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A Practical Approach to Automatic Welding System using Digital Control

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Abstract: This paper concerns with practical designing of few sub circuits of automatic welding system with digital control and is directed to the improvement of certain drive and guide means for a relatively freely carried welding of wheel rim and wheel spider for continuous welding of a part resting on a freely rotatable table. The drive and guide means are carried on the welding head and impart drive to the part while maintaining the welding head properly positioned relative to the part. The system presented is a slightly simplified version of a real automobile wheel-welding system. Although system operation is explained in terms of wheel welding, the design of the system has much in common with other welding operations utilizing the basic industrial automatic welding sequence of Squeeze, Weld, Hold, Release, and Standby with digital control.

Keywords: Flip Flops, Arc Welding, Electrodes, Gates, Timers, Counters.

I. INTRODUCTION

In the present age of mass production it is often required to automate the manufacturing process which was done manually. The process of joining in many applications is called welding. The welding operation utilizes five intervals of welding sequence of Squeeze, Weld, Hold, Release and Standby. A solid state logic system receives information from its signal converters about conditions in the apparatus being controlled through its output amplifiers. The system operator can set automatic cycle specifications on selector switches and those specifications are entered into the memory devices of the logic system and this system keeps the track of the progress of the automated cycle, knowing which steps have been completed and which step is to come next.

A. Squeeze
Once the electrode has engaged the metal, they are allowed to press against the surface for a short time before the welding current is turned on.

B. Weld
Current flows down, the electrode power leads to the electrodes and through the metal -to- metal contact between rim and spider, thereby creating the weld. There are four variables that can be adjusted by the operator depending on the type of material used to create a better weld.

1) Pulsations: The welding current does not flow continuously during the weld interval. It is turned on and off in short bursts, called pulsations. The operator sets the number of pulsations which are used to create the weld. Besides the number of pulsations, the number of cycles of current which flow during a single pulsation is also adjusted by the system operator as is the number of cycles "missed" between the pulsations. The current versus time during the weld interval, assuming that the welding current flows during the entire 180°of an ac half cycle.

2) Hot Interval: It can be seen that welding current flows for the three ac cycles. This is followed by an absence of current for two cycles. At the end of these two cycles, the current is turned on for another three cycles. Each time three cycles of current are completed, the system is said to have completed one current pulsation. The portions of the weld interval during which welding current is flowing are called Heat subintervals.
3) Cool Interval: The portions of the weld interval during which welding current absent are called cool subintervals
4) .Conduction angle: In addition to these variables, the number of degrees per half cycle that welding current flows is also adjustable. This number of degrees per half cycle during which current actually flows is called conduction angle.

C. Hold
Electrode pressure is maintained on the metal surfaces, but the welding current is turned off.

D. Release
The welding electrode cylinders are retracted, releasing the wheel from the electrodes.

E. Standby
The lift cylinder is retracted, lowering the finished wheel from the welding location.
The system remains standby until a new wheel is loaded to the lifting cradle.

II. BLOCK DIAGRAM

A) Sequence Initiation and Gating Circuit
Starting in this section, we will look closely at the details of operation for each of the sub circuits of Fig.1. Before we can do this effectively, we must decide on certain rules of nation. The rules we will use are explained in the next section.

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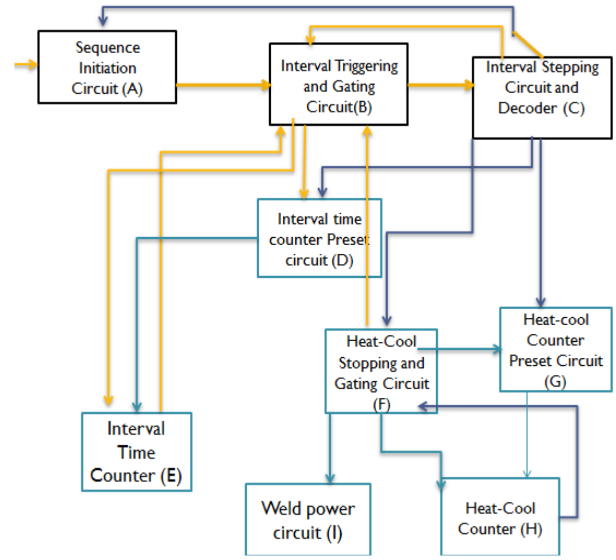

Fig.1 Block Diagram

B) Notation Used On Schematic Drawings and In the Written Text

Fig.2 is a schematic diagram showing the sequence initiation circuit and the interval triggering and gating circuit. Notice that some wires are labelled with capital letters. Each of these letters refers to a note at the bottom of the drawing, which explains the significance of that wire, telling what that wire accomplishes in the operation of the circuit. In the explanatory text, these wires will be identified by their letter labels.

