MicrUs and MicrUs Pro Series Ultrasound Systems

Echo Wave A Software

Measurements and Calculations Reference Manual

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Content

Echo Wave A Software Measurements and Calculations Overview 3
1 B mode general measurements and calculations 4
1.1 B Distance 4
1.2 B Area (Ellipse) 4
1.3 B Volume (1 ellipse) 5
2 M mode general measurements and calculations 6
2.1 M Distance 6
2.2 M Time 7
2.3 M Velocity 7
2.4 M Heart Rate (HR) 7
3 PW Doppler mode general measurements and calculations 8
3.1 One-point PW measurements 8
3.1.1 PW Velocity 8
3.1.2 PW Pressure Gradient (PG) 8
3.2 Two-point PW measurements 9
3.2.1 PW Velocities difference 9
3.2.2 PW Pressure Gradients (PG) difference 9
3.2.3 PW Time 9
3.2.4 PW Acceleration 9
3.2.5 PW Resistivity Index (RI) 10
3.2.6 PW Heart Rate (HR) 10
4 Conversion of measurement units 11
5 Revision History 12

Echo Wave A Software Measurements and Calculations Overview

This document presents equations that are used for Echo Wave A measurements and calculations.

- B mode measurements and calculations

  Distance
  Area (method: 1 ellipse)
  Circumference (method: 1 ellipse)
  Volume (method: 1 ellipse)

- M mode measurements and calculations

  Distance
  Time
  Velocity
  Heart Rate (method: 2 beats distance)

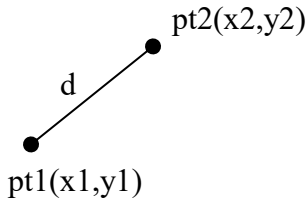
- PW mode general measurements and calculations

  One-point PW measurements and calculations:
    Velocity
    Pressure Gradient (PG)
  Two-point PW measurements and calculations:
    Velocities difference
    Pressure Gradients (PG) difference
    Time interval
    Acceleration
    Resistivity Index (RI)
    Heart Rate (2 beats)

1 B mode general measurements and calculations

In this section are presented basic equations that are used both for general measurements and calculations. **Please note that not all here described measurements may have control items in software user interface, but they may be used in other calculations.**

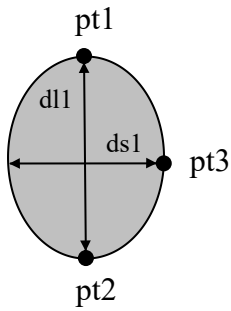
1.1 B Distance



Distance d between points pt1 and pt2 is calculated using the following equation:

$d(pt1, pt2) = \sqrt{(x1 - x2)^2 + (y1 - y2)^2}$.

1.2 B Area (Ellipse)

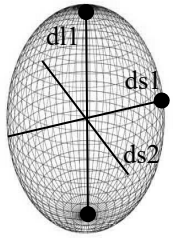


During measurements and calculations we assume that ellipse axis between two circular marker points pt1 and pt2 is "long axis", and axis with one circular endpoint marker pt3 is "short axis". And this "long axis" and "short axis" notation remains unchanged no matter what are real lengths of these axes.

Area S and circumference P (perimeter) of an ellipse with long axis length dl1 and short axis length ds1 are calculated using the following equations:

$$S = \frac{\pi \cdot dl1 \cdot ds1}{4},\ P = \pi \cdot \sqrt{\frac{1}{2}\left((dl1)^2 + (ds1)^2\right)}.$$

Volume V of an ellipsoid with axes lengths dl1, ds1, and ds2=ds1 is calculated using the following equation:



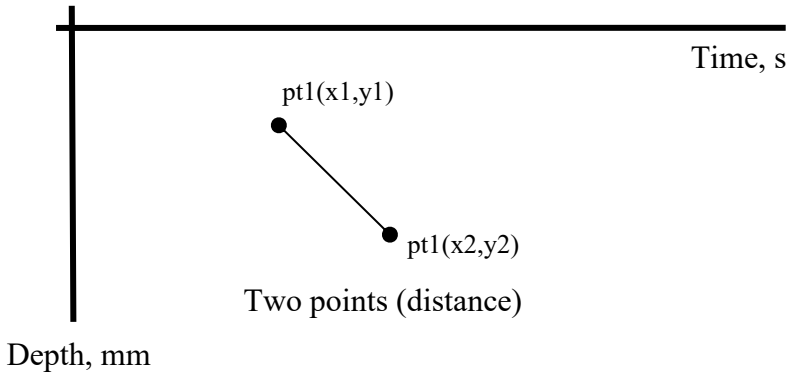
$$V = \frac{\pi \cdot dl1 \cdot ds1 \cdot ds2}{6}.$$

1.3 B Volume (1 ellipse)

See "B Area (Ellipse)" section.

