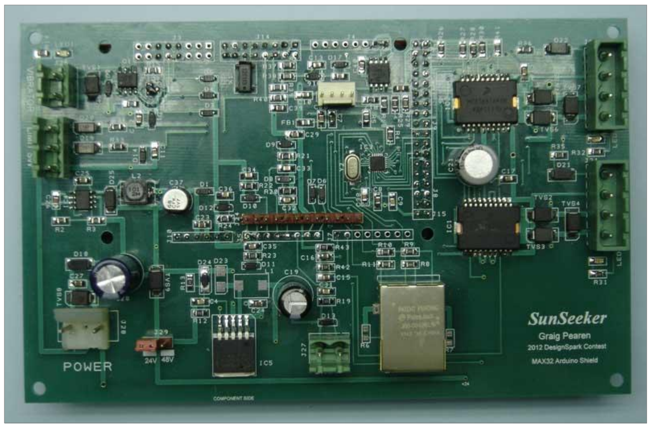
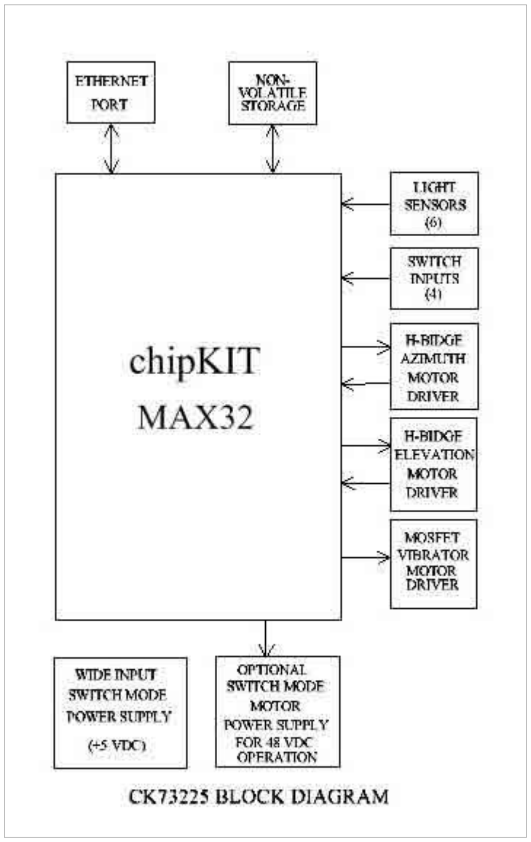
chipKIT MAX32 Contest Entry CK73225

SunSeeker is a controller which keeps solar photovoltaic (PV) arrays facing directly into the sun at all times. It is generally accepted that tracking the sun results in an annual increase in power production of about 30%. The major challenge is dealing with the infinite variety of weather and sky conditions. My design philosophy is to do as much in software as possible and keep the hardware simple. In spite of that, the circuit board is more than twice the size of the Max32, mostly due to the power electronics and surge protection devices. This contest submission is a design platform for developing the software algorithms to produce a high performance array tracker.



This project is a third generation prototype, each with a more powerful processor, more complex software, and more data logging. The Max32 will enable me to develop the Ethernet and Internet communication software, and to switch between different tracking algorithms depending on sky conditions. My objective for this contest was to replicate the functionality of the previous assembly language software in C++ using MPIDE. A few enhancements have been added but most of the additional features will be developed over the next two to three years. Prototypes using this chipKIT design will be evaluated on a 1.8kw and a 2.2kw array, both located at 53° north latitude.