If there is a set of parentheses following the explanatory note, the condition identified in the parentheses is the necessary for the wire to accomplish its purpose. For example, note Y reads "enable the count gate (LO)." This means that the wire labelled Y is the wire that enables the count gate to pass count pulses and that wire Y allows these count pulses to be passed only when it is LO.

When a wire comes into a subcircuit from another subcircuit, its function is to identify by a circular terminal having a label which is a word or short phrase. For example, the circular terminal labelled "release" in Fig.2 indicates that the wire is attached to that terminal originally comes from a release terminal in some other subcircuit and that terminal goes HI when the system enters into the release interval.

As another example, the wire attached to the terminal "interval time counter is counted out (LO)" comes from another subcircuit. When that terminal goes LO, it means that the interval time counter has counted out (counted down to zero). A precise explanation of the action of the terminal will be given in the written text.

Furthermore, the particular subcircuit being illustrated in a schematic drawing will have outputs going to other sub circuits as well as inputs coming from another subcircuit. Labelled circular terminals are used to indicate this situation too. When this is done, you can expect to come across that same label on an input terminal in some other subcircuit schematic. For example, the terminal labelled "preset the interval time counter (HI)" has a wire attached to it which goes off to some other subcircuit. The schematic diagram of that other subcircuit will show an input terminal with exactly the same label.

You cannot confuse input terminals with output terminals because input terminals are always wired to the inputs of solid-state gates, flip-flops, etc., while output terminals are always wired to the output terminals are always wired to the outputs of the solid-state circuit devices.

Regarding the identification of circuit parts in the explanatory text, here is the legend we shall follow.

Particular circuit devices (gates, flip-flops, etc.) appearing in the drawings having specific names are written in all capital letters ;examples: INTERVAL STEPPING ONE-SHOT, LIFT WHEEL PUSHBUTTON, SIGNAL CONVERTER2, NOR3. Specific sub circuits which are defined in the block diagram of Fig.1 are written capitalize; example: Interval Time Counter, Interval Stepping Circuit, and Heat –Cool Counter Present Circuit. Terminal labels and wire description (notes) are enclosed in quotation marks: examples: "welding current pulsation count pulses," "step the Interval Stepping Circuit (neg. edge)," Fig.1 shows only one line running from one block to another should not be interpreted to mean that there is only one wire running between the circuits in the actual wiring. There may be many wires running between those circuits which symbolize the flow of information only; it is not an exact wiring diagram. In the discussion which follows, a block connection line will be identified by two blocks being connected. The first letter denotes the sending block and second letter is the receiving block. For example, line AB would be the line that goes from block A to block B. Line BE is the line that goes from block B to block E. Line EB is the line that goes from block E to block B. Note that a given block may send information to another block as well as receive information from the block [1]. In order to understand the process properly the following techniques have been implemented as an application in the proposed paper.

