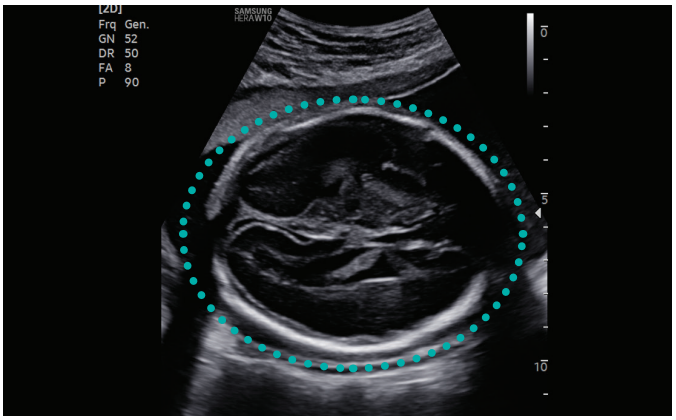
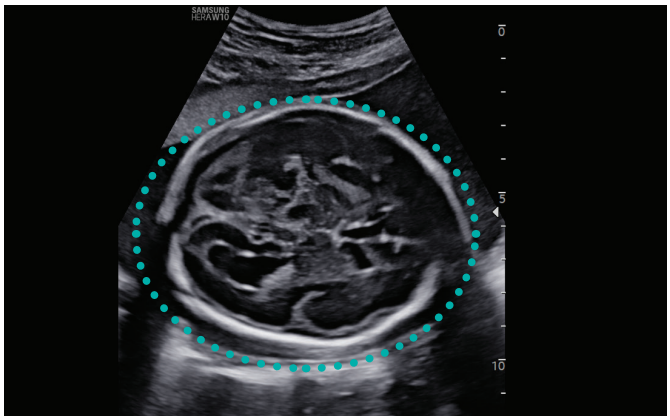
SAMSUNG

ShadowHDR™

A tool for visualization of attenuated shadow areas



ShadowHDR™ Off



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Background

Physics : Difference of resolution and penetration

Ultrasound generates less attenuation with lower frequency signals, enabling deeper penetration but lower resolution. Conversely, it provides better resolution images with higher frequency signals, but with more severe attenuation. [Fig1]

Different frequencies are applied for each depth based on these attributes. This optimization of the image to include more high frequencies in near regions and more low frequencies in the far regions, means that clearer images can be obtained at every level of penetration.

