Interfacing of Software Drivers on ARM9 Processor by Porting with Linux using HMI

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ABSTRACT
Software interface drivers for high speed embedded system using ARM9 SBC porting on Linux. The components used in the project are SBC, PC104 interface module, 8254 programmable interval timer, 16-bit high speed DAC and OPAMP544. Single board computer consists of VIA processor which runs on 200MHz. This SBC operates with Ubuntu version. The VIA processor operates the timer, DAC by interfacing with PC104 bus using LINUX commands. LINUX starts its booting from kernel. After we had accessed to Linux by entering username & password, a root is created and we can use devices, generate interrupt to perform operations. Microprocessor based phantom load device are free from the above constraints and serve the same purpose. It shows that HMI (Human Machine Interface) view by which a human can operate by giving the input's through touch panel which is processed via processor through DAC Board, so that it can generate noises free signals which is used to test the CT/PT (Current Transformer/Potential Transformer) for a given conditions. And separate control for each phase and different for Current Transformer CT and Potential Transformer PT with Unity, Leading, Lagging Power factor. It will work like a general Oscilloscope.

Key words: PC104, 8254, OPAMP544, Microcontroller, ARM9 Processor [1].

1. INTRODUCTION
Linux refers to the family of Unix-like computer operating systems that use the Linux kernel. Their development is one of the most prominent examples of free and open source software. The source code can be used, freely modified, and redistributed, both commercially and non-commercially, by anyone under licenses such as the GNU General Public License.
Linux can be installed on a wide variety of computer hardware, ranging from mobile phones, tablet computers and video game consoles, mainframes and super computers. However, desktop use of Linux has become increasingly popular in recent years, partly owing to the popular Ubuntu, Fedora, Mint, and Sun Solaris distributions and the emergence of net books and smart phones running an embedded Linux. Such a system uses a monolithic kernel, the Linux kernel, which handles process control, networking, peripheral and file system access. Device drivers are either integrated directly with the kernel or added as modules loaded while the system is running.

2. SYSTEM ESTABLISHMENT
To generate a sine wave, the microprocessor requires the digital signature of the wave. This is achieved by sampling a sine wave at particular intervals of time called sampling time and saving it in its equivalent binary value. In this project, a 50Hz sine wave is sampled out into 256 samples with a sampling time of 78μs, and the amplitude of sine wave at that instant is saved in its equivalent hexadecimal form and saved in the ROM (in the form of Look-Up-Table)

2.1 Generating 3-phase currents
In a 3-phase system, currents of the three phases are not equal all the time. Hence, in this circuit there are a total of 6 DAC’s that generate phase currents, of which 3 DAC’s generate a reference voltage (proportional to magnitude of load current of each phase) for each phase and other 3 DAC’s generate the phase currents. The reference voltage generated by the DAC’s is proportional to the current value (of that phase) that is given as the input value to the required magnitude of current. The output current from DAC08 is converted to the proportional voltage level. The Op-amp OPA544 converts the voltage to required current value.

2.2 Power Supply

![Fig 1: Power supply](image-url)
The input to the circuit is applied from the regulated power supply. The AC input i.e., 230V from the mains supply is step down by the transformer to 5V and is fed to a rectifier. The output obtained from the rectifier is a pulsating DC voltage. So in order to get a pure DC voltage, the output voltage from the rectifier is fed to a filter to remove any AC components present even after rectification. Now, this voltage is given to a voltage regulator to obtain a pure constant DC voltage.

3. HARDWARE OVERVIEW
The interfacing of software drivers on SBC by porting with Linux using HMI block diagram have three stages; i.e. input stage, arm processor and output stage.

