**Wake-up Stroke Prediction through IoT and its Possibilities**

**Abstract:**

Stroke onset during night-time sleep referred as wake-up stroke, where a patient awakens with stroke symptoms that were not present before falling asleep. The symptoms of wake-up stroke are not clearly known; it is only noticed upon waking. Without knowledge of the stroke onset time, this large group of patients is excluded from treatment with tissue plasminogen activator. This research studies stroke risk prediction during sleep, i.e., wake-up stroke prediction using Internet of Things (IOT). Stroke prediction through intelligence technology and prediction algorithms which controlled by hyper-connected self-machine learning engine. The idea achieved through building a knowledge base including physiological data, motion data, bio signal, risk factors and electronic health record. The physiological, bio-signal, and motion data will be measured through wearables and embedded sensors. This Project focused on briefly explaining the conceptual idea and related information of the elderly stroke prediction while sleeping using IOT.

**Proposed System**

This research project objective is to successful real-time detection and generation of alarms in cases of stroke onset while sleeping through Internet of Technology (IOT) especially for the elderly, which will allow the timely delivery of medical assistance. Stroke prediction through intelligence technology controlled by hyper-connected self machine learning engine. The idea achieved through building a knowledge base including physiological data, motion data, bio signal, risk factors and electronic health record. The physiological, bio-signal, and motion data will be measured through wearable sensors. After successfully creating a knowledge base, the hyper-connected self machine learning engine can predict stroke through its intelligence and prediction algorithms. If the proposed system predicts stroke symptom above 90%, it will generate an alarm to family, the victim, people around the victim, and healthcare professionals. Then the victim will get the timely medical assistance.

**Block Diagram:**

**POWER SUPPLY**

**IOT MODEM**

**PIC MICROCONTROLLER**

**TEMPERATURE SENSOR**

**HEART BEAT SENSOR**

**GPS MODULE**

**BLOOD PRESSURE SENSOR**

**Sensors:**

**1.Temperature Sensor:**

**Features:**

• Calibrated Directly in Celsius (Centigrade)

• Linear + 10-mV/°C Scale Factor

• 0.5°C Ensured Accuracy (at 25°C)

• Rated for Full −55°C to 150°C Range

• Suitable for Remote Applications

• Low-Cost Due to Wafer-Level Trimming

• Operates From 4 V to 30 V

• Less Than 60-μA Current Drain

• Low Self-Heating, 0.08°C in Still Air

• Non-Linearity Only ±¼°C Typical

• Low-Impedance Output, 0.1 Ω for 1-mA Load

**Description:**

The LM35 series are precision integrated-circuit temperature devices with an output voltage linearly proportional to the Centigrade temperature. The LM35 device has an advantage over linear temperature sensors calibrated in Kelvin, as the user is not required to subtract a large constant voltage from the output to obtain convenient Centigrade scaling. The LM35 device does not require any external calibration or trimming to provide typical accuracies of ±¼°C at room temperature and ±¾°C over a full −55°C to 150°C temperature range. Lower cost is assured by trimming and calibration at the wafer level. The low-output impedance, linear output, and precise inherent calibration of the LM35 device makes interfacing to readout or control circuitry especially easy. The device is used with single power supplies, or with plus and minus supplies. As the LM35 device draws only 60 μA from the supply, it has very low self-heating of less than 0.1°C in still air.

The LM35 device is rated to operate over a −55°C to 150°C temperature range, while the LM35C device is rated for a −40°C to 110°C range (−10° with improved accuracy). The LM35-series devices are available packaged in hermetic TO transistor packages, while the LM35C, LM35CA, and LM35D devices are available in the plastic TO-92 transistor package. The LM35D device is available in an 8-lead surface-mount small-outline package and a plastic TO-220 package.

