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AN1519

Recommended Crystals for Microchip Stand-Alone Real-Time Clock/Calendar Devices

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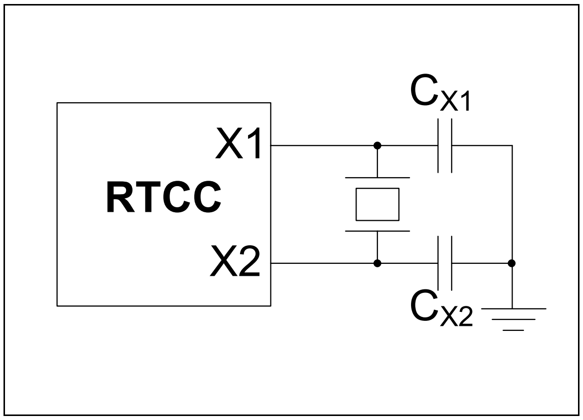
This document is designed to serve as a starting point when choosing a crystal to operate alongside the Microchip Stand-Alone Real-Time Clock/Calendar devices (Figure 1).

FIGURE 1: OSCILLATOR DIAGRAM



To oscillate as closely as possible to the desired frequency, a crystal must have load capacitors that match the value recommended by the crystal manufacturer, according to Equation 1.

Also, the oscillator pin capacitance (available in the device data sheet as COSC) must be included in CX1 and CX2, and stray board capacitance (C_{stray}) must be taken into consideration when choosing the capacitors.

EQUATION 1:

$$C_{load} = \frac{C_{x2} \bullet C_{x1}}{C_{x2} + C_{x1}} + C_{stray}$$

Where:

C_{x1} = Capacitor value on pin X1 + C_{pin}
C_{x2} = Capacitor value on pin X2 + C_{pin}
C_{stray} = Trace capacitance
C_{pin} = 3 pF typical

CONSIDERATIONS

The Microchip stand-alone RTCC's have been designed to work with 32.768 kHz tuning fork crystals with a load capacitance (CLOAD or CL) of 6-9pF. For tuning fork crystals, the frequency has a parabolic dependence on temperature. Therefore, when it changes, the frequency decreases accordingly, as shown in Equation 2 and Figure 2. See AN1413, *"Temperature Compensation of a Tuning Fork Crystal Based on MCP79410"* (DS01413).

EQUATION 2:

$$f = f_0 \times [1\text{-}Tc \times (T - T_0)^2]$$

Where:

f_0 = Frequency at turnover point

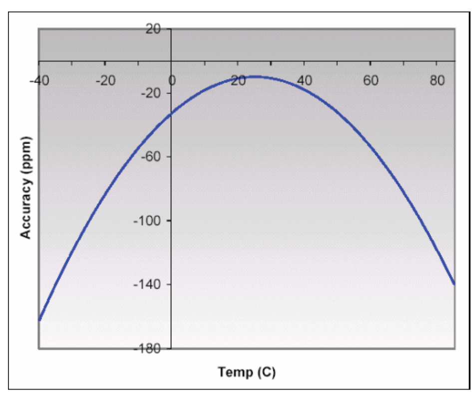
Tc = Temperature coefficient

$T\text{-}T_0$ = Deviation from turnover point

T = Current temperature (°C)

T_0 = Turnover point (°C)

FIGURE 2: PARABOLIC CURVE FOR TUNING FORK CRYSTALS



For best results, it is recommended that a ground ring should encompass the crystal and the X1 and X2 pins. See AN1365, *"Recommended Usage of Microchip Serial RTCC Devices"* (DS01365). Also, the traces from the RTCC to the capacitors and crystal should be as short as possible in order to minimize the stray board capacitance (C_{STRAY}). See AN1288, *"Design Practices for Low-Power External Oscillators"* (DS01288).

Table 2 shows recommended crystals and load capacitors.

Some crystal vendors use the term oscillation allowance as the sum of negative R value and ESR (Equation 3). The negative R (-R) which has been measured on the AC164140 RTCC PICtail™ board is a measure of the ability of the oscillator to drive the crystal over temperature (Figure 3). An oscillation allowance value of three to five times the crystal ESR will provide an acceptable margin. See AN943, *"Practical PICmicro® Oscillator Analysis and Design"* (DS00943) and AN949, *"Making Your Oscillator Work"* (DS00949).

CRYSTAL TEST RESULTS

The crystals listed in Table 1 have been tested on the AC164140 RTCC PICtail board (unless noted). The results are in Table 2.

TABLE 1: CRYSTAL TEST RESULTS

Crystal	Appendix
Citizen CMR200T-32.768KDZB-UT	**Appendix A: "CMR200T-32.768KDZB-UT"**
Citizen CFS206-32.768KDZB-UB	**Appendix B: "CMR-32.768KDZB-UB"**
ECS ECS.327-6-13X	**Appendix C: "ECS327-6-13X"**
ECS ECS.327-6-17X-TR	**Appendix D: "ECS.327-6-17X-TR"**
Epson MC405-32.7KE3R	**Appendix E: "EPSON MC405-32.7KE3R"**
Epson C002RX32.76K-EPB	**Appendix F: "EPSON C002RX32.76K-EPB"**
AVX ST3215SB32768C0HPWBB	**Appendix G: "AVX ST3215SB32768C0HPWBB"**
FOX NC38LF-32.768kHz	**Appendix H: "FOX MC38LF-32.768kHz"**
HK Crystals	**Appendix I: "HK Crystals"**

EQUATION 3:

$$\text{Oscillation Allowance} = |-R| + ESR\ [\Omega]$$

FIGURE 3: NEGATIVE RESISTANCE TEST SETUP

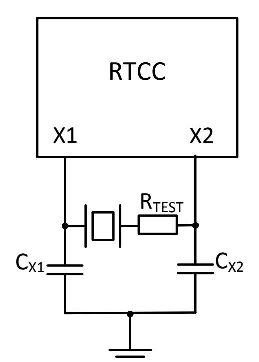


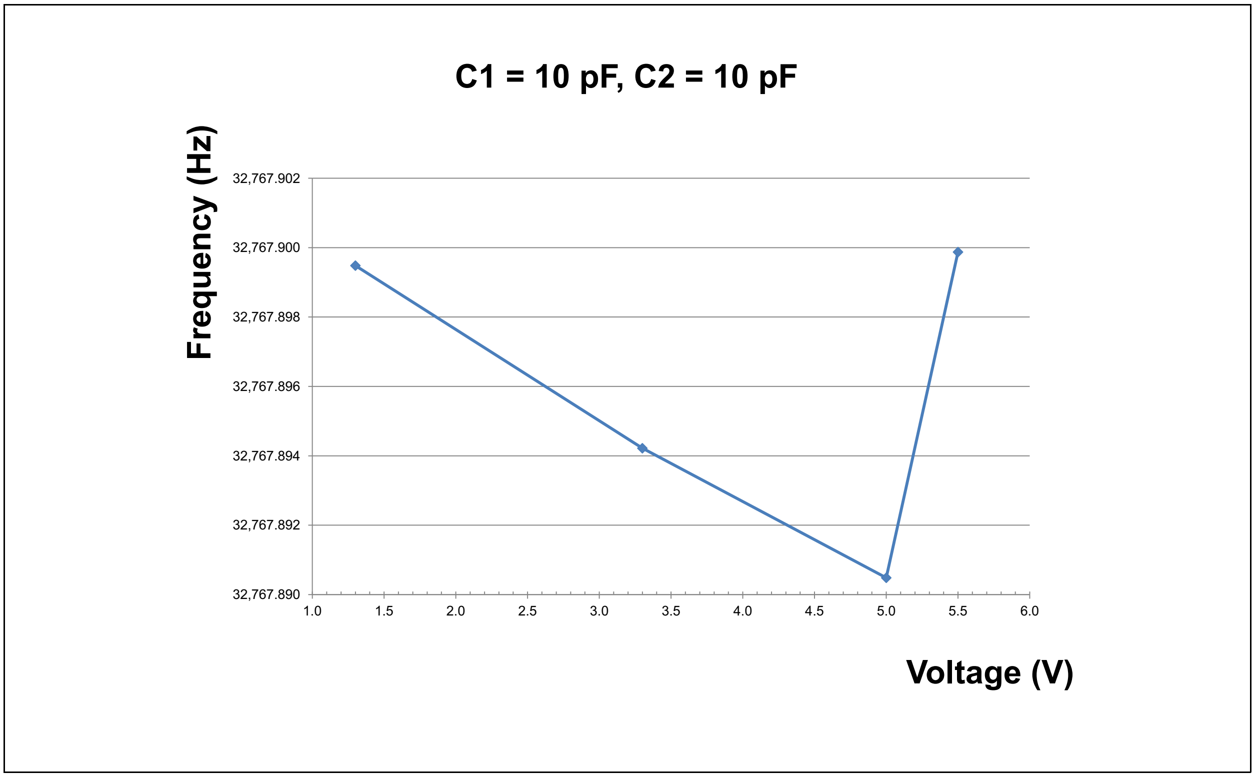
TABLE 2: CRYSTALS

Crystal Vendor	Crystal Part Number	ESR (Max.)	CLOAD (pF)	C1 Capacitor Value (pF)	C2 Capacitor Value (pF)	PPM Error (at 25°C)	Seconds/ Day	Oscillation Allowance	Oscillation Allowance/ ESR Ratio	Start-up Time (seconds)
Citizen	CMR200T-32.768KDZB-UT	50 kΩ	6	10	10	-3.17	-0.274	480 kΩ	9.6	1.3
Citizen	CFS206-32.768KDZB-UB	35 kΩ	6	10	12	-9.60	-0.829	780 kΩ	22.28	1.25
ECS	ECS.327-6-13X	35 kΩ	6	12	10	1.07	0.092	360 kΩ	10.28	1
ECS	ECS.327-6-17X-TR	40 kΩ	6	10	8.2	10.93	0.944	540 kΩ	13.5	1
Epson Crystals	MC405-32.7KE3R	50 kΩ	6	10	10	-1.71	-0.148	300 kΩ	6	1.5
Epson Crystals	C002RX32.76K-EPB	60 kΩ	6	12	10	-0.66	-0.057	370 kΩ	6.16	1.6
AVX Crystals	ST3215SB32768C0HPWBB	70 kΩ	7	10	12	-1.22	-0.105	800 kΩ	11.42	1
FOX Crystals	MC38LF-32.768kHz	35 kΩ	6	8.2	8.2	1.47	0.127	600 kΩ	17.14	1
HK Crystals	3T	40k	6	8.2	8.2	-4.36	-0.377	390 kΩ	9.75	0.85
HK Crystals	2T	40k	6	8.2	10	1.64	0.142	400 kΩ	10	1.1
HK Crystals	M3	50k	6	8.2	10	3.21	0.277	1600 kΩ	32	1
HK Crystals	M8	70k	7	10	12	-4.98	-0.430	1370 kΩ	19.57	0.5
HK Crystals	M8	70k	9	15	12	2.78	0.240	250 kΩ	3.57	0.75
HK Crystals	M3	50k	8	12	12	-1.96	-0.169	300 kΩ	6	1.4
HK Crystals	2T	40k	8	12	12	3.89	0.336	340 kΩ	8.5	1.7
HK Crystals	3T	40k	8	12	15	4.65	0.402	220 kΩ	5.5	1.2
Micro Crystal (**Note**)	CM7V-T1A	70 kΩ	7	10	12	3	0.259	300 kΩ	4.28	
Citizen (**Note**)	CM200S32.768KDZB-UT	50 kΩ	6	10	8	1.2	0.104	480 kΩ	9.6	
Seiko (**Note**)	SSP-T7-F	65 kΩ	7	10	12	-0.76	0.066	390 kΩ	6	
Seiko (**Note**)	VT-200-F	50 kΩ	6	9	9	-2.14	0.185	460 kΩ	9.2	

Note: Not included in this document.

