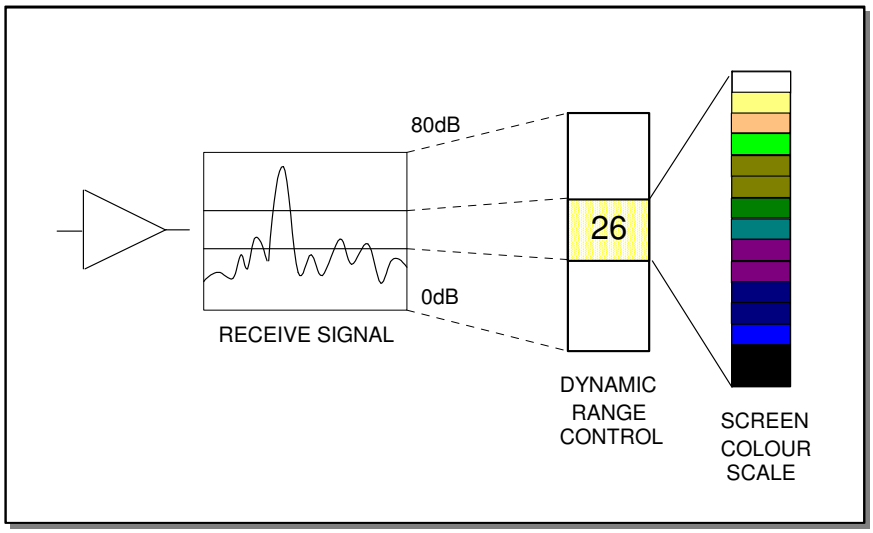
Decoding Sonar Scanline Data

Sonar Receiver Dynamic Range



The sonar receiver will accept a return signal in the region of 0 - 80dB. The dynamic range control is used to adjust the position of a sampling window within the 0-80dB dynamic range band of the receive signal.

The 'Dynamic Range Control' is a surface display function which has 2 parameters (which are sent to the Sonar in the 'mtHeadCommand' although not directly applied inside the Sonar).
These parameters are;

ADLow : This sets the Lower boundary of the sampling window. This value can be increased to make the Sonar display less sensitive and filter out background and receiver self noise.

ADSpan : This sets the width of the sampling window and therefore acts as a Contrast control.

To set the sampling period inside the Sonar, the following parameter is sent to the Sonar;

ADInterval : The ADInterval is the sample time period that is applied to the received Sonar echo signal. ADInterval is in units of 640 nanoseconds ($640 * 10^{-9}$).

Before the Sonar can start scanning it is sent parameters (which includes 'ADInterval') within an 'mtHeadCommand' command.

To calculate ADInterval for a Range Scale of 20 metres…

1. First calculate the travel time for the Sonar 'ping' over a 20 metre range scale;

Travel Time (20m) = 20 * 2 / 1500 *(where; 20 = metre range, 2 = for return path, 1500 = Velocity in m/s)*
= 26.67 milliseconds

2. Then calculate sample time for a certain number of samples ("Bins"). For instance, Bins = 200;

Sample Time = 26.67 msecs / 200
= 133.35 microseconds

3. Convert Sample Time to ADInterval which is in units of 640 nanoseconds;

ADInterval = 133.5 microseconds / 640 nanoseconds
= 208.59
= 209 (rounding to nearest whole number)

Decoding the Sonar scanline data…

During scanning, once a ping is complete the Sonar will send an 'mtHeadData' reply message. For the above example this would contain 200 samples ("Bins") for the 20 metre range scale.

In the 'mtHeadData' reply message;

DBytes :