2 M mode general measurements and calculations

Usually in M mode ultrasound image horizontal axis (x-axis) represents time (in seconds), and vertical axis (y-axis) represents depth (in milimeters). On M mode image are usually performed two-point -based measurements and calculations. For measurements and calculations we use (time [s], depth [mm]) coordinate system, where each point can be described by its time (in seconds [s]) and depth (in millimeters [mm]). For example, notation pt1(x1,y1)=(5,120) means that coordinates of point pt1 are x1=5s and y1=120mm. Here pt1 and pt2 are two end-points of one line (distance).



2.1 M Distance

Distance between points pt1 and pt2 is calculated using the following equation:

$d = abs (d1 - d2)$,

here

d [mm] - distance,
d1 [mm] - depth at point pt1,
d2 [mm] - depth at point pt2,
abs(…) means that is calculated absolute value.

2.2 M Time

Time interval (difference) between points pt1 and pt2 is calculated using the following equation:

t = abs (t1 - t2),

here

t [s] - time interval (difference),
t1 [s] - time at point pt1,
t2 [s] - time at point pt2.

2.3 M Velocity

Velocity between points pt1 and pt2 is calculated using the following equation:

Vel = abs (d2 - d1) / abs (t2 - t1),

here

Vel [mm/s] - velocity,
t1 [s] - time at point pt1,
d1 [mm] - depth at point pt1,
t2 [s] - time at point pt2,
d2 [mm] - depth at point pt2.

2.4 M Heart Rate (HR)

Heart Rate (HR) using markers pt1 and pt2 is calculated according to the following equation:

HR = 60*beats_num / abs(t2-t1),

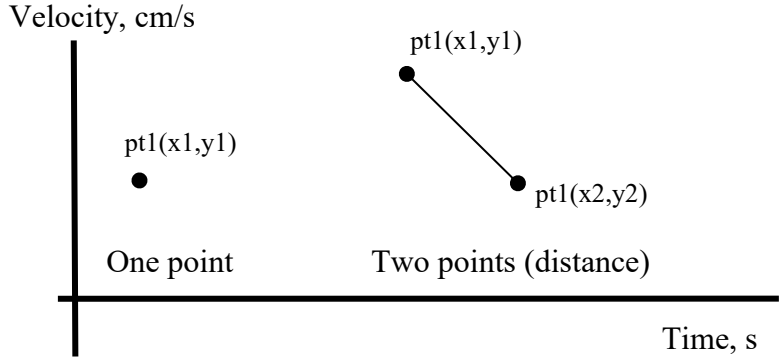
here

HR [beats/min] - Heart Rate in beats per minute,
abs(t2-t1) [s] - time interval between markers pt1 and pt2,
beats_num [beats] - the number of heart beats (e.g., 2) in measured time interval.

3 PW Doppler mode general measurements and calculations

Pulsed Wave (PW) Doppler mode measurements and calculations are available only for scanners that support PW Doppler scanning mode.

Usually in PW Doppler mode ultrasound image horizontal axis (x-axis) represents time (in seconds), and vertical axis (y-axis) represents velocity (in centimeters per second). On PW image we can perform one-point (one-marker) and two-point measurements and calculations. For measurements and calculations we use (time [s], velocity [cm/s]) coordinate system, where each point can be described by its time (in seconds [s]) and velocity (in centimeters per second [cm/s]). For example, notation pt1(x1,y1)=(5,20) means that coordinates of point pt1 are x1=5s and y1=20cm/s.



3.1 One-point PW measurements

3.1.1 PW Velocity

●
pt(x,y)=(time [s], velocity [cm/s])=(t,V)

If y axis of PW ultrasound image represents velocities, then velocity V at point pt is equal to this point's y coordinate value. Velocities may have both positive and negative values.

