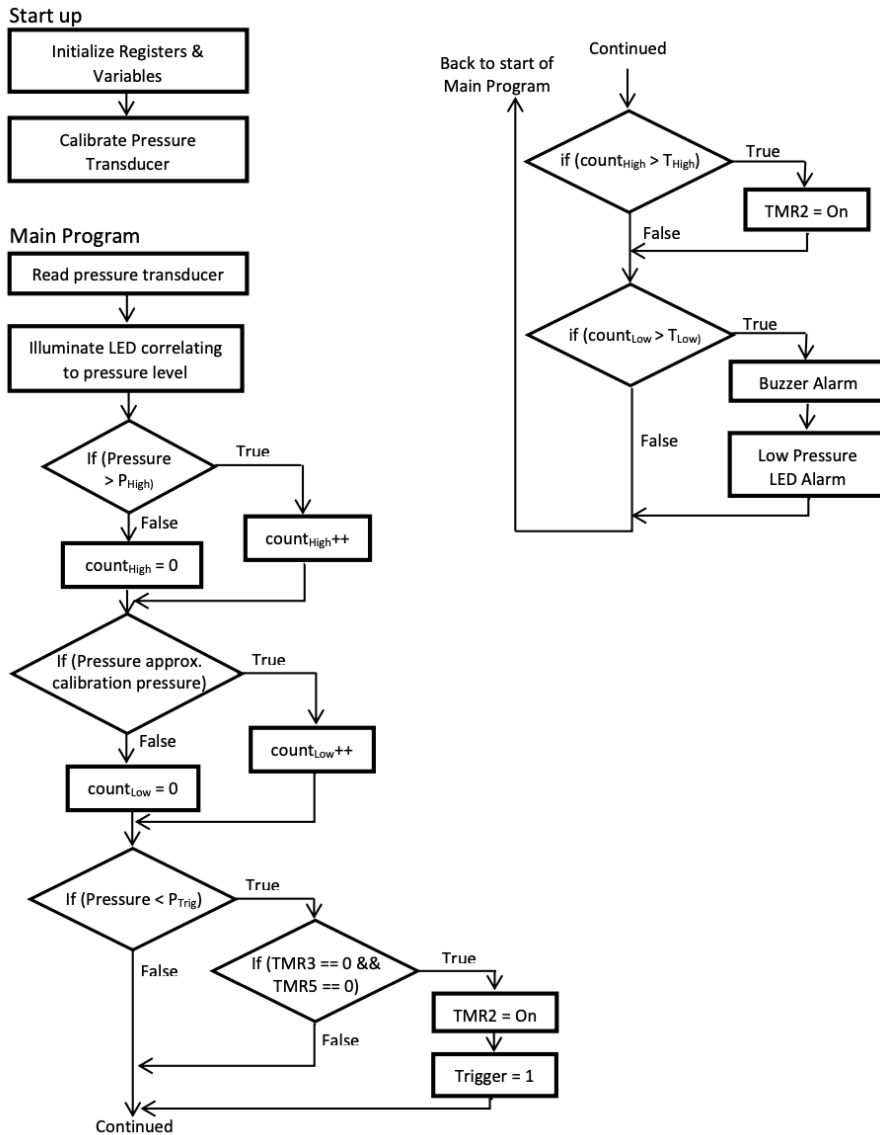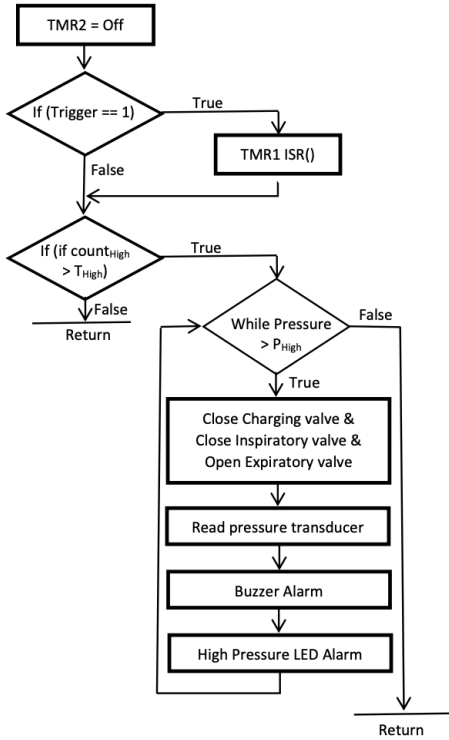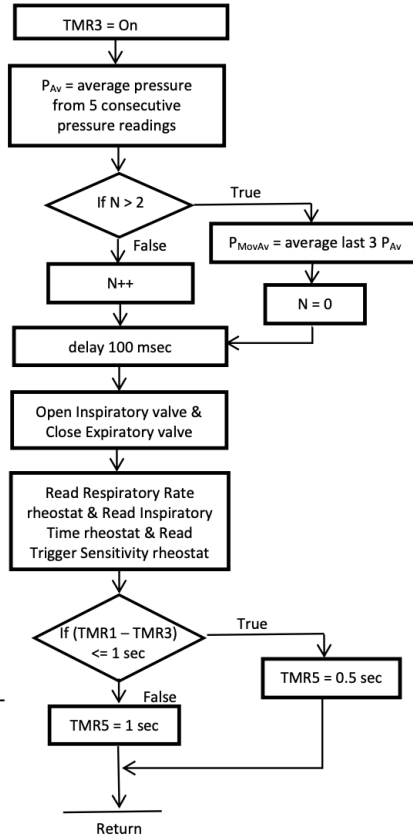Code block diagram. The 'Main Program' continuously cycles, sampling airway pressure, illuminating an LED corresponding to the pressure, and monitoring for periods of high or low pressure. It is interrupted at by the Interrupt Service Routines (ISRs). These ISRs are triggered at specific time intervals which largely are controlled by the two user-controlled inputs to the microcontroller for respiratory rate and inspiratory time, and also by certain hardware and software triggers to generate alarms. Not shown above are blocks for clearing interrupt flags after each ISR is triggered.
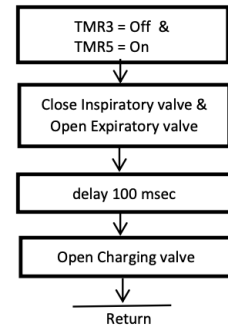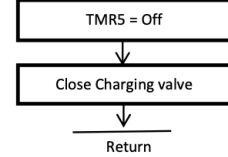
Start up

```
┌─────────────────────┐
│ Initialize Registers│
│    & Variables      │
└─────────────────────┘
          ↓
┌─────────────────────┐
│ Calibrate Pressure  │
│     Transducer      │
└─────────────────────┘
```

