

ARDMS Topic:
Ultrasound Instrumentation

Unit 16: Compression & Dynamic Range

Sononerds Ultrasound Physics
Workbook & Lectures

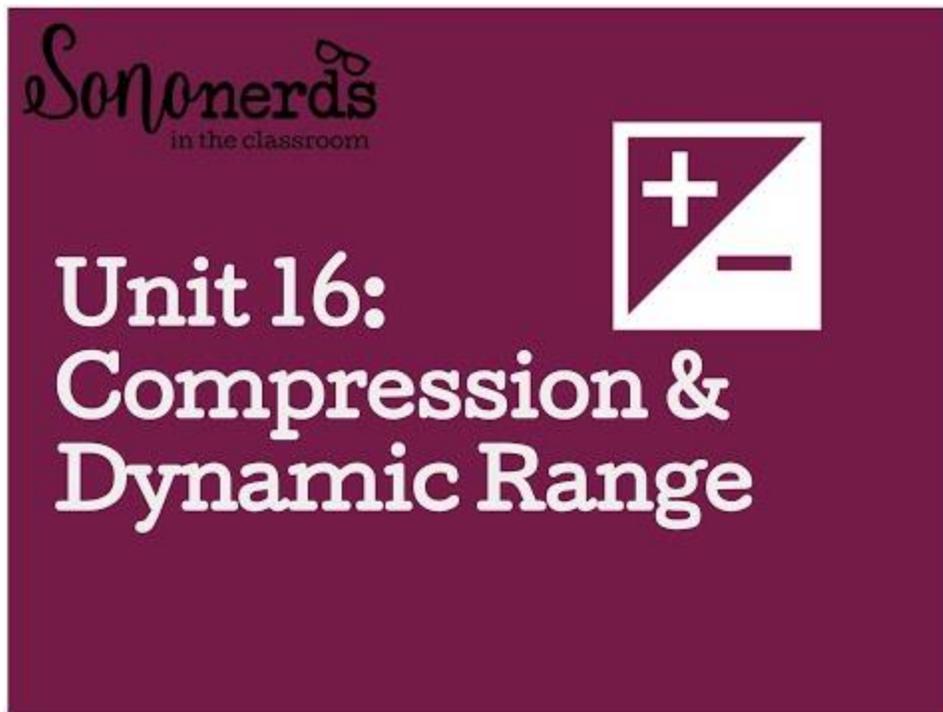
Unit 16: Compression & Dynamic Range

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Unit 16: Compression & Dynamic Range

[Entire Unit 16 Lecture:](#)



Did you know you can time jump to each section by using the “chapters” in the YouTube video playbar OR timestamps in the video description?

Unit 16: Compression & Dynamic Range

We've already talked about the idea of dynamic range and compression when we discussed receiver functions and contrast resolution. This unit is mostly a review, but another opportunity to understand the concepts further. Compression and dynamic range are used interchangeably, but to understand the concept, it might be helpful to think of dynamic range as the result of compression.

Section 16.1 Compression

Recall that compression is a two stage process:

- **1st compression**
- **2nd compression**

During either step of compression, there are 3 rules:

- 1. The largest signal must remain the largest**
- 2. The smallest signal must remain the smallest**
- 3. The range (choices of decibels) of signal in between is reduced**

Compression must occur to reduce the dynamic range without introducing errors.

16.1.1 First Compression

The first compression that the signal undergoes is performed automatically by the machine. This is NOT controlled by the sonographer and must occur so each component of the machine can **accurately** process the signal.

In general, the dynamic range decreases the more the information is processed. **The transducer has the highest dynamic range, where the archival system has the lowest.**

Component	Dynamic Range
Transducer	120 dB
Receiver	100 to 120 dB
Scan Converter (memory)	40 to 50 dB
Display	20 to 30 dB
Archive	10 to 30 dB

This means that the transducer is able to process a signal that is 1 trillion (1,000,000,000,000) times larger than the weakest signal. That is HUGE. Compare that to the archive system that can only process a signal that is 10 to 1000 times larger than its weakest signal.

As the signal is processed, we don't want to lose information about the strongest or weakest signals, so we compress them together to make their differences less drastic, without losing the hierarchy of strength.

