Crystal Oscillator Load Capacitors and Frequency Pulling

Load capacitors for a Pierce crystal oscillator from the specified load capacitance and the strays, with the frequency error of other values.

Method: Pierce oscillator load capacitance and crystal pulling

Input parameters

Unit system: SI

Parameter	Value	Unit
Specified load capacitance of the crystal	12.000	pF
Stray capacitance (pins and PCB, 2–5 pF)	3.0000	pF
Chosen capacitor C_1 (0 to use the ideal value)	18.000	pF
Chosen capacitor C_2	18.000	pF
Crystal shunt capacitance	3.0000	pF
Crystal motional capacitance	0.005000	pF

Calculated results

Parameter	Value	Unit
Ideal equal load capacitors 2(C_L − C_stray)	18.000	pF
Load capacitance with the chosen capacitors	12.000	pF
Frequency error with the chosen capacitors (ppm)	0	
Pulling sensitivity at C_L (ppm/pF)	-11.111	

Notes for this case

• C_L = $C_1C_2/(C_1 + C_2)$ + C_stray; pulling $\Delta f/f$ = (C_m/2)[1/(C_0 + C_L,actual) − 1/(C_0 + C_L)]. Too little load capacitance makes the oscillator run fast; too much, slow, and may weaken start-up.

Formula and method

$$C_1 = C_2 = 2(C_L - C_{stray}), \quad C_{L,actual} = \frac{C_1 C_2}{C_1 + C_2} + C_{stray}, \quad \frac{\Delta f}{f} = \frac{C_m}{2}\left[\frac{1}{C_0 + C_{L,actual}} - \frac{1}{C_0 + C_L}\right]$$

Variables

C_L	Specified load capacitance of the crystal	F
C_{stray}	Stray capacitance (pins and PCB, 2–5 pF)	F
C_1	Chosen capacitor C_1 (0 to use the ideal value)	F
C_2	Chosen capacitor C_2	F
C_0	Crystal shunt capacitance	F
C_m	Crystal motional capacitance	F
$C_1 = C_2$	Ideal equal load capacitors 2(C_L − C_stray)	F
$C_{L,actual}$	Load capacitance with the chosen capacitors	F
$\Delta f/f$	Frequency error with the chosen capacitors (ppm)	-
S	Pulling sensitivity at C_L (ppm/pF)	-

Method and standards

Crystal load capacitance and pulling.

Assumptions and limits

- Fundamental-mode Pierce oscillator; small pulling.

References

Pierce oscillator load capacitance and crystal pulling

Report details

Report reference	FCC-VTM6-W9AV (the same inputs always give the same reference)
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Release checks	3 reference cases of this calculator, computed independently, are checked on every release

Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/electrical/electronics/crystal-load-capacitors

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.