“Solar Mailbox” project

The purpose of this project is to develop a self sufficient Mailbox (real one) that will be powered only by the sun and that will display the number of the house, but only in accordance with the battery level. The system must work autonomously when there is or not enough light to charge the battery.

Pictures of the Solar Mailbox

Illustration 1: Final external Realization

Illustration 2: At night: Central Digit On, other one in PWM Modes

Illustration 3: Internal Wiring

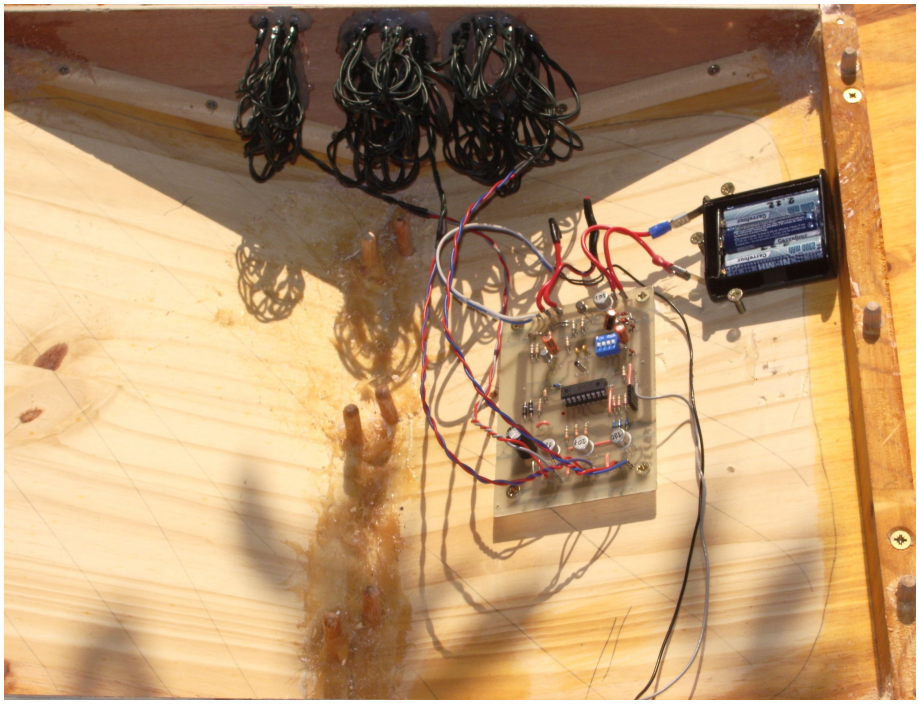
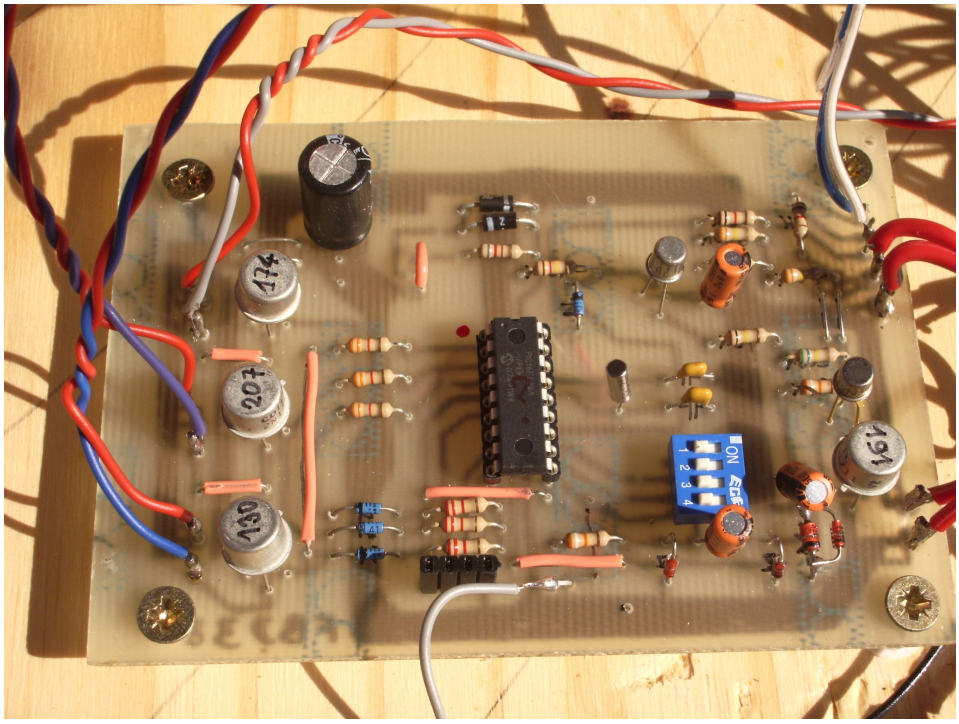