3.1 Input stage

a. Operational Amplifier 544: The OPA544 [5] is a high-voltage/high-current operational amplifier suitable for driving high power loads.

b. Programmable Timer 82C54: The Intel 82C54 [6] is a high-performance, CHMOS version of the industry standard 8254 counter/timer which is designed to solve the timing control problems common in microcomputer system design.

c. 74LS138 Decoder: The 74LS138 is an advanced high-speed CMOS 3 TO 8 LINE DECODER (INVERTING) [7] fabricated with submicron silicon gate. The chip is provided with 3 input pins (A, B, and C), 8 output pins (Y0* to Y7*) and 3 enable inputs (G1, G2A* and G2B*) to ease cascade connection and application of address decoders for memory systems.

d. DAC 08 – 8 bit Converter: The DAC08 series of 8-bit monolithic Digital-to-Analog converters provide very high speed performance coupled with low cost and outstanding applications flexibility.

e. 74LS244 OCTAL BUFFERS: These Octal buffers and line drivers are designed specifically to improve both the performance and density of three-state memory address drivers, lock drivers and bus-oriented receivers and transmitters

3.2 ARM9 Processor
➢ Basic ARM9 Features
a. 200 MHz ARM920T Processor
b. Linux, Microsoft Windows enabled MMU
c. 100 MHz System Bus
d. Serial EEPROM Interface  
e. 1/10/100 Mbps Ethernet MAC  
f. Two UARTs  
g. Two-port USB 2.0 Full Speed Host  
h. ADC  
i. Serial Peripheral Interface (SPI) Port

➢ **Advanced ARM9 features**

a. 12 Direct Memory Access (DMA) Channels  
b. Real-time Clock with software Trim  
c. Dual PLL controls all clock domains  
d. One 40-bit Debug Timer  
e. Interrupt Controller  
f. Boot ROM  
g. Package  
h. 208-pin LQFP

![ARM9 processor block diagram]

Fig 4: ARM9 processor block diagram.

The EP9302 is an ARM920T-based system-on-a-chip design with a large peripheral set targeted to a variety of applications like:

- Industrial controls  
- Digital media servers  
- Integrated home media gateways  
- Digital audio jukeboxes  
- Streaming audio players  
- Set-top boxes  
- Point-of-sale terminals  
- Thin clients  
- Biometric security systems  
- GPS & fleet management systems  
- Educational toys  
- Industrial computers  
- Industrial hand-held devices  
- Voting machines

It focuses on the design of the hardware of a microprocessor based phantom load device and the control software for the generation 3 – phase voltages and currents at different power factors (unity, leading and lagging) at 50VA burden. The device has to simulate voltages from 0 to 110V (RMS) and currents from 0 to 1A. This is achieved by sampling the sine wave and storing the sample values in the processors memory (ROM). These sample values are given out by the microprocessor (in binary form) to a digital-to-analog converter, which generates the desired sinusoidal waveform (for both voltage and current).

### 3.3 Output and Display

Device drivers [3] are software interfaces between software applications and hardware devices. As part of complex operating system, device drivers are considered extremely difficult to develop. They are usually developed in low-level programming languages, such as C, that cannot provide type safety and device semantics. Human
supervision exploits a dedicated interface (HMI - Human Machine Interface), which is hardware and software artifact for the acquisition of data and the control of the system. The magnitude of the sine wave can be changed by simply setting the desired value in the HMI. The implementation of this board demonstrates that a ARM processor (EP9302) can be programmed to perform the function of output sine waveform is a noise free signal, stepped up the required voltages/currents by using PT’s and CT’s respectively by using HMI interface. The board has been designed, assembled and tested by observing the waveforms over the HMI interface and by controlling it through the development software.

Fig 5: Experimental setup to interface ARM9 Processor using Linux by HMI.

It contains a Single board Computer based on via processor and which has PC104 bus. DAC Add on card which is designed to have voltage and current DACs along with 8254 timer is interfaced with SBC through PC104 bus. Linux OS is installed on top of the Hardware. In order to communicate with the low level hardware a device driver is written for PC104. The main functionality of the device driver is to output required sin samples on the DACs based on timer interrupt. This device driver is based on the architecture via processor and Linux operating system installed on it (Linux 2.6.31, UBUNTU).

