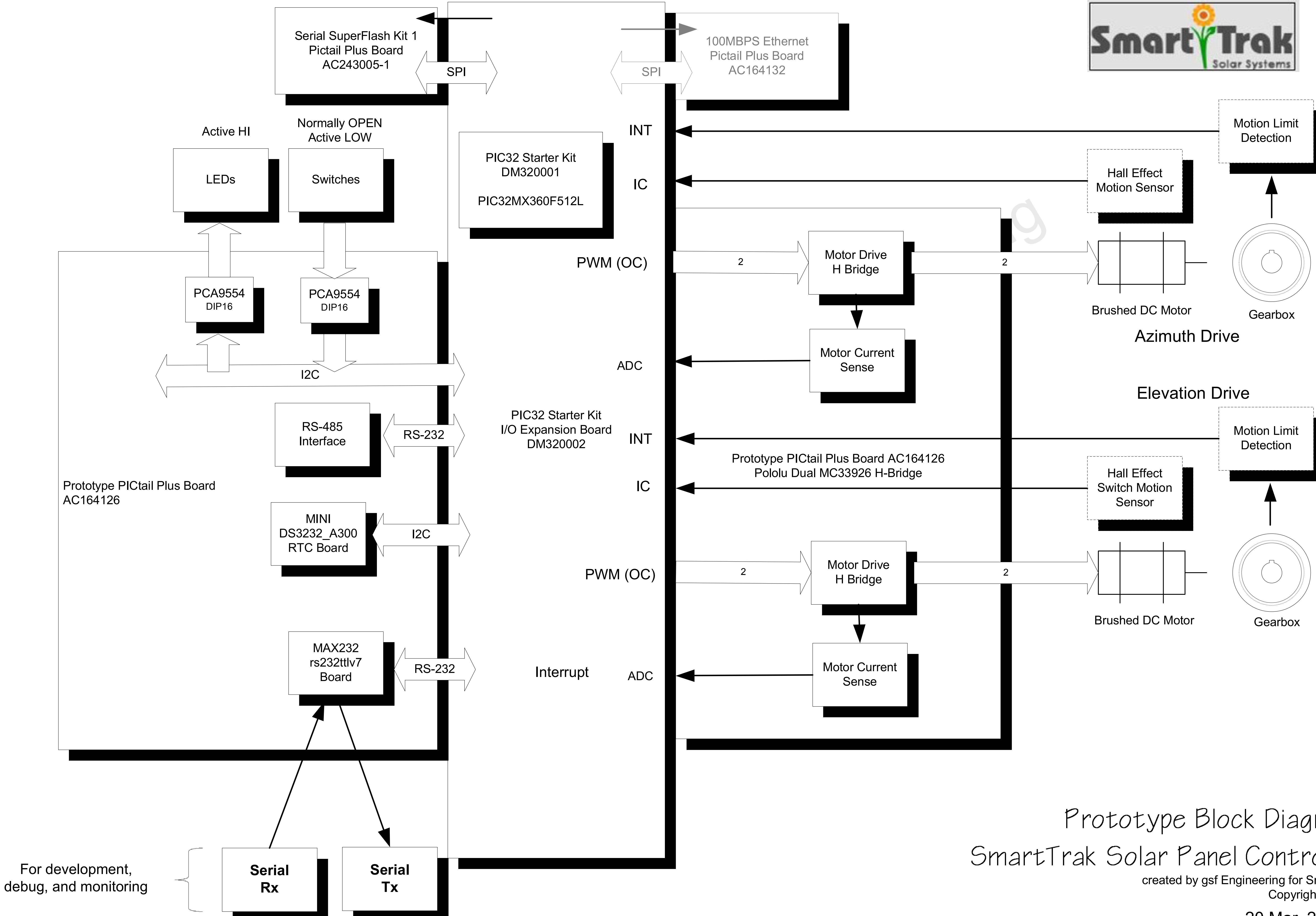


Prototype Block Diagram

SmartTrak Solar Panel Controller

created by gsf Engineering for SmartTrak

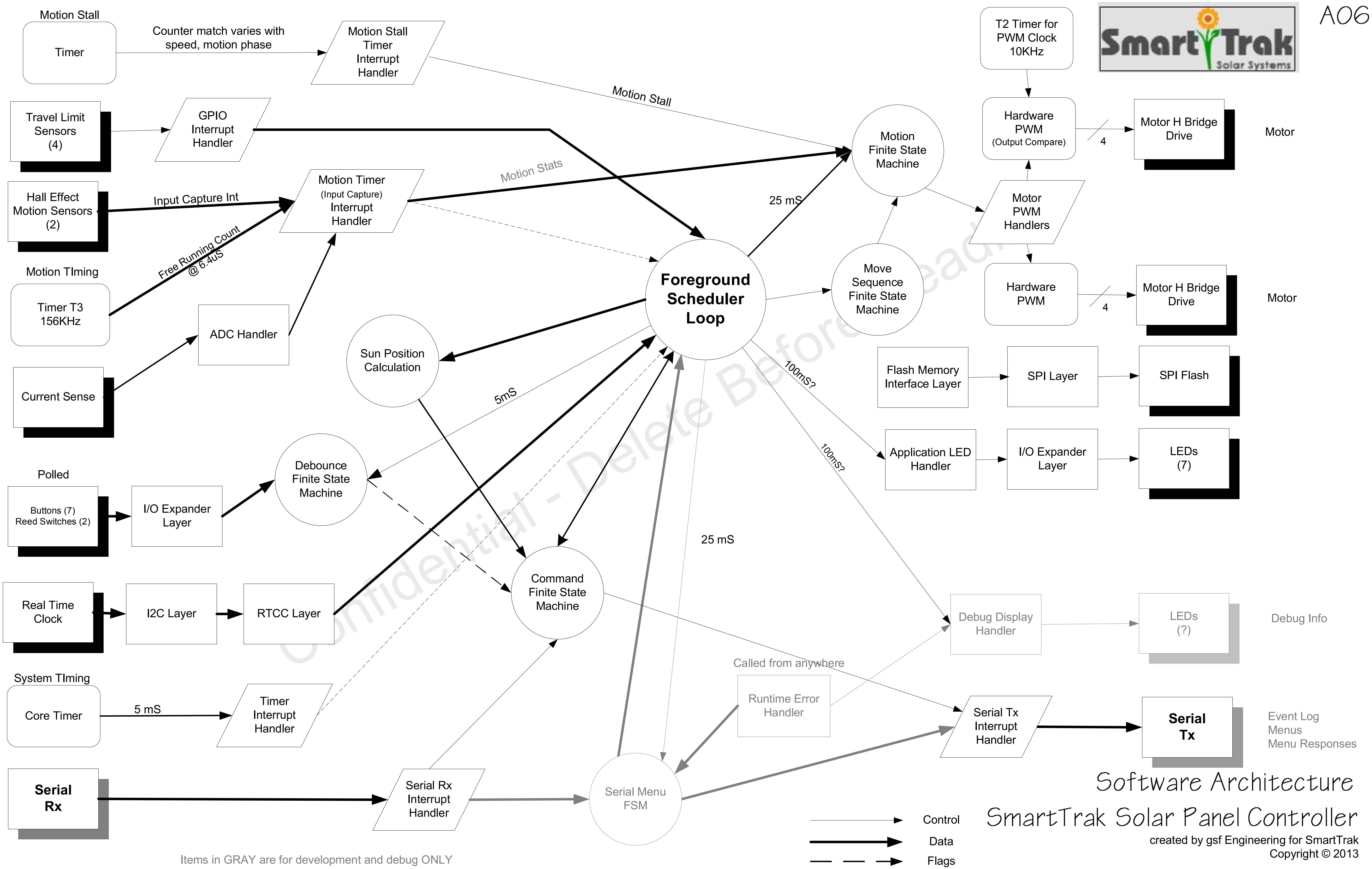
20 Mar, 2013

System Block Diagram

SmartTrak Solar Panel Controller

created by gsf Engineering for SmartTrak

20 Mar, 2013

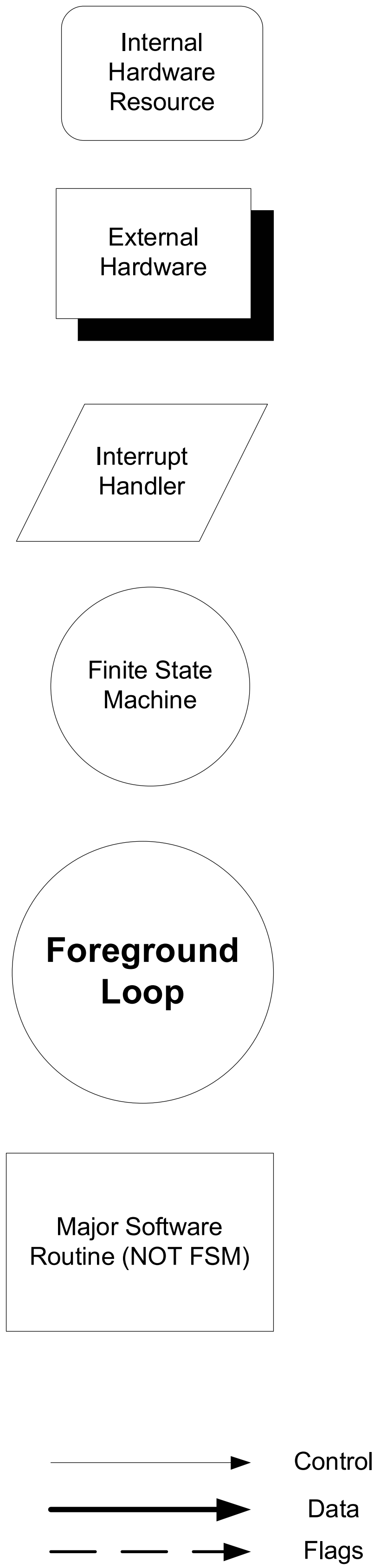


Software Architecture

SmartTrak Solar Panel Controller

created by gsf Engineering for SmartTrak

20 Mar, 2013

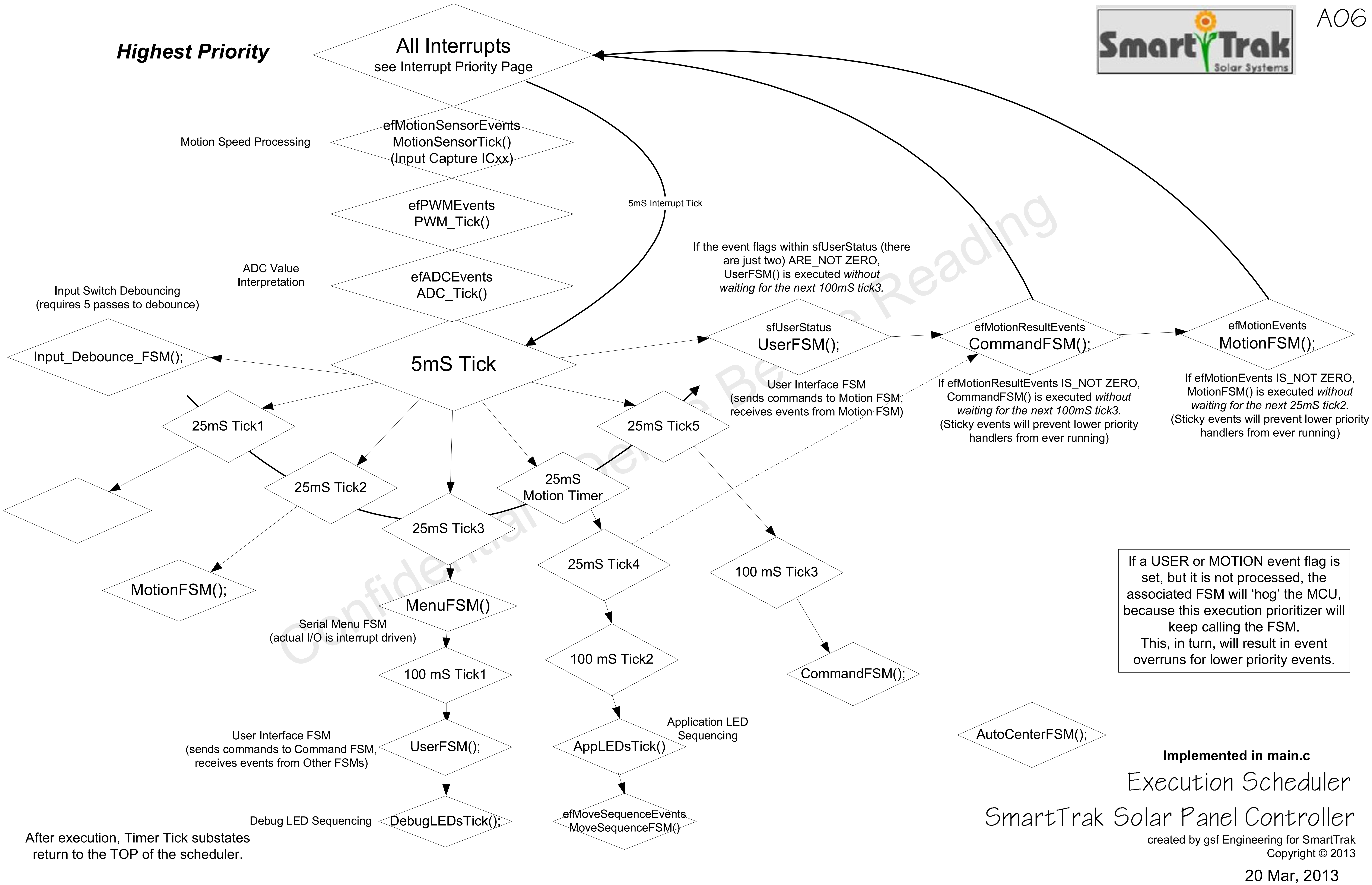


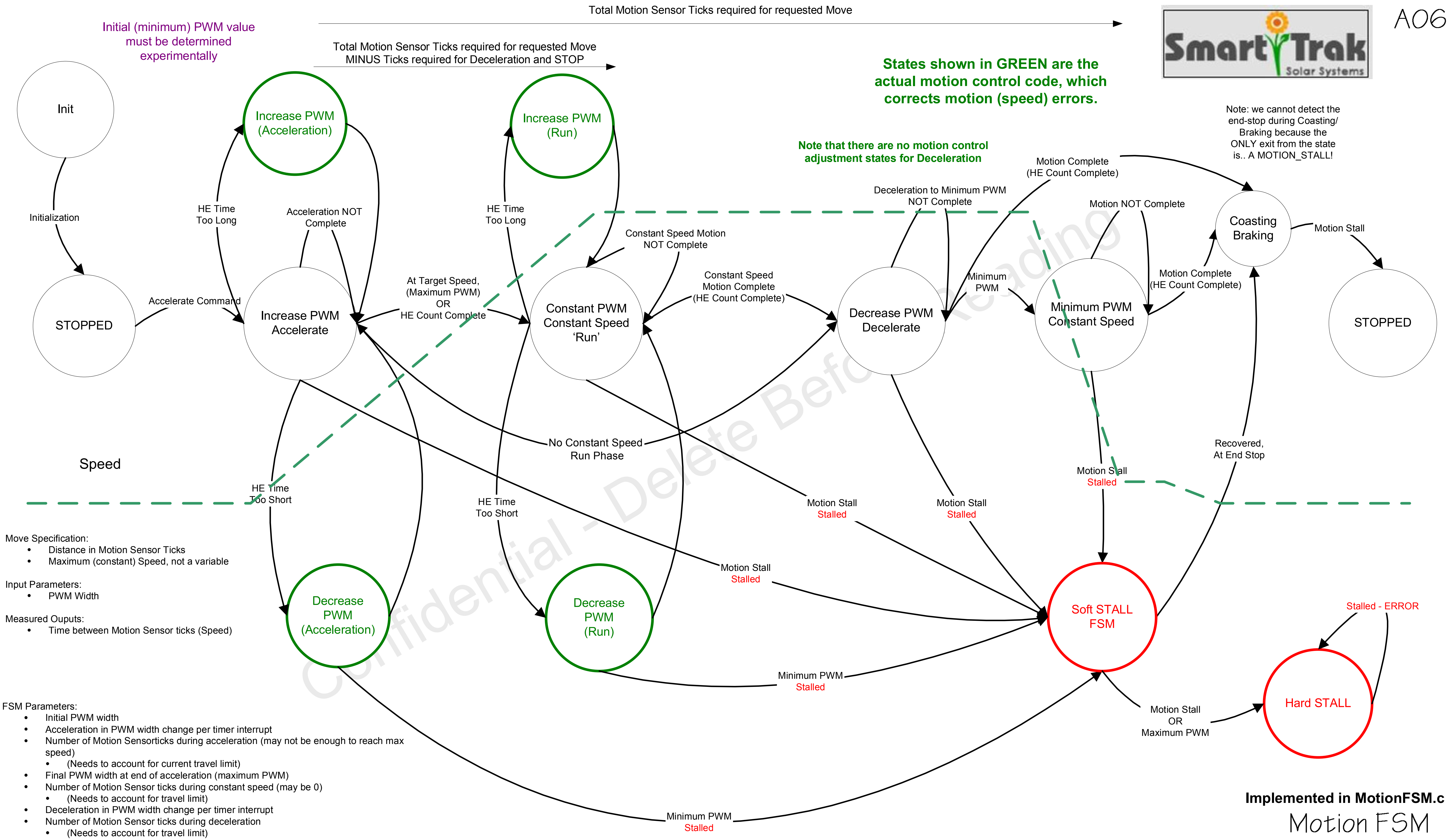
Drawing Legend

SmartTrak Solar Panel Controller

created by gsf Engineering for SmartTrak

20 Mar, 2013


A06
Highest Priority
All Interrupts
see Interrupt Priority Page
Motion Speed Processing
efMotionSensorEvents
MotionSensorTick()
(Input Capture ICxx)
efPWMEvents
PWM_Tick()
ADC Value
Interpretation
efADCEvents
ADC_Tick()
5mS Interrupt Tick
Input Switch Debouncing
(requires 5 passes to debounce)
Input_Debounce_FSM();
5mS Tick
If the event flags within sfUserStatus (there
are just two) ARE_NOT ZERO,
UserFSM() is executed *without*
waiting for the next 100mS tick3.
sfUserStatus
UserFSM();
efMotionResultEvents
CommandFSM();
efMotionEvents
MotionFSM();
User Interface FSM
(sends commands to Motion FSM,
receives events from Motion FSM)
If efMotionResultEvents IS_NOT ZERO,
CommandFSM() is executed *without*
waiting for the next 100mS tick3.
(Sticky events will prevent lower priority
handlers from ever running)
If efMotionEvents IS_NOT ZERO,
