Precision Digital Sine-Wave Generation with the TMS32010

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Precision Digital Sine-Wave Generation with the TMS32010

Abstract

This report presents two methods of sine-wave generation. The first method is a fast direct table lookup scheme suitable for applications where speech is critical. The second approach, an enhancement of the first, includes linear interpolation to provide higher accurate waveforms.

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INTRODUCTION

Sine-wave generators are fundamental building blocks of signal processing systems which are used in diverse applications, such as communication, instrumentation, and control. In the past, engineers usually designed these oscillators with analog circuitry. Now, however, new high-speed digital signal processors like the TMS32010 present designers with an alternative that in many cases is superior. The TMS32010 provides the speed and accuracy to produce stable, low-distortion sine waves over a wide range of frequencies.

This application report describes two different methods for implementing a digital sine wave generator using the TMS32010. The first method is a fast direct table lookup scheme suitable for applications not requiring extreme accuracy. The second approach, an enhancement of the first, includes linear interpolation to provide sine waveforms with a minimum of harmonic distortion.

DIRECT TABLE LOOKUP METHOD

The first algorithm is a simple, fast table lookup scheme. The sine values for N angles which are uniformly spaced around the unit circle are stored in a table which has the following format:

INDEX	ANGLE	SINE TABLE
0	0 X 360°/N	S[0] = sin(0 °/N)
1	1 X 360 °/N	S[1] = sin(360 °/N)
2	2 X 360°/N	S[2] = sin(720 °/N)
• ·		
	•	
•		
N-2	(N-2) X 360°/N	S[N-2] = sin((N-2) X 360 °/N)
N-1	(N-1) X 360°/N	S[N-1] = sin((N-1) X 360 °/N)

A sine wave is generated by stepping through the table at a constant rate (in effect, moving counterclockwise around the unit circle), wrapping around at the end of the table whenever 360° is exceeded. Using the table index as the angle parameter and DELTA as the step size, this lookup method generates the sequence:

S[mod(k X DELTA, N)] for k = 1, 2, 3, 4, ...

where mod(a,b) = remainder of the division a/b when this quotient is computed as an integer [e.g., mod(22.34,5) = 2.34)]

The 'mod' operator provides the wraparound at the end of the table. Figure 1 illustrates this algorithm.

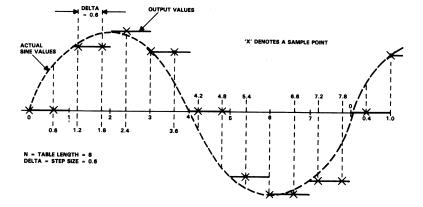


Figure 1. Direct Table Lookup

The sampled waveform generated is only an approximation to a sampled sinusoid. In general, the longer the table is the more resolution it provides, and consequently, the closer the approximation will be.

The frequency, f, of the sine wave depends on two factors:

- The time interval between successive samples, i.e., the sampling interval, t
- (2) The step size, DELTA

f is given by the equation:

 $f = \frac{DELTA}{t X N}$ [Hz] where t is expressed in seconds

Note that to satisfy the Nyquist criterion there must be at least two samples generated each sinusoid period. This requires that DELTA $\leq N/2$.

In Figure 1, N = 8 and DELTA = 0.6. If, for instance, eight samples are generated each millisecond, then t = 0.000125 seconds and

$$f = \frac{0.6}{8 \times 0.000125}$$
 Hz = 600 Hz

TMS32010 Implementation

This section describes the concise TMS32010 subroutine, given in Appendix B, which implements the table lookup scheme based on a sine table with 128 entries. Each time this subroutine is called, the next sample point is calculated. This subroutine uses:

- 138 (=128 + 10) words of program memory space (128 words for sine table storage and 10 words for program memory)
- (2) 6 words in data memory as working registers

If this program is used as a subroutine, each sample can be computed in 3.0 microseconds. However, if the code is inserted directly in line with the code of a master program, avoiding the overhead of a subroutine, a sample can be computed in 2.2 microseconds.

The values in the sine table are all scaled. The decimal values, +1.0 and -1.0, are represented by the two's complement hexadecimal values 4000 and C000, respectively. All other values are scaled and rounded to the closest hexadecimal number. Rounding is used, rather than truncation, to avoid adding unnecessary distortion.

The 16-bit data memory location 'ALPHA' serves as a modulo 128 counter which cycles through the sine table to select the sample points. ALPHA is regarded as having an integer and fractional part with the format:

Q

The 16-bit data memory locaion 'DELTA' contains the step size. DELTA has the same (integer.fraction) format as ALPHA. Every time the sine wave subroutine is called, the contents of ALPHA are incremented by the contents of DELTA. The integer portion of ALPHA (i.e., the eight MSBs) is the pointer to the sine table. However, because the table starts at address location SINE, this pointer is offset by the value for that address before the table is accessed. The eight most significant bits of ALPHA are masked when ALPHA is updated to insure that they never exceed 127. The routine returns the sine value in the data memory location 'SINA'.

For any given sampling interval, t, the frequencies which can be generated must be of the form

$$f = \frac{DELTA}{t X 128}$$
 [Hz] where t is expressed in seconds

Since DELTA has a precision of eight bits to the right of the decimal place, any desired frequency ($\leq 1/2t$ [Hz]) can be approximated with an error of no more than

$$\frac{1/256}{t X 128} [Hz] = \frac{1}{32768 X t} [Hz]$$

For example, if the sampling frequency is 8 kHz, then the frequency resolution is

$$\frac{8000}{32768}$$
 Hz = 0.25 Hz

Harmonic Distortion

Due to approximations made in calculating the samples of a sine wave of frequency f, a certain amount of the "energy" of the samples' waveform will fall into other frequencies as well. These frequencies are either:

- (1) Harmonic frequencies, nf, where n = 2, 3, 4, ..., or
- (2) Subharmonic frequencies, nf/m, where n and m are integers.

This spurious energy results in noise which is referred to as "harmonic distortion." It is usually measured in terms of Total Harmonic Distortion (THD) which is defined as the ratio

$$\mathbf{THD} = \frac{\mathbf{spurious harmonic energy}}{\mathbf{total energy of the waveform}}$$

There are two sources of error in the table lookup algorithm which cause harmonic distortion:

- Quantization error is introduced by representing the sine table values by 16-bit numbers.
- (2) Larger errors are introduced when points between table entries are sampled. This occurs when DELTA is not an integer.

The longer the sine table is, the less significant the second error source will be. Consequently, harmonic distortion decreases with increasing table length. Furthermore, when DELTA is an integer, quantization is the only error source, and THD is extremely small regardless of table size. THD is given for several table lengths and values of DELTA in Figure 2. Note that the figures in this table only represent the THD in the digitized sine wave. If the sine wave is reconstructed using a digital-to-analog converter and analog filters, these analog devices will contribute additional distortion. (The procedure for computing THD is described in Appendix A.)

LINEAR INTERPOLATION METHOD

To decrease the harmonic distortion for a given table size, an interpolation scheme can be used to compute the sine values between table entries more accurately. Linear interpolation is the simplest method to implement. This method uses the values of two consecutive table entries as the end points of a line segment. Sample points for parameter values falling between table entries assume values on the line segment between the points. This algorithm is illustrated in Figure 3.

DELTA THD 2.0 0.0000024 2.25 0.00300893 2.50 0.00240751 2.75 0.00300917 3.0 0.0000024 8.25 0.00300924 11.625 0.00300924 TABLE LENGTH: 64 THD 2.00 0.00000048 2.25 0.00075269 2.50 0.00075239 3.00 0.00007524 11.625 0.00075204 11.625 0.00079078	
2.25 0.00300893 2.50 0.00240751 2.75 0.00300917 3.0 0.0000024 8.25 0.00315807 TABLE LENGTH: 64 THD 2.00 0.00000048 2.25 0.00075269 2.50 0.00075239 3.00 0.000075204 11.625 0.00075204	THD
International International 2.50 0.00240751 2.75 0.00300917 3.0 0.00000024 8.25 0.00300924 11.625 0.00315807 TABLE LENGTH: 64 DELTA THD 2.00 0.00000048 2.25 0.00075269 2.50 0.00075239 3.00 0.00000018 8.25 0.00075204 11.625 0.00079078	0.00000024
2.75 0.00300917 3.0 0.00000024 8.25 0.00300924 11.625 0.00315807 TABLE LENGTH: 64 THD 2.00 0.00000248 2.25 0.00075269 2.50 0.00075239 3.00 0.00000018 8.25 0.00075204 11.625 0.00075078	0.00300893
Image: state	0.00240751
B.25 0.00300924 11.625 0.00315807 TABLE LENGTH: 64 THD DELTA THD 2.00 0.00000048 2.25 0.00075269 2.50 0.000060219 2.75 0.00075239 3.00 0.00000018 8.25 0.00075204 11.625 0.00079078	0.00300917
11.625 0.00315807 TABLE LENGTH: 64 THD DELTA THD 2.00 0.00000048 2.25 0.00075269 2.50 0.000060219 2.75 0.00075239 3.00 0.00000018 8.25 0.00075204 11.625 0.00079078	0.0000024
TABLE LENGTH: 64 DELTA THD 2.00 0.00000048 2.25 0.00075269 2.50 0.000075239 3.00 0.0000018 8.25 0.00075204 11.625 0.00079078	0.00300924
DELTA THD 2.00 0.00000048 2.25 0.00075269 2.50 0.00060219 2.75 0.00075239 3.00 0.00000018 8.25 0.00075204 11.625 0.00079078	0.00315807
DELTA THD 2.00 0.00000048 2.25 0.00075269 2.50 0.00060219 2.75 0.00075239 3.00 0.00000018 8.25 0.00075204 11.625 0.00079078	
2.00 0.00000048 2.25 0.00075269 2.50 0.00060219 2.75 0.00075239 3.00 0.00000018 8.25 0.00075204 11.625 0.00079078	
2.25 0.00075269 2.50 0.00075239 2.75 0.00075239 3.00 0.0000018 8.25 0.00075204 11.625 0.00079078	
2.50 0.00060219 2.75 0.00075239 3.00 0.00000018 8.25 0.00075204 11.625 0.00079078	
2.75 0.00075239 3.00 0.0000018 8.25 0.00075204 11.625 0.00079078	
3.00 0.00000018 8.25 0.00075204 11.625 0.00079078	
8.25 0.00075204 11.625 0.00079078	
11.625 0.00079078	
TABLE LENGTH: 128	0.00079078
DELTA THD	THD
2.00 0.0000054	0.00000054
2.25 0.00018859	0.00018859
2.50 0.00015080	0.00015080
2.75 0.00018835	0.00018835
3.00 0.0000012	0.00000012
8.25 0.00018889	0.00018889
11.625 0.00020128	0.00020128
0.20	