Main Program

```
┌─────────────────────────┐
│ Read pressure transducer│
└─────────────────────────┘
          ↓
┌─────────────────────────┐
│ Illuminate LED correlating│
│   to pressure level     │
└─────────────────────────┘
          ↓
     ◇ If (Pressure ──True──→  count_High++
       > P_High) ◇
          │ False                    │
     count_High = 0  ←───────────────┘
          ↓
     ◇ If (Pressure approx. ──True──→  count_Low++
       calibration pressure) ◇
          │ False                    │
     count_Low = 0  ←────────────────┘
          ↓
     ◇ If (Pressure < P_Trig) ──True──→ ◇ If (TMR3 == 0 &&
          │                               TMR5 == 0) ◇ ──True──→ TMR2 = On
          │ False                            │ False                 ↓
          │                                  │                   Trigger = 1
     Continued  ←─────────────────────────────┴───────────────────────┘
```

P_{High}, P_{Trig}, $count_{High}$, $count_{Low}$

Back to start of Main Program ← **Continued**

```
     ◇ if (count_High > T_High) ──True──→  TMR2 = On
          │ False                              │
          ↓ ←─────────────────────────────────┘
     ◇ if (count_Low > T_Low) ──True──→  Buzzer Alarm
          │ False                            ↓
          │                          Low Pressure LED Alarm
          ↓ ←─────────────────────────────────┘
```

