

## DESIGN OF THERMOSTAT

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### **Abstract**

*A thermostat is a component of a control system that will senses the temperature of a system and it will maintain the temperature below the maximum point. Thermostat maintains the temperature by switching between heating or cooling devices on or off, or regulating the flow of a heat transfer fluid as needed, to maintain the correct temperature. The thermostat system which designed by Xpedition software comprises more of circuit complexity and the board size is also large. So we have planned to reduce the complexity and size of the board so that we planned to design thermostat system in Xpedition. The TDIM FRAM thermostat reference design, featuring the MSP430FR4XX FRAM based ultra-low power microcontroller, is a fully functioning battery powered platform for the thermostat that allows user to evaluate the*

*MSP430FR4XX device in thermostat application the most popular thermostat is the digital electronic thermostat. This kind of thermostat has thermistors or other semiconductor temperature sensors to measure temperature. All hardware and software are available for developers to easily develop their own thermostat application.*

### **INTRODUCTION:**

A thermostat is a type of circuit that shows whether a measured temperature is above or below a point, and it will be used for protection and temperature control system when temperature is not calling for the unit to be running the coil releases and the contacts open causing the compressor and motor fan to stop, this will help us to maintain the temperature below the desired level, the board designed for this process using Xpedition to reduce the complexity and size of the board.

The TDIM FRAM thermostat which reference design, featuring the MSP430FR4XX ultra low power microcontroller, is a fully functioning battery powered platform which will consume low power and allows the users evaluate the MSP430FR4XX device in thermostat applications with Xpedition can develop the world's most complex electronic system in multi discipline enterprise environment that delivers competitive advantage to their product. All hardware and software's are available for developers to easily develop their own thermostat application.

### **PCB (PRINTED CIRCUIT BOARD):**

All the operating system is formed by interconnection and assemblies of the components. This type of connections are evolved into printed circuit boards, the first board was designed during the second world war by USA around 1950s which is called as printed wired boards after that the first PCB board was designed during 1995 by micro via technology. The boards were classified into two types single side board and double side board.

### **SINGLE SIDE PCB:**

In single side board the components will be placed over the one side of the board these types of boards will be used for the commercial purposes like toys and small electronics and it cannot be used for the complex electric connection. They are lower cost choice for consumer products.

### **DOUBLE SIDE BOARD:**

In this type of board the components will be placed in both sides of the board and these type of board will be used for the high complex circuit, and also multilayer board is also used for the boards like thermostat.

### **EVOLUTION:**

We can take control of the heat cold humidity ventilation and zoning through the device there are two types of thermostat which is programmable and non-programmable thermostat in programmable thermostat the application cannot be extended to multiple devices. The basic construction mechanism of non-programmable thermostat is to indicate the temperature level in the fixed device. The major advantage in non-programmable thermostat is it will require low cost to build and acquires less time to construct. The programmable thermostat can be used to high complex device and their application is quite large the designing process of MSP430FR4XX also requires more time, it can be through Xpedition upto multiple layers.

The first printed circuit board was pattern in 1925 by Charles Ducas it was evolutionary idea because it could eliminate complex wiring and provide consistent results and in 1947 first double printed circuit board with plated through-hole produce and in 1997 Valor computerised system released ODB++ printed circuit board manufacturing data format into public design.

### **COLOURS OF BOARD:**

There are different colours are available for the PCB board such as red, green, white, blue and black.

Common colour is used for PCB is green solder mask which will give us visual clearance and also it will increase the contrast of the pads, traces, printing and empty spaces just by seeing the board from the outside by using this we can easily identify the defects.

The black PCB board is very hard to handle cannot be able find easily the difference between traces and pads are very hard to find When the high heating is occurred the board surface will absorb the heat and it need hard effort.

White colour board is used to see the difference between the traces and pads clearly and also there will be no heat dissipation in the surface of the board. But the white printed circuit board is very hard to clean.

### **CLASSES OF PCB:**

There are several classes of PCB boards each will differs from manufacturing specification, materials and usage of the boards: Multi-layer, rigid flexi, flexible, high frequency and frequency backed PCBs.