MotionFSM() is executed *without*
waiting for the next 25mS tick2.
(Sticky events will prevent lower priority
handlers from ever running)
25mS Tick1
25mS Tick5
25mS Tick2
25mS
Motion Timer
25mS Tick3
25mS Tick4
100 mS Tick3
MotionFSM();
MenuFSM()
Serial Menu FSM
(actual I/O is interrupt driven)
100 mS Tick1
100 mS Tick2
CommandFSM();
If a USER or MOTION event flag is set, but it is not processed, the associated FSM will ‘hog’ the MCU, because this execution prioritizer will keep calling the FSM.
This, in turn, will result in event overruns for lower priority events.
AutoCenterFSM();
Application LED
Sequencing
User Interface FSM
(sends commands to Command FSM,
receives events from Other FSMs)
UserFSM();
AppLEDsTick()
Debug LED Sequencing
DebugLEDsTick();
efMoveSequenceEvents
MoveSequenceFSM()
After execution, Timer Tick substates
return to the TOP of the scheduler.
Implemented in main.c
Execution Scheduler
SmartTrak Solar Panel Controller
created by gsf Engineering for SmartTrak
Copyright © 2013
20 Mar, 2013



Move Specification:
- Distance in Motion Sensor Ticks
- Maximum (constant) Speed, not a variable

Input Parameters:
- PWM Width

Measured Ouputs:
- Time between Motion Sensor ticks (Speed)

FSM Parameters:
- Initial PWM width
- Acceleration in PWM width change per timer interrupt
- Number of Motion Sensorticks during acceleration (may not be enough to reach max speed)
  - (Needs to account for current travel limit)
- Final PWM width at end of acceleration (maximum PWM)
