VENTILATOR

FCM TEST -1

DOCUMENT:
R300620-01

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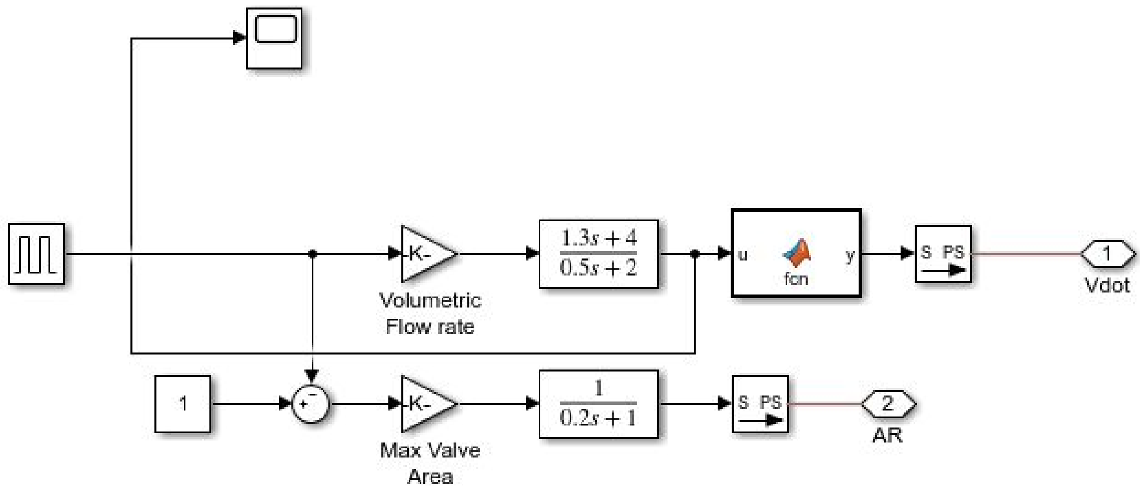
OBJECTIVE

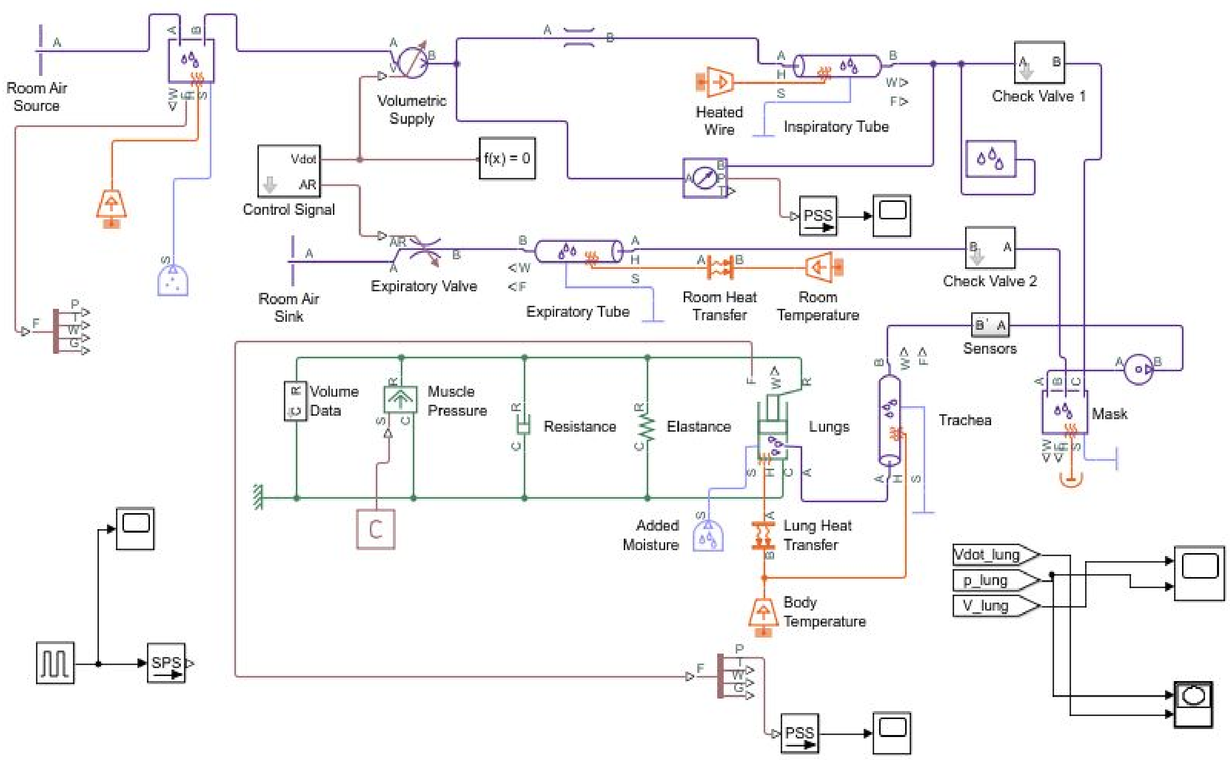
To observe the change in patterns of pressure and volume output signals by varying the shape of a constant flow rate signal for a set of constant input parameters

SCHEMATIC

Schematic control circuit for the input signal (Flow rate given to compressor)



Schematic control circuit (overall)



DESCRIPTION

The flow rate signal at the compressor, which is given as an input signal is obtained by applying a transfer function to a pulse generated signal with its control parameters being **Tidal volume, respiratory rate, I:E ratio.**

The pulse generated signal is defined by -
Amplitude = 1
Time period = 60/ respiratory rate seconds
Pulse width = IE_ratio/(IE_ratio+1) * 100
phase delay = 0

In this test, the transfer function which determines the shape of the signal is varied and the respective changes in output are observed thereby concluding about the optimal transfer function

Tidal volume = 1.5 L, Respiratory rate = 15 Breaths/ min, I:E Ratio = 1:2.5

The transfer function is of the form :

$$(a*s + b) / (c*s + d)$$

Where the coefficients a,b,c,d are restricted to certain ranges to preserve the nature

