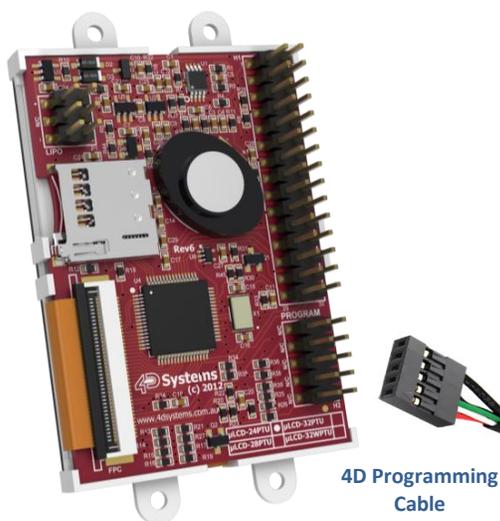
4D Programming Cable

6. Module Features

The uLCD-24PTU module is designed to accommodate most applications. Some of the main features of the module are listed below.

6.1. Display – 2.4" TFT Touch Screen

The uLCD-24PTU module is equipped with a 2.4" TFT display. Details of the display are listed below:

• Screen Size: 2.4" diagonal
• Resolution: 240 x 320
• Integrated 4-Wire Resistive Touch Screen
• Screen Dimensions: 42.70 x 60.25 x 3.70mm
• Viewing Area: 36.72 x 48.96mm
• Pixel Pitch: 0.153 x 0.153mm
• Brightness: 150cd/m2
• Contrast Ratio: 250:1
• Viewing Angle Above Centre: 20 degrees
• Viewing Angle Below Centre: 35 degrees
• Viewing Angle Left of Centre: 40 degrees
• Viewing Angle Right of Centre: 40 degrees
• Viewing Direction: 6 O'clock
• 4 Parallel LEDs for Backlighting

Note: The Displays used are the highest rated 'Grade A' Displays, which allow for 0-4 defective pixels. A defective pixel could be solid Black (Dead), White, Red, Green or Blue.

6.2. PICASO Processor

The module is designed around the PICASO Graphics Controller from 4D-Labs.

The PICASO is a smart Controller and the interface to the TFT- LCD displays is almost plug-n-play.

All of the data and control signals are provided by the chip to interface directly to the display.

Powerful graphics, text, image, animation and countless more features are built right inside the chip.

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The data sheet for the processor is available from the http://www.4dsystems.com.au website: *"PICASO-Processor-Datasheet-REVx.pdf"*

6.3. Audio

Audio playback support in the PICASO Processor enables the uLCD-24PTU module to play audio WAV files stored in the micro-SD memory card. PWM and an on-board audio amplifier with 8Ω speaker ensure ample audio output capability. A simple instruction enables the user to play/pause/stop audio files while continuing the execution of the user application code, such as display updates, touch recognition, communications, etc. The audio system also allows real time pitch change of audio samples.

For a complete list of audio commands please refer to the separate document titled: *"PICASO-4DGL-Internal-Functions.pdf"*

> **Note:** The on-board speaker is a small device designed to project into an audio cavity. It is not very loud by itself. To enable louder audio, it is recommended to use a larger external 8Ω speaker. See the 'Hardware Interface Pins' – 'System Pins' section for more information.

6.4. Lithium Batteries

The uLCD-24PTU module includes a battery charging circuit suitable for Lithium Ion (LiIon) and Lithium Polymer (LiPo) batteries, which is designed to work <u>only</u> with 3.7V batteries. If anything other than a LiIon or LiPo 3.7V battery is connected the module could be damaged. Features current sensing and reverse discharge protection using an on board Lithium charge management controller.

When the Lithium battery is connected and an external source (4.5V minimum) is connected to either of the +5V pins, the Lithium battery will be charged automatically. If the 5V source is disconnected, the Lithium battery will be switched in circuit and continue to power the module automatically.

Charge voltage = 4.2V, **Charge current** = ~210mA

When running from the Lithium battery, when the battery level drops down to ~3.7V, the Status input (connected to IO2) into the Picaso will be triggered indicating the battery is discharged. The display should then be connected to an external

5V source for charging. When the battery is at this cut off voltage, uSD card read and write operations should be avoided, as they may fail due to low voltage. It is up to the User to handle the operation of the display module when using a Lithium Battery.

WARNING: There is a large range of Lithium batteries available on the market. Some include safety circuits built in, while others do not. Lithium batteries can explode if short circuited, overcharged, if they get too hot, and can leak if they sit fully discharged for a prolonged period.
4D Systems recommends whenever Lithium batteries are used that caution and due diligence should be exercised to ensure the safety of the user and nearby people. While the chances of explosion or leakage may be minimal, 4D Systems recommends safe practices at all times when dealing with these batteries.
If Lithium Batteries are powering the module, it is highly recommended to periodically monitor the STAT pin. If the module is put to sleep, periodically wake the module to check the STAT pin.

6.5. SD/SDHC Memory Cards

The module supports micro-SD memory cards via the on-board micro-SD connector. The memory card is used for all multimedia file retrieval such as images, animations and movie clips. The memory card can also be used as general purpose storage for data logging applications. Support is available for off the shelf micro-SD and high capacity HC memory cards (4GB and above).

> **Note:** A microSD card capable of SPI is a requirement for all 4D Systems' display modules powered by Goldelox, Picaso or Diablo16 Processors. If a non-SPI compatible card is used, it will simply fail to mount, or may cause intermittent issues resulting in lock ups and crashing of the application. Please refer to the 4D Systems website for microSD cards offered by 4D Systems.

6.6. FAT16

The uLCD-24PTU uses off the shelf standard SDHC/SD/micro-SD memory cards with up to 2GB capacity usable with FAT16 formatting. For any FAT file related operations, before the memory card can be used it must first be formatted with

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FAT16 option. The formatting of the card can be done on any PC system with a card reader. Select the appropriate drive and choose the FAT16 (or just FAT in some systems) option when formatting. The card is now ready to be used in the PICASO based application.

The uLCD-24PTU also supports high capacity HC memory cards (4GB and above). The available capacity of SD-HC cards varies according to the way the card is partitioned and the commands used to access it.

The FAT partition is always first (if it exists) and can be up to the maximum size permitted by FAT16. Windows 7 will format FAT16 up to 4GB. Windows XP will format FAT16 up to 2GB and the Windows XP command prompt will format FAT16 up to 4GB.

