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# **The Guitar Chord Learning System**

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Hardware Description

April 19, 2005

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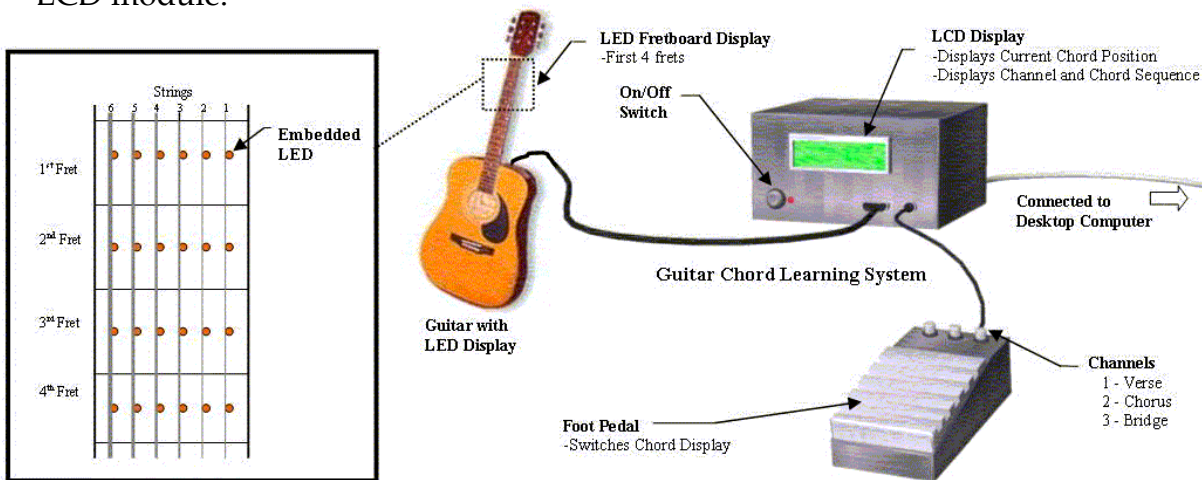
Electronics Engineering Technology

ETEC 474, Professor Morton

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# INTRODUCTION

The Guitar Chord Learning System (GCLS) is an educational tool designed to teach individuals basic guitar chord positioning techniques. Chord progression patterns from a song are entered into the user interface on a PC and then downloaded into the GCLS. As shown in Figure 1, the GCLS then outputs the proper finger positions utilizing a matrix of LEDs embedded into the fretboard. A foot pedal input unit controls the chord position output with respect to the downloaded chord progression displayed on the fretboard and LCD module.



**Figure 1: Guitar Chord Learning System**

This system gives the user the ability to learn any desired song by obtaining chord progression sequences from the internet. Because the GCLS can be used as a form of independent learning, the user will be able to grasp and improve guitar chord skills at his/her pace.

## **HARDWARE DESCRIPTION**

### **Microcontroller Unit**

The Guitar Chord Learning System is controlled by the MC9S12DP256B (9S12), depicted as “U1” in the appended schematic diagram. This 16-bit microcontroller features 256K bytes of Flash EEPROM, 12K bytes of RAM, and 4K bytes of byte-erasable EEPROM.

The 9S12 receives data input from the computer terminal via the Serial Communications Interface (SCI) and the foot pedal input through General I/O Port T. Port P is utilized to illuminate foot pedal channel LEDs with respect to the selected channel. Port A and Port K control the LCD screen, and the Serial Peripheral Interface (SPI) controls the embedded LED fretboard output.

### **RS232 Interface**

Asynchronous serial communication between the 9S12 and the PC is established through the SCI. The user-specified guitar chord sequence information is transmitted to the SCI through the RS232 serial port connection from the PC terminal program and stored in the 9S12's byte-erasable EEPROM. The SCI data pins from the 9S12 include the RX Data In (RXD0) and the TX Data Out (TXD0), as displayed in the section of the schematic diagram entitled “RS232 Interface.”

The Maxim MAX232A (U3) is a multichannel RS232 driver/receiver utilized in the RS232 Interface. Information is transferred to and received from the microcontroller through TXD0i (pin 10) and RXD0o (pin 11) of the MAX232A. The TXD0o (pin 7) and RXD0i (pin 8) transfers and receives information from the PC serial port through the DB9 female connector (J4) and standard 9 pin serial port cable. As shown in the schematic diagram, four 0.1uF external capacitors (C8 – C11) are required in the RS232 Interface circuitry.

