MIDDLE EAST TECHNICAL UNIVERSITY

ELECTRICAL-ELECTRONICS ENGINEERING DEPARTMENT

EE300 SUMMER PRACTICE REPORT

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1. INTRODUCTION

I did my summer practice in Stayer Factory at Spain/Madrid this summer. Reason because I do my summer practice in stayer, I am interesting power electronics. Stayer is one of the best welding factory in the world. Also, we are selling stayer products at my fathers' shop, this is another handle thing for me. My supervisor is Juan Pedro Uya Sanchez. He is electronic Engineer and Manager of the Control Quality Department. I worked at Laboratory to understand welding machines and had practice by working with technical persons. To develop myself, my supervisor gave me a project which I will explain detailed in report. Also, I did repair welding machines with technical persons. This experience helps me understand welding machine structure much more clearly. And learning problems with welding machines gains me a faster response when I face with any problems with electronic machines. I face a lot of problems in the factory because of having less practice. Despite the hardness, this summer practice is reaching the goal in my perspective.

2. DESCRIPTION OF THE COMPANY

2.1. COMPANY NAME

Stayer Iberica S.A.

2.2. COMPANY LOCATION

Address: Área empresarial de Andalucía Sector 1 C/ Sierra de Cazorla 7 28320 Pinto (Madrid) Spain coordinates: 40°15'52.6″N 3°41'50.1″W

Phone: +34 902 91 86 81

Email: info@grupostayer.com

Campus: Stayer Factory is seen at Figure 1.

Figure 1 Stayer Factory

2.3. GENERAL DESCRIPTION OF THE COMPANY

Grupo Stayer consists of three sub-companies. İmaport , Abrasivos Grinding and Stayer İberica. All companies are related each other. Abrasivos Grinding manufacture discs for using in power tools. Stayer produce welding machines and Power Tools. Customer is all the world, but they are especially active at Europe and South America. There are 60 Employees in factory. At laboratory that I give work, there are 9 employees 1 EE, 1 ME and 2 technicians. Sales area is very wide because power tools and welding machines are necessary even in a daily life. Biggest two opponent brands are Lincoln Electric (USA) for welding machine and Bosh (DEU) for power tools. The organizational chart of the company is shown in Figure 2. They develop numerous researched and developed projects to improve the existing products and the new products that are developed. They have an efficient quality control laboratory for compliance tests according to European application directives.

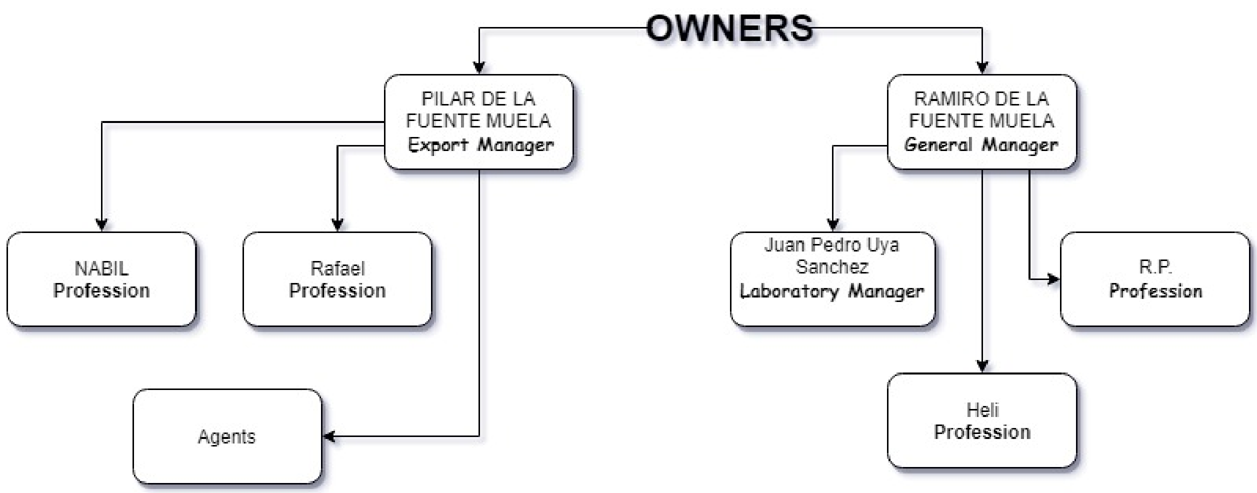

Figure 2 Organizational Structure of Stayer

2.4. BRIEF HISTORY OF THE COMPANY

Imaport S.A., constituted in January of 1976 as a marketing company of machinery for wood, metal and construction, has been the distributor of Stayer electrical power tools machinery in Spain until January 1989, when it is constituted Stayer Iberica S.A

Abrasivos Grinding S.A., constituted in December 1987 for the marketing of abrasive discs, creates in the early 90s the Oscar Diamant brand, for the sale of diamond discs, launching in 2000 the first factory of diamond disk of the Group localized in Madrid.

Stayer Ibérica S.A., acquires all assets of the company *Stayer Italia SpA* in 2005

3. UNDERSTANDING WELDING MACHINE

3.1. WELDING HISTORY

After human kind found the iron they tried to shape it to producing useful materials. Maybe the first welders are blacksmith. They increase temperature of iron and forging to merge or give a shape. After electricity found we produce high current to increase temperature and melt the iron. First machines are big and heavy. But, in 2010s welding machine is very small and compact thanks to electronic technology. Sample of Welding Machine is below Figure 3.