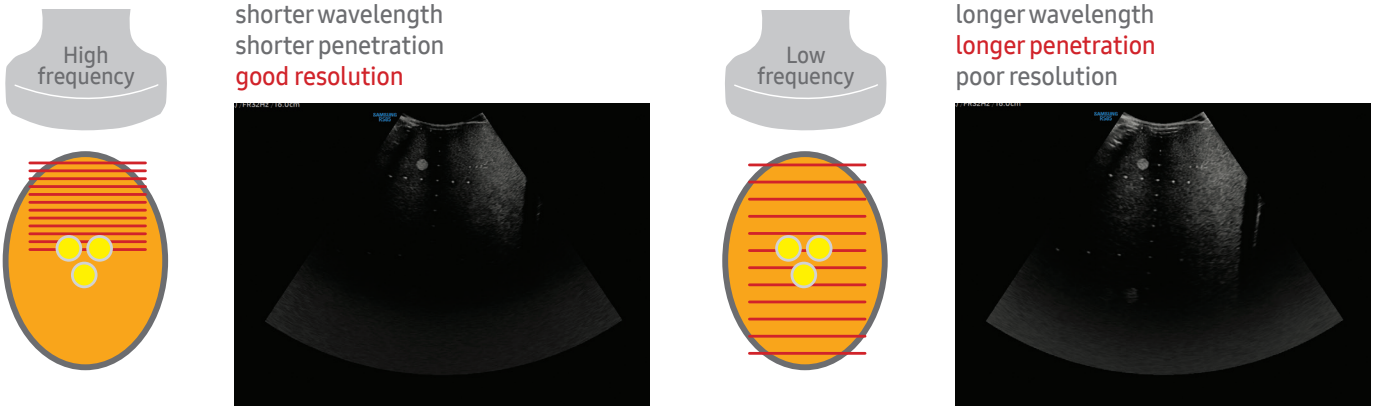


Fig1. Resolution and penetration relationship between frequencies

Frequency compounding technology

Conventional frequency compounding is a technique for synthesizing variable frequency images. By synthesizing close to high frequencies in the near area and close to low frequencies in the far area, the resolution of the near area is enhanced and the attenuation of the far area is reduced. Speckle noise is also reduced by simultaneously adding different frequency images [1]. (Fig 2)