Figure 2. Total Harmonic Distortion Using Direct Table Lookup

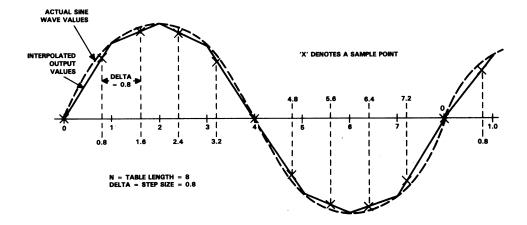


Figure 3. Linear Interpolation

This algorithm is based on the linear approximation

$$\begin{aligned} \sin(360\,^{\circ}(I+D)/N) &\cong \sin(360\,^{\circ}I/N) \\ &+ D \times \{\sin(360\,^{\circ}(I+1)/N) \\ &- \sin(360\,^{\circ}I/N) \} \end{aligned}$$

 $= S[I] + D X \{ S[I+1] - S[I] \}$ where N is the sine table length,

I is an integer such that $0 \le I \le N-1$, and

D is a decimal number such that $0 \le D < 1.0$

The value, S[I+1] - S[I], is the slope of the line segment between the two sample points which bracket the value I+D (i.e., $I \le I+D < I+1$).

All the values required for this interpolation scheme are stored in the following two tables:

INDEX	ANGLE	SINE TABLE	SLOPE TABLE
0	0 X 360°/N	$S[0] = sin(0^{\circ}/N)$	S(1) - S(0)
1	1 X 360 °/N	S[1] = sin(360 °/N)	S[2] - S[1]
2	2 X 360 °/N	S[2] = sin(720 °/N)	S(3) - S(2)
۰.			
N – 2	(N-2) X 360°/N	S[N - 2] = sin(360 °(N - 2)/N)	S[N ~ 1] - S[N - 2]
N – 1	(N-1) X 360°/N	S[N-1] = sin(360°(N-1)/N)	S[0] - S[N - 1]

TMS32010 Implementation

The sample TMS32010 implementation of this linear interpolation scheme, given in Appendix C, is an enhancement of the table lookup method. This subroutine is based on 128-entry sine and slope tables. Each time this subroutine is called, the next sample point is calculated. This subroutine uses:

(1) 276 (= 128 + 128 + 20) words of program memory space

(128 words for sine table storage,

128 words for slope table storage, and

20 words for program memory)

(2) 9 words in data memory as working registers

If this program is used as a subroutine, each sample can be computed in 5.4 microseconds. However, if the code is inserted directly in line with the code of a master program, avoiding the overhead of a subroutine, a sample can be computed in only 4.6 microseconds.

Just as in the table lookup algorithm, a sine wave is generated by stepping through the sine table at a constant rate, wrapping around at the end of the table whenever 360° is exceeded. The table index is used as the angle parameter, denoted by ALPHA.

DELTA denotes the step size for this routine also. In this case, however, sample points falling between the samples in the sine table are evaluated using the linear approximation formula given above.

The values in both the sine and slope tables are calculated in the same way as they were for the table lookup program. The decimal values, +1.0 and -1.0, are

represented by the two's complement hexadecimal values 4000 and C000, respectively. All hexadecimal values are rounded rather than truncated to the closest 16-bit representations to reduce quantization noise.

Because the method to compute the step size is the same as that used in the table lookup scheme, the frequency resolution will also be the same. However, because of the linear interpolation between table entries, sine values are no longer limited to the values stored in the table. This allows the error between the computed value and the actual value to be less.

Harmonic Distortion

Figure 4 lists the distortion of several sine waves generated using the TMS32010 linear interpolation routine for various table lengths and step sizes. These results clearly show that the distortion for a particular fractional step size decreases if the size of the table is increased just as in the direct table lookup case. However, for the same non-integer step size and the same table length, the distortion for the linear distortion method is much lower than that of direct table lookup.

These values were experimentally determined and the method used to compute them is given in Appendix A.

TABLE LENTH: 32	·
DELTA	THD
2,0	0.0000024
2.25	0.00169343
2.50	0.00135476
2.75	0.00169379
3.0	0.00000024
8.25	0.00169361
11.625	0.00177808
TABLE LENGTH: 64	
DELTA	THD
2.00	0.00000048
2.25	0.00018884
2.50	0.00015055
2.75	0.00018771
3.00	0.00000018
8.25	0.00018806
11.625	0.00019815
TABLE LENGTH: 128	
DELTA	THD
2.00	0.00000054
2.25	0.00000054
2.50	0.00000012
2.75	0.00000101
3.00	0.00000012
8.25	0.0000006
11.625	0.00000155

Figure 4. Harmonic Distortion Using Linear Interpolation

IMPLEMENTATION TRADE-OFFS

There are three trade-offs that must be considered when implementing the algorithms described above. They are speed, accuracy, and the size of the table ROM.

The direct table lookup method is the fastest implementation. Using a table that ranges from 0° to 360° , the routine needs only to address the table and compute the next angle. However, the table occupies more program memory space than is absolutely required.

To minimize the amount of program memory required for the sine table, one can take advantage of the symmetry of the sine function. By keeping track of the quadrant as ALPHA is increased, a table that ranges from 0° to 90° will be sufficient. This decreases the size of the table by three-fourths. However, the extra code necessary to keep track of the quadrant will increase the execution time of the routine.

If harmonic distortion is important, then some form of interpolation is needed. One can use the linear interpolation method of the second example or other approximations such as a Taylor Series or Maclaurin Series expansions carried out to the second- or third-order term, or beyond. These schemes will, however, also increase the amount of code as well as the execution time.

APPENDIX A: COMPUTATION OF TOTAL HARMONIC DISTORTION

To determine the Total Harmonic Distortion (THD) of a sampled data sine wave, the amount of energy due to frequency components other than the fundamental is divided by the total energy of the wave. This is computed from the formula:

THD = [E(total) - E(fundamental)] / E(total)

For the most accurate results, these energy terms should be calculated over a full cycle of the signal. In the case of a sine wave generated by either of the two methods, a full cycle may actually consist of several sinusoid periods. For instance, If N = table length = 128 and if DELTA = step size = 1.5, a cycle will only be completed for the smallest n for which n x 1.5 is evenly divisible by 128. This occurs for n = 256 which marks the end of the second sinusoid period.

In general, if DELTA = A/B where A and B are relatively prime integers, and N = table length, then the sequence x(n), n = 1,2,3, ... of sine-wave samples will cycle after no more than B x N points.

The amount of total "energy" in a cycle of this length is

$$E(total) = \sum_{n=0}^{BN-1} x^{2(n)}$$

The amount of "energy" in the fundamental frequency over this period is

$$E(\text{fundamental}) = 1/BN (|X(A)|^2 + |X(BN-A)|^2)$$

= 2/BN |X(A)|² for a real sequence

where the X(k) terms are terms of the Discrete Fourier Transform defined by the equation

$$X(k) = \sum_{n=0}^{BN-1} x(n)exp(-j(2\pi/N)nk)$$

The values given in Figures 2 and 4 are based on actual values computed by the TMS32010 for the two sample sine-wave generator programs. The computation of THD was carried out on a VAX 11/780 using the above formulas with double-precision floating-point arithmetic.