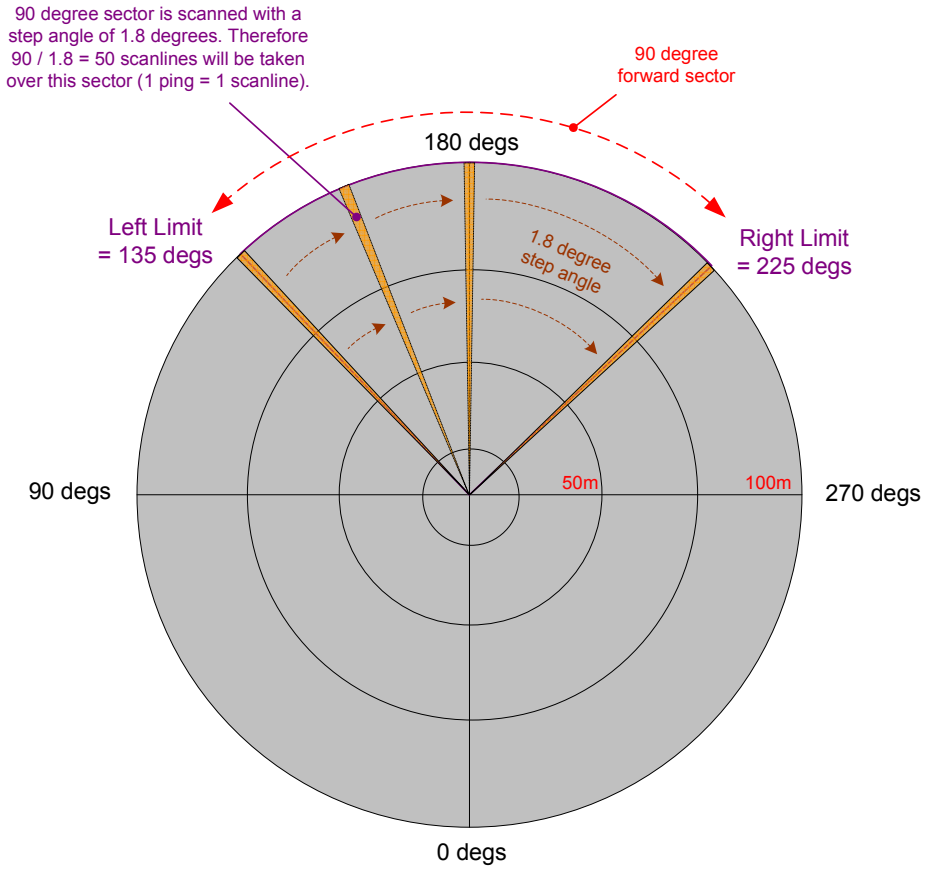
For 4-bit mode (i.e. AD sample window has 15 levels), 2 samples ("Bins") are packed to 1 Byte. Therefore for 200 samples, DBytes = 100.
For 8-bit mode (i.e. AD sample window has 255 levels), 1 sample ("Bin") is packed to 1 Byte. Therefore for 200 samples, DBytes = 200.

4-bit / 8-bit mode is set in the HdCtrl at Bit0 ('adc8on').

Bearing :

The Bearing is the current heading position of the rotating transducer. This is given in units of 1/16 Gradians. The Bearing will fall within the scan limits ('Left Limit' and 'Right Limit' fields in the 'mtHeadCommand') which are also stated in 1/16 Gradian units. Furthermore, the 'Step Size' (or 'Steps') field, also in 1/16 Gradian units, states the rotational angle between successive ping Bearings.

For example to scan a 90 degree forward sector with a Step Angle of 1.8 degrees;



[Left Limit = 135 degrees, Right Limit = 225 degrees. Step Angle = 1.8 degrees]

Worked Example…

A SeaKing DFS Sonar head (325 / 675kHz) is set to sweep **360 degrees** with a mechanical step interval of **0.9 degrees**.

The Range Scale is set to **100m** and **250** samples ("Bins") are taken over this 100m. The "Bins" are set to **8-bit** values.

Using a Velocity Of Sound (VOS) of **1467**m/s, the sampling interval ("ADInterval") is calculated to be…

Sampling Interval = (Range * 2 / Number of Bins) / VOS *(i.e. use 'Range *2' for Return Path)*
= 200 / 250 / 1467
= 0.000545 secs

ADInterval = Sampling interval in units of 640 nanoseconds
= 0.000545 / $640e^{-9}$
= **852**