High Priority Interrupt
(TMR2)

```
TMR2 = Off
```

If (Trigger == 1) — **True** → TMR1 ISR()

False

If (if count$_{High}$ > T$_{High}$) — **True**

False → Return

While Pressure > P$_{High}$ — **False** → Return

True

Close Charging valve & Close Inspiratory valve & Open Expiratory valve

↓

Read pressure transducer

↓

Buzzer Alarm

↓

High Pressure LED Alarm

Low Priority Interrupt #1
(TMR1)

```
TMR3 = On
```

↓

P$_{Av}$ = average pressure from 5 consecutive pressure readings

↓

If N > 2 — **True** → P$_{MovAv}$ = average last 3 P$_{Av}$ → N = 0

False

N++

↓

delay 100 msec

↓

Open Inspiratory valve & Close Expiratory valve

↓

Read Respiratory Rate rheostat & Read Inspiratory Time rheostat & Read Trigger Sensitivity rheostat

↓

If (TMR1 – TMR3) <= 1 sec — **True** → TMR5 = 0.5 sec

False

TMR5 = 1 sec

↓

Return

Low Priority Interrupt #2
(TMR3)

```
TMR3 = Off  &
TMR5 = On
```

↓

Close Inspiratory valve & Open Expiratory valve

↓

delay 100 msec

↓

Open Charging valve

↓

Return

Low Priority Interrupt #3
(TMR5)

```
TMR5 = Off
```

↓

Close Charging valve

↓

Return

Low Priority Interrupt #4
(Interrupt on Change pin RB0)