7. Display Precautions

• Avoid having to display the same image/object on the screen for lengthy periods of time. This will cause a burn-in which is a common problem with all types of display technologies. Blank the screen after a while or dim it very low by adjusting the contrast. Better still; implement a screen saver feature.

• Moisture and water can damage the display. Moisture on the surface of a powered display will cause the electrodes to corrode. Wipe off any moisture gently or let the display dry before usage.

• Dirt from fingerprint oil and fat can easily stain the surface of the display. Gently wipe off any stains with a soft lint-free cloth.

• The performance of the display will degrade under high temperature and humidity. Avoid such conditions when storing.

• Do not tamper with the display flex cable that is connected to the control board. This may affect the connection between the display and the driving circuitry and cause failure.

• Displays are susceptible to mechanical shock and any force exerted on the module may result in deformed zebra stripes, a cracked display cell and broken backlight

• Always use the mounting holes on the module's corner plates to mount the display.

8. Hardware Tools

The following hardware tools are required for full control of the uLCD-24PTU module.

8.1. 4D Programming Cable/Adaptor

The 4D Programming Cable and uUSB-PA5 Programming Adaptor are essential hardware tools to program, customise and test the PICASO Processor.

Either the 4D Programming Cable or the uUSB-PA5 Programming Adaptor can be used.

The 4D programming interfaces are used to program a new Firmware/PmmC and for downloading compiled 4DGL code into the processor. They even serve as an interface for communicating serial data to the PC.

The 4D Programming Cable and uUSB-PA5 Programming Adaptor are available from 4D Systems, www.4dsystems.com.au

Using a non-4D programming interface could damage your processor, and **void your Warranty.**

4D Programming Cable

uUSB-PA5 Programming Adaptor

8.2. Development Hardware

4D Systems has designed a development board compatible with the uLCD-24PTU, enabling easy prototyping to take place and to experiment with the uLCD-24PTU display module.

This development board is called the 4DevBoard, and is available from the 4D Systems website store, or from 4D Systems distributors.

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9. 4DGL - Software Language

The uLCD-24PTU utilises the PICASO processor, which belongs to a family of processors powered by a highly optimised soft core virtual engine, EVE (Extensible Virtual Engine).

EVE is a proprietary, high performance virtual-machine with an extensive byte-code instruction set optimised to execute compiled 4DGL programs. 4DGL (4D Graphics Language) was specifically developed from ground up for the EVE engine core. It is a high level language which is easy to learn and simple to understand yet powerful enough to tackle many embedded graphics applications.

4DGL is a graphics oriented language allowing rapid application development, and the syntax structure was designed using elements of popular languages such as C, Basic, Pascal and others.

Programmers familiar with these languages will feel right at home with 4DGL. It includes many familiar instructions such as IF..ELSE..ENDIF, WHILE..WEND, REPEAT..UNTIL, GOSUB..ENDSUB, GOTO, PRINT as well as some specialised instructions SERIN, SEROUT, GFX_LINE, GFX_CIRCLE and many more.

For detailed information pertaining to the 4DGL language, please refer to the following documents:
"4DGL-Programmers-Reference-Manual.pdf"
"PICASO-4DGL-Internal-Functions.pdf"

To assist with the development of 4DGL applications, the Workshop 4 IDE combines a full-featured editor, a compiler, a linker and a down-loader into a single PC-based application. It's all you need to code, test and run your applications.

4DGL is available to be written in two of the four environments offered by the Workshop 4 IDE, Designer and ViSi.

10. 4D Systems - Workshop 4 IDE

Workshop 4 is a comprehensive software IDE that provides an integrated software development platform for all of the 4D family of processors and modules. The IDE combines the Editor, Compiler, Linker and Down- Loader to develop complete 4DGL application code. All user application code is developed within the Workshop 4 IDE.

The Workshop 4 IDE supports multiple development environments for the user, to cater for different user requirements and skill level.

- The **Designer** environment enables the user to write 4DGL code in its natural form to program the uLCD-24PTU.
- A visual programming experience, suitably called **ViSi**, enables drag-and-drop type placement of objects to assist with 4DGL code generation and allows the user to visualise how the display will look while being developed.
- An advanced environment called **ViSi-Genie** doesn't require any 4DGL coding at all, it is all done automatically for you. Simply lay the display out with the objects you want, set the events to drive them and the code is written for you automatically. ViSi-Genie provides the latest rapid development experience from 4D Systems.
- A **Serial** environment is also provided to transform the uLCD-24PTU into a slave serial module, allowing the user to control the display from any host microcontroller or device with a serial port.

The Workshop 4 IDE is available from the 4D Systems website. www.4dsystems.com.au

For a comprehensive manual on the Workshop 4 IDE Software along with other documents, refer to the documentation from the 4D Systems website, on the Workshop 4 product page.

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10.1. Workshop 4 – Designer Environment

Choose the Designer environment to write 4DGL code in its raw form.

The Designer environment provides the user with a simple yet effective programming environment where pure 4DGL code can be written, compiled and downloaded to the uLCD-24PTU.
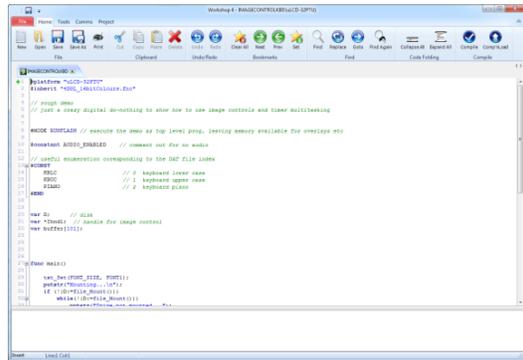
10.2. Workshop 4 – ViSi Environment

ViSi was designed to make the creation of graphical displays a more visual experience.