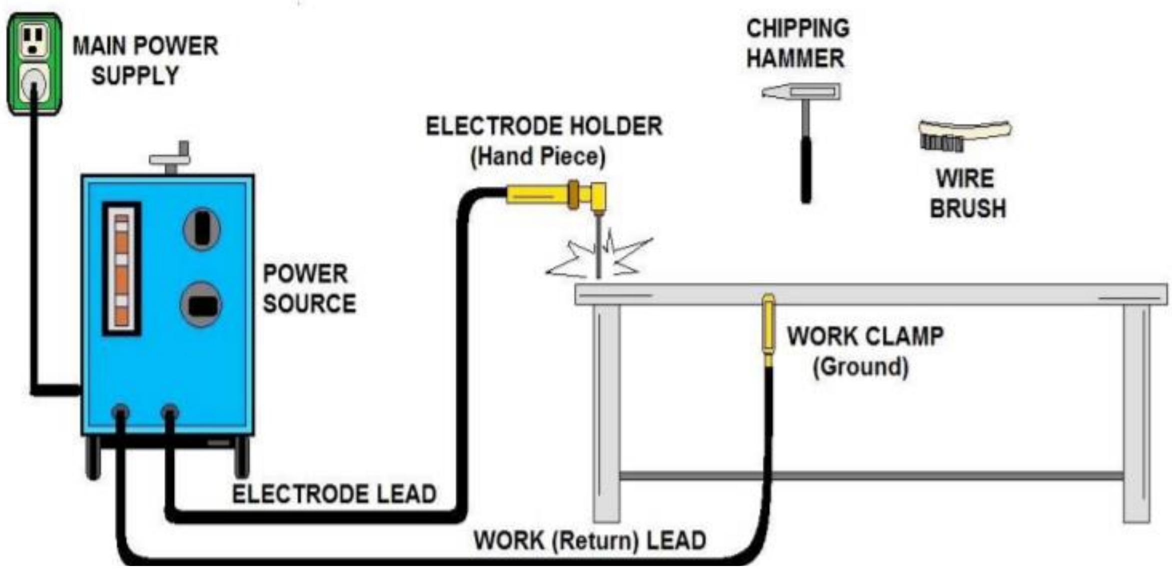

Figure 3 Sample of Welding Machine

3.2. HOW WELDING MACHINE WORKS

İn the simplest way, welding machine decrease voltage and increase current. High current produces a high temperature and electrode melts. Electrode consists of metal mixture. After freezing it is tight enough that merge two substance.

To provide high current we can use transformer. Before electronic developed welding machines are consist of a transformer. But, provide such high current, transformer is too big and heavy. Because of this disadvantage they are useful but not practical. To reduce size of transformer we can increase frequency to decrease inductance of transformer. The most important idea in welding machine is increasing frequency. It is hard to achieve but once we do it, high frequency led transformer be smaller. Difference between new and old Welding machine can be notices at Figure 4 .

Figure 4 New and Old Welding Machine

İncreasing frequency decrease size of transformer is proven by emf equation.

$$E_{rms} = \frac{2\pi}{\sqrt{2}} \times f \times N \times \varphi_{max}$$

When f ↑, N↓.

3.3. STRUCTURE OF WELDING MACHİNE

Although there are a lot of versions of welding machines (inverter machines), I will explain most popular welding machine (POTENZA 200). Most of welding machine structures are very similar. There are 3 subsystems. Power Supply Module, Switching Module and Logic module.

Power Supply Module: Power Supply Module on Figure 5 converts AC to DC to feed welding machine. Simply using Full wave rectifier (FWR) and capacitors. When first current flows into empty capacitor can damage system. To prevent this problem, we use a resistor at the output of FWR. After taking feedback from system that working relay active and resistor short so machine can start working with full power. Relay is protecting system. İf logic part is not working then relay is not active machine don't start working.

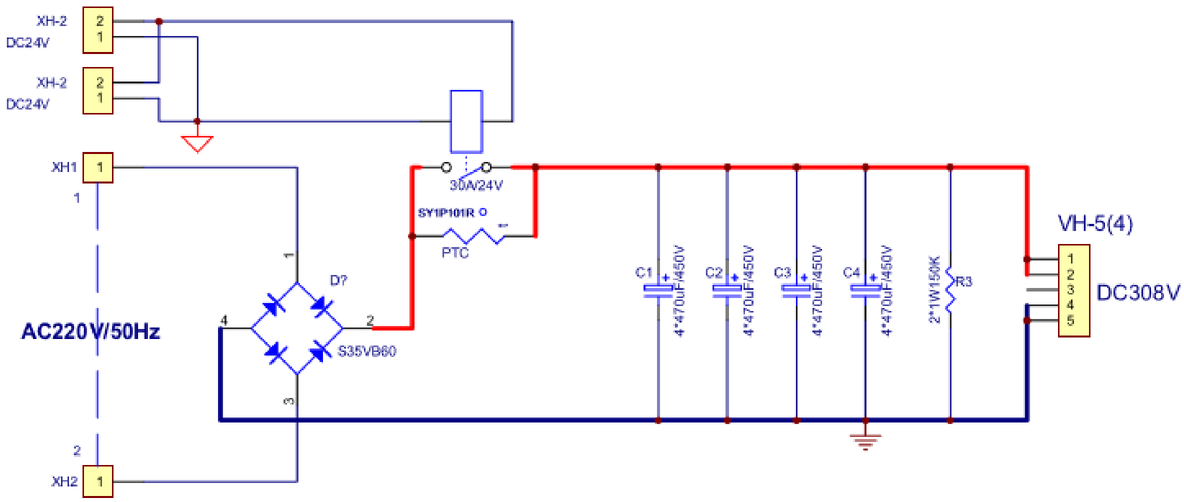

Figure 5 Power Supply Module

Switching Module: There are other subsystems in the switching module at Figure 6. DC Voltage from power supply will feed IGBT (H- BRIDGE) directly. And, this Voltage (380V) will convert to 24 V with transformer and by using LM78xx components we will have +5V, +15V and -15V to feed logic systems. To feed IGBT there are drivers which consist of mosfets. Driver is driven by PWM.