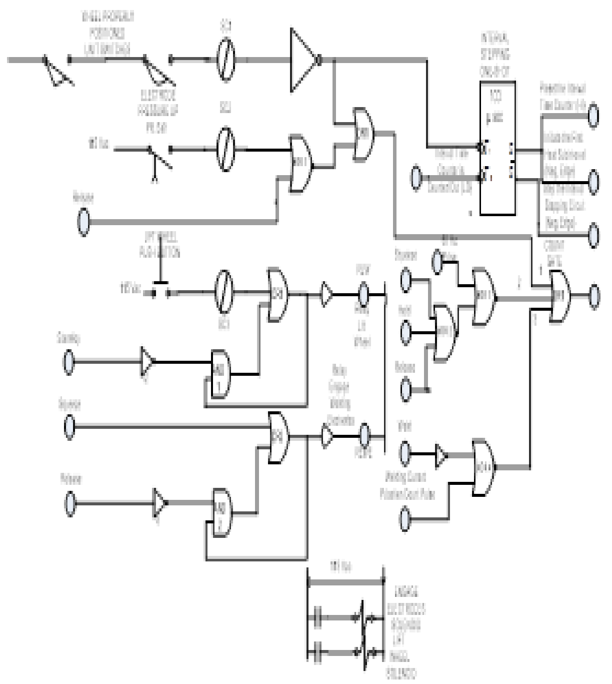

Fig.2 Sequence Initiation Circuit

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C. Circuit Operation:
The welding sequence begins when the operator presses and holds LIFT WHEEL PUSHBUTTON on the left side of fig.2 in the production process, this would be done when the operator sees that a wheel rim and spider have been properly loaded onto the lift cradle, as describes in the previous section .if the process is completely automated, there would be a solid-state signal or a relay contact instead of the pushbutton switch. At any rate, the application of 115v ac to input of SIGNAL CONVERTER3 will cause a voltage of +15Vdc, a HI, at the input of OR2. The bottom input of OR2 is LO at this time due to the fact that the standby terminal is HI while the system is standby. The output of OR2 goes HI, causing output amplifier OA1 to energize relay RLW. The normally open contact of relay RLW in the lower left of fig.2 closes, applying 115V ac to the LIFT WHEEL SOLENOID. The energization of this solenoid shifts the hydraulic valve which causes the lift cylinder to extend. When the lifting cradle has lifted the wheel rim and spider into proper position to be welded, the limit switches in the upper left of fig.2 close their contacts. This applies 115 Vac to SIGNAL CONVERTER1, causing a HI at the input of inverter I1. When this HI appears, the output of I1 goes LO; causing a negative edge on the wire X. this negative edge appears at T_1 terminal of the INTERVAL STEPPING ONE-SHOT.
The INTERVAL STEPPING ONE-SHOT has two trigger terminals, T_1 and T_2. It will fire when a negative edge appears at either one of its trigger terminals. Therefore the negative edge at T_1 causes the one-shot to fire, delivering an output pulse 100 µs in duration. As it fires, the $\overline{Q}$ output goes LO, creating a negative edge at the terminal labelled "Step the Interval Stepping Circuit (neg. edge)." These cause the interval stepping circuit to step out of standby and into the squeeze interval. This stepping action is discussed in detail in the next section.
Meanwhile, the Q output of the INTERVAL STEPPING ONE-SHOT remains HI for 100 µs, for longer than is necessary for the system to step into the squeeze. During this 100 µs, the "preset the Interval Time Counter" terminal is HI. The HI level on these terminals shifts the digit on the squeeze 10-position selector switches into the interval time counter. This shifting is discussed in the next coming sections.

When the system steps out of standby into squeeze, the standby terminal goes LO, and the squeeze terminal goes HI, on the left of Fig 2. Because standby is LO, the output of I2 goes HI. Since the bottom input of AND1 is also HI, the output of AND1 goes HI. This means that the LIFT WHEEL PUSHBUTTON can be released, because the bottom input of OR2 is now HI, eliminating the need for the top input of that gate to be HI. The OR2 gate has sealed itself up, as long as standby remains LO. This keeps RLW energized, keeping the wheel lifted up into the welding position.
As stated above, the squeeze terminal on the left of Fig.2 goes HI as the system steps into the squeeze interval. This causes the output of OR3 to go HI. The output feeds back into AND2, sealing up OR3 as long as the release terminal is LO. OR3 drives OA2, which in turn drives relay REWE. This relay energizes the ENGAGE ELECTRODES SOLENOID at the bottom of Fig.2, causing welding electrode cylinders to extend bringing the electrodes into contact with wheel rim and spider. The OR3-AND2 combination is another sealing circuit
When the pressure on the electrode is high enough, meaning that the welding electrodes have made firm contact with the metal, the ELECTRODES PRESSURE UP PR.SW. contact closes at the upper left of Fig.2. When the output of SIGNAL CONVERTER2 goes HI, the output of NOR1 goes LO. At this time both inputs of OR1 are LO causing wire Y to go LO. This enables the COUNT GATE, OR, to pass any pulses which show up on its number input 2. There are 60-Hz pulses existing on input 2 of OR4 at this time, so they feed through OR4 and show up on the "count pulses two Interval Time Counter" terminal. The squeeze time has begun, and Interval time counter start counting down from preset number.
Let us pause at this point to discuss the action of OR4 in gating the count pulses through the interval time counter. As long as the wire Y was HI, OR4 could not pass count pulses because its output was locked in the HI state by the HI on its number 1 input. Under this condition pulses appearing at its number 2 input could not get through to the output. Now that input 1 is LO, the OR4 output is able to respond pulses applied to its number 2 input (assuming that input 3 is LO). This is an example of gating pulses to a counter. The gate either passes or blocks the count pulses, in response to the command signal on its number 1 input. Of course, input 3 of OR4 has the same control ability to tell the COUNT GATE to pass or block count pulses.
The number 3 input of OR4 (the COUNT GATE) is LO at this time due to the weld terminal being LO. The I4 output is HI, causing the NOR4 output to go LO, bringing the number 3 input of OR4 to a LO logic level.
It was stated above that 60-Hz count pulses do in fact exist at input 2 of the COUNT GATE at the instant the squeeze time begins. Fig 2 shows that such pulses must come from the output of NOR3. Inspection of NOR3 reveals that the pulses appearing on its top input from the "60-Hz pulses" terminal will be passed to the output of NOR3 only if the bottom input is LO. When they are passed, the count NOR4 to pass any pulses which appear on the "welding current pulsation count pulses" terminal.