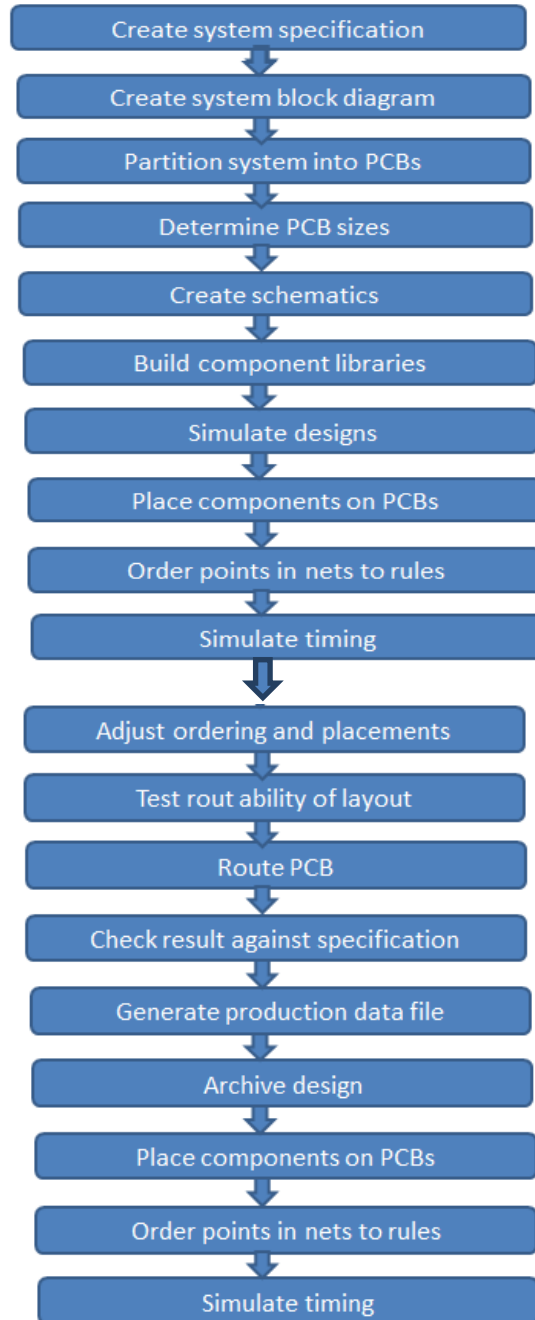
### **MULTILAYER PCB:**

These PCB have one or more layers which will inside in addition to having a conductor layer on its surface. The layers between the boards were connected to each other and to the outer layer using the via

and pads. These type of boards will be used for the super computer application and also used in the thermostat.

**FLEXIBLE RIGID:**

The board is made of combination both flexible and rigid. The flexible portion of the board Will be created first and finally it will be laminated with rigid portion. This process will help us to eliminate the harnesses of the wires and connectors. This type of boards will be used for computers, mobile phones and laptops.



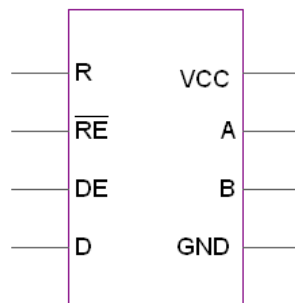
## DESIGN TOOLS:

There are several design tools are available for PCB designing process. The software like eagle, altium, allegro and xpedition. The Eagle software is developed by Autodesk and it is supported for all kind of operating system but in this software we can create up to few layer of board. In altium we can create upto multiple layers but the major drawback is this software is only available for only Microsoft operating system, creation of schematic and back annotate process is very easy to do. Allegro software is the most commonly used PCB designing software of all and it is available for all kind of operating system we can create multiple layers and also can create complex circuit but the usage of this software is very hard to learn the footprint of this software is very hard to know. Xpedition is very easy to learn and also we can create multiple layers in this software also the thermostat is designed in this software.