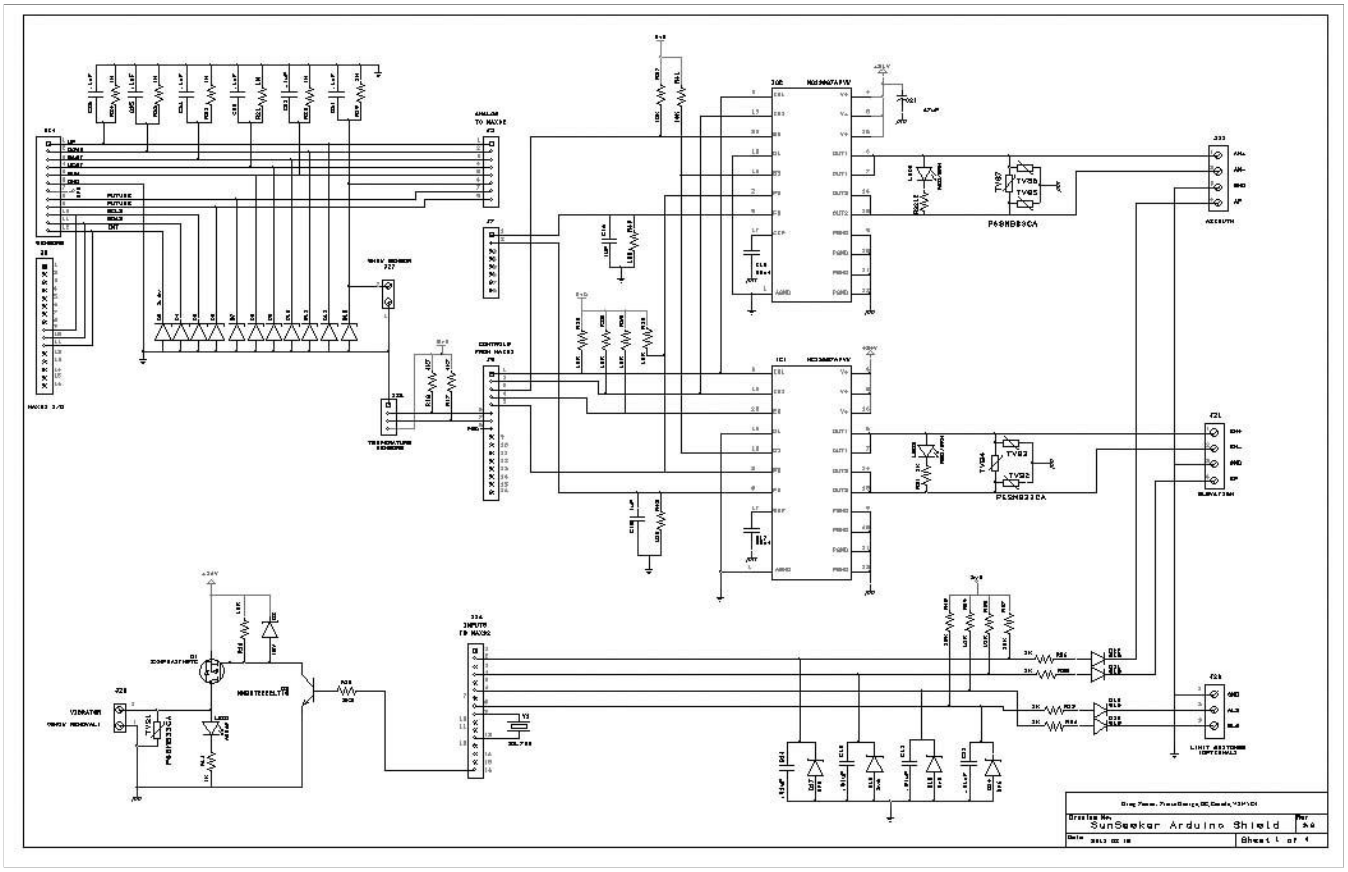

ETHERNET PORT
NON-VOLATILE STORAGE
chipKIT MAX32
LIGHT SENSORS (6)
SWITCH INPUTS (4)
H-BIDGE AZIMUTH MOTOR DRIVER
H-BIDGE ELEVATION MOTOR DRIVER
MOSFET VIBRATOR MOTOR DRIVER
WIDE INPUT SWITCH MODE POWER SUPPLY (+5 VDC)
OPTIONAL SWITCH MODE MOTOR POWER SUPPLY FOR 48 VDC OPERATION
CK73225 BLOCK DIAGRAM

SunSeeker is a full featured “bells-and-whistles” model that tracks the sun, deals with natural events such as snow, ice, high winds, and eclipses. It identifies sky conditions, compiles statistics, and communicates with computers or file servers. It measures motor current in milliamps, pulse widths in microseconds, PV module temperature, air temperature and the daily minimum and maximum temperatures with the times that those temperatures were first reached. These data collection capabilities enable *SunSeeker* to be used as a research tool to establish local climate data for PV system design and to facilitate software algorithm development and refinement.