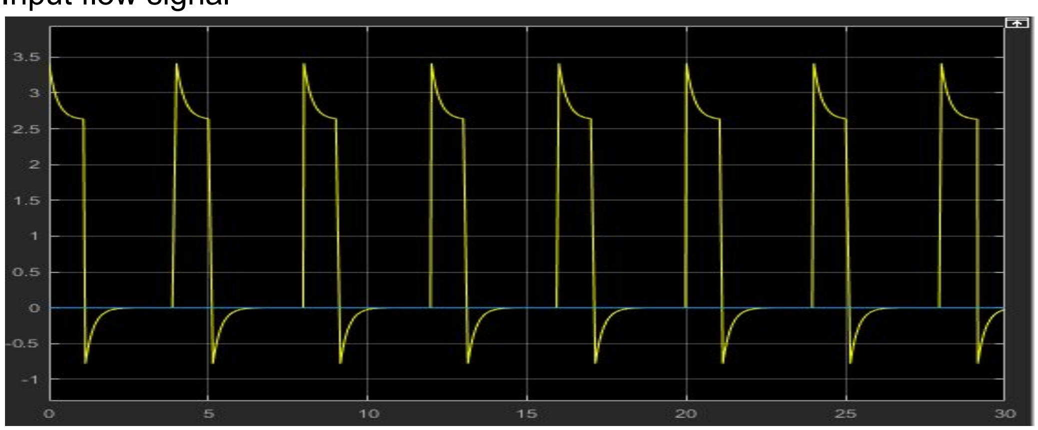
Other set parameters are -

PEEP = 5cm H20
MUSCLE PRESSURE = 5 cm H20
DAMPING COEFFICIENT = 294.2 kN-s/m
SPRING RATE = 1.18 MN/m

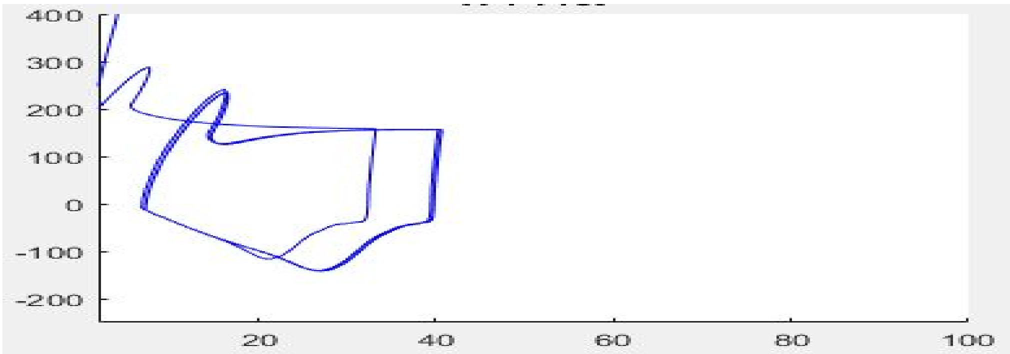
RESULTS

1) a=1.3, b=4, c=0.5, d=2

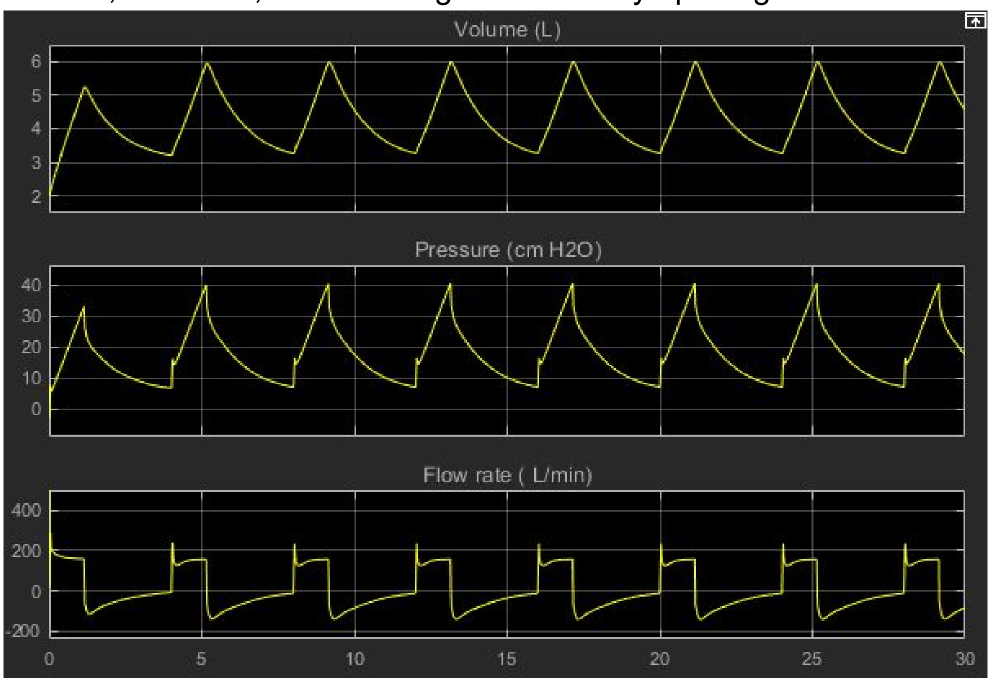
Input flow signal



Flow rate vs airway pressure

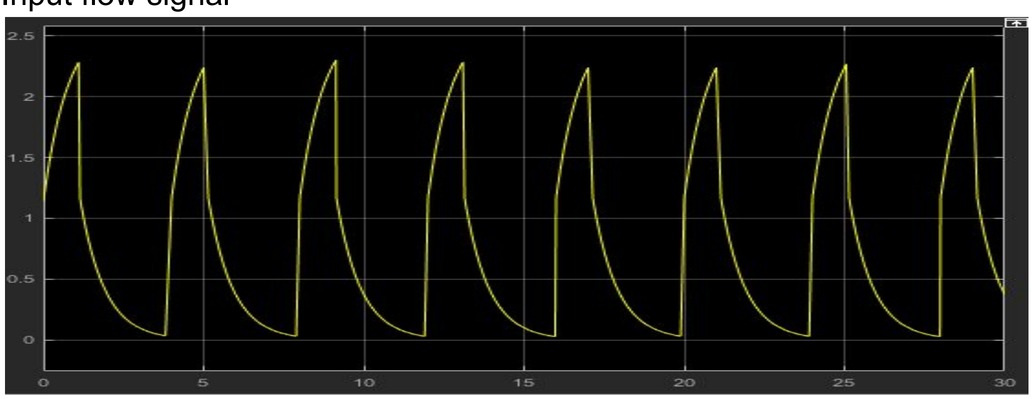


Volume, Pressure, Flow rate signals at airway opening