**2. Blood Pressure Sensor:**

Blood pressure monitors can use Korotkoff, Oscillometry, or Pulse Transit Time methods to measure blood pressure. They employ a pressure cuff, pump, and transducer to measure blood pressure and heart rate in three phases: Inflation, Measurement, and Deflation. They include an LCD, selection buttons, memory recall, power management, and USB interface. The pressure transducer produces the output voltage proportional to the applied differential input pressure. The output voltages of the pressure transducer range from 0 to 40 mV, which need to be amplified so that the output voltage of the DC amplifier has a range from 0 to 5V. Thus, we need a high-gain amplifier. Then the signal from the DC amplifier will be passed on to the band-pass filter.

The DC amplifier amplifies both DC and AC component of the signal. The filter is designed to have large gain at around 1-4 Hz and attenuate any signal that is out of the pass band. The AC component from filter is important for determining when to capture the systolic/diastolic pressures and heart rate of the patient. The final stage of the front end is an AC coupling stage, after which the signal is sent to analog to digital converters, and digitized.The digital measurements of pressure and heart rate are performed by the microprocessor. Measurements results are stored in EEPROM or FLASH memory as a data log that can be uploaded to a PC via USB.

The analog circuit is used to amplify both the DC and AC components of the output signal of pressure transducer so that we can use the MCU to process the signal and obtain useful information about the patient's health.

**3. Heart Beat Sensor:**

**DESCRIPTION:**

Heart beat sensor is designed to give digital output of heat beat when a finger is placed on it. When the heart beat detector is working, the beat LED flashes in unison with each heartbeat. This digital output can be connected to microcontroller directly to measure the Beats Per Minute (BPM) rate. It works on the principle of light modulation by blood flow through finger at each pulse.

**FEATURES**

• Heart beat indication by LED

• Instant output digital signal for directly connecting to microcontroller

• Compact Size

• Working Voltage +5V DC

**GLOBAL POSITIONING SYSTEM**

**DESCRIPTION**

Over the last five years Global Positioning Systems (GPS) have changed the way fieldwork is conducted. There are two principal reasons for using GPS in the field; these are navigation and determining co-ordinates for points in the GIS. This manual will not deal in depth with navigation, as this topic is described well elsewhere (for a good introduction see Simmonds (2004), which is included on the CD accompanying this book).

Navigation is touched on briefly in Section 6.1 and the reader should note that, even though GPS are excellent tools for field navigation, their very nature as electrical equipment means they are fallible. As such, a more traditional backup including a map and compass are essential.

GPS use satellite data to calculate an accurate position on the earth.

These calculations can relate the user’s position to almost any map projection within milli -seconds. All GPS work in a similar manner but they often look very different and have different software.

The most significant difference between GPS receivers is the number of satellites they can simultaneously communicate with. Most receivers are described as 12 channel meaning they can communicate with 12 satellites.

Older models may be 8 or even 5 channel with more modern receivers capable of communicating with 14 – 20. Given the current (2005) makeup of the GPS satellite’s constellation 12 channel is more than adequate. Almost all units have an LCD screen or at least software that links to a PC/PDA with an output screen. The unit might have several different pages that can be displayed on screen but usually the default page is very similar. Commonly on starting a receiver you will be presented with a map of the satellites in view.

**GNS HISTORY**

Though there are various land based navigational services such as DECA and Loran, this chapter looks purely at satellite GNS. In the 1950s the US Navy began a program to study navigation from artificial satellites. The first satellite navigational aid, TRANSIT, was accurate to approximately 160 m for stationary receivers. Moving receivers introduced additional errors of around 1 km per 1 m per second speed.

These initial tests were generally accurate for a ship at sea but were of limited use for navigating into ports or shallow waters. The TIMATION I satellites launched in 1967 allowed comparatively slow moving receivers to calculate positions via embedded atomic clocks. This was much more accurate for ships but soon the aviation industry became interested and a system was developed for faster objects. The current Global Position System suitable for aircraft and high-speed navigation, NAVSTAR, was initiated by the US Air Force in 1978.

**THE NAVSTAR SYSTEM**

The NAVSTAR system is managed by the Interagency GPS Executive Board (IGEB) of the US government. Details of this can be found on their website at www.igeb.gov. A statement by President G.W. Bush in December 2004 indicates that this may change in the future but the IGEB website remains an excellent source of up to date information.

