# Real-Time Acquisition and Display of Data and Video

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*Abstract:* - This paper describes the development of a prototype that takes in an analog National Television System Committee video signal generated by a video camera and data acquired by a microcontroller and display them in real-time on a digital panel. An 8051 microcontroller is used to acquire power dissipation by the display panel, room temperature, and camera zoom level. The paper describes the major hardware components and shows how they are interfaced into a functional prototype. Test data results are presented and discussed.

*Key-Words:* data acquisition, overlaying text over video, real-time video

## 1 Introduction

Text can be added to video sequences based on "layers." The idea is to run two clips at the same time, one having the video and the other having the text. In order for the clip lying at the back to be visible, the text layer except for the actual text must be made transparent using transparency properties and background keying. Playing one clip on top of another is referred to as "superimposing," often called matting or keying in television and film production [1]. Text in video frames can be classified as scene text and caption text. Scene text is text that occurs naturally in the 3-D scene being recorded and is distorted by perspective projection. Caption text comprises 2-D strings that are superimposed on to the video frame during the editing stage of production. Caption text is often referred to as overlay text, artificial text or superimposed text [2]. Scene texts appear as part of the captured scene, like store signs, street tags, and shirt logos. Text overlays are superimposed on top of the scenes, and include video titles, news anchor names, and sport scores.

This paper describes a real-time system that overlays acquired data on a digital video signal. The project involves the design, development, and testing of several major components and interfacing them into a functional unit. The objective is to obtain useful physical parameters such as temperature value, power dissipated by a display, and zoom level of a camera and overlay them over a video signal in real time before sending them to the display.

The overall system structure is shown in Figure 1. The black box that carries the NTSC video signal to the display device was configured to contain a video text overlay module to allow for text overlay, an LCD controller to support the LCD display and a microcontroller to allow data acquisition and serial communication. The major components of the system are: a CCD camera with an analog NTSC video output, devices that perform text overlay and analog-to-digital conversion, and the liquid crystal display (CCD) panel. Based on the system requirements, the initial components were CK3900 Analog NTSC video camera, the PD064VT4 TFT-LCD display panel, and the microMODUL-8051 SBC controller board, the BOB-3 overlay module, and the SFD064VT4-ADV the LCD controller, which perfectly interfaces with the PD064VT4 display.

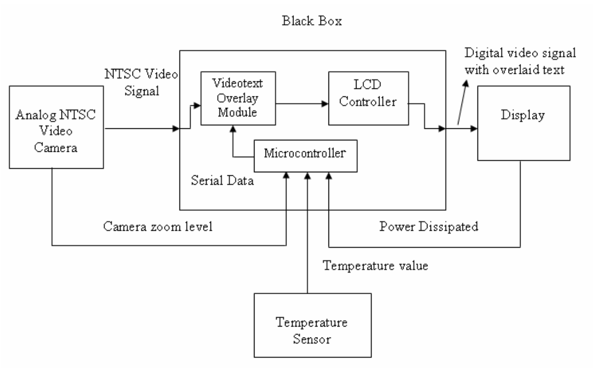


Figure 1. Overall system block diagram

## 2 Major System Components

The following sections briefly describe these components.

### 2.1 Analog NTSC Video Camera

The camera used in the prototype is a NTSC Meiji Techno Analog CCD Color Camera CK3900N. The video signal can be obtained either by using the BNC connection or the S-Video connection. Also pins 3 and 4 of the 9 pin Dsub simulate the Video out connection. This connection is utilized to minimize the wiring. The main features of the camera follow.

- 450 TV lines of horizontal resolution
- TV Standard - NTSC or PAL
- NTSC: 525 lines, 768 x 494 @ 30 fps
- Super sensitive 1/2" sensor EXview HAD CCD
- Improved sensitivity and image performance
- Based on latest Digital Signal Processing (DSP)
- Composite VBS and Y/C video output
- S/N ratio >50dB
- Employs 9 pin Dsub connector at camera rear panel for single cable connection

### 2.2 TFT LCD Panel

TFT-LCD products have the advantage of being slim and lightweight with low radiation and low energy consumption. TFT-LCD display from Prime View Displays bearing a product number 'PD064VT4' was selected for this application. It operates in transmissive mode and hence needs a backlight. Features of the display follow.