Illustration 4: PCB zoom



Explanations

The Mailbox is powered by a 5V/80mA Polysilicon solar cell. The sun energy is used to charge a 3 AA NiMH battery.
At night, when there is no light, the PIC is driving the 3 Digit according with a sequence which is defined in its program given in Annex.

Schematic Explanations

Refer to attached schematic

Charger_Control: The Solar Cell is charging the 3 AA NiMH cell trough the “Sziklai pair” composed by the T5 (2N2907) and T4 (1N1711). This is necessary to ensure a very low reverse current when the sun is off and the battery at full charge.
Control of the charge can be applied on D5 with a “1” level from the PIC , which will reverse the T6 that define the current in T5 base.
For Battery protection purpose, the value of Zener diode DZ6 must be 4.6V to prevent the battery for over-charging which will degrade significantly its life time. *This function is not yet managed by the PIC program and is reserved for further use.*

LED_OR_control: The 3 digits are controlled by 3 separate 2N1711 (each digit is compose about 20 white LED). The control signal is the OR between a PWM signal, that ensure a constant background level of light plus a “blinking” part which is the sequence generated by the PIC.

Sun_Sense: Just a low pas filter composed of R8 and C6. Beware that leakage current from the PIC can affect the level. This prevent R8 to be bellow 39KOhms.

Vbat_sense: These 2 diodes in serial create a 1.3V constant voltage that can be measured by the PIC to determine the level of the battery. *This function is not yet managed by the PIC program and is reserved for further use.*

Cpu: The PIC16F628 operates with a 32.768KHz crystal oscillator. This frequency have been selected, not to consume too much. In this condition, the PIC is able to operate down to 3V.

Behavioral Explanations

Apart when the Battery is totally low, the PIC is running and infinity loop which period is approximately 1 second, the red led is blinking accordingly.

During day light the ***SunSense*** signal is high and the PIC is not performing any operation (than the 1 second blinking loop). The Green led is on.
If the battery voltage is low enough, the Solar cell is charging it. If the Battery voltage is above 4.6V (3 times 1.3V), then the DZ6 is drawing the current to ground protecting the battery cells. *In the future **Vbat_sense** and **Stop_Charge** should be used.*

During night the SunSense signal get low and the PIC is programmed to:

- Generate a PWM signal (100Hz, Duty Cycle of 5%) on the PWM pin
- Generate a “blinking” sequence on the 3 separate control signals (1 minute period)