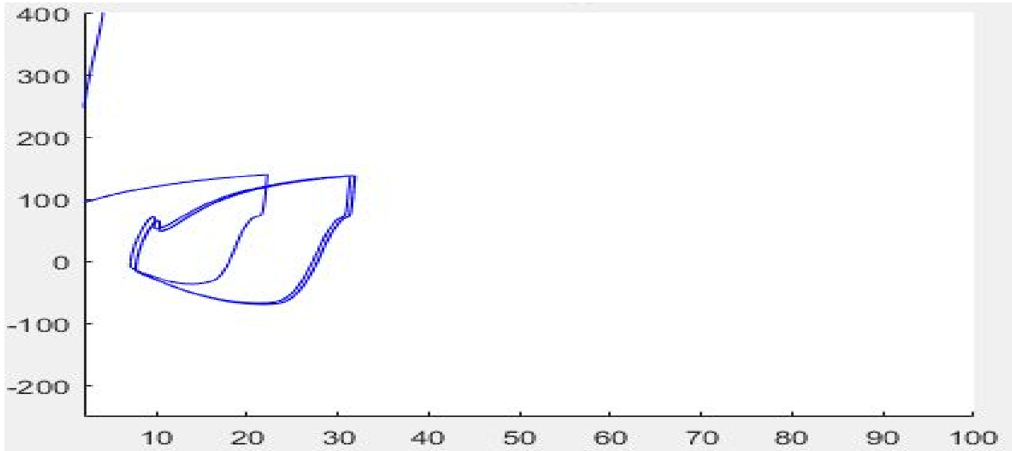


2) a=1.3, b=4, c=1.5, d=2

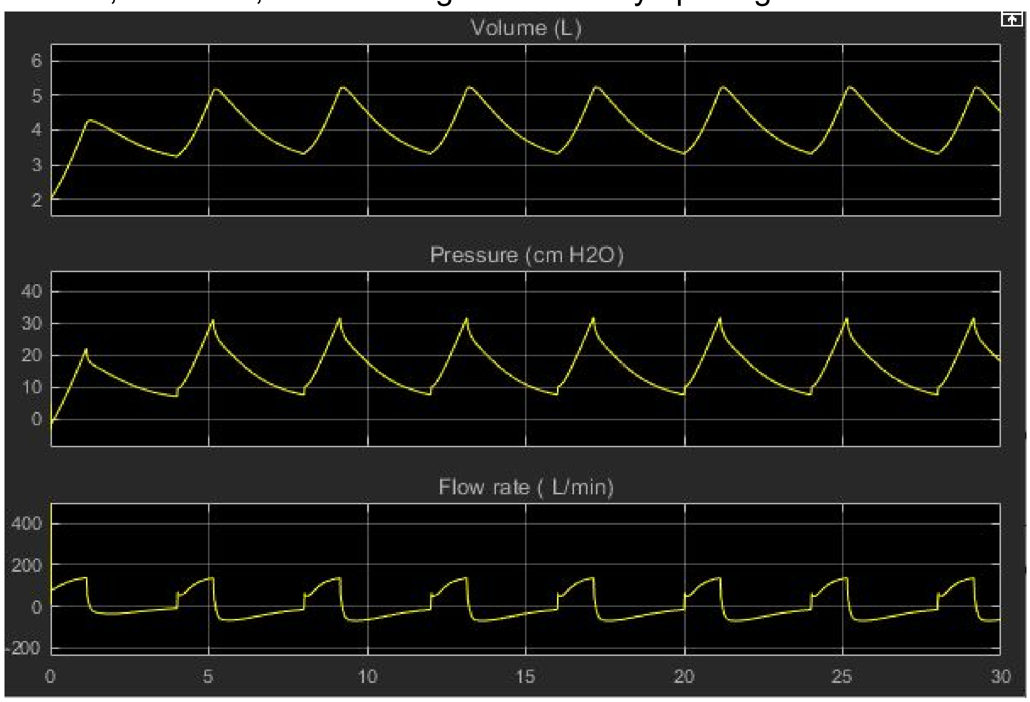
Input flow signal



Flow rate vs Airway pressure

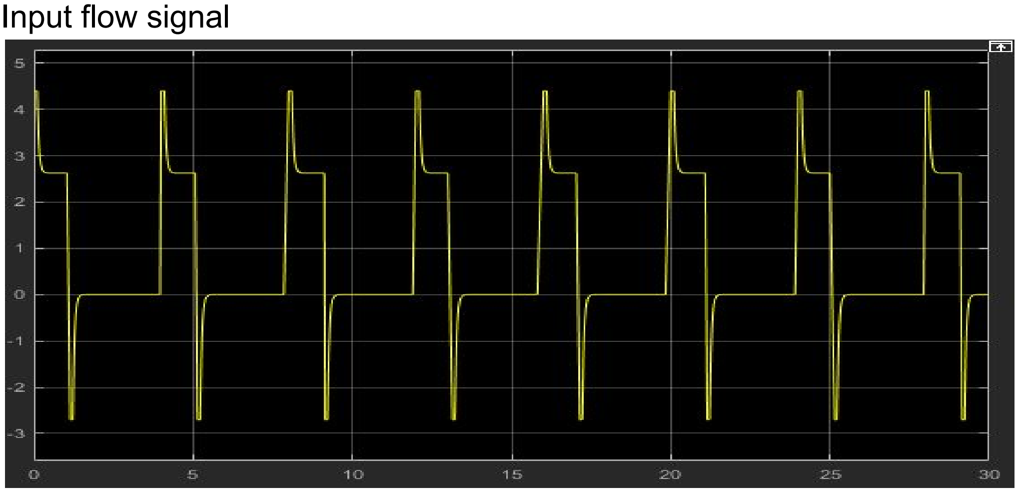


Volume, Pressure, Flow rate signals at airway opening

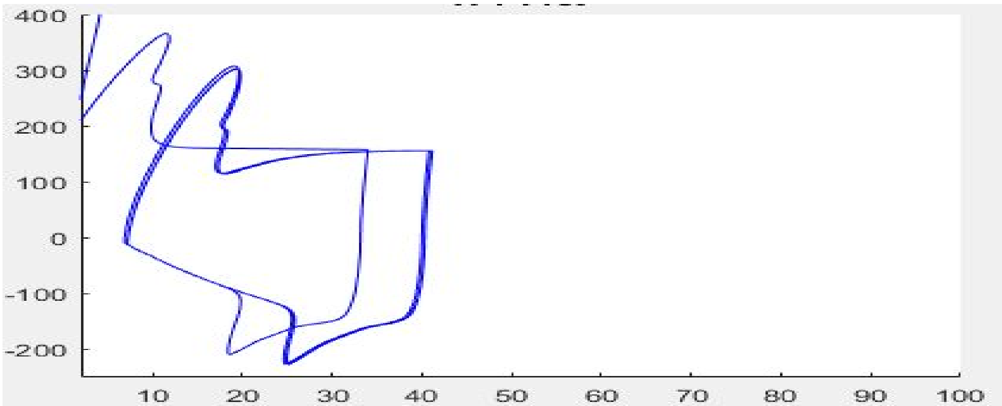


3) a=1.3, b=4, c=0.1, d=2

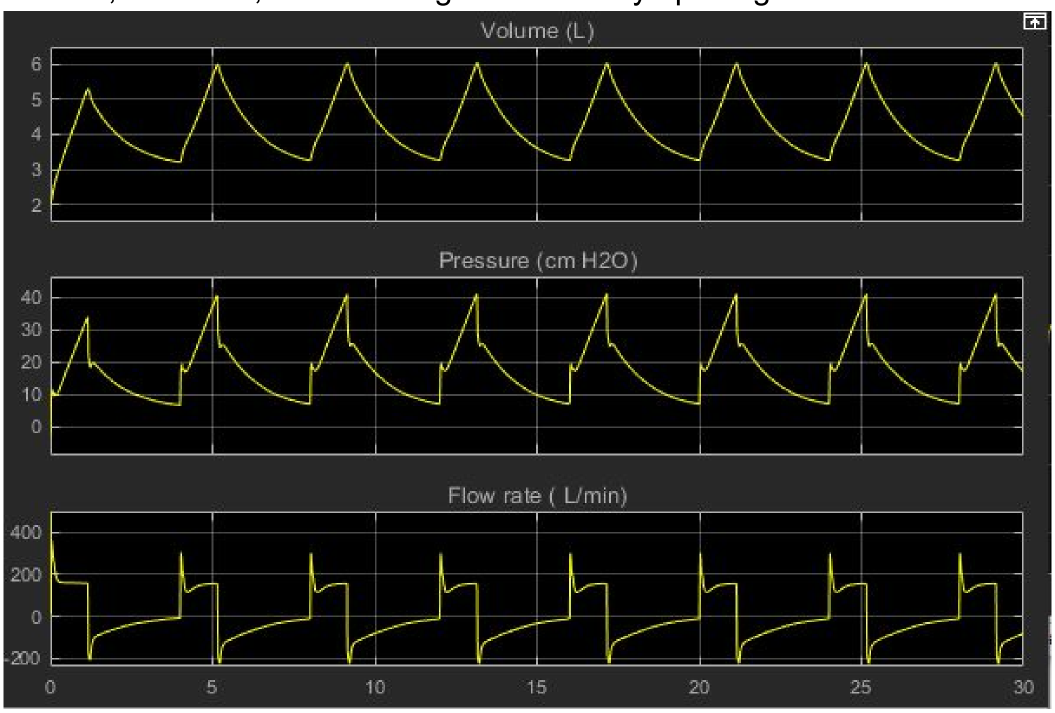
Input flow signal



Flow rate vs airway pressure