This compression helps each system component not introduce any errors into the image.

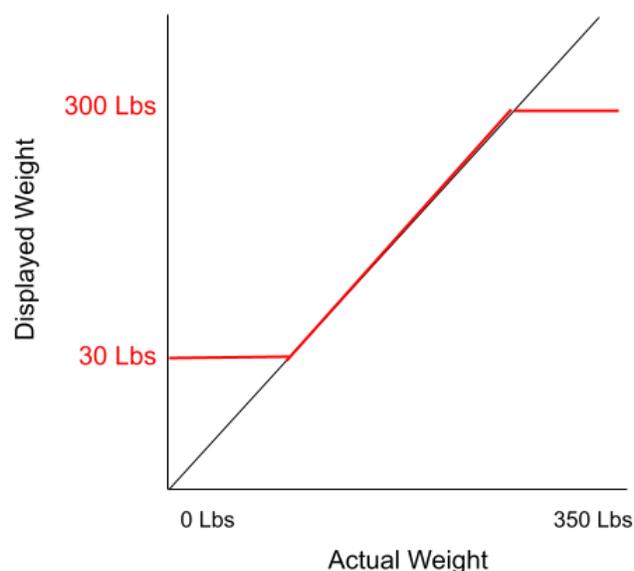
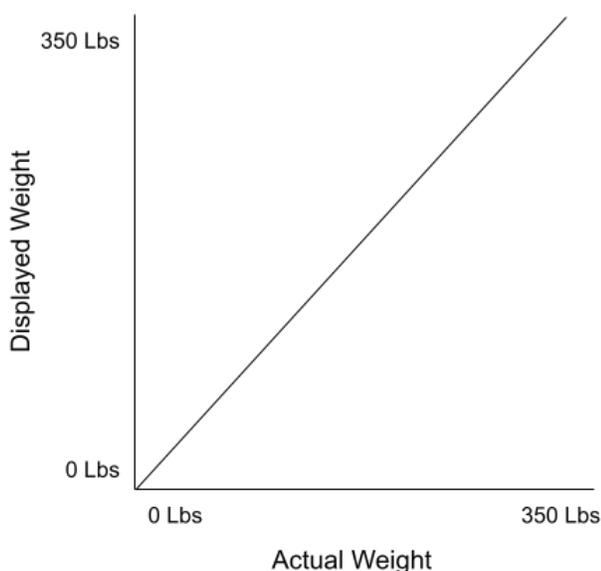
→ **Dynamic Range is measured in decibels**

Current physics textbooks offer us a few examples to help understand compression.

Dr. Sidney Edelman uses a bathroom scale:

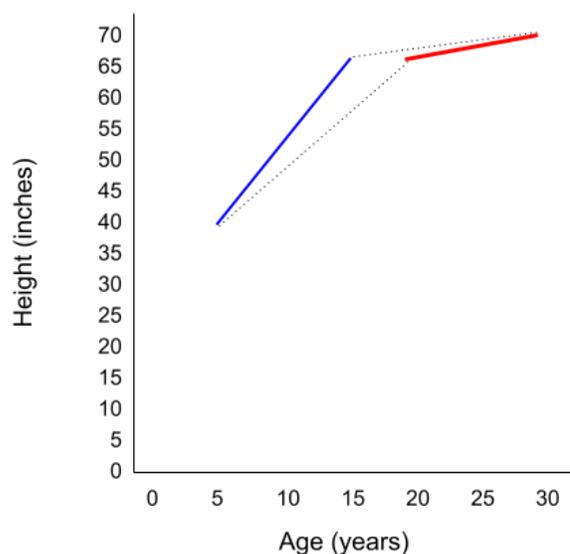
Your bathroom scale may only be able to display weights between 30 and 300 pounds.

If a person weighs less than 30 pounds their weight is too little to be displayed appropriately by the scale. In fact, it most likely won't even move the needle because it doesn't meet the scales threshold. If a person weighs more than 300 pounds, then their weight is too much to be displayed accurately. Any weight over 300 will still be displayed as 300 pounds due to maxing out the system.



Frederick Kremkau uses age:

If we look at the heights of an average 5 year old female compared to to a 15 year old male, their heights are very different. Compared to the heights of an average 20 year old female and 30 year male, the difference in heights have changed, but their age range has not.