- Number of Motion Sensor ticks during constant speed (may be 0)
  - (Needs to account for travel limit)
- Deceleration in PWM width change per timer interrupt
- Number of Motion Sensor ticks during deceleration
  - (Needs to account for travel limit)
- Minimum PWM width at end of deceleration

External FSM Events
- New Motion Command

Notes:
- Speed is measured by timing Motion Sensor Ticks
- Distance is measured by counting Motion Sensor Ticks
- To bring about a controlled stop at ANY time, change the number of Ticks to Move to ZERO

Implemented in MotionFSM.c

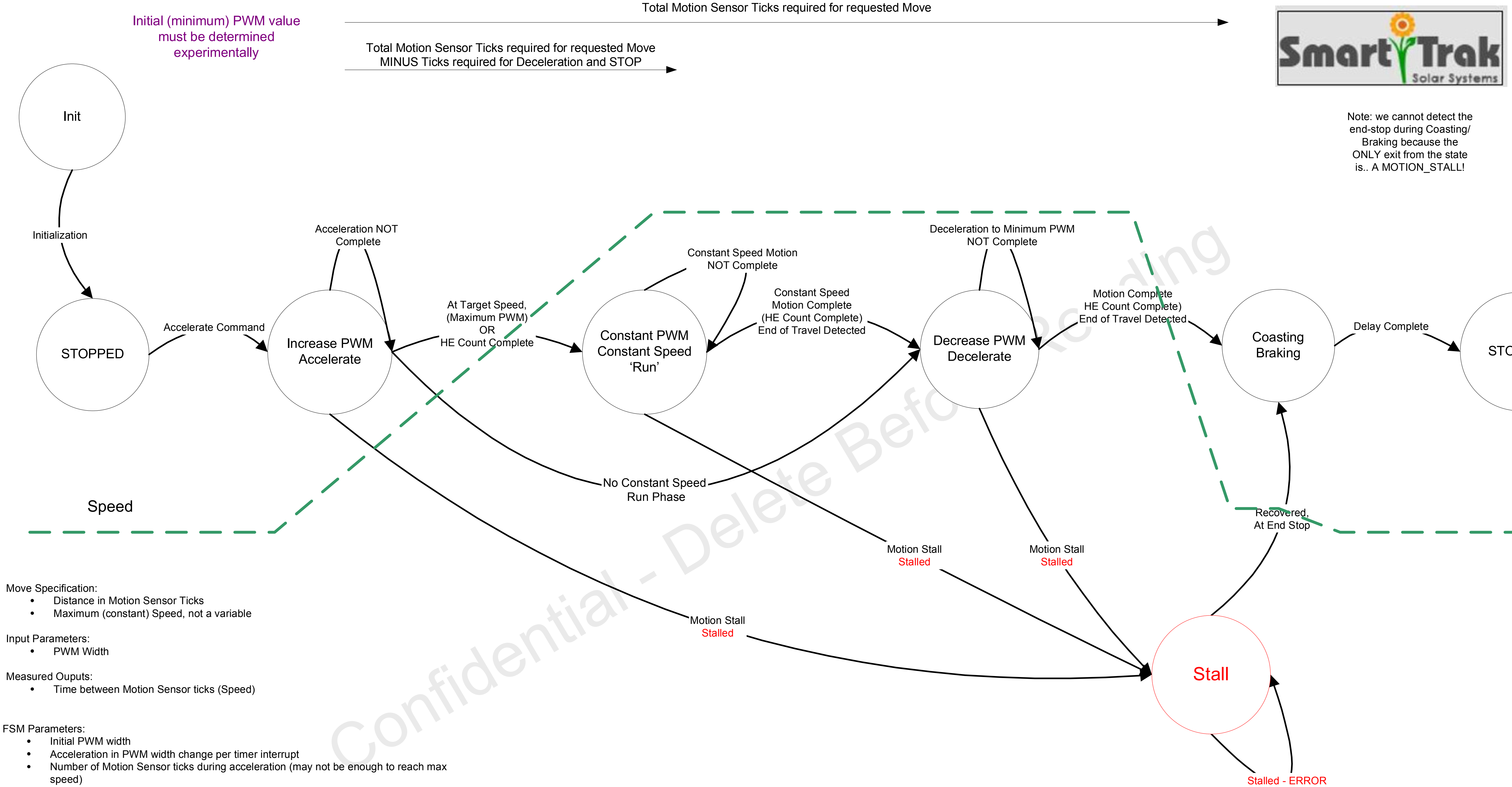
Motion FSM

SmartTrak Solar Panel Controller

created by gsf Engineering for SmartTrak

20 Mar, 2013

A06



Move Specification:
- Distance in Motion Sensor Ticks
- Maximum (constant) Speed, not a variable

Input Parameters:
- PWM Width

Measured Ouputs:
- Time between Motion Sensor ticks (Speed)

FSM Parameters:
- Initial PWM width
- Acceleration in PWM width change per timer interrupt
- Number of Motion Sensor ticks during acceleration (may not be enough to reach max speed)
  - (Needs to account for travel limit)
- Final PWM width at end of acceleration (maximum PWM)
- Number of Motion Sensor ticks during constant speed (may be 0)
  - (Needs to account for travel limit)
- Deceleration in PWM width change per timer interrupt
- Number of Motion Sensor ticks during deceleration
  - (Needs to account for travel limit)
- Minimum PWM width at end of deceleration

