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Embedded Based High Voltage Pulse Electric Field Generator for Food Preservation

L.Jones Nirmal M.E [1], Sanjevee V[2], Rakesh A[3], Harish Kumar D[4], Karunakaran M[5]

Assistant Professor, Department of EEE, Panimalar Institute of Technology, Chennai, India[1]

UG Students, Department of EEE, Panimalar Institute of Technology, Chennai, India[2,3,4,5]

ABSTRACT: Pulse electric fields (PEF) for the purification of food items is a for the most part explored zone today. The utilization of immersed decoration releases for the inactivation of small scale life forms has just barely become a region of intrigue. For improvement investigation of miniaturized scale living being inactivation with PEF, a beat power source s created. The driver circuits are continued from a little DC flowover the switch. Any parameter of the rectangular formed pulse can be wide-extending autonomously beat sufficiency, pulse width and reiteration rate for either bi-polar or mono- polar pulse trains. The postpone time among positive and negative pulse field can be made zero as to accomplish a "charge inversion" beat pair. PEF has been portrayed electrically. It generates a high voltage (15 kV) approximately in the frequency range from 250 Hz to 30 kHz. This high voltage applied for food pasteurization, which is placed between two electrodes. To examine the equipment affectivity which applied to apple juice pasteurization is to adjust time processing compatibility from 10 seconds to 60 seconds.. Based on measurement result indicates that average of voltage and current used is 17kV and 0,48mA. Electric field strength delivered to chamber is 0,65kV/cm. The longer time treatment of PEF it will reveal the number of microbes contained in apple juice will be decrease and specific input energy will be increases. According to Zeleny analisys, the best time processing of apple juice pasteurization is 10 seconds processing.

KEYWORDS: Purification, Pulse Amplitude, Pulse Width, Bipolar, Monopolar.

I.INTRODUCTION

Pulsed electric field (PEF) processing is a novel, non- thermal preservation method that has the potential to produce foods with excellent sensory and nutritional quality and shelf-life. High intensity pulsed electric field (HIPEF) processing involves the application of pulses of high voltage (typically 20 - 80 kV/cm) to foods placed between 2 electrodes. PEF treatment is conducted at ambient, sub- ambient, or slightly above ambient temperature for less than 1 s, achieved by multiple short duration pulses typically less than 5 µs and energy loss due to heating of foods as well as undesirable changes in the sensory properties of the food is minimized. For food quality attributes, PEF technology is considered superior to traditional heat treatment of foods because it avoids or greatly reduces the detrimental changes of the sensory and physical properties of foods (Quass, 1997). Although some studies have concluded that PEF preserves the nutritional components of the food, effects of PEF on the chemical and nutritional aspects of foods must be better understood before it is used in food processing (Qin et al., 1995b).

Some important aspects in pulsed electric field technology are the generation of high electric field intensities, the design of chambers that impart uniform treatment to foods with minimum increase in temperature, and the design of electrodes that minimize the effect of electrolysis. The large field intensities are achieved through storing a large amount of energy in a capacitor bank (a series of capacitors) from a DC power supply, which is then discharged in the form of high voltage pulses. Studies on energy requirements have concluded that PEF is an energy efficient process compared to thermal pasteurization, particularly when a continuous system is used (Qin et al., 1995a). Consumer demand has increasingly required processed food to have a more „natural" flavour and colour, with a shelf life that is sufficient for distribution and a reasonable period of home Volume 01, No.2, Feb 2015 Page 7 storage before consumption (Fellow, P. J., 2000). This can be achieved by minimal processing methods that preserve foods but also remain to a greater extent their nutritional quality and sensory characteristics by reducing the reliance on heat as the main preservative action. This minimal processing destroys microorganisms, and in some cases enzymes, and there are no substantial increases in product temperature. There is therefore little damage to pigments, flavour compounds and vitamins and, in contrast to heat processing, the sensory characteristics and nutritional value of foods are not degraded to a significant extent. The resulting products have higher quality and consumer appeal in markets where the retention of natural sensory characteristics can command premium prices.