- High contrast ratio: Contrast ratio is the ratio of the blackest black and the whitest white a TFT can display. The higher the contrast ratio, the better the image. The PD064VT4 offers a high contrast ratio of 400:1.
- Brightness: It is desired that the PEVIT display has a high brightness value. Brightness value of PD064VT4 is 400.
- Interface: TTL
- Slim and Compact size
- Operating temperature range -20$^{o}$F to 70$^{o}$F

### 2.3 LCD Controller Kit

A converter that allows successful signal transmission between analog and digital components is needed to convert the NTSC signal to digital. A LCD Controller board that interfaces the NTSC video signal with the PD064VT4 TFT LCD is needed. This controller should also have On-Screen Display (OSD) support. In other words the board has both the analog-to-digital converter (ADC) unit and an OSD unit integrated into a single board. Desired features of the controller follow.

- Video Input Signal: NTSC
- Interface Panel type: PD064VT TFT LCD
- Backlight inverter board included
- Controller to convert analog signals to digital
- OSD capabilities

The SFD064VT4, from AZ Displays, was identified as the interface board for PD064VT4 display panel.

### 2.4 The 8051 Microcontroller

The 8051 microcontroller development board, the microMODUL-8051 SBC from PHYTEC, is used in this project. Figure 2 shows a schematic of the board, which has the following features.

- On-board Flash-programming
- SBC in matchbox-size dimensions
- Requires a single power supply of 5V, typ. <200mA
- All ports and applicable logic signals extend to pin headers at the edges of the circuit board
- Controller signals and ports extend to standard-width (2.54 mm.) pins aligning board edges, allowing the board to be plugged into any target application like a “big chip” [3].

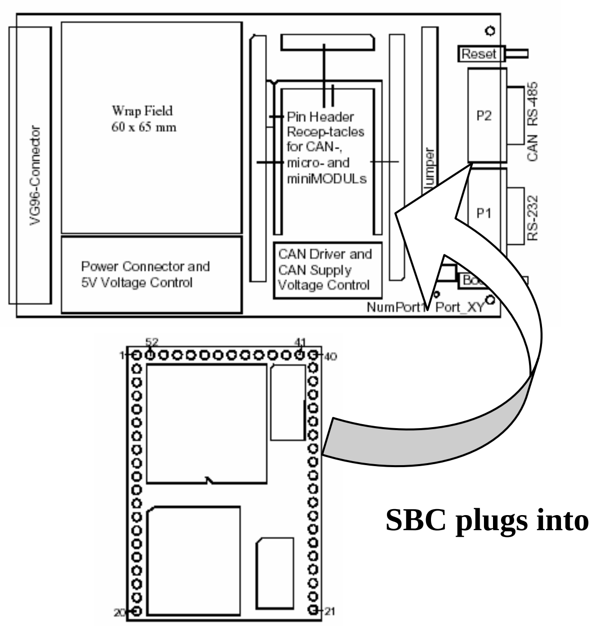


Figure 2. The 8051 Development Board

## 3 Data Acquisition

This section presents the mechanisms used to measure the parameters of interest; temperature, zoom level, and power dissipation. It also shows the interfacing of these components.

### 3.1 Capturing Room Temperature

The LM34 is used to capture the temperature value. LM34 series are widely used precision integrated-circuit temperature sensors. The LM34 is a voltage mode sensor whose output voltage is linearly proportional to the Fahrenheit temperature. It outputs 10mV/F. It is rated to operate over a −50°F to +300°F temperature range, which is a full span of 350. Moreover, LM34’s low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy [4].