External FSM Events
- New Motion Command

Notes:
- Speed is measured by timing Motion Sensor Ticks
- Distance is measured by counting Motion Sensor Ticks
- To bring about a controlled stop at ANY time, change the number of Ticks to Move to ZERO

Implemented in MotionFSM.c

Simplified Motion FSM

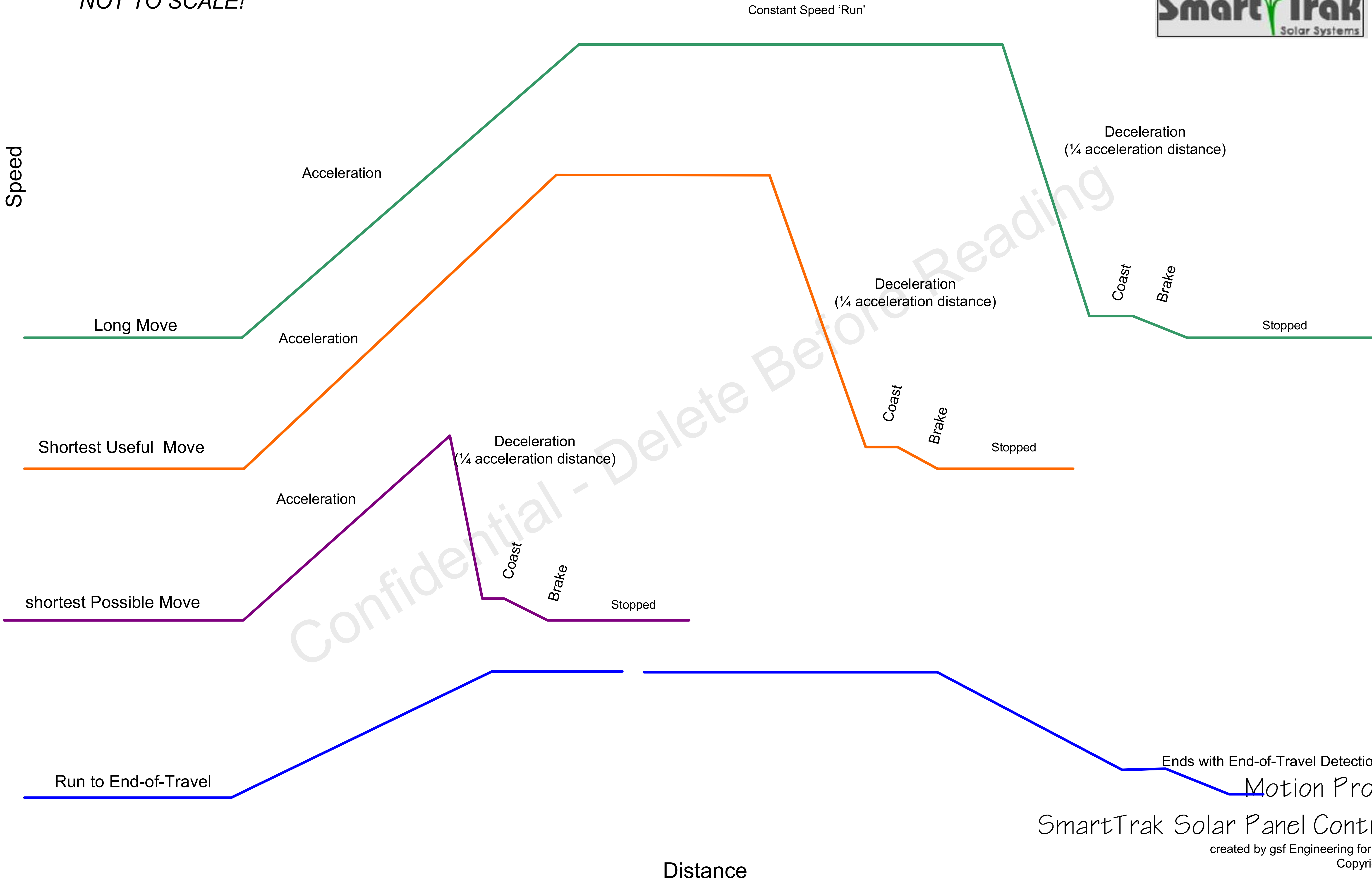
SmartTrak Solar Panel Controller

created by gsf Engineering for SmartTrak

20 Mar, 2013

NOT TO SCALE!