APPENDIX B: TMS32010 TABLE LOOKUP ROUTINE

GENER1	320 F	AMILY	MACRO	ASSEMBLER	2.1 83.076	17:14:48	1/18/84 PAGE 0001
0001 0002		*****	IDT *****	'GENER1	, **********	*****	*****
0003		*		INE WAVE G			*
0004		*	DIR	ECT TABLE	LOOKUP METHOD		*
0005					LOOKUP TABLE O		
0006					OF THE WAVE.	THE FREQUENC	
0007					ZE BY WHICH ON		
0008 0009					SISTS OF 128 E GLES BETWEEN (
0010		*****	*****	*********	**************************************	***************	JREED. ******
0011		*			TATION		*
0012		* THE	TMS320	10 USES FI	XED-POINT TWO'	S COMPLEMENT	T NUMBERS. *
0013		* EACH	16-BI	T NUMBER H	AS A SIGN BIT,		
0014				CTIONAL BI		E AFTER THE I	LETTER Q *
0015 0016					OF FRACTIONAL NUMBER, i.e.,		
0017					4 FRACTIONAL E		* 61 3
0018					******		*****
0019 0000 1	F900		в	START			
0001							
0020 0002		SINE	DATA	>0		SINE TABLE	
0021 0003 0022 0004			DATA DATA	>324 >646		JES ARE REPRI	
0023 0004			DATA	>964		FORMAT, i.e. 14 BITS AFT	
0024 0006			DATA	>C7C		ARY POINT.	SK THE
0025 0007	0F8D		DATA	>F8D			
0026 0008			DATA	>1294		·	
0027 0009			DATA	>1590			
0028 000A 0029 000B			DATA DATA	>187E >1B5D			
0030 000C			DATA	>1E2B			
0,031 000D			DATA	>20E7			
0032 000E	238E		DATA	>238E			
0033 000F			DATA	>2620			
0034 0010			DATA	>289A			
0035 0011 0036 0012			DATA DATA	>2AFB >2D41			
0037 0013			DATA	>2F6C			
0038 0014			DATA	>3179			
0039 0015			DATA	>3368			
0040 0016			DATA	>3537			
0041 0017 0042 0018			DATA	>36E5			
0042 0018			DATA DATA	>3871 >39DB			
0044 001A			DATA	>3B21			
0045 001B			DATA	>3C42			
0046 001C			DATA	>3D3F			
0047 001D			DATA	>3E15			
0048 001E			DATA	>3EC5			
0049 001F 0050 0020			DATA DATA	>3F4F >3FB1			
0051 0021			DATA	>3FEC			
0052 0022			DATA	>4000			
0053 0023	3FEC		DATA	>3FEC			

GENER1

0054 0024 3FB1 0055 0025 3F4F 0056 0026 3EC5 0057 0027 3E15 0058 0028 3D3F	DATA DATA DATA DATA DATA	>3FB1 >3F4F >3EC5 >3E15 >3D3F
0059 0029 3C42 0060 002A 3B21	DATA DATA	>3C42 >3B21
0061 002B 39DB 0062 002C 3871	DATA DATA	>39DB >3871
0063 002D 36E5	DATA	>36E5
0064 002E 3537	DATA	>3537
0065 002F 3368	DATA	>3368
0066 0030 3179	DATA	>3179
0067 0031 2F6C	DATA	>2F6C
0068 0032 2D41	DATA	>2D41
0069 0033 2AFB	DATA	>2AFB
0070 0034 289A	DATA	>289A
0071 0035 2620 0072 0036 238E	DATA DATA	>2620 >238E
0072 0036 238E 0073 0037 20E7	DATA	>236E >20E7
0074 0038 1E2B	DATA	>1E2B
0075 0039 1B5D	DATA	>1B5D
0076 003A 187E	DATA	>187E
0077 003B 1590	DATA	>1590
0078 003C 1294	DATA	>1294
0079 003D 0F8D	DATA	>F8D
0080 003E 0C7C	DATA	>C7C
0081 003F 0964	DATA	>964
0082 0040 0646	DATA	>646
0083 0041 0324 0084 0042 0000	DATA DATA	>324 >0
0084 0042 0000 0085 0043 FCDC	DATA	>FCDC
0086 0044 F9BA	DATA	>F9BA
0087 0045 F69C	DATA	>F69C
0088 0046 F384	DATA	>F384
0089 0047 F073	DATA	>F073
0090 0048 ED6C	DATA	>ED6C
0091 00 49 EA 70	DATA	>EA70
0092 004A E782	DATA	>E782
0093 004B E4A3	DATA	>E4A3
0094 004C E1D5 0095 004D DF19	DATA DATA	>ElD5 >DF19
0095 004D DF19 0096 004E DC72	DATA	>DF19 >DC72
0098 004E DC72	DATA	>D9E0
0098 0050 D766	DATA	>D766
0099 0051 D505	DATA	>D505
0100 0052 D2BF	DATA	>D2BF
0101 0053 D094	DATA	>D094
0102 0054 CE87	DATA	>CE87
0103 0055 CC98	DATA	>CC98
0104 0056 CAC9	DATA	>CAC9 >C91B
0105 0057 C91B 0106 0058 C78F	DATA DATA	>C91B >C78F
0107 0059 C625	DATA	>C625
0107 0035 0025	DAIA	- 0025

0108 005A C4DF		DATA	>C4DF
0109 005B C3BE		DATA	>C3BE
			>C2C1
0110 005C C2C1		DATA	
0111 005D C1EB		DATA	>ClEB
0112 005E C13B		DATA	>C13B
0113 005F C0B1		DATA	>C0B1
0114 0060 C04F		DATA	>C04F
0115 0061 C014		DATA	>C014
0116 0062 C000		DATA	>C000
0117 0063 C014		DATA	>C014
0118 0064 C04F		DATA	>C04F
0119 0065 COB1		DATA	>C0B1
0120 0066 Cl3B		DATA	>C13B
0121 0067 ClEB		DATA	>C1EB
0122 0068 C2C1		DATA	>C2C1
0123 0069 C3BE		DATA	>C3BE
0124 006A C4DF		DATA	>C4DF
0125 006B C625		DATA	>C625
0126 006C C78F		DATA	>C78F
0127 006D C91B		DATA	>C91B
0128 006E CAC9		DATA	>CAC9
0129 006F CC98		DATA	>CC98
			>CE87
0130 0070 CE87		DATA	
0131 0071 D094		DATA	>D094
0132 0072 D2BF		DATA	>D2BF
0133 0073 D505		DATA	>D505
0134 0074 D766		DATA	>D766
0135 0075 D9E0		DATA	>D9E0
0136 0076 DC72		DATA	>DC72
0137 0077 DF19		DATA	>DF19
0138 0078 E1D5		DATA	>E1D5
0139 0079 E4A3		DATA	>E4A3
0140 007A E782		DATA	>E782
			>EA70
0141 007B EA70		DATA	
0142 007C ED6C		DATA	>ED6C
0143 007D F073		DATA	>F073
0144 007E F384		DATA	>F384
0145 007F F69C		DATA	>F69C
0146 0080 F9BA		DATA	>F9BA
0147 0081 FCDC		DATA	>FCDC
0148 0082			
0149 0082 7FFF	Ml	DATA	>7FFF
0150 0083			
0151	*****	******	******
0152	* "	MEMORY I	OCATIONS USED*

0153			
0154 0000	DELTA	EQU	0
0155 0001	ALPHA	EQU	1
0156 0002	SINA	EQU	2
0157 0003	TEMP	EQU	3
		-	4
0158 0004	MASK	EQU	
0159 0005	OFSET	EQU	5
0160 0083			

*WORKSPACE REGISTER

GENERI 320 FAMILY MACRO ASSEMBLER 2.1 83.076 17:14:48 1/18/84 PAGE 0004 *********************** 0161 0162 * NECESSARY INITIALIZATIONS: * INITIALIZED TO >7FFF FOR 128 POINT TABLE 0163 * MASK * * OFSET INITIALIZED TO THE ADDRESS AT THE BEGINNING 0164 * 0165 OF TABLE. * ALPHA INITIALLY CLEARED 0166 INITIALIZED TO INCREMENT VALUE USING 08 FORMAT. * 0167 * DELTA 0168 * SET DATA PAGE POINTER 0169 0083 6F00 START LDP Ω 0170 0084 7E82 LACK M1 0171 0085 6704 TBLR MASK 0172 0086 7E02 LACK SINE 0173 0087 5005 SACL OFSET 0174 0088 7F89 ZAC ALPHA 0175 0089 5001 SACL DELTA, PA1 * IN THIS EXAMPLE, 0176 008A 4100 IN * DELTA IS INPUT 0177 008B F800 L1 CALL SWAVE1 008C 008F' ******************************** 0178 REST OF PROGRAM 0179 ***************************** 0180 0181 008D F900 в Ll 008E 008B' 0182 008F 0183 0184 * SINE WAVE SUBROUTINE: * THIS ROUTINE EXTRACTS THE SINE OF AN ANGLE FROM THE 0185 * TABLE AND RETURNS THE VALUE IN THE DATA LOCATION 0186 * 'SINA'. IT USES A FRACTIONAL STEP SIZE TO COMPUTE 0187 * THE NEXT POINT OF THE WAVE. IT TAKES 2.6 microseconds 0188 0189 * TO EXECUTE. ***** ********************************* 0190 0191 008F 2801 SWAVE1 LAC ALPHA.8 *ISOLATE INTEGER PORTION 0192 0090 5803 TEMP SACH 0193 0091 2003 LAC TEMP 0194 0092 0005 ADD OFSET *SINE VALUE FROM TABLE (014) 0195 0093 6702 TBLR SINA 0196 0094 2001 LAC ALPHA *COMPUTE NEXT ADDRRESS 0197 0095 0000 ADD DELTA *MODULO 128 MASK = >7FFF 0198 0096 7904 AND MASK *SAVE NEXT ADDRESS 0199 0097 5001 SACL ALPHA 0200 0098 7F8D RET *RETURN TO MAIN PROGRAM END 0201 NO ERRORS, NO WARNINGS