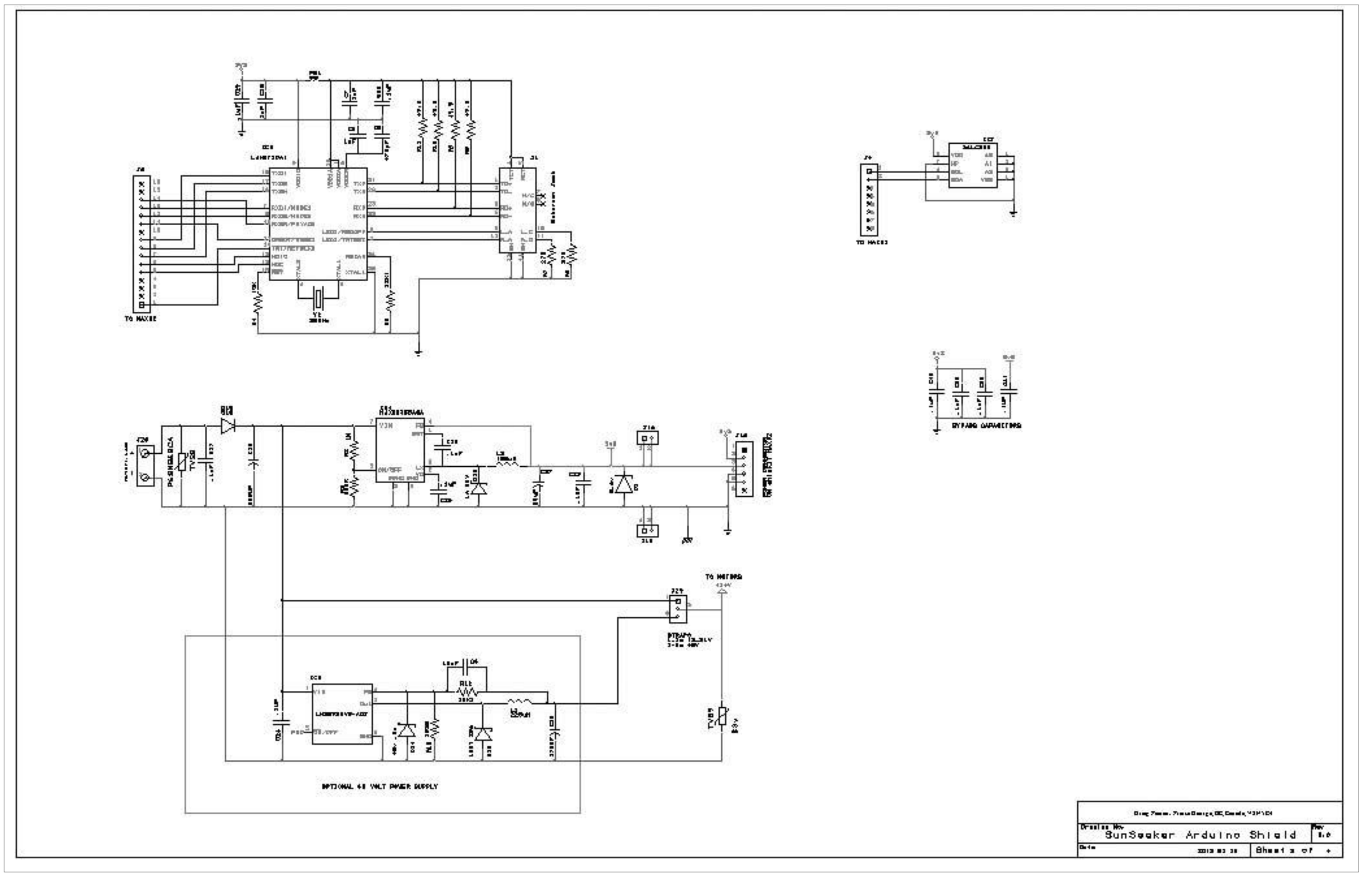
Diagnostic software watches the motors to detect any hardware fault that may occur. The H-bridges have internal fault detection, the current drawn by the motors is monitored, and the pulses from the motor drive assemblies are counted to show both movement and position. *SunSeeker* is designed to operate at any voltage between 12 and 48 volts nominal battery voltage The *SunSeeker* board contains two switching mode power supplies. The 5 volt supply provides 5 volts to both the Max32 board and the shield. The optional 24 volt power supply is enabled by the processor only when needed to run the motors from a 48 volt power system.