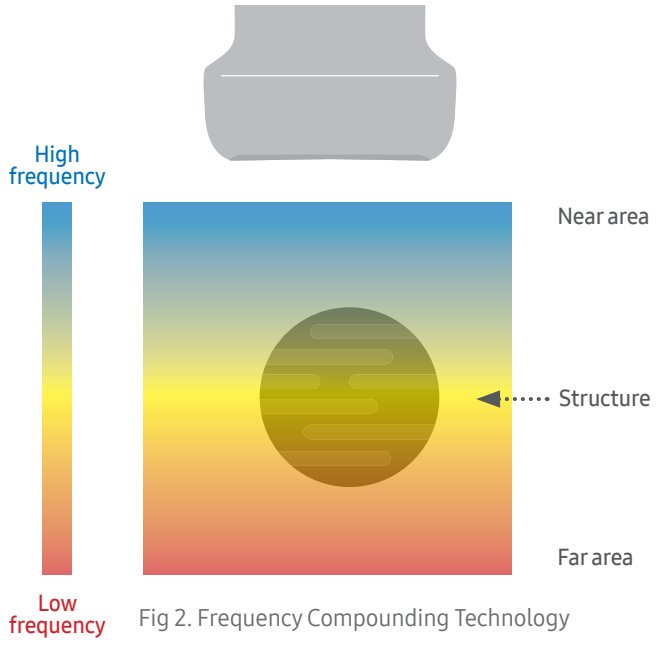


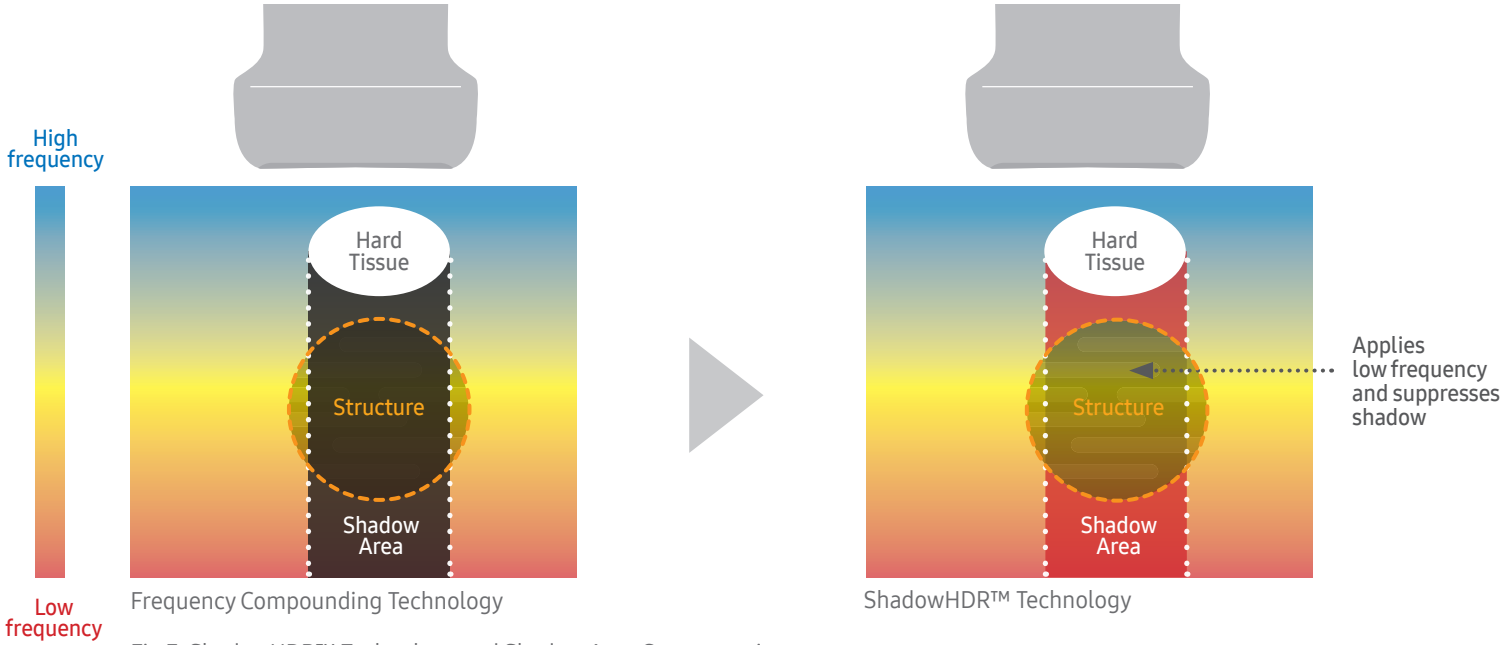
Fig 2. Frequency Compounding Technology

Visualization of attenuated areas

Samsung's ShadowHDR™ technology

When a bone or hard tissue is placed in the image area, a shadow area is generated under the tissue. This may occur simultaneously in the near area or in multiple areas, and shadows may occur due to attenuation in any area. In these areas, low frequency signals are not properly used for compensation. In addition, there is a difficulty in expressing the shadow area as it does not use the compression method to better express the shadow area.

ShadowHDR™ technology creates multiple frequency band images, detects the shadow area from the high frequency band images, and synthesizes the low frequency band images by increasing the blending ratio of the low frequency band images. This way, the shadow area is clearly visible regardless of the depth. After that, in order to compensate for the brightness of the shadow area, it is imaged by expressing it with appropriate brightness using the HDR tone mapping [2,3] technique. (Fig 3)



Frequency Compounding Technology

ShadowHDR™ Technology

Fig 3. ShadowHDR™ Technology and Shadow Area Compensation

Breast without ShadowHDR™

Breast with ShadowHDR™

Fig 4. ShadowHDR™ technology on breast

In the image of the breast above, the shadow was caused by the nipple, but when ShadowHDR™ was applied, the shadow area where the attenuation occurred was compensated for. (Fig 4)

How to use ShadowHDR™

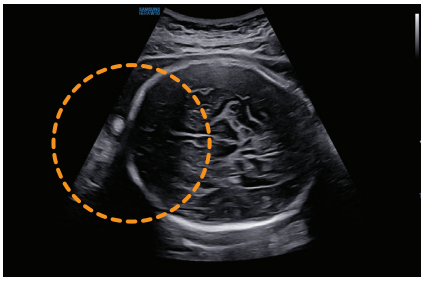
UI button configuration and Strength Index adjustment

When the ShadowHDR™ function is turned on to compensate for the shadow to a certain level, the index value is set as the default strength. The user can adjust the ShadowHDR™ compensation amount by adjusting the strength index if necessary. If the index is increased, it will increase the shadow brightness and compensate for the brightness of darker regions, but it may increase noise in some areas.

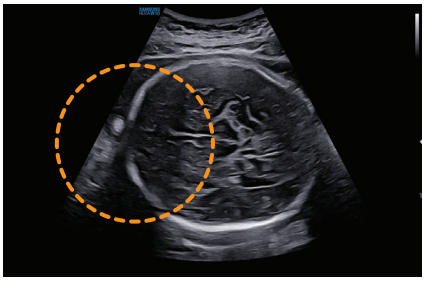
"ShadowHDR" button
Select this button to enable ShadowHDR™.

