



MX-COM, INC. MiXed Signal ICs

APPLICATION NOTE

Generation of Non-Standard CTCSS Tones

MX-COM manufactures several integrated circuits that encode and decode CTCSS tones at the EIA RS-220 standard frequencies. In many instances, however, using tones of slightly different frequencies may be desirable. Because these MX-COM ICs use switched capacitor technology, tone frequencies may be shifted simply by changing the crystal or clock input. The following five tables list alternative tones that can be encoded and decoded by the MX165C (Table 4), MX365A (Table 2), MX465 (Table 5), and the MX375 (Table 3), and encoded by the MX315A (Table 1).

Each table lists the tone frequencies for three crystal values for each chip. The MX165C, MX315A and MX365A use a nominal crystal value of 1.0 MHz; the table lists tone frequencies for 1.008 MHz and 1.024 MHz crystals as well as for 1.0 MHz. The MX375 and MX465 uses a 4.0 MHz nominal crystal value; these tables list frequencies for 4.0 MHz, 4.032 MHz, and 4.096 MHz crystals. The column labeled as "Divisor" for each table lists the quotient of the clock frequency divided by the tone frequency. This column can be used to calculate the clock frequency required to generate other tone frequencies. Each table also lists the D5-D0 program code input associated with each divisor and tone frequency group. Each code is listed in both binary and hexadecimal formats. As an example, to encode a 70.0 Hz tone with the program code input D5-D0 = 011111 = 1F Hex, the required clock would be calculated in the following manner:

D5	D4	D3	D2	D1	D0
0	1	1	1	1	1

Divisor = 13908

Tone frequency = 70.0 Hz

Required clock frequency = Divisor * Tone Frequency
= 13908 * 70.0 Hz
= 973560 Hz

When using these ICs in this manner, you must remember the following:

1. When the clock is changed, the audio pass band limits will change proportionately. These changes will be fairly small, however. For example, in the MX165C using a 1.024 MHz crystal, the lower limit will change to $(1.024/1.0) * 300 = 307$ Hz, and the upper limit will change to $(1.024/1.0) * 3000 = 3072$ Hz.
2. In the MX375, the frequency inversion carrier frequency will also change proportionately from its nominal value of 3333 Hz. For example, with a 4.096 MHz clock, the carrier frequency will change to $(4.096/4.0) * 3333$ Hz = 3413 Hz. For proper communication, the transmitter and receiver must use the same inversion carrier frequency.
3. For best results, a crystal oscillator design should drive the clock inverter input with signal levels of at least 40% of V_{DD} , peak to peak. Tuning fork crystals generally cannot meet this requirement. To obtain crystal oscillator design assistance, consult your crystal manufacturer. Operation of this device without a Xtal or Clock input may cause device damage.

