



Easy Technical Guide to Understand PC Motherboard, Troubleshoot Problems and Its Repair: PART- I

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ABSTRACT : With the widespread use of computers in each and every field and with the technological advancement in semiconductor processing industries, it is required to evaluate the performance of the computer in a profound manner. This requires the thorough knowledge of personal computers. Motherboard is heart of any computer system. In a computer system in different parts, different faults may arise. In this paper details of motherboard is discussed. In the first part of this paper series different VRM circuit of motherboard is discussed in detail. Also, technical guide is suggested for troubleshooting of VRM circuit faults and its remedies.

KEY WORDS : Computer, Motherboard, CPU, VRM Circuit, SMPS.

I.INTRODUCTION

Today, with tremendous advances in Information technologies, the use of information systems turned out to be explicitly. Computer system typically include a combination of hardware components and software, application programs, system programs, processors, buses, memory, input/output devices etc. Today, more sophisticated computer software has evolved to take advantage of the higher performance of the hardware, resulting in computer systems that are much more powerful than just a few years ago.

Fault diagnosis in the Electronics field has received a lot of attention in research literature over the last years. Several theoretical and practical fault troubleshooting techniques have been developed and experimented to automate the diagnostic process of electronic devices.[1,2,3]

Today, because of widespread use of computers, fault diagnosis is becoming very vital in the field of information technology and computer engineering, particularly in personal computer troubleshooting. Acquiring the troubleshooting knowledge from expert computer technical persons is limited because it requires up gradation of continuous learning, training and practice in maintenance skills which over a period of time dramatically increase organization operating costs and reduces the net productivity. Basically, PC troubleshooting covers a variety of problems which includes hardware problems, software problems, network problems, operating system problems and application software problems. This may impose a maintenance nightmare for large-scale enterprises and IT infrastructures as the number of possible technical problems and finding their solutions can become very large and complex.

Modern PC motherboards are very modular in their design and so easily accessible. Anyone with a basic understanding of how they work should be able to diagnose and repair basic motherboard-related faults on a PC[4,5].Several researchers [6,7] have diagnosed and troubleshoot computer faults.

This paper discusses the details of motherboard sections, Functions of Voltage Regulator Module(VRM) on the motherboard, its troubleshooting and remedies.

II.DETAILS OF MOTHERBOARD

The synonymous words used for motherboard are Main board, System board. The motherboard is considered to be mother of the personal computer (PC) or controller/holder/common connecting point of all other devices required to run a PC.



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The motherboard is the main Printed Circuit Board (PCB) in a Personal Computer that is used to integrate and control all other components and devices in a complete computer system. It contains various components like CPU, memory, BIOS and basic controllers that are required to operate the system. Different types of motherboards are available which are built and designed with a limited range of specific components that can be used in them, which are dependent upon the manufacturers design. An important thing to understand that all motherboards are not same. They may integrate some of the same technologies. But the way those technologies work together may be completely different in nature. Some can appear to be very similar, yet have hidden differences. Their appearance can vary in circuit board size, shape, design, capabilities and configuration possibilities.

Since, the components and parts of a motherboard can vary from minor differences to great ones, it is important to understand what a motherboard consists of.

The next set of sections will give the idea of the main components that a motherboard consists of, uses or is integrated with.

III.GENERAL BLOCK DIAGRAM OF THE COMPUTER MOTHERBOARD

In present scenario most of the motherboards available are of integrated type. Fig.1 shows the general block diagram of Integrated Motherboard. Integrated Motherboards have assemblies /components that are otherwise installed as expansion boards, integrated or built right onto the board. The serial and parallel ports, the IDE and floppy drive and joystick all connect directly to the motherboard. The advantages of these types of motherboards are it tends to force up some space inside the case and allows for better accessibility and air flow. The systems are comparatively cheaper to produce because there is less material involved and less installation. Testing can be done at the same time. These particular assemblies are generally fairly stable. But the disadvantage is that if the problem of controller failure or broken pin arises they are more expensive to repair/replace

The main functions of the motherboard are –

- (i) To mount the components on a computer system.
- (ii) To Control elements of BUS changes to suit the different components.
- (iii) To manage supply for components on the main board.
- (iv) To provide host clock to synchronize the operation of the system.