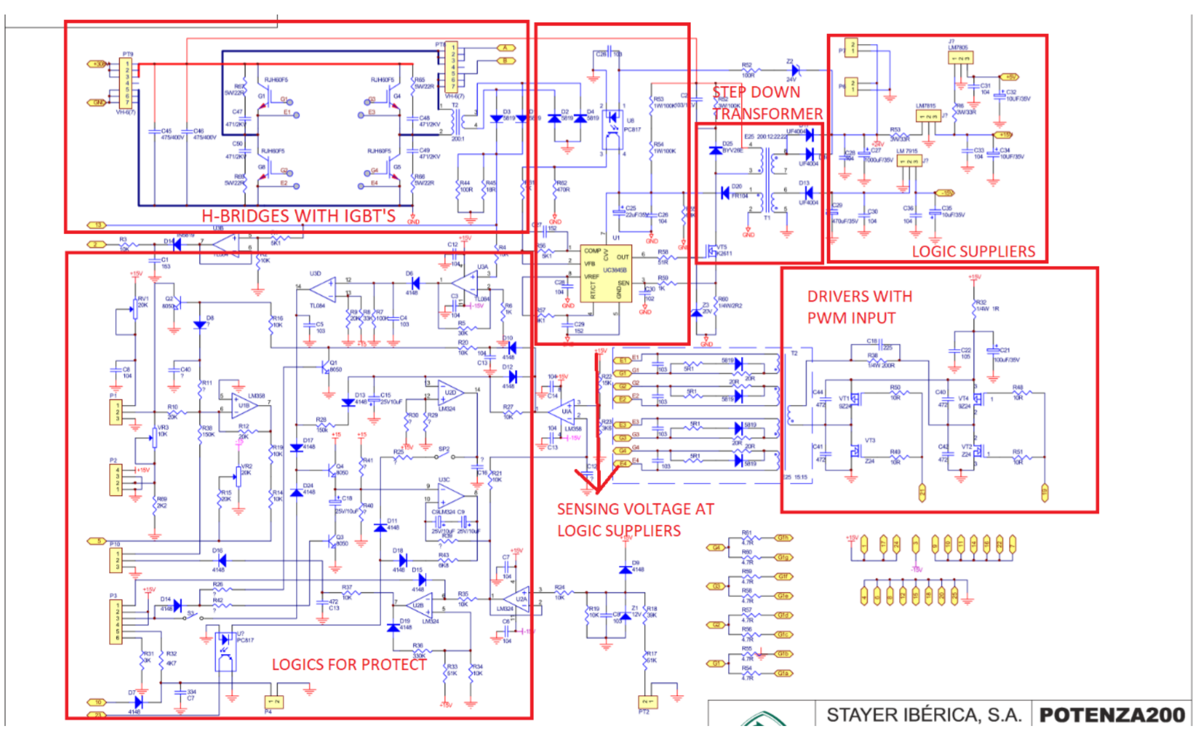

Figure 6 MAIN (SWITCHING) BOARD

Logic PCB: Logic PCB module at Figure 7 provides PWM for Drivers. PWM with 45 kHz.