MX315A										
Divisor	Xtal Freq 1.0 MHz	Xtal Freq 1.008 MHz	Xtal Freq 1.024 MHz	Program Codes						HEX
				Binary Codes						
				D5	D4	D3	D2	D1	D0	
14912	67.06	67.60	68.67	1	1	1	1	1	1	3F
14415	69.37	69.93	71.04	1	1	1	0	0	1	39
13920	71.84	72.41	73.56	0	1	1	1	1	1	1F
13454	74.33	74.92	76.11	1	1	1	1	1	0	3E
12989	76.99	77.61	78.84	0	0	1	1	1	1	0F
12555	79.65	80.29	81.56	1	1	1	1	0	1	3D
12121	82.50	83.16	84.48	0	1	1	1	1	0	1E
11718	85.34	86.02	87.39	1	1	1	1	0	0	3C
11284	88.62	89.33	90.75	0	0	1	1	1	0	0E
10943	91.38	92.11	93.57	1	1	1	0	1	1	3B
10540	94.88	95.64	97.16	0	1	1	1	0	1	1D
10261	97.46	98.24	99.80	1	1	1	0	1	0	3A
10013	99.87	100.67	102.27	0	0	1	1	0	1	0D
9672	103.39	104.22	105.87	0	1	1	1	0	0	1C
9331	107.17	108.03	109.74	0	0	1	1	0	0	0C
9021	110.85	111.74	113.51	0	1	1	0	1	1	1B
8711	114.80	115.72	117.56	0	0	1	0	1	1	0B
8432	118.60	119.55	121.45	0	1	1	0	1	0	1A
8122	123.12	124.10	126.07	0	0	1	0	1	0	0A
7843	127.50	128.52	130.56	0	1	1	0	0	1	19
7595	131.67	132.72	134.83	0	0	1	0	0	1	09
7316	136.69	137.78	139.97	0	1	1	0	0	0	18
7068	141.48	142.61	144.88	0	0	1	0	0	0	08
6851	145.96	147.13	149.46	0	1	0	1	1	1	17
6603	151.45	152.66	155.08	0	0	0	1	1	1	07
6386	156.59	157.84	160.35	0	1	0	1	1	0	16
6169	162.10	163.40	165.99	0	0	0	1	1	0	06
5952	168.01	169.35	172.04	0	1	0	1	0	1	15
5766	173.43	174.82	177.59	0	0	0	1	0	1	05
5549	180.21	181.65	184.54	0	1	0	1	0	0	14
5363	186.46	187.95	190.94	0	0	0	1	0	0	04
5177	193.16	194.71	197.80	0	1	0	0	1	1	13
4929	202.88	204.50	207.75	0	0	0	0	1	1	03
4836	206.78	208.44	211.75	1	1	1	0	0	0	38
4743	210.84	212.53	215.90	0	1	0	0	1	0	12
4588	217.96	219.70	223.19	0	0	0	0	1	0	02
4433	225.58	227.38	230.99	0	1	0	0	0	1	11
4278	233.75	235.62	239.36	0	0	0	0	0	1	01
4123	242.54	244.48	248.36	0	1	0	0	0	0	10
3999	250.06	252.06	256.06	0	0	0	0	0	0	00

Table 1: MX315A

MX365A										
	Xtal Freq	Xtal Freq	Xtal Freq	Program Codes						HEX
				Binary Codes						
Divisor	1.0 MHz	1.008 MHz	1.024 MHz	D5	D4	D3	D2	D1	D0	
14914	67.05	67.59	68.66	1	1	1	1	1	1	3F
14426	69.32	69.87	70.98	1	1	1	0	0	1	39
13908	71.90	72.48	73.63	0	1	1	1	1	1	1F
13450	74.35	74.94	76.13	1	1	1	1	1	0	3E
12994	76.96	77.58	78.81	0	0	1	1	1	1	0F
12536	79.77	80.41	81.68	1	1	1	1	0	1	3D
12108	82.59	83.25	84.57	0	1	1	1	1	0	1E
11712	85.38	86.06	87.43	1	1	1	1	0	0	3C
11285	88.61	89.32	90.74	0	0	1	1	1	0	0E
10919	91.58	92.31	93.78	1	1	1	0	1	1	3B
10553	94.76	95.52	97.03	0	1	1	1	0	1	1D
10279	97.29	98.07	99.62	1	1	1	0	1	0	3A
10004	99.96	100.76	102.36	0	0	1	1	0	1	0D
9668	103.43	104.26	105.91	0	1	1	1	0	0	1C
9333	107.15	108.01	109.72	0	0	1	1	0	0	0C
9028	110.77	111.66	113.43	0	1	1	0	1	1	1B
8723	114.64	115.56	117.39	0	0	1	0	1	1	0B
8418	118.80	119.75	121.65	0	1	1	0	1	0	1A
8143	122.80	123.78	125.75	0	0	1	0	1	0	0A
7869	127.08	128.10	130.13	0	1	1	0	0	1	19
7595	131.67	132.72	134.83	0	0	1	0	0	1	09
7320	136.61	137.70	139.89	0	1	1	0	0	0	18
7076	141.32	142.45	144.71	0	0	1	0	0	0	08
6832	146.37	147.54	149.88	0	1	0	1	1	1	17
6619	151.09	152.30	154.72	0	0	0	1	1	1	07
6374	156.88	158.14	160.65	0	1	0	1	1	0	16
6161	162.31	163.61	166.21	0	0	0	1	1	0	06
5947	168.14	169.49	172.18	0	1	0	1	0	1	15
5764	173.48	174.87	177.64	0	0	0	1	0	1	05
5551	180.15	181.59	184.47	0	1	0	1	0	0	14
5368	186.29	187.78	190.76	0	0	0	1	0	0	04
5185	192.86	194.40	197.49	0	1	0	0	1	1	13
4910	203.65	205.28	208.54	0	0	0	0	1	1	03
4758	210.17	211.85	215.21	0	1	0	0	1	0	12
4575	218.58	220.33	223.83	0	0	0	0	1	0	02
4422	226.12	227.93	231.55	0	1	0	0	0	1	11
4270	234.19	236.06	239.81	0	0	0	0	0	1	01
4148	241.08	243.01	246.87	0	1	0	0	0	0	10
3996	250.28	252.28	256.29	0	0	0	0	0	0	00

