# REMOTELY CONTROLLED WELDING MACHINE USING POWER LINE COMMUNICATION

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***Abstract:*** This paper presents controlling of welding machine from remote side using power line communication technique. Welding is nothing but a fabrication process used to join objects, usually metals or plastics or thermoplastics together. While welding process is going on the work pieces are melted at the joining points and basically filter material is added to form a pool of molten material that solidifies to become a strong joint. Vice versa Brazing and Soldering does not involve melting the work pieces instead they use lower melting point material which gets melt between the work pieces to join them together and will act as an adhesive between them.

To weld different types of work pieces whose thickness is different current has to be change from using potentiometer which is available on welding machine panel. This paper presents the technique for welding machine to vary the current from remote side say welder is doing welding and the welding machine is 100 meters apart from him. If anyone client having no. of welding machines say 100 no's then using single remote he can set the different current for different machines and will carry his work continuously by removing transmitter unit. For this I decided to go with Power Line Communication for its easy approach and cost effective.

***Key words:*** **Welding Machine, Power Line Communication, Voltage to frequency converter, frequency modulation, impedance matching, pic microcontroller, remote.**

## 1. INTRODUCTION

For controlling any electronic machine we have a remote which contains only necessary functions on it. Let's take an example of TV Remote. The TV Remote contains the functions to control TV parameters from anywhere. The function performed by TV remotes is Volume Control, Channel Selection, Brightness Control, Color Control, Turn off and turn on the TV Set etc. This communication is done by RF Communication. The TV remote contains an Infrared LED which emits infrared light which cannot seen by open eyes. After pressing button on the remote that LED will glow and emits infrared. On the front side of TV Set the Infrared Receiver is available which receives infrared signal from remote and does that appropriate function. But assume if someone has 2 or 3 TV sets from same manufacturer and if viewer want to change the channel of only one TV Set then it causes the problem because while changing the channel the infrared waves can be decoded by all TV set and all TV sets will show that channel. Instead of Infrared if we use Zig-bee then it will face same type of problem but only difference is that you can control it from larger distance than Infrared which is near about 1Km. Now we have another wireless communication which is widely used now a days is GSM (Global System for Mobile) Communication. It will provide large distance communication and you can control your device from any location and anywhere. But that controlling is depends on the SIM card range. If you will get better range then you can control it very easily in fraction of second. But if you are at very remote place like in sea or any remote area you will not get that much powerful range to control your device from remote location.

If we provide separate Welding Remote for every machine then it will become very costly and also it will cause wave Interference due to multiple signals. So there is only one option to control welding machine remotely is using Wired Communication instead of Wireless Communication. In wired communication Power Line Communication is best any also it is very cost effective. Typically Power Line Communication is used in the MODEM of broadband connection. The telephone line carries the data of telephone conversation in digital form and also it carries Internet data available from server. The telephonic conversation data is decoded at telephone using demodulation and de-multiplexing techniques. So that the user will listen the sound from opposite party and also speaks same time. MODEM is nothing but (**MO**DULATION and **DEMOD**ULATION) unit. It will decode and de-multiplex the internet data available from server. And the data sent by user is modulated and multiplexed with another signals using MODEM and injected that signal into the telephone line which is nothing but power line. With this communication technique manufacturer can use single wire for multiple uses instead of single use which is carrying power from one place to another place. It needs powerful Isolation from power line which is capable to withstand even in thousands of voltage and will not damage any circuitry interfaced with it. Single telephone line can carry multiple types of data for multiple users [5] [6] [9].

This key feature of Power Line Communication motivates me to do my project. As we know and as mentioned earlier to weld any work piece we have to short the positive and negative terminal then only circuit will completes its path and current will starts to flow from positive to negative direction. The work piece body will act as negative or ground terminal and the welding holder which contains either welding tungsten rod or copper wire acts as positive terminal. The current will flows from the welding rod and will causes to melt the material. According to the plate thickness welder will change the current.

## 2. BLOCK DIAGRAM

**Transmitter Side (Remote) -**

According to my design I am providing the separate transmitter for welder who will do welding from remote side and he is near about 100 Meter apart from power source. The receiver section will be fitted into the Welding Power Source itself. On the remote means Transmitter I have provided one Isolated Point for short circuiting between positive and negative terminal. The work piece will become negative for the transmitter device and the welding torch will become positive for same. After short circuiting current

starts to flow from positive to negative terminal.