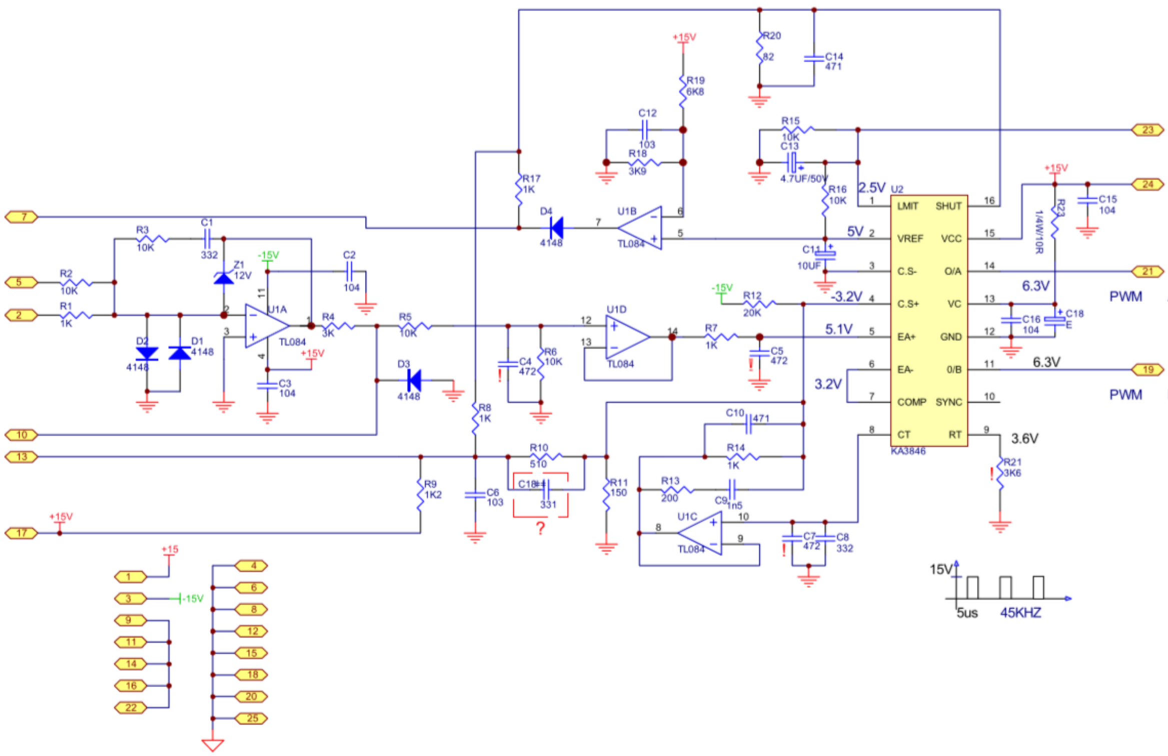

Figure 7 LOGIC PCB

Total Structure Explanation: Total structure shown at Figure 8 by block diagram. 230Vac convert to 380 Vdc at the power supply module. 380 V convert by step down transformer and supply voltage for logic circuits. UC 3845B component control if there draining over current and adjust voltage level to logic suppliers. Logics for protect part give feedback to PWM module, control temperature to prevent failure and adjust output current in different conditions. PWM module produce to PWM voltage. At the driver part these two signal combined with CMOS. Combined PWM drives IGBT (H-Bridge). IGBT can handle with very high current.

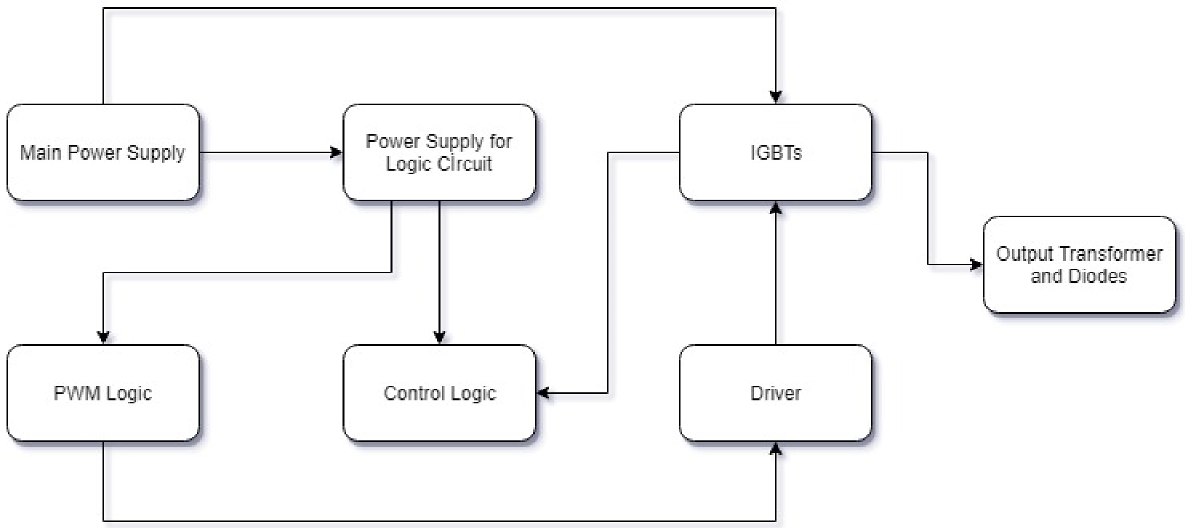

Figure 8 Block Diagrams of Welding Machine

Output Transformer and Diodes: Signal with a high voltage and frequency enter transformer. At this transformer voltage decrease and current increase. Because of high current we use a smaller transformer. After transformer signal rectified at diodes and send to Electrode
IGBT: IGBT is generally using for switching purposes. Based on the basic structure of the IGBT, a simple circuit can be drawn using PNP and NPN Transistors and MOSFET. You can see the inner structure of IGBT in Figure 9, IGBT Structure and Circuit Working with Applications [7], (2015, June 03).