APPENDIX C: TMS32010 LINEAR INTERPOLATION ROUTINE

GENER	2	320	FAMILY	MACRO	ASSEMBLER	2.1 83.	076	10:54:48	1/19/84 PAGE 0001
0001				IDT	'GENER2	2 *			
0002			*****	******	*******	*******	******	******	*****
0003			*	SINE	WAVE GENE	ERATOR			*
0004			*		AR INTERPO				*
0005			* THIS	S PROGR	AM USES A	LOOKUP T	ABLE OF	SINE VALUES	S TO *
0006			* COM	PUTE TH	E SAMPLES	OF THE W	AVE. T	HE FREQUENC	Y IS *
0007			* DETI	ERMINED	BY THE SI	ZE BY WH	ICH ONE	HE FREQUENC	UGH *
0008			* THE	TABLE.	THE TABI	E CONSIS	TS OF 1	28 ENTRIES "	ፐዠልጥ ★
0009			* CORI	RESPOND	TO EQUALI	Y SPACED	ANGLES	BETWEEN 0 BLE ENTRIES MATION,	AND *
0010			* 360	DEGREE	S. POINTS	5 BETWEEN	THE TA	BLE ENTRIES	ARE *
0011			* APPI	KOX I MAT	ED USING A	LINEAR	APPROXI	MATION,	*
0012 0013			* Sin	(A)~=	<pre>sin(INT[A] + {sin(INT]</pre>	/ []]]]]]]]]]]]]]]	i		
0013							TRUINTL	A])}xFRACT[/ TWO CONSEC	
0015			* SINI	TABLE	FNTRIFS 1	PF STOPF	CEN ANI	SEDADATE TAI	
0016			* THE	SLOPE	TABLE IS A	1.50 128	ENTRIES	LONG	*
0017			*****	******	*******	*******	******	SEPARATE TAI	*****
0018			*	NOTE					*
0019			* THE	TMS320	10 USES FI	XED-POIN	T TWO'S	COMPLEMENT	*
0020			* NUMI	BERS.	EACH 16-BI	T NUMBER	HAS A	SIGN BIT. i	*
0021			* INTI	EGER BI	TS, AND (]	.5-i) FRA	CTIONAL	BITS. THE	*
0022			* VALU	JE AFTE	R THE LETT	ER Q REF	ERS TO	THE NUMBER	OF *
0023			* FRAG	CTIONAL	BITS THAT	ARE REP	RESENTE	D BY THAT	*
0024		•				NUMBER I	S CONSI	DERED TO HAV	VE *
0025					NAL BITS.			*******	*****
	0000							<u>,</u>	
		F900		в	START				
1		0104							
0029			*						
		7FFF		DATA	>7FFF		*MASK	VALUES	
	0003	OFFF	M2	DATA	>0FFF				
0032									
		0324	SINE	DATA DATA	>0 >324			INE TABLE	
	0005			DATA	>646		* VALUE:	S ARE REPRES	SENTED
	0007			DATA	>964		*TH QI	4 FORMAT, i ARE 14 BITS	.e., C lemed
	0008			DATA	>C7C		*THE B	INARY POINT	5 AFTER
		0F8D		DATA	>F8D				•
		1294		DATA	>1294				
0040	000B	1590		DATA	>1590				
	000C			DATA	>187E				
		1 B 5D		DATA	>1B5D				
		1E2B		DATA	>1E2B				
		20E7		DATA	>20E7				
	0010			DATA	>238E				
		2620		DATA	>2620				
004/	0012	289A		DATA	>289A				
0049		27255		D3 77 3	>2100				
	0013			DATA DATA	>2AFB				
0049	0013 0014	2D41		DATA	>2D41				
0049 0050	0013 0014 0015			DATA DATA	>2D41 >2F6C				
0049 0050 0051	0013 0014 0015 0016	2D41 2F6C		DATA	>2D41				
0049 0050 0051 0052	0013 0014 0015 0016	2D41 2F6C 3179 3368		DATA DATA DATA	>2D41 >2F6C >3179				

0054 0019 36E5	DATA	>36E5
0055 001A 3871	DATA	>3871
0056 001B 39DB	DATA	>39DB
0057 001C 3B21	DATA	>3B21
0058 001D 3C42	DATA	>3C42
0059 001E 3D3F	DATA	
		>3D3F
0060 001F 3E15	DATA	>3E15
0061 0020 3EC5	DATA	>3EC5
0062 0021 3F4F	DATA	>3F4F
0063 0022 3FB1	DATA	>3FB1
0064 0023 3FEC	DATA	>3FEC
0065 0024 4000	DATA	>4000
0066 0025 3FEC	DATA	>3FEC
0067 0026 3FB1	DATA	>3FB1
0068 0027 3F4F	DATA	>3F4F
0069 0028 3EC5	DATA	>3EC5
0070 0029 3E15	DATA	>3E15
0071 002A 3D3F	DATA	>3D3F
0072 002B 3C42	DATA	>3C42
0073 002C 3B21	DATA	>3B21
0074 002D 39DB	DATA	>39DB
0075 002E 3871	DATA	>3871
	DATA	
		>36E5
0077 0030 3537	DATA	>3537
0078 0031 3368	DATA	>3368
0079 0032 3179	DATA	>3179
0080 0033 2F6C	DATA	>2F6C
0081 0034 2D41	DATA	>2D41
0082 0035 2AFB	DATA	>2AFB
0083 0036 289A	DATA	>289A
0084 0037 2620	DATA	>2620
0085 0038 238E		>238E
	DATA	
0086 0039 20E7	DATA	>20E7
0087 003A 1E2B	DATA	>1E2B
0088 003B 1B5D	DATA	>1B5D
0089 003C 187E	DATA	>187E
0090 003D 1590	DATA	>1590
0091 003E 1294	DATA	>1294
0092 003F 0F8D	DATA	>F8D
0093 0040 0C7C	DATA	>C7C
0094 0041 0964	DATA	>964
0095 0042 0646	DATA	>646
0096 0043 0324	DATA	>324
0097 0044 0000	DATA	>0
0098 0045 FCDC	DATA	>FCDC
0099 00 46 F9BA	DATA	>F9BA
0100 0047 F69C	DATA	>F69C
0101 0048 F384	DATA	>F384
0102 0049 F073	DATA	>F073
0103 004A ED6C	DATA	>ED6C
0104 004B EA70	DATA	>ED0C
0104 0046 EA/0		
	DATA	>E782
0106 004D E4A3	DATA	>E4A3
0107 004E E1D5	DATA	>ElD5

GENER2

0108 004F DF19 0109 0050 DC72	DATA DATA	>DF19 >DC72
0110 0051 D9E0	DATA	>D9E0
0111 0052 D766	DATA	>D766
0112 0053 D505	DATA	>D505
0113 0054 D2BF	DATA	>D2BF
0114 0055 D094	DATA	>D094
0115 0056 CE87	DATA	>CE87
0116 0057 CC98	DATA	>CC98
0117 0058 CAC9	DATA	>CAC9
0118 0059 C91B	DATA	>C91B
0119 005A C78F	DATA	>C78F
0120 005B C625 0121 005C C4DF	DATA DATA	>C625 >C4DF
0121 005C C4DF 0122 005D C3BE	DATA	>C3BE
0122 005D C3BE 0123 005E C2C1	DATA	>C2C1
0123 005E C2C1 0124 005F C1EB	DATA	>ClEB
0125 0060 C13B	DATA	>C13B
0126 0061 COB1	DATA	>C0B1
0127 0062 C04F	DATA	>C04F
0128 0063 C014	DATA	>C014
0129 0064 C000	DATA	>C000
0130 0065 C014	DATA	>C014
0131 0066 C04F	DATA	>C04F
0132 0067 COB1	DATA	>C0B1
0133 0068 C13B	DATA	>C13B
0134 0069 C1EB	DATA	>C1EB
0135 006A C2C1	DATA	>C2C1
0136 006B C3BE	DATA	>C3BE
0137 006C C4DF	DATA	>C4DF
0138 006D C625	DATA	>C625 ·
0139 006E C78F	DATA	>C78F
0140 006F C91B	DATA	>C91B
0141 0070 CAC9	DATA	>CAC9
0142 0071 CC98	DATA	>CC98
0143 0072 CE87	DATA	>CE87
0144 0073 D094	DATA	>D094
0145 0074 D2BF 0146 0075 D505	DATA DATA	>D2BF >D505
0148 0075 D505 0147 0076 D766	DATA	>D305
0148 0077 D9E0	DATA	>D9E0
0149 0078 DC72	DATA	>DC72
0150 0079 DF19	DATA	>DF19
0151 007A E1D5	DATA	>E1D5
0152 007B E4A3	DATA	>E4A3
0153 007C E782	DATA	>E782
0154 007D EA70	DATA	>EA70
0155 007E ED6C	DATA	>ED6C
0156 007F F073	DATA	>F073
0157 0080 F384	DATA	>F384
0158 0081 F69C	DATA	>F69C
0159 0082 F9BA	DATA	>F9BA
0160 0083 FCDC	DATA	>FCDC
0161 0084 0324	TSLOPE DATA	>324

*SLOPE BETWEEN TWO

*SINE ENTRIES (Q14)