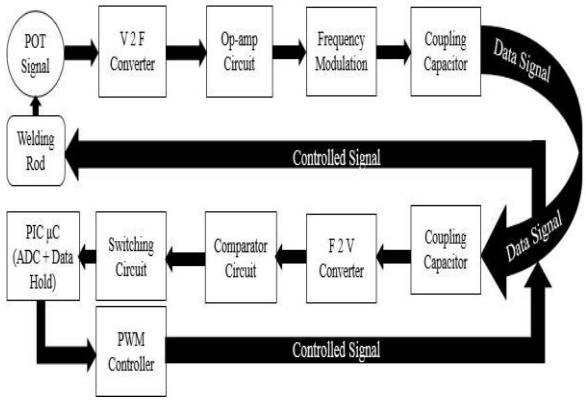


Fig. 2.1 Block Diagram

The welder will set the current value in terms of Ampere by varying potentiometer on it. I have provided the LCD (Liquid Crystal Display) at transmitter side. So that it will show the current value in proportion with voltage available from Potentiometer Terminal. That DC voltage is input to the Voltage to Frequency block. The circuitry in this block will give frequency output in proportion with the dc voltage. The output waveform of this point is somewhat different and unknown to us. So to bring it in known and standard waveforms like Square wave, Sine wave or Triangular wave I used op-amp circuitry in non-inverting mode. As we know op-amp gives output in terms of square wave which lies between +VCC and –VCC.

The square output of op-amp will acts as input for Frequency Modulation block which will modulate the available frequency according to the carrier frequency which has designed using external passive components like resistors and capacitors. Because of this modulation the frequency of DC signal gets increase and it will not superimpose with machine frequency. If we will not do modulation then in power line the machine frequency will absorb the frequency obtained by transmitter. Even using Low Pass Filter we cannot illuminate machine frequency because this frequency is the frequency of IGBT on which IGBT triggers itself. The modulated output after frequency modulation has given to the coupling capacitor. Coupling Capacitor is the Box capacitor which has not any polarity and it can sustain up to 1000V. KT11 is that capacitor which I used in my project to block dc voltage of power line and will inject the modulated frequency in the power line.

**Power Line –**

According to the Electronic Standards there are different types of wires used for different voltages. As voltage increases the thickness of wire will also increase otherwise that wire will get spoil and will causes fire at the location. We are using 35 Sq. mm thickness wire for Positive and Negative terminal which called as Power Cable for welding as per NEMA. As Welding Machine operating frequency is high near about 20 kHz frequency it provides high impedance at output terminal of machine. So, it I connects the remote directly to the power source then it will not work. Even if we varies the pot from transmitter side we will not get change in voltage at receiver side. Receiver side will give 0 V constantly. This happens because of Impedance Mismatching of transmitter and power source. As we know the characteristic of an Operational Amplifier is that "It has high input impedance and low output impedance". Due to the op-amp at transmitter side the remote will works at very low impedance. And the power source works at very high impedance. So this mismatching between impedances will cause the failure in the circuitry and it will prevent the modulated frequency to reach up to receiver located in power source. So for Impedance Matching I designed one inductor for positive terminal of power source. Using Circular Ferrite Core I made some turns of wire on it and I connected it to the positive terminal of power source at receiver side. But at high frequency my designed Inductor was getting saturate. So I reduced the turns of it until I did not get the output at receiver side. At 22 turns of inductor it works properly and gives somewhat output at receiver side which varies according with the pot signal from transmitter side.

**Receiver Side -**

The frequency transmitted by transmitter which is in proportion with the dc voltage through Power Line has decoded by receiver circuit which is located in Welding Power Source. Here also I have provided coupling capacitor at the input terminal of receiver to prevent DC voltage of power line. The coupling capacitor will allows only frequency to pass from it.

The same KA 331 IC is used as Frequency to Voltage Converter at receiver side as shown in fig. 2.3. The obtained frequency from coupling capacitor has given to the input terminal of IC. Using same values of passive components and doing some necessary changes at receiver side I got the same DC voltage transmitted from transmitter using potentiometer. Now, question arises that "Why, I have not done Frequency Demodulation at receiver side?" as mentioned in above section of Power Line the operating frequency of welding machine is very powerful and we cannot illuminate it. As compare with the machine the frequency obtained from frequency modulation is very weak. So after coming in the power line the machine's frequency absorbs the modulated frequency little bit. If we connects the DSO at the output of Frequency Modulation Circuit we will see the value of present frequency and if we connects the DSO at output of coupling capacitor we will see the drop down in modulated frequency. For this reason I have not designed any Demodulation Circuitry at receiver side. If I designed it then we will not get proper output at receiver side.