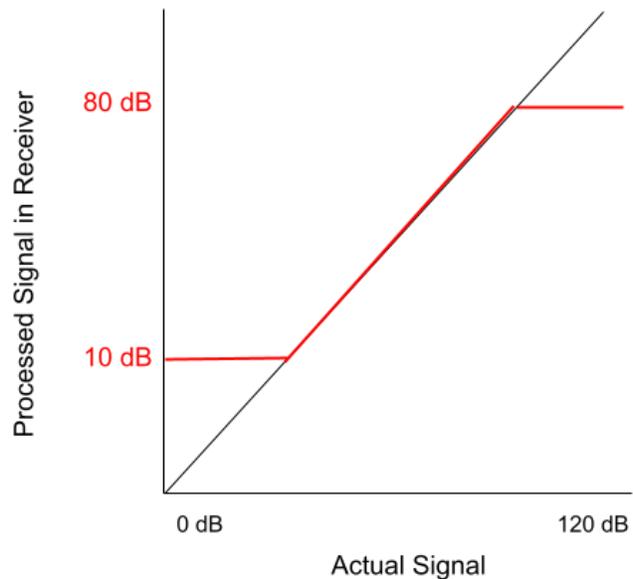
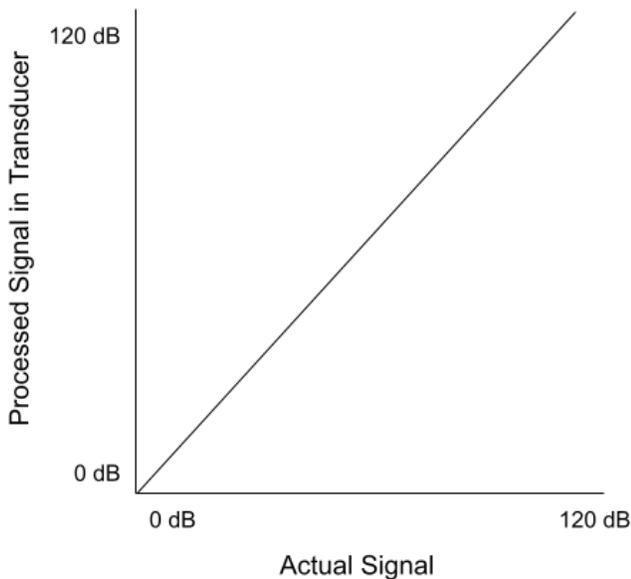


This concept also helps us to understand amplification during the process.

We will see a similar occurrence with the ultrasound system components. The transducer may be able to process signals up to 120 dB. But the receiver can only process signals up to 80 dB. The signals above the 80 dB maximum cannot accurately be used by the receiver. Compression assigns ALL of the strengths above 80 dB as maximum values, thus allowing a larger spread of values for the middle.

Very weak signals returning won't even register in the receiver (this is why there is pre-amplification, to try to bump those weaker signals enough to be recognized by the receiver). So now all weak signals register as the minimum of 10 db for the receiver to be able to use them.

Strong is still strong, weak is still weak, but there are fewer options in between.