## LIBRARY CREATION AND DATA MANAGEMENT:

The first process has to be carried out before the creation of board is library creation and data management it will help us to place the components for our requirement and there is no need of footprint for the components when we create our own library symbols.

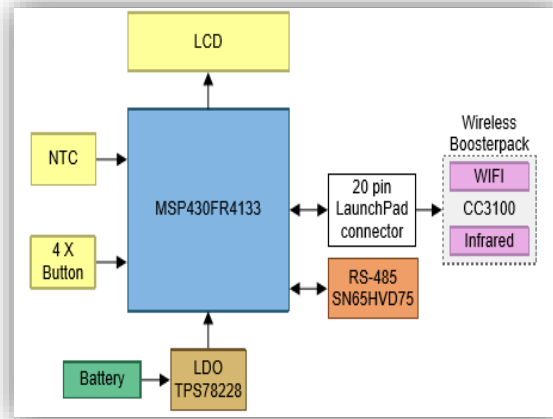
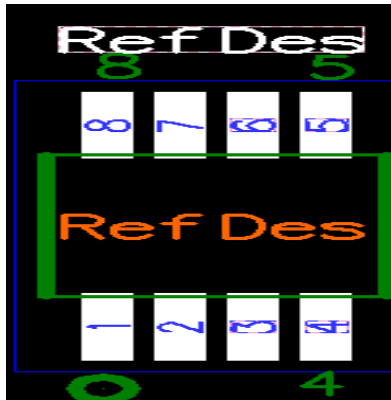
Xpedition has library to create and manage all physical parts which required for complex PCB system. It will have all predefined symbols, pad stack, cockpit and logical to physical pin mapping. The management of symbols and solution scalable, by supporting also for the small design required up to high complex and incorporative symbols. By using those created library component user can save time by avoiding searching components. It will provide the creation and as well as design process steps which will help the users. The creation of library symbols can use not only for the certain projects can also use for the several projects and by using the key we can share the designs to other users who work on the same project and design.



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## SN65HVD23x:

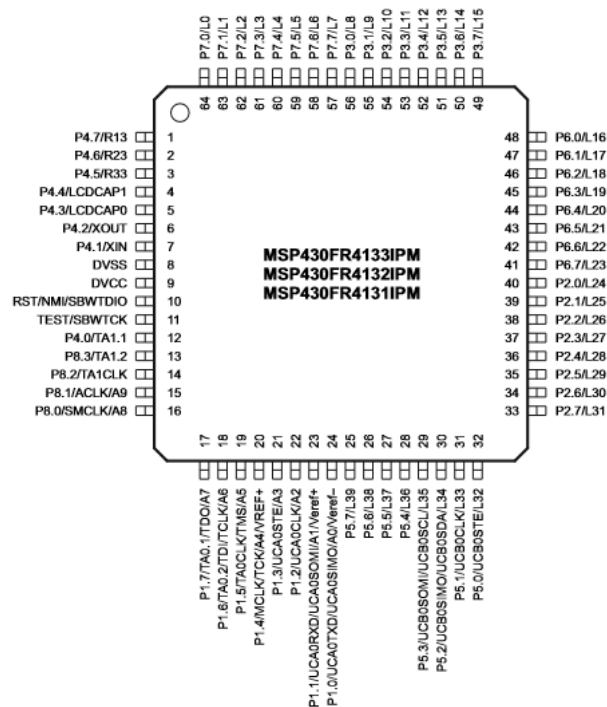
After the creation of library file symbol will be created to place on the board where it will be converted to board component.



**BLOCK DIAGRAM:**

**MSP430FR4133 (MICROCONTROLLER):**

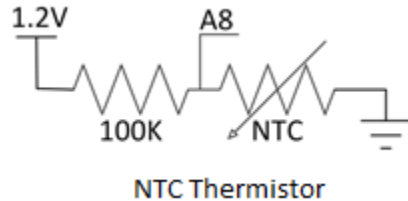
MSP430FR4133 is a microcontroller family which supports low cost LCD applications which gives benefits on integrated 10-bit ADC such as remote controls, thermostats, smart meters, blood glucose monitors and blood pressure monitors. The MCU feature a powerful 16-bit RISK CPU, and constant generators which contribute to maximum code efficiency. It will control the digital oscillator to wake up at 10µ from low power mode to active mode.



