Comparative Analysis of MEMS vs. Quartz

ABSTRACT

Over the years there has been a natural evolution of frequency control devices. This has come about due to the various requirements, some being cost driven, others performance/reliability issues and others by the ever reducing design cycle times.

The incumbent quartz based devices have long since been the standard by which most of the new invention devices are compared, at least from a marketing standpoint. This is due to the long history of quartz as a very stable, high quality material. Frequency versus temperature response as well as aging, jitter and phase noise characteristics are well chronicled in the industry. However a concise technical correlation of such characteristics with the 'replacement' technology is rather elusive. This exercise seeks to apply standard measurement techniques under the same test conditions for all devices for direct comparison of performance and capability.

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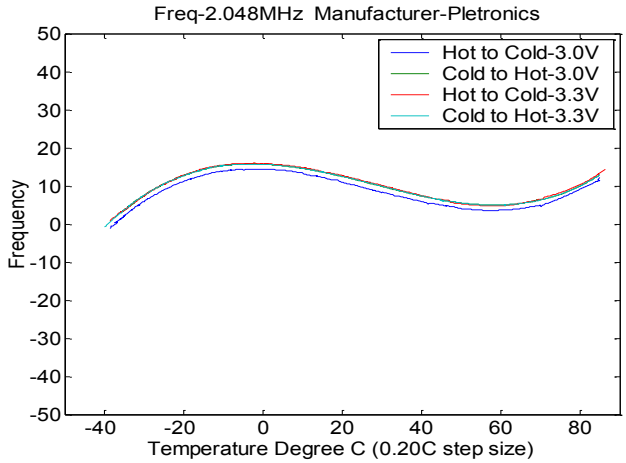
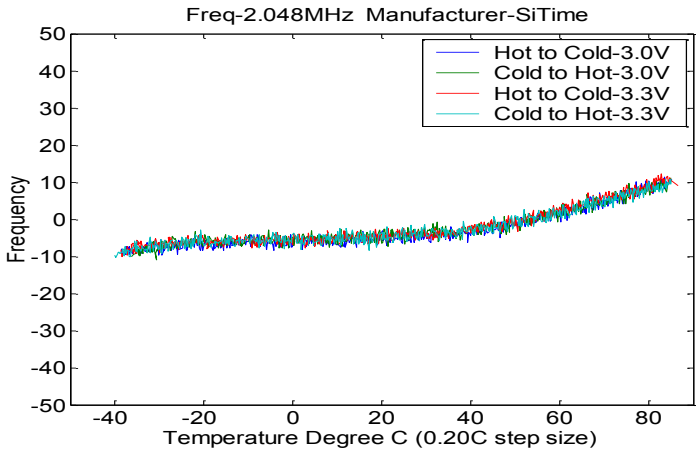
1 COMPARISON: FREQUENCY OVER TEMPERATURE

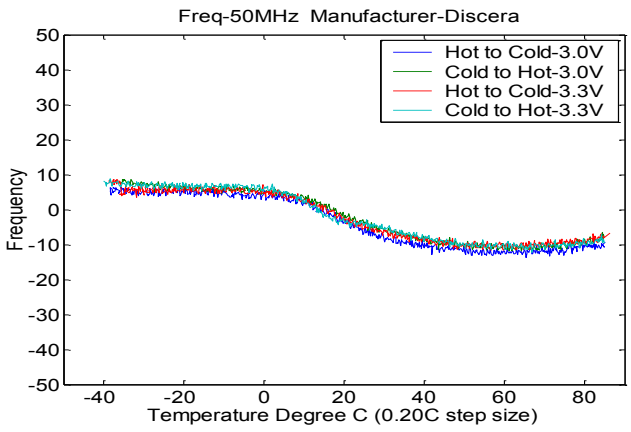
All devices characterized were commercially purchased to ensure a random sampling of the technology. This data represents the technology that was commercially available at the time of the study. All devices were tested at 0.2°C step size in the same test system at the same time. Excursions in the data are a function of the devices short term stability. This was typical of all devices tested from SiTime and Discera.