A06

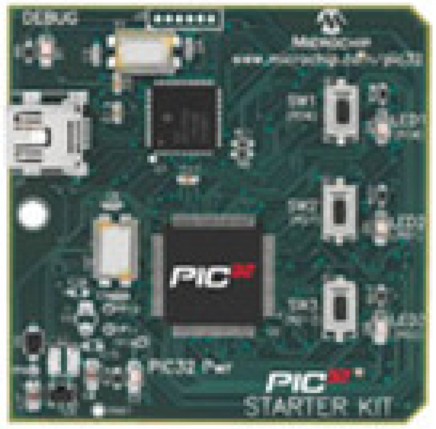


Motion Profiles

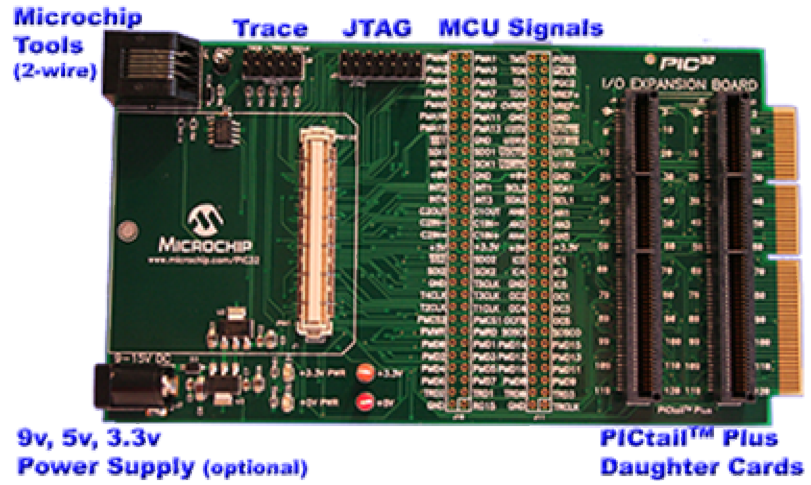
SmartTrak Solar Panel Controller

created by gsf Engineering for SmartTrak

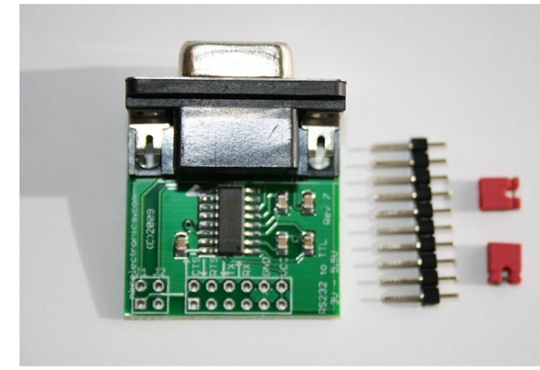
20 Mar, 2013



PIC32 Starter Kit DM32001

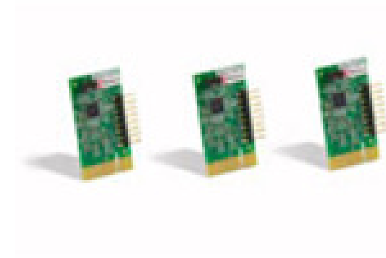


PIC32 Starter Kit I/O Expansion Board DM32002

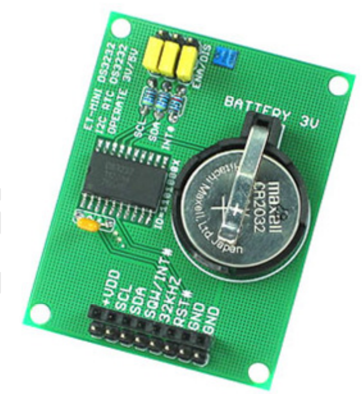


RS-232 Level Shifter and DB-9

Prototype PICtail Plus Board
AC164126

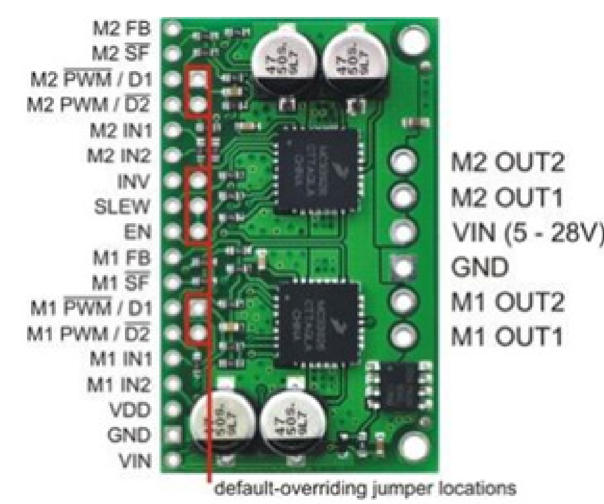


Serial SuperFlash Kit 1
AC243005-1



RTCC MINIDS3232_A300

100MBPS Ethernet Pictail Plus Board
AC164132



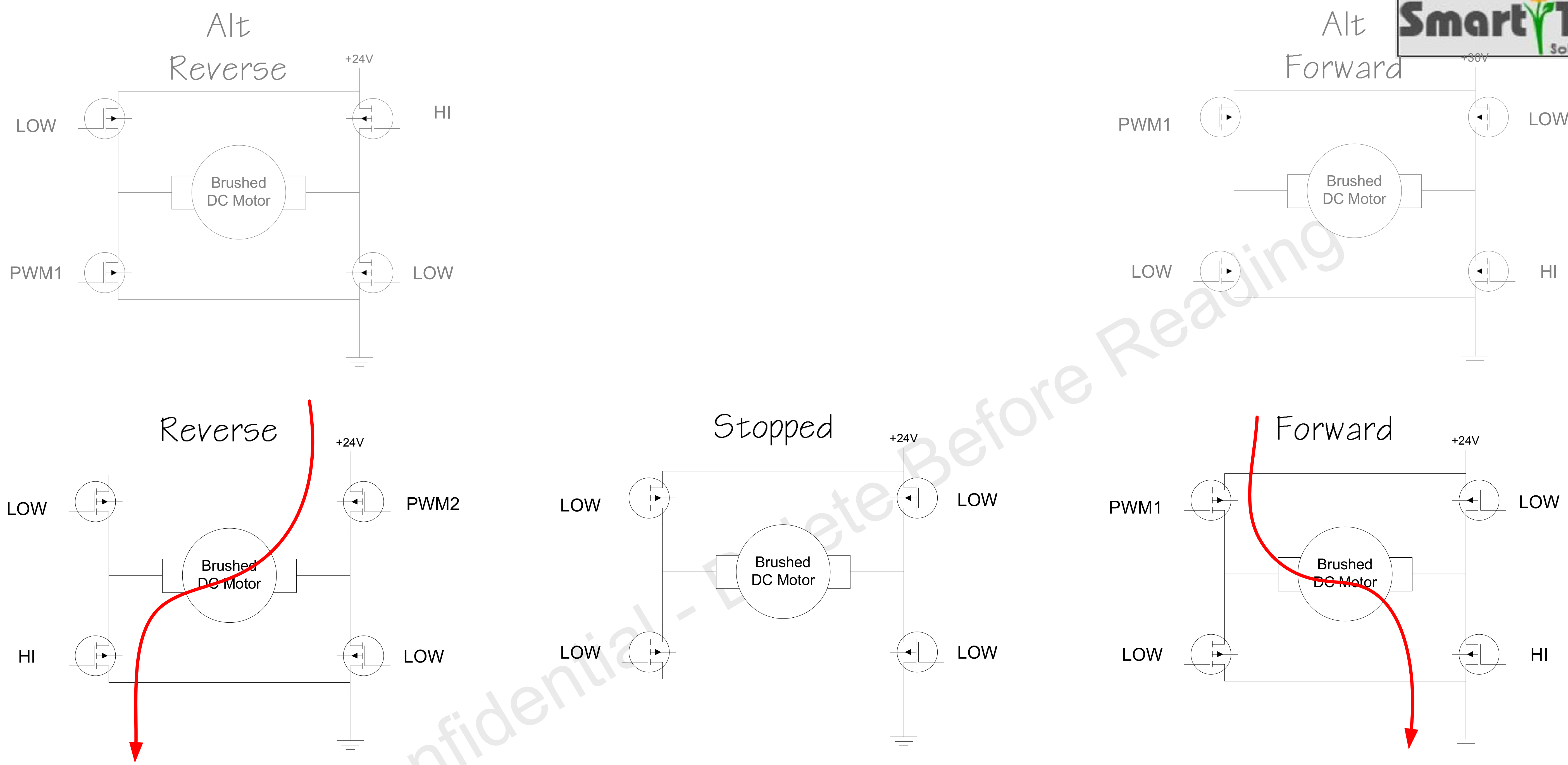
Pololu Dual MC33926 H-Bridge

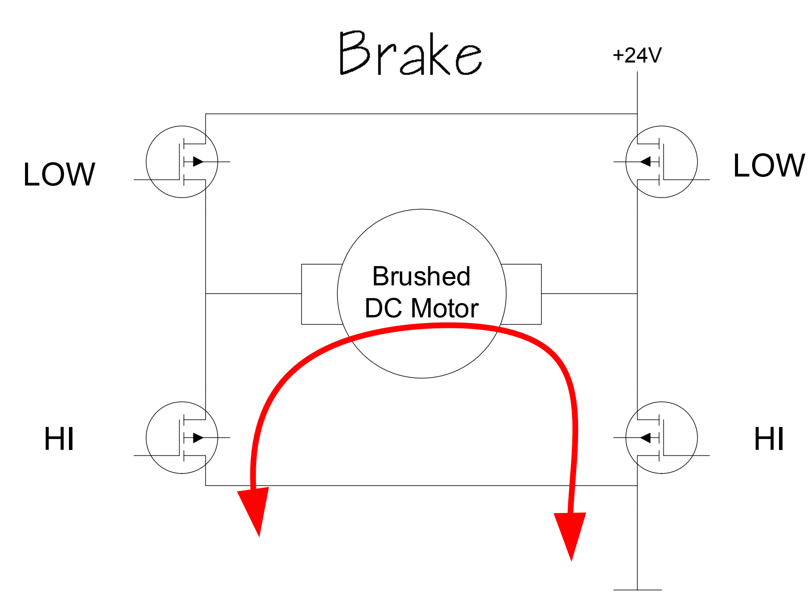
Prototype Peripherals

SmartTrak Solar Panel Controller

created by gsf Engineering for SmartTrak