ViSi is a great software tool that allows the user to see the instant results of their desired graphical layout. Additionally, there is a selection of inbuilt dials, gauges and meters that can simply be placed onto the simulated module display. From here each object can have its properties edited, and at the click of a button all relevant 4DGL code associated with that object is produced in the user program. The user can then write 4DGL code around these objects to utilise them in the way they choose.
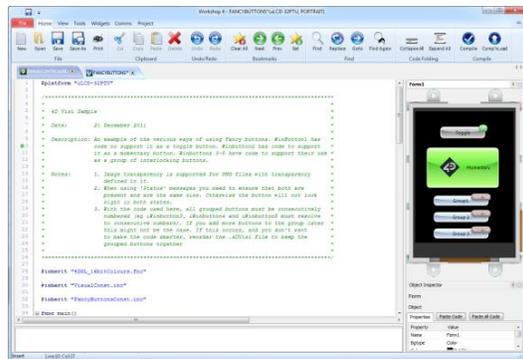
10.3. Workshop 4 – ViSi Genie Environment

ViSi Genie is a breakthrough in the way 4D Systems' graphic display modules are programmed. It is an environment like no other, a code-less programming environment that provides the user with a rapid visual experience, enabling a simple GUI application to be 'written' from scratch in literally seconds.

ViSi Genie does all the background coding, no 4DGL to learn, it does it all for you.

Pick and choose the relevant objects to place on the display, much like the ViSi Environment (See Section 11.2), yet without having to write a single line of code. Each object has parameters which can be set, and configurable events to animate and drive other objects or communicate with external devices.

Simply place an object on the screen, position and size it to suit, set the parameters such as colour, range, text, and finally select the event you wish the object to be associated with, it is that simple.

In seconds you can transform a blank display into a fully animated GUI with moving sliders, animated press and release buttons, and much more. All without writing a single line of code!

ViSi Genie provides the user with a feature rich rapid development environment, second to none.
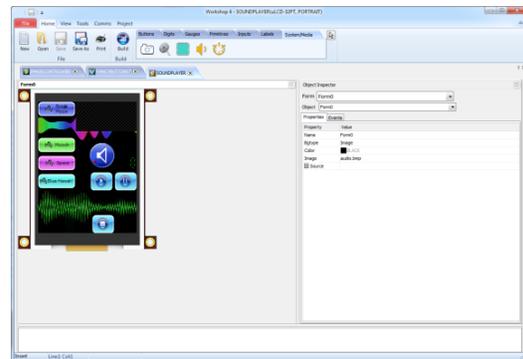
10.4. Workshop 4 – Serial Environment

The Serial environment in the Workshop 4 IDE provides the user the ability to transform the uLCD-24PTU into a slave serial graphics controller.

This enables the user to use their favourite microcontroller or serial device as the Host, without having to learn 4DGL or program in a separate IDE. Once the uLCD-24PTU is configured

and downloaded to from the Serial Environment, simple graphic commands can be sent from the users host microcontroller to display primitives, images, sound or even video.

Refer to the "**Serial Command Set Reference Manual**" from the Workshop 4 product page on the 4D Systems website for a complete listing of all the supported serial commands

By default, each module shipped from the 4D Systems factory will come pre-programmed ready for use in the Serial mode.

11. Starter Kit

4D Systems highly recommends all first time buyers of 4D Systems' displays, to purchase the Starter Kit when purchasing their first 4D Systems display solution.

The Starter Kit provides all the hardware that is required to get the user up and running.

Not all development environments and features will be needed by every user, however by purchasing the display solution in a Starter Kit, it ensures that if you want to take full advantage of the 4D Systems display solution and try out each of the 4D Workshop4 Environments, upgrade PmmC/firmware, you can.

The **Designer** environment can utilise every feature of the display, however depending on the user requirements, a micro-SD (uSD) card may not be required. The uSD card is used when displaying images/video/sound, along with datalogging to uSD, and a programming cable is definitely required for downloading compiled code and PmmC/Firmware updates.

The **ViSi** environment is the same as Designer in terms of feature utilisation, but is image based so requires a uSD card, along with a programming cable.

The **ViSi-Genie** environment is also image based, and therefore requires a uSD card and programming cable also.

The **Serial** environment does not require either a uSD or Programming cable to be used, however can utilise both depending on the user requirements. The uSD card can be used for such things as storage of multimedia files and datalogging, and the Programming cable for PmmC/Firmware updates, or changing to one of the other three programming environments.

The Starter Kit includes:
- 4D Programming Adaptor or Cable
- 2Gb microSD Card
- 5 way cable for easy connection to a breadboard or host
- Display Module
- Quick Start Guide

Simply select the Starter Kit option when purchasing the chosen display module on the 4D Systems shopping cart, or from your local distributor.

12. Notes

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microLCD PICASO DISPLAY

microLCD PICASO DISPLAY

13. Mechanical Details

VIEW A
SCALE 2 : 1

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS SURFACE FINISH: TOLERANCES: LINEAR: ANGULAR:	TITLE: Picaso microLCD Display - uLCD-24PTU	A3

	NAME	DATE
DRAWN	JB	15/01/2013
CHK'D		
APPV'D		

4D SYSTEMS

DO NOT SCALE DRAWING   REVISION 6   SCALE: 2:1   SHEET 1 OF 1
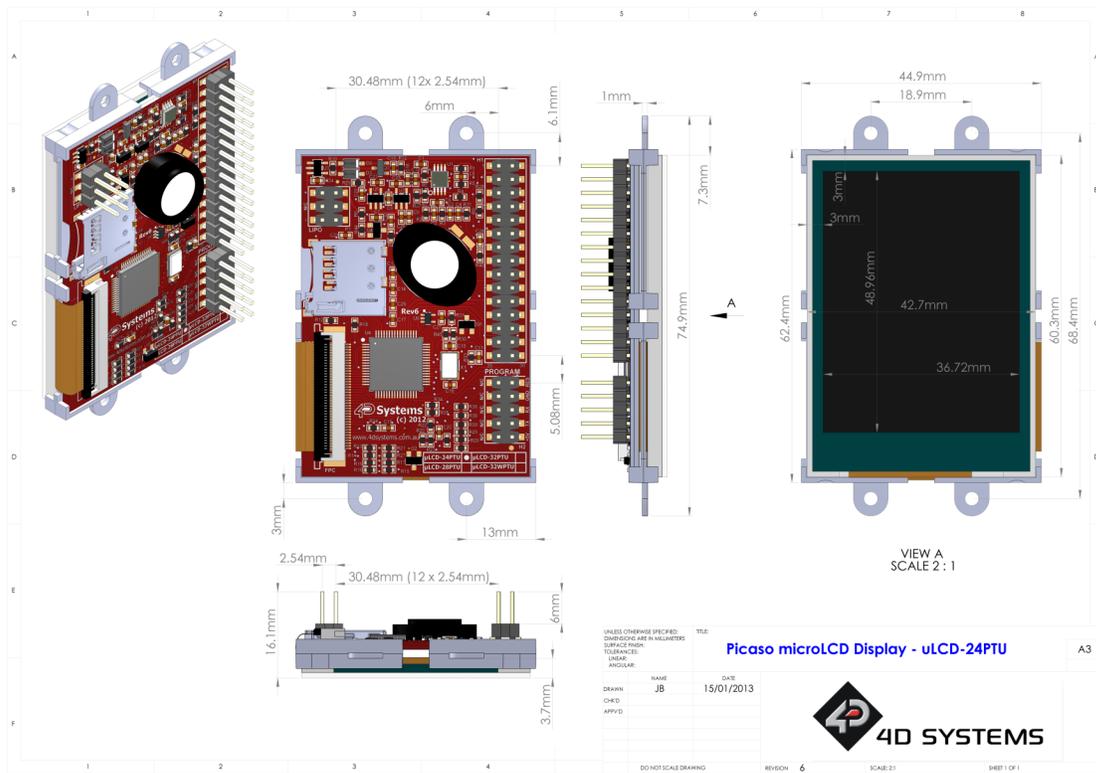
14. Schematic Diagram