PIC Source Code

```
// ------------------------------------------------------------------------------------
//
//                                          Boite aux Lettres
//
//      (C) F. Druilhe 30 Juillet 2009
//
// ------------------------------------------------------------------------------------

#include <htc.h>
// Define Crystal Oscilator frequency
#define _XTAL_FREQ 32768UL

// Configure the Chip
__CONFIG(LP & WDTDIS & PWRTDIS & BORDIS & LVPEN & UNPROTECT);

// ------------------- Global Variables ----------------------
#define LED_SEQ 60
unsigned char                led_count;     // Led Counter
unsigned char                program;       // Number of sequence to execute
unsigned char                sec_count;     // Second counter
unsigned char                min_count;     // Minute counter
unsigned char                hour_count;    // Hours counter
unsigned int                 day_count;     // Day counter
unsigned char                sun_rise;      // First sun variation

// ----- Local Working variables
char                  c, d;                        // Local Variables


// Led Sequence
char    led_table[LED_SEQ] = {/* "8", "O", "1", void */
               0b0000, 0b0010, 0b1010, 0b1000, 0b1000, 0b1100, 0b0100, 0b0000, 0b0000, 0b0000,
               0b0000, 0b0010, 0b1010, 0b1000, 0b1000, 0b1100, 0b0100, 0b0000, 0b0000, 0b0000,
               0b0000, 0b0000, 0b0000, 0b0000, 0b0000, 0b0000, 0b0000, 0b0000, 0b0000, 0b0000,
               0b1110, 0b1110, 0b1000, 0b1000, 0b0110, 0b0110, 0b1110, 0b1110, 0b0000, 0b0000,
               0b0000, 0b0000, 0b0000, 0b0000, 0b0000, 0b0000, 0b0000, 0b0000, 0b0000, 0b0000,
               0b0010, 0b1000, 0b0100, 0b0000, 0b0100, 0b1000, 0b0010, 0b0000, 0b0000, 0b0000
               };

// Initializations
void initPORT(void)
       {
       // Port A: RA0: Vref_in
       //         RA1: L3Ctrl_out
       //         RA2: L1Ctrl_out
       //         RA3: L2Ctrl_out
       //         RA4: nc
       //         RA5: MCLR input
       //         RA6: Osc
       //         RA7: Osc
       TRISA = 0b11110001;
       // Port B: RB0: CellSence_in
       //         RB1: Rx_in
       //         RB2: Tx_out
       //         RB3: PWM_out
       //         RB4: Conf0_in
       //         RB5: Conf1_in
       //         RB6: StopChrg_out
       //         RB7: GLedCtrl_out
       // port directions: 1=input, 0=output
       TRISB = 0b00110011;
       // Option: PS:         000
       //                PSA:        0       assigned to Timer0
       //                T0SE:       0       faling edge
       //                T0CS:       0       internal clock
       //                INTEDG:     1       rising Edge (sunshine)
       //                nRBPU:      1       pull-ups disable
       OPTION = 0b11000000;
       // Set the Port to off
       PORTB = 0b00000000;
       PORTA = 0b00000000;
       // Program PWM frequency is 100Hz with a ratio is 5%, active high
       //      PR2:           0x51    (81); Freq = 32768/4/(PR2+1) = 99.9024 Hz
       PR2 = 0x51;
       //      CCPR1L:        0x8             (16/4); FreqOn = 32768/(PR2+1) = 2000Hz
       CCPR1L = 0x4;
```

```
        //              CCP1CON:       CCP1X:  0       Lsb
        //                                     CCP1Y:  0       ..
        //                                     CCP1M3..0: 1110         PWM active high
        CCP1CON= 0x0E;
        //              T2CON:         T2CKPS1..0:    00              Predividor by 1
        //                                     TMR2ON:         0               Off
        //                                     TOUTPS3..0:    0000    Postdividor by 1
        T2CON   = 0;
}

#define enable_PWM     T2CON = 0b00000100
#define disable_PWM    T2CON = 0b00000000

void initVAR()
{
        // Init Variables
        program= 0;
        led_count = 0;
        sun_rise = 0;
        // Init Time
        sec_count = 0;
        min_count = 0;
        hour_count = 0;
        day_count = 0;
}

// Main
void main(void)
        {
        initPORT();             // Init platform Ports
        initVAR();              // Init Variables
        while (1){
                PORTB = 0b10000000;    // Set Green Led on
                __delay_ms(100);       // small delay
                PORTB = 0b00000000;    // Clear Green Led off
                //------- Read Sun Level
                c = PORTB & 0b00000001;
                if (c) {
                        //----------- Sun raise: reset everything
                        led_count = 0;                          // Reset Led Counter
                        sun_rise = 0;
                        PORTA = 0b00000000;                     // Clear all Led Bits
                        disable_PWM;
                } else {
                        //----------- Sun fall: light on Leds
                        if (!sun_rise) {
                                enable_PWM;
                                sun_rise = 1;
                        }
                        // Execute the current led sequence
                        c = led_table[led_count] & 0b00001110;// Get the sequence in the table
                                                              // and mask in case
                        PORTA = c;                            // Set leds
                        led_count++;                          // Increment the Led Counter
                        if (led_count >= LED_SEQ) led_count = 0;     // Reset led sequence
                }
                //---------------- Complement to 1 second --------------------
                __delay_ms(900);                              // one second
                //------- Increment overall time
                sec_count++;
                if (sec_count >= 60) {
                        sec_count = 0x0;
                        min_count++;
                        if (min_count >= 60) {
                                min_count = 0x0;       // Hours not manged yet
                                hour_count++;
                                if (hour_count >= 24) {
                                        hour_count = 0;
                                        day_count++;   // Increment Day
                                }
                        }
                }
        }
}
```