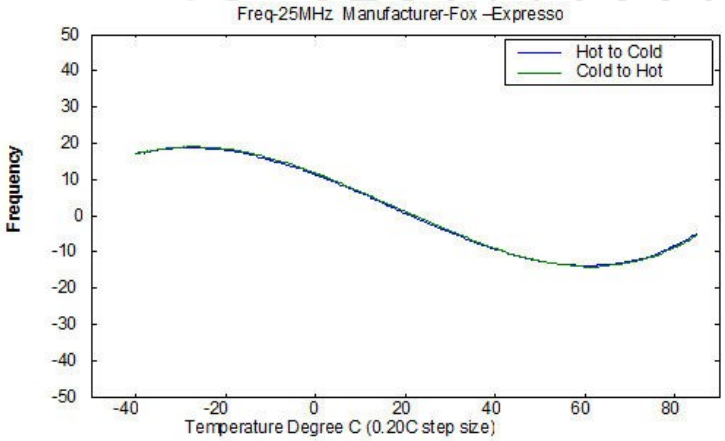
Electrical Characteristics Reviewed:

- Frequency vs. temperature
- Phase Noise/Jitter
- Short term Stability
- Start Time
- Current
- Long term Stability (Aging)









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2 COMPARISON: PHASE NOISE

The Agilent 5052 test system was used on all devices above 10.0MHz. The Agilent 5500 test system was used on all devices below 10MHz.

Marker Frequency	10Hz	100Hz	1E+3Hz	10E+3Hz	100E+3Hz	200E+3Hz	1E+6Hz	2E+6Hz	10E+6Hz	20E+6Hz	
	dBc/Hz										ps RMS
Discera ASFLM1-3.6864 MHz	-70.94	-94.22	-106.16	-100.57	-110.10	-117.87	N/A				123.27
Discera ASFLM1-14.31818 MHz	-40.56	-78.33	-88.28	-86.80	-95.34		-116.90	-124.69			322.17
Discera ASFLM1-33.333 MHz	-44.78	-71.82	-85.57	-78.46	-89.09		-112.63	-118.68			175.89
Discera ASFLM1-25.0 MHz	-50.57	-71.97	-85.77	-80.88	-89.04		-112.60	-117.66	N/A		192.94
Fox FXO-HC735-25.0 MHz	-79.51	-106.60	-126.28	-132.37	-142.33		-139.89	-143.41			2.59
PLE SM5545TEV-25.0 MHz	-75.23	-103.92	-135.71	-148.34	-153.03		-155.99	-156.40			3.64
SiTime EMK23H2H-25.0 MHz	-13.10	-47.40	-76.82	-75.92	-86.91	N/A	-114.84	-122.02			960.59
Discera ASFLM1-50.0 MHz	-36.83	-67.95	-78.32	-69.54	-79.09		-104.57		-126.66	-133.30	321.28
Fox FXO-HC735-50.0 MHz	-69.46	-101.42	-118.06	-117.35	-128.28		-135.90		-140.42	-140.62	4.10
PLE SM5545TEV-50.0 MHz	-80.17	-111.62	-145.61	-146.88	-145.50		-158.08	N/A	-160.00	-162.59	0.98
SiTime EMK23H2H-50.0 MHz	-19.05	-54.74	-69.39	-69.24	-81.47		-108.83		-136.87	-133.91	1030.49
PLE SM7745DV-106.25 MHz	-82.33	-113.78	-140.94	-151.68	-162.69		-163.30		-168.84	-164.27	0.36

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3 COMPARISON: JITTER

Full bandwidth is defined as a measurement from 10Hz to highest possible frequency for that device based on the test and measurement equipment. The Agilent 5052 test system was used on all devices above 10.0MHz. The Agilent 5500 test system was used on all devices below 10.0MHz.

	RMS Jitter Summary		
Frequency	Device	Full Bandwidth	12 kHz - 20 MHz
3.6864 MHz	Discera ASFLM1-3.6864 MHz	123.3 psec	N/A
14.31818 MHz	PLE SM55-14.31818 MHz	0.9 psec	0.2 psec
	Discera ASFLM1-14.31818 MHz	266.3 psec	210.3 psec
25 MHz	Discera ASFLM1-25.0 MHz	269.5 psec	250.0 psec
	Fox FXO-HC735-25.0 MHz	4.1 psec	3.6 psec
	PLE SM5545TEV-25.0 MHz	0.7 psec	0.6 psec
	SiTime EMK23H2H-25.0 MHz	2836.7 psec	243.6 psec
33.333 MHz	PLE SM55-33.333 MHz	1.5 psec	0.6 psec
	Discera ASFLM1-33.333 MHz	375.7 psec	303.0 psec
50 MHz	Discera ASFLM1-50.0 MHz	419.1 psec	385.2 psec
	Fox FXO-HC735-50.0 MHz	4.6 psec	3.4 psec
	PLE SM5545TEV-50.0 MHz	9.1 psec	0.3 psec
	SiTime EMK23H2H-50.0 MHz	1162.5 psec	378.4 psec
106.25 MHz	PLE SM7745DV-106.25 MHz	1.1 psec	0.2 psec
	Fox FXO-HC730-106.25 MHz	3.8 psec	3.3 psec
	SiTime EMK13H2H-106.25 MHz	2363.2 psec	336.7 psec
	Silicon Labs LVDS 106.25 MHz	5.4 psec	2.7 psec
156.25 MHz	PLE PE99-156.25 MHz	1.5 psec	0.6 psec
161.0 MHz	Silicon Labs LVPECL 161.0 MHz	1.0 psec	0.6 psec