Remember the weld intervals differs from the squeeze , hold and release intervals in that the preset number represent how many welding current pulsation are required to complete the interval , rather than how many ac lines cycles. Every time a current pulsation completed, the heat – cool stepping and gating circuit delivers a count pulse to the "welding current pulsation count pulses" terminal. From there the pulse is passed through NOR4, through OR4, and eventually into the Interval Time Counter.
As before, the interval time counter counts backward one bit for each pulse it receives. When it reaches zero, it once again supplies a negative edge to T2 of the interval stepping one shot. The one shot triggers the interval stepping circuit by means of the negative edge appearing at the "step the interval stepping circuit" terminal. The system leaves weld and enters hold and the hold 10-

position selector switch settings are preset into the interval time counter. The interval stepping circuit takes away the weld signal and sends out the hold interval signal. Therefore the weld terminal in Fig.2 goes LO, disabling NOR4. The hold terminal feeding NOR2 goes HI, causing the bottom input of NOR3 to go back LO. Once again the 60-Hz pulses are routed through NOR3, through OR4, to the interval time counter. The hold interval begins counting out.

When hold is complete, the interval stepping one shot receives another negative edge on its T2 input, and its$\overline{Q}$output delivers a negative edge to the "step the interval stepping circuit (neg. edge)" terminal. That negative edge steps the system into Release. The same actions occur again, resulting in the Release selector switch settings being shifted into the interval time counter. NOR3 immediately begins passing the 60-Hz pulses, and the release interval beings counting out.

The release terminal on the lower left Fig.2 goes HI at this time. This causes the top input of AND2 go LO, breaking the seal on OR3 for the first time since the system enter the squeeze interval. Output amplifier OA2 goes to a LO level, deenergizing relay REWE. When the ENGAGE ELECTRODES SOLENOID deenergizes, the welding electrode cylinders react, releasing the wheel. Although the ELECTRODE PRESSURE UP PR. SW. contact opens, allowing signal CONVERTOR 2 to go LO, the output of NOR1 remains LO because its bottom input is now held HI by the release terminal. It is necessary to keep the NOR1 output LO in order to keep wire Y at a LO level, allowing the COUNT GATE, OR4 to continue passing count pulses. When these pulses have driven the interval time counter to zero, the INTERVAL STEPPING ONE-SHOT is triggered once again by the "interval time counter is counted out" terminal.

When the systems interval stepping circuit leaves the release interval, it steps into the standby condition. On the far left of Fig.2, the standby terminal goes HI, causing the I2 output to go LO. This LO is applied to the top input of AND1, breaking the seal on OR2. Output amplifier OA1 goes LO, which causes relay RLW to deenergize. This deenergizes the LIFT WHEEL SOLENOID, lowering the finished wheel. The WHEEL PROPERLY POSITIONED LIMIT SWITCHES open, causing SIGNAL CONVERTER1 to go LO. The output of I1 goes HI, returning wire X to its initial HI state. Wire Y is also HI at this time.

This completes the discussion of circuit action for the sequence initiation circuit and the interval triggering and gating circuit in the next section we will deal with the interval stepping circuit and decoder.

The Interval Stepping Circuit And Decoder, Interval Stepping Circuit, Decoder, Heat Cool Counter Preset Circuit, Heat–Cool Stepping And Gating Circuit.

These circuits are not extensive. The interval stepping circuit itself consists of three flip-flops and an AND gate. The decoder is a diode decoding matrix having six input lines and five output lines, the designed decoder also has five output drivers When the first negative edge is arrives at the circuits input terminal, the "step the Interval Stepping circuit (negative edge)" terminal on the left FFA toggles into the ON state because both J and K are HI. J of FFA is HI because $\dot{C}$ is HI with FFC in the OFF state.The negative edge at CK of FFA also appears at CK of FFC. At this time, though, the output of AND3is LO, holding J of FFC LO. FFC therefore stays OFF. AND3 is LO because both A and B, the inputs to AND3, are LO at the instant the negative edge appears. Therefore after the first pulse, the states of the flip-flop are ABC=100.When the second negative edge appears at input terminal, J of FFA is still HI, so FFA toggles to the OFF state. The negative edge is delivered to CK of FFC also, but the AND3 output is still LO because B is LO at this instant. Therefore FFC again stays OFF. When the output goes LO it delivers a negative edge to CK of FFB. This causes FFB to toggle into the ON state [3].

To preset the heat cool counter, the LOAD terminals must be driven LO at the same time that Los are delivered to the common terminals of a pair of selector switches.

The heat –cool stepping and gating circuit goes into action only during the weld interval. During that interval, its functions are to keep track of the heat and cool subintervals and to control the stepping from one sub interval to the next [3]

D. Interval Stepping Circuit and Decoder

Fig.3 is a schematic diagram of the Interval Stepping Circuit and Decoder. These circuits are not extensive. The interval stepping circuit itself consists of three flip-flops and an AND gate. The decoder is a diode decoding matrix having six input lines and five output lines, the designed decoder also has five output drivers.