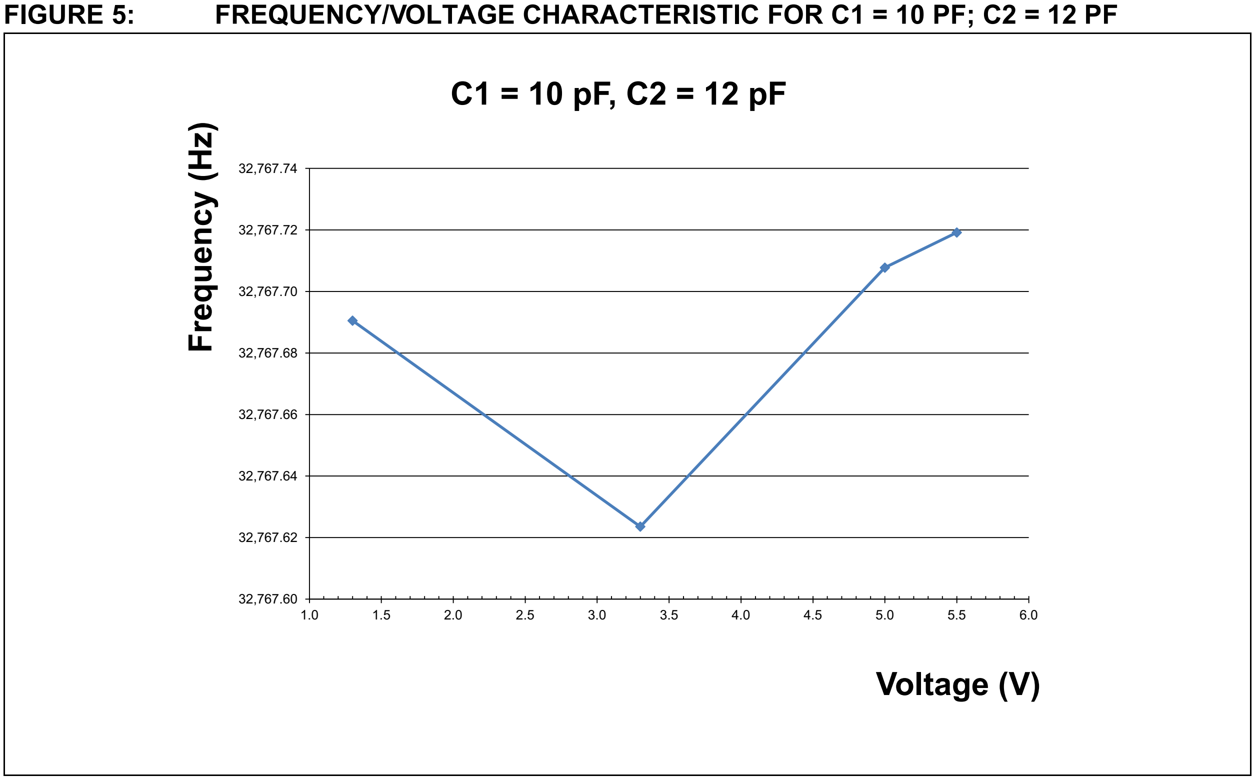
APPENDIX A: CMR200T-32.768KDZB-UT

FIGURE 4: FREQUENCY/VOLTAGE CHARACTERISTIC FOR C1 = 10 PF; C2 = 10 PF



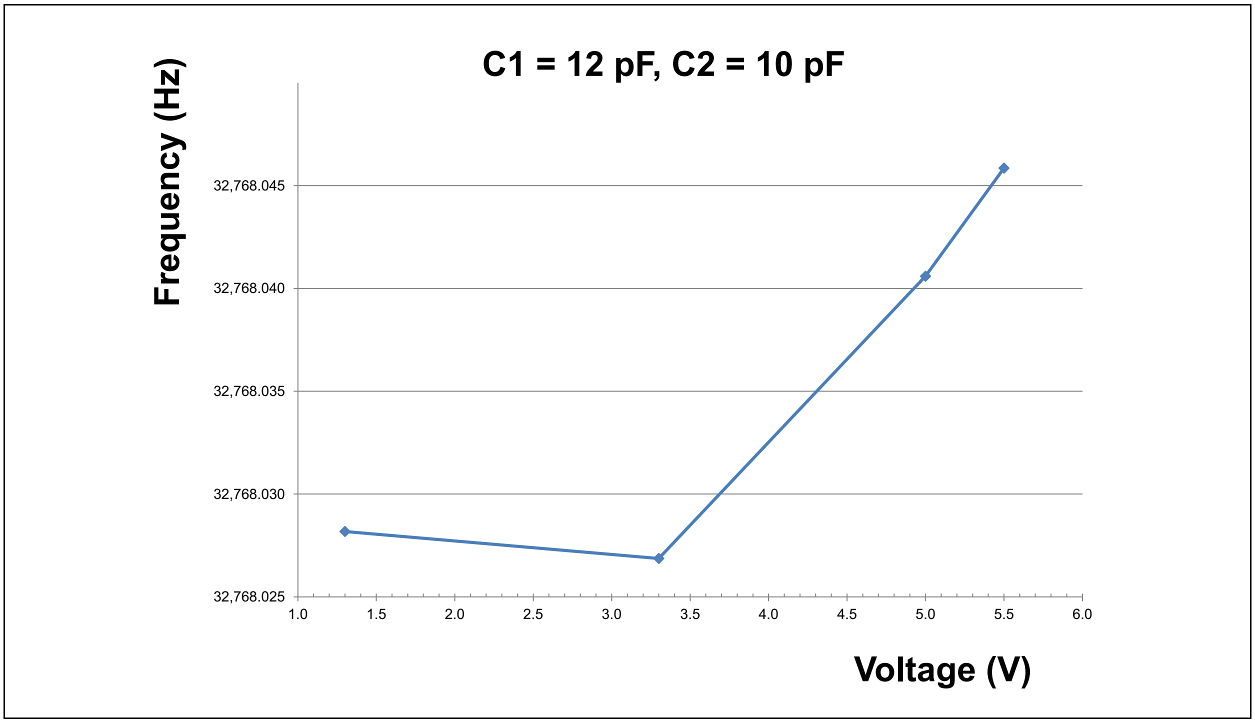
APPENDIX B: CMR-32.768KDZB-UB

FIGURE 5: FREQUENCY/VOLTAGE CHARACTERISTIC FOR C1 = 10 PF; C2 = 12 PF



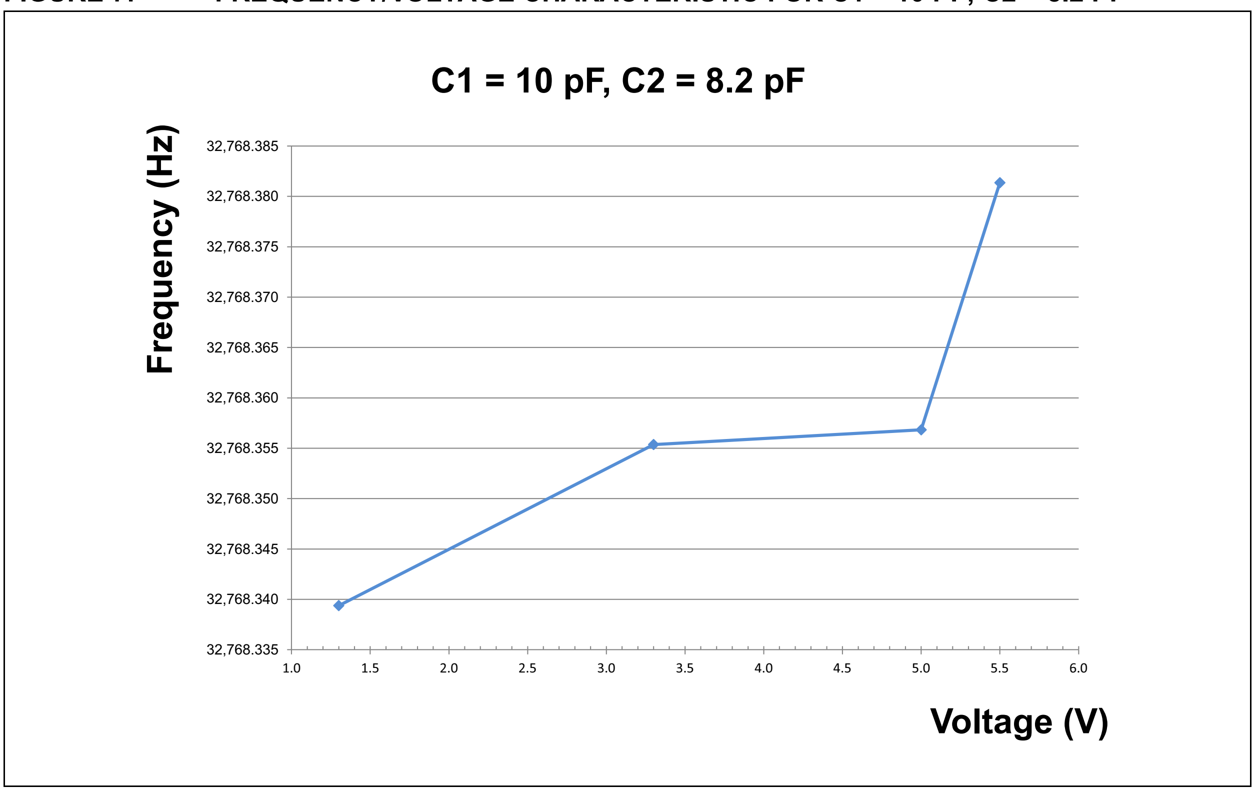
APPENDIX C: ECS327-6-13X