IV.DETAIL DESCRIPTION OF MAIN COMPONENTS OF THE MOTHERBOARD

1. **CPU SOCKET (TO PLUG CPU)** : Depending on the category of motherboard, different types of CPU sockets are available to plug the CPU. Following Table 1 shows the type of the motherboard and their corresponding socket used.
2. **NORTH BRIDGE CHIPSET (GMCH)**: North chipset is used to control high speed devices like CPU, RAM and Video Card. This chip set controls the Bus speed and Switches controlled data ensuring that data between the components is smooth and continuous. Also, it controls the

speed of CPU and RAM. This type of Chipset controls the switches so that each data stream passes in a fixed period of time like a traffic light.

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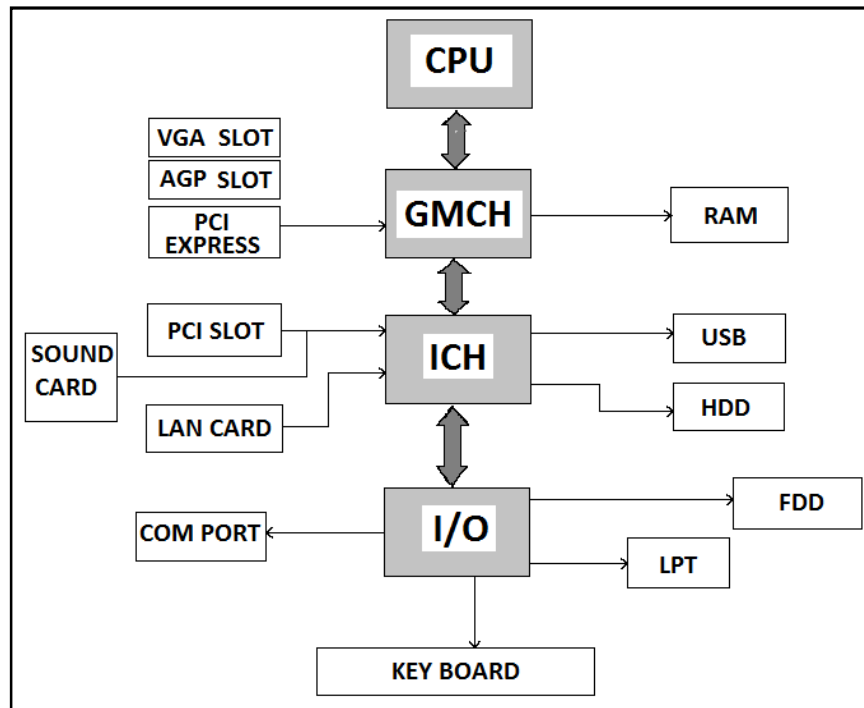


Fig :1 General Block Diagram of Integrated Motherboard

Table :1 Type of Motherboard and their Corresponding Socket

CPU ON THE MOTHERBOARD	CPU SOCKET USED
Pentium 3	370
Pentium 4	478
Pentium D	775
Intel Core i3 , i5	1156
Intel Core i7	1366

3. **SOUTH BRIDGE CHIPSET : (ICH - INPUT/OUTPUT CONTROLLER HUB)** : The function of the south bridge chipset is similar to the driver components like – Sound Card, Network Card, Hard Drive, CD-ROM drive, USB Port, BIOS IC and S I/O.
4. **ROM BIOS (READ ONLY MEMORY – BASIC IN-OUT SYSTEM)** : ROM is a Read Only Memory IC whereas BIOS is a program that is loaded in ROM by the main board manufacturer. The main function of the BIOS programs are
 - 1 To start the Computer, and to maintain the operation of the CPU.
 - 2 To check the faults of RAM and Video Card.
 - 3 To manage the chipset drives for North Chipset, South Chipset, S I/O IC and Onboard Video.