Table 2: MX365A

MX375										
Divisor	Xtal Freq 4.0 MHz	Xtal Freq 4.032 MHz	Xtal Freq 4.096 MHz	Program codes						HEX
				Binary codes						
				D5	D4	D3	D2	D1	D0	
59657	67.05	67.59	68.66	1	1	1	1	1	1	3F
55633	71.90	72.48	73.63	0	1	1	1	1	1	1F
53800	74.35	74.94	76.13	1	1	1	1	1	0	3E
51975	76.96	77.58	78.81	0	0	1	1	1	1	0F
50144	79.77	80.41	81.68	1	1	1	1	0	1	3D
48432	82.59	83.25	84.57	0	1	1	1	1	0	1E
46849	85.38	86.06	87.43	1	1	1	1	0	0	3C
45142	88.61	89.32	90.74	0	0	1	1	1	0	0E
43678	91.58	92.31	93.78	1	1	1	0	1	1	3B
42212	94.76	95.52	97.03	0	1	1	1	0	1	1D
41114	97.29	98.07	99.62	1	1	1	0	1	0	3A
40016	99.96	100.76	102.36	0	0	1	1	0	1	0D
38673	103.43	104.26	105.91	0	1	1	1	0	0	1C
37331	107.15	108.01	109.72	0	0	1	1	0	0	0C
36111	110.77	111.66	113.43	0	1	1	0	1	1	1B
34892	114.64	115.56	117.39	0	0	1	0	1	1	0B
33670	118.80	119.75	121.65	0	1	1	0	1	0	1A
32573	122.80	123.78	125.75	0	0	1	0	1	0	0A
31476	127.08	128.10	130.13	0	1	1	0	0	1	19
30379	131.67	132.72	134.83	0	0	1	0	0	1	09
29280	136.61	137.70	139.89	0	1	1	0	0	0	18
28305	141.32	142.45	144.71	0	0	1	0	0	0	08
27328	146.37	147.54	149.88	0	1	0	1	1	1	17
26474	151.09	152.30	154.72	0	0	0	1	1	1	07
25497	156.88	158.14	160.65	0	1	0	1	1	0	16
24644	162.31	163.61	166.21	0	0	0	1	1	0	06
23790	168.14	169.49	172.18	0	1	0	1	0	1	15
23057	173.48	174.87	177.64	0	0	0	1	0	1	05
22204	180.15	181.59	184.47	0	1	0	1	0	0	14
21472	186.29	187.78	190.76	0	0	0	1	0	0	04
20740	192.86	194.40	197.49	0	1	0	0	1	1	13
19642	203.65	205.28	208.54	0	0	0	0	1	1	03
19032	210.17	211.85	215.21	0	1	0	0	1	0	12
18300	218.58	220.33	223.83	0	0	0	0	1	0	02
17690	226.12	227.93	231.55	0	1	0	0	0	1	11
17080	234.19	236.06	239.81	0	0	0	0	0	1	01
16592	241.08	243.01	246.87	0	1	0	0	0	0	10
15982	250.28	252.28	256.29	0	0	0	0	0	0	00