microLCD PICASO DISPLAY
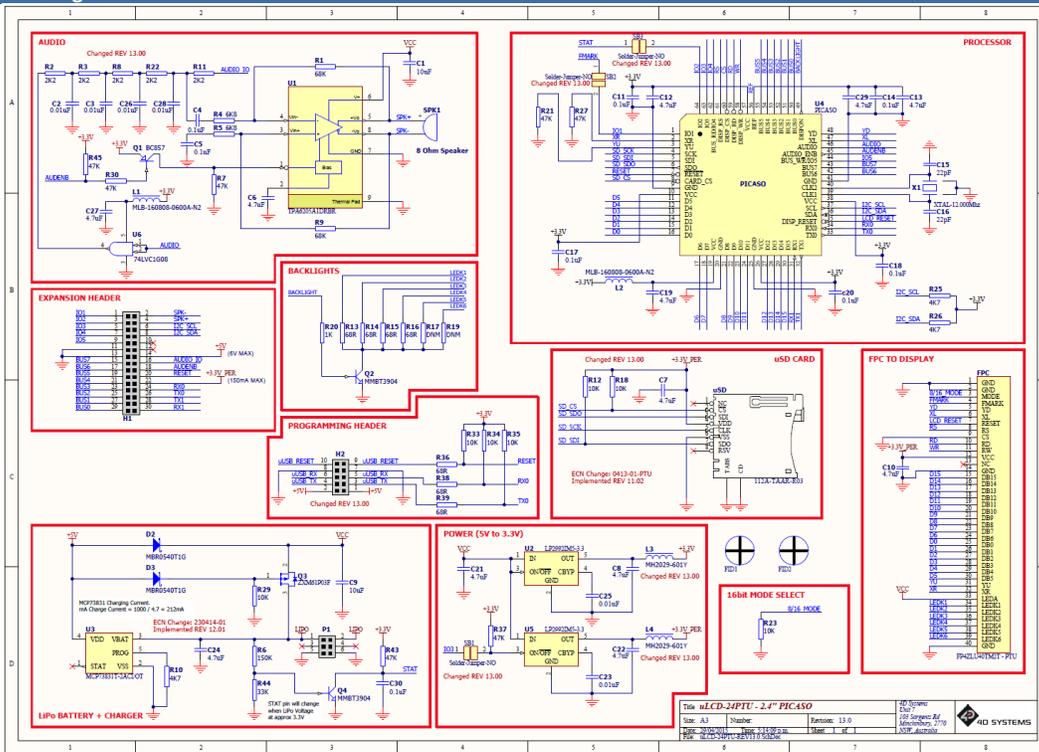
15. Specifications and Ratings

ABSOLUTE MAXIMUM RATINGS
Operating ambient temperature .... -15°C to +65°C
Storage temperature .... -30°C +70°C
Voltage on any digital input pin with respect to GND .... -0.3V to 6.0V
Voltage on SWITCH pin with respect to GND .... -0.3V to 6.0V
Voltage on VCC with respect to GND .... -0.3V to 6.0V
NOTE: Stresses above those listed here may cause permanent damage to the device. This is a stress rating only and functional operation of the device at those or any other conditions above those indicated in the recommended operation listings of this specification is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

RECOMMENDED OPERATING CONDITIONS					
Parameter	**Conditions**	**Min**	**Typ**	**Max**	**Units**
Supply Voltage (VCC)		4.0	5.0	5.5	V
Operating Temperature		-10	--	+60	°C
Input Low Voltage (VIL)	VCC = 3.3V, all pins	VGND	--	0.2VCC	V
Input High Voltage (VIH)	VCC = 3.3V, non 5V tolerant pins	0.8VCC	--	VCC	V
Input High Voltage (VIH)	All GPIO pins, RX0 and TX0 pins	0.8VCC	--	5.5	V
Reset Pulse	External Open Collector	2.0	--	--	µs
Operational Delay	Power-Up or External Reset	500	--	3000	ms

GLOBAL CHARACTERISTICS BASED ON OPERATING CONDITIONS					
Parameter	**Conditions**	**Min**	**Typ**	**Max**	**Units**
Supply Current (ICC)	VCC = 5.0V, heavily depends on screen usage conditions, sleep mode	10	125	220	mA
Output Low Voltage (VOL)	VCC = 5.0V, IOL = 3.4mA	--	--	0.4	V
Output High Voltage (VOH)	VCC = 5.0V, IOL = -2.0mA	2.4	--	--	V
Capacitive Loading	All pins	--	--	50	pF
Flash Memory Endurance	PICASO PmmC Programming	--	10000	--	E/W