Volume, Pressure, Flow rate signals at airway opening

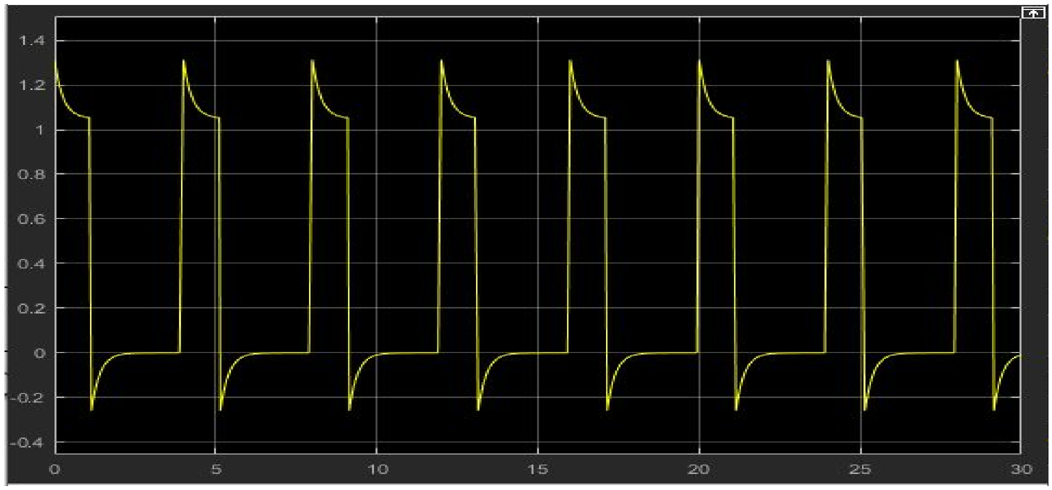


REMARKS

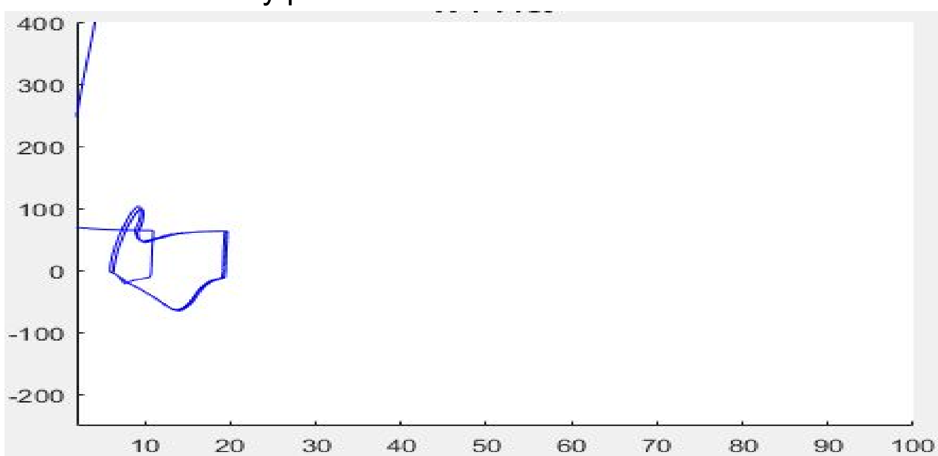
On changing the value of ‘c’, from 0.1 to 1.5, we can observe that peaks are sharper and cause abrupt changes in the parameters. this is evident from plots of Flow rate and Flow rate vs pressure.
The ideal value of C for which the original shape is not compromised but the sudden, sharp peaks are reduced is 1.3.