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- 4 To Gives CMOS set up Default setting for machines.
5. **S I/O IC (SUPER INPUT/OUTPUT CONTROLLER)** : IC S I/O controls the serial port like COM Port, PS/2 Port etc and Parallel Ports like Printers, Scanner, Floppy Controller. S I/O, Supervises other departments main activities to provide signals. This is an integrated power switch control circuit which generates Reset Signal.
 6. **CLOCK PULSE GENERATOR CIRCUIT** : Clock Pulse Generator circuit plays an important role on the motherboard. This circuit synchronizes operation of entire computer system simultaneously. If this is broken, clock circuit components cannot work on the motherboard. After the first operation, this circuit is a main source of supply.
 7. **VOLTAGE REGULATOR MODULE (VRM)** : For CPU core voltage this is a power supply control circuit. This is made from 12V/2A circuit voltage available from SMPS. This circuit is used to adjust the voltage level to 1.5V and current up to 10 Amp which is used for CPU. The circuit includes components like MOSFET, PWM IC, Phase Driver IC, Filter Circuit (LC filter) etc.
 8. **AGP OR PCI EXPRESS** : AGP or PCI Express Slot are controlled by NORTH Chipset which are used to add Video Card.
 9. **RAM SLOT** : RAM Slot is used to add RAM on the Motherboard. This RAM is controlled by the NORTH Chipset. This Memory is very essential intermediate in any computer system.
 10. **PCI SLOT** : PCI slot is controlled by SOUTH Chipset which is an extension to add Sound Card, Network Card etc.
 11. **IDE PORT** : This is controlled by SOUTH Chipset used to connect IDE drive like-HDD,CD-ROM,DVD etc.
 12. **SATA PORT : (Serial Advance Technology Attachment)** : SATA is a technique to connect Hard Disk drive to computer. This is an alternative of PATA. Before SATA came, PATA was known as Parallel ATA, is a IDE standard. To join SATA Hard Disk drive to computer thin cable is used which is connected to SATA Port available on the motherboard. Now a days most of the computers uses SATA Port.
 13. **USB PORT (Universal Serial Port)** : The main function of this port is transfer data serially with high speed from USB device. Different types of USB Ports are used having different data transfer speed which is, (i) USB 1.0 version – 1.5Mbps (ii) USB 1.1 version – 1.2Mbps (iii) USB 2.0 version – 480Mbps
 14. **AUDIO DRIVER CHIP** : The main function of this chip is to convert digital audio information (available from ICH) into analog audio signal and to give this Analog audio signal to Audio port. There are different uses of this chip. Audio driver chip is available in different versions and watts.

V.POWER SOURCE CONTROLLER ON THE MOTHEBOARD

The functions of the power source circuit on the motherboard are – To control the power switch and to provide stable voltage to CPU , Chipset , RAM , Video Card and other components.

DIFFERENT POWER SOURCES USED FOR VARIOUS BLOCKS ON THE MOTHERBOARD :

A. Switch Mode Power Supply :

This has two parts (i) Standby (ii) Main Source (Main Power) When we plug this into 220VAC power source , then immediately standby 5V supply is given to SOUTH chipset and S I/O IC.(Until Power switch is pressed , main source will not work means mains power is not available) The Pin details of Motherboard Power Connector are as shown in Table : 2.



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Table : 2 Pin details of Power Connector

COLOUR OF THE WIRE	SUPPLY VOLTAGE (VOLT)
Yellow	12 V
Red	5 V
Orange	3.3V
White	-5V
Blue	-12V
Black	GND / Common
Purple	5V STB (First Level)
Green	P.On (Open Source Command)
Grey	PG (Power Good Signal)

B. VOLTAGE REGULATOR CIRCUIT

- (1) Without Voltage Regulation, supply voltage given to the components directly :There are certain components where supply is given directly from switch mode power supply without using voltage regulator.

These components are (i) Clock Generator IC (Clock Pulse) – Supply of 3.3.V from direct source (ii) SOUTH Chipset – 3.3V ,5V or 5V STB direct voltage. (iii) S I/O IC – 3.3V or 5V STB from direct source.

All these components finds power from SMPS.

- (2) Circuit Voltage : Some components like, CPU, RAM, Video Card and NORTH Chipset normally operates at low voltage level. For these components ,source voltage 3.3V,5V or 12V is reduce to low voltage level 1.3V to 2.5V
- (a) VRM Circuit for CPU : (Voltage Regulator Module Circuit for CPU) – VRM is a voltage regulator circuit for CPU. This circuit functions in such a way that it reduces the SMPS voltage (12V) to low voltage which is given to CPU. Depending on the type of CPU, electric current is increased by MOSFET.
On the Motherboard for Pentium 3 CPU, VRM circuit changes the voltage from 5V to about 1.7V.
- (b) Chipset Voltage Regulator Circuit : This is a voltage regulator circuit for Chipset. Intel NORTH and SOUTH Chipset uses 1.5V supply where as VIA Chipset normally uses 3V etc.
- (c) RAM Voltage Regulator Circuit : Here the voltage regulator circuit is used to increase or decrease voltage. In PENTIUM 3 system SDRAM uses 3.3V which does not require voltage regulator.DDR RAM uses 2.5V , DDR 2RAM uses – 1.8V,DDR 3 RAM uses -1.5V

VI.ANALYSIS OF POWER SUPPLY CIRCUIT ON THE MOTHER BOARD

- (I) When plugged in - Standby power on SMPS activity - Motherboard receives Stand by 5V through purple wire.