TOUCH SCREEN CHARACTERISTICS					
Parameter	**Conditions**	**Min**	**Typ**	**Max**	**Units**
Linearity		--	--	<1.5	%
Terminal Resistance X	X film side	300	400	800	Ohm
Terminal Resistance Y	Y film side	300	600	800	Ohm
Durability – Scratch Test	Stylus Pen or Finger Sliding	100	--	--	K
Durability – Tap Test	Stylus Pen or Finger Press	1	--	--	Million
Transparency	Non Glare	80	--	--	%

microLCD PICASO DISPLAY

OPTICAL CHARACTERISTICS						
Parameter		**Condition**	**Min**	**Typ**	**Max**	**Units**
Contrast ratio (Centre point)		Back-light On	--	250	--	--
Luminance of white (Centre point)			160	200	230	Cd/m^2
White Uniformity			80	--	--	%
Response Time	Rising + Falling (Tr + Tf)		--	30	--	ms
Colour Chromaticity (CIE 1931)	White, Wx		0.283	0.303	0.323	
	White, Wy		0.305	0.325	0.345	
	Red, Rx		0.606	0.626	0.646	
	Red, Ry		0.614	0.334	0.354	
	Green, Gx		0.257	0.277	0.297	
	Green, Gy		0.529	0.549	0.569	
	Blue, Bx		0.122	0.142	0.162	
	Blue, By		0.102	0.122	0.142	
Viewing Angle	Vertical above Centre	Contrast Ratio $\geq$ 10	20			Degrees
	Vertical below Centre		35			
	Horizontal Left of Centre		40			
	Horizontal Right of Centre		40			

ORDERING INFORMATION
Order Code: uLCD-24PTU
Package: 105mm x 65mm x 30mm
Packaging: Module sealed in antistatic foam padded 4D Systems Box

16. Hardware Revision History

Revision Number	Date	Description
6	12/06/2012	• Initial release of PTU revision
8	10/07/2012	• R29 / R32 / R6 /R44 have changed values
11.1	19/02/2013	• Resistor R46 has been implemented to enable GPIO usage for IO3 if removed • Resistor R22 is no longer mounted • Resistors R8, R28, R29, R32, R44 have changed values
11.2	26/02/2013	• R18 specified as 1M2, must be Do Not Mount (DNM) and not inserted during SMT
12.1	23/04/2014	• Battery charging circuit has been improved
13.0	29/04/2015	• Resistors R7, R28, R46 have been removed and replaced with solder jumpers (SB1 / SB2 /SB3) • Both sides of the H2 Programming Header are now connected to its dedicated signals • Audio Amplifier circuitry has been improved to remove background noise • Power circuit has been changed: U2 & U5 are different components now and L3 and L4 have been added. 30Pin Header 3.3V output can deliver 150mA instead of 20mA. R4 current limiting resistor has been removed. • SD Card circuit has been changed: R18 is now 10k Resistor.

microLCD PICASO DISPLAY

17. Legal Notice

Proprietary Information

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18. Contact Information

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For Sales Support: sales@4dsystems.com.au

Website: www.4dsystems.com.au

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Zohaib Arshad

https://www.linkedin.com/in/arshadzohaib

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OBJECTIVE:
Engineering position to apply my technical abilities and education.

EDUCATION:
Bachelors of Science   Expected Graduation: **Spring 2016**
Electrical and Electronics Engineering, CSU Sacramento

RELATED COURSES:

Electronics II*	Power System Analysis	Probability and Random Signals
CMOS and VLSI Design*	Modern Communication System	Signal Processing and Linear Systems
Feedback Systems*	Microprocessor Design	Applied Electromagnetics

KNOWLEDGE AND SKILLS

Programming (Familiar): PHP • C/C++
Software Applications: MS Office 2003 – 2013 • Cadence PSpice • Cadence Virtuoso • Quartus II • ModelSim-Altera • NI Multisim 13.0
Operating Systems: Windows 10 • Windows 7 • OS X
Verbal Languages: Bilingual: English/Punjabi

WORK EXPERIENCE:

Division of Design and Construction   **US Bureau of Reclamation**   **09/14 – Present**
Engineering Intern

Research and design possible solutions to various projects using test data and drawings such as building, switchgear and device layouts. Review contract submittals to confirm contractor has met the Bureau of Reclamation standards while also taking into consideration the input of electrical, civil and mechanical engineers overseeing each project. Plan, budget, present and execute annual equipment purchases, modernize office workflow through training and implementing IT solutions. Maintaining engineering design and support document archives, and inventory of all IT equipment in the division through cloud based services. Trouble shoot various issues involving workstations, network connectivity, software accessibility and printers.

Sales Associate   **Old Navy**   **05/10 – 08/14**

Duties included providing excellent customer service, cashier, greeting customers, recovery of products and maintaining a clean and organized environment.

PROJECT EXPERIENCE:

Microprocessor Design Project – R/C Vehicle   **Fall 2013**

Designed an Autonomous object avoiding car using the Arduino Uno microcontroller and an ultra-sonic servo sensor. Also assisted team member creating an android app to control the car via Bluetooth. This was completed over a 4 week period. The team consisted of four members. We presented the results covering details of each mode, Autonomous and Bluetooth, time management, problem, testing, debugging and total cost analysis.

ACTIVITIES AND ACCOMPLISHMENTS:
IEEE Member: Fall 2014 - Present
Dean's Honor List: Fall 2013, Spring 2014, Fall 2014
MEP Academic Mentor: Spring 2015
SHPE Member: Fall 2013-Present
NSBE Member : Fall 2013-Present
MESA/MEP Member: Fall 2013-Present

Reference available by request

Jashanjit S. Badwal

9551 Fox Wind Court, Elk Grove, CA 95758   (916) 548-6355   sbadwalz@gmail.com

OBJECTIVE: To obtain a challenging position in computer engineering where I can apply my technical abilities and expertise.

EDUCATION

In progress: **BS, Computer Engineering** • CSU Sacramento • May 2016

Certified Java Developer • Silicon Valley Career Institute   07/2012

Certified J2EE Web Developer • Silicon Valley Career Institute   09/2012

RELATED COURSES

Advanced Logic Design	Programming Concept and Methodology I & II
Computer Hardware System Design	Introduction to Computer Architecture
Network Analysis of Circuits	Introduction to System Programming in Unix
Signal Processing and Linear System	Data Structures and Algorithm Analysis
Probability & Random Signal	Operating System Principles
Computer Network & Internet	Advance Computer Organization
Electronics I	Operating System Pragmatic
Embedded Processing System Design	Senior Design Project I*
CMOS & VLSI*	

*In Progress as of Fall 2015

STRENGTHS

Software: Xilinx ISE, Quartus Altera, PSpice, JGrasp, Multisim, Eclipse, Netbeans, MS Office

Hardware: Power Analyzer, Max32, Spartan 3E, FPGA, Oscilloscope, Analogy Discovery, Arduino, Propeller, Raspberry Pi, Microchip Picket 3