4) a=1.3, b=4, c= 1.3, d=5

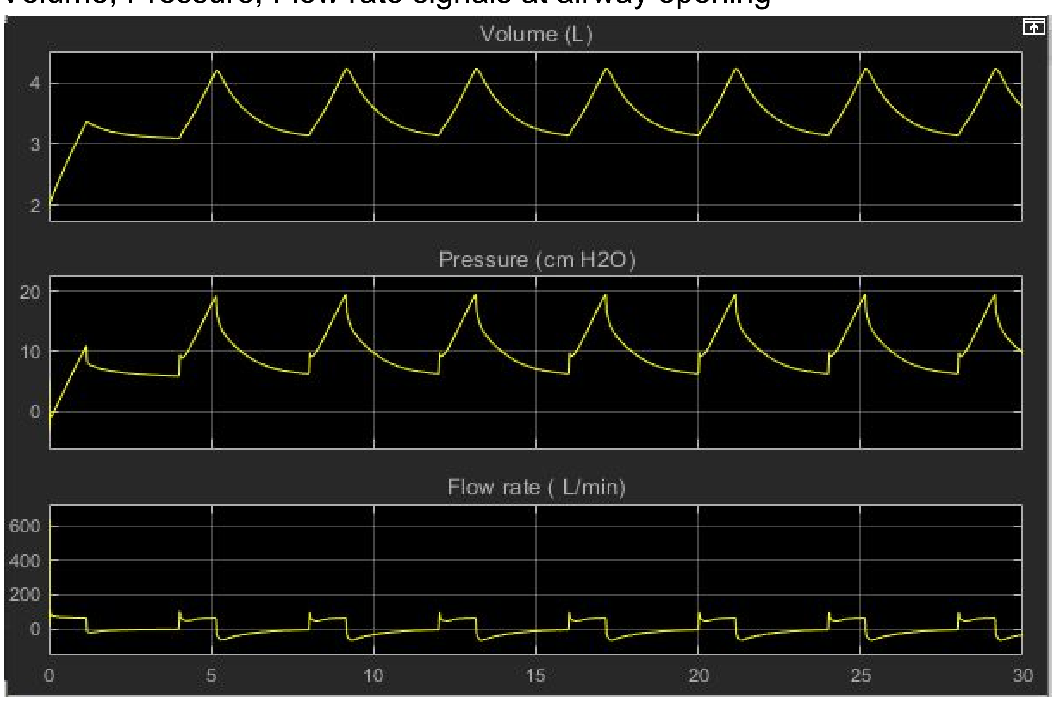
Input flow rate signal



Flow rate vs Airway pressure

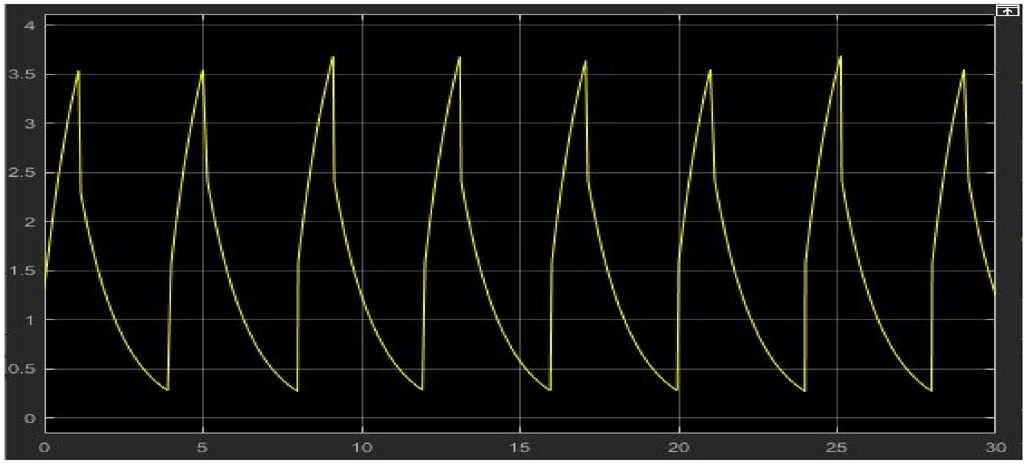


Volume, Pressure, Flow rate signals at airway opening

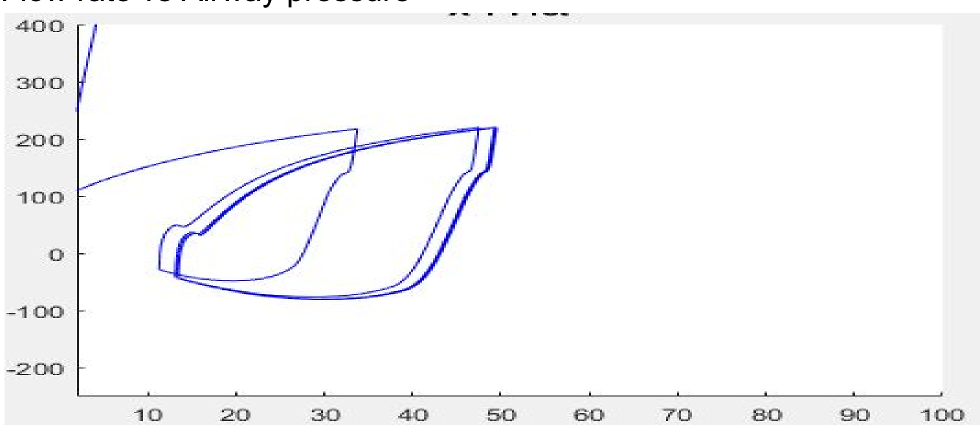


5) a=1.3, b=4, c= 1.3, d=1

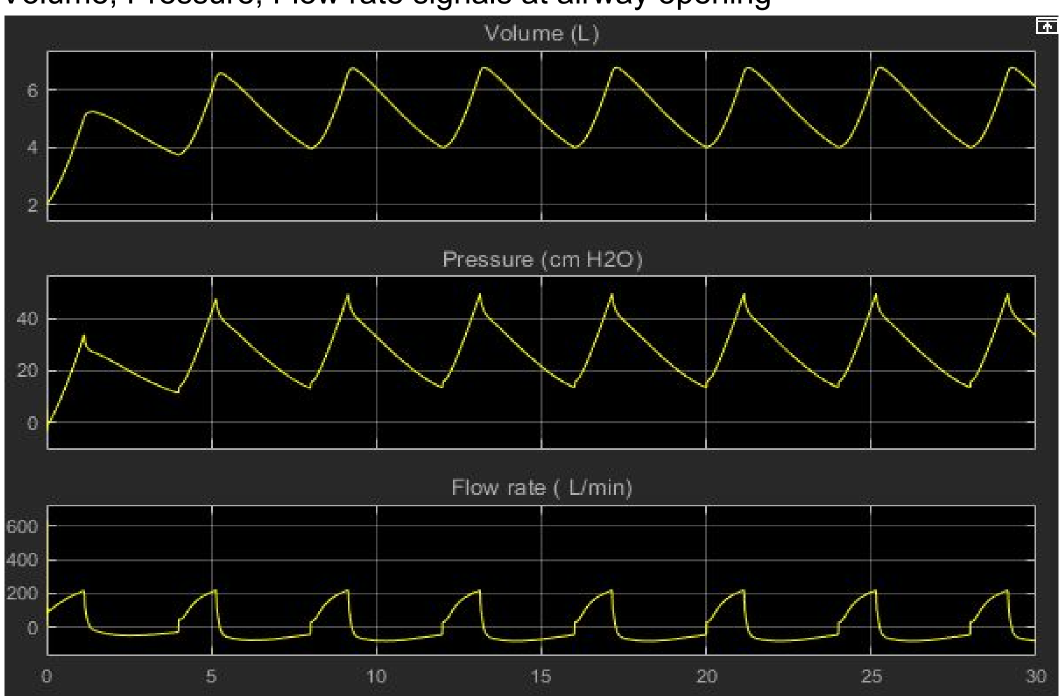
Input flow rate signal



Flow rate vs Airway pressure



Volume, Pressure, Flow rate signals at airway opening

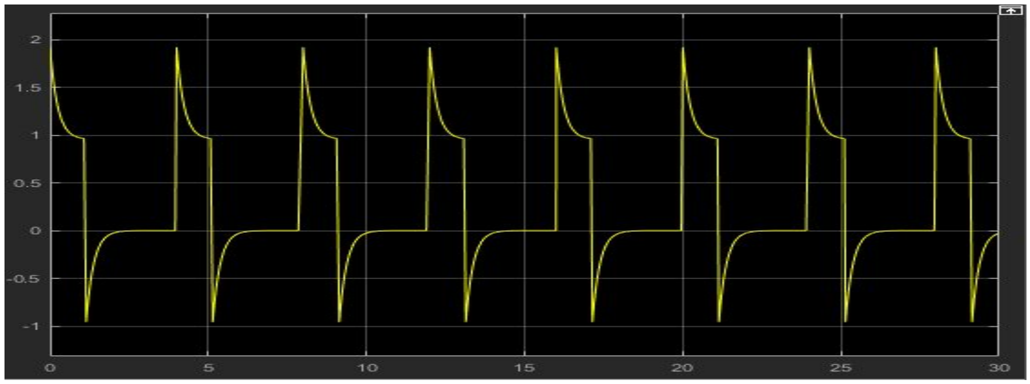


REMARKS

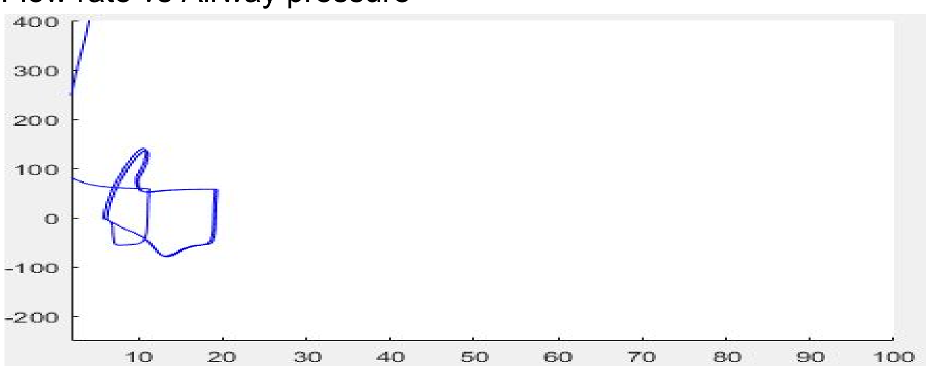
For constant flow rate, d = 5.5 can be chosen. for d < 5, the flow takes the form of ascending flow rate. for higher values of d, flow rate values have decreased further to very low values.