Table 3: MX375

MX165C											
Divisor	Xtal Freq 1.0MHz	Xtal Freq 1.008MHz	Xtal Freq 1.024MHz	Program Codes							Hex
				Binary Codes							
				D5	D4	D3	D2	D1	D0		
14930	66.98	67.52	68.59	1	1	1	1	1	1	3F	
14426	69.32	69.87	70.98	1	1	1	0	0	1	39	
13908	71.901	72.48	73.63	0	1	1	1	1	1	1F	
13435	74.431	75.03	76.22	1	1	1	1	1	0	3E	
12993	76.965	77.58	78.81	0	0	1	1	1	1	0F	
12551	79.677	80.31	81.59	1	1	1	1	0	1	3D	
12124	82.483	83.14	84.46	0	1	1	1	1	0	1E	
11712	85.383	86.07	87.43	1	1	1	1	0	0	3C	
11300	88.494	89.20	90.62	0	0	1	1	1	0	0E	
10934	91.456	92.19	93.65	1	1	1	0	1	1	3B	
10553	94.76	95.52	97.03	0	1	1	1	0	1	1D	
10263	97.435	98.21	99.77	1	1	1	0	1	0	3A	
10004	99.96	100.76	102.36	0	0	1	1	0	1	0D	
9668	103.429	104.26	105.91	0	1	1	1	0	0	1C	
9333	107.147	108.00	109.72	0	0	1	1	0	0	0C	
9013	110.954	111.84	113.62	0	1	1	0	1	1	1B	
8708	114.84	115.76	117.60	0	0	1	0	1	1	0B	
8418	118.793	119.74	121.64	0	1	1	0	1	0	1A	
8128	123.028	124.01	125.98	0	0	1	0	1	0	0A	
7854	127.328	128.35	130.38	0	1	1	0	0	1	19	
7595	131.674	132.73	134.83	0	0	1	0	0	1	9	
7320	136.612	137.70	139.89	0	1	1	0	0	0	18	
7076	141.323	142.45	144.71	0	0	1	0	0	0	8	
6847	146.044	147.21	149.55	0	1	0	1	1	1	17	
6603	151.441	152.65	155.08	0	0	0	1	1	1	7	
6375	156.875	158.13	160.64	0	1	0	1	1	0	16	
6161	162.311	163.61	166.21	0	0	0	1	1	0	6	
5963	167.708	169.05	171.73	0	1	0	1	0	1	15	
5749	173.936	175.33	178.11	0	0	0	1	0	1	5	
5566	179.654	181.09	183.97	0	1	0	1	0	0	14	
5368	186.289	187.78	190.76	0	0	0	1	0	0	4	
5185	192.864	194.41	197.49	0	1	0	0	1	1	13	
4911	203.645	205.27	208.53	0	0	0	0	1	1	3	
4743	210.848	212.53	215.91	0	1	0	0	1	0	12	
4590	217.853	219.60	223.08	0	0	0	0	1	0	2	
4438	225.339	227.14	230.75	0	1	0	0	0	1	11	
4285	233.359	235.23	238.96	0	0	0	0	0	1	01	
4133	241.97	243.91	247.78	0	1	0	0	0	0	10	
3995	250.282	252.28	256.29	0	0	0	0	0	0	00	