0164 0087 0318 DATA >318 0165 0088 0311 DATA >311 0166 0089 0307 DATA >317 0167 008A 02FC DATA >2FC 0168 008E 02EE DATA >2EE 0167 008D 02CE DATA >2DF 0170 008E 02AT DATA >2EC 0171 008E 02AT DATA >2EC 0173 0090 0291 DATA >2AT 0174 0091 027A DATA >246 0177 0092 0261 DATA >22B 0176 0093 0246 DATA >20D 0177 0096 01EF DATA >20D 0178 0095 02D DATA >246 0177 0096 01EF DATA >1EF 0180 0097 01CF DATA >1A 0181 0098 01AC DATA >1A	0162 0085 0322 0163 0086 031E	DATA DATA	>322 >31E
0166 0089 0307 DATA >307 0167 008A 02FC DATA >2FC 0168 008E 02EE DATA >2DF 0170 008D 02CE DATA >2DF 0171 008E 02BC DATA >2CE 0171 008E 02BC DATA >2BC 0172 008F 02A7 DATA >2A7 0173 0090 0291 DATA >291 0174 0091 02TA DATA >246 0177 0092 0261 DATA >20D 0176 0093 0246 DATA >20D 0178 0095 02D DATA >20D 0179 0096 01EF DATA >1EF 0180 0097 01CF DATA >1AE 0181 0098 01AC DATA >1AE 0182 0099 018C DATA >1AE 0183 009C 0121 DATA >16A			
0167 008A 02FC DATA >2FC 0168 008B 02EE DATA >2DF 0170 008D 02CE DATA >2CE 0171 008E 02CE DATA >2CE 0172 008F 02A7 DATA >2BC 0173 0090 0291 DATA >2A7 0173 0090 0291 DATA >2A7 0173 0090 0291 DATA >2A7 0175 0092 0261 DATA >246 0177 0094 022B DATA >22B 0178 0095 020D DATA >22B 0178 0096 01EF DATA >1EF 0180 0097 01CF DATA >1AE 0182 0099 018C DATA >1AE 0183 009A 016A DATA >146 0184 009B 04A DATA >EC 0186 009F 0BO DATA >B0			
0168 008B 02EE DATA >2EE 0169 008C 02DF DATA >2DF 0170 008D 02CE DATA >2EC 0171 008E 02BC DATA >2BC 0172 008F 02A7 DATA >2A7 0173 0090 0291 DATA >2A7 0173 0090 0291 DATA >2A7 0175 0092 0261 DATA >261 0176 0093 0246 DATA >246 0177 0094 022B DATA >22B 0178 0095 020D DATA >22B 0178 0097<01CF			
0169 008C 02DF DATA >2DF 0170 008D 02CE DATA >2DC 0171 008E 02BC DATA >2BC 0172 008F 02A7 DATA >2PI 0174 0091 027A DATA >291 0174 0091 027A DATA >201 0175 0092 0261 DATA >246 0177 0094 02B DATA >22B 0176 0093 0246 DATA >22B 0177 0094 02B DATA >22B 0178 0095 020D DATA >20D 0179 0096 01EF DATA >1EF 0180 0097 01CF DATA >1A 0181 0098 01AC DATA >1A 0182 0099 018C DATA >1A 0183 009A 016A DATA >16A 0184 009B 016A DATA >16A <			
0170 008D 02CE DATA >2CE 0171 008E 02BC DATA >2BC 0172 008F 02A7 DATA >2A7 0173 0090 0291 DATA >27A 0174 0091 027A DATA >27A 0175 0092 0261 DATA >246 0177 0094 022B DATA >22B 0178 0095 02D DATA >22B 0179 0096 01EF DATA >1EF 0180 0097 01CF DATA >1AE 0181 0098 01AE DATA >1AE 0182 0099 018C DATA >1AE 0183 009A 016A DATA >16A 0184 009B 0146 DATA >121 0186 009F 00BO DATA >80 0187 00A0 0089 DATA >89 0190 00A1 0062 DATA >62			
0171 008E 02BC DATA >2BC 0172 008F 02A7 DATA >2A7 0173 0090 0291 DATA >291 0174 0091 027A DATA >27A 0175 0092 0261 DATA >261 0176 0093 0246 DATA >246 0177 0094 022B DATA >22B 0178 0095 020D DATA >20D 0179 0096 01EF DATA >1CF 0180 0097 01CF DATA >1AE 0182 0099 018C DATA >1AE 0182 0099 016A DATA >16A 0183 0094 016A DATA >146 0184 009E 00FC DATA >EC 0186 009F 00B0 DATA >B0 0180 00A1 062 DATA >B0 0180 00A1 062 DATA >FEC <			
0172 008F 02A7 DATA >2A7 0173 0090 0291 DATA >291 0174 0091 027A DATA >27A 0175 0092 0261 DATA >261 0176 0093 0246 DATA >246 0177 0094 022B DATA >22B 0178 0095 020D DATA >22B 0178 0095 020D DATA >22B 0178 0096 01EF DATA >1EF 0180 0097 01CF DATA >1AE 0182 0099 018C DATA >1AE 0183 0098 0146 DATA >146 0184 009E 00FC DATA >121 0186 0097 00FC DATA >89 0189 00A0 0089 DATA >89 0180 00A1 0062 DATA >89 0190 00A1 0062 DATA >FFC			
0173 0090 0291 DATA >291 0174 0091 027A DATA >27A 0175 0092 0261 DATA >261 0176 0093 0246 DATA >246 0177 0094 022B DATA >22B 0178 0095 020D DATA >22B 0179 0096 01EF DATA >1EF 0180 0097 01CF DATA >1CF 0181 0098 01AE DATA >1A 0181 0098 01AC DATA >1AE 0183 0090 01AT >16A DATA >146 0183 009A 016A DATA >146 0184 009E 00AC DATA >16A 0184 009E 00AC DATA >16C 0184 009E 00AC DATA >16C 0186 009TC DATA >80 0180 0AAA >80 0190 0AA FEC			
0174 0091 027A DATA >27A 0175 0092 0261 DATA >261 0176 0093 0246 DATA >246 0177 0094 022B DATA >22B 0178 0095 02D DATA >22D 0179 0096 01EF DATA >1EF 0180 0097 01CF DATA >1AE 0181 0098 01AE DATA >1AE 0182 0099 018C DATA >1AE 0183 009A 016A DATA >16A 0184 009B 0146 DATA >146 0185 009C 0121 DATA >121 0186 009F 00BO DATA >80 0189 00A0 089 DATA >80 0190 00A1 062 DATA >89 0190 00A1 062 DATA >89 0190 00A4 FFCC DATA >FFC5 <td< td=""><td></td><td></td><td></td></td<>			
0175 0092 0261 DATA >261 0176 0093 0246 DATA >246 0177 0094 022B DATA >22B 0178 0095 020D DATA >20D 0179 0096 01EF DATA >1EF 0180 0097 01CF DATA >1AE 0181 0098 01AE DATA >1AE 0182 0099 018C DATA >1AE 0182 0099 018C DATA >16A 0183 0098 0146 DATA >146 0185 009C 0121 DATA >121 0186 009D 00FC DATA >62 0187 009E 00D6 DATA >89 0190 00A1 0062 DATA >89 0190 00A1 0062 DATA >14 0193 00A4 FFEC DATA >14 0193 00A4 FFEC DATA >FF2C			
0176 0093 0246 DATA >246 0177 0094 022B DATA >22B 0178 0095 020D DATA >20D 0179 0096 01EF DATA >1EF 0180 0097 01CF DATA >1AE 0182 0099 018C DATA >1AE 0182 0099 016A DATA >16A 0183 009A 016A DATA >16A 0184 009B 0146 DATA >121 0186 009C 017A >121 DATA >16A 0184 009B 00ATA >160 DATA >166 0186 009F 00BO DATA >89 D190 00A1 0062 DATA >89 0190 00A1 0062 DATA >89 D192 00A3 O14 DATA >14 0193 00A4 FFEC DATA >FFC D194 00A5 FFC5 DATA >FF25 0196			
0177 0094 022B DATA >22B 0178 0095 020D DATA >20D 0179 0096 01EF DATA >1EF 0180 0097 01CF DATA >1AE 0182 0099 018C DATA >1AE 0183 0097 016A DATA >1AE 0183 009A 016A DATA >146 0184 009B 0146 DATA >146 0184 009E 016C DATA >121 0186 009D 00FC DATA >226 0187 009E 00D6 DATA >26 0180 00A0 0089 DATA >89 0190 00A1 062 DATA >89 0192 00A3 014 DATA >14 0193 00A4 FFC5 DATA >FFC2 0194 00A5 FFC5 DATA >FF77 0197 0A8 FF50 DATA >FF2A			
0178 0095 020D DATA >20D 0179 0096 01EF DATA >1EF 0180 0097 01CF DATA >1CF 0181 0098 01AE DATA >1AE 0182 0099 018C DATA >18C 0183 009A 016A DATA >146 0184 009B 0146 DATA >146 0185 009C 0121 DATA >121 0186 009D 0FC DATA >16A 0186 009F 0DBO DATA >166 0187 009E 00D6 DATA >56 0188 009F 00BO DATA >80 0190 00A1 062 DATA >89 0190 00A1 062 DATA >80 0192 00A3 014 DATA >14 0193 00A4 FFC5 DATA >FFC5 0196 00A7 FF77 DATA >FF73 <td< td=""><td></td><td></td><td></td></td<>			
0179 0096 01EF DATA >1EF 0180 0097 01CF DATA >1CF 0181 0098 01AE DATA >1AE 0182 0099 018C DATA >1AE 0183 0090 016A DATA >16A 0184 009B 0146 DATA >146 0185 009C 0121 DATA >121 0186 009D 00FC DATA >121 0186 009D 00FC DATA >121 0186 009F 00B0 DATA >16A 0187 009E 00ATA >E0 0188 009F 00B0 DATA >80 0190 00A1 0062 DATA >62 0191 00A2 03B DATA >38 0192 00A3 0014 DATA >14 0193 00A4 FFCC DATA >FFC5 0194 00A5 FF25 DATA >FF77 0197			
0180 0097 01CF DATA >1CF 0181 0098 01AE DATA >1AE 0182 0099 018C DATA >18C 0183 009A 016A DATA >16A 0184 0099 0146 DATA >146 0185 009C 0121 DATA >121 0186 009D 00FC DATA >16A 0187 009E 00D6 DATA >166 0188 009F 00B0 DATA >B0 0189 00A0 0089 DATA >89 0190 00A1 0062 DATA >89 0190 00A1 0062 DATA >14 0193 00A4 FFEC DATA >14 0193 00A4 FFEC DATA >14 0193 00A4 FFEC DATA >FFEC 0194 00A5 FF50 DATA >FF50 0195 00A6 FF9E DATA >FF9E			
0181 0098 01AE DATA >1AE 0182 0099 018C DATA >18C 0183 009A 016A DATA >16A 0184 009B 0146 DATA >146 0185 009C 0121 DATA >121 0186 009D 00FC DATA >EC 0187 009E 00D6 DATA >BO 0188 009F 00B0 DATA >BO 0189 00A0 0089 DATA >BO 0189 00A1 0062 DATA >BO 0190 00A1 0062 DATA >SB 0192 00A3 0014 DATA >14 0193 00A4 FFC5 DATA >FFC5 0194 00A5 FFC5 DATA >FF77 0197 00A8 FF50 DATA >FF2A 0198 00A9 FF2A DATA >FE2A 0199 00AA FF04 DATA >FE2A		DATA	
0182 0099 018C DATA >18C 0183 009A 016A DATA >16A 0184 009B 0146 DATA >146 0185 009C 0121 DATA >121 0186 009D 00FC DATA >FC 0187 009E 00D6 DATA >FC 0188 009F 00B0 DATA >B0 0189 00A0 0089 DATA >89 0190 00A1 0062 DATA >62 0191 00A2 003B DATA >3B 0192 00A3 0014 DATA >14 0193 00A4 FFCC DATA >FFC5 0194 00A5 FFC5 DATA >FF75 0195 00A6 FF9E DATA >FF75 0196 00A7 FF77 DATA >FF75 0196 00A7 FF77 DATA >FF2A 0199 00AA FF04 DATA >FE2A			
0183 009A 016A DATA >16A 0184 009B 0146 DATA >146 0185 009C 0121 DATA >121 0186 009D 00FC DATA >121 0186 009E 00BC DATA >16A 0187 009E 00BC DATA >16 0188 009F 00BO DATA >BO 0189 00A0 0089 DATA >89 0190 00A1 0062 DATA >62 0191 00A2 003B DATA >38 0192 00A3 0014 DATA >14 0193 00A4 FFEC DATA >FFC5 0194 00A5 FFC5 DATA >FF75 0196 00A7 FF77 DATA >FF75 0197 00A8 FF50 DATA >FF24 0199 00AA FF04 DATA >FE04 0201 00AC FEBA DATA >FE31			
0184 009B 0146 DATA >146 0185 009C 0121 DATA >121 0186 009D 00FC DATA >FC 0187 009E 00D6 DATA >D6 0187 009E 00D6 DATA >B0 0187 009E 00A0 DATA >B0 0189 00A0 0089 DATA >89 0190 00A1 0062 DATA >62 0191 00A2 003B DATA >14 0192 00A3 0014 DATA >14 0193 00A4 FFEC DATA >FFEC 0194 00A5 FFC5 DATA >FF25 0195 00A6 FF9E DATA >FF9E 0196 00A7 FF77 DATA >FF77 0197 00A8 FF50 DATA >FF2A 0199 00AA FF04 DATA >FE14 0200 00AB FEDF DATA >FE96		DATA	>18C
0185 009C 0121 DATA >121 0186 009D 00FC DATA >FC 0187 009E 00D6 DATA >D6 0187 009E 00D6 DATA >D6 0188 009F 00B0 DATA >B0 0189 00A0 0089 DATA >89 0190 00A1 0062 DATA >62 0191 00A2 003B DATA >38 0192 00A3 0014 DATA >14 0193 00A4 FFEC DATA >FFEC 0194 00A5 FFC5 DATA >FFC5 0195 00A6 FF9E DATA >FF9E 0196 00A7 FF77 DATA >FF77 0197 00A8 FF04 DATA >FF204 0200 00AF FE0F DATA >FE0F 0201 00AC FEBA DATA >FE0F 0201 00AC FEBA DATA >FE05			
0186 009D 00FC DATA >FC 0187 009E 00D6 DATA >D6 0188 009F 00B0 DATA >B0 0189 00A0 0089 DATA >89 0180 00A1 0062 DATA >62 0191 00A2 003B DATA >3B 0192 00A3 0014 DATA >14 0193 00A4 FFEC DATA >FFC 0194 00A5 FFC5 DATA >FFC2 0195 00A6 FF9E DATA >FF2C 0196 00A7 FF77 DATA >FF77 0197 00A8 FF50 DATA >FF2A 0198 00A9 FF2A DATA >FF2A 0199 00AA FF04 DATA >FE2A 0200 00AB FEDF DATA >FE2A 0201 00AC FEBA DATA >FE2A 0202 00AD FE96 DATA >FE31			
0187 009E 00D6 DATA >D6 0188 009F 00B0 DATA >B0 0189 00A0 0089 DATA >89 0190 00A1 0062 DATA >62 0191 00A2 003B DATA >3B 0192 00A3 0014 DATA >14 0193 00A4 FFEC DATA >FFC 0194 00A5 FFC5 DATA >FFC5 0195 00A6 FF9E DATA >FF77 0196 00A7 FF77 DATA >FF77 0196 00A7 FF77 DATA >FF20 0196 00A7 FF77 DATA >FF77 0197 00A8 FF04 DATA >FF2A 0199 00AA FF04 DATA >FE2A 0199 00AA FF04 DATA >FE2A 0201 00AC FEBA DATA >FE2A 0202 00AD FE96 DATA >FE24 <tr< td=""><td></td><td>DATA</td><td>>121</td></tr<>		DATA	>121
0188 009F 0080 DATA >B0 0189 00A0 0089 DATA >89 0190 00A1 0062 DATA >62 0191 00A2 003B DATA >38 0192 00A3 0014 DATA >31 0193 00A4 FFEC DATA >14 0193 00A4 FFEC DATA >14 0193 00A4 FFEC DATA >14 0193 00A4 FFEC DATA >FFEC 0194 00A5 FFC5 DATA >FFC5 0195 00A6 FF9E DATA >FF77 0196 00A7 FF77 DATA >FF74 0196 00A7 FF50 DATA >FF24 0199 00AA FF04 DATA >FE74 0200 00AB FEDF DATA >FE96 0201 00AC FE8A DATA >FE74 0202 00AD FE96 DATA >FE52			
0189 00A0 0089 DATA >89 0190 00A1 0062 DATA >62 0191 00A2 003B DATA >38 0192 00A3 0014 DATA >34 0192 00A3 0014 DATA >14 0193 00A4 FFEC DATA >14 0193 00A5 FFC5 DATA >FFEC 0194 00A5 FFC5 DATA >FFC5 0195 00A6 FF9E DATA >FF77 0196 00A7 FF77 DATA >FF77 0196 00A7 FF77 DATA >FF50 0198 00A9 FF2A DATA >FF24 0199 00AA FF04 DATA >FE96 0201 00AC FEBA DATA >FE96 0202 00AD FE96 DATA >FE96 0203 00AF FE52 DATA >FE96 0204 00AF FE52 DATA >FE96 <t< td=""><td></td><td>DATA</td><td>>D6</td></t<>		DATA	>D6
0190 00A1 0062 DATA >62 0191 00A2 003B DATA >3B 0192 00A3 0014 DATA >14 0193 00A4 FFEC DATA >1755 0194 00A5 FFC5 DATA >FF55 0195 00A6 FF9E DATA >FF9E 0196 00A7 FF77 DATA >FF77 0197 00A8 FF04 DATA >FF204 0198 0039 FF2A DATA >FF04 0200 00AF FE0F DATA >FE0F 0201 00AC FEBA DATA >FE3A 0202 00AD FE96 DATA >FE96 0203 00AE FE74 DATA >FE52 0205 00B0 FE31 DATA >FE52 <		DATA	>B0
0191 00A2 003B DATA >3B 0192 00A3 0014 DATA >14 0193 00A4 FFEC DATA >FFEC 0194 00A5 FFC5 DATA >FFC5 0195 00A6 FF9E DATA >FF25 0196 00A7 FF77 DATA >FF77 0197 00A8 FF50 DATA >FF20 0198 00A9 FF2A DATA >FF2A 0199 00AA FF04 DATA >FE04 0200 00AB FE0F DATA >FE2A 0201 00AC FEBA DATA >FE0F 0201 00AC FEBA DATA >FE96 0202 00AD FE96 DATA >FE96 0203 00AE FE74 DATA >FE96 0204 00AF FE52 DATA >FE96 0205 00B0 FE31 DATA >FE96 0206 00B1 FE11 DATA >FD73 <td></td> <td></td> <td></td>			
0192 00A3 0014 DATA >14 0193 00A4 FFEC DATA >FFEC 0194 00A5 FFC5 DATA >FFC5 0195 00A6 FF9E DATA >FF75 0196 00A7 FF77 DATA >FF77 0197 00A8 FF50 DATA >FF70 0198 00A9 FF2A DATA >FF2A 0199 00AA FF04 DATA >FEDF 0201 00AC FEBA DATA >FEDF 0201 00AC FEBA DATA >FE96 0202 00AD FE96 DATA >FE96 0203 00AE FE74 DATA >FE96 0204 00AF FE52 DATA >FE96 0205 00B0 FE31 DATA >FE96 0206 00B1 FE11 DATA >FE931 0206 00B3 FD55 DATA >FD573 0208 00B3 FD55 DATA >FD573			
0193 00A4 FFEC DATA >FFEC 0194 00A5 FFC5 DATA >FFC5 0195 00A6 FF9E DATA >FF25 0195 00A7 FF77 DATA >FF77 0196 00A7 FF77 DATA >FF77 0196 00A7 FF77 DATA >FF20 0198 00A9 FF2A DATA >FF2A 0199 00AA FF04 DATA >FE04 0200 00AB FEDF DATA >FEDF 0201 00AC FEBA DATA >FE9A 0202 00AD FE96 DATA >FE9A 0202 00AD FE95 DATA >FE9A 0204 00AF FE52 DATA >FE92 0205 00B0 FE31 DATA >FE93		DATA	
0194 00A5 FFC5 DATA >FFC5 0195 00A6 FF9E DATA >FF75 0196 00A7 FF77 DATA >FF77 0197 00A8 FF50 DATA >FF70 0198 00A9 FF2A DATA >FF20 0199 00AA FF04 DATA >FE04 0200 00AB FEDF DATA >FE0F 0201 00AC FEBA DATA >FE96 0202 00AD FE96 DATA >FE96 0203 00AF FE74 DATA >FE96 0203 00AF FE74 DATA >FE96 0203 00AF FE74 DATA >FE96 0204 00AF FE52 DATA >FE96 0205 00B0 FE31 DATA >FE31 0206 00B1 FE11 DATA >FD53 0208 00B3 FD55 DATA >FD57 0209 00B4 FDBA DATA >FD86			
0195 00A6 FF9E DATA >FF9E 0196 00A7 FF77 DATA >FF77 0197 00A8 FF50 DATA >FF50 0198 00A9 FF2A DATA >FF2A 0199 00AA FF04 DATA >FE0F 0200 00AB FEDF DATA >FEDF 0201 00AC FEBA DATA >FE96 0202 00AD FE96 DATA >FE96 0203 00AE FE74 DATA >FE96 0204 00AF FE52 DATA >FE96 0203 00AE FE74 DATA >FE96 0204 00AF FE52 DATA >FE92 0205 00B0 FE31 DATA >FE52 0205 00B1 FE11 DATA >FD53 0206 00B3 FDD5 DATA >FD57 0208 00B3 FDD5 DATA >FD8A 0210 00B5 FD9F DATA >FD86			
0196 00A7 FF77 DATA >FF77 0197 00A8 FF50 DATA >FF50 0198 00A9 FF2A DATA >FF2A 0199 00AA FF04 DATA >FF2A 0200 00AB FEDF DATA >FEDF 0201 00AC FEBA DATA >FEBA 0202 00AD FE96 DATA >FE96 0203 00AE FE74 DATA >FE96 0204 00AF FE52 DATA >FE72 0205 00B0 FE31 DATA >FE931 0206 00B1 FE11 DATA >FD53 0208 00B3 FDD5 DATA >FD55 0209 00B4 FDBA DATA >FD55 0210 00B5 FD9F DATA >FD86 0210 00B7 FD6F DATA >FD6F 0211 00B6 FD65 DATA >FD6F 0212 00B7 FD6F DATA >FD6F			
0197 00A8 FF50 DATA >FF50 0198 00A9 FF2A DATA >FF2A 0199 00AA FF04 DATA >FF04 0200 00AB FEDF DATA >FEBA 0201 00AC FEBA DATA >FE96 0202 00AD FE96 DATA >FE96 0202 00AD FE96 DATA >FE96 0203 00AE FE74 DATA >FE74 0204 00AF FE52 DATA >FE52 0205 00B0 FE31 DATA >FE531 0206 00B1 FE11 DATA >FD53 0208 00B3 FDD5 DATA >FD55 0209 00B4 FDBA DATA >FD59 0210 00B5 FD9F DATA >FD56 0210 00B5 FD9F DATA >FD66 0211 00B6 FD66 DATA >FD66 0212 00B7 FD6F DATA >FD67			
0198 00A9 FF2A DATA >FF2A 0199 00AA FF04 DATA >FF04 0200 00AB FEDF DATA >FEDF 0201 00AC FEBA DATA >FEBA 0202 00AD FE96 DATA >FE96 0203 00AE FE74 DATA >FE74 0204 00AF FE52 DATA >FE52 0205 00B0 FE31 DATA >FE31 0206 00B1 FE11 DATA >FE13 0207 00B2 FDF3 DATA >FD53 0208 00B3 FDD5 DATA >FD54 0210 00B5 FD9F DATA >FD8A 0210 00B5 FD9F DATA >FD86 0212 00B7 FD6F DATA >FD6F 0213 00B8 FD59 DATA >FD6F 0214 00B9 FD44 DATA >FD44			
0199 00AA FF04 DATA >FF04 0200 00AB FEDF DATA >FEDF 0201 00AC FEBA DATA >FEBA 0202 00AD FE96 DATA >FE96 0203 00AE FE74 DATA >FE74 0204 00AF FE52 DATA >FE52 0205 00B0 FE31 DATA >FE31 0206 00B1 FE11 DATA >FE11 0207 00B2 FDF3 DATA >FDF3 0208 00B3 FDD5 DATA >FD55 0209 00B4 FDBA DATA >FDBA 0210 00B5 FD9F DATA >FD86 0211 00B6 FD66 DATA >FD66 0213 00B8 FD59 DATA >FD67 0214 00B9 FD44 DATA >FD44			
0200 00AB FEDF DATA >FEDF 0201 00AC FEBA DATA >FEBA 0202 00AD FE96 DATA >FE96 0203 00AE FE74 DATA >FE52 0205 00B0 FE31 DATA >FE51 0206 00B1 FE11 DATA >FE11 0207 00B2 FDF3 DATA >FDF3 0208 00B3 FDD5 DATA >FDBA 0210 00B5 FD9F DATA >FDBA 0211 00B5 FD9F DATA >FD86 0212 00B7 FD6F DATA >FD6F 0213 00B8 FD59 DATA >FD6F 0214 00B9 FD44 DATA >FD44			
0201 00AC FEBA DATA >FEBA 0202 00AD FE96 DATA >FE96 0203 00AE FE74 DATA >FE74 0204 00AF FE52 DATA >FE52 0205 00B0 FE31 DATA >FE31 0206 00B1 FE11 DATA >FE11 0207 00B2 FDF3 DATA >FDF3 0208 00B3 FDD5 DATA >FD51 0209 00B4 FDBA DATA >FD55 0210 00B5 FD9F DATA >FD86 0211 00B6 FD66 DATA >FD6F 0212 00B7 FD6F DATA >FD6F 0213 00B8 FD59 DATA >FD6F 0214 00B9 FD44 DATA >FD44			
0202 00AD FE96 DATA >FE96 0203 00AE FE74 DATA >FE74 0204 00AF FE52 DATA >FE52 0205 00B0 FE31 DATA >FE31 0206 00B1 FE11 DATA >FE11 0207 00B2 FDF3 DATA >FD53 0208 00B3 FDD5 DATA >FD55 0209 00B4 FDBA DATA >FD54 0210 00B5 FD9F DATA >FD86 0210 00B5 FD6F DATA >FD66 0212 00B7 FD6F DATA >FD65 0213 00B8 FD59 DATA >FD65 0214 00B9 FD44 DATA >FD44			
0203 00AE FE74 DATA >FE74 0204 00AF FE52 DATA >FE52 0205 00B0 FE31 DATA >FE31 0206 00B1 FE11 DATA >FE11 0207 00B2 FDF3 DATA >FD53 0208 00B3 FDD5 DATA >FD55 0209 00B4 FDBA DATA >FDBA 0210 00B5 FD9F DATA >FD86 0212 00B7 FD6F DATA >FD66 0213 00B8 FD59 DATA >FD6F 0214 00B9 FD44 DATA >FD44			
0204 00AF FE52 DATA >FE52 0205 00B0 FE31 DATA >FE31 0206 00B1 FE11 DATA >FE11 0207 00B2 FDF3 DATA >FDF3 0208 00B3 FDD5 DATA >FDBA 0210 00B5 FD9F DATA >FD9F 0211 00B6 FD86 DATA >FD86 0212 00B7 FD6F DATA >FD6F 0213 00B8 FD59 DATA >FD6F 0214 00B9 FD44 DATA >FD44			
0205 00B0 FE31 DATA >FE31 0206 00B1 FE11 DATA >FE11 0207 00B2 FDF3 DATA >FDF3 0208 00B3 FDD5 DATA >FDBA 0209 00B4 FDBA DATA >FDBA 0210 00B5 FD9F DATA >FD86 0211 00B6 FD66 DATA >FD66 0212 00B7 FD6F DATA >FD66 0213 00B8 FD59 DATA >FD64 0214 00B9 FD44 DATA >FD44			
0206 00B1 FE11 DATA >FE11 0207 00B2 FDF3 DATA >FDF3 0208 00B3 FDD5 DATA >FDD5 0209 00B4 FDBA DATA >FDBA 0210 00B5 FD9F DATA >FD9F 0211 00B6 FD86 DATA >FD86 0212 00B7 FD6F DATA >FD59 0213 00B8 FD59 DATA >FD59 0214 00B9 FD44 DATA >FD44			
0207 00B2 FDF3 DATA >FDF3 0208 00B3 FDD5 DATA >FDD5 0209 00B4 FDBA DATA >FDBA 0210 00B5 FD9F DATA >FD9F 0211 00B6 FD86 DATA >FD86 0212 00B7 FD6F DATA >FD67 0213 00B8 FD59 DATA >FD59 0214 00B9 FD44 DATA >FD44			
0208 00B3 FDD5 DATA >FDD5 0209 00B4 FDBA DATA >FDBA 0210 00B5 FD9F DATA >FD9F 0211 00B6 FD86 DATA >FD86 0212 00B7 FD6F DATA >FD6F 0213 00B8 FD59 DATA >FD59 0214 00B9 FD44 DATA >FD44			
0209 00B4 FDBA DATA >FDBA 0210 00B5 FD9F DATA >FD9F 0211 00B6 FD86 DATA >FD86 0212 00B7 FD6F DATA >FD6F 0213 00B8 FD59 DATA >FD6F 0214 00B9 FD44 DATA >FD44			
0210 00B5 FD9F DATA >FD9F 0211 00B6 FD86 DATA >FD86 0212 00B7 FD6F DATA >FD6F 0213 00B8 FD59 DATA >FD59 0214 00B9 FD44 DATA >FD44			
0211 00B6 FD86 DATA >FD86 0212 00B7 FD6F DATA >FD6F 0213 00B8 FD59 DATA >FD59 0214 00B9 FD44 DATA >FD44			
0212 00B7 FD6F DATA >FD6F 0213 00B8 FD59 DATA >FD59 0214 00B9 FD44 DATA >FD44			
0213 00B8 FD59 DATA >FD59 0214 00B9 FD44 DATA >FD44			
0214 00B9 FD44 DATA >FD44			
0215 00BA FD32 DATA >FD32			
	0215 00BA FD32	DATA	>FD32