The following small sample of code is the heart of tracking the sun using light sensors. This critical code provides the basic tracking function and sets up the conditions that are used for other decision making software.

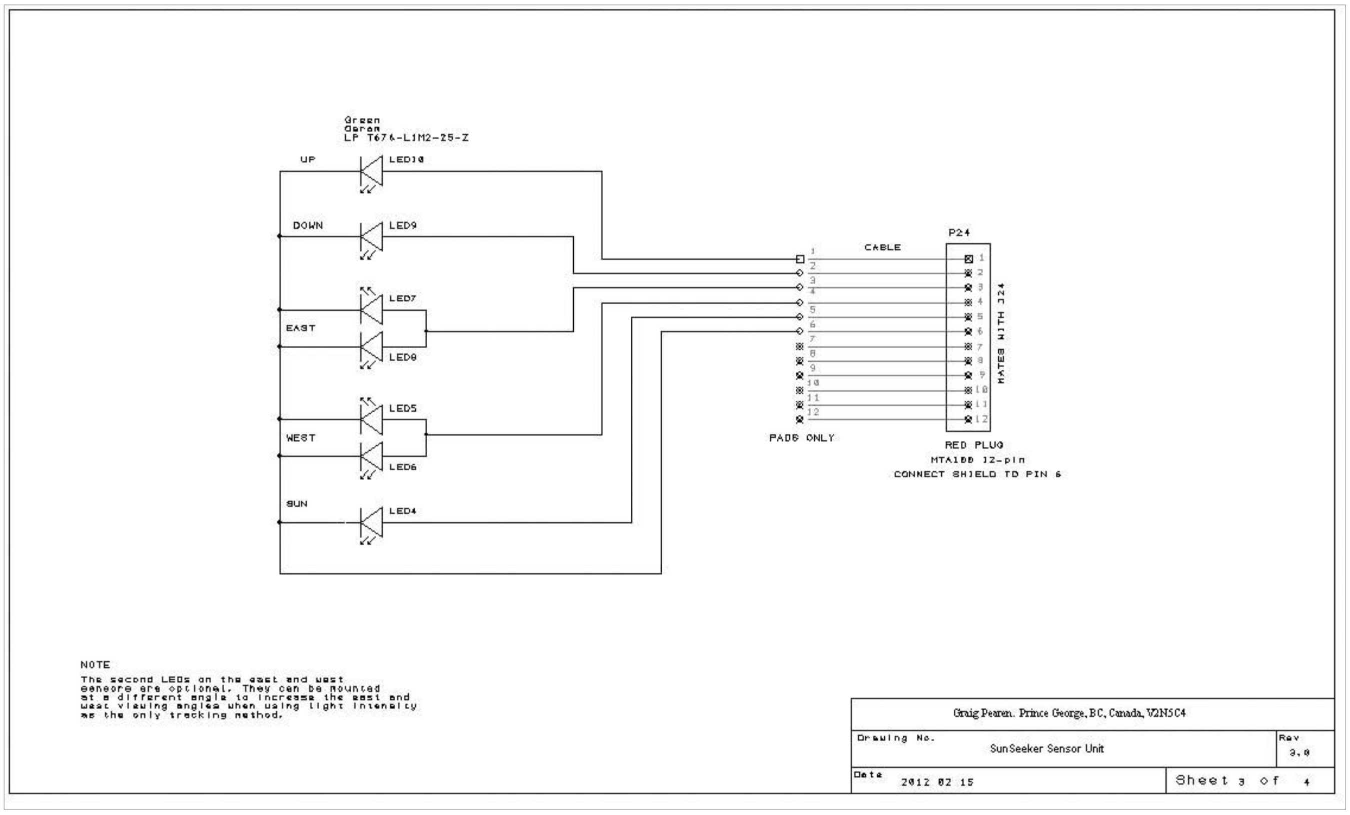
```
 /*------------------------------- TRACKING ----------------------------------

          - Compare the light readings
          - Move the array if required
          - Skip azimuth tracking if it is failed
          - skip elevation tracking if it is failed or disabled (snow accumulation)

   */

void Track() {
  if (! azfail){
     if (lightWest > lightEast) {
       if (! digitalRead(pinAzEnable)) West();   // start west tracking
     }

    if (lightEast > lightWest) {
      if (! digitalRead(pinAzEnable)) East();     // start tracking east
    }
  }

  if (! (elfail || snow || vertical)){           // abort if elevation is disabled
    if (lightUp > lightDown) {
      if (! digitalRead(pinElEnable)) Up();      // start tracking up
    }

    if (lightDown > lightUp) {
      if (! digitalRead(pinElEnable)) Down();    // start tracking down
    }
  }
}

/*----------------------- READ THE LIGHT INTENSITY SENSORS --------------------