The extensive low power mode combines with architecture is optimised to extended battery life in portable application. MSP430FR41X MCU are support by software and hardware ecosystem with code examples and reference design to get design quickly.

## NTC THERMISTOR:

NTC thermistor are resistors with a negative temperature co-efficient, the resistance will decrease with increasing temperature. They are used as current limiting device and temperature sensors. These type of sensors are used between the range of  $-55^{\circ}\text{C}$  to  $200^{\circ}\text{C}$ . This sensors are five times more effective than that of silicon temperature sensors. The non-linearity relationship between temperature and resistance exposed by NTC resistors posed a great challenge when using analog circuit for accurate temperature measurement, but rapid development of digital circuits solved the problem computing of precise values by interpolating tables or by solving equations.



## TEMPERATURE RESPONSE:

While most NTC thermistors are used for temperature management, there are different families of thermistors which are used for temperature approaching zero as well as designed for use above  $150^{\circ}\text{C}$ . The temperature sensitivity of NTC sensor is represented as “Percentage change per degree Celsius “. It will always depend on the material used and specifies of production process, and it will vary from -3% to -6% per $^{\circ}\text{C}$ .

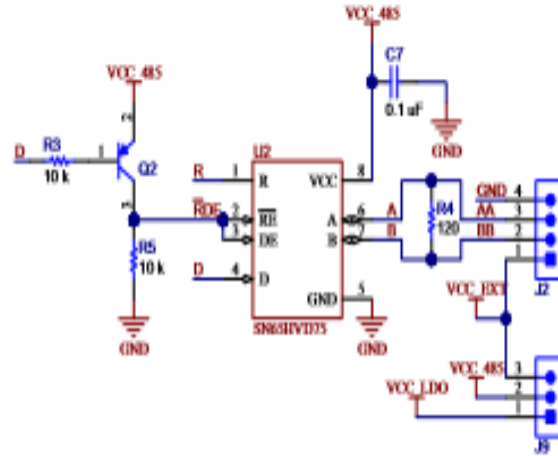
These type of thermistors will have much steeper resistance temperature when compared to platinum alloy which translates to better temperature sensitivity. Even so, RTD remain the most accurate sensor with their being 0.5% of measured temperature and it will be used for measuring between  $-200^{\circ}\text{C}$  to  $800^{\circ}\text{C}$ .

## HEAT CAPACITY:

It represents heat level which requires to increase the temperature of the thermistor by  $1^{\circ}\text{C}$ . and it is usually represented in  $\text{mJ}/^{\circ}\text{C}$ . By knowing the precise heat level is great importance when using the NTC thermistor sensor as an current limiting device, as it defines the speed of NTC thermistor sensor.

## RS-485:

TIA-485 is referred to as RS-485 standard, its specifies the characteristics electrical behaviour of drivers and receivers to balance the digital multi-point system the industrial network always covers over long distances and use a single pair of twisted cable to keep the cost of cabling down. It will operates in half duplex mode, which means a bus node can either transmit or receive the data with in a same cable. The major limitations of half duplex network are the master node can transmit and receive a data using the same cable but cannot be done it in same time. Time critical networks will utilize the full duplex configuration, where master cable can transmit and receive the data through different cables simultaneously. This will increase the data transmission speed to reduce latency but also doubles the cabling requirements. These type of multi-point system are commonly used at data rates below 2Mbps. These type of devices will help the designers to overcome through the signal degradation issues through high output drive capability and also accurate switching performance for both 3.3V and 5V supplies.