The use of an external electrical field for a few microseconds induces local structural changes and a rapid breakdown of the cell membrane. Based on this phenomenon, called electroporation, many applications of high intensity pulsed electric fields (HIPEF) have been studied in the last decades. In the area of plant and microbial genetics pulsed electric fields are applied to cause an electroporation of cell membranes to infuse foreign material such as DNA into the cell (Neumann, 1996; Zimmermann, 1996). This process of reversible pore formation has to be controlled to maintain viability of the organisms during the application of the PEF. Due to the reversible permeabilization, the cells repair their membranes through resealing the electropores immediately after the PEF treatment. At higher treatment intensity PEF can be utilized for the inactivation of microorganisms by an irreversible breakdown of the cell membrane. HIPEF consists of a number of components including a

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power source, capacitor tank, a switch, treatment chamber, voltage current and temperature sensors and aseptic packaging equipment. Generation of different voltage waveforms in PEF: exponential pulses, square pulses, bipolar pulses and oscillatory pulses. Formation of pores and cell membranes by HIPEFs is not entirely understood. Zimmermann et al., (1974), applying the dielectric rupture theory, concluded that membrane rupture is caused by an induced transmembrane potential approximately 1V larger than the natural potential of the cell membrane. The reversible or irreversible rupture (or electroporation) of a cell membrane depends on factors such as intensity of the electric field, number of pulses, and duration of pulses. The plasma membranes of cell become permeable to small molecules after being exposed to an electric field; permeation then causes swelling and the eventual rupture of the cell membrane.

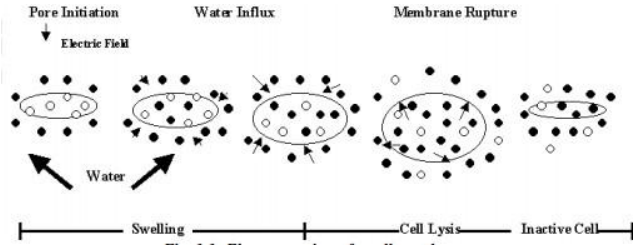

Fig. 1: Electroporation of a cell membrane

II.RELATED WORK

Reineke et al inspected the inactivation of endospores by a consolidated warm and pulse electric field (PEF) treatment. The blend of moderate warming and aprotected PEF-chamber, joined with a holding tube and a warmth exchanger for cooling, empowered a fast warmth inside microseconds[1]. Jaeger H et al examined the Trade activity of the PEF innovation and commercialisation of oversaw items. This article contains a short assessment of the innovation's standard, history and phrasing just as recommendations of a suitable name and procedure portrayal, considering client acknowledgment and outline ofthe innovation dependent on our parsing center gatherings interviews. It is fundamental for the attractiveness of another innovation that it brings to the table express advantages for clients [2]. Suwandy V et al investigated the properties of pulse electric field (PEF) and maturing on the trim power, protein profile, and posthumous proteolysis of hamburger sides were inspected utilizing a scope of beat electric field medicines. PEF treatment diminished the trim power of meat LL and SM muscles by up to 19%. The decrease in the shear power in the LL was not influenced by the treatment focus while the decrease in the SM needed on PEF recurrence [3].

Faridnia et al contemplated the impacts of cold as pre-treatment going before to beat electric field (PEF) on thenature of hamburger semitendinosus qualities. PEFfundamentally expanded emetic misfortune yet not cooking misfortune. A two log-unit increment in oxygen consuming microbial sums during log period of solidified mollified PEF-treated examples was emphatically related with expanded cleanse misfortune [4]. Sobrino-López A et alcontemplated unique thought because of its latent capacity use in treating fluid nourishments while getting high beat electric field and its applications in consistent stream handling. In item advancement examine, the nature of milk and dairy items are improved by utilizing high beat electric field [5]. Sharma P et al inspected the inactivation of Gram- negative likewise Gram-positive microscopic organisms in whole milk by pulse electric field (PEF). It permits the pre- sun powered warming of milk and stepwise middle safeguarding remained related with warm sanitization. Gram-negative organisms were less impervious to PEF than Gram-positive microbes. PEF treatment with stepwisetransitional cooling after pre-warming can possibly sanitize entire milk [6].