Next task was to hold the voltage which is available at receiver side because after setting proper current the welder will remove transmitter and starts the welding. So, for that I have to hold that voltage until it not changes again by connecting transmitter. For holding I used PIC Microcontroller as shown in fig. 2.4. Because of its special features like in-built ADC, in-built DAC, in-built EEPROM memory etc. When transmitter is connected to the power line the receiver will give excess 0.8 V adding with the input voltage. Means if the pot is at 2.1 V then receiver will give 2.8 V output because I have not done Frequency Demodulation at receiver side. If the pot is at 6.8 V then receiver output will be at 7.6 V. After removing transmitter from power line connection the modulated frequency in the power line will become zero and only machine frequency is available in power line. So, that machine frequency decodes by receiver using frequency to voltage converter. It is at 9.8 V after removing transmitter from power line.

The PIC (Peripheral Interface Controller) Microcontroller is the digital device works on 5V DC voltage. It has in-built ADC (Analog to Digital Converter), DAC (Digital to Analog Converter) and EEPROM (Electrically Erasable Programmable Read Only Memory). This microcontroller does

not required any other peripherals to connect it. The analog input port will do analog to digital conversion of up to 5V analog voltage. So to bring the 2.1 V to 6.8 V into the range of 0 V to 5 V I have designed voltage subtractor circuit using op-amp. That obtained voltage I have hold in EEPROM memory of PIC Microcontroller. The comparator block which I designed is for transistor as switch circuit. As I mentioned earlier after removing of transmitter side the voltage appear on receiver side is 9.8 V and after subtraction it will become 7 V and will appears on the analog input port of the PIC Microcontroller. This over voltage may causes microcontroller to fail in operation.

Using op-amp as comparator circuit and transistor I made one switching circuit. When that switch will give output of 5 V then only the PIC Microcontroller will reads data from EEPROM and DAC; at 0 V it will only does operation of ADC and writing the data in EEPROM memory [3].

The DAC output of PIC Microcontroller has been given to the op-amp as buffer circuit. So that it will not damage PIC Microcontroller and it will not allow any drop down in output voltage due to the load connected to it. The output of op- amp as buffer has given to the input of op-amp as adder circuit where the voltage we subtracted after Frequency to Voltage conversion is getting added in to it. That is I am adding 2.8 V in the output of PIC Microcontroller [3].

The final output of an op-amp as adder circuit has provided to the existing PWM IC mounted on Control Card of the Welding Power Source. According to the input voltage the PWM pulses will varies and triggers the gate of IGBT. The variation on PWM pulses due to input voltage will causes variation of firing angle (α) of IGBT. Therefore we will get increase in current in proportion with increase in voltage.

**POT Signal -**

According to NEMA, for getting better quality of welding the welding has to be done as shown in below graph. To do welding in very good manner the minimum voltage of potentiometer has to be on 2.1 V and maximum voltage has to be on 6.8 V. At 2.1 V the minimum current has been provided to the welding rod or wire feeder

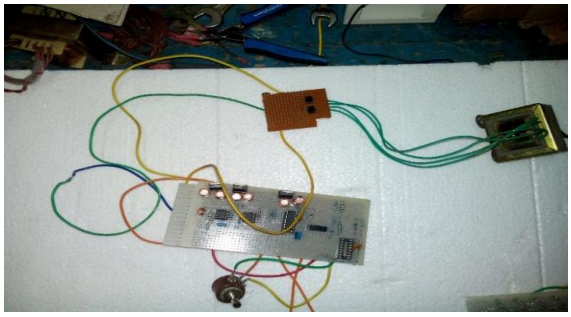

Fig.2.2 Transmitter Unit

for melting it. The current will never become zero. The minimum current at 2.1 V is 5 Amperes.

Fig. 2.4 shows that there are five stages for getting better welding quality that are Preflow, Upslope, Welding Current, Downslope and Post flow. The welder will set the voltage required for welding according to thickness of work piece. After that he will press the torch switch. After pressing torch switch the gas will start to flow for some time and after current will come and starts to increment linearly with respect to time. At the set voltage means if the pot is at 6.8 V then it will provide maximum current according to machines current capacity. If it is at in between 2.1 V to 6.8 V then the proportion current will come according to Ohm' Law V=I.R. As V increases I increases and R in nothing between resistance of tungsten welding rod or copper wire. The upslope is nothing but the raise in current to set down at appropriate voltage with respect to time. After that welder will get constant current and will do welding consistently. After releasing torch switch if the current suddenly drops down it causes the damage of work piece and welding will get spoil. For that downslope is used which is in contrast of upslope. The current will linearly decrease and reaches to its minimum current. After reaching minimum current the gas will flow for some defined time period and then welding process will get complete.