The user application will be interfacing with device driver to pass on the required unity/Lead/lag parameters through IOCTL function. Based on these values the device driver will output the pre-defined sin samples on to the DAC. Also the other functionality of the user application is to set the voltage and current references. The input value from the end user is through HMI which is on top of user application. HMI will pass the values to user application through TCP/IP communication. The main parameters that are passed to user application is the amplitude of voltage and current, unity flag, Lead/Lag in degrees. It will receive the calculated sin samples from user application for display on HMI.

4. FLOW OF SOFTWARE EXECUTION

4.1 HMI
1. User will input values in the HMI [4] display for Voltage, Current and Unity, Lead/Lag angles
2. User will click on “Run” Button to pass the values to User application through TCP/IP communication in the following format
   $VR,<<value>>,VB,<<value>> .....n

4.2 User Application
1. Insert PC104DAC driver module in kernel space
2. open the driver PC104DAC for performing operations on driver
3. Initialize user application as server and connect with HMI using TCP/IP protocol
4. Loop for getting data from HMI and pushing data to driver until ‘q’ is pressed for quit. Goto step5. If other key is pressed Goto step 12
5. Read data from HMI
6. If packet starts with ‘$’ character then goto step 6
7. Parse the client data collected from HMI
8. Send the Flag data like unity/Lead/Lag to PC104DAC driver through IOCTL calls
9. Set the reference levels for DAC
10. Send the calculated sin sampled data to HMI for display
11. Goto step4
12. Close socket connections
13. Close the driver
14. Remove the PC104DAC driver from kernel space

4.3 PC104DAC Driver
1. Init module gets executed on inserting the driver by user application
2. Register DAC Card as Character Device driver with major number 246
3. Initialize the interrupt line 9 which will execute interrupt_handler based on 8254 timer for every 56 microseconds
4. In interrupt handler, the sin samples gets output on DAC based on the Flags. The flags are Unity, Lead and Lag
5. IOCTL call will take care to set the unity/lead/lag flags.

5. EXPERIMENTAL RESULTS
Obtained results shows that HMI (human machine interface) view by which a human can operate by giving the inputs through touch panel which is processed via ARM processor using DAC board so that it can generate noise free signals which is used to test CT/PT (current transformer/potential transformer). This will work like a general Oscilloscope for the given conditions separate control for each phase, different current transformer and potential transformer with unity, leading and lagging power factors.

![Fig 6: HMI for CT/PT without unity, leading and lagging power factors](image)

![Fig 7: HMI for CT/PT with 120° phase shift unity, leading and lagging power factors](image)

6. ADVANTAGES
a. The function of this device is to simulate CT and PT conditions for testing the generator control DCS panels.
b. A microprocessor based phantom load device serves the same purpose with very less maintenance and is easy to transport. Such a device can be used for testing of various other instrumentation and control equipments.
c. LSR Panels to simulate active power for Hydro control EHGC (Electro Hydraulic Governor Control) and various transducers like voltage, current, frequency, active and reactive power, etc. in other control and instrumentation.
d. Majorly used in electrical surveillance to check the defects, identifying the problem and to correct the 3-phase voltage & currents.

7. APPLICATIONS
- Secondary Injection device are widely used in the fields of Instrumentation and Control Engineering Application.
- In Power Plants, these devices serve the purpose of testing and calibration of control panels and various other control equipments.

CONCLUSIONS
The sinusoidal voltage and current waveforms have been generated by the Embedded processor based 3-phase Phantom Load Simulator device. The board has been designed, assembled and tested by observing the waveforms over the HMI interface and by controlling it through the development software. The magnitude of the sine wave can be changed by simply setting the desired value in the HMI. The implementation of this board demonstrates that a ARM processor (EP9302) can be programmed to perform the function of output sine waveform is a noise free signal, stepped up the required voltages/currents by using PT’s and CT’s respectively by using HMI interface the wave forms are shown.

FUTURE SCOPE
In this device, a microprocessor can be replaced with a DSP processor, which is much faster in operation and doesn’t require any values to be stored (as in LUT). With its ability to perform calculations at a faster rate and less parameters to be used, the DSP processor is said to give an accurate sine wave.

REFERENCES

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