Ercolin D et al concentrated to utilize sub-atomic techniques to assess the microbiota of eight crude dairy animals' milk models at biotype and class equivalent. A reliable sub-atomic distinguishing proof of crude milk microbiota is critical for the investigation of themicrobiological nature of crude milks and for the count of the science at species level so as to advance improved frameworks, forestalling sullying and having the best conditions for the putting away of milk [7]. Wouters P et al talked about the likely to market the non-warm pulse electric field (PEF) innovation as another method to protect food items has gotten the thought of the food business that necessities to satisfy clients worries for new items. In this survey, examined the basic advancement elements and fundamental highlights of food items that control the bacterial inactivation energy [8]. Hodgins A et al talked about the obstacle approach, temperature, corrosiveness, and number of pulse field were blended to augment bacterial inactivation in squeezed orange. The impact of PEF imparted to the expansion of nisin, lysozyme, or a blend of both to squeezed orange was likewise considered [9].

III.METHODOLOGY

The proposed framework manages the thought assembling a composite canister dependent on the rule of pulse electric field. Pulse electric field lead is a potential non-warm innovation for food treatment. It is commonly accepted that the vitality proficiency of this procedure is improved when the electric field dissemination is made increasingly homogeneous

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expecting that a base field quality Is required for electroporation of the cell layer and that electric fields in abundance of this base reason bothersome nearby warmth misfortunes. In arrangement extremely high electric fields can be framed in a fluid item without the warm breakdown portion by development of supposed 'watery' or 'lowered' decoration launches. A microcontroller is utilized which goes about as the focal handling component for the whole framework.

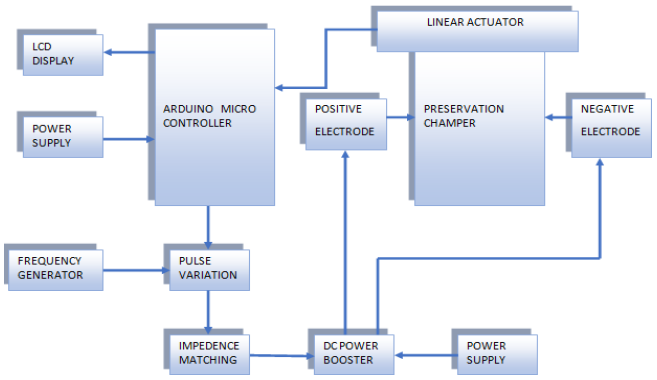

Fig 1:Block Diagram

A. Hardware Requirements

- Arduino Uno R3
- DC-DC Power booster
- Power Supply Unit
- Linear Actuator
- Frequency Generator
- 16*2 Lcd

B. Software Requirement

- ARDUINO IDE
- Embedded C

IV.HARDWARE IMPLEMENTATION

A. Arduino UNO

The Arduino UNO is an open-source microcontroller board based on the Microchip ATmega328P microcontroller and developed by arduino. The board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits. The board has 14 Digital pins, 6 Analog pins, and programmable with the Arduino IDE (Integrated Development Environment) via a type B USB cable. It can be powered by a USB cable or by an external 9 volt battery, though it accepts voltages between 7 and 20 volts. It is also similar to the Arduino Nano and Leonardo. The hardware reference design is distributed under Common Creative Attribution Share-Alike 2.5 license and is available on the arduino website. Layout and production files for some versions of the hardware are also available. "UNO" means one in Italian and was chosen to mark the release of ArduinoSoftware (IDE) 1.0.The UNO board and version 1.0 of arduino Software (IDE) were the reference versions of arduino, now evolved to newer releases. The UNO board is the first in a series of USB arduino boards, and the reference model for the arduino platform. The ATmega328P on the arduino UNO comes pre programmed with a boot loader that allows uploading new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol. The UNO also differs from all preceding boards in that it does not use the FTDI USB- toserial driver chip. Instead, it uses the Atmega16U(Atmega8U2 up to version R2) programmed as a USB-to-serial converter.

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Fig -2: Arduino Board

C. LCD

Liquid Crystal Display (LCD) is used to display the output to the user in the form of GUI (Graphic User Interface) and a mono chromatic display. LCD used in this project is JHD162A series. There are 16 pins in all. They are numbered from left to right 1 to 16 (if you are reading from the backside). Generating custom charcters on LCD is not very hard. It requires the knowledge about custom generated random access memory (CG-RAM) of LCD and the LCD chip controller. Most LCDs contain Hitachi HD4478 controller. CG-RAM is the main component in making custom characters. It stores the custom characters once declared in the code. CG-RAM size is 64 byte providing the option of creating eight characters at a time. Each character is eight byte in size.