Languages: Java, C/C++, HTML, JavaScript, Verilog, VHDL, X86 Assembly, Visual Studio

Operating Systems: Windows 8.1, Windows 8, Windows 7, Windows XP, Android, Linux, Unix

PROJECT EXPERIENCE

Embedded Systems Project – Autonomous Swarm   **Spring 2015**

Designed, constructed and tested an embedded processor system project. All address decoding, control functions, input and output ports, handshaking signals and interrupt control was implemented in an FPGA. The system interfaces to a microcontroller system. This project needed the use of an assembler, a C compiler and either VHDL or Verilog to fully validate our project. Laboratory techniques include oscilloscopes, logic analyzers, protocol analyzers and programmers for EPROMs, FLASH and microcontrollers. We used several communication boards such as Arduino Uno, Mega, and the Microchip Max32 combined with the communication protocol such as SPI bus, I2C, UART, and Bluetooth. A project consisted of a swarm of R/C cars collaborating together with TARS(a Marine corps robot from the movie Interstellar) and a robotic arm to perform surveying of new land as well as reconnaissance. The cars communicated with each via the different protocols we studied in class and used various sensors to determine the location of a specific object.

16- bit MIPS Processor   **Fall 2014**

Worked in a two-person team through the design and development and implementation phase of a 16-bit MIPS processor with a 5-stage pipeline. Behavioral modeling in Verilog was used to implement load/Store word operation, integer arithmetic, and branching, Simple branch prediction, forwarding and hazard detection were also implemented.

Microprocessor Design Project – R/C Vehicle   **Fall 2013**

Designed a Weaponized remote controlled vehicle that was using an Android application using the Arduino UNO microcontroller. User commands were sent to via a Bluetooth socket connection, with the Android Application as the master and the Arduino UNO microcontroller as the slave. The weapon system uses a modified nerf gun with electronically controlled trigger system. Aiming makes use of servo motors and the Arduino UNO microcontroller and aim is controlled with the Android App.

WORK EXPERIENCE

Software Intern Undergrad Lvl   *Intel Corporation*   **6/14 to Present**

Assist the Bluetooth Systems & Architecture team by supporting the Requirements Engineering work methodology. Manage the requirements in the JAMA tool, enabled requirements reuse from Marketing to Product to Feature requirements, enable requirement to test case coverage, and develop scripts to create an easy-to-use development flow. Perform Power Optimization tests on different platform for Bluetooth using Power Analyzer and ProBite tools. Working with System Validation Engineers to successfully complete the Power Automation Project for Bluetooth.

Hardware Support   *SMUD*   **9/13 to 11/13**

Assist with various PC support activities related to the movement of computer equipment and materials, as well as configuration and installation of personal computers. Use Altiris Deployment Solutions to push out images to desktops and laptops. Create new asset/update the existing asset for each user's hardware equipment.

Client Services Helpdesk Support   *CA Dept of Education*   **9/06 to 8/12**

Provided Level 1 support to end users on Outlook, Virus, active directory, and on hardware, and software problems. Worked with email, LAN, and WAN team, installing images, clearing port security, preparing documentations for various procedures, completed projects like hardware and software inventory, configuring Outlook 2007 and 2010 to integrate with Project 2003.

Hardware Assembler   *Chase/WAMU Conversion Project*   **10/09**

Worked as team member for assembling new desktop computers, monitors and peripherals. Disassembled old computer equipment. Installed basic peripherals, including pin pads and check scanners. Troubleshoot network connectivity and resolved hardware/software problems that allow proper desktop functionality.

ACTIVITIES:

Member of Association of Computer Machinery

Leonardo Jacobo

(916)595-0877

leonardojacobo98@gmail.com   www.linkedin.com/in/leonardojacobo

OBJECTIVE: Pre-professional engineering position.
EDUCATION: Bachelor of Science, Computer Engineering (Spring 2016), GPA 3.0 (current), CSU Sacramento

RELATED COURSES:

System Programming in Unix	Network Analysis	Computer Interfacing
Computer hardware system design	Signals and Systems	Operating System Principles
Data structures and Algorithm Analysis	Advanced Logic Design	CMOS and VLSI Design
Advanced Computer Organization	Computer Network and Internet	Electronics I
Operating System Pragmatics	Embedded Processor System Design	

KNOWLEDGE AND SKILLS

Programming: HTML, Java, C, C#, C++, Verilog, VHDL, Assembly, Lua, Python, Perl, Powershell, AngularJS
Systems: Windows, Linux, Unix *Bilingual:* English/Spanish(speaking and writing) *Other skills:* Demonstrates ability to execute advance communication skills in both technical and business domain; adept in managing a large number of colleagues and projects in high-profile organizations; Systematic & Dynamic problem-solver with the ability to assess various constituent group needs.

PROJECT EXPERIENCE:

Embedded Systems Project:
Part of a five person team, with a three week limit on creating a project from the ground up. The objective of the design was to construct an automated RC swarm that would perform reconnaissance in a specified area. Utilized various laboratory techniques including oscilloscopes, logic analyzers, protocol analyzers and programmers for EPROMs, FLASH and microcontrollers, while addressing decoding, control functions, input and output ports, handshaking signals and interrupt controls on a FPGA. Several communication boards were implemented such as Arduino Uno, Mega, and the Microchip Max32 combined with the following communication protocols SPI bus, I2C, UART, and Bluetooth. The validation/debugging process required the use of an assembler, C compiler, and Verilog

Microprocessor Design Project R/C Car: As a member of a four person microprocessor project team, designed an autonomous object-avoiding car that was controlled via an Android application. The system was controlled through the Arduino UNO micro controller. The autonomous portion of the project utilized an ultrasonic sensor mounted on top of a servo motor. The end user commands were sent through an Android application using the Bluetooth 2.1 protocol, via a socket connection, with the Android application acting as the master and the Arduino UNO microcontroller with Bluetooth module as the slave. The Android application allowed on the spot enabling of autonomous mode. Manual control was available by the simple click of a button on the application.

16-Bit MIPS CPU: Constructed and simulated the data path and control unit for a 16 bit, pipelined, MIPS CPU for a given instruction set of 18 instructions. Used a 4-stage pipeline data path including hazard detection as well as an ALU control unit. Implemented our design in Verilog and executed simulations to exhaustively examine individual components as well as validating the complete design with assembly programs provided by instructor.