20 Mar, 2013





H-Bridge Operation

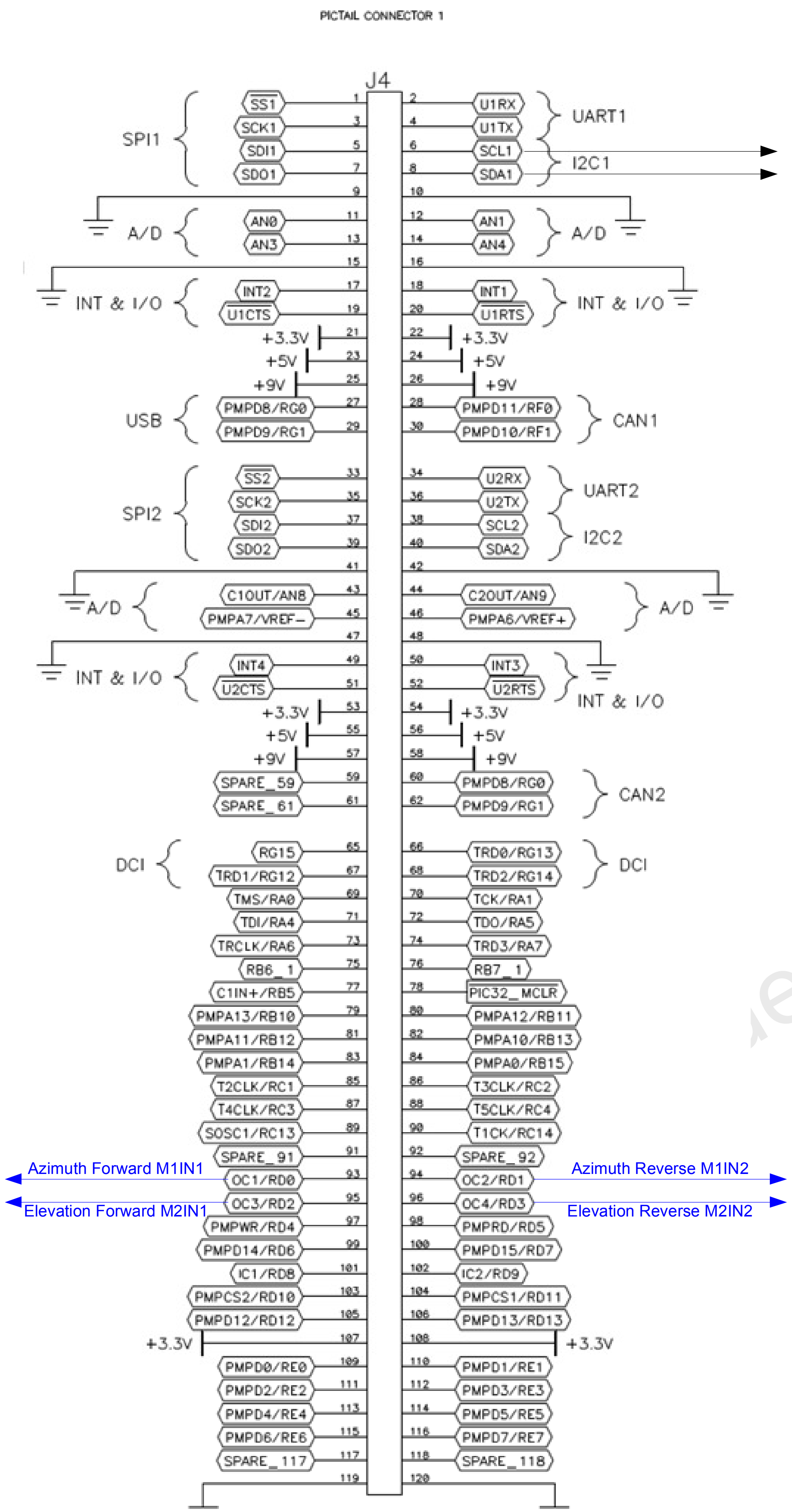
SmartTrak Solar Panel Controller

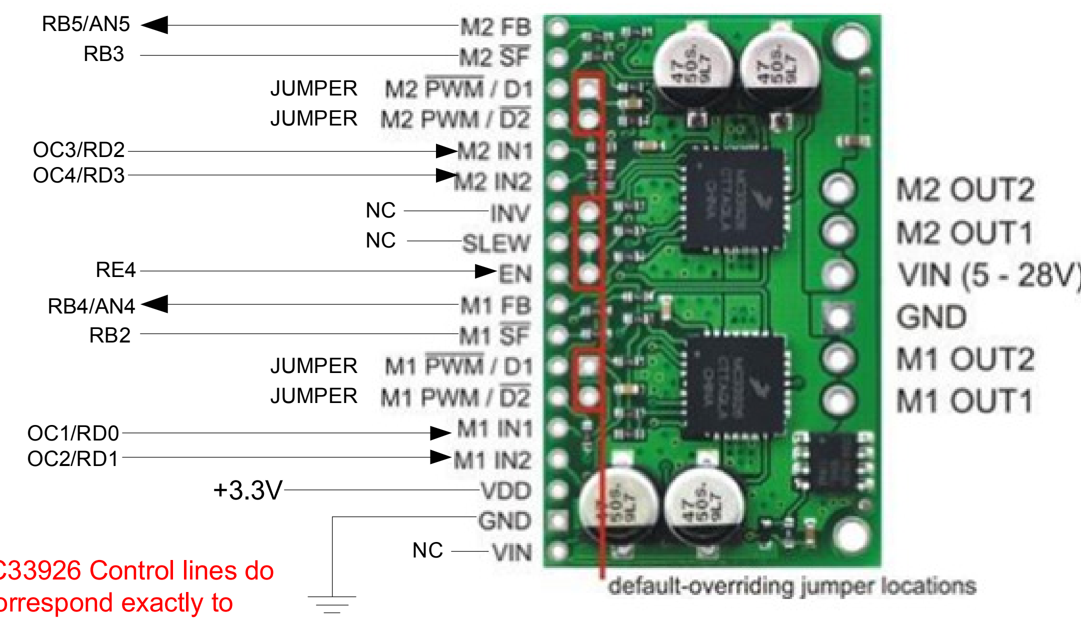
created by gsf Engineering for SmartTrak

20 Mar, 2013

A06

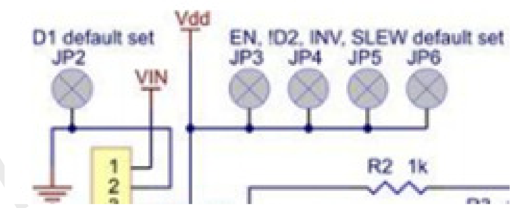
SLEW	default (open) low = SLOW
INV	default (open) low = NON INVERTED
EN	default (open) low = SLEEP, **must be driven HIGH by MCU**
D1	default (open) high = DISABLED, **must be driven LOW by jumper**
/D2	default (open) low = DISABLED, **must be driven HIGH by jumper**



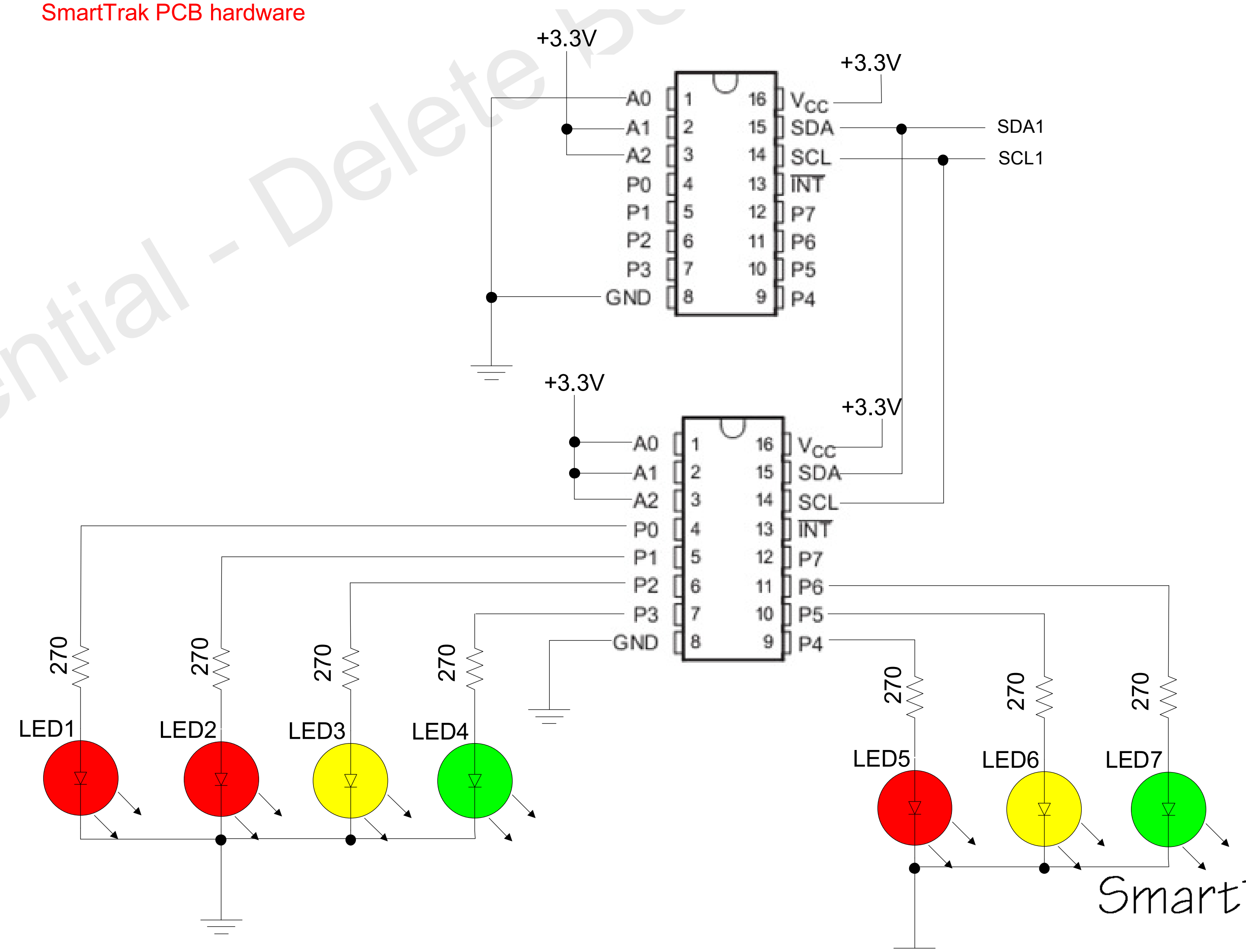


Note: MC33926 Control lines do not correspond exactly to SmartTrak PCB hardware

Note that all Jumpers EXCEPT D1 are pulled HI.
D1 must be pulled LOW



M2OUT2	Elevation REVERSE PWM
M2OUT1	Elevation FORWARD PWM
M1OUT2	Azimuth REVERSE PWM
M1OUT1	Azimuth FORWARD PWM