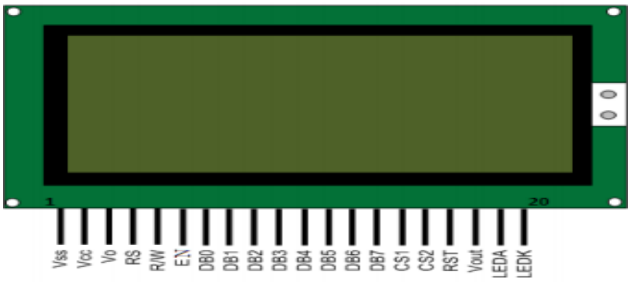

Fig 3: LCD

C. High Voltage Pulse Generator (HVPG)

HPVG components consist of High Voltage DC Power Supply (HVDC),Switch (S), High Voltage Switch (HVS), Signal Generator (SG), and Capacitor Storage (SC). Figure
2 shows the design of the HVPG electrical circuit. The transformer uses Cockcroft Walton (CW) voltage multiplier tubes to increase the grid voltage from 220 VAC to 400 VAC and from 400 VAC to 5500 VDC. The input voltage of the voltage multiplier is taken from the secondary side of the single-phase transformer (220 VAC). A 14-stage cascade was built for the CW voltage multiplier, each stage containing two capacitors and two diodes. The main components used to build a voltage multiplier circuit are a voltage converter, a series of 1000 μF/600 V single capacitance series smoothing capacitors, a series of couplingcapacitors and a series of power rectifying diodes 600 V/40 1N1190A. It consists of connections

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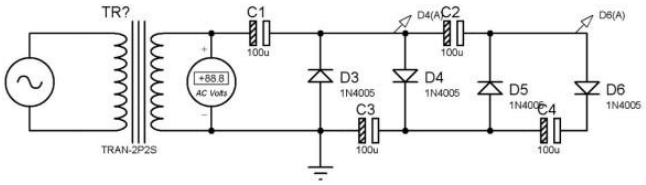

Figure 4:A typical HVPG Electrical circuit diagram

D. LM2587 DC BOOST Converter

This LM2587 DC – DC Boost Converter Component Breakout Panel is important for venturing up a DC power flexibly to a propelled DC power gracefully. It utilizes the LM2587 help converter IC from Texas Apparatuses. It is advantageous for proposition requiring steady, consistent force from a DC power gracefully. Info Voltage Series:3.5V – 30V, Output voltage arrangement: 4.0V-30V (Please guarantee that the yield setting voltage is higher than the

E. RELAY

A relay is an electromechanical switch, which perform ON and OFF operations without any human interaction. General representation of double contact relay is shown in fig. Relays are used where it is necessary to control a circuit bya low-power signal (with complete electrical isolation between control and controlled circuits), or where several circuits must be controlled by one signal.

Fig 5:Relay

Arduino IDE is used to write the program in C and C++ programming language. This helps to convert the executablecode into a text file and also loaded into Arduino board. It accommodate a text editor for writing code, message area. Itchecks the error and also we can make changes wherever possible. Using USB port we can able to dump the code in Arduino UNO. It consist of toolbar button that allowing to create , save, open and upload the program.

V.IMPLEMENTATION

A packed pulse generator achieved of delivering high voltage pulse with half most extreme thicknesses as short as nanoseconds and amplitudes as high as 10 kV has been perceived to empower flow and prospective in vivo and in vitro examination concerning the properties of ultra-short, entering electric fields on natural significant. This pulse generator is little, unassuming, and liberated from saturable attractive center points, which ordinarily present plentifulness jitter and an undesirable association amongabundancy and pulse thickness. Instead of a non-straight pulse framing system is a solitary stage thunderous system that drives a bank of crossing point recuperation diodes. Thediodes reason as an initial change that changes over current from an inductor to a resistive burden. The utilization of air- center inductors in the ringing system brings about a fixed yield beat with plentifulness that scales directly with input voltage and a pulse thickness that is self-deciding of adequacy. The ability to scale the yield abundancy freely of the pulse thickness abbreviates the arrangement for tests that include pulse with various electric field qualities yet a similar ascent time and span.