Student facilitator, Havok Project Anarchy Hack-a-thon Fall 2013: Facilitated in a 30 hour long Intel sponsored Hack-a-thon for high school students. The students used the Project Anarchy design suite which is a complete end to end game engine and state-of-the-art toolset for mobile applications. As a facilitator I assisted the students by answering questions about the engine and recommending design methods. Gained proficiency in Lua, a fast, lightweight, embeddable scripting language, as well as extensive knowledge about Vforge.

WORK EXPERIENCE:

Non-Volatile Solutions Group Solid-State Drive Intern, Intel Corporation, 28 hours/week   9/15 to Present
Responsible for creating and maintaining a web interface framework for product validation status/indicators, mapping validation testing to the product requirements document and helping instrumenting debug activities using a Protocol Analyzer, Oscilloscope etc). Work on non-volatile memory from material science and process research, through component design, manufacturing, ASIC, board, solid state drives and SW solutions. Deliver disruptive solutions that are transforming computing across all segments from Internet Portal Data Centers (IPDCs) to Consumer Client Devices such as Ultrabooks and Tablets

Data Center Engineering Computing Intern, Intel Corporation, 20 hours/week   1/15 to 8/15
Student intern in work-study program, gaining valuable understanding of state-of-the-art operating systems, virtual environments, system management, network storage and encryption while learning how to build and maintain various client/server architectures. Assisted in VDI self-service portable project phase I, completing the design of the enhancement, delivered prototype, implemented new database that can support new requirements and future growth. Scripting/Automation of task to provide efficient work flow in environment.

Information Technology (IT) Specialist, U.S. Geological Survey, 24 hours/week   8/14 to 1/15
IT support for the California Water Science Center. Resolves retrieval problems by altering design to meet requirements. Prepared reports by collecting, analyzing, and summarizing information. Established and revised databases by conferring with analysts and programmers to code and retrieve data. Supports end-users with IT-related problems in a responsive and service oriented manner. Provides input and recommendations to the organization surrounding new and existing hardware and software technologies and how these technologies can assist the business.

AWARDS AND ACCOMPLISHMENTS: Dean's Honor Roll, National Science Foundation Scholarship, National Action Council for Minorities in Engineering (NACME) Scholarship, Louis Stokes Alliance for Minority Participation (LSAMP) Program.

Didier (Dj) Mponte

2407 Larkspur Ln. # 274, Sacramento, CA 95825   (916)-833-3759   djmponte@gmail.com

EDUCATION   *In progress:* **BS Electrical/Electronics Engineering** • CSU, Sacramento • May 2016 • McNair Scholar

RELATED COURSES

Embedded Processor System Design	Biomedical Signal Analysis & Processing	Digital Control Systems*
Introduction to Microprocessors	Probability & Random Signals	Machine Vision*
Microelectronics I	Energy Systems Optimization & Control*	Network Analysis
Power Electronics*	Electromechanical Conversions	Strategic Management*
Logic Design	Smart Electric Power Grid*	Applied Electromagnetics
		Spring 2015

SKILLS

Software/Hardware

Verilog • Quartus II • Modelsim • Matlab • C/C++ • Python • ADS • Parallax Spin Code • PSPICE • MS Office
Function Generator • Oscilloscope • Digital Multi-meter • Power Supply • Cyclone IV FPGA
3D Printing • Laser Cutting • AutoCAD

Leadership/Management/Communication

• Effective project management, team, and organizational skills
• Strong analytical, product design, and problem solving skills
• Well-refined written, verbal, and presentation skills

WORK EXPERIENCE

Product Design Intern   **The Shop @ VSP Global Innovation Lab**   *11/14 – Present*
Applied Design thinking ideology, direct observation, and empathy to develop smart wearable device and mobile application for the aging population.

Telecommunications Engineering Intern   **Sacramento Municipal Utility District (SMUD)**   *10/14 – 2/15*
Learned and utilized AutoCAD to design schematics for electrical layouts and components for various sub-stations and or network wiring. Applied fiber optic principles to design layouts and processed documentation in SAP.

Vehicle Systems Engineering Intern   **Bay Area Rapid Transit (BART)**   *6/14 – 8/14*
Applied engineering practices and research to debug and test revenue vehicle circuits. Analyzed BART Train schematics and wiring diagrams in order to install new components and or to conduct further circuit analysis to existing problems. I was also responsible for writing design proposals, procedures for installations, as well as vehicle maintenance bulletins to improve the reliability, availability, and safety of the revenue vehicles.

Student Researcher   **California Smart Grid Center**   *11/13 to present*
Conduct in-depth research into leading edge technology and develop products designed to aid in the dissemination of information and integration of renewable distributed power generation sources and Home Area Networks (HAN) required for power conservation and the Smart Home of the future.

Engineering Student Assistant   **California Air Resources Board**   *9/13 to 12/13*
Compile and distribute local, State and Federal air quality regulation information. Responsible for analyzing fleet vehicle regulation compliance accurately and making appropriate recommendations to companies.

Co-Founder & CFO   **Nickel and Dime Auto**   *1/12- 9/12*
Worked on strategies to increase company profits through research, marketing, and outreach. Processed financial documents in compliance with California State Law.

PROFESSIONAL ACTIVITIES AND ACHIEVEMENTS

Chapter President, CSUS National Society of Black Engineers
Dean's Honor List, Spring 2013, Fall 2013
Recognized by the California State Legislature for involvement in *Solar Suitcase* Project

PROJECT EXPERIENCE

Vision Based Control System (In Progress)
As part of a two man team, we are building a RC car with a camera tripod mounted on top that will use machine vision techniques to measure the distance between the subject as well as perform facial recognition. The data will be sent to our PID controlled RC car, which will keep a specified distance between the subject as well as control the tripod to track and follow the face it detects.

Gesture Controlled Wearable Device (In Progress)
Developing a simple gesture based control wearable to control LEDs utilizing an EMG sensor and microcontroller. The EMG sensor is developed using electrodes and digital signal processing via Matlab. This processed signal gets stored within the arduino-based microcontroller. Control signals are saved based on hand gesture. Once these various hand gestures are detected an LED, or series of LEDs would shine specified color schemes.

McNair Scholar: Research in Energy Storage Technology (In Progress)
Currently researching into the field of Energy Storage Technology, its impact on renewable energy adoption, and strategies to lower the cost of the overall renewable energy adoption with ultimate goals of decreasing our dependency on oil and creating a cleaner, greener environment for all.