### **Foot Pedal**

The foot pedal, which controls the LED fretboard display and channel selection, is essentially a unit made up of switches, as depicted in the schematic diagram section entitled “Foot Pedal.” Three normally open SPST momentary push-button switches, labeled as SW1 – SW3, are used to represent the GCLS channel selection input. The pedal switch, SW4, is a snap-action lever switch contained within the foot pedal module. All switches are connected in the active-high circuitry configuration to protect the microcontroller, with the pull-up resistors (R4 – R7) on the input lines. The foot pedal input is received by PT1 – PT4 of the 9S12, as shown in the schematic diagram.

Three Foot Pedal LEDs, LED1 – LED3, are standard 5mm light emitting diodes connected active-low. The LED output signals are controlled by PP0 – PP2 and illuminate in correspondence with the selected channel. Foot Pedal data is transferred and received by the microcontroller via a cable uniting connectors P3 and J3.

## **LCD Module**

The Lumex LCM-S02002DSF, depicted as LCD1 on the schematic diagram, is the 16 pin, 2-line by 20-character backlit LCD module implemented to display GCLS output information. The LCD module receives information from 8 pins connected to Port A (PA0 – PA7) and 3 pins connected to Port K (PK0 – PK3), shown in the “LCD Module” section of the schematic.

A voltage divider network, made up of R9 and R10 connected to LCD inputs VSS (pin 1), VDD, (pin 2), and VO (pin 3), is used to provide a fixed LCD contrast setting. Because the backlight of the LCD module is essentially an LED, a current limiting resistor tied to the source, R8, is placed in series with the anode (pin 15), with the cathode (pin 16) tied to ground.

## **Embedded LED Fretboard**

The schematic diagram section entitled “Embedded LED Fretboard” displays 24 LEDs (LED5 – LED28) configured as a 4 x 6 matrix in relationship to the upper four frets and six string positions of a standard guitar neck. Surface-mount LEDs with a forward drop of 2V, 20mA are implemented for space efficiency management. All LEDs are physically embedded into the neck flush with the fretboard.

The embedded LED fretboard is controlled by the 9S12 through the SPI. The MAX7221 (U5) serially interfaced LED display driver, is an LED Driver that is generally found in 8 digit seven segment LED display applications, however it can be used to drive up to 64 LEDs individually. The LED Driver receives information from the following output SPI connections: the select signal (/SS0), clock (SCK0), and master-in-slave-out (MOSI0). As shown in the schematic diagram section “LED Driver,” a current limiting resistor, R14, is implemented to control the LED intensity. The illumination intensity can also be manipulated through software from 15/16 to 1/16 of the maximum brightness with respect to the current limiting resistor. A bypass capacitor, C19, is utilized to minimize power-supply ripple due to the peak driver currents.

Because the digit pins of the LED Driver are designed to sink current, the cathode of each LED is connected to pins DIG0 – DIG5 in correspondence to the string position. The segment pins of the LED Driver source current to the anode of each LED, connected to the SEGA – SEGD, with respect to each fret position. Each LED can be controlled individually through software by sending a 16-bit word from the 9S12 to the LED Driver. The most significant byte of this word represents the address of the digit pins whereas the least significant byte represents the data of the segment pins.

### **Microcontroller Supporting Circuitry**

The other resources in the 9S12 utilized, shown in the schematic diagram, include the Reset Circuitry, Crystal Circuitry, and BDM Connector.

The /Reset pin of the 9S12 is connected to reset circuitry as a safety precaution to protect the system. The MAX6314 low-power CMOS microprocessor supervisory circuit (U4) is implemented, shown in the section entitled “Reset Circuitry.” As stated in the MAX6314 specifications, “the reset circuit asserts a reset signal whenever the VCC supply voltage falls below a preset threshold or whenever manual reset is asserted. Reset remains asserted for an internally programmed interval (reset timeout period) after VCC has risen above the reset threshold or manual reset is deasserted.”

The Crystal Circuitry is a 16 MHz oscillator circuit made up of a crystal (X1) and capacitor (C1 and C2) network. This circuit is implemented to clock the 9S12 and is connected the XTAL, EXTAL, and VSSPLL pins of the 9S12.

The BDM Connector is a 10 pin male header (J6) used for interfacing with the Noral debugging software. Loading and updating the final program into the 256K byte Flash EEPROM is performed through this connector.

