Ministry of Higher Education
Pyramids Higher Institute (PHI) for Engineering and Technology, 6th of October
Electronics and Communications Engineering Department

وزارة التعليم العالي
معهـد الأهرامـات العـالي للهنـدسـة والتكنولوجيا بالسادس من أكتوبر
قسم هندسة الالكترونيات والاتصالات

Telephone Circuits and Switches

GSM Based Robot Control Using DTMF

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Objective:

Design and implement a GSM-based robot control system utilizing Dual-Tone Multi-Frequency (DTMF) technology to enable remote operation and management. The objective encompasses the development of robust hardware and software solutions, including GSM module integration, DTMF signal processing, and real-time control algorithms, aimed at providing seamless and reliable remote control capabilities for the robot. The project seeks to demonstrate proficiency in telecommunications integration, embedded systems programming, and robotics engineering, while addressing practical challenges such as signal latency, network reliability, and system scalability.

Introduction:

In today's technologically-driven landscape, the quest for precise control over mobile robots stands as a prominent pursuit. As human ingenuity continuously seeks innovative and cost-effective solutions, the emergence of mobile-controlled autonomous robotic vehicle systems serves as a testament to this endeavor. Leveraging the ubiquity and significance of mobile phones in our daily lives, the enhancement of autonomous robotic vehicles through mobile phone control emerges as a logical progression.

Navigating a mobile robot entails three fundamental phases: Sensing, Processing, and Commanding. These phases, orchestrated through a blend of sensors, processing units, and communication channels, play pivotal roles in achieving precise and efficient operation. Sensors such as cameras, proximity sensors, and laser range finders gather information about the robot's surroundings, enabling informed decisions and effective navigation.

At the core of this paradigm lies GSM (Global System for Mobile Communications), a widely adopted standard for cellular communication. Integrated GSM modules within robots establish remote communication links, enabling users to interface with these machines using standard mobile phones.

Complementing GSM technology is DTMF (Dual-Tone Multi-Frequency), a method for audible signaling widely used in telecommunication systems. DTMF tones encode commands, allowing users to remotely navigate and interact with the robot through standard mobile phone keypads.

One of the key advantages of utilizing DTMF signaling in conjunction with GSM modules is the ability to communicate over long distances with minimal interference. This enables operators to remotely control robots from virtually anywhere with cellular coverage, opening up possibilities for applications in remote monitoring, surveillance, and exploration.

Furthermore, the widespread availability of mobile phones ensures users have access to a familiar and intuitive interface for interacting with robotic systems. This democratization of control empowers individuals from diverse backgrounds to leverage the capabilities of autonomous mobile robots for various tasks, from agricultural automation to disaster response.

In addition to enhancing control capabilities, our approach addresses concerns related to security and reliability. By leveraging encryption and authentication features inherent in GSM technology, we ensure secure communication channels, mitigating the risk of unauthorized access or tampering.

In summary, our document presents a comprehensive framework for controlling and navigating autonomous mobile robots using mobile phones and DTMF signaling via GSM modules. Through innovative technology integration and user-friendly interfaces, we envision a future where mobile-controlled robotic systems play a central role in advancing automation and enhancing human productivity across diverse domains.

Circuit Diagram and software:

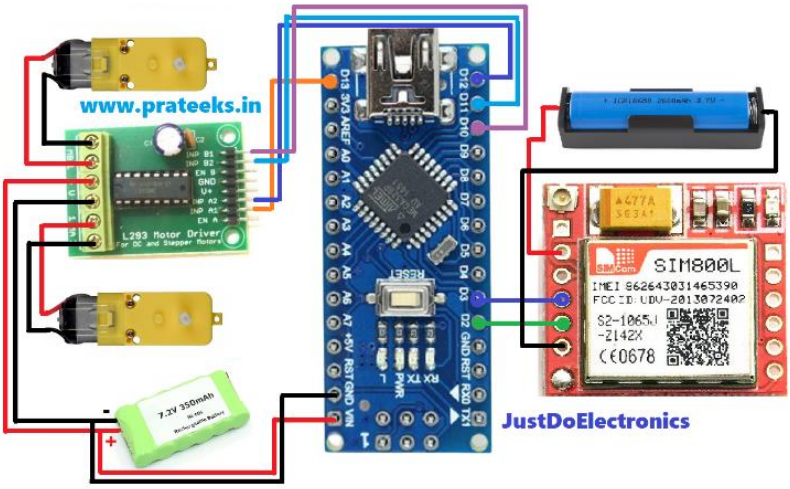


Fig 1.1 Circuit Diagram

1. The **Arduino Nano** is a compact and versatile board based on the ATmega328 microcontroller. It's similar to the Arduino Duemilanove but comes in a smaller package. It lacks a DC power jack but can be powered via Mini-B USB, unregulated external power supply (6-20V), or regulated external power supply (5V). It automatically selects the highest voltage source shown in Fig 1.2.

   In terms of **memory**, the ATmega328 has 32 KB of flash memory (2 KB used for the bootloader), 2 KB of SRAM, and 1 KB of EEPROM.

   For **input and output**, the Nano offers 14 digital pins that can be configured as either inputs or outputs, operating at 5 volts. Each pin can handle up to 40 mA and has an internal pull-up resistor. There are also 8 analog inputs with 10-bit resolution (1024 different values). Analog pins 6 and 7 cannot be used as digital pins.

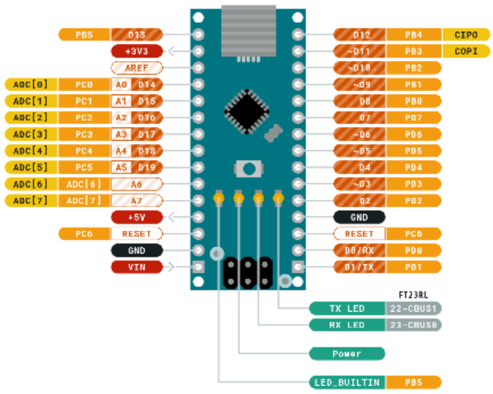


Fig 1.2 Arduino UNO pinout

2. The **SIM800L** is a versatile quad-band GSM/GPRS module operating on frequencies including GSM850MHz, EGSM900MHz, DCS1800MHz, and PCS1900MHz.

   Key features of the SIM800L include a MicroSIM slot for the SIM card, an antenna for network signal reception, microphone and speaker pin outs for audio communication, and a ring functionality for call indication.

   It's important to note the power supply requirements for the SIM800L, which range from 3.4V to 4.4V DC with a minimum current draw of 2A. Caution is advised when connecting it to power sources, as it should not be directly connected to an Arduino board or any 5V source without a regulator. Additionally, for optimal serial communication, a voltage translator may be necessary shown in Fig 1.3.

Fig 1.3 GSM SIM800L

3. The **L293D** is a versatile motor driver IC designed for bidirectional control of two DC motors independently shown in Fig 1.4. It offers high current capability (up to 600 mA continuous per channel), wide operating voltage range (4.5V to 36V), and built-in diode protection against voltage spikes. Its logic-level inputs simplify interfacing with microcontrollers, and it's available in 16-pin DIP and surface-mount packages for flexibility. The IC requires minimal external components, making it easy to use. However, users must ensure motor currents remain within its maximum ratings to avoid overheating and damage.

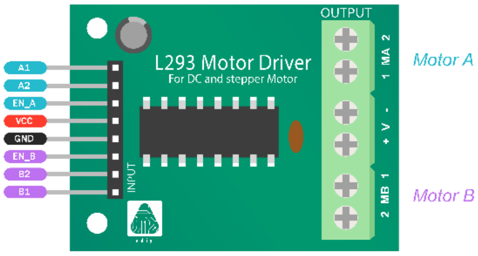


Fig 1.4 L293D motor driver

4. A **DC geared motor with wheel** in autonomous cars is an electrical device that converts electrical energy into mechanical motion, crucial for functions like propulsion and steering. It operates on direct current (DC) power and is used in various systems within autonomous vehicles, such as propulsion motors for driving wheels or steering motors for directional control. These motors enable the car to move, accelerate, decelerate, and navigate autonomously, playing a key role in the vehicle's overall functionality and movement capabilities shown in Fig 1.5.