FIGURE 6: FREQUENCY/VOLTAGE CHARACTERISTIC FOR C1 = 12 PF; C2 = 10 PF



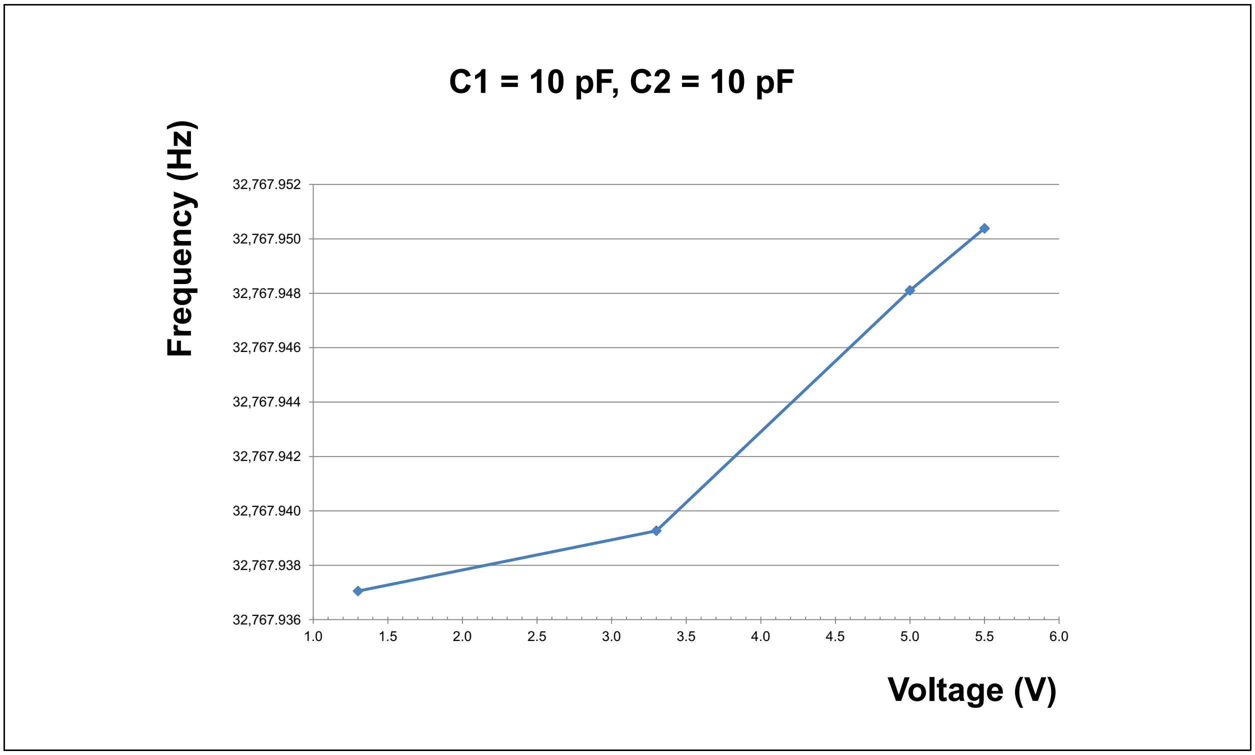
APPENDIX D: ECS.327-6-17X-TR

FIGURE 7: FREQUENCY/VOLTAGE CHARACTERISTIC FOR C1 = 10 PF; C2 = 8.2 PF



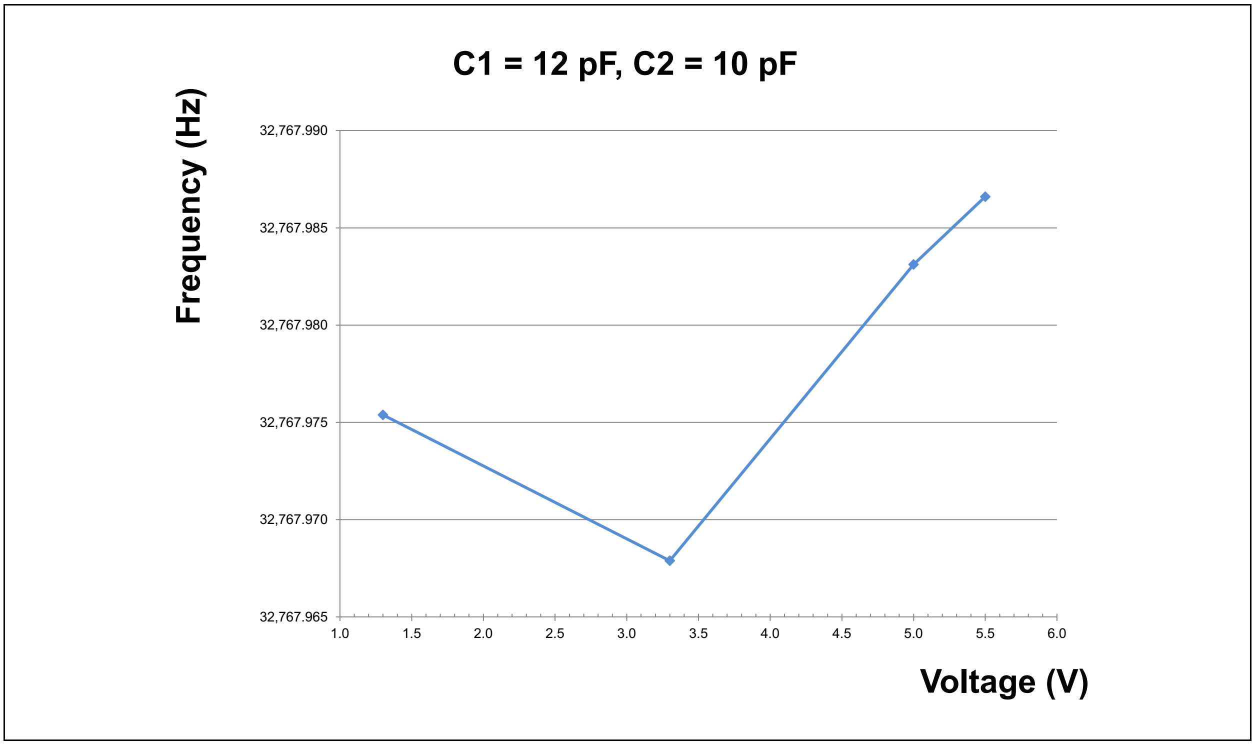
APPENDIX E: EPSON MC405-32.7KE3R

FIGURE 8: FREQUENCY/VOLTAGE CHARACTERISTIC FOR C1 = 10 PF; C2 = 10 PF



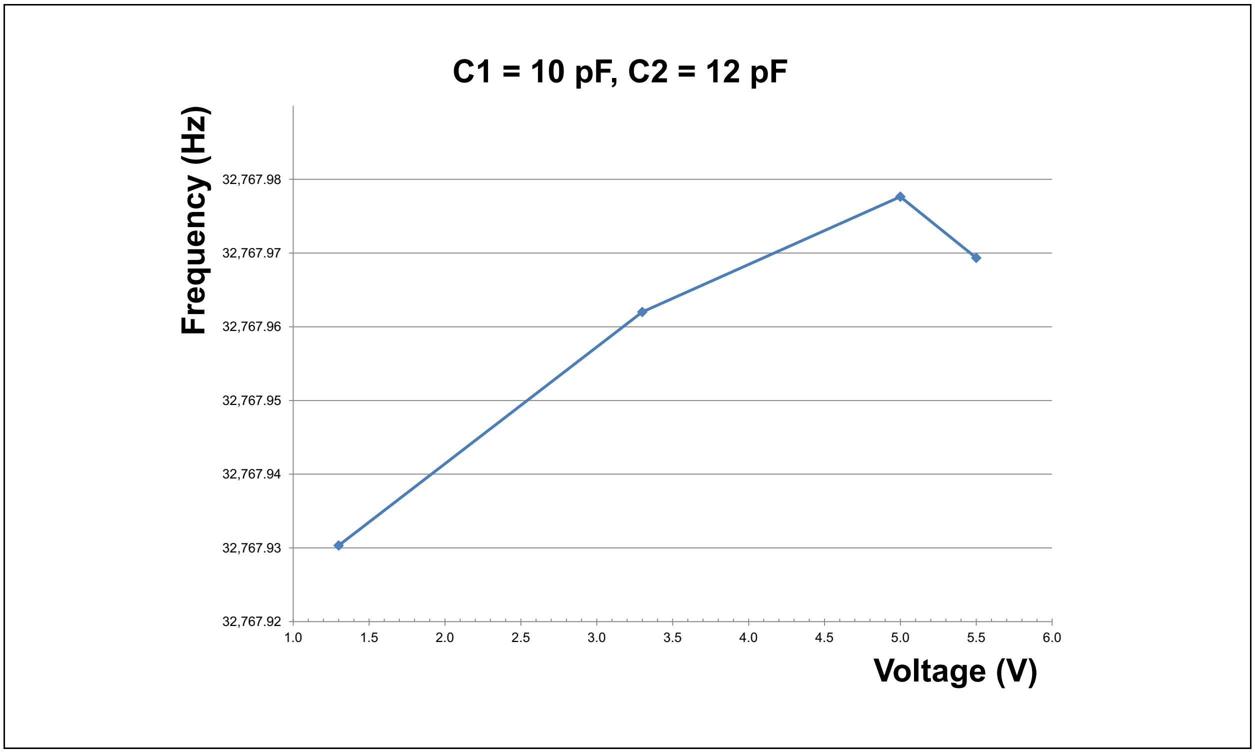