As the LM34 measures temperatures lying in the range of −50° to +300°F, the corresponding voltages that are read from LM34 fall in the range -0.5V to 3.0V. But the 8051 can accept analog voltages in the range 0-5V and produces a 10-bit digital value. In order to make better utilization of 10-bit resolution provided by on-board ADC and to avoid a range of voltages being considered noise, the voltage signal ranging from 0.5V to 3.0V has been amplified to match the 8051 input range of 0V-5V. The voltage signal produced by the sensor is carried to 8051 SBC via three stages; High-Impedance buffer stage, Gain stage and Inverting stage as shown in Figure 3. In the first stage the LM741 acts as a unity gain buffer amplifier otherwise called a voltage follower. A voltage follower circuit makes a copy of the input voltage at the output without drawing any current from wherever the input voltage terminal is attached. It is necessary to have a high-impedance buffer stage between LM34 and gain stage to avoid loading the LM34 sensor as it would affect the voltage produced by sensor and thus the voltage measurement.

The second stage includes a basic inverting amplifier with an offset adjustment at the non-inverting input terminal of the LM741. The LM741 reads the voltage output of the first stage which indicates the temperature on a scale of 10mV/°F. Since the input voltage readings include negative voltages, it is necessary to offset the input voltage by 0.5V to obtain positive readings. Offset adjustment will give the readings in the range 0 to 3.5V. The 143K resistor in the feedback loop and the input resistance (100K POT) are responsible for amplifying the signal to fall in the range 0-5V. Usage of potentiometer (POT) for input resistor makes it possible to obtain variable gain.

Since the amplifier used in the second stage is an inverting amplifier, an additional stage is required to invert the output voltage. The third stage acts as an inverting stage to convert the negative signals to positive with a negligible gain. This temperature sensing circuit operates with an error of +/- 1.

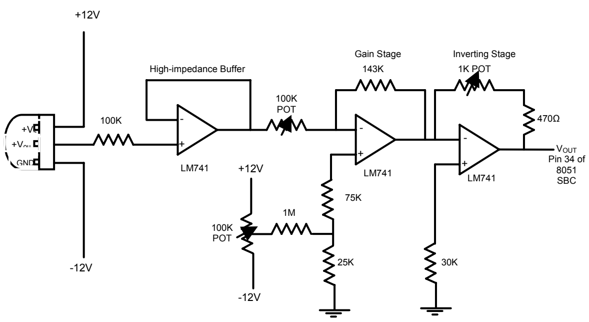


Figure 2. Circuit for capturing temperature

## 3.2 Capturing Camera Zoom Level

Changing the focal length of the camera results in two important effects that are immediately obvious: lens' angle of view and its magnifying power. Angle of view refers to how much of a scene the lens covers and magnification is inversely related to the lens' angle of view. Increasing the focal length, called zoom in, results in narrowing the angle of view and hence magnifying the objects in scene making them appear larger than they actually are. Conversely, decreasing the focal length (zooming out) results in widening the angle of view thus covering wide sweep of the scene and at the same time reducing the objects in the scene to fit into the image.

From the above explanation it is obvious that being able to capture the angle of view would allow computing the focal length. And converting the captured value to corresponding voltages is necessary to be able to feed the 8051 analog port. The idea behind developing the unit to capture the zoom value is to use a potentiometer having a movable wiper representing a transducer. The potentiometer is mechanically coupled to the zoom lens mechanism for generating a voltage signal representative of the viewing angle of zoom lens. The potentiometer is placed right below the lens as can be seen in Figure 4, in a way such that rotating the lens results in the movement of the potentiometer wiper producing varied voltage signal values. In general for example, an analog level of 0% (0V) indicates that the lens is at its wide shot (wide and tight shot descriptions may be reversed for some camera lens, consult the manufacturer). An analog level of 100% (4.3V) indicates that the lens is at its tight shot. Signal conditioning/amplification was not employed in developing this circuit as the obtained voltages lie in the range 0 - 4.3V which is close to the 0-5V analog input range of 8051. A formula to compute the zoom value or focal length is formulated based on the linear relation the voltage holds with the lens' angle of view. The unit operates with an error of +/- 0.2.