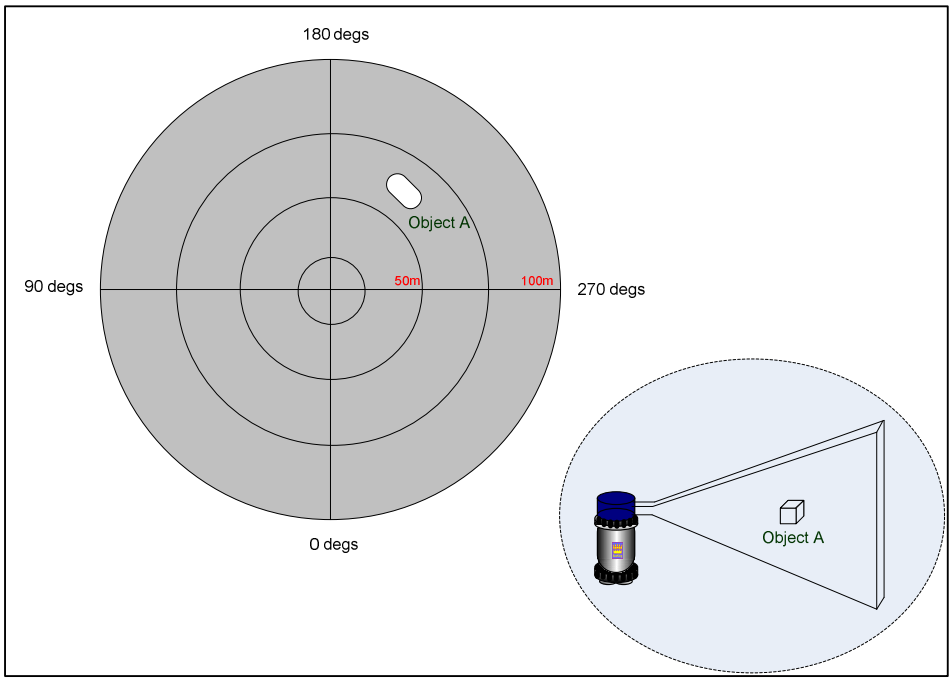
1. First send parameters to the Sonar head to configure it for the above settings. These Parameters are sent in the '**mtHeadCommand**' which is constructed as follows;

40	**30**	**30**	**34**	**43**	**4C**	**00**	**FF**	**02**	**47**	**13**	**80**	**02**	**1D**
Hdr '@'	Hex Length = 76 bytes				Bin Length = 76 bytes		Tx Nde 255	Rx Nde 02	No. Byte = 71	**mtH 'dC md**	Seq = End	Nde 02	V3B Par-ams
07	**23**	**02**	**99**	**99**	**99**	**02**	**66**	**66**	**66**	**05**	**A3**	**70**	**3D**
HdCtrl * = 8967		HdType = 02	TXN, Ch1 (325kHz) = 43620761				TXN, Ch2 (675kHz) = 90596966				RXN, Ch1 (325kHz) = 104689827		
06	**70**	**3D**	**0A**	**09**	**13**	**01**	**E8**	**03**	**00**	**00**	**E0**	**18**	**53**
	RXN, Ch2 (675kHz) = 151666032				TxPulse-Len = 275 usec		Range-Scale = 100m		LeftLim = 0 (1/16 Grad)		RightLim = 6368 (1/16 Grad)		ADSp'n = 83
30	**6B**	**6B**	**5A**	**00**	**7D**	**00**	**19**	**10**	**54**	**03**	**FA**	**00**	**E8**
ADLow = 48	Iga-in, Ch1	Iga-in, Ch2	Slope, Ch1 = 90		Slope, Ch2 = 125		Mo'Tme = 25	Step Size = 16	ADInterval = 852		Nbins = 250		Max ADbuf
03	**64**	**00**	**40**	**06**	**01**	**00**	**00**	**00**	**53**	**53**	**30**	**30**	**6B**
= 1000	Lockout = 100 usec		MinorAxis-Dir = 1600 (1/16 Grad)		Maj'Axis Pan	Ctl2 = 0	ScanZ = 0		AD Sp'n Ch1	AD Sp'n Ch2	AD Low Ch1	AD Low Ch2	Iga-in Ch1
6B	**00**	**00**	**5A**	**00**	**7D**	**00**	**00**	**00**	**00**	**00**	**0A**		
Iga-in, Ch2	Adc Set, Ch1	Adc Set, Ch2	Slope, Ch1 = 90		Slope, Ch2 = 125		Slope Delay, Ch1 = 0		Slope Delay, Ch2 = 0		LF		

*** HdCtrl** = 8967 = **0010001100000111**
{8-bit ADC, Continuous Scan, ScanRight, Upright Orientation, Motor On, Transmitter On, ADCMux Off for DFS, Use Chan 1 (=325kHz), Raw ADC (always), Has Motor, No Heading Offset, No PingPong, No Stare, ReplyASL (always), No hThrRec, Don't Ignore Centre Sensor}