0216 00BB FD21	DATA	>FD21
0217 00BC FD12	DATA	>FD12
0218 00BD FD04	DATA	>FD04
0219 00BE FCF9	DATA	>FCF9
0220 00BF FCEF	DATA	>FCEF
0221 00C0 FCE8	DATA	>FCE8
0222 00C1 FCE2	DATA	>FCE2
0223 00C2 FCDE	DATA	>FCDE
0224 00C3 FCDC	DATA	>FCDC
0225 00C4 FCDC	DATA	>FCDC
0226 00C5 FCDE	DATA	>FCDE
0227 00C6 FCE2	DATA	>FCE2
0228 00C7 FCE8	DATA	>FCE8
0229 00C8 FCEF	DATA	>FCEF
0230 00C9 FCF9	DATA	>FCF9
0231 00CA FD04	DATA	>FD04
0232 00CB FD12	DATA	>FD12
0233 00CC FD21	DATA	>FD21
0234 00CD FD32	DATA	>FD32
0235 00CE FD44	DATA	>FD44
0236 00CF FD59	DATA	>FD59
0237 00D0 FD6F 0238 00D1 FD6F 0239 00D2 FD9F 0240 00D3 FDBA 0241 00D4 FDD5 0242 00D5 FDF3 0243 00D6 FE11	DATA DATA DATA DATA DATA DATA DATA DATA	>FD55 >FD6F >FD86 >FD9F >FDBA >FDD5 >FDF3 >FE11
0244 00D7 FE31	DATA	>FE31
0245 00D8 FE52	DATA	>FE52
0246 00D9 FE74	DATA	>FE74
0247 00DA FE96	DATA	>FE96
0248 00DB FEBA	DATA	>FEBA
0249 00DC FEDF	DATA	>FEDF
0250 00DD FF04	DATA	>FF04
0251 00DE FF2A	DATA	>FF2A
0252 00DF FF50	DATA	>FF50
0253 00E0 FF77	DATA	>FF77
0254 00E1 FF9E	DATA	>FF9E
0255 00E2 FFC5	DATA	>FF25
0256 00E3 FFEC	DATA	>FFC5
0257 00E4 0014	DATA	>14
0258 00E5 003B	DATA	>3B
0259 00E6 0062	DATA	>62
0260 00E7 0089	DATA	>89
0261 00E8 00B0	DATA	>B0
0262 00E9 00D6	DATA	>D6
0263 00EA 00FC	DATA	>FC
0264 00EB 0121	DATA	>121
0265 00EC 0146	DATA	>146
0266 00ED 016A	DATA	>16A
0267 00EE 018C	DATA	>18C
0268 00EF 01AE	DATA	>1AE
0269 00F0 01CF	DATA	>1CF