The current specification requires satellites to orbit the Earth in one of six orbits inclined at different degrees to the equator, between –55° +55° at an altitude of 20,200 km. The DoD maintains 4 satellites in each orbital plane, giving a total constellation of 24 satellites, currently supported by up to 5 spares. Satellites are being replaced over time and the newest satellites are referred to as GPS IIR SVs.

**WORKING**

GPS signals do not contain positional data. The position reported by the receiver on the ground is a calculated position based on range-finding triangulation. GPS positioning is achieved by measuring the time taken for a signal to reach a receiver. Almost one million times a second the satellite transmits a one or a zero in a complex string of digits that appears random. In actuality this code is not random and repeats every 266 days. The receiver knows that the portion of the signal received from the satellite matches exactly with a portion it generated a set number of seconds ago.

The DoD maintains very accurate telemetry data on the satellites and their positions are known to a high level of precision. This simple operation allows the distance to a satellite to be calculated accurately. When the distance to three satellites is known then there is only one point at which the user can be standing. This principle is demonstrated in the diagrams on the following pages.

**ACCURACY**

The signal transmitted by the satellites has a potential accuracy of <1 m but several factors influence this and reduce the actual resolution. The US military designed the end user of the SPS to be able to resolve a position 95.4% of the time (two standard deviations) to an accuracy of 100 m in X and Y (longitude and latitude) and 156 m in Z. Using the PPS service the end user should be able to resolve 22 m in X and Y and 27 m in Z. These are very conservative estimations and actual accuracy will lie between the theoretical resolution and these design schematics.

**REAL WORLD ACCURACY**

Most manufacturers quote receiver accuracy as <15 m. The total effect of the typical errors shown in  [Table 6-2](#page42) is closer to 30 m but repeated tests show that under good conditions the accuracy of a standard civilian set using the SPS signal on L1 should be considerably better than this.

The distance of any given point from the actual location is called the dilution of precision. Sometimes data is quoted in circular error probability (CEP). The CEP describes a circle of a radius containing 50% of the data. A typical GPS might have a CEP of 3 metres. More commonly the 2σ dilution of precision is quoted.

This is equal to the square root of the sum of the values of a data set minus the average value of the data squared divided by the number of points in the series. The 2σ dilution of a 12 channel GPS receiver is often assumed to be a circle with a radius of ± 7.5 m (a 15 m diameter circle around a point’s true location).

To see the significance of the standard deviation of a dataset, imagine plotting all values in a dataset against the frequency with which each value occurs. Figure 6-11 gives an example, using the error found in many GPS readings taken at a point. In this case, the mean value is 0, and the other values are distributed to either side in a characteristic bell-shaped curve.

This shape indicates a ‘normal’ data distribution (also called Gaussian); many statistical measures and tests assume that data are normally distributed in this way. In the case of the standard deviation, if data are distributed normally, then we can say that:

* 1.68.2% of all values lie within ± 1 σ of the mean
* 2.95.4% of all values lie within ± 2 σ of the mean
* 3.99.7% of all values lie within ± 3 σ of the mean

So, for example, when GPS are described as having 7.5 m accuracy to 2σ this

means that 95.4% of readings are within error margin.

In many cases data will not be distributed normally. For example, if the data in the distribution is skewed to one side, has more than one peak, or if the number of values is relatively small then the curve may not be Gaussian. In such cases, the standard deviation must be used more conservatively, e.g. 2σ contain 75% of the data, rather than 95.4%, or may not be applicable at all.

**CORRECT GPS HANDLING**

As discussed above GPS receivers are only accurate when used correctly. Improper use or failure to consider environmental factors such as canopy cover or urbanisation will result in severely degraded data. This section discusses how the GPS should be used in the field and important considerations when using them on expeditions. The time taken to do this can vary considerably and is an important consideration for fieldwork.

When a GPS receiver has a satellite fix it can be used in one of two ways. Location points can be recorded at a user’s discretion by clicking a button on the receiver (usually Mark or similar) or automatically at given time or distance intervals. These two methods are referred to as Waypoints and Track points respectively.