6) a=1.9, b=4, c= 1.3, d=1

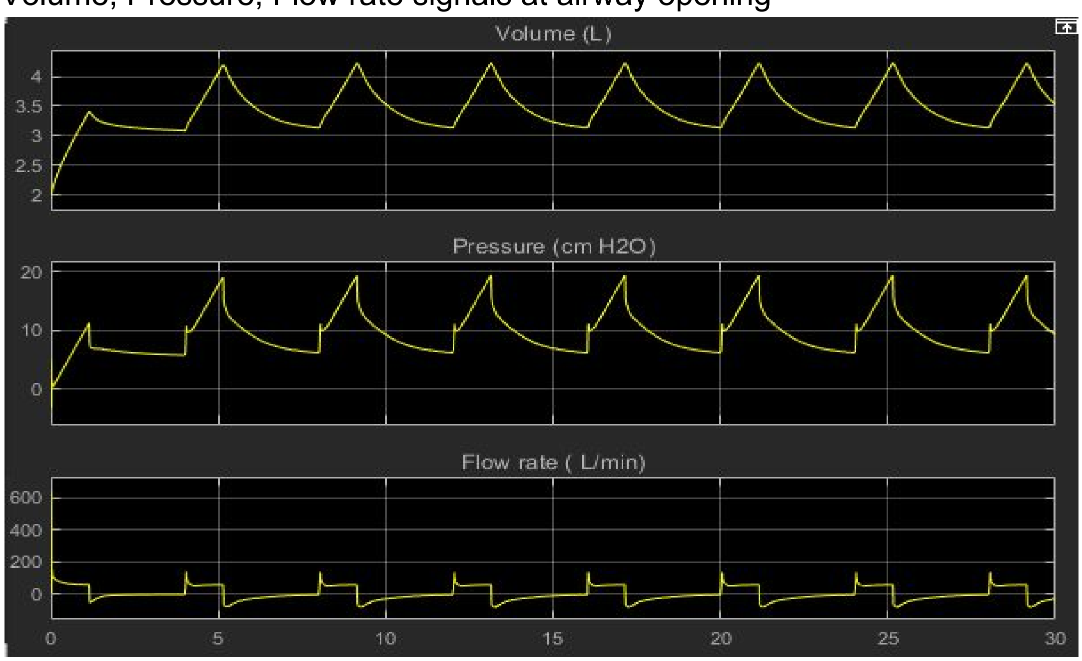
Input flow rate signal



Flow rate vs Airway pressure

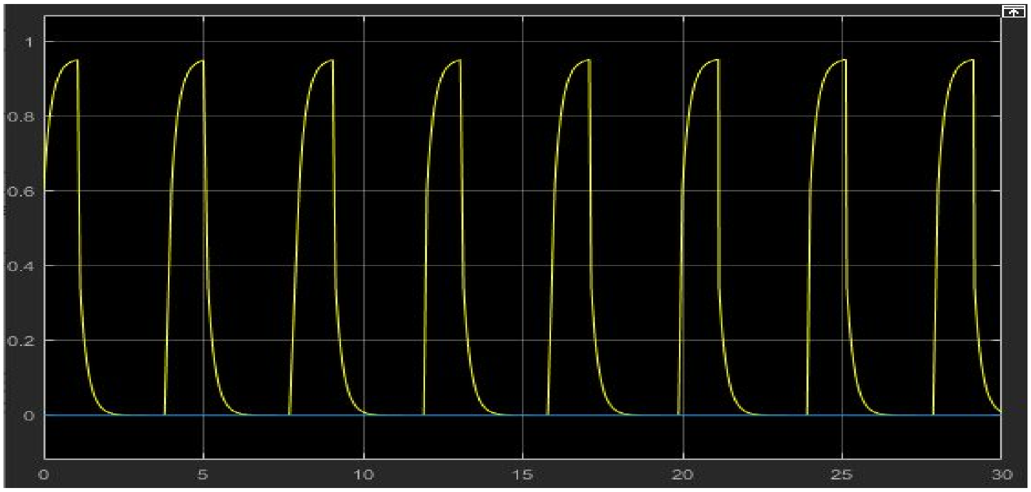


Volume, Pressure, Flow rate signals at airway opening



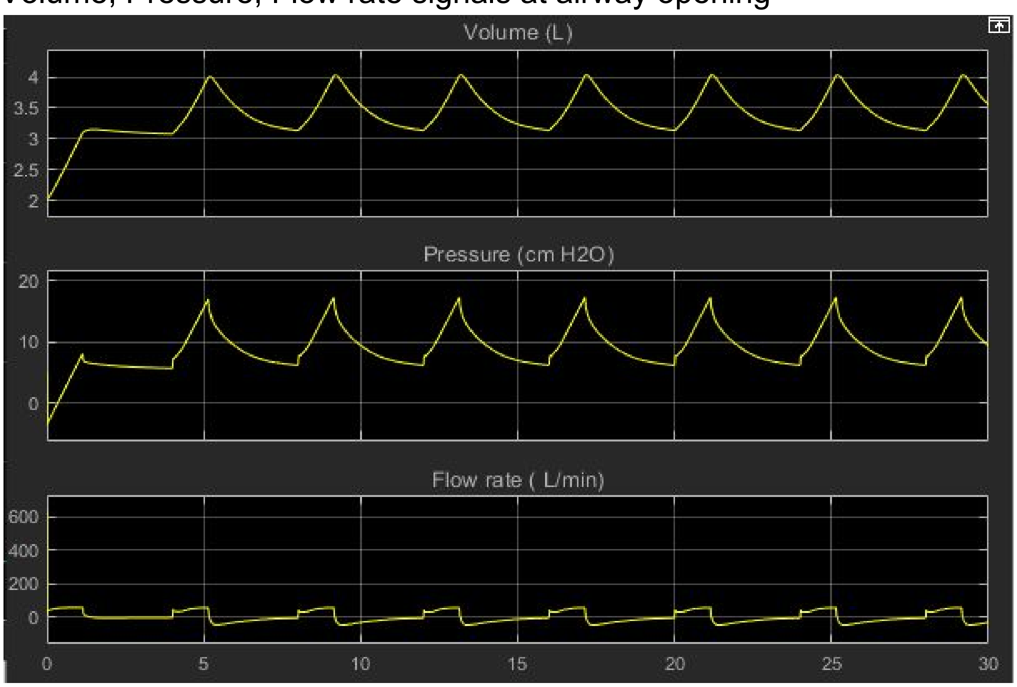
7) a=0.6, b=4, c= 1.3, d=1

Input flow rate signal

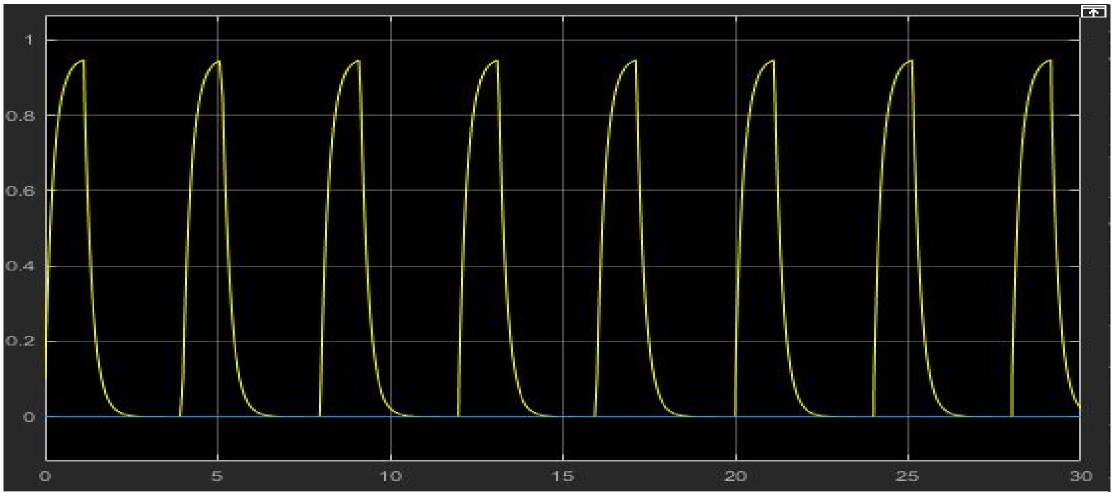


Flow rate vs Airway pressure

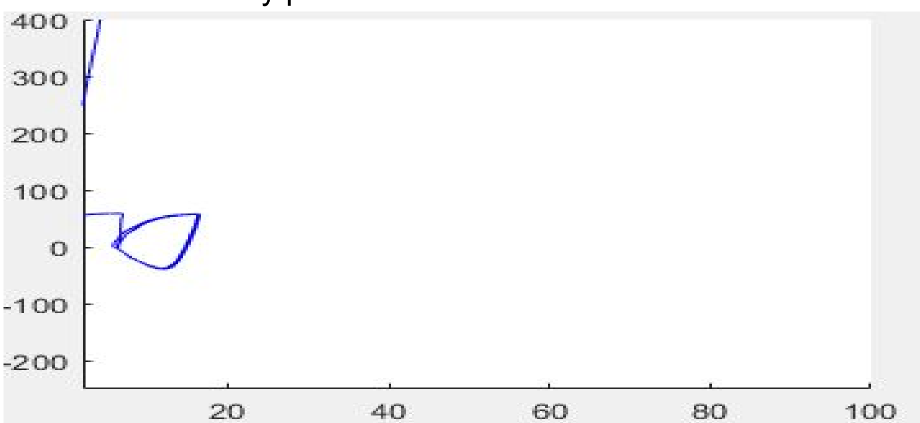