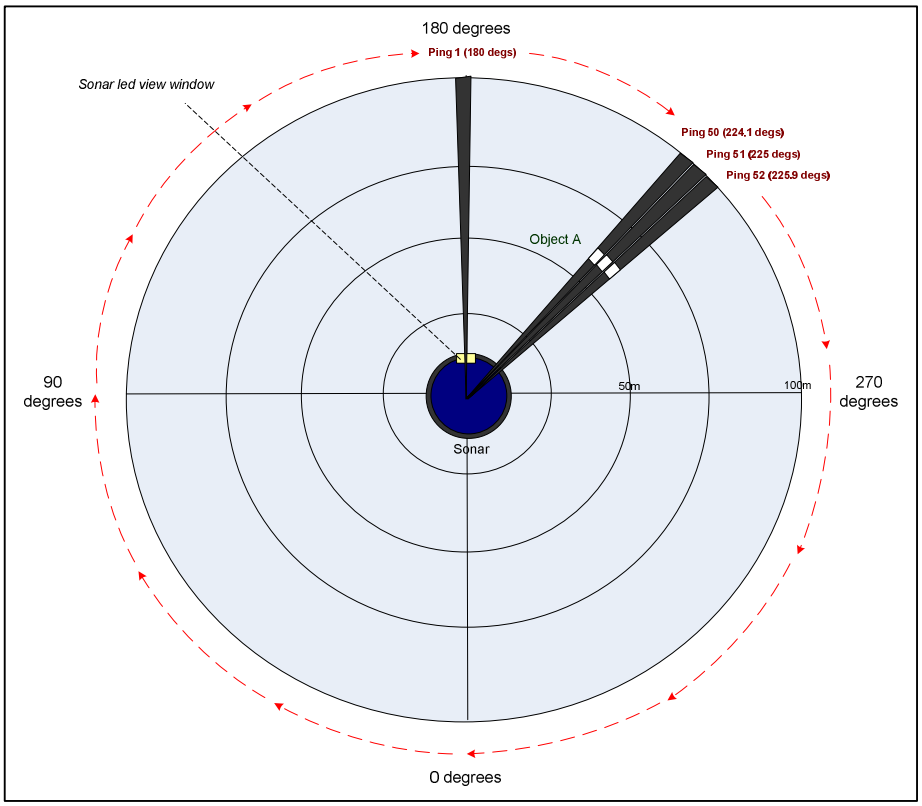
N.B. 16-byte 'V3B' Gain Parameter message is appended for Dual Channel operation (Byte 14 = 1Dh) for dual channel device such as SeaKing DFS.
For Single Channel devices, set Byte 14 to 01h and do not include V3B Parameter block.
Remember to calculate 'Hex/Bin Length' and 'No. Byte' fields accordingly.

2. An object is encountered at bearing 225 degrees and at distance 70m approx.

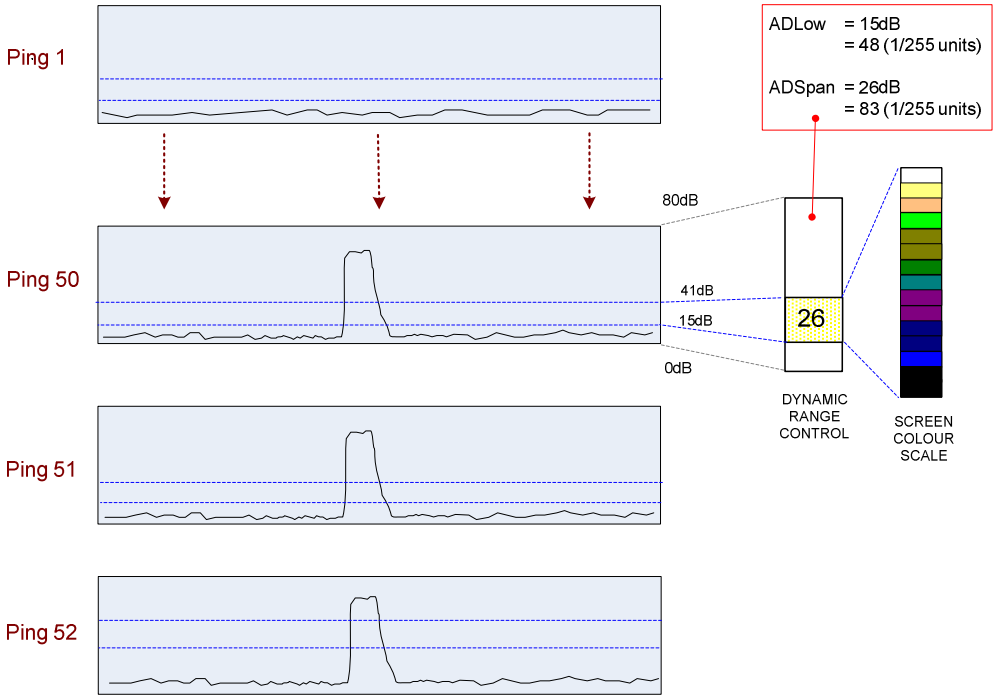


The mechanical step angle is 0.9 degrees and an echo will be returned off the object at 3 adjacent pings (at bearings of 224.1, 225, 225.9 degrees).