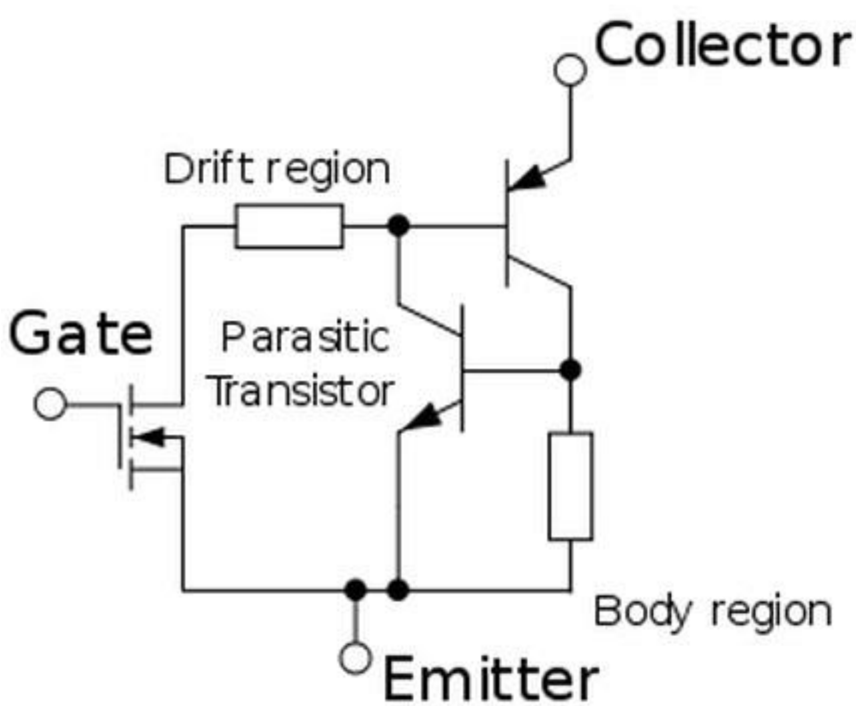

Figure 9 Circuit Diagram of IGBT

4. PROJECT

Welding machine is widely using in industrial, construction and a lot of place. While using welding machine, welder can use a long cable to reach far place. This cause a voltage drop on cable and result is entering less then 230Vac in to welding machine. Sometimes welder use a voltage generator, but it cannot supply 230Vac consistently. Even in Industry, voltage can vary sometimes. İt increase or decrease. This varying voltage is a dangerous situation for welding machine or any kind of machine. I am going to design a circuit to prevent machine from this dangerous situation. Result can be applied any kind of machine but specifically, ı will modify this circuit for welding machine using. There is an interesting information that in the contrast of first sense, low voltage is much more dangerous than high voltage. The reason is, when working with low voltage there is a lot of impulse when polarity is changing. İmpulse cause high current and damaged components. Of course, high voltage is dangerous too. But, because of high voltage having less impulse and shape is much more likely a sinusoidal only problem is high voltage. İn this case capacitors are in danger because their capacity is maximum 400 Vdc which is provided at 282 Vac. Block Diagram of Project shown on Figure 10.

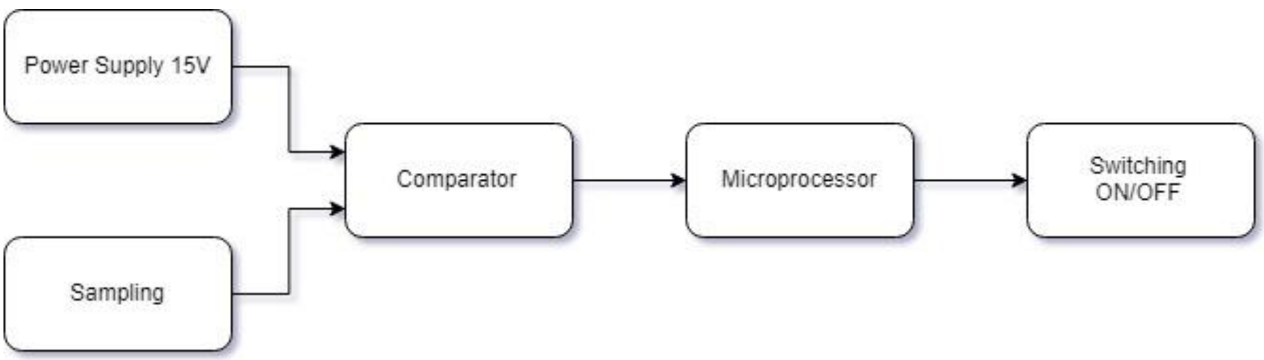

Figure 10 General Structure of Project

Deciding the limits: So, maximum limit is 282 Vac obviously but for safer situation we shouldn't select 282 Vac clearly. Despite of this discussion, ı will not decide voltage limits because there is a standard for safe voltage limit for welding machine. Protocol says that maximum is %10 (253 Vac) and minimum is %10 (207 Vac)

Hysteresis Effect: Limiting voltage with a one boundary can be very dangerous because when voltage is varying machine will start and stop. This starts, and stops can damage machine a lot. To prevent this problem, I use a hysteresis effect concept. Hysteresis can be simply explained by lagging a signal. Figure 11 shows the hysteresis characteristic. Hysteresis effect can be applied by op-amp using Schmitt trigger but, in this project, I choose to use microcontroller because it is easier for me and a good practice to learn microcontroller. For do that I decide 4 boundaries (253-240-220-207). Despite 253 and 207, 220 and 240 are arbitrarily selected.

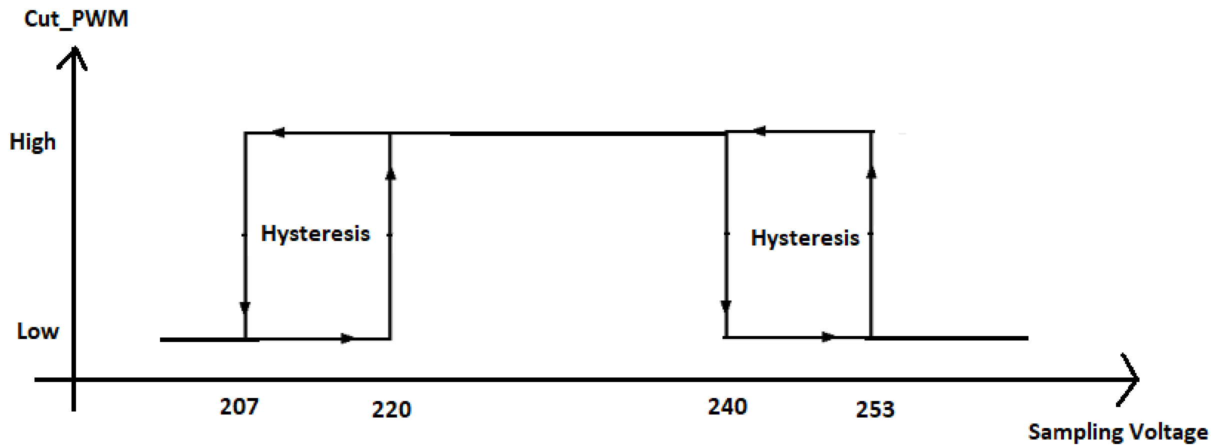

Figure 11 Cut_PWM Hysteresis Effect

LM317 3-Terminal Adjustable Regulator: The LM317 device is an adjustable three-terminal positive-voltage regulator capable of supplying more than 1.5 A over an output-voltage range of 1.25 V to 37 V [2]. It requires only two external resistors to set the output voltage. The device features a typical line regulation of 0.01% and typical load regulation of 0.1%. It includes current limiting, thermal overload protection, and safe operating area protection. Feeding logic circuit with LM317 is very handle. It is stable and has a current protection. 1.5 A is far enough so it will be not a problem. I adjust 15V to feeding circuit. I only use this transistor when I use prototype because welding machine has its own 15V.