Buzzer Alarm x3 pulses
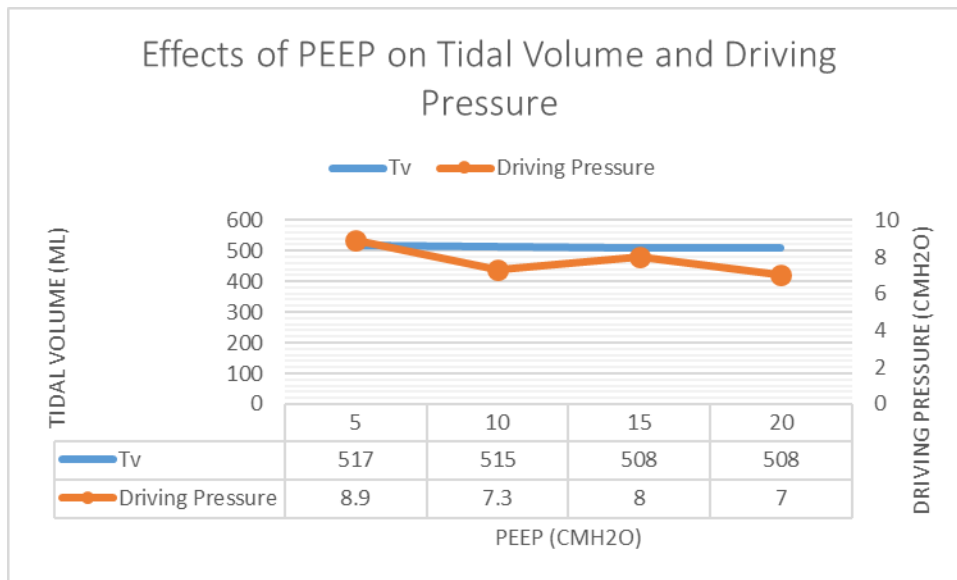
↓

Toggle Battery Backup Indicator LED

↓

Return
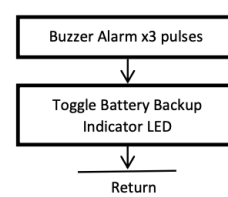
Increasing chamber size with stable lung compliance and airway resistance. Approximate increase of 45 mL for every additional chamber tab added.
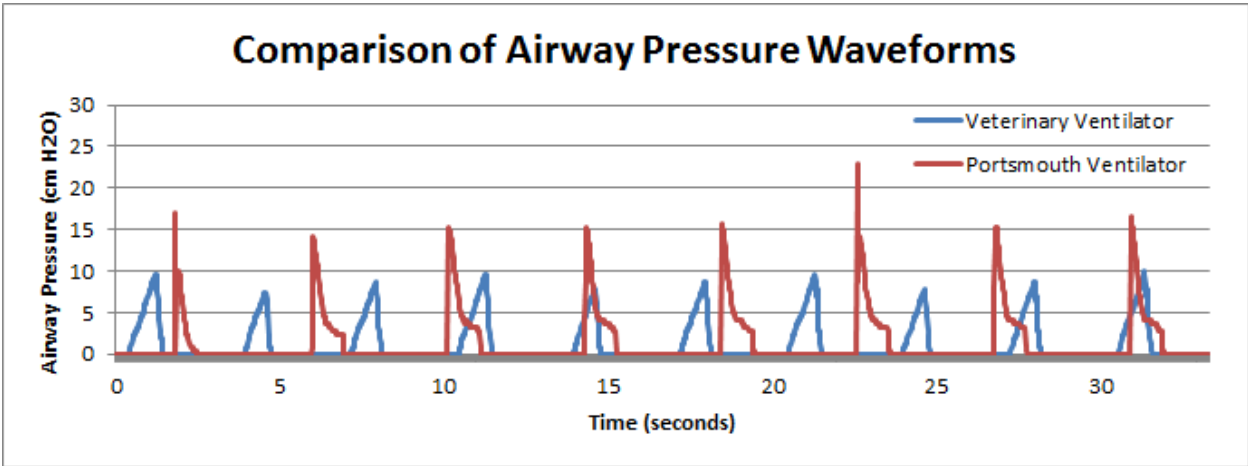

Effect of Chamber Size on Tidal Volume and Plateau Pressure
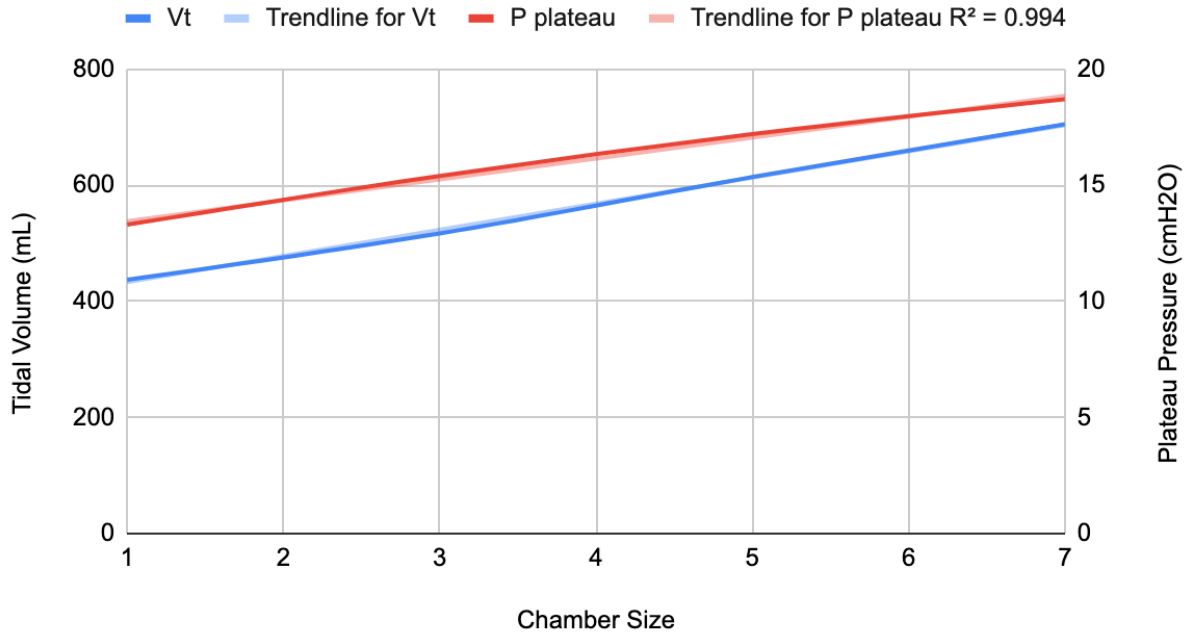
Effects of PEEP on tidal volumes and driving pressure