3.1.2 PW Pressure Gradient (PG)

●
pt(t,V)

Pressure Gradient (PG) at point pt is calculated using the following equation:

$PG = 4 \cdot V^2$,

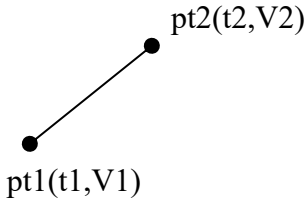
here

PG [mmHg] - Pressure Gradient,
V [m/s] - velocity,
1 m/s = 100 cm/s.

Reference:

Oh, J.K., J.B. Seward, A.J. Tajik. The Echo Manual. 2nd ed., Lippincott, Williams, and Wilkins, (1999), p. 64.

3.2 Two-point PW measurements



For two-point PW measurements we use coordinates (time,velocity) of two end-points pt1 and pt2 of one line (distance).

3.2.1 PW Velocities difference

Velocity difference between points pt1 and pt2 is calculated using the following equation:

Vel_diff = abs (V1 - V2),

here

Vel_diff [cm/s] - velocities difference,
V1 [cm/s] - velocity at point pt1,
V2 [cm/s] - velocity at point pt2,
abs(…) means that is calculated absolute value.

3.2.2 PW Pressure Gradients (PG) difference

Pressure Gradients (PG) difference between points pt1 and pt2 is calculated using the following equation:

PG_diff = abs (PG1 - PG2),

here

PG_diff [mmHg] - Pressure Gradients (PG) difference,
PG1 [mmHg] - Pressure Gradient at point pt1,
PG2 [mmHg] - Pressure Gradient at point pt2.

For Pressure Gradient (PG) calculation please see "PW Pressure Gradient" section.

3.2.3 PW Time

Time difference (time interval) between points pt1 and pt2 is calculated using the following equation:

t = abs (t2 - t1),

here

t [s] - time difference (time interval),
t1 [s] - time at point pt1,
t2 [s] - time at point pt2.

3.2.4 PW Acceleration

Acceleration between points pt1 and pt2 is calculated using the following equation:

Acc = abs (V2 - V1) / abs (t2 - t1),

here

Acc [cm/s2] - acceleration,
t1 [s] - time at point pt1,
V1 [cm/s] - velocity at point pt1,
t2 [s] - time at point pt2,
V2 [cm/s] - velocity at point pt2.

Reference:

Zwiebel, W.J. Introduction to Vascular Ultrasonography. 4th ed., W.B. Saunders Company, (2000), p. 52.

3.2.5 PW Resistivity Index (RI)

Resistivity Index (RI) between points pt1 and pt2 is calculated using the following equation:
RI = abs (abs(V1) - abs(V2)) / max (abs(V1), abs(V2)),

here

RI [unitless] - Resistivity Index,
V1 [cm/s] - velocity at point pt1,
V2 [cm/s] - velocity at point pt2,
max(…,…) means that we get maximal value from two passed values.

References:

Evans, D.H., N. McDicken. Doppler Ultrasound: Physics, Instrumentation and Signal Processing. Second Edition. John Wiley & Sons, (2000), p. 456.

Burns, Peter N. The Physical Principles of Doppler and Spectral Analysis. Journal of Clinical Ultrasound, November/December, 1987, vol. 15, no. 9, p.586.

Kurtz, A.B., W.D. Middleton. Ultrasound - the Requisites. Mosby Year Book, Inc., (1996), p. 467.

3.2.6 PW Heart Rate (HR)

Heart Rate (HR) using markers pt1 and pt2 is calculated according to the following equation:
HR = 60*beats_num / abs(t2-t1),

here

HR [beats/min] - Heart Rate in beats per minute,
abs(t2-t1) [s] - time interval between markers pt1 and pt2,
beats_num [beats] - the number of heart beats in measured time interval (usually 1 or 2).

4 Conversion of measurement units

1 cm = 10 mm
1 cm2 = 100 mm2
1 cm3 = 1000 mm3
1 cm3 = 1 ml
1 m/s = 100 cm/s
1 cm/s = 10 mm/s
1 min = 60 s

5 Revision History

Revision	Revision Date	Description of Revision	Revision Author
1.0.0	2019.10.07	Initial Release	V.Perlibakas
1.0.1	2020.05.14	Changed first page photo.	V.Perlibakas
1.2.0	2020.08.11	Added information about M mode measurements.	V.Perlibakas
1.2.1	2020.08.13	Added section “M Heart Rate”.	V.Perlibakas
1.3.0	2022.09.29	Added information about PW mode measurements	V.Perlibakas
1.3.1	2022.12.08	Updated company information.	V.Perlibakas

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