LM7815 Voltage Regulator: This transistor is three terminal positive regulator [4]. It converts wide range voltage to 15V and can supply over 1A. Welding machine has this transistor to feed logic systems. Since also I need 15V I use this source to simplify circuit.

LM7805 Voltage Regulator: Same as 7815 except providing 5V [4]. I use two LM7895, one to feeds microprocessor and other one to feed led at the output of the comparator.

LM339N Quad Differential Comparators: The LM339 consists of four independent voltage comparators that are designed to operate from a single power supply over a wide range of voltages [1]. Operation from dual supplies also is possible, if the difference between the two supplies is 2 V to 36 V. I use comparator instead of op-amp because open and short characteristic of comparators at the output is very useful for decreasing power consumption. When it is open static power consumption is 0.

PIC 12F508: The PIC12F508 device from Microchip Technology are low-cost, high-performance, 8-bit, fully-static, Flash-based CMOS microcontrollers [3]. Because its low cost it is widely used. Also, in this project I try to construct a cheap, practical and portable circuit. It consumes very little power and consumes almost nothing when there is no changing at input values. This microcontroller suits perfect for this project. I use MPLAB for compiling the codes. Codes are below:

```
/*
 * File:   W2
```

```c
 * Author: Burak Kemal Kara
 * MCU: 12F508
 * Date 08_01_2018
 *
 * Despcription: practice of protection for overvoltage and
 * undervoltage conditions applied to Inverter welding machines.
 */
#ifndef _XTAL_FREQ
#define _XTAL_FREQ 4000000 //4Mhz FRC internal osc. Calibration by linker.
#endif
#include <stdio.h>
#include <stdlib.h>
#include <xc.h>
#pragma config OSC = IntRC      // Oscillator Selection bits (internal RC os-
cillator)
#pragma config WDT = OFF        // Watchdog Timer Enable bit (WDT disabled)
#pragma config CP = ON          // Code Protection bit (Code protection on)
#pragma config MCLRE = OFF      // GP3/MCLR Pin Function Select bit (GP3/MCLR
pin function is digital input, MCLR internally tied to VDD)
#define cut_PWM GP5
#define diagnostics_LED GP4
#define status_low_low GP3
#define status_low_high GP2
#define status_high_low GP1
#define status_high_high GP0

int main(int argc, char** argv) {
    /* Configuration of working options (bit 0-7, value 0/1)
        7: Not enabled (1): el "Wake-up on change bit"
        6: Not enabled (1): "Weak Pull-ups"
        5: Enabled internal oscillator (0): as clock source (Fosc/4)
        4: Edge selection for TMR0 (0): (lo to hi)
        3: Prescaler assigned to (0) TMR0
        2,1,0: (010) Prescaler 2,56 ms for each decimal unit
    */
    OPTION = 0b11000010;
    /*
     Pinout 12F508
        1: VDD (2 to 5.5 Vdc)
        2: GP5  output to cut PWM (suppose 1 is pwm on)
        3: GP4  output to diagnostics led
        4: GP3  input low-low
        5: GP2  input low-high
        6: GP1  input high-low
        7: GP0  input high-high (suppose that 1 is overvoltage)
        8: VSS  (0 Vdc)
     */
   TRISGPIO = 0b00001111; /* (1 input, 0 output)*/
   cut_PWM = 0;
   diagnostics_LED = 0;
   int check=1;

 while (1) {
    diagnostics_LED = 1;
    if(status_high_high){ /*Voltage is greater than 253, system should be stop
to prevent and damage */
            cut_PWM=1;
            check=0;
      }else if (status_high_low){ /*Voltage is between 253 and 240, İt can be
OK but, good to stop if system is already unstable */
```

```
            if(check==0){
                  cut_PWM=1;
                  check=0;
            }else{
                  cut_PWM=0;
                  check=1;
            }
      }else if (status_low_high){ /*Voltage is between 240 and 220, system is
running perfectly */
            cut_PWM=0;
            check=1;
      }else if (status_low_low){ /*Voltage is between 220 and 207, İt can be
OK but, good to stop if system is already unstable */
            if(check==0){
                  cut_PWM=1;
                  check=0;
            }else{
                  cut_PWM=0;
                  check=1;
            }
      }else{ /*Voltage smaller than 207, System STOPS */
            cut_PWM=1;
            check=0;
            }
  }
 return (EXIT_SUCCESS);
}
```

Sampling: To decide how much voltage is entering welding machine I should convert AC to DC then decide with comparator. I use 22:1 Step down Transformer to get smaller AC voltage. Afterwards by using full wave rectifier and capacitor I get around 22 V. It is hard compare at this point by voltage divider I reduce this voltage to enough to compare.

TIP31C Power Transistor: TIP31C is npn power transistor [5].This npn transistor is appropriate for switching purpose .