APPENDIX F: EPSON C002RX32.76K-EPB

FIGURE 9: FREQUENCY/VOLTAGE CHARACTERISTIC FOR C1 = 12 PF; C2 = 10 PF



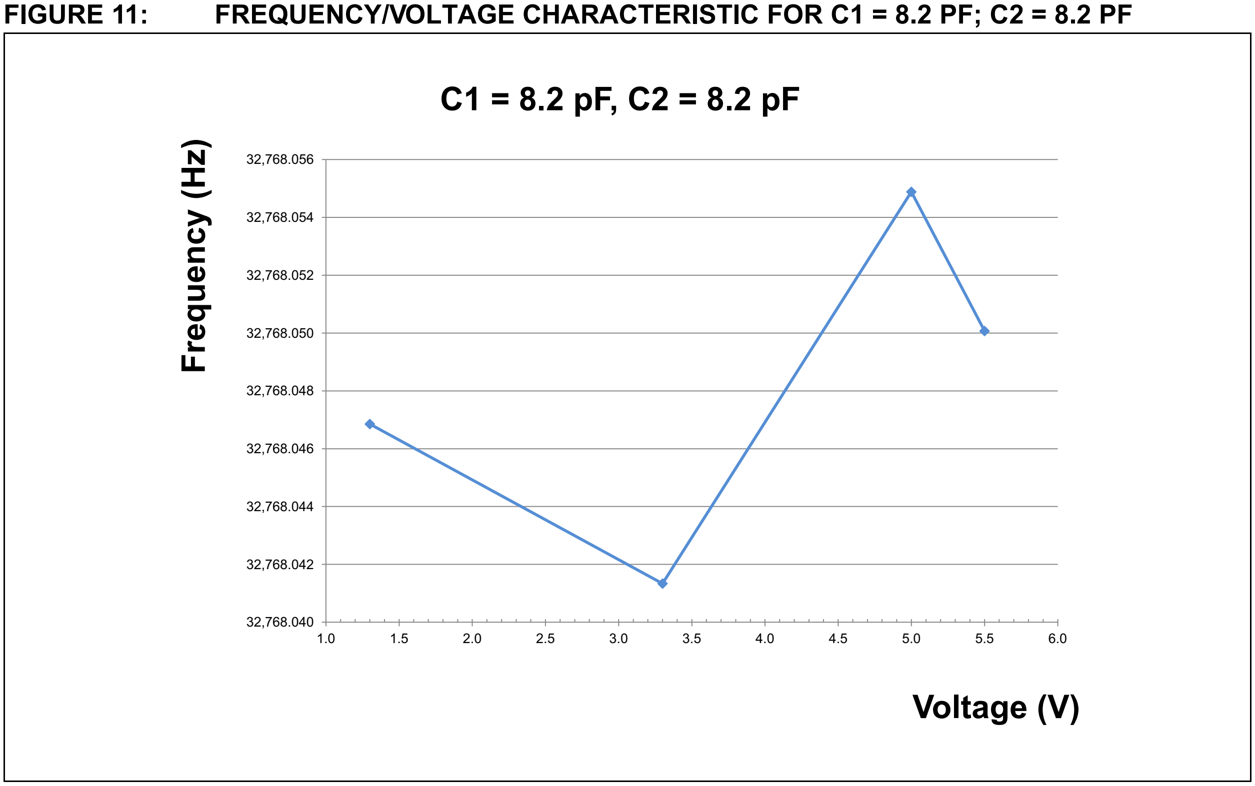
APPENDIX G: AVX ST3215SB32768C0HPWBB

FIGURE 10: FREQUENCY/VOLTAGE CHARACTERISTIC FOR C1 = 10 PF; C2 = 12 PF



APPENDIX H: FOX MC38LF-32.768KHZ

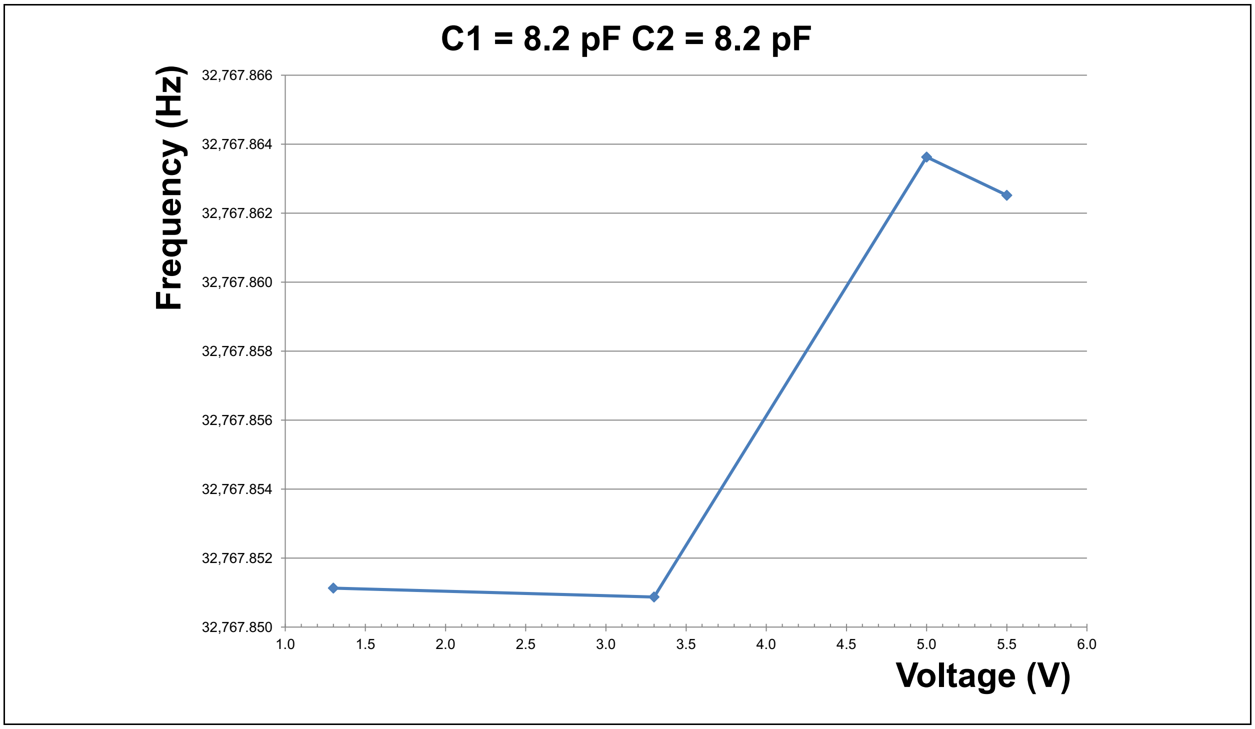
