EXAMPLE SINE FUNCTION CALCULATIONS

input angle:
θ_{in} = \$03E8 = 00 000011 11101000

The quadrant is $00_2 \rightarrow \theta_{in}$ is a first quadrant angle

The index is $000011_2 \rightarrow$ the index is \$3,therefore the fourth entry in TBL and DTBL will be used to calculate the angle

The fraction is $11101000_2 \rightarrow$ this number will be used for interpolation

The form of TBL and DTBL:

index	TBL*	DTBL*
0	0	12867
(0°)	0	0
1	402	12859
(1.41°)	0	0
2	804	12843
(2.82°)	0	0
3	1205	12820
(4.23°)	0	0
4	1606	12789
(5.64°)	0	0

* TBL and DTBL are shown in decimal

CALCULATING THE SINE DIRECTLY FROM THE TABLE

From this table and using simple interpolation we can directly calculate the sine of \$03E8.

To begin we determine the angle involved. Since index=3 the angle is between 4.23° and 5.64°, i.e. 4.23° plus some fraction of 1.41°. There are \$FF increments between 4.23° and 5.64° so the fraction \$E8 indicates that the fractional angle is \$E8/\$FF*1.41° or, after converting to decimal, 232/255*1.41° = 1.28°. The angle in question is then 4.23° (index=3) + 1.28° = 5.51°.

The answer is then sine(5.51°)*16384 = 1573.18 = \$0625. Note that the sine must be multiplied by $2^{15}=16384_{10}$ to make sure that sine(90°) corresponds to bit 15 in the binary representation of the sine, i.e. $0100\ 0000\ 0000\ 0000_2$.

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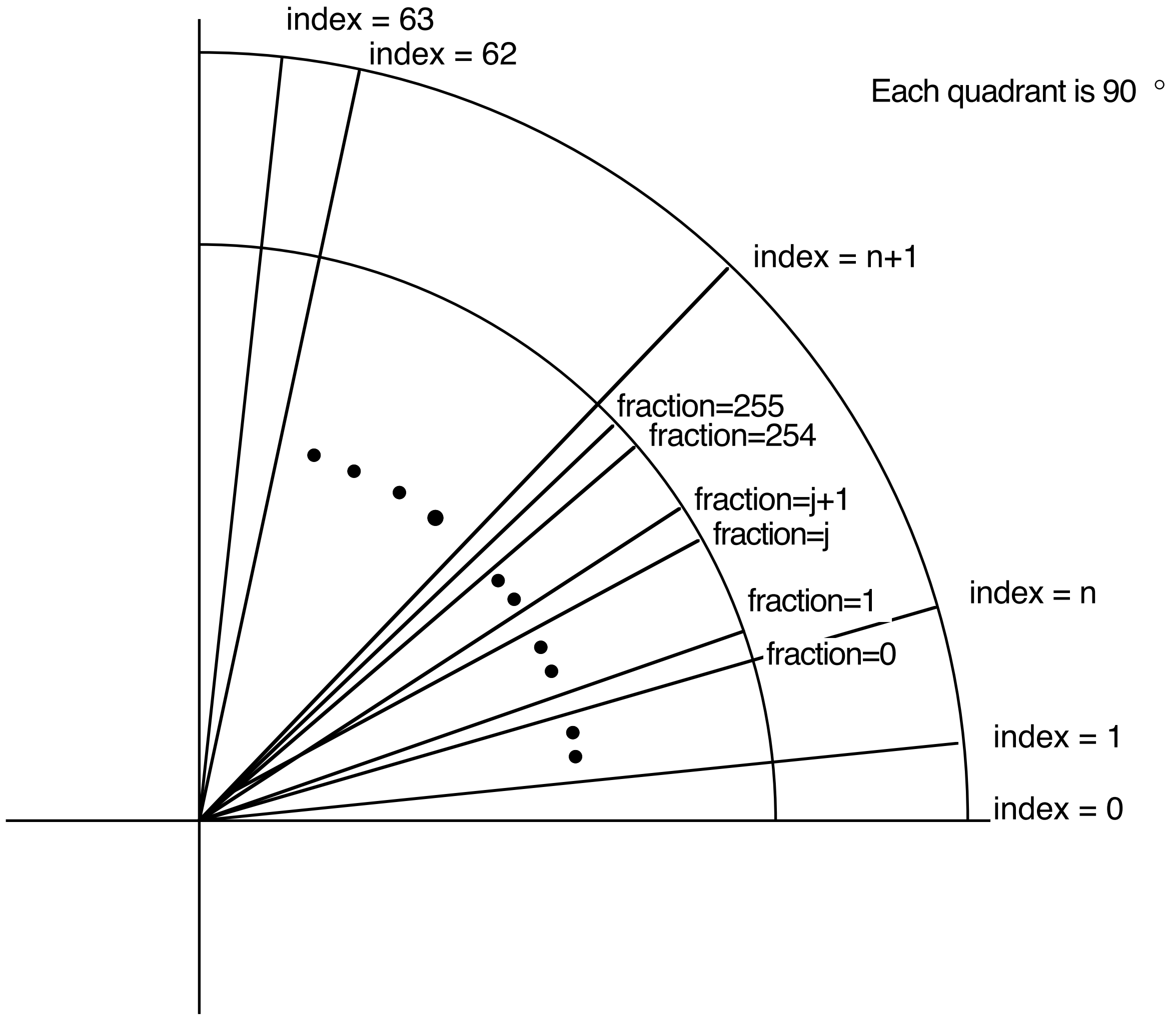