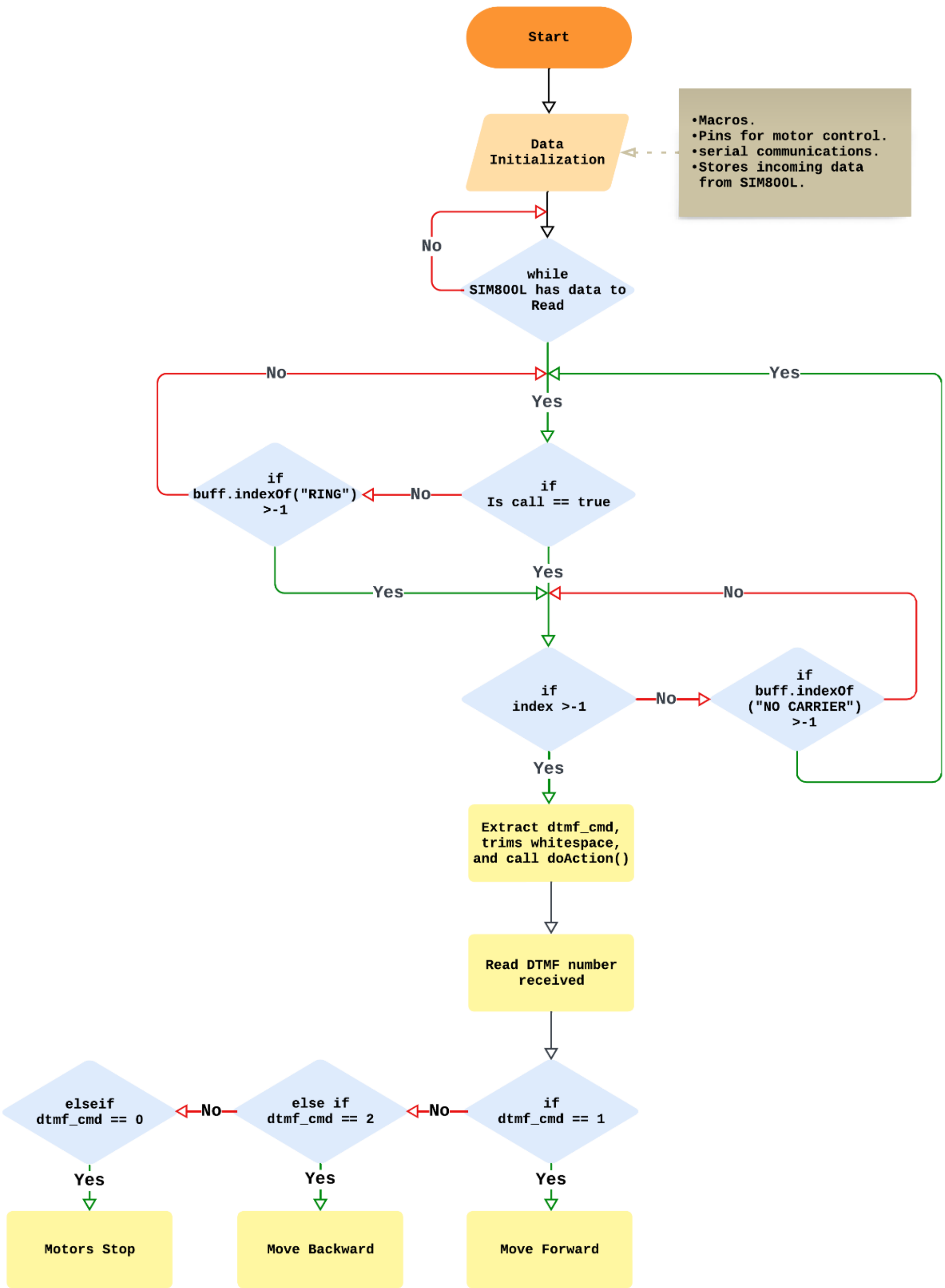
Fig 1.5 DC geared motor

5. The **Li-Ion 18650 battery** is a compact and efficient power source widely utilized across various industries. Featuring a typical capacity of 2000 mAh and a nominal voltage of 3.7V, it offers reliable performance for a multitude of electronic devices. Its flat top positive cap and rechargeable nature enhance usability and longevity.