Volume, Pressure, Flow rate signals at airway opening



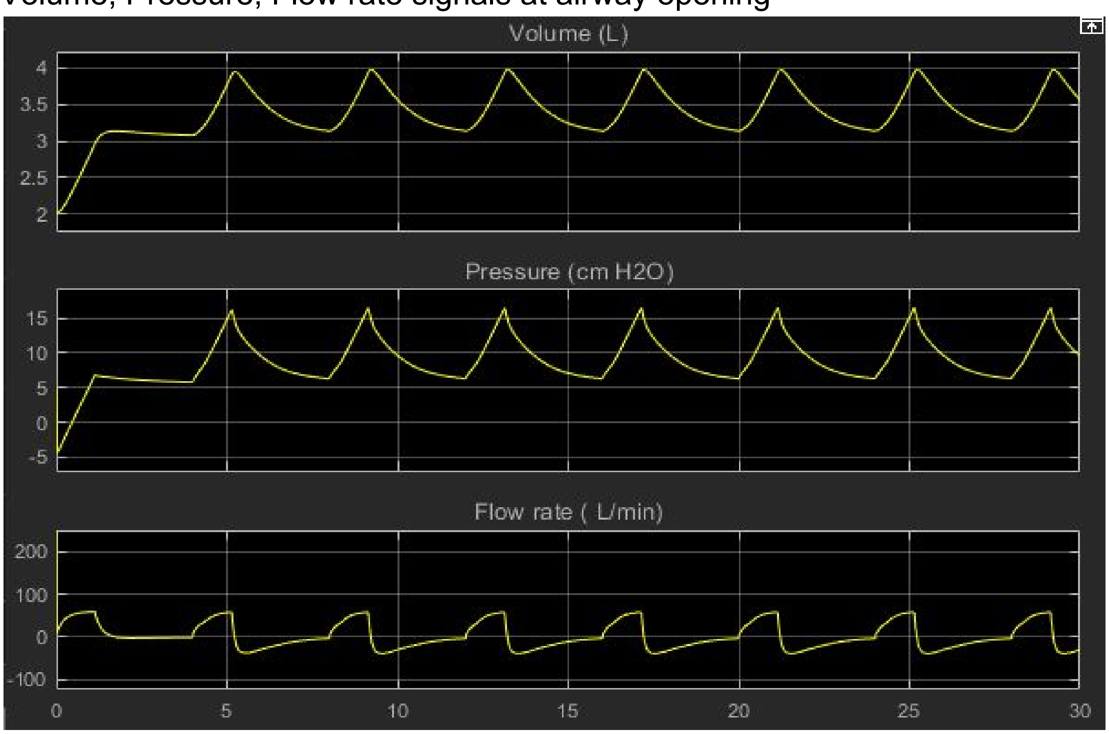
8) a=0.1, b=4, c= 1.3, d=1



Flow rate vs Airway pressure



Volume, Pressure, Flow rate signals at airway opening

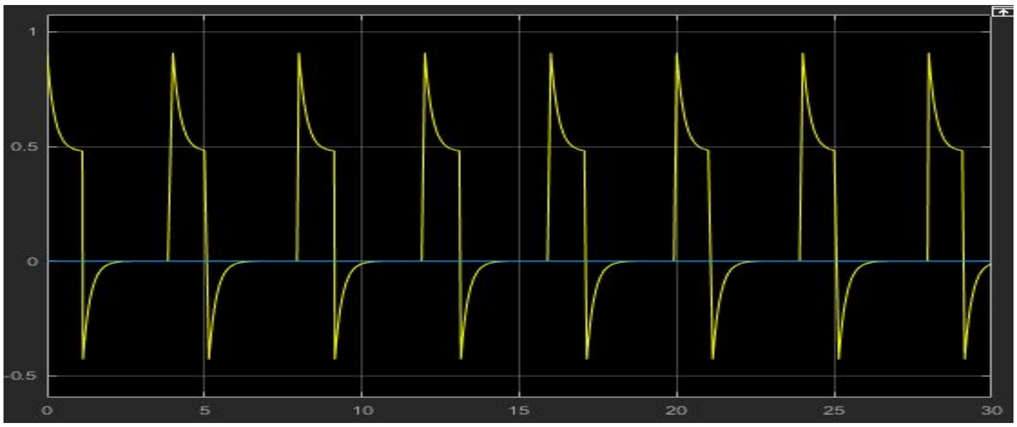


REMARKS

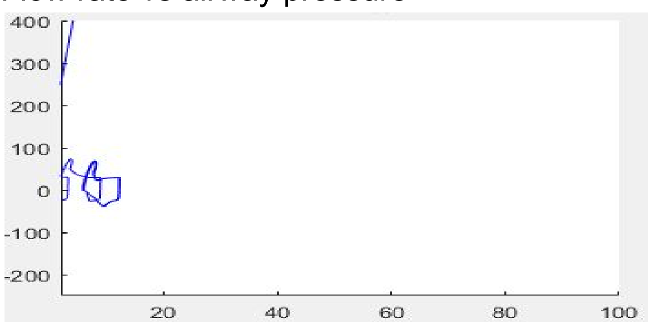
As the value of ‘a’ decreases, the signal changes from constant flow rate type to ascending flow rate type. Also the fall is less steep. optimum value of a is 0.9-1.2

