All in one Measuring Devices using ARM

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***Abstract*— The work titled "All in one measuring device using ARM" integrates all basic electric circuit analysis tools such as function generator, digital multimeter and oscilloscope along with variable DC power supply. Function generators are used to subject circuits to different kinds and real time inputs. Multimeter is a device used to measure electrical parameters such as voltage, current, resistance etc. Oscilloscope is an electronic device which is used to visualize waveforms and measure waveform parameters. In addition to these measurement devices variable DC power supply integrated in the work helps to subject circuits to different input operating conditions. A Graphical user Interface (GUI) constitutes the software section of the work. Individual measurement device and variable power supply are bulky, occupy more space and are expensive which cannot be afforded by students and electronics hobbyists. The proposed system fulfills the basic circuit analysis needs of students and electronics hobbyists and the small size and portable nature of the designed system allows it to be carried anywhere and everywhere and the overall cost of the designed system is roughly 2 to 3 times lesser when compared to the cost of buying individual devices. Even though the designed system fulfills the basic analysis requirements, commercially available models offers better performance characteristics and more features when compared to the designed system. The limitations of the designed system open up opportunities for enhancing performance and integration of features similar to commercial models which comes under future scope of the work.**

***Keywords*— ARM, Function Generator, Digital Multimeter, Oscilloscope, Variable DC Power Supply, GUI, All in one.**

I. INTRODUCTION

The work titled "All in one measuring device using ARM" integrates 4 different devices required for basic circuit analysis. The work integrates variable DC power supply, function generator, digital multimeter and an oscilloscope. Function generator is an electronic device which produces different types of electrical waveforms. Multimeter is a device used to measure electrical parameters such as voltage, current, resistance etc. Multimeters are used widely in circuit testing and debugging. Oscilloscope is an electronic device which is used to visualize waveforms and measure waveform parameters. In addition to these measurement devices variable DC power supply integrated in the work helps to subject circuits to different input operating conditions. The work is divided into hardware and software sections. Hardware section comprises of a main processing unit, generating, acquisition, measurement and communication sections. The main processing unit could be implemented using an ARM controller. Based on the results of a pro con analysis ARM controllers provides better pros and offer fewer cons which favored the use of an ARM controller as the main processing unit. A Graphical user Interface (GUI) constitutes the software section of the work. The devices can be controlled through a GUI which provides a sophisticated user experience. The inexpensive final result which is also compact proves to be an ideal solution to all analysis requirements of electronics hobbyists and students.

A. Aim

The work aims at provide a portable, compact and relatively cheaper solution to traditional lab equipment such as function generator, digital multimeter and oscilloscope used for circuit analysis and testing.

B. Literature Survey

Function Generator is an electronic device capable of generating waveforms with variable frequency and amplitudes. Analog electronic function generators capable of producing waveforms up to 50KHz were first introduced to the commercial market by General Radio in 1928[1]. Function Generators can be implemented either in analog or digital domains. Function generator can implement in digital domain using Direct Digital Synthesis (DDS). DDS has become one of the most important technology in the recent years for frequency generation. AD9XXX digital function generator series from Analog devices offer options of 1 to 4 output channels, 10bit to 14bit DAC resolution and frequencies up to 3.6GHz[2]. Donald Macadie, a British post office engineer invented the multimeter. The first multimeter was capable of measuring Voltage, Current and Resistance. It was initially called AVOmeter. AVOmeter was commercially marketed by Automatic Coil winder & Electrical Equipment Company (ACWEECO)[3]. Advancements in multimeters include diode test, continuity test, frequency measurement, temperature measurement, RPM measurement, Relative measurement etc. Recent multimeters have communication capabilities to transmit data and receive data from external devices, data storage and touch screen capabilities. Tweezer styled DMM with high precision measurement capability have been designed for better measurement of SMT component parameters. With advancements in ASIC design and fabrication the size of digital multimeters has shrunk over the period of time. Pen sized digital multimeters have been developed with minimum design and small PCB's. André-Eugène Blondel a French physicist is recognized as the inventor of electromagnetic oscillograph. Electromagnetic oscillograph was used to observe alternating signals. Oscillograph used a pen arm attached to a moving coil which traced ink record on a moving paper chart. General Radio Company introduced the first commercial one box cathode ray oscilloscope in 1931. Hewlett Packard (HP) invented sampling technology in 1960. Tektronix invented the first portable oscilloscope and storage oscilloscope in 1961 and 1964 respectively. In 1971, Hiro Moriyasu from Tektronix invented the Digital Oscilloscope. Nicolet Instrument designed the first Digital Storage Oscilloscope (DSO) in 1980. HP introduced the first fully digital and microprocessor-based oscilloscopes in 1982. In 1996, HP introduced Mixed Signal Oscilloscope (MSO). Tektronix invented Digital Phosphor Oscilloscope