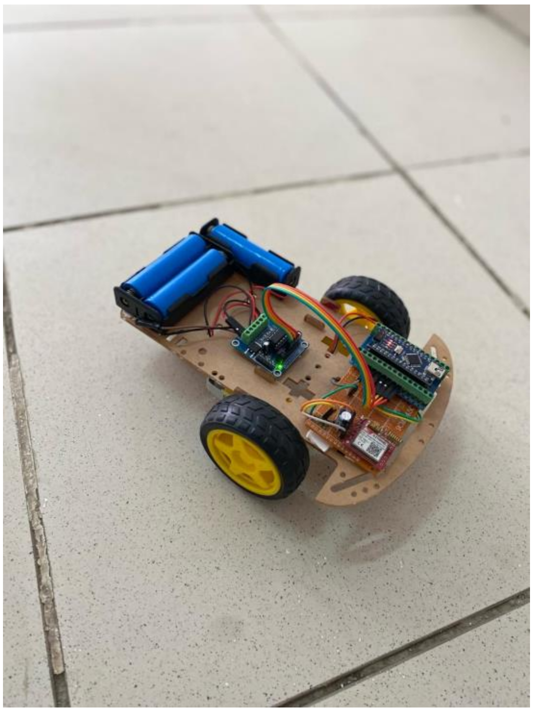
   With dimensions of 65mm in length and 18mm in diameter, the Li-Ion 18650 battery shown in Fig 1.6 is designed to fit seamlessly into a range of applications without compromising on power output. Furthermore, its safety features include a discharge end voltage of 2.5V and a charging maximum voltage of 4.20V, ensuring optimal performance and longevity.

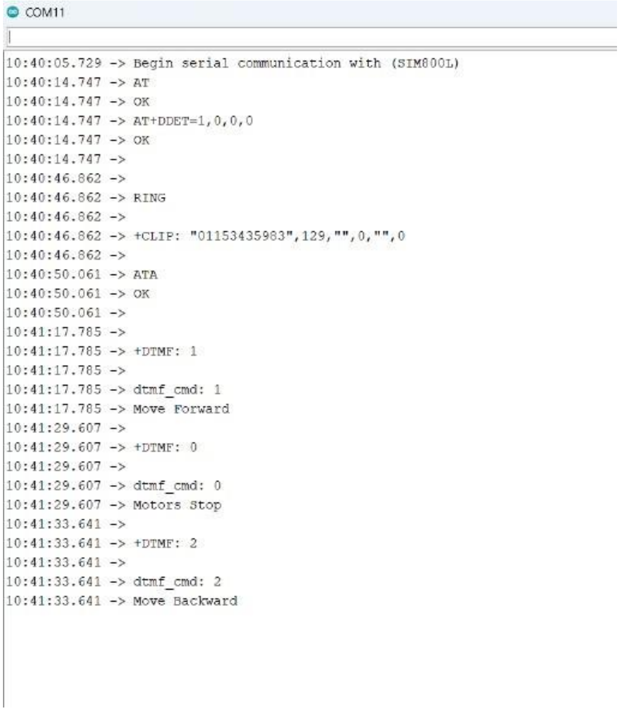
Fig 1.6 Li-Ion 18650 battery

FlowChart


Start
Data Initialization
•Macros.
•Pins for motor control.
•serial communications.
•Stores incoming data from SIM800L.
while SIM800L has data to Read
No
Yes
if Is call == true
if buff.indexOf("RING") >-1
if index >-1
if buff.indexOf ("NO CARRIER") >-1
Extract dtmf_cmd, trims whitespace, and call doAction()
Read DTMF number received
if dtmf_cmd == 1
else if dtmf_cmd == 2
elseif dtmf_cmd == 0
Move Forward
Move Backward
Motors Stop

Results and Testing:





To test and observe the output we been through those steps:

1. Setup Hardware: Connected the Arduino with the SIM800L module and the motor driver and Ensuring proper connections.
2. Monitor Serial Output: We open the Arduino IDE's Serial Monitor to check the results.
3. Make a Call: Calling the SIM800L's by the SIM card we put it inside the module. It auto-answered and enabled DTMF detection.
4. Send DTMF Tones: During the call, we pressed certain keys (0,1,2) on the calling mobile keypad to send DTMF tones.
5. Observe Motor Actions: The motors moved forward, backward, or stop based on the DTMF tones sent.
6. End Call: We hanged up the call from the mobile. And we also tested that if we can end the call from the Serial Monitor on the Arduino IDE.
7. Verify Output: We checked the Serial Monitor for debug messages and comparing the actual results and the results from the Serial Monitor to confirm DTMF reception and motor actions.

Conclusion:

In conclusion, with the help of DTMF technology, the robot can be controlled remotely, overcoming the limitation of RF communication, which has a limited range. With the use of a smartphone or other comparable device, users can operate the robot remotely, giving them flexibility and convenience. The circuit enables quick and responsive control over the robot's movements and actions by facilitating real-time communication between the user and the robot. It will give the service provider extremely smooth control over a large area network. The project's software provides excellent control over the robot's movement.

Appendix:

GitHub Code

https://github.com/MahmoudElbhrawy/GSM-Based-Robot-Control-Using-DTMF

Features

- **ATmega328** Microcontroller
  - High-performance low-power 8-bit processor
  - Achieve up to 16 MIPS for 16 MHz clock frequency
  - 32 kB of which 2 KB used by bootloader
  - 2 kB internal SRAM
  - 1 kB EEPROM
  - 32 x 8 General Purpose Working Registers
  - Real Time Counter with Separate Oscillator
  - Six PWM Channels
  - Programmable Serial USART
  - Master/Slave SPI Serial Interface
- **Power**
  - Mini-B USB connection
  - 7-15V unregulated external power supply (pin 30)
  - 5V regulated external power supply (pin 27)
- **Sleep Modes**
  - Idle
  - ADC Noise Reduction
  - Power-save
  - Power-down
  - Standby
  - Extended Standby
- **I/O**
  - 20 Digital
  - 8 Analog
  - 6 PWM Output

GSM SIM800L

Table 1: Module information

	SIM800H	SIM800L
GSM	850,900,1800 and 1900MHz	850,900,1800 and 1900MHz
BT	Support	Not support
FLASH	32Mbit	16Mbit
RAM	32Mbit	32Mbit

2.2. SIM800H&SIM800L Key Features

Table 2: SIM800H&SIM800L key features

Feature	Implementation
Power supply	3.4V ~4.4V
Power saving	Typical power consumption in sleep mode is 1.04mA (BS_PA_MFRMS=9)
Frequency bands	Quad-band: GSM 850, EGSM 900, DCS 1800, PCS 1900. SIM800H&SIM800L can search the 4 frequency bands automatically. The frequency bands can also 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 (option)
Temperature range	Normal operation: -40°C ~ +85°C Storage temperature -45°C ~ +90°C
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 debug port	**Serial port:** Default one Full modem serial port 1200bps to 460800bps. 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. upgrading firmware **Debug port:** USB_DN and USB_DP Can be used for debugging and upgrading firmware.
Phonebook management	Support phonebook types: SM, FD, LD, RC, ON, MC.
SIM application toolkit	GSM 11.14 Release 99
Real time clock	Support RTC
Timing functions	Use AT command set
Physical characteristics	Size: 17.8*15.8*2.4mm Weight:1.35g
Firmware upgrade	Main serial port or USB port.(recommend to use USB port)

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

AT+DDET DTMF Detection Control	
Test Command **AT+DDET=?**	Response **+DDET: (0,1),(0-10000),(0,1),(0,1)** **OK**
	Parameters See Write Command
Read Command **AT+DDET?**	Response **+DDET: <mode>,<interval>,<reportMode>,<ssdet>** **OK**
	Parameters See Write Command
Write Command **AT+DDET=<mode>[,<interval>][,<reportMode>][,<ssdet>]**	Response **OK** **ERROR**
	Unsolicited Result Code 1)If <reoportMode> is set to 0 **+DTMF: <key>** 2)If <reportMode> is set to 1 **+DTMF: <key>,<last time>**