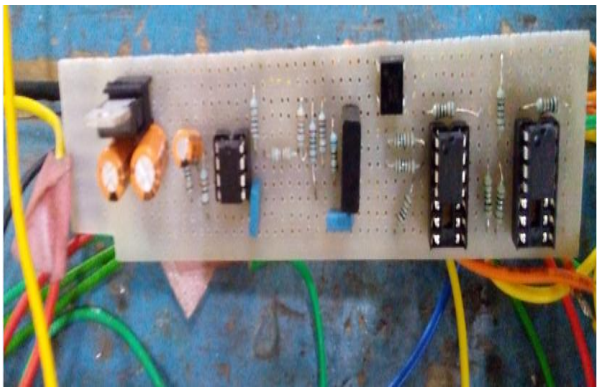

Fig. 2.3 Receiver Unit

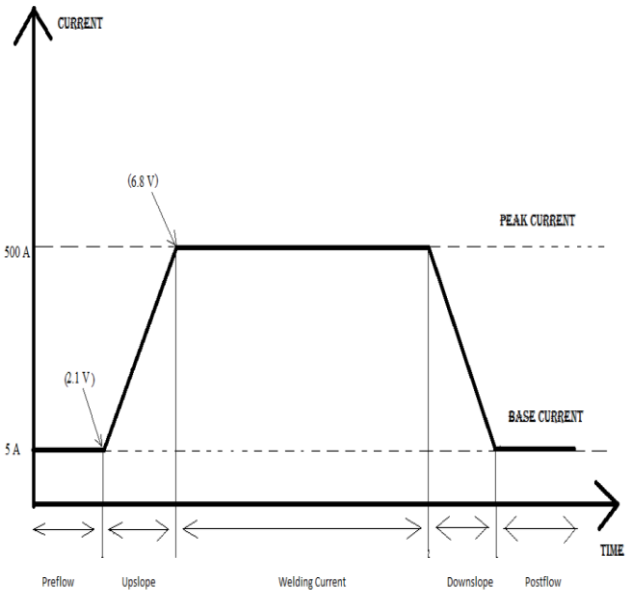


Fig. 2.4 Standard Welding Graph

## 3. RESULTS

### 3.1 Output Waveform of Voltage to Frequency Converter-

As I mentioned in earlier sections the KA 331 will give frequency output with respect to the input DC signal. The frequency varies as input DC signal changes. But due to non-linearity in components the waveform will not be in proper manner as shown

in fig. 3.1.

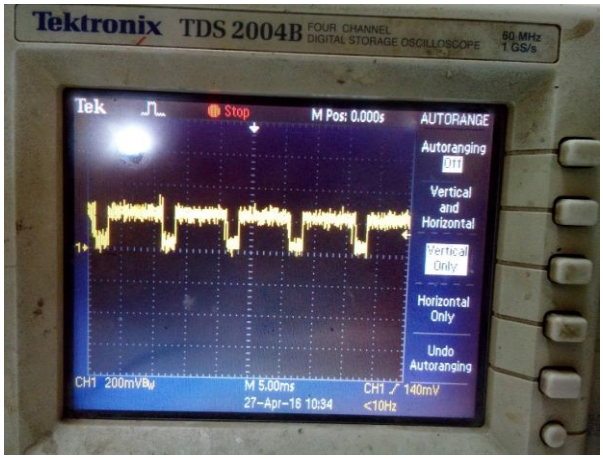


Fig. 3.1 Frequency Output

**3.2 Operational Amplifier Output-**

For getting proper waveform I designed op-amp circuitry in non-inverting mode. As we know the characteristic of op-amp is that it gives square wave output which lies between +VCC and –VCC. Fig. 3.2 shows the output waveform of op-amp with same frequency which converted by KA 331. And also it works as amplifier to amplify dc voltage of signal so that the signal cannot get distortion.