Distribution of angles using <quadrant, index,fraction> notation

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From this table the correct values of TBL and DTBL to be used for the calculation are:

TBL($3) = 1205_{10} = $04B5
DTBL($3) = 12820_{10} = $3214

The first calculation is to multiply fraction times DTBL($3) using the MULU instruction

From θ_{in}, fraction is 111010002 = $E8. Assuming $E8 is in Dx and $3214 is in Dy, the result of the instruction MULU Dx,Dy will be

Before the MULU

	15 0
register Dx	0 0 E 8

	15 0
register Dy	3 2 1 4

After the MULU

	31 16	15 0
register Dy	0 0 2 D	6 2 2 0

To complete the calculation we need to add this to TBL($3). If we assume that we have put TBL($3) into register Dz we would have

	31 16	15 0
register Dz	X X X X	0 4 8 5

The problem is that the original binary points of TBL and DTBL are NOT the same (see next page) so that we cannot directly add these numbers together. We will keep the format of TBL and shift the MULU result in register Dy so that the numbers can be correctly added together.

The number in Dy is

$0000\ 0000\ 0010\ 1101\ 0110\ 0010\ 0010\ 0000_2$

which needs to be shifted 13 bits to the right before it can be correctly added to Dz. A LSR of 13 bits results in the new contents of Dy:
$0000\ 0000\ 0000\ 0000\ 0000\ 0001\ 0110\ 1011_2$ = $016B
which can now be directly added to Dz (word length) to give $0620, the correct answer.

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	31 … 16	15 … 0
register Dy	0 0 0 0	0 1 6 B
register Dz	X X X X	0 4 B 5
register Dz	X X X X	0 6 2 0

This was a first quadrant angle, sines in other quadrants can be computed using the appropriate trig identity:

In the second quadrant:

sine(x) = sine(180°-x) or, in hex, sine(x) = sine($8000-x)

In the third quadrant:

sine(x) = - sine(x-180°) or, in hex, sine(x) = - sine(x-$8000)

In the fourth quadrant:

sine(x) = - sine(360°-x) or, in hex, sine(x) = - sine($10000-x)

NOTE: you should set the sign bit of your result after computing the angle.

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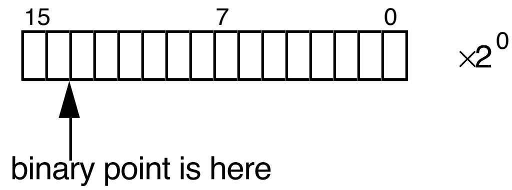
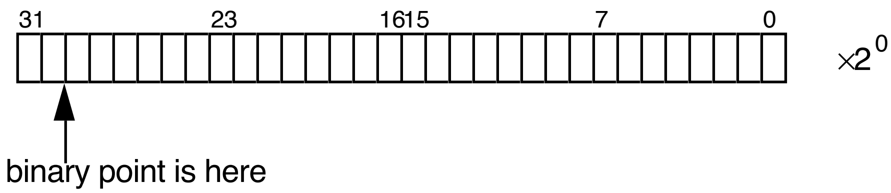
FIXED POINT ARITHMETIC

The math used in the sine lab is an example of fixed point arithmetic.