"Strength Index" button
Press the left side of the button to decrease the strength index. Press the right side to increase the strength index.

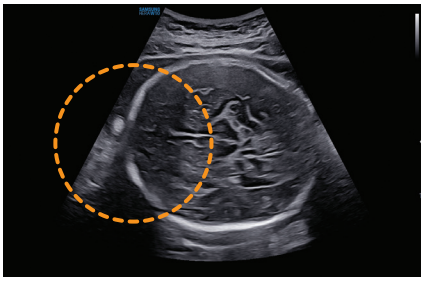
Compensation of shadow according to Strength Index



Index level 1



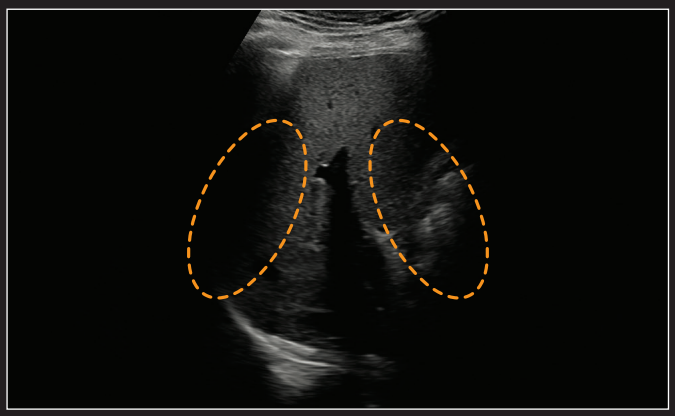
Index level 3



Index level 5

Liver

The shadow is caused by the ribs. In the mid-far area, the shadow is well-compensated.



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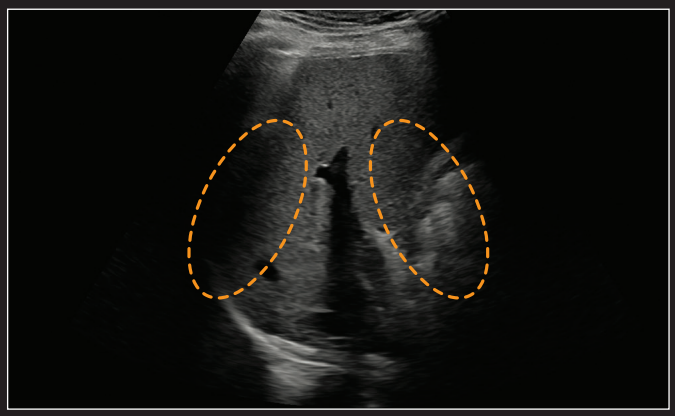
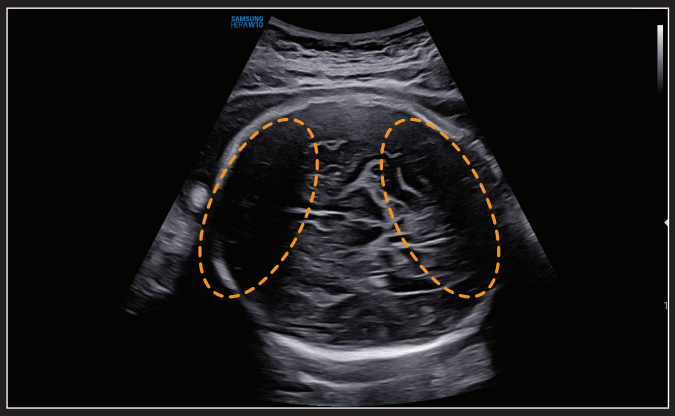


ShadowHDR™ On

Fetal brain

The shadow is caused by the fetal skull. It is useful for checking the brain structure at the back of the bone.