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- (II) When you press the switch, whole circuit will start working - To control sources of main board, To provide the voltages P. ON = 0V for Booting, To provide voltage to the motherboard 3.3V, 5V, 12V and secondary sources like -5V and -12V.
- (III) 3.3V power supply given directly to clock generator IC, SOUTH chipset BIOS or S I/O IC.
- (IV) 1.5V for Intel Chipset, 3V for Chipset VIA
- (V) From SMPS +12V supply through VRM circuit 1.5V or different low voltages are given to the different types of CPU.
- (VI) 5V to chipset or PCI expansion card from this regulator circuit is used to derive 2.5V which is used to give supply to RAM IC.

IN THE FIRST PART OF THESE PAPER SERIES VRM CIRCUIT FOR CPU IS DISCUSSED IN DETAIL

VII.DETAILS OF VRM CIRCUIT

VRM is known by different technical terminology viz. Voltage Regulator Modulation, CPU supply circuit, CPU core circuit and V-core circuit. VRM is a term used to collectively describe the combination of MOSFETs (and Driver ICs), capacitors and chokes (coil) which are used to accomplish the power objectives.

A Voltage Regulator Module is responsible for the voltage delivered to different electrical components. The main function of this circuit is to generate core voltage for CPU.

Most of the CPU has a specified operating voltage of somewhere in the range of 1.1V-2.0V with different current capacity ranging between 10A to 45A.

MOSFETs or Metal-Oxide Semiconductor Field-Effect Transistors are responsible for the actual amplification and switching of signals and assist in voltage identification when communicating with the CPU. The CPU tells the MOSFET for the required voltage and the MOSFET uses a series of logic gates to assist in delivering that voltage (From the 12V supply).

A. MAIN COMPONENTS OF VRM CIRCUIT

- (I) PWM IC : (Pulse Width Modulator) This gives pulse to the oscillator to control the Gate of the Power MOSFET
- (II) Phase Driver IC : This is used to distribute the two opposite ranges of phase signal to the Gate of the Power MOSFET
- (III) Power MOSFET : This acts according to PWM pulse control signal and Oscillator output signal to the Gate of the MOSFET. When +ve pulse of phase signal occurs MOSFET becomes ON and during -ve pulse of phase signal MOSFET becomes OFF.
- (IV) Coils and Capacitors : Used in conjunction with each other to filter out DC voltage pulses supply into pure DC volt.

Different VRM circuits are available for different motherboard. Basic Circuit Diagram of VRM CIRCUIT is shown in Fig.2.

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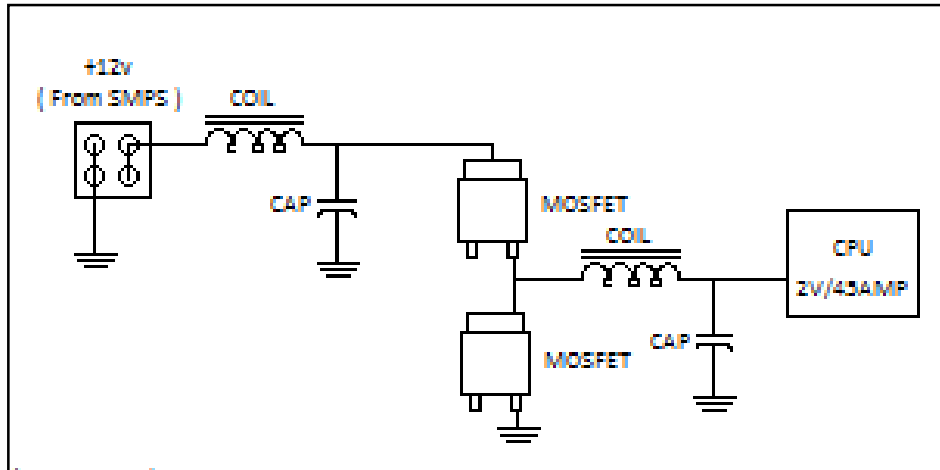


Fig.2 Basic Circuit Diagram of VRM

When SMPS is switched ON, +12V supply goes to drain of MOSFET through LC filter and at CPU one can measure voltage about 0.85V through the output LC filter circuit. Number of MOSFET group as well as number of LC filter circuit can be utilized which depends on the manufacturer’s design and stability / capacity of CPU.