## **Power Supply**

The microcontroller and all external circuitry of the GCLS require a steady 5 volt supply. As shown in the schematic diagram section entitled "Power Supply," DC power in ( $V_{in}$ ) is supplied to the system by a wall transformer ranging from 5 to 9 volts with a maximum current rating of 1 amp. The LM2931T-5 (U2) 3 lead package is utilized to provide a 5 volt regulated output (+5V). Two 10uF bypass capacitors (C17 and C18) are placed before and after the regulated voltage output to maintain stability. Because of the potentially large worst case power dissipated by the LED driver, a heat sink is attached to the regulator to protect the circuit board and surrounding circuitry.

A standard SPST rocker switch (SW5) is implemented to turn the GCLS unit on and off. The Power On LED (LED4) illuminates when the system is powered.

## Guitar Chord Learning System – Parts List

| Item | Quantity | Part Description                                    | Designators                 |
|------|----------|-----------------------------------------------------|-----------------------------|
| 1    | 2        | Cap – Mono, X7R, RAD, 10%, 22pF/50V                 | C1, C2                      |
| 3    | 11       | Cap – Mono, X7R, RAD, 10%, 0.1uF/50V                | C3, C7 - C13, C15, C16, C19 |
| 5    | 2        | Cap – Mono, X7R, RAD, 10%, 10uF/50V                 | C4, C14                     |
| 7    | 1        | Cap – Mono, X7R, RAD, 10%, 330pF/50V                | C5                          |
| 9    | 1        | Cap – Mono, X7R, RAD, 10%, 0.003uF/50V              | C6                          |
| 11   | 1        | Cap – Mono, X7R, RAD, 10%, 10uF/6V                  | C17                         |
| 13   | 1        | Cap – Mono, X7R, RAD, 10%, 10uF/25V                 | C18                         |
| 15   | 1        | Crystal, 16MHz 30PPM CA-301, 16.000M-C              | X1                          |
| 17   | 1        | IC, Microcontroller, Motorola MC9S12DP256B, 16-bit  | U1                          |
| 19   | 1        | IC, Voltage Regulator, LM2931T-5, 5V output         | U2                          |
| 21   | 1        | IC, RS232 Interface, Maxim MAX232A                  | U3                          |
| 23   | 1        | IC, Reset Circuit, Maxim MAX6314                    | U4                          |
| 25   | 1        | IC, LED Driver, Maxim MAX7221                       | U5                          |
| 27   | 1        | Jack, PCB mount, 2 x 8, 16 pin socket               | J1                          |
| 29   | 1        | Jack, radial, 10 pin socket                         | J2                          |
| 31   | 2        | Jack, 9 pin Serial, DB9, female                     | J3, J4                      |
| 33   | 1        | Jack, DC Power Jack, Normally Closed Shunt          | J5                          |
| 35   | 1        | Jack, BDM, 10 pin, male header                      | J6                          |
| 37   | 1        | LCD Module, Lumex LCM-S02002DSF, 20x2, backlit      | LCD1                        |
| 39   | 4        | LED, T1 3/4, 2V/20mA, Red                           | LED1 - LED4                 |
| 41   | 24       | LED, SMT, 2V/20mA, Red                              | LED5 – LED28                |
| 43   | 1        | Plug, PCB mount, 2 x 8, 16 pin                      | P1                          |
| 45   | 1        | Plug, radial, 10 pin                                | P2                          |
| 47   | 1        | Plug, 9 pin Serial, DB9, male                       | P3                          |
| 49   | 4        | Resistor, Metal Film, 1%, 221Ω/0.25W                | R1, R2, R3, R15             |
| 51   | 4        | Resistor, Metal Film, 1%, 1k Ω/0.25W                | R4, R5, R6, R7              |
| 53   | 1        | Resistor, Metal Film, 5%, 5Ω/0.125W                 | R8                          |
| 55   | 1        | Resistor, Metal Film, 1%, 18kΩ/0.125W               | R9                          |
| 57   | 1        | Resistor, Metal Film, 1%, 680kΩ/0.125W              | R10                         |
| 59   | 1        | Resistor, Metal Film, 1%, 3.99kΩ/0.25W              | R11                         |
| 61   | 1        | Resistor, Metal Film, 1%, 22.1Ω/0.25W               | R12                         |
| 63   | 1        | Resistor, Metal Film, 1%, 3.01kΩ/0.25W              | R13                         |
| 65   | 1        | Resistor, Metal Film, 1%, 10.2kΩ/0.25W              | R14                         |
| 67   | 3        | Switch, Pushbutton, Momentary, SPST, Normally Open  | SW1 - SW3                   |
| 69   | 1        | Switch, Snap-Action w/ Lever, SPDT, 3A @ 125/250Vac | SW4                         |
| 71   | 1        | Switch, Rocker, SPST, 6A @ 125/250Vac               | SW5                         |