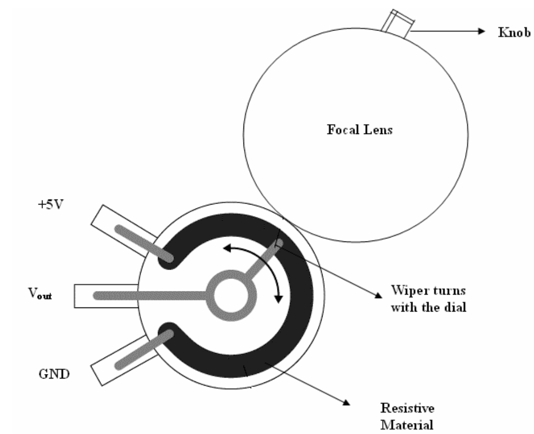


Figure 4. Mechanism for capturing zoom level

## 3.3 Capturing Power Dissipation

In order to calculate the power dissipated by the Display panel and its accompanying components (LCD controller kit), a very small resistor of known value is placed in series with the display system. Capturing the voltage drop across this resistor helps determine the current flowing through the display. Since the voltage supplied for the display is constant and the amount of current flowing in the resistor and display are always the same, it is enough to calculate the current flowing into display to determine the total power dissipated.

Two LM741 amplifiers are used in two different stages of the circuit as shown in Figure 5. Amplifier in the first stage acts as a differential amplifier. The differential amplifier measures the difference between two input signals (-) and (+). The input signal at the inverting input terminal is the actual voltage supplied i.e., +12V and the input at non-inverting input terminal is the supplied voltage less the voltage dropped across the 2Ω resistor. As the variation in the current flowing through the display unit is very minute, in the range ± 0.1 or ± 0.2, the voltage measured across the 2Ω resistor lies in the range -1.5V to -1.7V. The negative voltage output at this stage is due to the higher voltage input at the inverting input terminal. This leads to a second amplification stage that provides the necessary gain to match the output voltage range to the analog input range of the 8051 and also results in positive voltages.

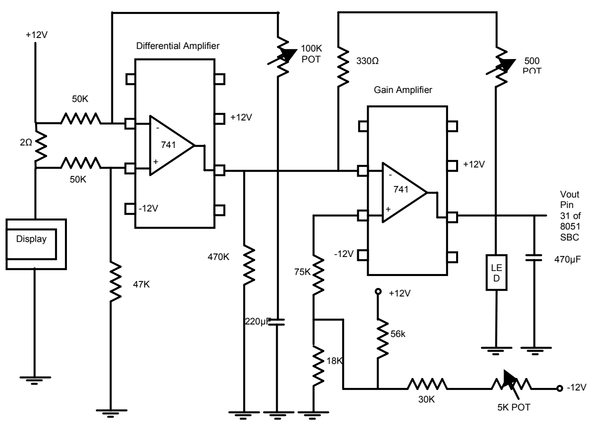


Figure 5. Circuit for measuring power

The LM741 in the second stage is used to attain a variable gain and to offset the negative input voltages. This stage is similar to the second stage of the temperature capturing unit. This circuit also uses two capacitors each at output points of two stages in order to slow down the response time. An LED is also attached to the output voltage point to illustrate the change in the amount of power dissipated at different lighting conditions.

The output produced by the developed unit is the amplified value of the voltage dropped across the 2Ω resistor. The circuit has a gain of 4.6 and a negative offset voltage of 1.42V. Therefore the actual voltage drop across the 2Ω resistor is obtained by dividing the voltage read less the offset voltage with the gain factor. In order to calculate the power (P = V * I) dissipated by the display unit it is necessary to know the voltage (V) applied and the amount of current (I) flowing through the display. As the 2Ω resistor is in series with the display unit, the current flowing through the resistor is the same as the current flowing through the display unit. Amount of current flowing across resistor is calculated using Ohm's law (V = I * R) since the values of V and R are known (V = 12V and R = 2Ω).