16.1.2 Second Compression

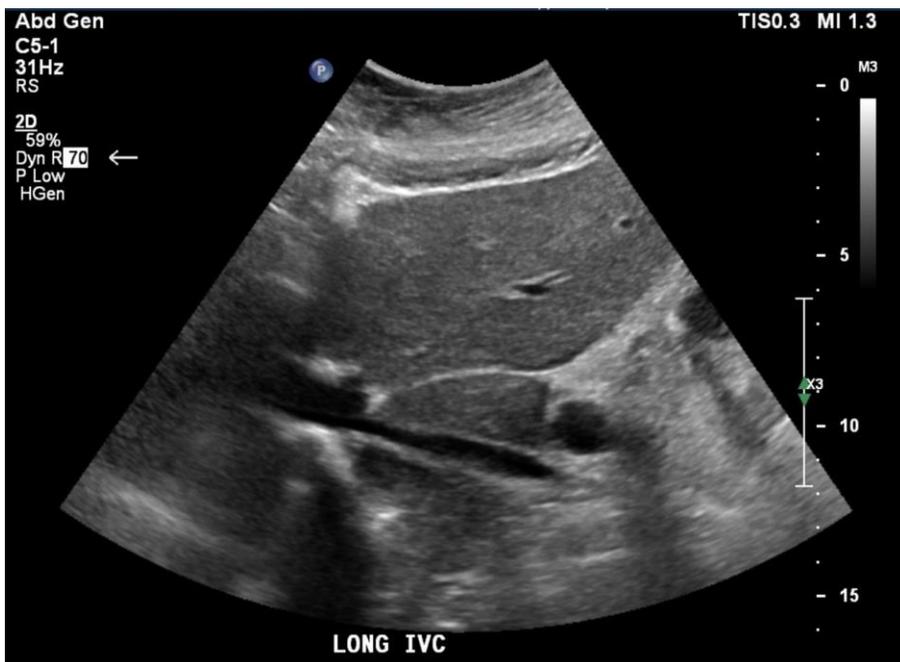
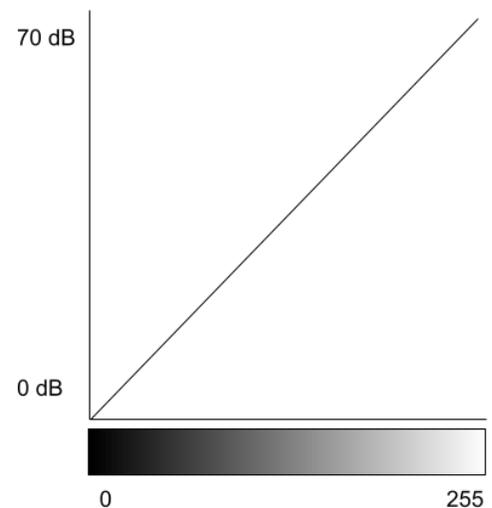
Second compression **is adjustable by the sonographer.** There is a knob on the machine typically labeled “compression” or “dynamic range.” By adjusting this knob, you are adjusting the spread or choices of grays the system will use to display the reflector strengths.

When you increase dynamic range, you are increasing the number of grays for the machine to use. This results in a lot of gray tones in the image, creating an image with **low contrast.**

For example:

A system with 256 shades of gray and a dynamic range of 70 dB means that machine is going to distribute the returning echoes over the 256 shades and 70 dB. This means a change for about 0.27 dB for every shade of gray used.

It's important to note though that MOST of the echoes returning from the body are probably falling in that upper range (40–60 dB). We still have a few blacks (0 dB) and a few whites (70 dB) but most of our image is represented by the mid level grays because there are so many shades to represent the small changes.