Overall Structure: I use Kicad for design my circuit on Figure 12. İt is easy to follow all lines on KiCad while soldering on PCB. Project circuit consist of 3 PCB board

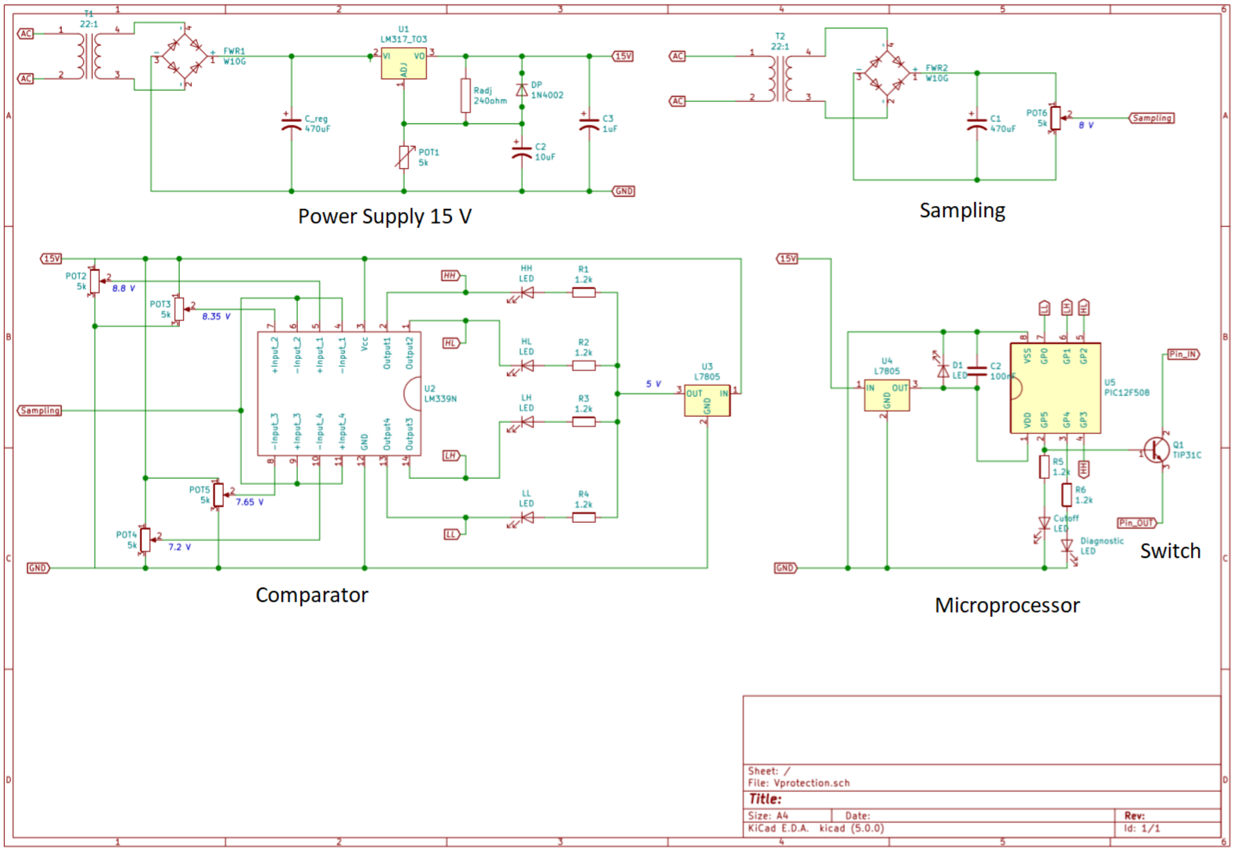

Figure 12 Overall Structure of Protection Circuit on KiCAD

Switch directly control the welding machine. There is a component which serve to prevent machine from high temperature. This component is short when temperature is greater than specific value. I fasten my switch to this component parallelly. When Cut_PWM is on, switch on and component short. Otherwise switch open and machine works. After I modify POTENZA 200 on Figure 13 with protection module I try if it is working with an AC Triac.