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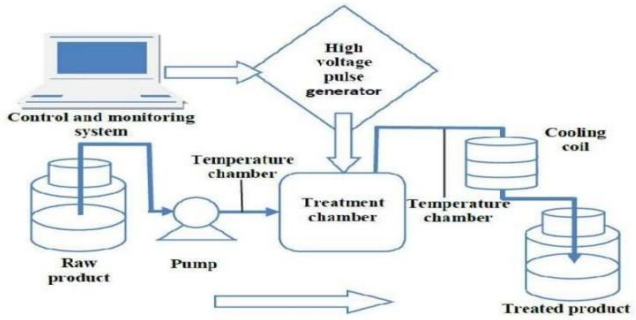

Fig 7.Flow Diagram

The ATmega-328 was used to achieve control of the pulse. The code which generates the square waveform was written on the Arduino platform. Also, a button input on the microcontroller controls the pulse rates. The pulse rates generated for this project are:

- 0Hz at 5.5kV,
- 1Hz at 5.5kV
- 2Hz at 5.5kV

The effect of high voltages at various pulse rates is tested.For the feedback and display, a 16x2 alphanumeric Liquid Crystal Display (LCD) connected to the microcontroller . A power switch was also used to power on and off the pulse control system.

VI.RESULTS AND DISCUSSION

The framework exhibited to be a business and compelling inworking. The microcontroller ATmega8 end up being a superior framework for process. Pulse electric field innovation is a very employable technique for the insurance and preparing of an assortment of food items absent really any influencing their quality focuses. The benefit of PEF incorporates.

- It keeps up the shading, flavor and smell of the food.
- PEF can slaughter the microbes and lethargic bacteriummoreover.
- Initial cost is all the more yet running expense is less.
- Less time is required to finish the procedure.
- Shelf life of milk is broadened is 24 days.

Table 1 shows the PEF Processing of chosen fluid nourishments. The different parameters can be broke down like Peak pulse electric field, Pulse length, Pulse number, Initial temperature, Maximum temperature and Shelf life for various food items Fresh squeezed apple, Apple juice from concentrate, Raw skim milk, Eggs and Green Pea soup.

Food	Peak pulse electric field(kV/cm)	Pulse duration(seconds)	Pulse number	Initial temperature (Degree celcuis)	Maximum temperature (Degree celcius)	Shelf life(No.of.days)
Fresh apple juice	50	4	16	8.15±1.5	45±5	21
Apple juice from concentrate	50	4	10	8.15±1.5	45±5	28
Raw skim milk	40	2	22	10±1.5	50±4	14
Eggs	35	2	10	8.15±1.5	45±5	28
Green Pea soup	35	2	32	22±2	53±2	10

Table 1: PEF Processing of Selected Liquid Foods

Figure 8 shows the different PEF preparing of chosen fluidfood items. Be that as it may, explore on PEF ought not be constrained uniquely towards bacterial inactivation yetadditionally towards the check of some wastage incitingcompound and enzymatic responses, holding of useful parts in food during and after treatment. PEF-treated items are generally considered as "barely treated nourishments" thatenergizes negative picture in the psyche of customer that thefood isn't very much handled and may cause genuinewellbeing recommendations in the wake of taking care of.The composite container has been amassed and tried.

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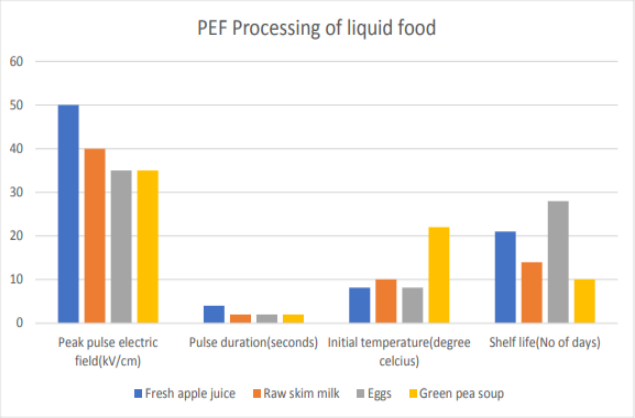

Fig. 8: PEF Processing of Selected Liquid Foods

VII.CONCLUSION

Pulse electric field stands an imaginative, non- warm strategy of food conservation. In pulse electric field innovation, the exceptionally ground-breaking factor is treatment of electric field quality. It is identified with electromechanical precariousness of cell layer. pulse electricfield can be considered as a potential option in contrast to customary warm strategies, for example, purification. Endeavors ought to be made to build up some development to lessen the expense in pulse electric field handling strategy with the goal that it very well may be broadly utilized for saving a wide assortment of nourishments. There is a need to consider the impact of pulse electric field in mix with heat or different obstacles on the inactivation of bacterial spores in different kinds of nourishments. PEF can be used as continuous process but, after processing, products have tobe packaged hygienically and kept cool during storage. Using some of antimicrobial substances prolongs the shelf life of foods within pulsed electric fields. An application of PEF for food preservation provides the tremendous potential to preserve high quality products at lower temperatures and short residence time to retain the fresh-like character and nutritional value of the products.

