Grade Crossing Controller

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Contents

The Project

On the CV we have several grade crossings that need to be animated. We use the Walthers crossing flashers and the IOWA Scale Engineering sound modules for our crossing. Since there are several trackage configurations we have decided to use an Arduino Nano as the crossing controller. This allows us flexibility for controlling approach, exit, and overall timing of the crossing signals.

Arduino Sketch: GradeCrossing 1.3

Features

The software provides:

- Multiple tracks per crossing
- Handle different track counts left, right, and at the road crossing
- Three sensor operation:
    - "Distant" sensors per track to detect the approach and exit of a train
    - A crossing sensor at the road (per track) to confirm the train
- Handle a train hitting a distant sensor but stopping short of the crossing
- Allow a train to exit and hit the distant exit sensor without triggering the flashers

- Determine of the most probable exit track to minimize alerts on exit
- Multiple crossings on a single Arduino depending on ports
- Auto-calibrating analog sensors using photoresistors or phototransistors
- Sensor sensitivity control
- Optional sound control
- Optional gate control either servo or digital (not tested)

The Design

When a train hits a distant sensor, the lights and sound alerts are activated after an optional *WaitABitSecs* delay. They will continue for *TimeoutSecs* seconds or until the crossing sensor is hit. If the timeout occurs the alert will stop. If the crossing sensor is hit the alert will start or continue until the crossing sensor is cleared. Hitting the crossing sensor will also set the most probable exit distant sensor to *ignore until cleared*. It will not trigger an alert on the exit of a train.

The timer *GateDlyMs* controls when the gate is dropped after the lights are started, and when the gate is raised after the crossing sensor clears.

The timer *LiteDlyMs* controls when the lites and sound are stopped after the crossing sensor clears.

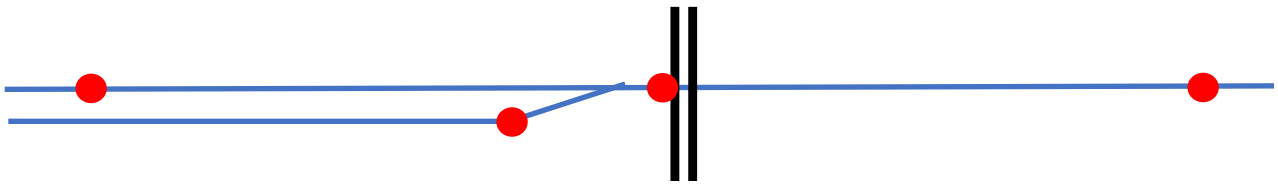
Sensors in the track may be either analog or digital. Sound control is a digital outout. Gate control may either a servo or a digital output. There are *define* statements which specify what is up/down or on/off.

Digital sensor reading for track/train detection is straightforward. Analog sensors are integrated over *LoopMS* interval (milliseconds) to average variance in LED or other variable lighting. Analog sensors are also recalibrated every *RecalibrateMts* minutes to adjust for changes in room lighting.

Placing Sensors

Two *distant* sensors and a *crossing* sensor are required as a minimum. The distant sensors should be placed where one desires the crossing signal to start. An optional delay can be invoked if a distant sensor is too distant. The *crossing* sensor should be as close to the road as possible.

In other trackage configurations sensors may be placed to reflect operational considerations. For example, a main line with a siding could have the main line sensors reasonably distant, but it would make sense for the siding sensor to be near the fouling point of the turnout to enter the main, allowing a train in the siding to approach the crossing and wait for a meet without triggering the signals.



Software: Definitions

A crossing is defined with these defines and data structures:

```
// Define the active crossings - NumXings crossings
// each crossing - up to NumTrks tracks, up to 3 sensors per track
// number of gate controls per crossing
#define NumXings 1
```

```
#define NumTrks  2
#define NumGates 2
//
// dont change:
#define NumSnsrs NumTrks * 3

// Sensor types for in-track sensors: digital or analog
#define DigType   0
#define AlgType   1

// Crossing gate type:
#define SrvoType  1
// -- or DigType for gate control

// Define crossing (XingDef) array elements
typedef struct {
  // input sensors analog or digital - DigType - AlgType
  int SnsrType;
  // first sensor address
  uint8_t SnsrLst[NumSnsrs];
  // first crossing lamp address of two in sequence - left/right lamp flash control
  uint8_t FirstLite;
  // sound address - digital mode or empty 0
  uint8_t SoundCntl;
  // gate address - digital mode or empty 0
  uint8_t GateCntl[NumGates];
  // GateType SrvoType or DigType
  int GateType;
} XingDef;
```