**ASSESSING DATA QUALITY**

GPS is a valuable tool for expeditions but the ease with which buttons can be clicked and data collected can lead to poor scientific practice. The team should always be conscious of what the GPS is recording and whether the data is of a high or low standard.

When using waypoints, the user has the opportunity to select readings of a high quality. The quality of data can be very important to an expedition. If a position is to be recorded in the field for future visits then poor quality data may make the location ambiguous.

The difference between a good fix (±5 m) and a poor fix (±20 m) may place the waypoint on the wrong side of a river or crevasse making relocating the point or making interpretations very difficult. The GPS receiver will show the quality of data within the sky view as an estimated positional error (EPE).

**CALCULATION AND STORING OF POSITION DATA**

When assessing data quality it is important to understand how the GPS is arriving at its results. The NAVSTAR system was designed to work with a mathematical model of the Earth. This model was the shape of an ellipsoid (a three dimensional ellipse flattened at the poles and elongated at the equator) and the GPS calculates positions relative to this model. The GRS80 (Geodetic Reference System 1980) ellipsoid is the model that was taken for use with NAVSTAR. This is a good approximation of the shape of the Earth.

It was modified slightly to be the World Geodetic Survey 1984 (WGS84) and this is the common reference system that all receivers use. This best fit of the whole Earth is not accurate for all areas and most countries use their own ellipsoid. In Britain the ellipsoid used is the Airy 1830 ellipsoid. When displaying data the GPS will by default display co-ordinate information according to the WGS84 ellipsoid. This is acceptable for latitude and longitude but would often give unexpected and erroneous height data.

The height of topography above or below a hypothetical ellipsoid is often of limited use and a more conventional description is often required. As described in Chapter 2 a geoid is a model of the earth defined as a surface where the lines of gravitational force are perpendicular*.* Mean sea level itself is not constant across the globe; it can alter by as much as 2 m, depending on where it is measured. Heights in Britain are measured relative to the tide gauge at Newlyn, Cornwall.

Even the best geoid available will still not tally with every country's maps and heights, because there is often a discrepancy in the zero altitude used. The geoid and mean sea level are commonly very close to one another, so heights against the geoid are an acceptable measure of heights against mean sea level. These two measurements do not diverge by large amounts (up to a maximum of 2 m but most commonly sub-metre) though they can both diverge by up to +85 m or –102 m against the WGS84 ellipsoid.

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**UNDERSTANDING PRECISION AND IMPROVING ACCURACY**

GPS accuracy is better than 15 m (around 6 m by 8 m). GPS receivers are often called upon to report data more precisely than this. The UTM system is a measurement of metres from a datum in 1 m intervals. The common degrees minutes and seconds system is also often more accurate than the resolution of the GPS receiver. The Earth is approximately 6,378,200 m in radius at the equator giving an equatorial circumference of 40,075,413 m.

If this is divided into degrees minutes and seconds each degree is 111,320.6 m, each minute is 1,855.34 m and each second is 30.92 m. When divided decimally each fraction of a second is 3.1 m. This means that the data is recorded to 3 m intervals, which is still more accurate than the GPS is actually capable of. This level of precision (how many decimal points quoted) is often incorrect and caution should be taken when using seemingly accurate information.

**Improving Accuracy (Standard Methods)**

There are a number of techniques for reducing dilution and improving data quality. The signals sent from the NAVSTAR satellites are accurate to the centimetre scale. This accuracy is downgraded by the various factors discussed in Section 6.5.1. In October 2001 the US Military released their first indication of the post-SA quality of the data. Their findings indicate that though the signal is now accurate to at least 13 m, local errors will often reduce this.

If a GPS receiver can be used in an area of unobstructed sky the position should be as accurate as the diagrams shown in Section 6.5.4. If a reading has to be taken in an area of obscured sky, then a GPS can be combined with more traditional surveying techniques. If a point of clear sky can be found, then the expedition can mark this point using the GPS as normal.

The co-ordinates of the desired point can then be calculated by surveying a line back from the known point to the required location. To do this the expedition would have to use a compass to measure the angle from the known point to the desired location then accurately measure the distance between them. The exact method of transforming this information to the GIS will depend on the co-ordinate system used. This process is shown in Plate 5.