Effects of PEEP on Tidal Volume and Driving Pressure

	5	10	15	20
Tv	517	515	508	508
Driving Pressure	8.9	7.3	8	7

TIDAL VOLUME (ML)

DRIVING PRESSURE (CMH2O)

PEEP (CMH2O)

Tv — Driving Pressure

Airway pressure waveforms *in vivo*

Pressure waveform measured at the y-piece of the breathing circuit using the Portsmouth ventilator. This was recorded toward the end of the study using 7 expansion chambers (tidal volume approximately 705cc, or 8.4cc/kg) and 10 cmH2O PEEP. The tracing shows the brief pressure impulse immediately following chamber depressurization. Sampling here was 60Hz, and discrete analysis shows only one data point at each of the pressures above 20 cmH2O, suggesting that the pressure exceeded 20 cmH2O for 33 milliseconds or less.

Portsmouth Ventilator Airway Pressure Waveform
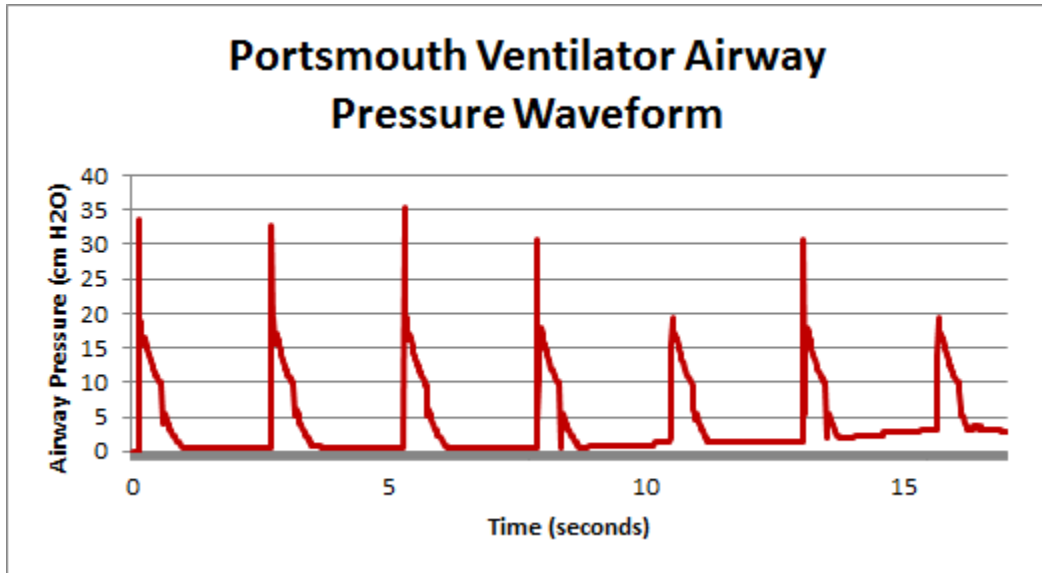
Average Tidal Volume Delivery with Varying Pulmonary Mechanics, 520 mL Tidal Volume

Resistance cmH$_2$O/L/s	Compliance mL/cmH$_2$O	Tidal Volume	% Difference from baseline
5	30	491	-5.58%
5	70	522	0.38%
5	100	531	2.11%
5	120	535	2.88%
10	30	487	-6.34%
10	70	515	-0.96%
10	120	522	0.38%
12	50	517	-0.58%
12	20	481	-7.50%
15	50	514	-1.15%
15	20	475	-8.65%
20	20	473	-9.03%
20	30	480	-7.69%
20	70	498	-4.23%
20	120	507	-2.50%
50	100	487	-6.34%