FIGURE 11: FREQUENCY/VOLTAGE CHARACTERISTIC FOR C1 = 8.2 PF; C2 = 8.2 PF



APPENDIX I: HK CRYSTALS

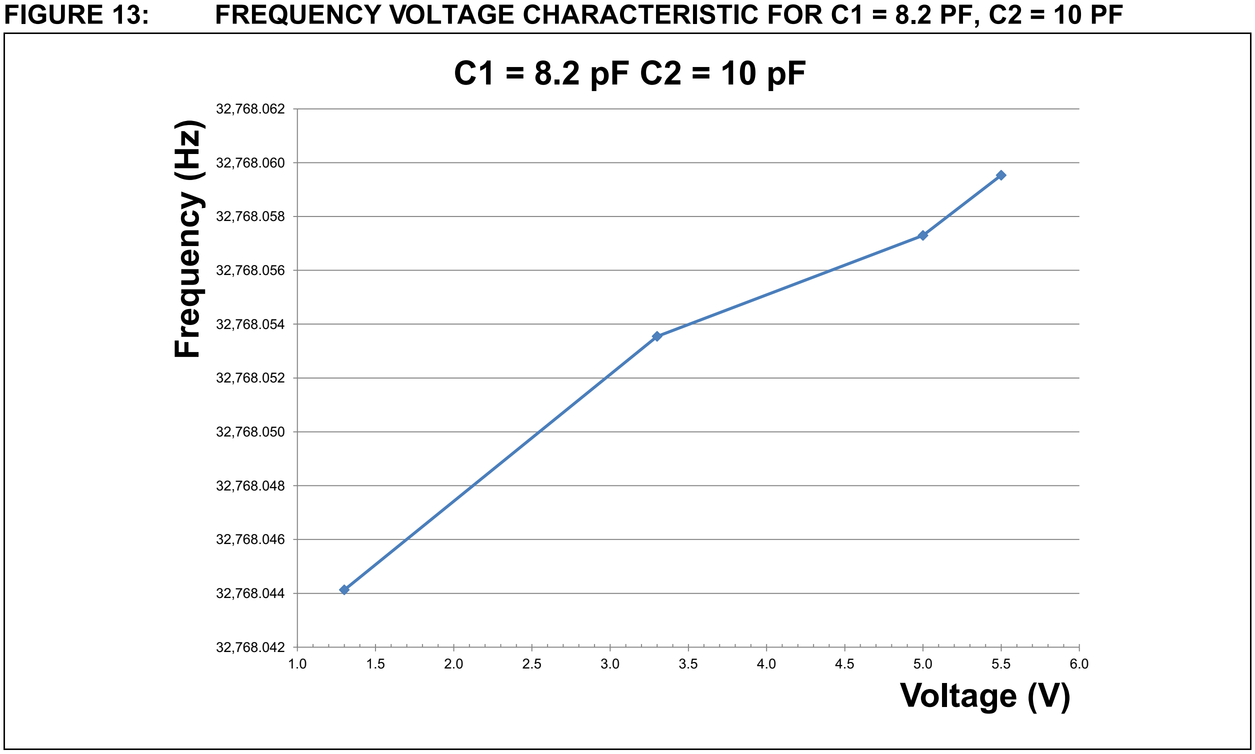
I.1 HK 3T 6PF

FIGURE 12: FREQUENCY VOLTAGE CHARACTERISTIC FOR C1 = 8.2 PF, C2 = 8.2 PF



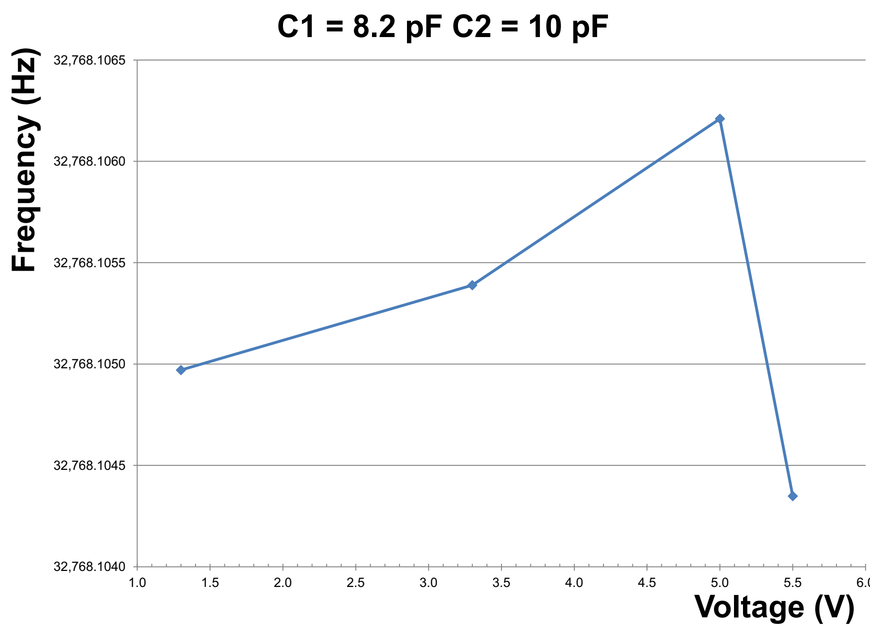
I.2 HK 2T 6PF

FIGURE 13: FREQUENCY VOLTAGE CHARACTERISTIC FOR C1 = 8.2 PF, C2 = 10 PF



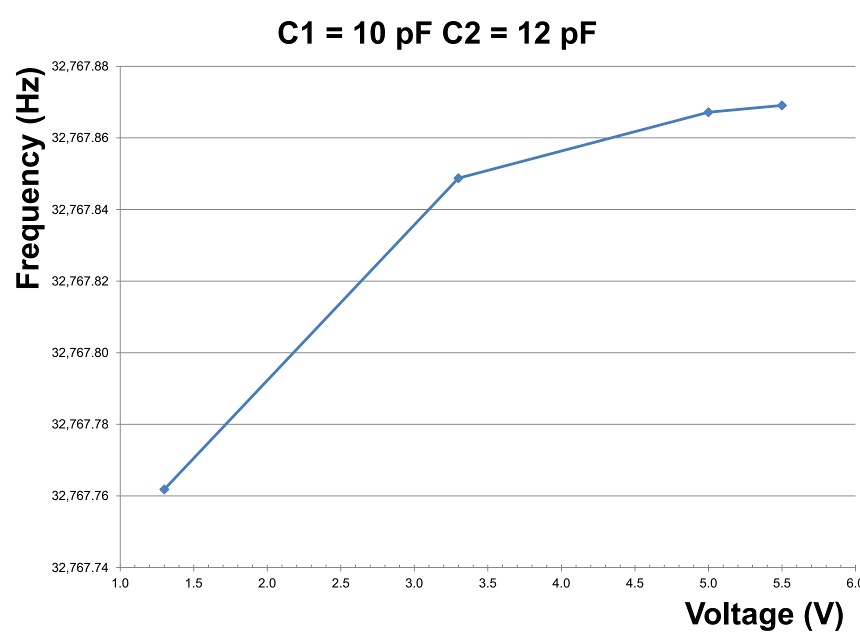