## 3.4 Interfacing the components

Hooking up the camera with BOB-3 was through the video out connection, pin 4 of the 9 pin Dsub connector, available on the back end of the camera and video in (pin 30) on BOB-3. With this interface the system gets its first input, the NTSC analog color video signal. Next, connecting the BOB-3 with 8051 was based on synchronizing the baud rate necessary for establishing communication between the two components. Nearest baud rate the 8051 (Infineon C504-L) microcontroller could be programmed to, to match with any of the varied baud rate range supported by BOB-3 was 2400 baud with an error rate of 0.16%. This error rate is acceptable as the communication is always possible as long as the error rate is less than 1%. The 8051 is programmed for 2400 baud rate while the BOB-3 is hard coded for 2400 baud rate making very few changes in its basic hook up as shown in Figure 6.

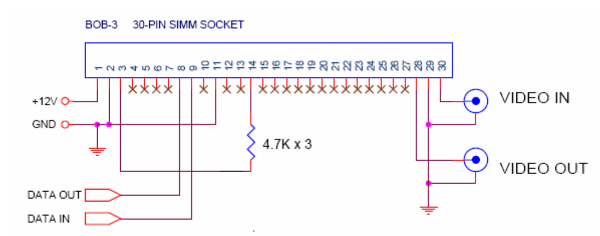


Figure 6. Hook up for 2400 baud rate

The composite video out from pin 28 of BOB-3 which is an NTSC analog video signal with data parameters superimposed is carried to the PD064VT4 digital display via the SFD064VT4 – ADV boards. i.e., video signal from BOB-3 is supplied to the controller/driver board of the SFD064VT4 kit, at connection labeled CN9 in order to convert the analog video signal to digital video signal. The digital signal from driver board is carried to the display panel via a cable connected between CN2 of driver board and CN2 of Display panel. The inverter board is connected to display panel at connection CN1 in order to supply the back light necessary to light up the display. The Key board is connected to SFD064VT4 controller board (connection from CN1 of keyboard to CN3 of driver board) that allows controlling On Screen Display such as setting display parameters (contrast, brightness, sharpness, volume etc). Interfacing the connections explained above is shown in Fig. 7.

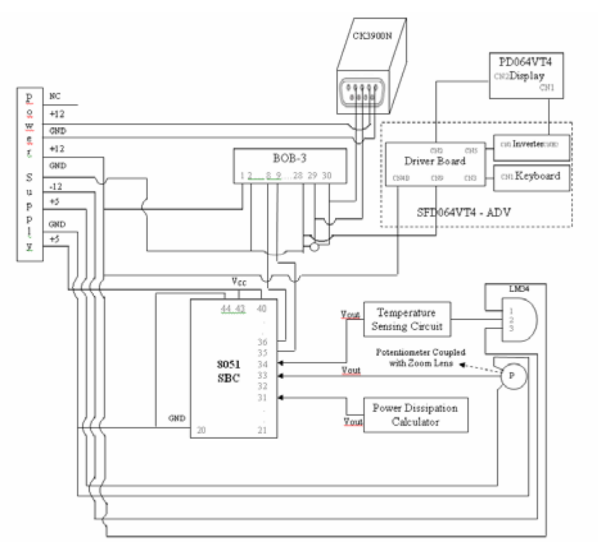


Figure 7. Interfacing Connections

### 3.5 Programming

Programming the system was accomplished in C++ and assembly using μVision3, an Integrated Development Environment (IDE) that helps develop embedded applications [5-8]. FlashTools98 is a software program used to interact with the flash EEPROM located on the microcontroller module.