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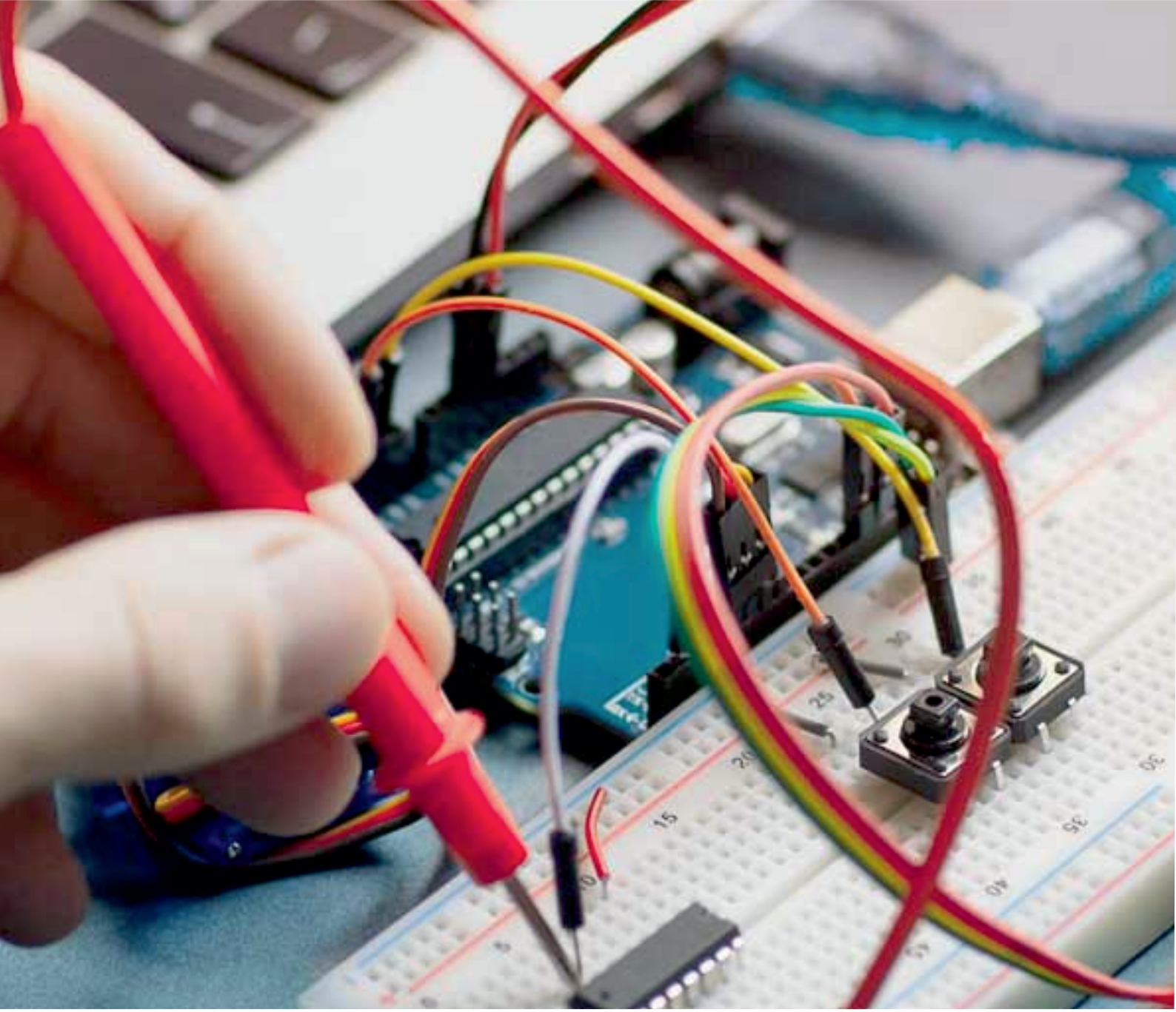

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