Connector at rear of
H-Fang Motor

Wire Define:	
Pin 1	motor−
Pin 2	motor+
Pin 3	hall GND
Pin 4	hall +(5-24)V
Pin 5	hall A
Pin 6	hall B
Pin E	Ground

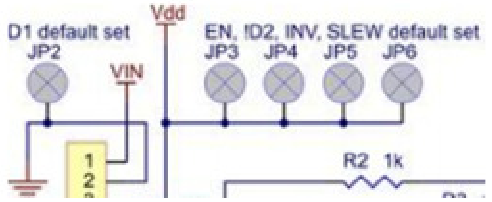
PicTail Plus Wiring

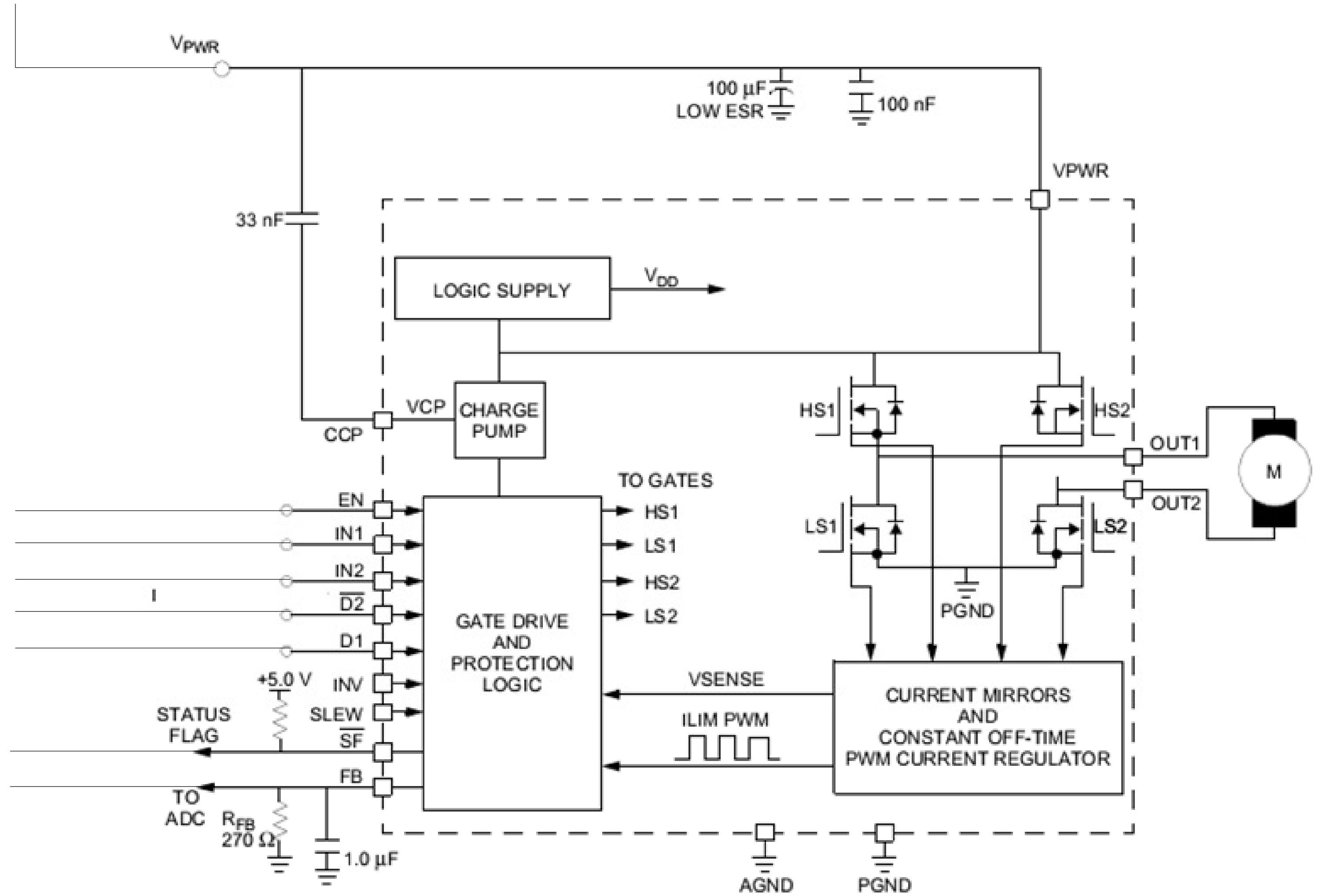
SmartTrak Solar Panel Controller

created by gsf Engineering for SmartTrak

20 Mar, 2013

Note that all Jumpers EXCEPT D1 are pulled HI.
D1 must be pulled LOW





A06

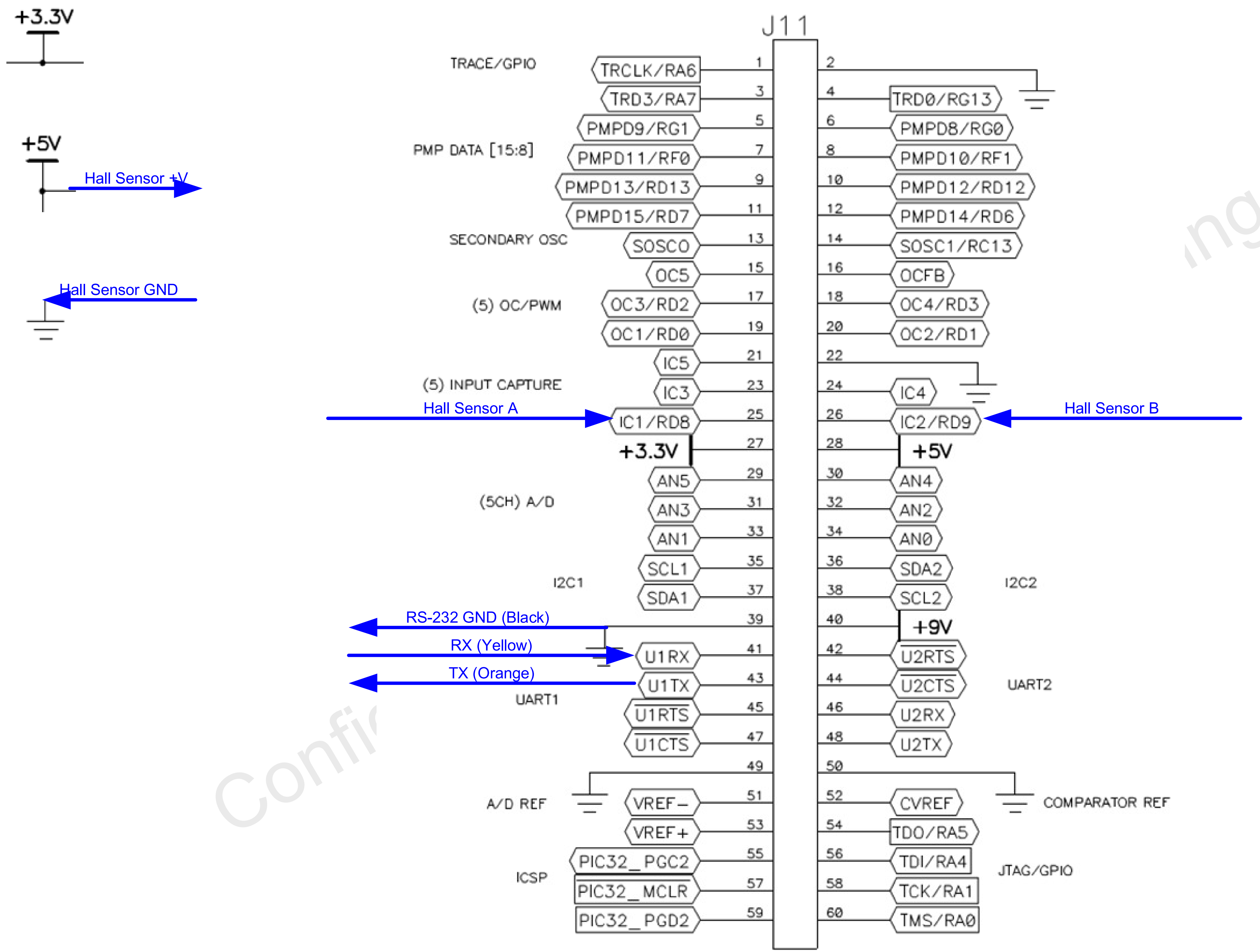
MC33926 Wiring

SmartTrak Solar Panel Controller

created by gsf Engineering for SmartTrak

20 Mar, 2013

A06



Connector at rear of
H-Fang Motor

Wire Define:	
Pin 1	motor−
Pin 2	motor+
Pin 3	hall GND
Pin 4	hall +(5-24)V
Pin 5	hall A
Pin 6	hall B
Pin E	Ground