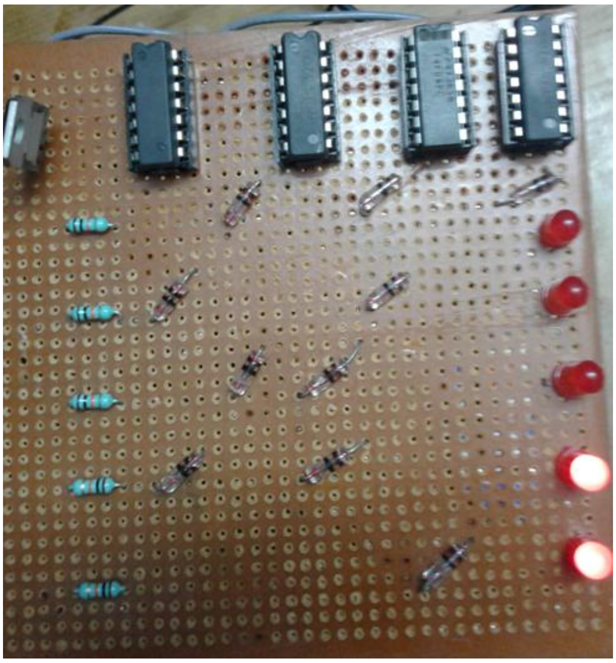

Fig. 3 Interval Stepping Circuit

In Fig.3, the flip-flop outputs have been identified by the letter name of the individual flip-flops. That is, the outputs of flip-flop A are labeled A and $\bar{A}$ and the same for flip-flops B and C. Table1 shows the sequence of the flip-flops as pulses are delivered. The digit 1 in table1 means that

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the flip-flop is ON; while a 0 means that the flip-flop is OFF. In the standby condition all flip-flops are OFF. When the first negative edge is arrives at the circuits input terminal, the "step the Interval Stepping circuit (negative edge)" terminal on the left of Fig.3, FFA toggles into the ON state because both J and K are HI. J of FFA is HI because Ċ is HI with FFC in the OFF state. The negative edge at CK of FFA also appears at CK of FFC. At this time, though, the output of AND3 is LO, holding J of FFC LO. FFC therefore stays OFF. AND3 is LO because both A and B, the inputs to AND3, are LO at the instant the negative edge appears. Therefore after the first pulse, the states of the flip-flop are ABC=100. When the second negative edge appears at input terminal, J of FFA is still HI, so FFA toggles to the OFF state. The negative edge is delivered to CK of FFC also, but the AND3 output is still LO because B is LO at this instant. Therefore FFC again stays OFF. When the output goes LO it delivers a negative edge to CK of FFB. This causes FFB to toggle into the ON state. The state of the circuit is ABC=010 after the second Pulse. When the third stepping pulse negative edge arrives at the input terminals, FFA toggles into the ON state as before, since J of FFA is HI. The negative edge appears at CK of FFC, but once again J of FFC is LO. It is LO because the top input of AND3 is LO at the instant the negative edge arrives. After the third pulse, the state of the flip-flop circuit is ABC=110. On the fourth negative edge, FFA toggles into the OFF state because its J input is still HI. The negative edge appears at CK of FFC also this time the output of AND3 is HI, so FFC toggles into the ON state. The output of AND3 is HI when the edge arrives because both FFA and FFB are ON at that instant. FFB also receives a negative edge at its CK input when A goes LO. It therefore toggles into the OFF state. The state of the flip-flop circuit is ABC=001 after the fourth pulse. When the fifth step pulse negative edge arrives at the input terminal, J of FFA is LO, because Ċ is now LO. Therefore FFA remains in the OFF state. The negative edge appears at CK of FFC as usual. This time the J input of that flip-flop is LO because both AND gate inputs are LO. FFC therefore turns OFF, making the state of the circuit ABC=000. After five step pulses the interval stepping circuit has returned to its original state.