[e.g. If the mechanical step angle was increased to 2.7 degrees then only one echo would be returned (at bearing = 225 degrees)]



From the above example it can be seen that Ping 1 has no echoes. The samples for Ping 1 are plotted with colour level = black which is the base colour of the screen colour scale. Pings 50 – 52 are the pings that have the echo reflection off Object A. The echo reflection can be seen below in pings 50 - 52…

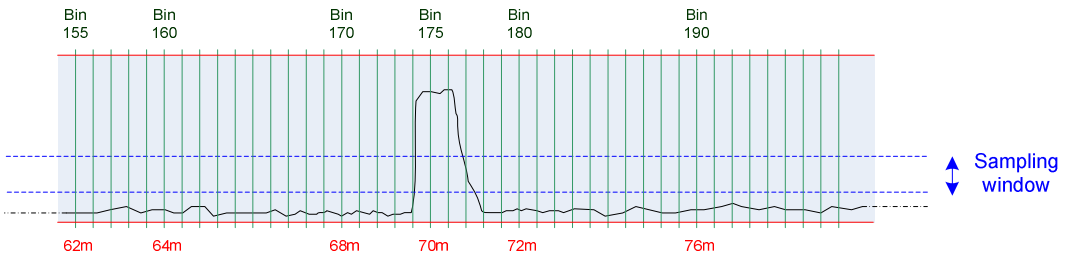


… In this case the display sampling window is set between 15 and 41dB of the full dynamic range (0..80dB) of the received Sonar signal. The display sampling window is set by the ADLow and ADSpan values. The ADLow value of 15dB sets the sampling to be above low level noise such as backscatter and receiver self noise, which will be evident in the received signal. Resultantly, all low level noise is not contained within the display sampling window and therefore will not be included in the Sonar plot.

The echo reflection off Object A has signal amplitude which is above the sampling window (ADLow + ADSPan = 41dB). Therefore this will be sampled at the highest colour level (= White) on the screen colour scale.

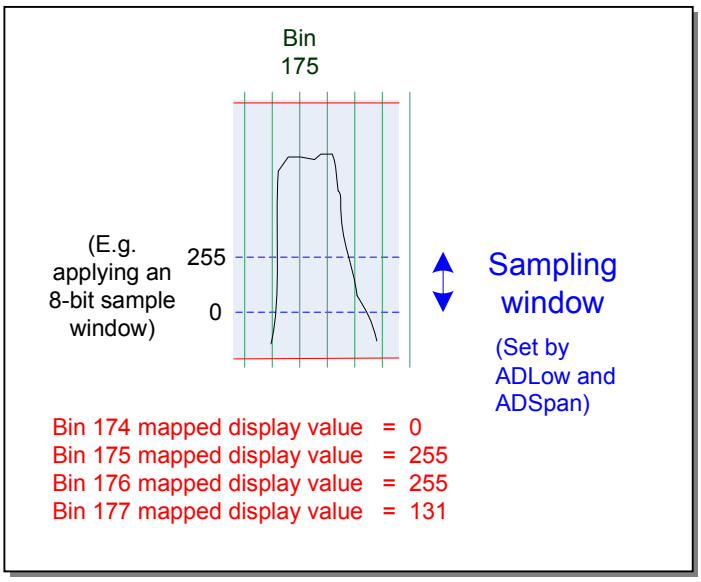
The Sonar PPI display above shows the 'white' level echoes on the screen plot at bearings 224.1, 225 & 225.9 degrees.

If we take a closer inspection of ping 50 (Bearing = 249 Grads)…



There are 250 range samples (“Bins”) taken over the 100m range scale. The Object A is at range 70m which will be sampled around Bin 175 *(i.e. 70m / 100m * 250Bins = Bin 175)*.

The display sampling window, within the 80dB Receiver, is 15dB -> 41dB. This sampling window is set in the Sonar receiver by sending ADLow and ADSpan parameters in the ‘mtHeadCommand’ command.