(DPO) in the year 1998. In 2006, PicoScope 5000 a USB connected oscilloscope was introduced to the market. Digital signal processing techniques are adding new functionalities of spectrum and logic analyzers to modern oscilloscopes. A new line of oscilloscopes called Mixed Domain Oscilloscopes (MDO) were introduced by Tektronix in 2011. MDO is a combination of oscilloscope and spectrum analyzers. In 2013, Teledyne LeCroy (formerly called 'LeCroy') demonstrated a 100GHz real time oscilloscope. Faster digital components and innovative design are being used to stretch the storage bandwidth without undue increase in cost and size. Modern oscilloscopes can also be connected to a network for printing, file sharing, internet access, and advanced communication functions like sending e-mails triggered by programmed events. In 2015, Tektronix launched 200Gs/s sample rate oscilloscopes. Keysight announced Infinium UXR series oscilloscopes with a bandwidth of 110GHz with sampling rate of 256Gs/s in 2018[4].

II. WORKING PRINCIPLE

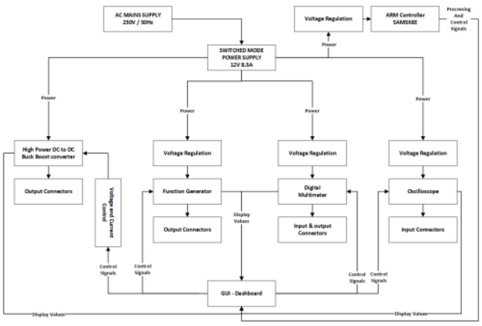

Fig.1 System Block Diagram

The Fig.1 shows, system is powered through 230V 50Hz AC mains power supply. AC main is fed to SMPS which regulates and provides an output DC voltage of 10 - 14V and up to 8.5A. The output of SMPS is further regulated to satisfy different power requirements. The regulated supply from SMPS powers SAM3X8E. SAM3X8E receives instructions from GUI and passes on to respective individual devices. The data from the device is captured by SAM3X8E which processes the data and sends the processed information back to GUI for visual representation thus acting both as a processor and a controller.

The processed signal is encoded and transmitted to an external PC for visualizing the data. GUI deployed on an external computer provides the user an interactive medium to toggle between different devices and access their functionality.

A. Variable DC power supply

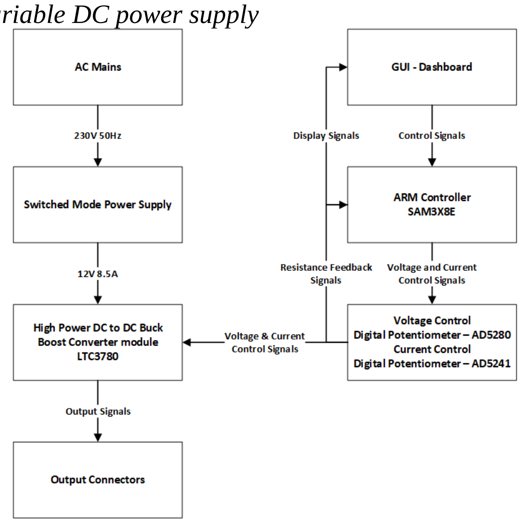

Fig.2 Block Diagram of Variable DC Power Supply

Fig.2 represents block diagram of Variable DC power supply. The SMPS provides output voltage from 10 to 14V and output current up to 8.5A. This further acts as the power source to a high-power DC to DC buck - boost converter module. LTC3780 is a high-performance buck-boost switching regulator controller. Buck and boost operation of LTC3780 provide an output range of 0V to 30V. Voltage and current is controlled through potentiometers. Digital potentiometers are used to control the voltage and current digitally.

When the user modifies voltage or current knob in GUI, control signals are passed to SAM3X8E an ARM controller. The controller passes these control signals to the digital potentiometers serially. The resistance of the potentiometers varies which modifies the output voltage and current.