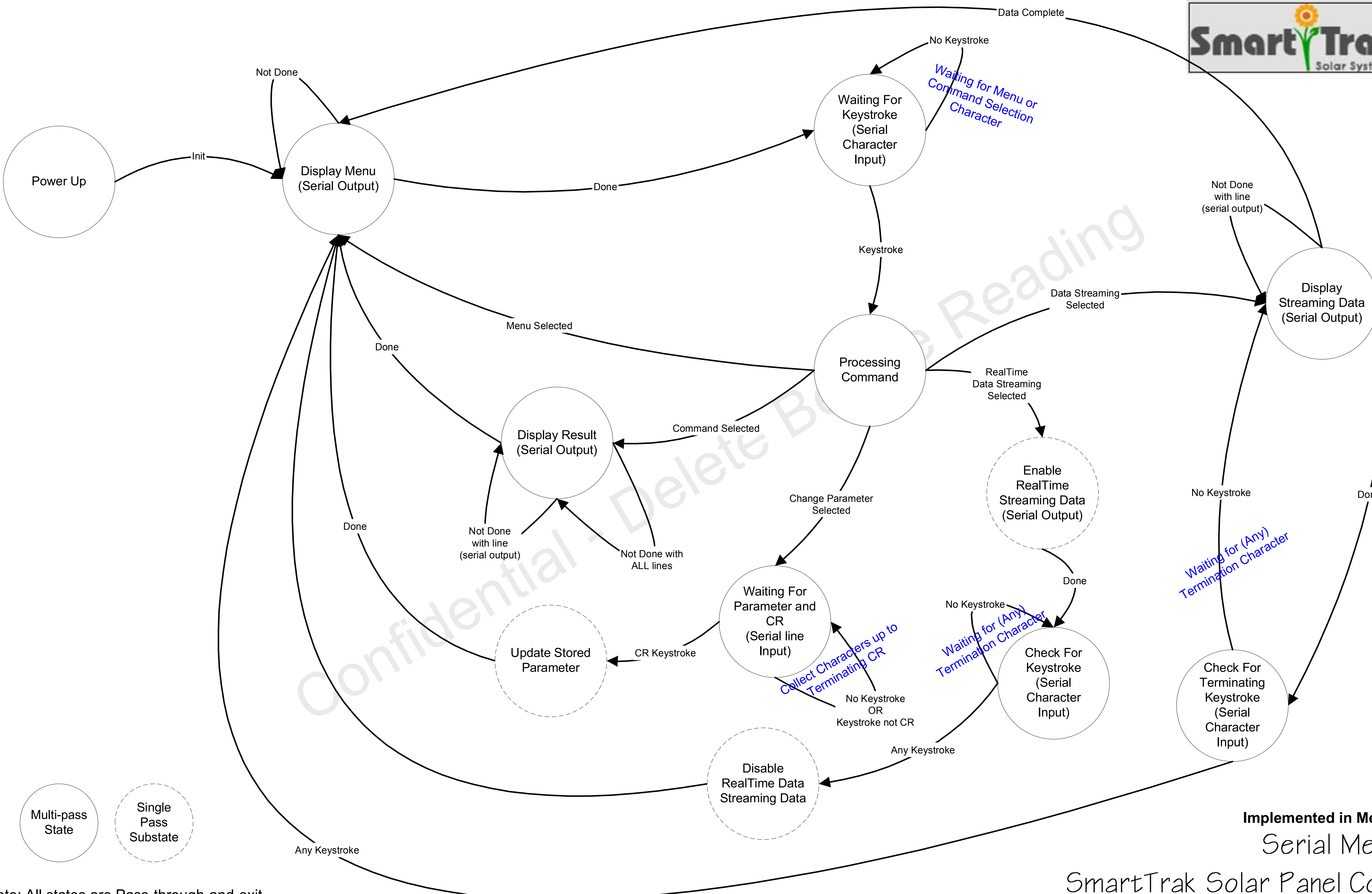
PIC32 SK Wiring

SmartTrak Solar Panel Controller

created by gsf Engineering for SmartTrak

20 Mar, 2013

A06



Note: All states are Pass-through-and-exit,
called on a 25mS timer tick from the foreground loop,
so that this can co-exist with the rest of the application

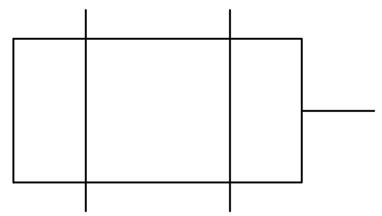
Implemented in MenuFSM.c

Serial Menu FSM

SmartTrak Solar Panel Controller

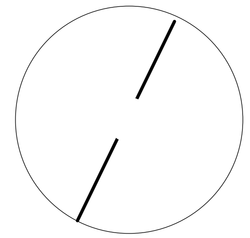
created by gsf Engineering for SmartTrak

20 Mar, 2013

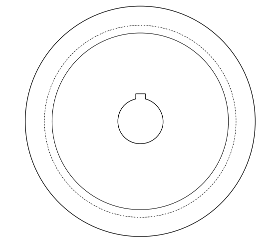


Motor
Kv 83 rpm/V (Measured)
No Load 1800 RPM

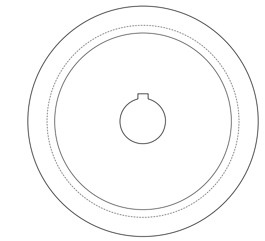
PWM drive at 10KHz (arbitrarily selected) Starting PWM value 20%, based on prior experience



Motion Sensor (Hall Effect) 2 ticks per MOTOR revolution



Planetary Gearbox 575:1



Slew Gearbox 73:1

- Max Motor Gearbox Velocity: 18.8 degrees/sec
  - 30 motor revolutions/sec (1800 RPM)
  - 3.13 output shaft revolutions/min (1127 degrees/min)
  - 0.0522 output shaft revolutions/sec (18.8 degrees/sec)
  - 60 Motion Sensor ticks/sec
  - 16.7mS per Sensor tick (0.31 degrees/tick)
    - TMR3 = (80MHz/2)/256, 156KHz, 6.40uS/count
    - 5219 TMR3 counts per Motion Sensor tick
- Max Acceleration: x.xxx degrees/s/s
  - assuming linear acceleration from 0 to x.xxx degrees/s/s
    - x.xx shaft revolutions
    - xx.x motor revolutions
    - xxxx Motion Sensor ticks

PWM is set by a 16 bit value, so the PWM can be adjusted on every Motion Sensor tick.

- 1.00 degree Total Motion:
  - 0.0028 output shaft revolutions
  - 0.2028 input shaft revolutions
  - 116.6 motor revolutions
  - 233.2 motion sensor ticks
  - 0.065 minutes, 3.89S at maximum speed (no accel or decel)
- Minimum motion 0.00429 degrees
  - 0.5 motor revolutions
  - 1 Motion Sensor tick TOTAL
- Longest Motion Sensor tick timing:
- accelerating from 0 at 9.4 degrees/s/s
  - using d = 0.5 * a * t ^2, for d = 4.7 degrees, t = 1.0S
    - xxxxx TMR3 counts per motion sensor tick
    - **xx.xx times longer than the 16.7mS tick at max speed**
    - **this time, which is not entirely accurate because we will start with at least 20% duty cycle, will nonetheless be used to determine the *maximum motion timeout* value**

Mechanical Characteristics Travel Limits:

1.00 Degree Move
(This is an example, final specs not determined)

- **0.0028 Output Shaft Revolutions Motion Profile**
  - 233 Motion Sensor Wheel ticks TOTAL
  - 58 ticks accelerating from 0 at 9.4 degrees/s/s
    - using d = 0.5 * a * t ^2, for d = 4.7 degrees, t = 1.0S
  - 58 ticks decelerating at 2.35 degrees/s/s (1:4)
    - using d = 0.5 * a * t ^2, for d = 4.7 degrees, t = 2.0S
  - 117 ticks at full speed, 16.7mS per tick
    - t = 1.95S
  - **for a total 4.95S move**
  - **observed x.xxS move starting at 20% duty cycle**

Total Required Motion 16 Degrees/hour
16 x 1.0 Degree Move
16 x 4.95S = **79.2S** in a 3600S hour

Note: these timing calculations are based on starting motion at 0% PWM, and ramping up from there.
In reality, we will start the PWM will be started at 20% (or higher), which makes the calculations more complicated, and better done with a spreadsheet - but this method of calculation provides worst-case timing.

Azimuth Motion Math

SmartTrak Solar Panel Controller

created by gsf Engineering for SmartTrak

20 Mar, 2013