9) a=0.9, b=2, c= 1.3, d=1

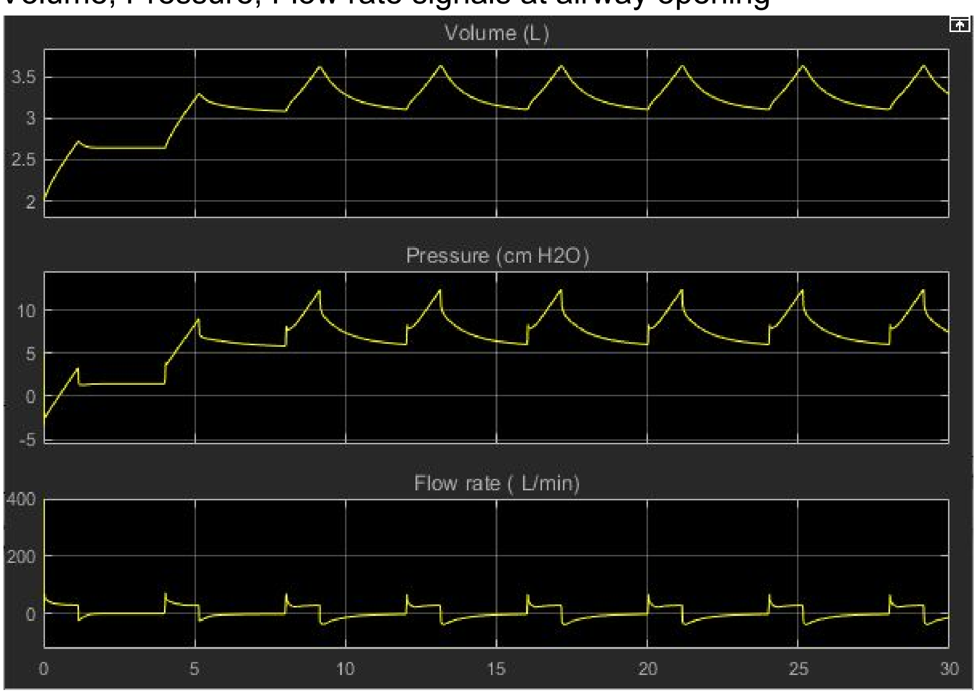
input flow rate signal



Flow rate vs airway pressure

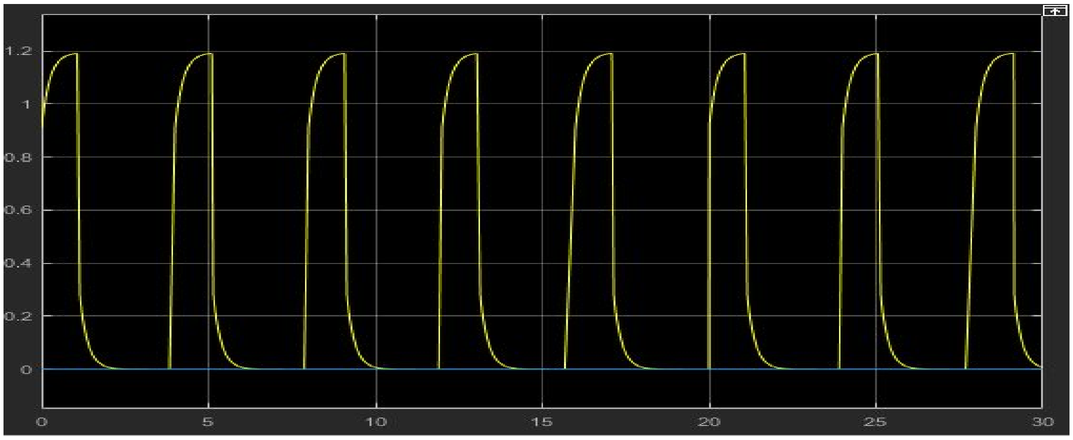


Volume, Pressure, Flow rate signals at airway opening

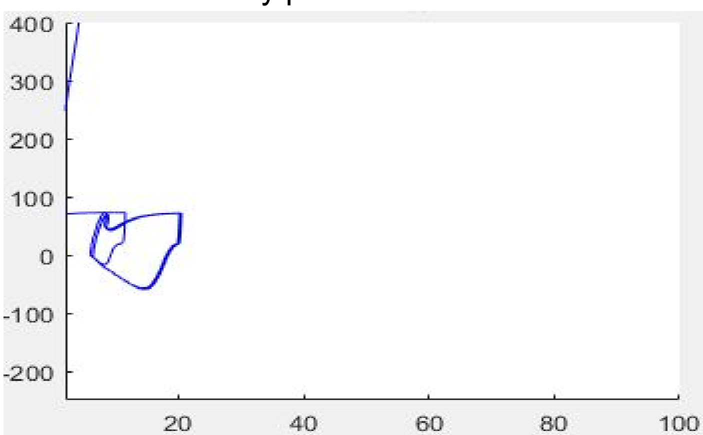


10) a=0.9, b=5, c= 1.3, d=1

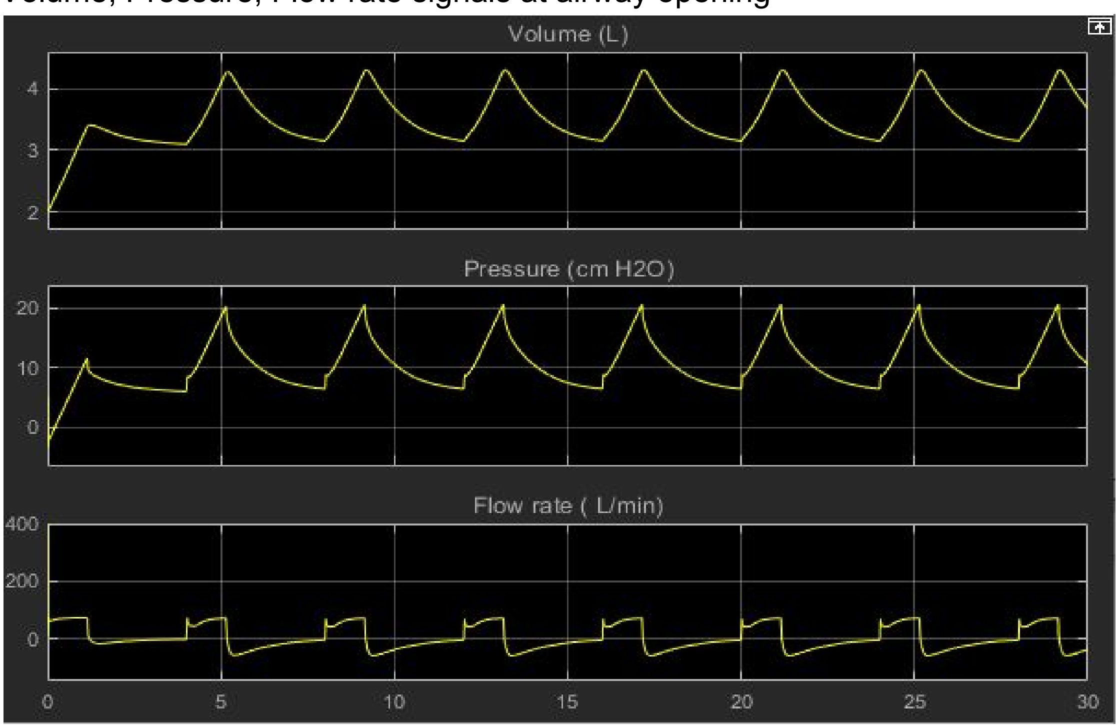
input flow rate signal



Flow rate vs Airway pressure



Volume, Pressure, Flow rate signals at airway opening



REMARKS

By decreasing the value of ‘b’, flow rate and pressure values drop down to a large extent. Hence the optimum value of b lies around 4 - 5.4

CONCLUSION

1) The error is not controlled in the first loop and hence it shows deviant values. from the second loop onwards, error is corrected and required trend is followed.
2) The 10 test cases show different requirements of flow rate by the patient and the consequential results of pressure and volume.

   For a transfer function of the form :

   $$(a*s + b) / (c*s + d)$$

   the ranges of coefficients have been found for all possible requirements. For example, a=1.3, b=4, c=0.5, d=2 is representative of a constant flow rate, while a=1.3, b=4, c=1.5, d=2 represents an ascending flow rate.
3) The amplitude, frequency, phase width of the signals can be scaled up and down by changing the control parameters, Tidal volume, respiratory rate and I:E ratio. Changes in transfer function only control the primary shape of the signal.