Combining basic surveying and GPS work can be an effective method for surveying points and entering them back in the GIS later. It is, however, a very time consuming method and the accuracy reported on the GPS should be considered to see if the additional work is required.

As well as using the GPS in areas of unobstructed sky, there are additional methods for improving the SPS accuracy without the need for the PPS information. The most commonly occurring value in a distribution is referred to as the modal. By taking the modal value of the distribution, a point’s most likely true location should be significantly more accurate.

**Improving Accuracy (Manual Post Processing)**

As this chapter has stressed on numerous occasions high accuracy GPS data is often no real benefit to an expedition. However, if this accuracy is needed and the party cannot borrow equipment or purchase a several thousand pound DGPS system then there are alternatives.

Many methods for improving GPS accuracy rely on accurately sited base-stations in close proximity to the expedition and or a degree of expense. In remote expeditions on a tight budget these two facets make many of the techniques inaccessible. As we have seen from Section 6.10 a differential GPS can be corrected by using signals from a point of known location. The section on averaging also suggests that if a GPS left for a length of time any point can be surveyed to a high degree of accuracy.

Based on these two facts it might seem logical to assume that a GPS could be setup at a base-camp and used to calibrate a roving receiver in the field. If all the readings of the base-camp GPS were recorded for a day then at the end of the day the roving GPS could have all of its readings post-processed to remove the errors at all the waypoints. Unfortunately, this is not possible.

Because not even NMEA data (the complete output of all the calculated data performed by a GPS as shown in Section 6.9) contains the details about the SV used when making the calculation you cannot know if the calculated error from the base-camp GPS has any relevance to the waypoints recorded by the GPS. Proper differential GPS record the pseudo-range data.

This pseudo-range contains the information about the individual satellites and can be used to correct the signals appropriately. If a user tries this without the complete data then the processed information will be meaningless and less accurate than a standard waypoint. If the pseudo-range data can be obtained then there is the possibility of post-processing the data.

**6. LCD DISPLAY**

**DESCRIPTION**

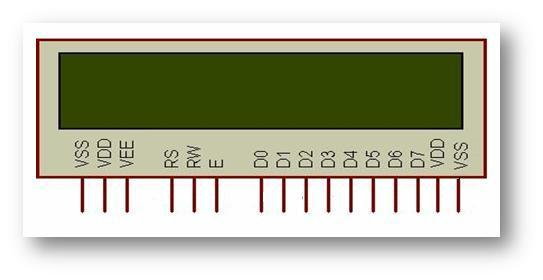
LCD (Liquid Crystal Display) screen is an electronic display module and find a wide range of applications. A 16x2 LCD display is very basic module and is very commonly used in various devices and circuits. These modules are preferred over  [seven segments](http://www.engineersgarage.com/content/seven-segment-display) and other multi segment  [LEDs](http://www.engineersgarage.com/content/led). The reasons being: LCDs are economical; easily programmable; have no limitation of displaying special & even  [custom characters](http://www.engineersgarage.com/microcontroller/8051projects/create-custom-characters-LCD-AT89C51) (unlike in seven segments),  [animations](http://www.engineersgarage.com/microcontroller/8051projects/display-custom-animations-LCD-AT89C51) and so on.

A **16x2 LCD** means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, Command and Data.

The command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc. The data register stores the data to be displayed on the LCD. The data is the ASCII value of the character to be displayed on the LCD. Click to learn more about internal structure of a  [LCD](http://www.engineersgarage.com/insight/how-lcd-works).

The most commonly used Character based LCDs are based on Hitachi's HD44780 controller or other which are compatible with HD44580. In this tutorial, we will discuss about character based LCDs, their interfacing with various microcontrollers, various interfaces (8-bit/4-bit), programming, special stuff and tricks you can do with these simple looking LCDs which can give a new look to your application.

**PIN DIAGRAM**



**Pin Diagram of LCD**

**PIN DESCRIPTION**

The most commonly used LCDs found in the market today are 1 Line, 2 Line or 4 Line LCDs which have only 1 controller and support at most of 80 characters, whereas LCDs supporting more than 80 characters make use of 2 HD44780controllers.