I.3 HK M3 6PF

FIGURE 14: FREQUENCY VOLTAGE CHARACTERISTIC FOR C1 = 8.2 PF, C2 = 10 PF



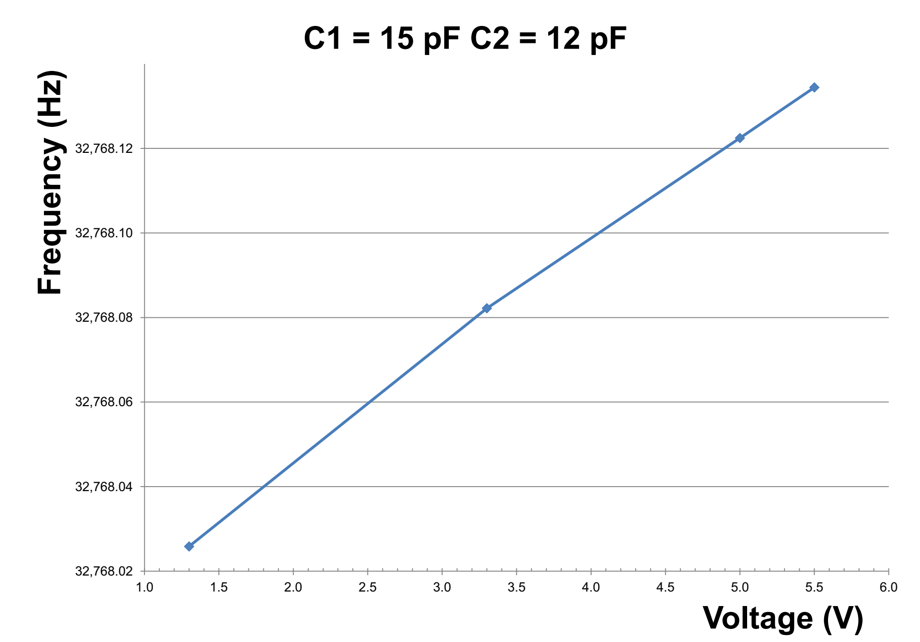
I.4 HK M8 7PF

FIGURE 15: FREQUENCY VOLTAGE CHARACTERISTIC FOR C1 = 10 PF, C2 = 12 PF



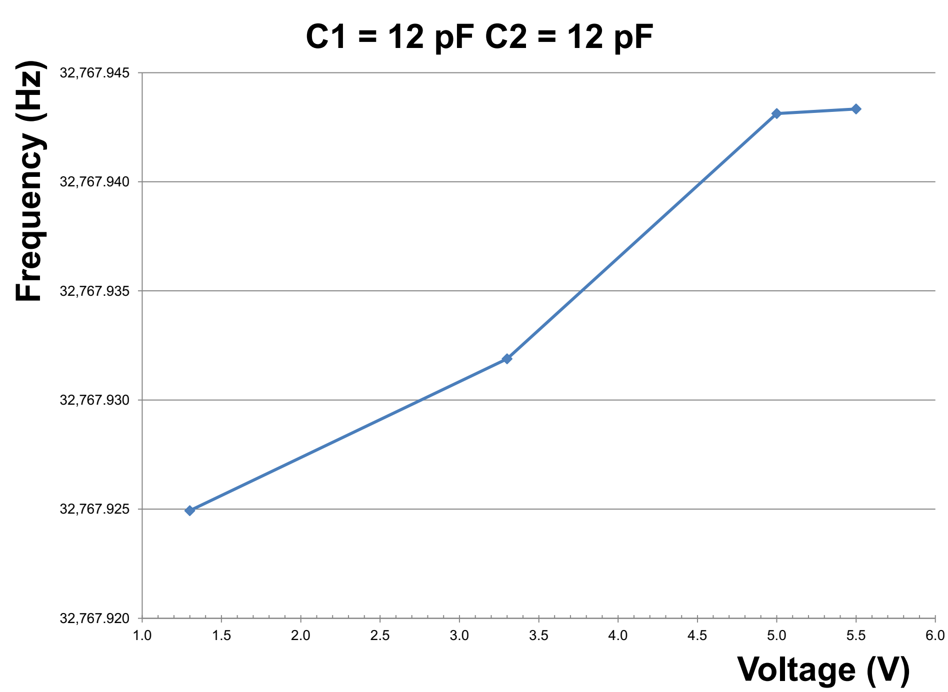
I.5 HK M8 9PF

FIGURE 16: FREQUENCY VOLTAGE CHARACTERISTIC FOR C1 = 15 PF, C2 = 12 PF



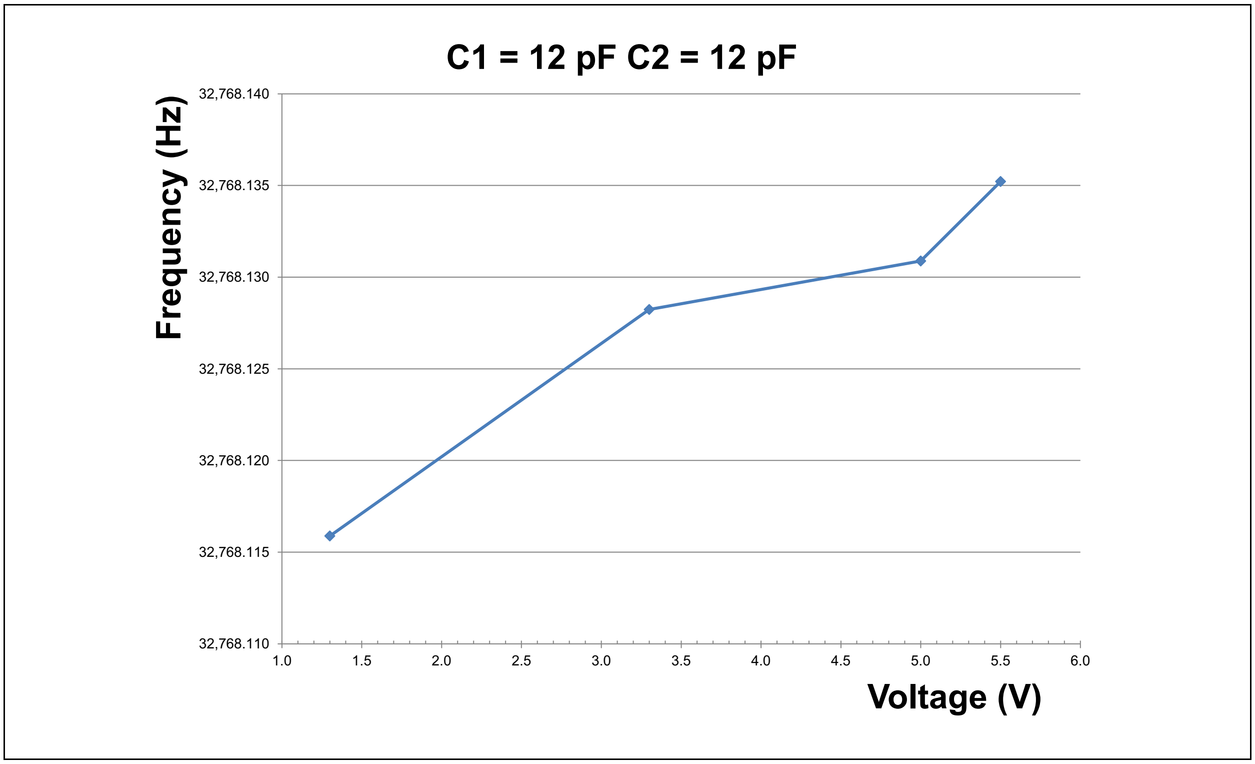