Table 1 Interval stepping circuit flip-flops conditions

Number of stepping pulses delivered	Flip-flops			System interval
	A	B	C	
Start	0	0	0	Standby
1	1	0	0	Squeeze
2	0	1	0	Weld
3	1	1	0	Hold
4	0	0	1	Release
5	0	0	0	Standby

E. Decoder

The decoder takes the in coded information and puts out a logic HI on one of its output terminals. All the other terminals are held LO while the proper one goes HI.The way the decoder does this is by looking at a portion of the binary sequence that represents the complete state of the interval stepping circuit. It focuses on that portion that makes one particular state unique. For example, table 1 show that when the interval stepping circuit is in the squeeze interval, the state is 100. A search of the other entries in table 1 reveals that no other row has A=1 and B=0. Therefore the AB=10 combination makes that state unique, different from all other states. If the system is in squeeze, all four of the other horizontal output lines will be LO because at least one diode pulls each line down LO. For example, the weld output line is being pulled down by the diode pointing into Ā.An output line being pulled down LO means that current is flowing through the 10KΩ lead in resistor on the left of that line and then through a diode to ground. The 15v of the supply is dropped across that 10kΩ lead in resistor leaving only a small voltage on the line itself. Germanium diodes are used in this diode matrix because of their lower forward voltage drop across the p-n junction.

Another example may help to clarify the working of the decoder. Consider the release interval in table 1. The state of the interval stepping circuit is ABC=001.. A search of the other entries in table 1 reveals that no other interval has C=1. Therefore the single bit C=1 distinguishes the release interval from all four other intervals and makes it unique. The decoder takes the advantage of this fact in that it has a single diode pointing from the release output line into the C vertical input line. If C is HI, as it would be during the release interval, the release output line goes HI. If C goes LO, as it would be during any other interval, the release output line is pulled down LO. Therefore the release output line goes HI when the C flip-flop turns ON, and only then. Again, the Decoder is locking at the unique portion of the state of the flip-flop circuit and using that portion to control the output line. The driver attached to each output line has the function of isolating the line from the other sub circuits, so the sub circuits cannot degenerate the quality of the signal level on the output line. Degeneration of the signal level could occur if the sub circuits were to draw too much current away from the line when it was HI or if they were to dump too much current into the line when it was LO.

F. Heat Cool Stepping and Gating Circuit

The heat –cool stepping and gating circuit goes into action only during the weld interval. During that interval, its functions are to keep track of the heat and cool subintervals and to control the stepping from one sub interval to the next. The circuit is shown in Fig.4. The circuits begin operation when the weld terminal goes HI on the far left of Fig.4 This terminal goes HI when the system enters the weld interval. At that time the "initiate the first heat subinterval" terminals also goes HI, coming from the Q output of the INTERVAL STEPPING ONE SHOT. Therefore the output of AND4 goes HI because both of its inputs are HI at this time. When the INTERVAL STEPPING ONE SHOT output pulse end after 100µs , the "initiated the first Heat subinterval" terminal goes back LO, driving the top input of AND4 back LO, causing a negative edge to appear at trigger terminal T1 of the HEAT –COOL ONE -SHOT. The firing of the HEAT COOL ONE –SHOT causes its output to go LO, which causes the negative edge to appear at the

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clock terminal of the HEAT COOL FLIP-FLOP .this make the flip-flop toggle into the ON state. The HEAT –COOL FLIP-FLOP was in the OFF state prior to the system entering the weld interval because it's clear input was held LO by the weld terminal. A LO on the CL terminal of a JK flip-flop clears the flip-flop. While the HEAT COOL ONE SHOT is still firing, the terminal labeled preset the heat cool counter is HI. The on this terminal is fed to the heat cool counter preset circuit along with the HI signal on the heat terminal. Together, these signals cause the HEAT SELECTOR SWITCH settings to be shifted into the heat cool counter. When the HEAT COOL ONE SHOT pulse ends, the output of the one shot goes back to HI. This HI signal is routed to AND5 and AND6. The AND6 gate now has all inputs HI, so it brings the enable SCR gate control circuit terminal high, allowing the welding SCRs to commence firing. The welding transformer therefore starts delivering welding current to the wheel rim and spider.

Meanwhile, AND5 has been enabled to pass 60Hz pulses to the terminal labeled count pulses to heat cool counter. Since the welding transformer is carrying 60Hz current, one pulse is delivered to the heat cool counter for every cycle of welding currents. The heat cool counters counts backwards to zero, just like the interval time counter.

When the preset number of cycles of the welding current have occurred, the heat cool counter is counted out terminal on the left of Fig.4 goes LO, triggering the heat cool one shot again, this time from terminal T2.The one shot fires putting a high level on the preset the heat cool counter, the terminal once again and causing the HEAT – COOL FLIP-FLOP toggle into the OFF state. This make the Heat terminal go LO and the cool terminal go HI. The weld interval is now in the cool subinterval. The negative edge appearing on the Q terminal of the HEAT-COOL FLIP-FLOP As it turns OFF is applied to trigger terminal T of the WELDING CURRENT PULSATION ONE SHOT. This one shot delivers a 25µs pulse to the welding current pulsation count pulses terminal, indicated that welding current pulsation has been completed. Therefore the welding current pulsations that have just finished causes the interval time counter to count down by one digit. Since the weld interval has just now entered the cool subinterval, the cool interval is HI and the heat terminal is LO. The output of AND6 goes LO, causing a LO to appear on the terminal labeled enable the SCR gate control circuit.