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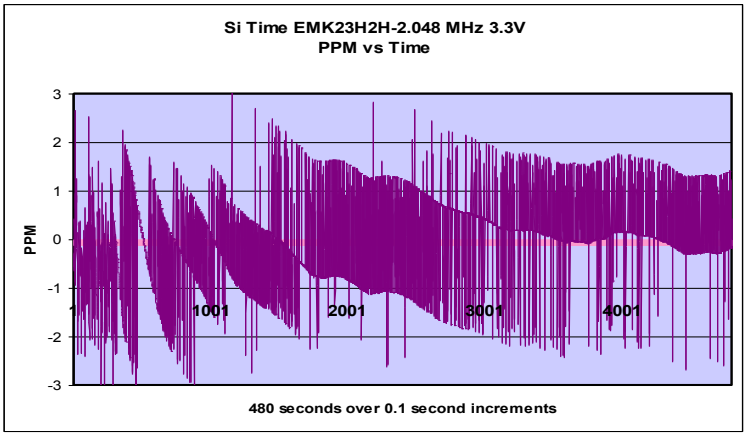
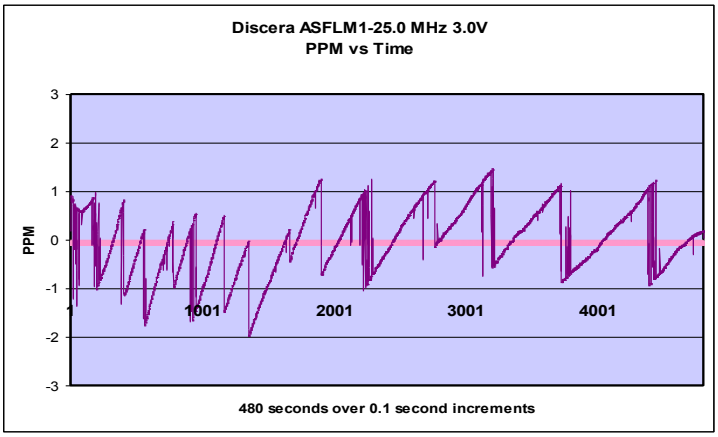
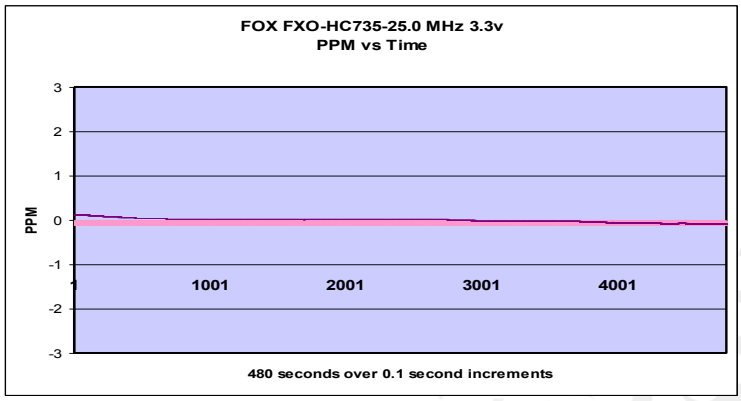
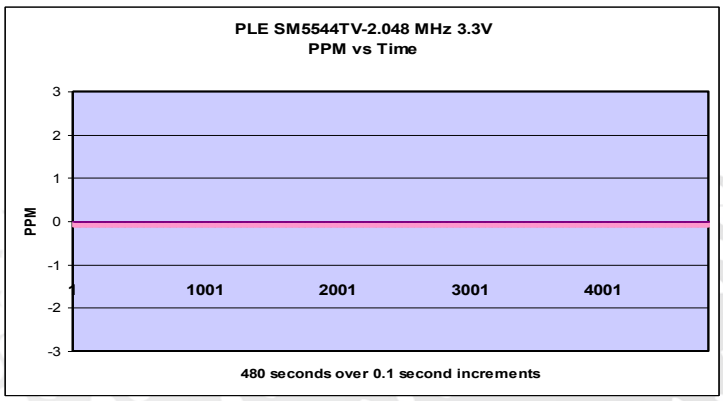
4 COMPARISON: SHORT TERM STABILITY

The short term stability data is defined as frequency measurements taken every 0.1 seconds for 8 minutes with the DUT stabilized at 25°C. The devices were tested with an Agilent 53152 frequency counter connected directly to a rubidium standard. The plots presented are characteristic of the manufacturer's technology.