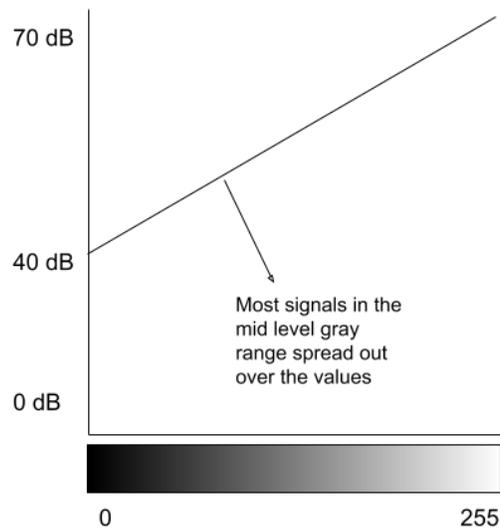


**WIDE/HIGH dynamic range =
MORE grays displayed =
LOW contrast**

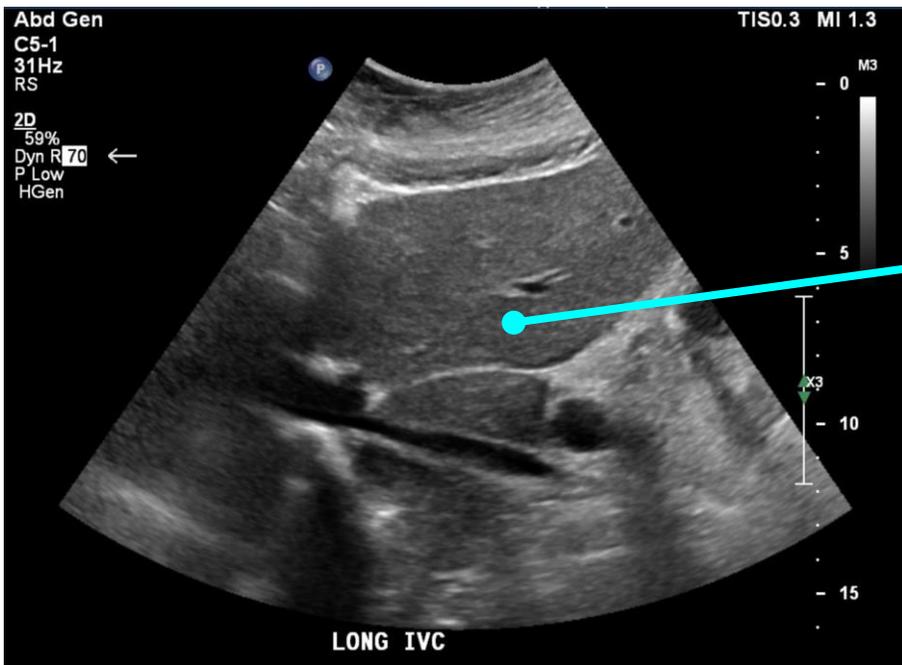
When you decrease dynamic range, you are decreasing the number of grays for the machine to use. This results in more blacks and whites being used in the image, creating an image with **high contrast**.

For example:

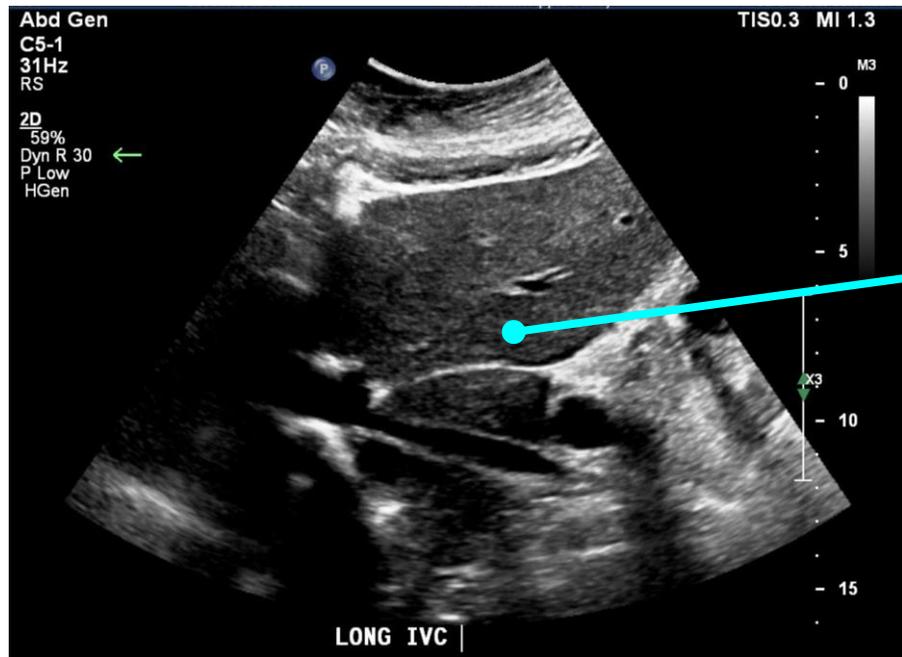
A system with 256 shades of gray and a dynamic range of 30 dB means that first, the machine is going to assign black to more of the low level echoes and then assign a gray shade for the rest. So from 40 dB and on, a change in gray shade is represented by only 0.11 dB change.