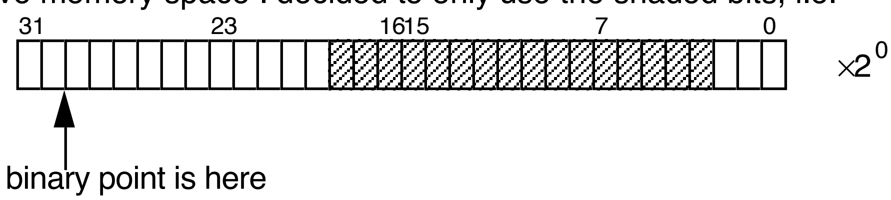
The numbers from TBL are in the format:



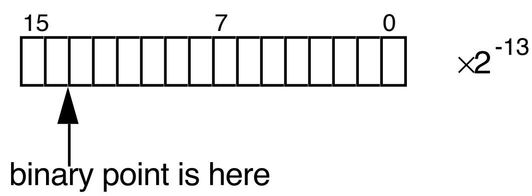
The original format for numbers from DTBL was:



This format was fine except that there were no 1's in any bit higher than bit 18. So, to save memory space I decided to only use the shaded bits, i.e.

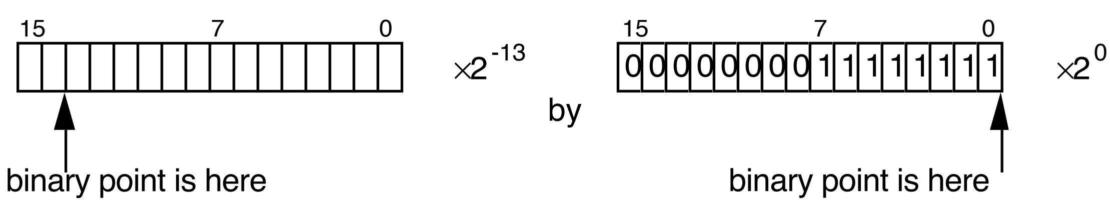


which are only 16 bits so they could be represented as a single word as shown below



This format saves most of the significant information in DTBL.

Now consider what happens when the offset is multiplied by this number from DTBL using a MULU instruction, i.e. multiply



to yield the 32-bit result

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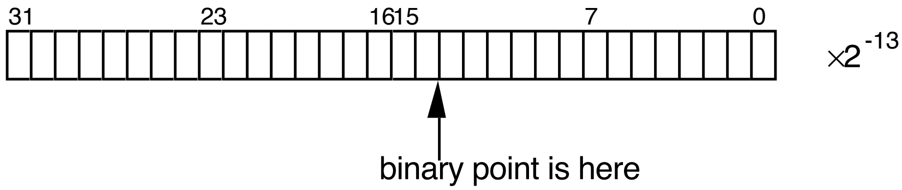
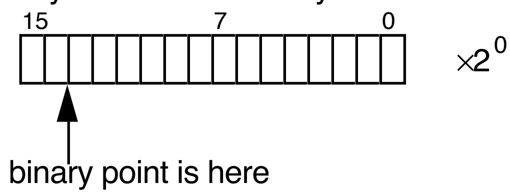
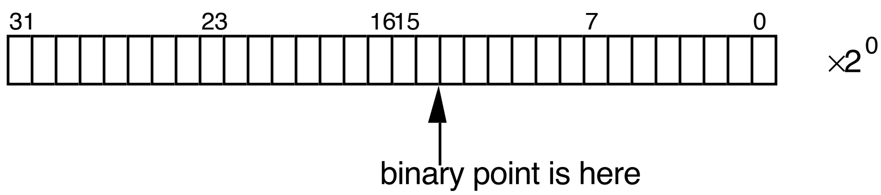


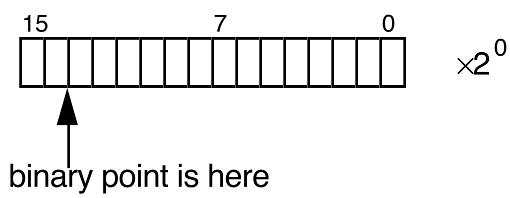
Now this cannot be directly added to the entry from TBL



because they are in different formats. The first thing to do is make the exponents the same, i.e. we have to get rid of the 2^{-13} exponent by shifting the number in the register 13 bits to the right. This requires a little thought—the location of the binary point does not change as a result of this shift BUT the exponent has now become 2^0.



The format of the lower word in the register is the same as the entry from TBL so that the numbers can now be added together as 16-bit binary numbers in the format:



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