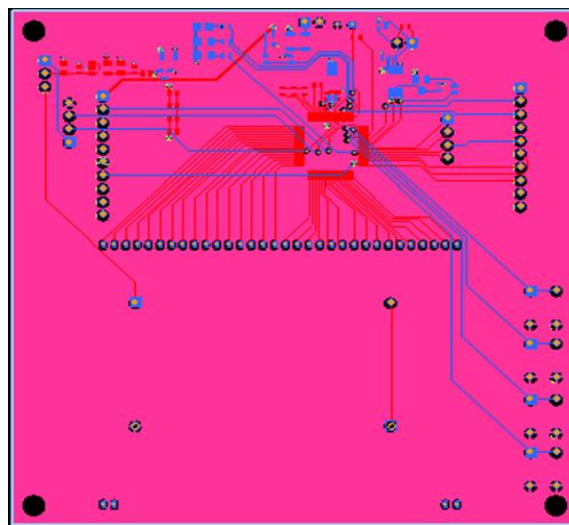


RS-485

**OUTPUT:**

**ROUTING:**

After placing the components over the board the routing process is carried out through mentor graphics, should specify the component area for all the traces over the board and should keep space to make drill the board for through-hole component and the board ratio will be fixed as per the usage components the routing process must be in proper manner while routing through multiple layers. The mentor graphics will provide us the future to see the routing lines separately.



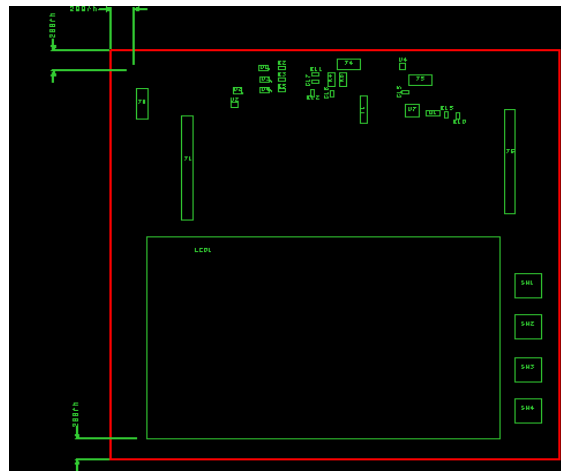
**BOTTOM LAYER:**

In Xpedition we can create multiple layers in which components will be placed bottom and top of the board and connections can be given through the layers between the boards which are separated from each other. It will shows us the components which are all places at the bottom layer.



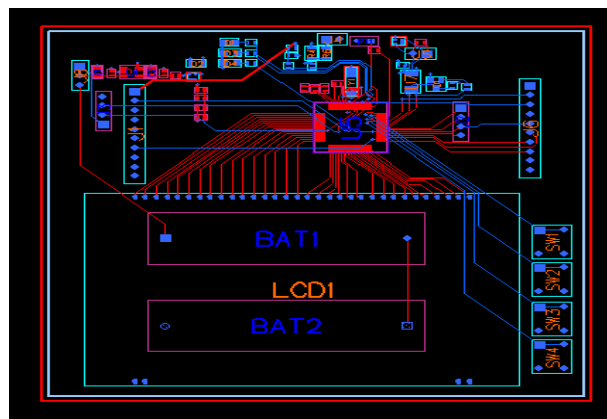
**TOPLAYER:**

Most of the main components will be placed on the top layer to show the uses of all the components are visible and can be easily observed,



**PLACEMENTS OF THE COMPONENTS:**

After all the assembly and routing process we can stimulate the design to check weather the connections are correct or not by passing the input through the thermostat.





### **ADVANTAGES OF THERMOSTAT:**

1. They are able to concentrate more on their jobs and don't need to worry about the device were we placed it.
2. It reduce the power consumption and work effectively even in the low power.
3. The smart thermostat will reduce power consumption up to 20%.
4. It can also be controlled by smart devices like mobile phone even in far away distance.

### **ADVANTAGES OF XPEDITION:**

1. It provides system design into manufacturing execution.
2. Xpedition can design a board upto multiple layers.
3. With Xpedition global engineering research and development team developing the most complex electronic systems.
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