The definition below represents the track diagram shown above: A main track with a siding. The sensors are analog and on the main track are A0 & A2. The siding sensor is A1. The crossing sensor is A3. The crossing lights are digital outputs 2 & 3. The sound is digital output 4. There are no gates.

```
// 1 trk south, 2 trks at crossing, 1 trk north
// main+siding south, 1 trk at crossing, 1 trk north
// A crossing is defined by the following array
XingDef Crossing [NumXings] =
//  SnsrType, EastSnsr[NumTrks], WestSnsr[NumTrks], XingSnsr[NumTrks],
  {  AlgType, A0, A1,            A3,    0,          A2, 0,
//     FirstLite, SoundCntl, GateCntl, GateType
       2,         4,         0,0,      NoGate};
// and the WaitABitSecs array
// East wait, West wait
int WaitABitSecs[NumXings][NumTrks*2] =
  {0,0,0,0};
//
// Sensitivity - sensor must be within % of lowest to trigger
#define Sentivity 16
// if digital track sensors use clear for occupied, true
#define DigInvert true
//
// FlashIntvl - ms per flash for crossing lites
#define FlashIntvl 700
// TimeoutSecs - turn off after distant hit but center not hit
#define TimeoutSecs 20
// GateDlyMs - number of ms after sensing and lites/bell start before gates drop
//           - also number of ms after sensing clears gates go up
#define GateDlyMs 4500
// LiteDlyMs - number of ms after sensing clears that lites and bell stop
#define LiteDlyMs 3500
```

Sensor setup: When installing or debugging an installation, I found a need to confirm that the Arduino was detecting the sensor properly. I decided to use the on-board LED 13 for this purpose. You can choose some other digital output for this purpose. A 0 (zero) will disable this feature.

```
// if SnsrActiveLED is non-zero, light the LED indicated if any sensor is active
#define SnsrActiveLED 13
// #define SnsrActiveLED 0
```

When I tested on the layout, I used a train with logging cars and a very short logging caboose. This caused the sensors to alternate between clear and occupied while the train was passing. I decided to place a timer to hold a sensor *occupied* (in software) to control swings caused by skeleton cars or couplings.

```
// hold occupied status for this time to minimize bounce (false clear)
// - for couplers, skeleton cars - in milliseconds
#define HoldOccMS 1000
```

Other Defines

```
// if digital track sensors use clear for occupied, true
#define DigInvert true
//
// FlashIntvl - ms per flash for crossing lites
#define FlashIntvl 700
//
// ************************************************************************
// END USER TUNEABLE Defines
// ************************************************************************
// Change anything below here at your own risk
// ************************************************************************
// analog sampling controls - needed to average light flicker
// length of sample integration in millisecs
// 34 ms for 60 cycle lighting mains
// 40 ms for 50 cycle lighting mains
#define LoopMS 34

// Occupied threshold - 3 means that reading must be in the high/low 3rd of the
high/low range
// for the sensor to be occupied
#define OccLimit 3

// Servo defines for gate
#define GateDownS 0
#define GateUpS   90
#define FullArc   120
Servo CrossingGate[NumXings];

// high/low defines for digital gate
#define GateDown HIGH
#define GateUp   LOW

// high/low defines for sound
#define SndOff   HIGH
#define SndOn    LOW

// define lampon/off
#define LampOn   LOW
#define LampOff  HIGH

// ***************** Trace & Debug
```

```
// 0 - no trace; 1 - events; 2 - flow and data
//   3 - even more
#define Trace 0
// delay in ms for main loop sampling
// -- if tracing/debugging
#define MainLoopDlyMS 5000
```

Board Schematic

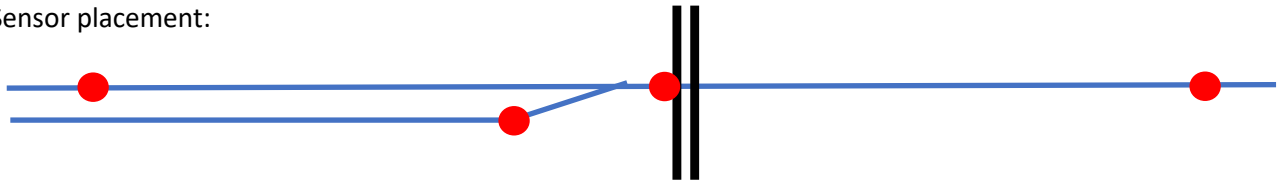
There is a separate document for the board wiring: GateCrossinglBoard.docx.

Specifics for the Central Vermont

South Coventry

Note re crossing lights: The **red** leads are the +5 volt common.

Sensor placement:



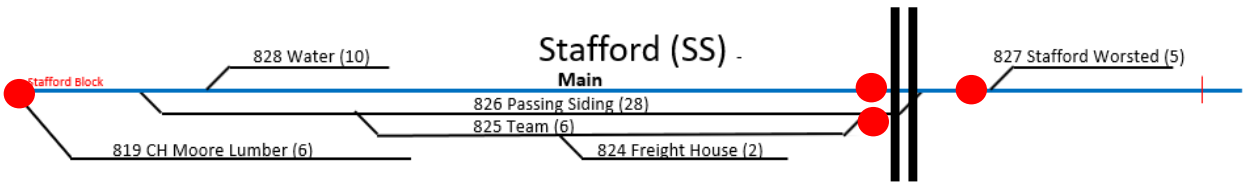
Software configuration:

```
// DEFINITIONS for Central Vermont South Coventry
// main+siding south, 1 trk at crossing, 1 trk north
// A crossing is defined by the following array
XingDef Crossing [NumXings] =
//  SnsrType, EastSnsr[NumTrks], WestSnsr[NumTrks], XingSnsr[NumTrks],
  {  AlgType, A0, A1,            A3,    0,          A2, 0,
//     FirstLite, SoundCntl, GateCntl, GateType
       2,         4,         9, 10,    NoGate};
// and the WaitABitSecs array
// East wait, West wait
int WaitABitSecs[NumXings][NumTrks*2] =
  {0,0,0,0};
//
// Sensitivity - sensor must be within % of lowest to trigger
#define Sentivity 16
// if digital track sensors use clear for occupied, true
#define DigInvert true
//
// FlashIntvl - ms per flash for crossing lites
#define FlashIntvl 700
// TimeoutSecs - turn off after distant hit but center not hit
#define TimeoutSecs 20
// GateDlyMs - number of ms after sensing and lites/bell start before gates
drop
//           - also number of ms after sensing clears gates go up
#define GateDlyMs 4500
// LiteDlyMs - number of ms after sensing clears that lites and bell stop
#define LiteDlyMs 3500
// END DEFINITIONS for Central Vermont South Coventry
```

Stafford

Note re crossing lights: The **black** leads are the +5 volt common.

Sensor placement:



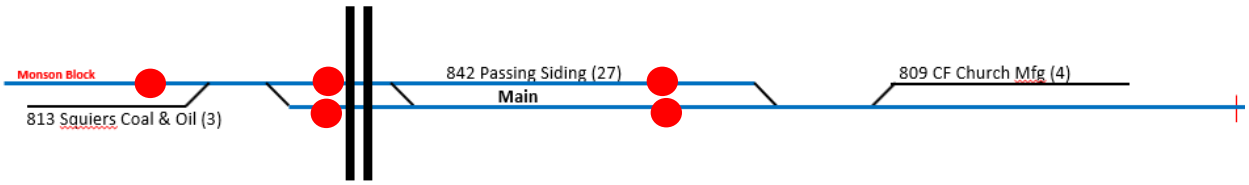
Software configuration:

```
// DEFINITIONS for Central Vermont Stafford
// 1 trk south, 2 trks at crossing, 1 trk north
// delay approach from south 10 secs
// A crossing is defined by the following array
XingDef Crossing [NumXings] =
//  SnsrType, EastSnsr[NumTrks], WestSnsr[NumTrks], XingSnsr[NumTrks],
  {  AlgType, A0, 0,             A3,    0,          A1,   A2,
//     FirstLite, SoundCntl, GateCntl, GateType
       2,         4,         0, 0,     NoGate};
// and the WaitABitSecs array
// East wait, West wait
int WaitABitSecs[NumXings][NumTrks*2] =
  {10,  0,  0,  0};
//
// Sensitivity - sensor must be within % of lowest to trigger
#define Sentivity 2
// if digital track sensors use clear for occupied, true
#define DigInvert true
//
// FlashIntvl - ms per flash for crossing lites
#define FlashIntvl 700
// TimeoutSecs - turn off after distant hit but center not hit
#define TimeoutSecs 20
// GateDlyMs - number of ms after sensing and lites/bell start before gates
drop
//           - also number of ms after sensing clears gates go up
#define GateDlyMs 4500
// LiteDlyMs - number of ms after sensing clears that lites and bell stop
#define LiteDlyMs 3000
// END DEFINITIONS for Central Vermont Stafford
```

Monson

Note re crossing lights: The **black** leads are the +5 volt common.

Sensor placement:



Software configuration:

```
// DEFINITIONS for Central Vermont Monson
// 1 trk south, 2 trks at crossing, 1 trk north
// delay approach from south 0 secs
// approach from south probably exits on trk 2 main north
// A crossing is defined by the following array
XingDef Crossing [NumXings] =
//  SnsrType, EastSnsr[NumTrks], WestSnsr[NumTrks], XingSnsr[NumTrks],
```

```
  {  AlgType,    A0, 0,            A1, 0,            A2,  A3,
//     FirstLite, SoundCntl, GateCntl, GateType
       2,         4,         0, 0,     NoGate};
// and the WaitABitSecs array
// East wait, West wait
int WaitABitSecs[NumXings][NumTrks*2] =
  {0,  0,  0,  0};
// Sensitivity - sensor must be within % of lowest to trigger
#define Sentivity 3
// if digital track sensors use clear for occupied, true
#define DigInvert true
//
// FlashIntvl - ms per flash for crossing lites
#define FlashIntvl 700
// TimeoutSecs - turn off after distant hit but center not hit
#define TimeoutSecs 20
// GateDlyMs - number of ms after sensing and lites/bell start before gates
drop
//           - also number of ms after sensing clears gates go up
#define GateDlyMs 4500
// LiteDlyMs - number of ms after sensing clears that lites and bell stop
#define LiteDlyMs 3000
// END DEFINITIONS for Central Vermont Monson
```