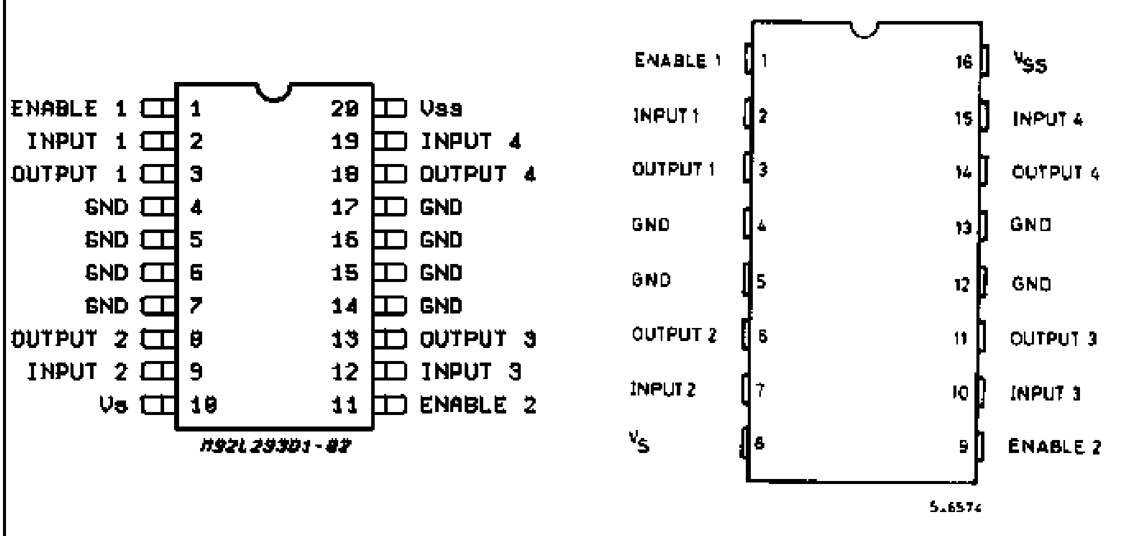
	Parameters <**mode**> Disable or enable DTMF detection control 0 Disable 1 Enable <**interval**> The min interval between two same key URC. The range is 0-10000, the default value is 0. unit is ms. <**reportMode**> URC report mode 0 Key value reported only 1 Key value and last time are reported, the last time is in ms <**key**> Keytone detected, 0-9,*,#,A,B,C,D.if <ssdet> is 1,Single frequency sound 1400 and 2300 is supported too, when single frequency 1400HZ sound or 2300HZ sound is detected, +DTMF:1400 or +DTMF:2300 is reported <**last time**> Duration of keytone playing. unit is ms. <**ssdet**> Single frequency sound detect function on off 0 Switch off 1 Switch on
Parameter Saving Mode	AT&W_SAVE
Max Response Time	-
Reference	Note The parameters <**interval**> ,<**reportMode**> and <**ssdet**> can not power off save

Motor Driver L293D

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_S	Supply Voltage	36	V
V_{SS}	Logic Supply Voltage	36	V
V_i	Input Voltage	7	V
V_{en}	Enable Voltage	7	V
I_o	Peak Output Current (100 µs non repetitive)	1.2	A
P_{tot}	Total Power Dissipation at T_{pins} = 90 °C	4	W
T_{stg}, T_j	Storage and Junction Temperature	– 40 to 150	°C

PIN CONNECTIONS (Top view)



SO(12+4+4) Powerdip(12+2+2)

THERMAL DATA

Symbol	Decription	DIP	SO	Unit
$R_{th\ j\text{-}pins}$	Thermal Resistance Junction-pins max.	–	14	°C/W
$R_{th\ j\text{-}amb}$	Thermal Resistance junction-ambient max.	80	50 (*)	°C/W
$R_{th\ j\text{-}case}$	Thermal Resistance Junction-case max.	14	–	

M92L293D1-01 OUT2 OUT4

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