This results in shutting off the welding transformer by disabling the SCR gate control circuit. Meanwhile, the preset the heat cool counter terminal is still HI, so the preset numbers on the COOL SELECTOR SWITCHES are shifted into the heat cool counter. When the HEAT COOL ONE SHOT output pulse ends after 100µs and 5 is enabled once again. The heat cool counter again starts counting down as it receives the 60Hz pulses. When the heat cool counter reaches zero, indicating the cool subinterval is completed, it sends another negative edge to the HEAT COOL ONE SHOT by way of the heat cool counter is counted out terminal. The one shot repeats its previous action, namely toggling the HEAT COOL FLIP FLOP into the ON state, presetting the HEAT SELECTOR SWITCH settings into the heat cool counter and then re-enabling AND5 and AND6 when it finishes firing. Notice that as the system goes from the cool subinterval to the heat subinterval, a positive edge appears at T of the WELDING CURRENT PULSATION ONE SHOT. This one shot does not fire on a positive edge, and no pulse appears at the welding current pulsations count pulse terminal.

Fig.4 Heat-Cool stepping and gating circuit

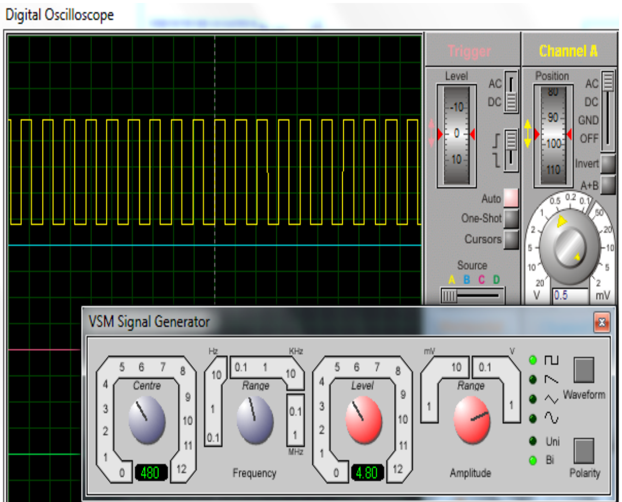

Fig. 5: Oscilloscope output as logic 1 and logic 0 for Heat-Cool stepping and gating circuit.

III.RESULTS AND DISCUSSIONS

(A) Sequence Initiation Circuit:
The Interval Stepping One-Shot has two trigger terminals, T1 and T2. It will fire when a negative edge appears at either one of its trigger terminals. Therefore the negative edge at T1 causes the one shot to fire, delivering an output pulse 100us in duration. As it fires, the $\overline{Q}$ output goes LO, creating a negative edge at the terminal labeled "Step the Interval Stepping Circuit (neg. edge)." These cause the interval stepping circuit to step out of standby and into the squeeze interval. The waveforms showed in fig.6represent the output voltage across the supply and load.

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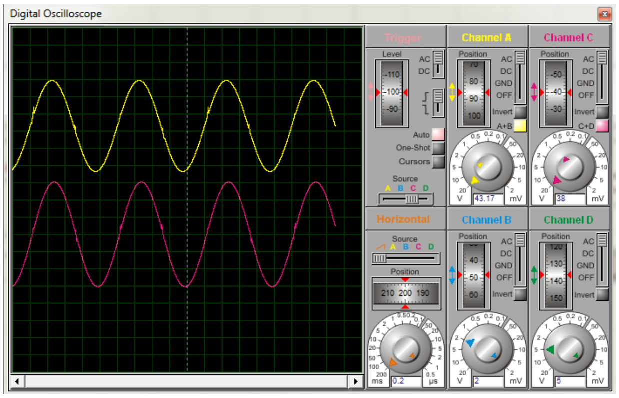

Fig6. Waveforms across supply and Load voltage

(B)Interval Stepping and Decoder circuit**:**
It can be seen from Table 1 that the interval stepping circuit steps through five separate states, never varying the order. It remains in any given state until it gets a step signal to step into a new state. These features make it an ideal circuit for keeping track of which interval the system is currently in. All that is necessary is to convert the state of the flip-flops, expressed as a sequence of binary bits, into a useful form for the other sub circuits of the system. This is the function of the designed interval stepping circuit is shown in Fig.7.