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B. Function Generator

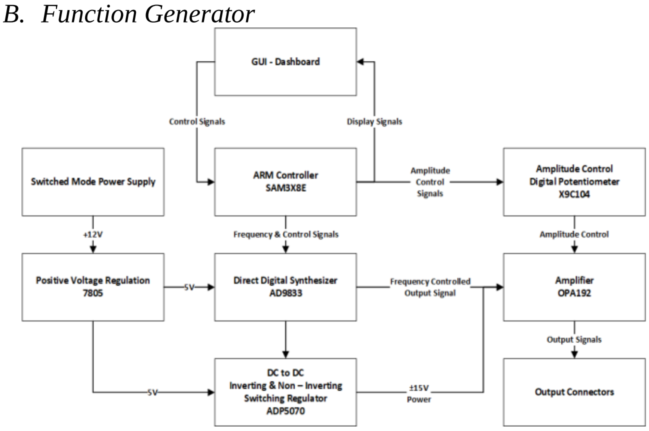

Fig.3: Block Diagram of Function Generator

Fig.3 represents block diagram of function generator. The regulated 5V powers AD9833, a monolithic DDS[5] IC, capable of generating Sine, Square and Triangle waveform, and ADP5070 switching regulator. OPA192, a high precision rail to rail OpAmp is used for output amplification. ADP5070 provides ±15V and powers OPA192. X9C104, a digital potentiometer is used for controlling the amplitude. 4mm banana jacks are used as output connectors.

AD9833 is a Direct Digital Synthesizer. The maximum output of AD9833 is 0.65V. An external amplifier is required to amplify the signal to desirable amplitudes. Frequency of output waveform can be modified by changing the register contents of AD9833. The maximum frequency generated by AD9833 is 12.5MHz. As the frequency crosses 10MHz, distortions are observed.

SAM3X8E control AD9833 through SPI protocol. Serial commands from GUI are sent to the microcontroller which modifies the shift register contents of AD9833 which changes the frequency and type of waveform generated. A digital potentiometer is controlled by SAM3X8, to change the amplitude.

C. Digital Multimeter

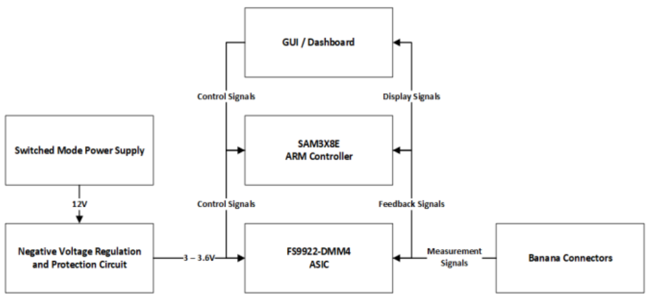

Fig. 4: Block Diagram of Digital Multimeter

Fig.4 represents block diagram of Digital Multimeter. FS9922-DMM4 is a 6000 count 3-digit, high performance, low power, high precision dual DAC, 8-bit embedded microprocessor digital multimeter ASIC manufactured by Fortune Semiconductor Corporation. Operating voltage of FS9922-DMM4 is in the range 3V to 3.6V and it consumes less than 2mA during active operation.

FS9922-DMM4 contains 5 registers, depending on the content of register different mode and function are automatically selected. A user can select between 6 modes and 5 functions. Modes include voltage, current, resistance, capacitance, diode measurement and continuity test. Functions include Select, Range, Max, Min and Relative measurement.

D. Oscilloscope

Fig.5: Block Diagram of Oscilloscope

Fig. 5 describing the oscilloscope, which is a device for plotting electrical signals varying in time domain. Oscilloscope is comprised of 5 main components: Probes and connectors, signal acquisition circuit, ADC, processor and display.

The first component is probes and connector. Probes and connectors have a crucial impact on the measurements as they induce resistive, capacitive and inductive load which alter the measurement of signals. BNC connectors with 50Ω / 75Ω impedance are used as female connectors which are used to receive signals from a male BNC cable. The basic BNC connector is a male type mounted at each end of a cable. This connector has a center pin connected to the center cable conductor and a metal tube connected to the outer cable shield. A rotating ring outside the tube locks the cable to any female connector [6]. A current probe can be used during power measurements [7]. Passive probes have different attenuation factors which determine the maximum measurable speed and voltage. A 10X probe can measure higher speeds and voltages when compared to a 1X probe and also offers better performance. 10X probes are the most commonly used for typical applications [8].