Table 4: MX165C

MX465										
	Xtal Freq	Xtal Freq	Xtal Freq	Program Codes						Hex
				Binary Codes						
Divisor	4.0MHz	4.032MHz	4.096MHz	D5	D4	D3	D2	D1	D0	
59719	66.98	67.52	68.59	1	1	1	1	1	1	3F
57703	69.32	69.87	70.98	1	1	1	0	0	1	39
55632	71.901	72.48	73.63	0	1	1	1	1	1	1F
53741	74.431	75.03	76.22	1	1	1	1	1	0	3E
51972	76.965	77.58	78.81	0	0	1	1	1	1	0F
50203	79.677	80.31	81.59	1	1	1	1	0	1	3D
48495	82.483	83.14	84.46	0	1	1	1	1	0	1E
46848	85.383	86.07	87.43	1	1	1	1	0	0	3C
45201	88.494	89.20	90.62	0	0	1	1	1	0	0E
43737	91.456	92.19	93.65	1	1	1	0	1	1	3B
42212	94.76	95.52	97.03	0	1	1	1	0	1	1D
41053	97.435	98.21	99.77	1	1	1	0	1	0	3A
40016	99.96	100.76	102.36	0	0	1	1	0	1	0D
38674	103.429	104.26	105.91	0	1	1	1	0	0	1C
37332	107.147	108.00	109.72	0	0	1	1	0	0	0C
36051	110.954	111.84	113.62	0	1	1	0	1	1	1B
34831	114.84	115.76	117.60	0	0	1	0	1	1	0B
33672	118.793	119.74	121.64	0	1	1	0	1	0	1A
32513	123.028	124.01	125.98	0	0	1	0	1	0	0A
31415	127.328	128.35	130.38	0	1	1	0	0	1	19
30378	131.674	132.73	134.83	0	0	1	0	0	1	9
29280	136.612	137.70	139.89	0	1	1	0	0	0	18
28304	141.323	142.45	144.71	0	0	1	0	0	0	8
27389	146.044	147.21	149.55	0	1	0	1	1	1	17
26413	151.441	152.65	155.08	0	0	0	1	1	1	7
25498	156.875	158.13	160.64	0	1	0	1	1	0	16
24644	162.311	163.61	166.21	0	0	0	1	1	0	6
23851	167.708	169.05	171.73	0	1	0	1	0	1	15
22997	173.936	175.33	178.11	0	0	0	1	0	1	5
22265	179.654	181.09	183.97	0	1	0	1	0	0	14
21472	186.289	187.78	190.76	0	0	0	1	0	0	4
20740	192.864	194.41	197.49	0	1	0	0	1	1	13
19642	203.645	205.27	208.53	0	0	0	0	1	1	3
18971	210.848	212.53	215.91	0	1	0	0	1	0	12
18361	217.853	219.60	223.08	0	0	0	0	1	0	2
17751	225.339	227.14	230.75	0	1	0	0	0	1	11
17141	233.359	235.23	238.96	0	0	0	0	0	1	01
16531	241.97	243.91	247.78	0	1	0	0	0	0	10
15982	250.282	252.28	256.29	0	0	0	0	0	0	00

Table 5: MX465

The EIA RS-220 specification divides the standard frequencies into three groups. They are tabulated below with the program codes used in MX-COM ICs:

Group A		Group B		Group C	
Freq	Code	Freq	Code	Freq	Code
67.0	3F	71.9	1F	74.4	3E
77.0	0F	82.5	1E	79.7	3D
88.5	0E	94.8	1D	85.4	3C
100.0	0D	103.5	1C	91.5	3B
107.2	0C	110.9	1B		
114.8	0B	118.8	1A	97.4	3A
123.0	0A	127.3	19	69.3	39
131.8	09	136.5	18	206.5	38
141.3	08	146.2	17		
151.4	07	156.7	16		
162.2	06	167.9	15		
173.8	05	179.9	14		
186.2	04	192.8	13		
203.5	03	210.7	12		
218.1	02	225.7	11		
233.6	01	241.8	10		
250.3	00				

Table 6: EIA RS-220 Specifications Groups A, B, and C

Note that with the exception of the 67.0 Hz tone in Group A, the programming codes are in reverse sequential order in relation to the tone frequencies for each group. Again, with the exception of 67.0 Hz, also note that the first hexadecimal digit for Group A is 0, the first digit for Group B is 1, and the first digit for group C is 3.

For more general information about these ICs, see the MX-COM Product Handbook and the MX-COM MX165C, MX315A, MX365A, MX375, and MX465 Data Bulletins.

MX-COM does not test its CTCSS ICs (MX165C, MX315A, MX365A, MX375, and MX465) at crystal or clock frequencies other than the nominal frequency specified in the Performance Specifications section of the Data Bulletin, and as such, makes no guarantee of the performance of the device when used with a non-specified crystal or clock frequency. MX-COM does not assume responsibility for the use of its ICs in the manner described in this application note in any circuit or product.