Before starting the internal operation of the LCD, control information is temporarily stored into these registers to allow interfacing with various MCUs, which operate at different speeds, or various peripheral control devices. The internal operation of the LCD is determined by signals sent from the MCU.

**Pin Description of LCD**

|  |  |  |  |
| --- | --- | --- | --- |
| **Pin No** | **Function** | **Name** |  |
|  |  |  |  |
| 1 | Ground (0V) | Ground |  |
|  |  |  |
|  |  |  |  |
| 2 | Supply voltage; 5V (4.7V – 5.3V) | Vcc |  |
|  |  |  |  |
| 3 | Contrast adjustment; through a variable resistor | VEE |  |
|  |  |  |  |
| 4 | Selects command register when low; and data register | Register |  |
|  |  |
|  | Select |  |
|  | when high |  |
|  |  |  |
|  |  |  |  |
| 5 | Low to write to the register; High to read from the register | Read/write |  |
|  |  |  |  |
| 6 | Sends data to data pins when a high to low pulse is given | Enable |  |
|  |  |  |  |
| 7 |  | DB0 |  |
|  |  |  |  |
| 8 |  | DB1 |  |
|  |  |  |  |
| 9 |  | DB2 |  |
|  |  |  |  |
| 10 |  | DB3 |  |
|  | 8-bit data pins |  |  |
|  |  |  |  |
| 11 |  | DB4 |  |
|  |  |  |  |
| 12 |  | DB5 |  |
|  |  |  |  |
| 13 |  | DB6 |  |
|  |  |  |  |
| 14 |  | DB7 |  |
|  |  |  |  |
| 15 | Backlight VCC (5V) | Led+ |  |
|  |  |  |  |
| 16 | Backlight Ground (0V) | Led- |  |
|  |  |  |  |

**Character LCD pins with 2 Controller**

|  |  |  |  |
| --- | --- | --- | --- |
| **Pin No.** | **Name** | **Description** |  |
|  |  |  |  |
| Pin no. 1 | **D7** | Data bus line 7 (MSB) |  |
|  |  |  |  |
| Pin no. 2 | **D6** | Data bus line 6 |  |
|  |  |  |  |
| Pin no. 3 | **D5** | Data bus line 5 |  |
|  |  |  |  |
| Pin no. 4 | **D4** | Data bus line 4 |  |
|  |  |  |  |
| Pin no. 5 | **D3** | Data bus line 3 |  |
|  |  |  |  |
| Pin no. 6 | **D2** | Data bus line 2 |  |
|  |  |  |  |
| Pin no. 7 | **D1** | Data bus line 1 |  |
|  |  |  |  |
| Pin no. 8 | **D0** | Data bus line 0 (LSB) |  |
|  |  |  |  |
| Pin no. 9 | **EN1** | Enable signal for row 0 and 1 |  |
| (1stcontroller) |  |
|  |  |  |
|  |  |  |  |
| Pin no. 10 | **R/W** | 0 = Write to LCD module |  |
| 1 = Read from LCD module |  |
|  |  |  |
|  |  |  |  |
| Pin no. 11 | **RS** | 0=Instruction input |  |
| 1 = Data input |  |
|  |  |  |
|  |  |  |  |
| Pin no. 12 | **VEE** | Contrast adjust |  |
|  |  |  |  |
| Pin no. 13 | **VSS** | Power supply (GND) |  |
|  |  |  |  |
| Pin no. 14 | **VCC** | Power supply (+5V) |  |
|  |  |  |  |
| Pin no. 15 | **EN2** | Enable signal for row 2 and 3 |  |
| (2ndcontroller) |  |
|  |  |  |
|  |  |  |  |
| Pin no. 16 | **NC** | Not Connected |  |
|  |  |  |  |

**BF - BUSY FLAG**

Busy Flag is an status indicator flag for LCD. When we send a command or data to the LCD for processing, this flag is set (i.e BF =1) and as soon as the instruction is executed successfully this flag is cleared (BF = 0). This is helpful in producing and exact amount of delay for the LCD processing. To read Busy Flag, the condition RS = 0 and R/W = 1 must be met and The MSB of the LCD data bus (D7) act as busy flag. When BF = 1 means LCD is busy and will not accept next command or data and BF = 0 means LCD is ready for the next command or data to process.