**NARROW/LOW dynamic range =
LESS grays displayed =
HIGH contrast**



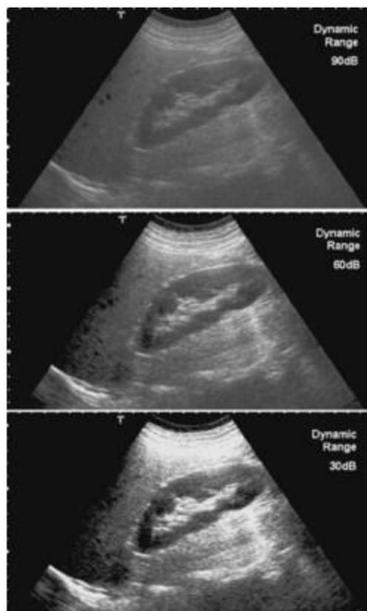
This pixel represented by shade # 200 of 256 in a 70 dB range has to be 0.2 dB different from a surrounding echo to be a different shade of gray. The subtle change is not noticed. If this pixel is a 45 dB, a 46 dB echo is only 5 shades of gray different.



The same pixel represented by shade # 135 of 256 only has to be 0.1 dB different from surrounding echo when the dynamic range is reduced to 30 dB. This allows for more subtle changes to be noticed. If this pixel is a 45 dB, it not only starts as a darker shade, but a 46 dB echo is now 10 shades of gray different.

Low Contrast

High Contrast



Increasing the dynamic range

16.1.3 Clinical Discussion

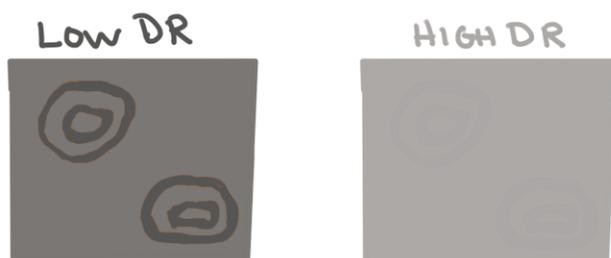
The limiting factor of dynamic range was more closely tied to the memory of the scan converter. When there were few choices to start with (like bistable) the choice of grays were limited. Now that we have 256 shades of gray, we can improve our contrast by using all the grays to represent a narrower range of returning echoes.



This typically means that a larger range of low level echoes are assigned black or a dark gray. You need to be careful when reducing dynamic range to not hide pathology that would come back as low level echoes.



For example, fresh thrombus tends to be more hypoechoic. Decreasing the dynamic range will hide the thrombus because it will be assigned the same black as the blood around it.



Compare that though to a pathology that might be represented by very similar echogenicities. If a given pathology would return an echo very similar to the tissue it is found in, high dynamic range will not provide enough contrast resolution to be able to see it.

For example, liver mets with a wide dynamic range might produce a signal of 45 dB and the liver is 46 dB. In a wide dynamic range, the grays assigned will be too similar for the eye to detect.

Section 16.2 Activities ← [Link to Answers](#)

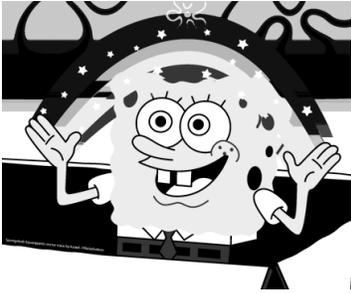
1. Fill in the blanks

_____ is a method of reporting the difference in signals that an ultrasound component can accurately measure.	
Dynamic range is measured in _____.	
_____ is a process of reducing dynamic range without introducing errors.	
The _____ has the widest dynamic range in an ultrasound system.	
The _____ has the narrowest dynamic range in an ultrasound system.	
Is the compression that occurs between machine components adjustable by the sonographer?	

2. What are the three rules of compression?

1	
2	
3	

3. Sort the phrases for these images:



High Contrast Low Contrast
Wide Dynamic Range
Narrow Dynamic Range

Section 16.3 Nerd Check!

1. What are the two stages of compression and who controls which?
2. What are the 3 rules of compression?
3. Why does compression occur?
4. What component has the widest DR?
5. What component has the narrowest DR?
6. What is DR measured in?
7. What does a wide dynamic range mean for contrast?
8. What a high dynamic range mean for the amount of grays displayed?
9. What does a low dynamic range mean for contrast?
10. What does a narrow dynamic range mes for the amount of grays displayed?
11. Clinically what do you need to be careful of when reducing the DR too much?
12. Clinically what do you need to be aware of when increase the DR too much?