The Sonar will return 250 “Bins” which are set to be 8-bit amplitude values (0..80dB). The sampling window falls within this 0...80dB scale and the Bin data is sampled and mapped onto a colour scale for display purposes…

Bin 174:
The 8-bit mapped display value of this Bin is 0, i.e. the sample amplitude of the Bin is below the Sampling Window. It will therefore be plotted with colour Black on the colour scale (see previous).

Bins 175,176:
The 8-bit mapped display value of these Bins are both 255, i.e. the sample amplitude of the Bins are above the Sampling Window at these sample points.
These Bins will therefore be plotted with colour White on the colour scale (see previous).

Bin 177:
The 8-bit mapped display value of this Bin is 131, i.e. the sample amplitude of this Bin is in the middle of the Sampling Window. It will therefore be plotted with a colour that is midway in the colour scale (i.e. Purple or Green as in previous).

The 'mtHeadData' Data Reply from the Sonar is as follows; = Bins

40	**30**	**31**	**32**	**38**	**28**	**01**	**02**	**FF**	**00**	**02**	**80**	**02**	**19**
Hdr '@'	Hex Length = 296 bytes				Bin Length = 296 bytes		Tx Nde 02	Rx Nde 255	Sin-gle pckt	**mtH ead D'ta**	Seq = End	Nde 02	->
01	**02**	**10**	**00**	**07**	**23**	**E8**	**03**	**99**	**99**	**99**	**02**	**6B**	**5A**
Cou nt = 281	= Son h'd	Stat -us	Sw-eep	HdCtrl = 8967		Range = 100m		TxN = 1717986821				Gai n = 51%	->
00	**53**	**32**	**00**	**00**	**54**	**03**	**00**	**00**	**E0**	**18**	**10**	**80**	**0A**
Slo-pe= 90	ADS p'n	ADL ow	Heading Offset = 0		AD Interval = 852		L.Limit = 0		R.Limit = 6368 (1/16 Grad)		Ste-ps = 16	Bearing = 3984 (1/16 Grad)	
FA	**00**	**00**	**00**	**00**			**13**	**C4**	**CC**	**59**		**05**	**06**
Dbytes = 250		Bin 1 = 0	Bin 2 = 0	Bin 3 = 0	→	→	Bin 174 = 19	Bin 175 =196	Bin 176 =204	Bin 177 =89	→	Bin 249 = 5	Bin 250 = 6
0A													
LF													

IMPORTANT: Byte 10 ("Byte Count") = 0 in above example to indicate that Multi-packet mode is not used by this device and that all 'mtHeadData' replies will be single packet messages.

Further Notes and Examples…

To calculate the range of the 55th Bin in the 200 sample set (i.e. 'NBins' = 200) for the 20 metre range scale;

Range (55th Bin) = Range Scale(m) * Current Sample / Total Samples
= 20 * 55 / 200
= 5.5 metres
The time of the 55th Bin = Current Sample * ADInterval
= 55 * (209 * 640e^{-9})
= 7.35 milliseconds *(return path time)*

The value in the 'Bin' fields (i.e. "Bin1", "Bin2", "Bin3", …etc) of the 'mtHeadData' reply message are the amplitude values of the echo return signal. These will be 4-bit or 8-bit values according to the HdCtrl Bit0 ('adc8on') setting.

The amplitude values for each 'Bin' must be mapped onto the display colour scale using the '**ADSpan**' and '**ADLow**' sample window size boundaries. These 2 parameters must also be sent in the 'mtHeadCommand' to the Sonar, although they are not directly applied within the Sonar and are actually applied in the surface display software.

For instance, for ADLow of 40 and ADSpan of 50, an 8-bit Bin value of 60 would have amplitude of;

ADLow and ADSpan are in units of 1/255, where 0..255 = 0..80dB.
For ADLow = 40, this is equal to 40/255 * 80 = 12.55dB.
For ADSpan = 50, this is equal to 50/255 * 80 = 15.69dB.
Therefore the sampling window within the 80dB Receiver is **12.55dB -> 28.24dB**.

For the 8-bit Bin value = 60;

Bin (dB) = 80dB * 60 / 255 = **18.82dB**

Note: For purpose of plotting onto Sonar PPI display, the Bin value of 18.82dB would fall within the Colour map (12.55 -> 28.24dB). Therefore, for 8-bit display sampling the Colour Map would have 255 levels and a Bin value of 60 would be plotted at the following colour level within the 0..255 Colour Map…

8-bit Colour level of Bin = 255 * (18.82 – 12.55) / (28.24 – 12.55)
= **102**