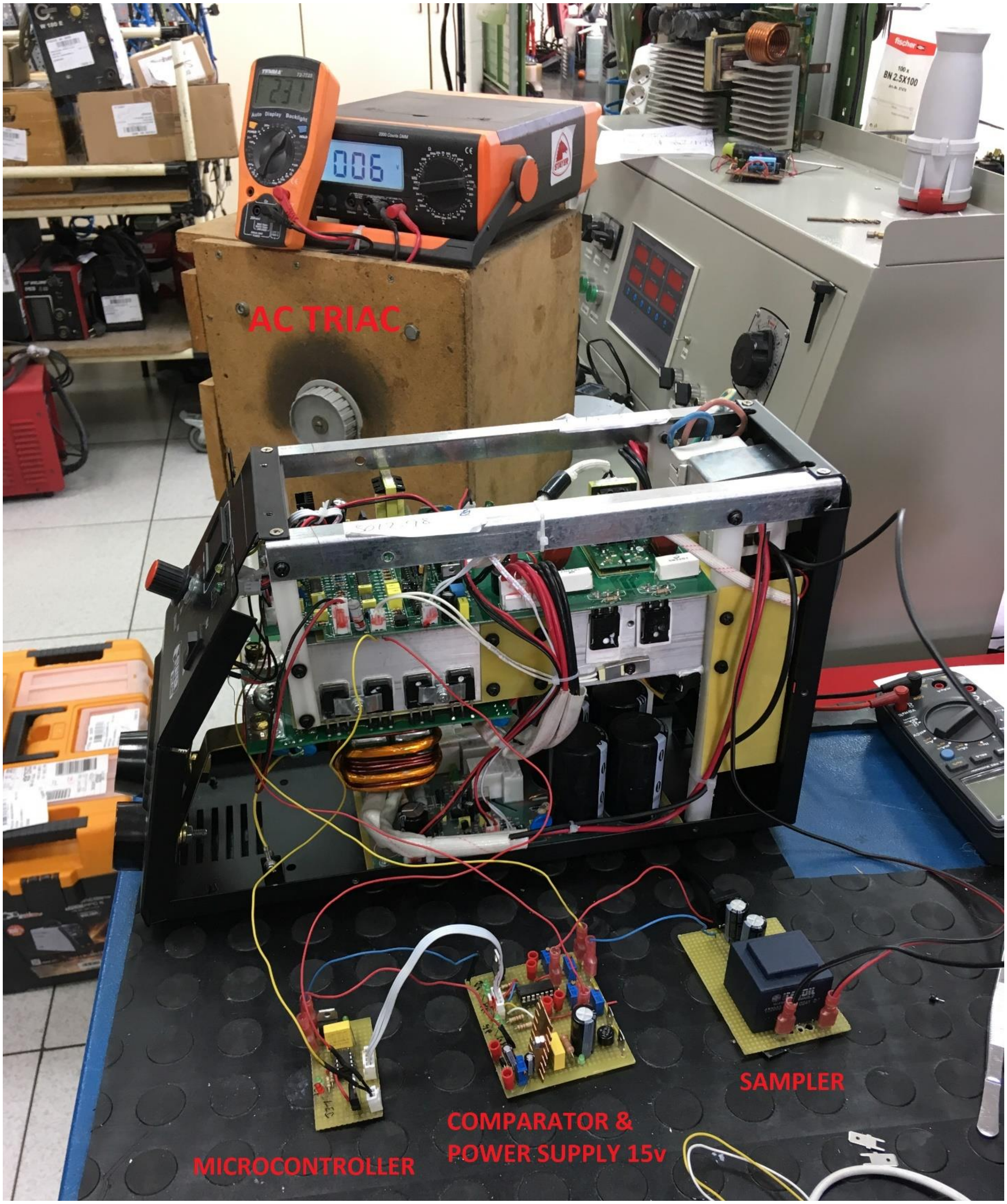

Figure 13 POTENZA 200 with Protection Module

5. REPAIRING

I also repaired machines on m summer practise. After knowing how to welding machine works, repairing is more easy but it need a lot of practise. I experience some common failure on welding machines.

IGBTs: IGBTs failure most because they drive a lot power and any inconvenience make them fail. My project’s aim is preventing IGBTs fail.

Driver: Drivers fail second most. They are directly affecting by high or low voltage. Some case IGBT fail but driver survive. I measure Driver by oscilloscope. I expect to see pulse. For example, POTENZA 200 driver output is shown at Figure 14.

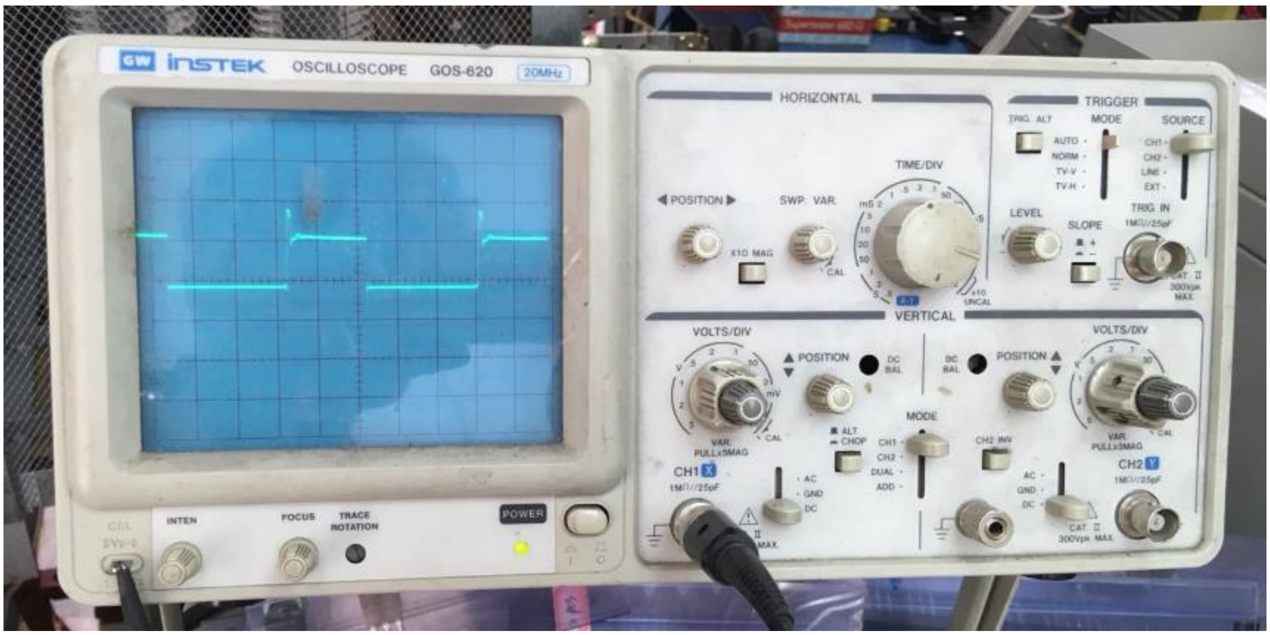

Figure 14 POTENZA 200 Driver Output

15V Power Supplier: LM7815 component fails third most. İt supply to logic unit. İf any damage at logic part this component fails.

Power Supply: If there is a problem at power supply there is two option. İt can be capacitors or resistor which parallel to relay. Resistor can damage if machine take to much consumption.

Logic Parts: I rarely see problems at logic parts. At that time, I need to check logic parts one by one.

6. CONCLUSION

In the light of al these informations that I learned in my summer practise, I am more experienced. I enlightened my vision on my profession. I also see how hard to work in a real job. This experience will affect lessons that I will take on my fourth grade. I also see that information that we learnt in university are applying widely on industry. I figured out that I am good with theory but weak with practise. It is good to understand my weakness.

7. REFERENCES

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[2] LM317 3-Terminal Adjustable Regulator

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[3] PIC12F508 8-Bit Flash Microcontroller

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[4] LM78XX 3-Terminal 1 A Positive Voltage Regulator

http://www.mouser.com/ds/2/149/LM7805-189995.pdf

[5] TIP31C Power Transistor

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