**INSTRUCTION REGISTER (IR) AND DATA REGISTER (DR)**

There are two 8-bit registers in HD44780 controller Instruction and Data register. Instruction register corresponds to the register where you send commands to LCD e.g LCD shift command, LCD clear, LCD address etc. and Data register is used for storing data which is to be displayed on LCD. when send the enable signal of the LCD is asserted, the data on the pins is latched in to the data register and data is then moved automatically to the DDRAM and hence is displayed on the LCD. Data Register is not only used for sending data to DDRAM but also for CGRAM, the address where you want to send the data, is decided by the instruction you send to LCD. We will discuss more on LCD instruction set further in this tutorial.

**COMMANDS AND INSTRUCTION SET**

Only the instruction register (IR) and the data register (DR) of the LCD can be controlled by the MCU. Before starting the internal operation of the LCD, control information is temporarily stored into these registers to allow interfacing with various MCUs, which operate at different speeds, or various peripheral control devices. The internal operation of the LCD is determined by signals sent from the MCU. These signals, which include register selection signal (RS), read/write signal (R/W), and the data bus (DB0 to DB7), make up the LCD instructions (Table 3).

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There are four categories of instructions that:

* + Designate LCD functions, such as display format, data length, etc.
  + Set internal RAM addresses
  + Perform data transfer with internal RAM
  + Perform miscellaneous functions

**LCD INSTRUCTIONS AND COMMAND**

**Frequently used commands and instructions for LCD**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **NO.** | **INSTRUCTION** | |  |  | **HEX** | **DECIMAL** |  |
|  |  | | | |  |  |  |
| 1 | Function Set: 8-bit, 1 Line, 5x7 Dots | | | | 0x30 | 48 |  |
|  |  | | | |  |  |  |
| 2 | Function Set: 8-bit, 2 Line, 5x7 Dots | | | | 0x38 | 56 |  |
|  |  | | | |  |  |  |
| 3 | Function Set: 4-bit, 1 Line, 5x7 Dots | | | | 0x20 | 32 |  |
|  |  | | | |  |  |  |
| 4 | Function Set: 4-bit, 2 Line, 5x7 Dots | | | | 0x28 | 40 |  |
|  |  |  |  |  |  |  |  |
| 5 | Entry Mode |  |  |  | 0x06 | 6 |  |
|  |  |  |  |  |  |  |  |
|  | Display | off | Cursor | off |  |  |  |
| 6 | (clearing | display without | | clearing | 0x08 | 8 |  |
|  | DDRAM content) | |  |  |  |  |  |
|  |  | |  |  |  |  |  |
| 7 | Display on Cursor on | |  |  | 0x0E | 14 |  |
|  |  | |  |  |  |  |  |
| 8 | Display on Cursor off | |  |  | 0x0C | 12 |  |
|  |  | | |  |  |  |  |
| 9 | Display on Cursor blinking | | |  | 0x0F | 15 |  |
|  |  | |  |  |  |  |  |
| 10 | Shift entire display left | |  |  | 0x18 | 24 |  |
|  |  | |  |  |  |  |  |
| 11 | Shift entire display right | |  |  | 0x1C | 30 |  |
|  |  | | | |  |  |  |
| 12 | Move cursor left by one character | | | | 0x10 | 16 |  |
|  |  | | | |  |  |  |
| 13 | Move cursor right by one character | | | | 0x14 | 20 |  |
|  |  | |  |  |  |  |  |
| 14 | Clear Display (also | | clear | DDRAM | 0x01 | 1 |  |
| content) |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  | | | |  |  |  |
| 15 | Set DDRAM address or cursor position | | | | 0x80 | 128 |  |
| on display |  |  |  |  |
|  |  |  |  |  |  |  |
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