Charge Balancing Battery Management Control System
Developed a generator based battery management control system using two DC motors, a microcontroller, and an elastic shaft to switch the polarity of the motors to make them generators. The design was able to measure the value of the lithium ion battery using the microcontroller, set a desired voltage level, and allow the generator to charge the battery to this desired value.

Regional Finance Chairperson, NSBE
As the 2014 Regional Finance Chairperson, my duties were to communicate, strategize, and enhance the relationships between our organization and our corporate partners while also seeking new partnerships. In doing so, I organized a career fair for our Fall Regional Conference, hosted an Exhibitors meeting, connected business professionals with top tier talent within our membership, negotiated contracts with various corporate partners and generated a regional all time high of $74,000+ all within four months of taking my position.

Customized Home Automation System
Working within a four-man team, created a customized home automation system. The system provided the user with a motion detecting apparatus used for an alarm system, a pH sensor to measure the pH levels in the homeowner's pool and fish tank, and a customized web server. The web server provided our user interface, real time video surveillance, displayed the data from the sensors, and allowed the user to turn on and off appliances through our web application. My task was to configure the ultrasonic sensor to continuously rotate 180 degrees and simultaneously record and display the distance of the nearest objects or persons.

Regional Leadership Conference, NSBE
As Regional Leadership Conference Chairperson, planned and hosted NSBE chapters across 13 western states on how to effectively lead their organization. While managing 20+ Regional Executive Board Members, developed the three-day event program and agenda for the conference. Reached out to corporate sponsors for budget support and participation.

Solar Suitcase Project, Green Technical Education
Led a team of 7 people in constructing solar suitcases which served to provide citizens of third world countries power and lighting to compensate for power outages. The *Solar Suitcase* consisted of an 18-watt solar panel, a 12-volt battery, and user interface, which monitored the power usage and battery level. Personally responsible for leading my team on building the product, which required a strong understanding of following procedures in sequence and prototyping of the *Solar Suitcase* prior to instruction.

Harpreet Sidhu

https://www.linkedin.com/in/harpreetsinghsidhu

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OBJECTIVE:
Engineering position to apply my technical abilities and education.

EDUCATION:
Bachelors of Science   Expected Graduation: **Spring 2016**
Electrical and Electronics Engineering, CSU Sacramento   Major GPA: **3.90**; Overall GPA: **3.115**

RELATED COURSES:

Electronics II*	Advanced Logic Design	Probability and Random Signals
CMOS and VLSI Design*	Embedded Processor System Design	Signal Processing and Linear Systems
Feedback Systems*	Microprocessor Design	Applied Electromagnetics

KNOWLEDGE AND SKILLS
Programming: PHP • Verilog • VHDL • HTML • SQL
Programming (Familiar): MySQL • JavaScript • C# • C/C++ • Spin • Assembly • Machine • Python • Scripting • VBA • jQuery • AngularJS • Bootstrap Framework
Software Applications: MS Office 2003 – 2013 • Cadence Allegro • Cadence PSpice • Cadence Virtuoso • PHPStorm • Quartus II • ModelSim-Altera • NI Multisim 13.0 • MS DOS • Xilinx ISE Design Tool
Operating Systems: Windows XP – Windows 10 • OS X • Linux (familiar)
Verbal Languages: Bilingual: English/Punjabi

WORK EXPERIENCE:

Data Center Group Platform Application Engineering Intern   **Intel Corporation**   **05/14 – Present**

Designed and Developed an application using PHP, Perl, C#, VBA, JavaScript, and MySQL that is able to analyze, extract, process, and generate Cadence Allegro designs. Crucial data on customer board designs were extracted. All data was filtered to give the end user exactly what was requested. Developed metrics for each interface on the board design, ex. PCI-E, I/O, Clocks. Developed a search engine for all board design components, nets, pins, and ref des, to allow an easy way to find what a user wants. Developed a caching system to provide a user experience that allowed for near instantaneous data processing. Developed a system for user rights management to work with corporate wide SAML site federation, used with authentication and content management.

Summer Intern   **Intel Corporation**   **07/12 – 08/12**

Selected to be an intern for a six-week program supporting the increasing of US-based Engineers.
Developed, prototyped, and presented a business plan. Engineered a quad copter robot. We conducted test flights and competed against IUEE interns for the longest flight time. Wrote, troubleshot, and demo'd a working C# application. Attended NorthWestern University's Engineering Design and Communication Course (EDC). During this time my team and I researched, developed, and then tested multiple prototypes of our given item, which all lead to a complete final design. Design development included following FAA and TSA guidelines in building a more versatile piece of travel luggage. One improvement to the design of the common travel luggage was implementing a trapezoidal shape.

PROJECT EXPERIENCE:

Embedded Systems Project – Autonomous Swarm   **Spring 2015**

Objective of the design was to create an autonomous swarm of vehicles to do reconnaissance. Designed, developed, tested, debugged, and managed a project with a 5 person team, to complete within 3 weeks. A FPGA, series of Microcontrollers were used to implement the design. Address decoding, control functions, input and output, ports, handshaking signals, and interrupt control were implemented in the FPGA, with an interface to a series of microcontrollers wirelessly. Communication protocols used include SPI bus, I2C, UART, and Bluetooth. Laboratory techniques include writing test benches, using oscilloscopes, logic analyzers, protocol analyzers, and programmers for EEPROM, FLASH, and microcontrollers. Code was written in C and Verilog.

Microprocessor Design Project – R/C Vehicle   **Fall 2013**

Objective of the design was to develop a user controlled vehicle with controlled accessories, such as a nerf gun. All development was done in course of 4 weeks. Designing, testing, debugging, and management were required of this project with a 4 person team. Android application worked in parallel with an Arduino Uno Microcontroller to control a weaponized R/C vehicle. Communication Protocols used include, Bluetooth, I2C, PWM. Code was written in C.

ACTIVITIES AND ACCOMPLISHMENTS:
IEEE Member: Fall 2014 - Present
Dean's Honor List: *Fall 2011*
SHPE Member (Part of the Outreach Committee): *Spring 2012-Present*
NSBE Member : *Fall 2013-Present*
MESA/MEP Member: *Spring 2012-Present*
EOP/Leadership Initiative: *Summer 2011, Fall 2011, Spring 2012*

Reference available by request