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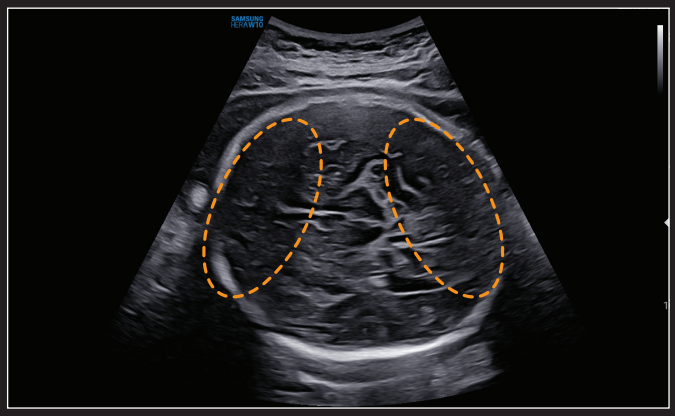
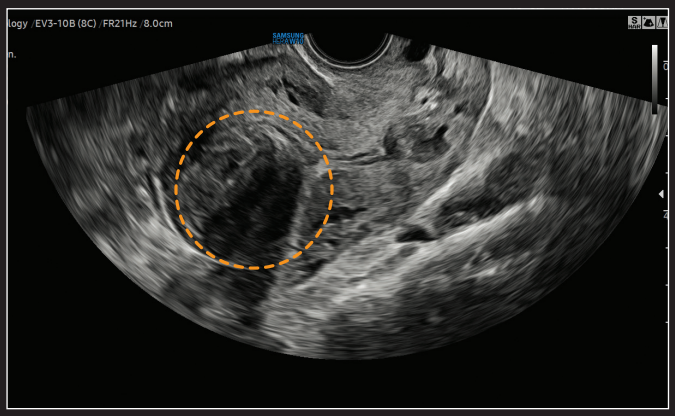


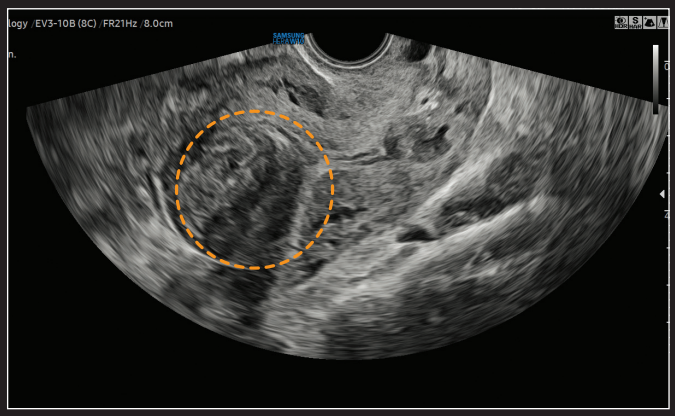
ShadowHDR™ On

Myoma

The shadow is caused by a uterine fibroid. The signal is improved at the some shadow areas in the myoma.



ShadowHDR™ Off



ShadowHDR™ On

HDR Tone Mapping [2, 3]:

The technology compensates for the brightness information of the shadow area using the image brightness information. This occurs after separating brightness information for each area and differential information corresponding to details other than brightness. In these references, they did not use the multi-frequency band images for shadow suppression. Therefore, there are limitations of the shadow suppression performance.

Precautions

1. In the compensated shadow area, noise may increase and resolution may decrease slightly.
2. Compared to a wide shadow, a very thin shadow is difficult to detect and may not be well-compensated for.
3. It is not effective in strong shadows without ultrasonic signals.

References

1. Diagnostic Ultrasound Imaging: Inside Out, 2014
2. Alperen Degirmenci, Douglas P. Perrin, Robert D.Howe “High Dynamic Range Ultrasound Imaging.” International Journal of Computer Assisted Radiology and Surgery, May 2018, Volume 13, Issue 5, pp 721–729
3. Xiao Y, Boily M, Hashemi HS, Rivaz H. “High-Dynamic-Range Ultrasound: Application for Imaging Tendon Pathology.” Ultrasound in Medicine & Biology Volume 44, Issue 7, July 2018, Pages 1525-1532.

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