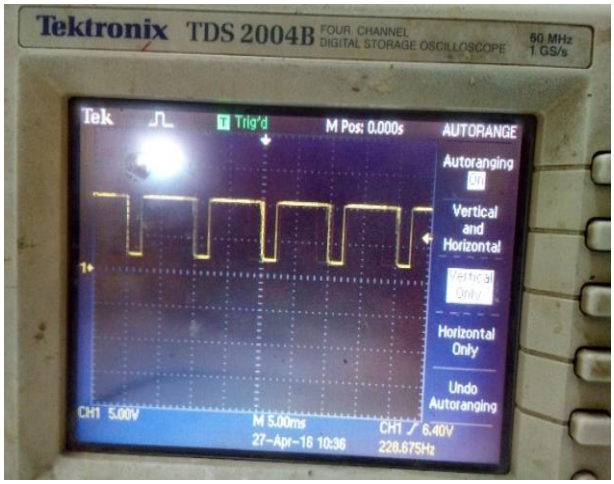


Fig. 3.2 Frequency Output Waveform of op-amp

**3.3 Frequency Modulated Output-**

As said earlier, the operating frequency of welding machine is very high. If I connect the op-amp output directly to the power line then the machine's operating frequency will absorb the input converted frequency. For this it is necessary to do frequency modulation which increases the frequency of modulating signal as per carrier frequency design. I have designed carrier frequency for 200 KHz using resistors and capacitors. As the input frequency changes the output frequency also changes. Here, for 2.5V DC the frequency given by KA 331 is 228.675 Hz as shown in fig. 3.2. For same voltage the frequency modulation circuit gives square wave output with 143.556 KHz frequency.

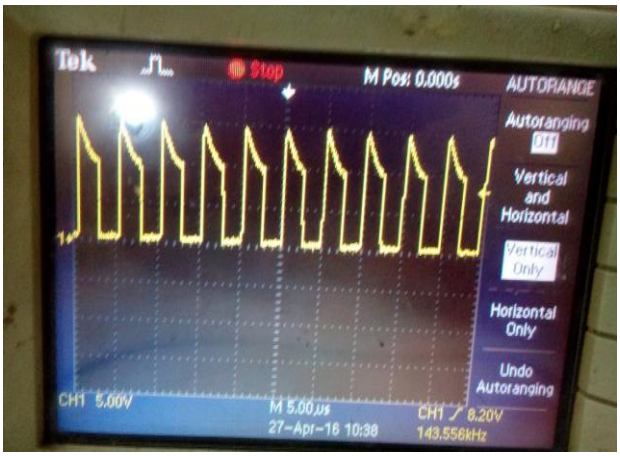


Fig. 3.3 Modulated Signal

**3.4 Modulated Waveform in the Power Line-**

As mentioned in earlier sections, the machine's operating frequency absorbs the modulated frequency because of high power factor of machine. As shown in above figure the modulated frequency output for 2.5Vdc is 146.556 KHz but, after injecting that modulated frequency into the power line using coupling capacitor the frequency drops down and the 146.556 KHz frequency becomes 5.57 KHz frequency and this frequency decodes at receiver side using KA 331 as frequency to voltage converter.

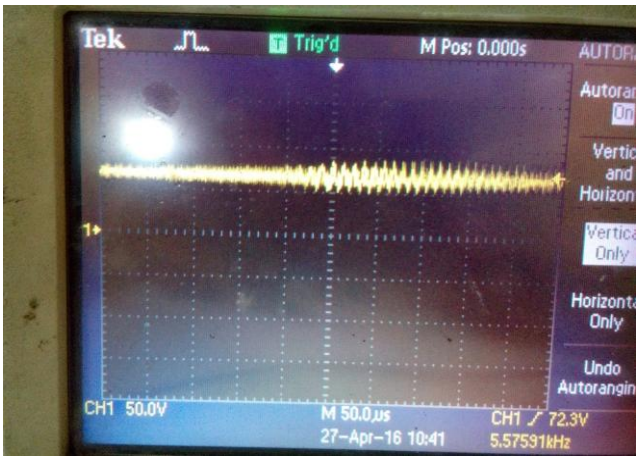


Fig. 3.4 Modulated Waveform at output of capacitor and input at power line

## 4. CONCLUSION

This circuit design is very reliable and cost effective. The user can use it very easily and by providing LCD Display at transmitter side he can also see the Current value on which he is working. The components used in this circuitry are easily available. As the voltage available from transmitter is getting store into EEPROM memory of PIC Microcontroller in digital format. As the feature of

EEPROM memory is it is non-volatile memory means even after power failure it can store the last updated value without failing. Using power line communication we can extend the length of power line up to 100 to 150 meters. User only need to take positive and negative terminal from machine to his working place. Same transmitter unit can use for different machines. It will not affect another machines while changing the setting of potentiometer. It is very low cost system up to rs. 1500/-.

Further improvement in this is we can take current feedback from power line at transmitter unit which shows the previous value of potentiometer and displays on it. So that user can get know about his previous work.

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