           - Read all the light sensors, use the upper 8 bits only
           - take 4 readings and average them

     EXIT: - light levels are set
           - sky.condition is set
*/

void Light (){
  int temp=0;
  for(int i=0; i<5; i++) temp = temp + (analogRead(pinEastSensor) >> 2);
  lightEast = temp >> 2;

  temp=0;
  for(int i=0; i<5; i++) temp = temp + (analogRead(pinWestSensor) >> 2);
  lightWest = temp >> 2;

  temp=0;
  for(int i=0; i<5; i++) temp = temp + (analogRead(pinUpSensor) >> 2);
  lightUp = temp >> 2;

  temp=0;
  for(int i=0; i<5; i++) temp = temp + (analogRead(pinDownSensor) >> 2);
  lightDown = temp >> 2;

  temp=0;
  for(int i=0; i<5; i++) temp = temp + (analogRead(pinSunSensor) >> 2);
  lightSun = temp >> 2;

  if (lightSun < DAWN)  skyCondition = DARK;
  else if (lightSun < CLOUD){
    if (mode == PARKED) skyCondition=DAWN;
    else skyCondition=DUSK;
    }
  else if (lightSun < HAZE)  skyCondition = CLOUDY;
  else if (lightSun < SUN)   skyCondition = HAZY;
  else                       skyCondition = SUNNY;

  temp=0;
  for(int i=0; i<5; i++) temp = temp + (analogRead(pinSnowSensor) >> 2);
  lightSnow = temp >> 2;
}
```