0270 00F1 01EF 0271 00F2 020D 0272 00F3 022B 0273 00F4 0246 0274 00F5 0261 0275 00F6 027A 0276 00F7 0291 0277 00F8 02A7 0278 00F9 02BC 0280 00FB 02DF 0281 00FC 02EE 0280 00FB 02DF 0281 00FC 02EE 0283 00FE 0307 0284 00FF 0311 0285 0100 0318 0286 0101 031E 0287 0102 0322 0288 0103 0324 0289 0104	DATA DATA DATA DATA DATA DATA DATA DATA	>1EF >20D >22B >246 >261 >27A >291 >2A7 >2BC >2CE >2CE >2CF >2CF >307 >311 >318 >318 >31E >322 >324		•
0290 0291		OCATIONS USED *		
0292		**************************************		
0293 0000	DELTA EQU	0		
0294 0001 0295 0002	ALPHA EQU	1		
0296 0002	SLOPE EQU SINA EQU	2 3		
0297 0004	TEMP EQU	4	*SCRATCH PAD LOCATION	
0298 0005	MASK1 EQU	5	*MASK FOR MODULO 128	POINTER
0299 0006	MASK2 EQU	6	*ISOLATE FRACTIONAL P.	
0300 0007 0301 0008	OFSET1 EQU OFSET2 EOU	7	*ADDRESS OF SINE TABL	
0302			*ADDRESS OF SLOPE TAB	
0303		ITIALIZATIONS:		*
0304		IALIZED TO >7FFF	FOR 128 POINT TABLE	*
0305		IALIZED TO >0FFF		*
0306 0307		TO THE ADDRESS A	T THE BEGINNING OF	*
0308	OTHE		T THE BEGINNING OF	*
0309			PECT TO SINE TABLE	*
0310		IALLY CLEARED		*
0311 0312		IALIZED TO INCRE	MENT VALUE USING	*
0313	ÿ vu v	'ORMAT **************	*****	***
0314 0104				
0315 0104 6F00	START LDP	0	*SET DATA PAGE POINTE	R.
0316 0105 7E04 0317 0106 5007	LACK	SINE	*SINE TABLE ADDRESS.	
0318 0107 7E84	SACL LACK	OFSET1 TSLOPE	*SLOPE TABLE ADDRESS.	
0319 0108 1007	SUB	OFSET1	STOLE LADER ADDUESS.	
0320 0109 5008	SACL	OFSET2		
0320 0109 5008 0321 010A 7E02	SACL	Ml	*RETRIEVE MASK1.	
0320 0109 5008	SACL		*RETRIEVE MASK1. *RETRIEVE MASK2.	