Fig.3 shows VRM circuit with Buck and Oscillator IC. As shown in Fig.3 signal of different pulses comes from PWM, according to that pulses, Oscillator gives their phase sequence to the gate of the Power MOSFET. More number of Power MOSFET group used to increase the longevity of Motherboard. Some design of motherboard consists of single VRM Chip which includes programmable circuit, voltage sense and Oscillator.

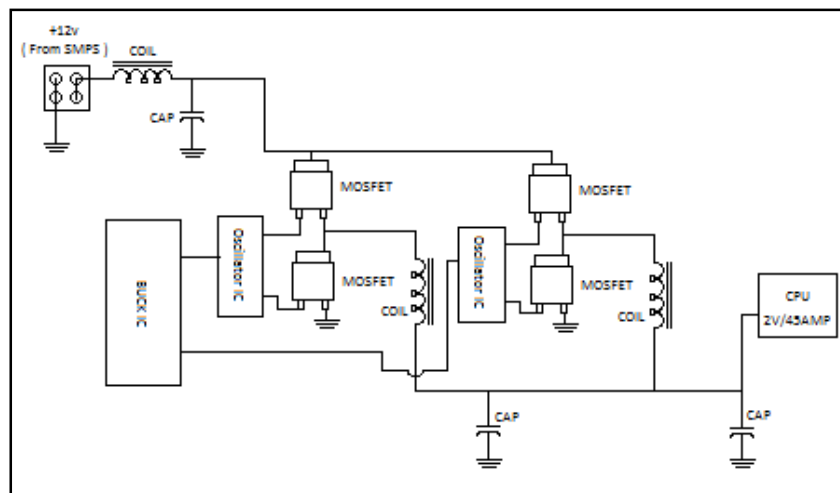


Fig.3 VRM circuit with Buck and Oscillator IC

Fig.4 shows complete VRM circuit diagram in which S I/O, Buck IC, Oscillator IC, MOSFETs, CPU and SMPS section works together.

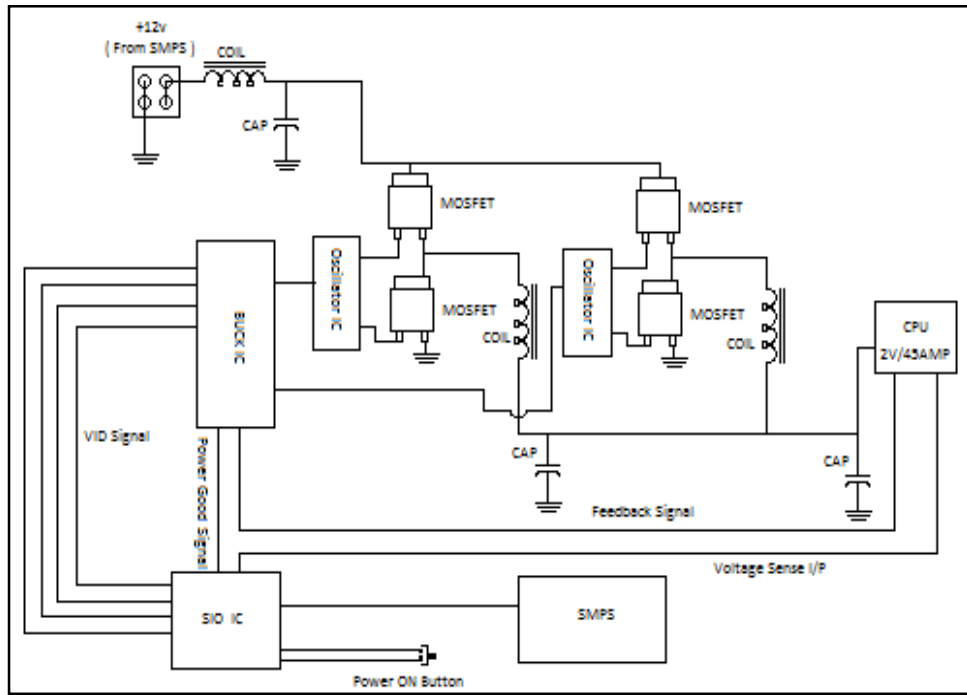


Fig.4 Complete VRM circuit diagram

Following steps describes the working function of VRM circuit shown in Fig 4.