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5 COMPARISON: START TIME & SUPPLY CURRENT

The start time was measured from power supply on until the units reached amplitude and frequency. The supply was turned on with the equivalent of a debounced moment switch.

Start Time & Supply Current Summary				
Frequency	Device	Vcc	Start Time	Icc
2.048 MHz	Si Time EMK23H2H-2.048 MHz	3.3V	15.00 ms	14.25 mA
	PLE SM5544TV-2.048 MHz	3.3V	0.25 ms	1.09 mA
3.6864 MHz	Discera ASFLM1-3.6864 MHz	3.0V	2.15 ms	2.68 mA
25.00 MHz	Discera ASFLM1-25.0 MHz	3.0V	2.15 ms	3.39 mA
	Si Time EMK23H2H-25.0 MHz	3.3V	13.45 ms	12.94 mA
	FOX FXO-HC735-25.0 MHz	3.3V	0.02 ms	26.93 mA
	PLE SM5545TEV-25.0 MHz	3.3V	0.13 ms	2.51 mA
50.00 MHz	Discera ASFLM1-50.0 MHz	3.0V	2.22 ms	3.78 mA
	Si Time EMK23H2H-50.0 MHz	3.3V	14.45 ms	18.59 mA
	FOX FXO-HC735-50.0 MHz	3.3V	0.02 ms	26.70 mA
	PLE SM5545TEV-50.0 MHz	3.3V	1.95 ms	7.15 mA
106.25 MHz	Si Time EMK13H2H-106.25 MHz	3.3V	14.64 ms	17.01 mA
	PLE SM77-106.25 MHz	3.3V	0.58 ms	17.42 mA
	Silicon Labs LVDS 106.25 MHz	3.3V	6.73 ms	111.19 mA
	FOX FXO-HC730-106.25 MHz	3.3V	0.01 ms	29.64 mA
156.25 MHz	PLE PE99-156.25 MHz	3.3V	0.59 ms	95.48 mA
161 MHz	Silicon Labs LVPECL 161.0 MHz	3.3V	????	119.97 mA
	Silicon Labs LVPECL 161.1328 MHz	3.3V	6.36 ms	120.00 mA

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6 COMPARISON: LONG TERM STABILITY (AGING)

		Hours Aged Summary					
Frequency	Manufacturer	0	46	125	384	2928	Total PPM
2.048 MHz	Si Time	0.157	0.105	0.87	-0.381	-1.336	-1.493
	PLE (Pletronics)	0.054	0.004	-0.059	0.02	-0.002	-0.056
3.6864 MHz	Discera	0.804	0.58	-0.606	1.177	-0.025	-0.829
	PLE (Pletronics)	0.031	-0.01	-0.115	0.147	-0.091	-0.122
14.31818 MHz	Discera	1.819	0.923	-0.596	-0.276	-1.006	-2.825
	PLE (Pletronics)	0.072	0.05	-0.01	0.07	0.048	-0.024
25.00 MHz	PLE (Pletronics)	0.247	0.062	0.023	0.018	-0.005	-0.252
	Discera	0.103	0.217	-0.594	0.156	-1.189	-1.292
	Si Time	-0.89	-0.006	-1.827	-0.407	-0.177	0.713
	PLE (Pletronics)	0.116	0.032	-0.025	0.134	-0.09	-0.206
33.333 MHz	Discera	0.613	0.861	0.731	-0.024	-0.837	-1.45
	PLE (Pletronics)	0.101	0.056	0.015	0.071	-0.03	-0.132
40.0 MHz	Si Time	-0.02	0.488	0.442	-0.971	0.546	0.566
	PLE (Pletronics)	0.008	-0.011	-0.012	-0.005	-0.033	-0.041
48.0 MHz	Si Time	1.068	-0.205	-0.12	0.832	-0.023	-1.091
50.00 MHz	Discera	0.28	0.517	0.728	-0.578	-0.647	-0.927
	Si Time	-0.44	-1.903	-0.407	0.61	-0.633	-0.193
	PLE (Pletronics)	0.1	0.076	0.002	0.07	0.036	-0.064
66.0 MHz	Si Time	-0.015	0.631	-0.063	0.451	0.447	0.462
	PLE (Pletronics)	0.101	0.334	-0.174	0.037	0.019	-0.082
100 MHz	Si Time	-0.288	-0.769	-1.279	-0.074	-1.719	-1.43
106.25 MHz	Si Time	-0.461	-0.307	-1.041	1.601	-0.006	0.455
125.0 MHz	Si Time	0.162	-0.771	-0.908	0.772	-0.662	-0.824

7 CONCLUSION

The data presented represents the most accurate side by side characterization of technologies intended to compete with quartz based product. The technology chosen for any application should be done based on an understanding of the abilities and limitations of the technology and the requirements of the application.