### 3.6 Final Prototype

Figure 8 shows the final view of the system developed.

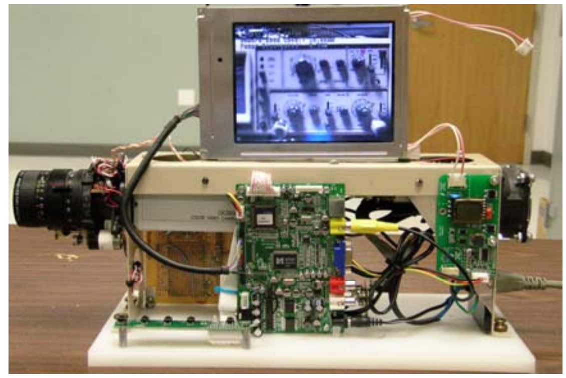

Figure 8. Final system

## 4 Testing of the Prototype

The prototype was tested to examine its performance. In order to test for extreme conditions the LM34 sensor was exposed to liquid nitrogen to sense the negative temperatures below -50°F, compressed air (freezer spray) to sense lower temperatures starting from 0°F and has been heated with the soldering iron to sense the temperatures ranging from room temperature to its maximum readable limit of 300°F. Table 1 illustrates the experimental results obtained when tested under different temperature conditions.

Table 1 Temperature test results

| Exp. | V (V) | $T_t$ (°F) | Te (°F) | % error |
|---|---|---|---|---|
| 1 | 3 | 300 | 299 | 0.33 |
| 2 | 0.75 | 75 | 74.75 | 0.33 |
| 3 | -0.04 | - 4 | -3.17 | 20 |
| 4 | -0.50 | -50 | -49.6 | 0.8 |

Testing the zoom capture unit was quite easy as the lens is marked around the circumference of the zoom adjusting knob indicating the focal length. Using the marked focal length values as test points the obtained zoom values were compared to test the accuracy of the results. Table 2 illustrates the experimental results obtained when tested for different focal length settings.

Table 2 Zoom level test results

| Exp. | V (V) | $Z_t$ (mm) | Ze (mm) | % error |
|---|---|---|---|---|
| 1 | 4.30 | 8.5 | 8.52 | 0.0025 |
| 2 | 1.8 | 21 | 21.01 | 0.0047 |
| 3 | 0.9 | 33 | 33.01 | 0.0047 |
| 4 | 0 | 51 | 50.90 | 0.19 |

Capturing power dissipation was tested under different lighting conditions to observe the variations in the amount of power utilized. Maximum power consumption of the display unit as per the datasheets is 8.4W. When the unit was tested under normal conditions it consumed 6.5 W approximately. The power consumption was reduced to 1.85 W when tested in a darker atmosphere. Maximum power consumption of 8.39 W was observed by testing the unit by increasing the brightness. Table 3 demonstrates the different power consumption observed under different lighting conditions. $P_t$ in column 4 is the theoretical value of the power dissipated (product of V applied and I obtained) and Pe in column 5 is the experimental value of the power dissipated as observed on the text over video. % error in the last column represents the percentage error resulting from the formula $(P_t - P_e) / P_t * 100$.

## 5 CONCLUSION

This paper describes the design and development of a prototype that allows overlaying text onto a digital video signal in real-time. An 8051 miicrocontroller is programmed to capture the parametric values, convert them to digital signals, then serially transmit the data to the overlay module. Test results shows that the system achieved the desired results.

Table 3 Power dissipation test results

| Exp | V (V) | I (mA) | $P_t$ (W) | Pe (W) | % error |
|---|---|---|---|---|---|
| 1 | 12 | 700 | 8.40 | 8.39 | 0.1 |
| 2 | 12 | 625 | 7.5 | 7.43 | 0.9 |
| 3 | 12 | 550 | 6.60 | 6.50 | 1.5 |
| 4 | 12 | 400 | 4.8 | 4.7 | 1.5 |

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