1. When Power ON switch is pressed , +12 V supply from SMPS gives signal of 0.85V to CPU through 1st MOSFET
2. CPU gives Volt sense signal to S I/O IC
3. According to Volt sense signal S I/O IC gives VID signal to BUCK IC
4. BUCK IC changes its frequency with respect to VID signal received
5. According to this frequency from BUCK IC the Driver IC gives pulses to 1st and 2nd MOSFET gate terminal
6. MOSFET gives respected output voltage and Current (For example : 2V/45 Amp, 1.5V/10Amp etc) to CPU
7. When CPU receives their required supply Feedback signal (load resistor) active for BUCK IC
8. After receiving feedback signal from CPU , BUCK IC generate power good signal for S I/O IC.
9. Now,S I/O IC give SMPS Green wire to logic low signals so the SMPS remain continuously ON.

B. FEATURES OF VRM CIRCUIT

1. This voltage converter circuit reduces the voltage from 12V to low level voltage of about 2.0V, 1.5V etc and increases the current level up to about 45A, 10A etc respectively.
2. Because of the MOSFET used, loss of energy is very less so that it has good efficiency,
3. It has 4 pin connector to input +12V on the Motherboard.
4. VRM circuit adjusts the CPU voltage automatically depending on the voltage sense from the CPU and as a result S I/O generates VID signals which is applied to PWM IC. o/p of PWM IC given to MOSFET.



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VIII.RESULTS & DISCUSSION

FAULT FINDING AND REMEDIES OF VRM SECTION :

After switching on SMPS, First check the supply on CLOCK IC, RAM IC and GMCH IC. If it is OK then one can conclude that VRM section is Faulty.

Major Faults are,

1. CPU Fan becomes On and then OFF
2. CPU cannot Heat
3. Repeatedly Restart Problem
4. Hanging of Computer after POST screen
5. No Display

The troubleshooting problems / path of fault finding are discussed as shown below.

For Fig.2,

Path of Fault findings are,

- (i) Check +12V signal from SMPS (No signal from SMPS , Signals are Loading)
- (ii) Check Filter Capacitor (Capacitors may be Budge)
- (iii) Check MOSFET (MOSFET may be open , Short or Dry solder)
- (iv) Check MOSFET PAD (Corrugated surface)

Remedies are,

- (i) Repair or Replace SMPS
- (ii) Filter capacitor should be replaced
- (iii) Replace MOSFET according to their number
- (iv) MOSFET PAD should be cleaned by Cleaning solution.

For Fig.3,

Path of Fault findings are,

- (i) Check +12V signal from SMPS (No signal from SMPS , Signals are Loading)
- (ii) Check Filter Capacitor (Capacitors may be Budge)
- (iii) Check MOSFET (MOSFET may be open , Short or Dry solder)
- (iv) Check MOSFET PAD (Corrugated surface)
- (v) Check Oscillator IC (Heat up or Dry solder)
- (vi) Check BUCK IC (Heat up or Dry solder)

Remedies are,

- (i) Repair or Replace SMPS
- (ii) Filter capacitor should be replaced
- (iii) Replace MOSFET according to their number
- (iv) MOSFET PAD should be cleaned by Cleaning solution.
- (v) Replace Oscillator IC according to their number
- (vi) Replace BUCK IC according to their number



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For Fig.4,

Path of Fault findings are,

- (i) Check +12V signal from SMPS (No signal from SMPS , Signals are Loading)
- (ii) Check Filter Capacitor (Capacitors may be Budge)
- (iii) Check MOSFET (MOSFET may be open , Short or Dry solder)
- (iv) Check MOSFET PAD (Corrugated surface)
- (v) Check Oscillator IC (Heat up or Dry solder)
- (vi) Check BUCK IC (Heat up or Dry solder)
- (vii) Check S I/O
- (viii) Check CPU socket

Remedies are,

- (i) Repair or Replace SMPS
- (ii) Filter capacitor should be replaced
- (iii) Replace MOSFET according to their number
- (iv) MOSFET PAD should be cleaned by Cleaning solution.
- (v) Replace Oscillator IC according to their number
- (vi) Replace BUCK IC according to their number
- (vii) Clean CPU socket
- (viii) Replace CPU processor

IX. CONCLUSION

This paper presented an overview of Motherboard Block Diagram, Detail description of Motherboard Components, its uses and importance. Details about the power sources used for different sections of motherboard are discussed in detail. Diagnosis of different faults that may occurs in VRM section is described and its remedies are suggested.

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