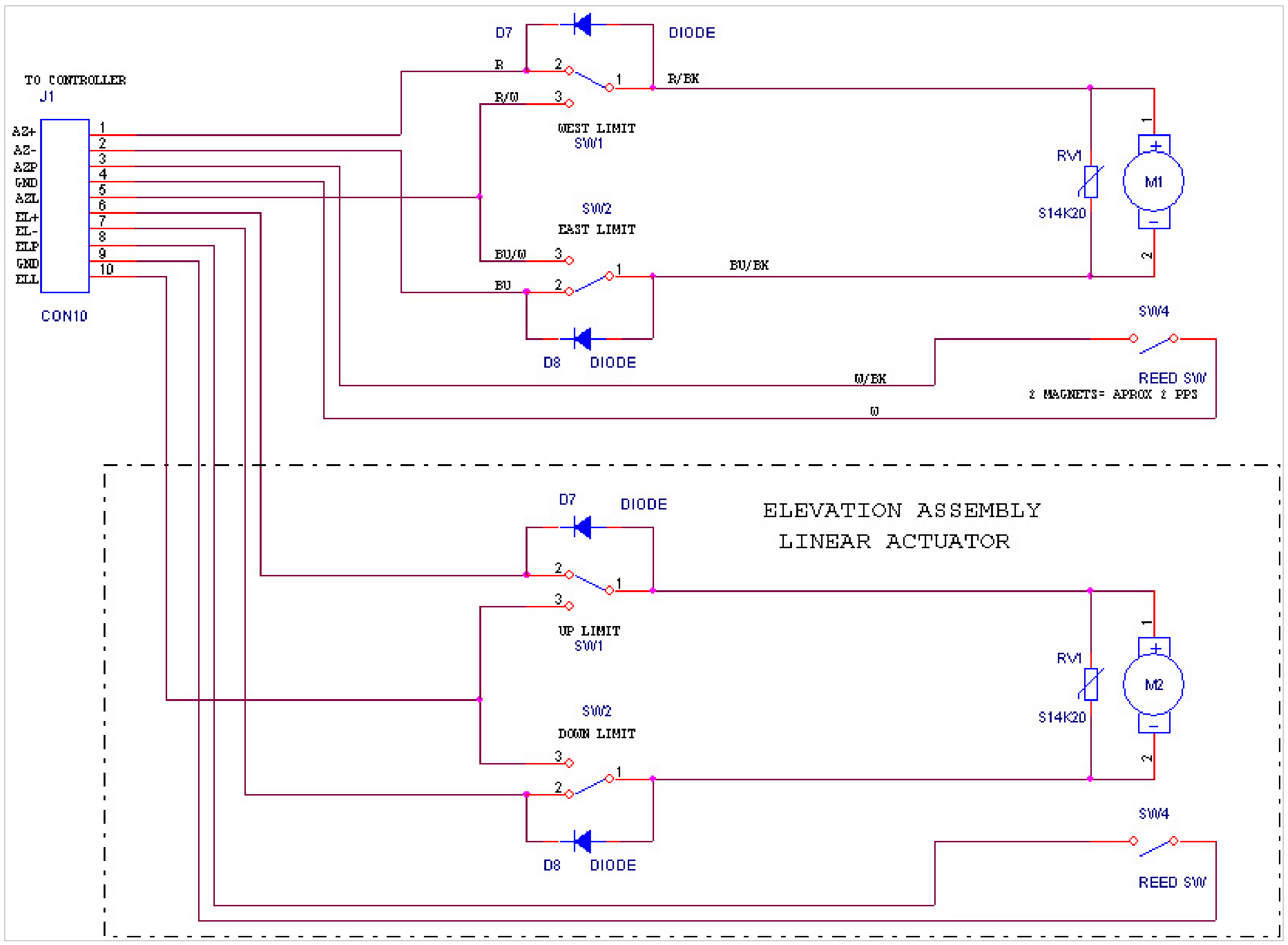
Schematic-1 Motor drivers and signal conditioning



Schematic-2 Ethernet, power supplies, non-volatile storage


Green
Osram
LP T676-L1M2-25-Z
UP
LED10
DOWN
LED9
LED7
EAST
LED8
LED5
WEST
LED6
SUN
LED4
CABLE
P24
1
2
3
4
5
6
7
8
9
10
11
12
MATES WITH J24
PADS ONLY
RED PLUG
MTA100 12-pin
CONNECT SHIELD TO PIN 6
NOTE
The second LEDs on the east and west sensors are optional. They can be mounted at a different angle to increase the east and west viewing angles when using light intensity as the only tracking method.
Graig Pearen. Prince George, BC, Canada, V2N5C4
Drawing No.
SunSeeker Sensor Unit
Rev
3.0
Date
2012 02 15
Sheet 3 of 4

Schematic-3 Light sensors



Schematic-4 Motor drive assemblies