GENER2	320	FAMILY	MACRO	ASSEMBLER	2.1 8	3.076	10:54:48	1/19/ PAGE 00	
0324 010D	6706		TBLR	MASK2					
0325 010E			ZAC	MADICE					
0326 010F	5001		SACL	ALPHA		*START	ANGLE AT	ZERO.	
0326 010F 0327 0110 0328 0111	4100		IN	DELTA, P.	A1	*FOR T	ANGLE AT HIS EXAMPL IS INPUT.	Ε,	
0328 0111	F800	Ll	CALL	SWAVE2		*DELTA	IS INPUT.	•	
0112	0115	,					· · ·		
0329				******		*			
0330		*		OF PROGRAM		*			
0331 0332 0113	8000			Ll	*****	*			
	0111		D	LT.					
0333 0115	0111								
0334 0115									
0335		*****	*****	*******	*****	********	********	******	*
0336		* SINE	WAVE S	SUBROUTINE	:			1	*
0337		* THIS	ROUTI	NE COMPUTE	S THE	SINE OF A	N ANGLE AN	י ס	k
0338		* RETU	RNS TH	E VALUE IN	DATA	LOCATION	'SINA'. I	T USES '	k
0339		* A FR	ACTION	AL STEP SI	ZE TO	AUTOMATIC	ALLY COMPU	TE THE	*
0340		* ADDR	ESS OF	THE NEXT	POINT	OF THE SI	NE WAVE. I	T	*
0341 0342		* TAKE	5 5.0 1	NE COMPUTE E VALUE IN AL STEP SI THE NEXT microsecon	as 10.	EAECUTE.	*********	*******	*
0342 0115	2801	SWAVE?	T.AC	ALPHA,8					-
0344 0116	5804	GHATBL	SACH			*ISOLA	TE INTEGER	PORTION	N
0345 0117	2004		LAC	TEMP					
0345 0117 0346 0118	0007		LAC ADD	OFSET1					
0347 0119	6703		TBLR	SINA		*GET C	LOSEST LOW ENTRY (b) FOR CORRE	ER SINE-	-
0348 011A	0008		ADD TBLR	OFSET2		*TABLE	ENTRY (b)	•	
0349 011B	6702			SLOPE		*SLOPE	FOR CORRE	SPONDING	G INTERVA
0350 0110	2401		LAC AND	ALPHA,4		* ISOLA	TE FRACTIO AKE Q8 NUM	NAL POR	FION
0351 011D 0352 011E			SACL	MASKZ TEMP		AND M	AKE Q8 NUM	BER INTO	J Q12.
0353 011E			LT	TEMP					
0354 0120			MPY	SLOPE		* mx			
0355 0121			PAC	02012					
0356 0122			ADD	SINA,12					
0357 0123			SACH	SINA,4		* y = 1	mx + b.		
0358 0124			LAC	ALPHA DELTA		*COMPU	TE ADDRESS	OF NEX	r point.
0359 0125			ADD			*OF WA	VE.		
0360 0126			AND	MASK1		*CLEAR	MOST SIGN	IFICANT	BIT.
0361 0127 0362 0128			SACL	ALPHA			NEXT ADDRE N TO MAIN		
0362 0128	/ 00		RET END			~RETUR	N TO MAIN	FRUGRAM	•
NO ERRORS,	NO W	ARNINGS							
no biddid,									