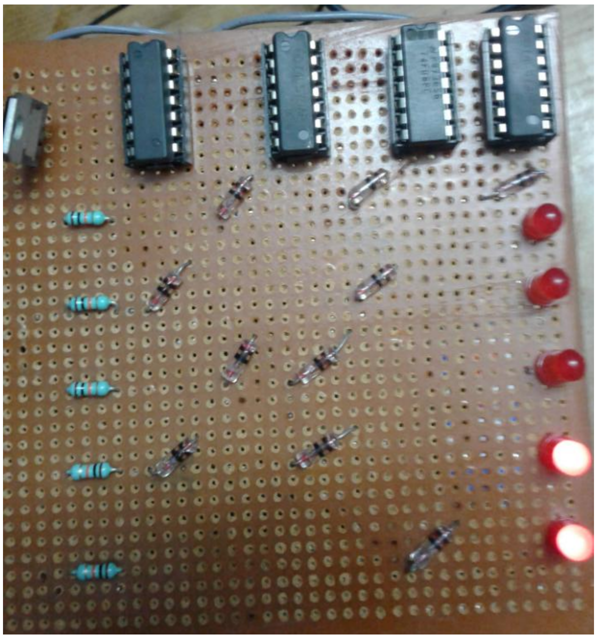

Fig.7 Interval Stepping and decoder Circuit, System is making a Transition from Hold to Release Mode.

(C) Heat –Cool Stepping and Gating Circuit:
The Results Fig.5 shows that the cycle is repeated over and over until the proper number of welding current pulsations has been counted by the interval time counter. At that point it is observed that the system will step out of weld and enter into hold. The weld terminal in Fig.4 will go LO and the entire heat cool stepping and gating circuit will be disabled. Further, the position selector switches option in the design makes the system user defined. Fig.8 shows the PCB layout of the circuit and Fig9. Shows the hardware.

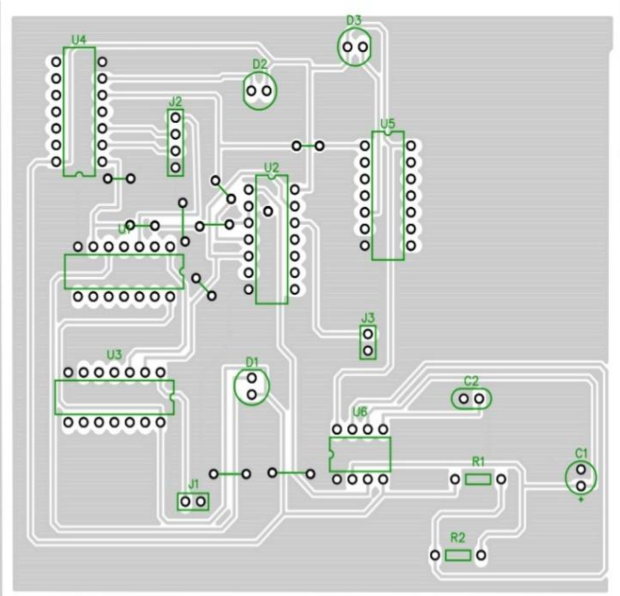

Fig.8PCB layout of Heat –Cool Stepping and Gating Circuit

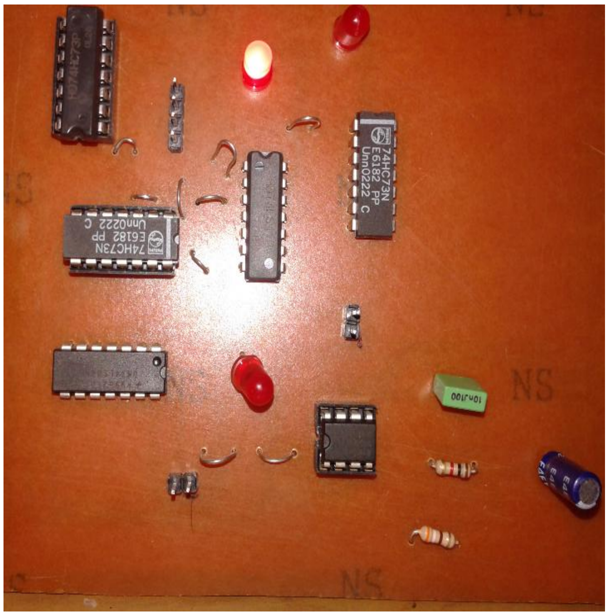

Fig.9 Hardware of Heat cool Stepping and Gating, It shows that current circuit is in COOL sub interval

IV. CONCLUSION

The proposed paper gives the better understanding and results for the practical designed interval stepping circuit using decoder technique and also two sub intervals of weld interval that is Heat-Cool stepping with user defined timing counter circuits has been designed and the designed control kit fairly gives the better results which are desirable for welding industry for the operations of the automatic Arc welding system. Further all the Designed circuit operations are analyzed with the Proteus software simulation results and Practical boards have been developed. Thus, the designed interval stepping circuit gives the correct order of the five intervals of the welding system in order to automatically weld the two given metal pieces successfully.

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