I.6 HK M3 8PF

FIGURE 17: FREQUENCY VOLTAGE CHARACTERISTIC FOR C1 = 12 PF, C2 = 12 PF



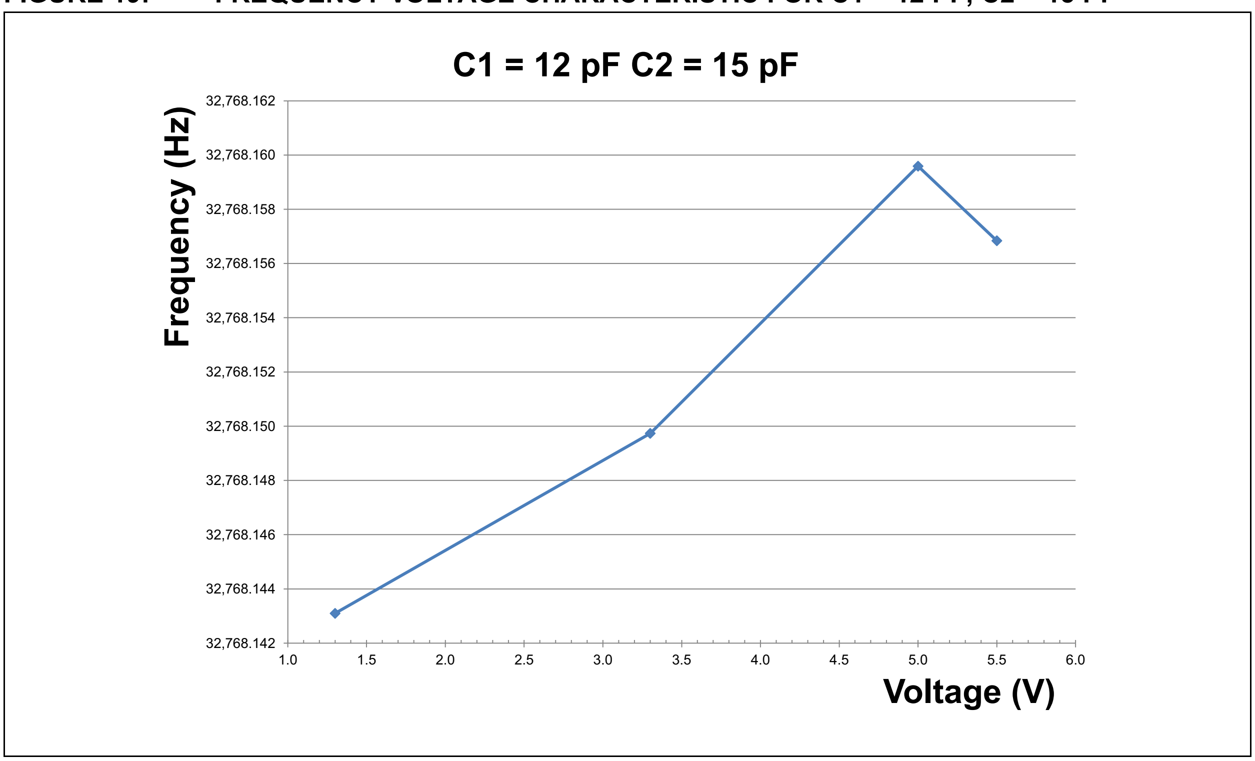
I.7 HK 2T 8PF

FIGURE 18: FREQUENCY VOLTAGE CHARACTERISTIC FOR C1 = 12 PF, C2 = 12 PF



I.8 HK 3T 8PF

FIGURE 19: FREQUENCY VOLTAGE CHARACTERISTIC FOR C1 = 12 PF, C2 = 15 PF



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