Periodic Interrupts

- **Data acquisition (Lab 6, 7) samples ADC**
- **Signal generation output to DAC**
  - **Audio player (Lab 8)**
  - **Communications**
- **Digital controller**
  - **FSM**
  - **Linear control system (EE362K)**

Read Book Sections 9.1, 9.2, 9.4, 9.6.1, 9.6.2, 9.10

Moore example in Metrowerks

Open example and run with FollowPC mode

1) Where does the 9S12 spend most of its time?

2) How do we recover this lost productivity?

```
const struct State{
  unsigned char Out;   // Output to Port T
  unsigned short Time; // Time in msec to wait
  const struct State *Next[4];  // if input =0,1,2,3
};
typedef const struct State StateType;
typedef StateType *     StatePtr;

#define SA &fsm[0]
#define SB &fsm[1]
#define SC &fsm[2]
#define SD &fsm[3]
#define SE &fsm[4]
#define SF &fsm[5]
StateType fsm[6]={
      {0x01,2,{SB,SC,SD,SE}},   // SA,SB fast alternate toggle
      {0x02,2,{SA,SC,SD,SE}},   // SB
      {0x03,1,{SA,SC,SD,SE}},   // SC both on
      {0x00,1,{SA,SC,SD,SE}},   // SD both off
      {0x00,10,{SA,SC,SD,SF}},  // SE,SF together toggle
      {0x03,10,{SA,SC,SD,SE}}   // SF
};

StatePtr Pt;  // Current State
unsigned char Input;

//---------FSMInit------------------
// initialize FSM, clock, initial state SA
// inputs: none
// outputs: none
void FSMInit(void){
  Pt = SA;        // Initial State
  DDRT |= 0x03;    // PT1,PT0 outputs
  DDRH &= ~0x03;   // PH1,PH0 inputs
}
void main(void) {
  PLL_Init();     // 24 MHz
  Timer_Init();   // TCNT at 1.5 MHz
  FSMInit();
  asm cli
  for(;;) {
    PTT = (PTT&0xFC)+Pt->Out; // Output depends on state
    Timer_Wait1ms(Pt->Time);  // Time to wait in this state
```

```
    Input = PTH&0x03;         // Input=0,1,2,or 3
    Pt = Pt->Next[Input];     // Next state depends on input
  }
}
```

Redesign using output compare interrupts

Foreground Solution

; 1. Perform output for the current state
; 2. Wait for specified amout of time
; 3. Input from the switches
; 4. Go to the next state depending on the input
; 1. Perform output for the current state
; 2. Wait for specified amout of time
; 3. Input from the switches
; 4. Go to the next state depending on the input
…

What is the computer doing most of the time?

Background Solution

Ritual

; 1. Perform output for the current state
; 2. Set TC0 to Wait for specified amout of time

Output compare interrupt service routine

; 3. Input from the switches
; 4. Go to the next state depending on the input
; 1. Perform output for the current state
; 2. Set TC0 to Wait for specified amout of time

Show Moore_DG128 example

Move to background

More accurate
Frees up cycles to perform other tasks

Merge OC_DG128 and Moore files

Debugging techniques when using interrupts

Profiling

1) Is the interrupt occurring? Is a function being called?
Add global counters, initialize to 0
Add `counter++` inside ISR, inside function

2) Is the interrupt occurring? Is a function being called?
Find unused I/O pins, initialize to outputs
Add `PTP |= 0x01;` at beginning of ISR, function
Add `PTP &= ~0x01;` at end of ISR, function
View bits with a logic analyzer or scope

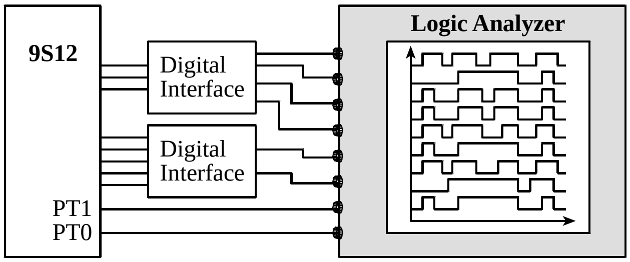
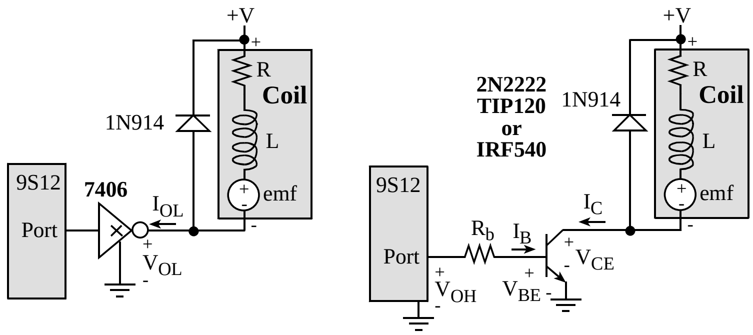


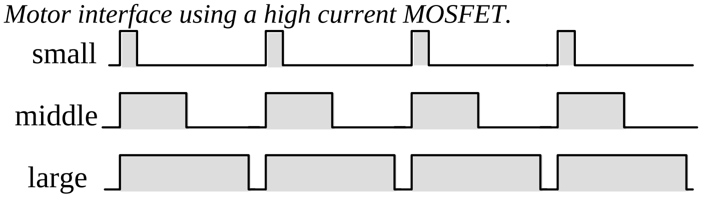
Figure 9.14. A logic analyzer and example output.

Pulse-width modulation (a way to adjust output power)

Any diode is fine (e.g., 1N914)



Motor interface using a high current MOSFET.



Output compare every 1ms
Length is a variable from 0 to 10
Every 10 interrupts make PM0 high
Every Length interrupts make PM1 low
Duty cycle is **Length/10**
Maximum power is V_m^2/R
Delivered power is V_m^2/R * **Length/10**

Build the output compare solution in Metrowerks
Simulate in TExaS
Run on actual board