Signal acquisition circuit is composed of two parts – Attenuator and Trigger. The trigger is associated with a threshold that activates a sweep when the signal passes it. Attenuation is the ratio of the probe's input signal amplitude to the output signal amplitude, usually measured at DC. Many probes are called “10X” probes, meaning that the signal applied to the oscilloscope is 1/10th of the actual input signal amplitude [9].

The third component is ADC. Analog to Digital convertor is used to samples analog signals and convert them from analog to digital which can be understood by digital devices like microcontrollers and processors. The signals from the signal acquisition circuit are sampled by an ADC which are later fed as input to a processor which processes these values. The processed values are converted into voltage readings. An ADC can be controlled by a processor using a set of commands which alter register contents of an ADC.

The fourth component of an oscilloscope is a processor. A processor is required to convert the sampled readings to the desired format. A processor controls various parameter such as sampling rate of ADC etc. The processor encodes the processed data and transfers the data to the display device, which in this case is display of the GUI.

E. GUI

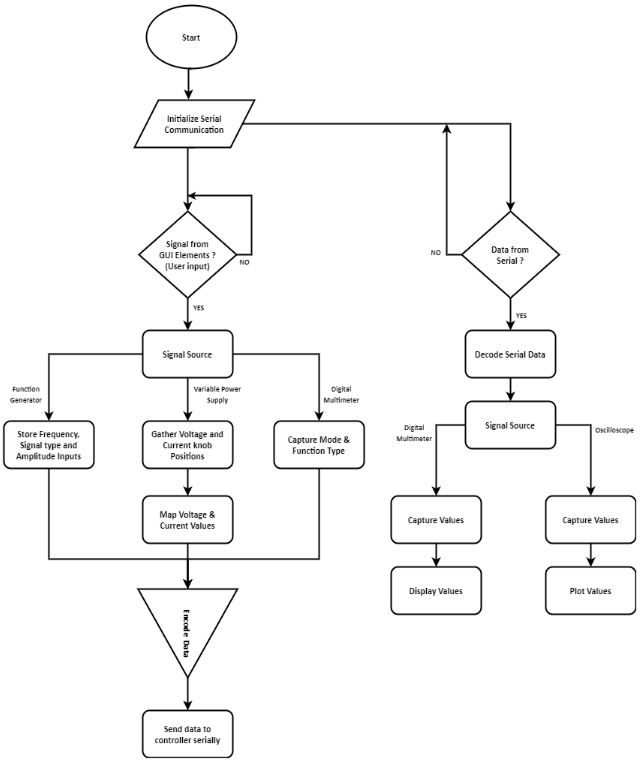

Fig.7: Hardware and Software interface Flowchart

Users interact with devices through a GUI. The GUI is built using PyQt5[10] using python language. GUI consists buttons, knobs and sliders as input elements and labels, text fields as output elements. PySerial is used for serial communication between the devices.

Serial communication between devices is initialized by 2 triggers – Signal from GUI (User input) and Serial data from device. The former is initialized whenever a user modifies parameters through GUI elements. The latter initializes communication when GUI receives information from the devices.

III. CONCLUSION

The variable DC power supply system was designed to generate 0 - 30V theoretically. The variable DC power supply generated output voltages from 0.8V to 29.7V practically. The function generator was designed to produce sine, square and triangle waveforms of frequency up to 1MHz and amplitude of ±15V theoretically. Practically, the function generator was capable of generating sine, square and triangle waveforms of frequencies up to 0.99MHz and amplitudes of ±14V. The digital multimeter is designed to measure voltage, current, resistance. Additionally, the digital multimeter was designed to perform continuity test. The oscilloscope was designed with a maximum sampling rate of 0.6MS/s. Waveforms were visualized in GUI.

REFERENCES

[1] https://en.wikipedia.org/wiki/Function_generator
[2] https://www.analog.com/en/parametricsearch/11018#/
[3] https://en.wikipedia.org/wiki/Multimeter
[4] http://oscopes.info/background/2265-oscilloscope-milestones
[5] https://www.analog.com/en/analog-dialogue/articles all-about-direct-digital- synthesis/.html
[6] https://www.webopedia.com/TERM/B/BNC_connector.html
[7] https://in.tek.com/blog/what-is-an-oscilloscope-probe
[8] https://engineering.case.edu/lab/circuitslab/sites/engineering.case.edu.lab.circuitslab/files/docs/Oscilloscope_Fundamentals_-_Tektronix.pdf
[9] https://www.instructables.com/id/Girino-Fast-Arduino-Oscilloscope/
[10] https://en.wikipedia.org/wiki/Python_(programming_language)