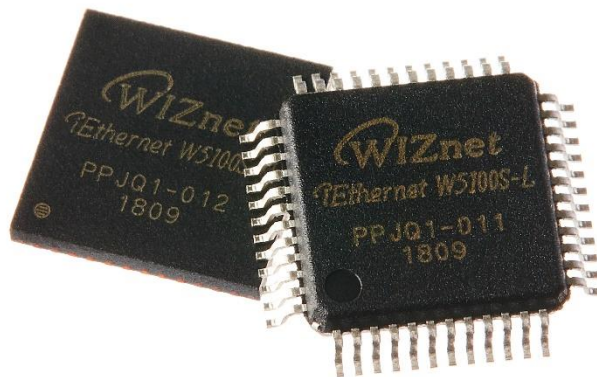


# Crystal Selection Guide

## Application Note

Version 1.0.0



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## 1 Introduction

This document provides Crystal Selection Guide for the W5100S IC.

## 2 Selection Guide

The Oscillator transconductance  $g_m$  of the W5100S is 8.43 and the gain margin should be greater than 6.9897. The gain margin can be calculated by the following formula.

$$\text{gain margin} = \frac{g_m}{g_{m\text{crit}}}$$

$g_m$ : Oscillator transconductance

$g_{m\text{crit}}$ : Oscillation loop critical gain

Therefore, to determine whether the crystal is suitable, the  $g_{m\text{crit}}$  (oscillation loop critical gain) should be calculated.  $g_{m\text{crit}}$  can be calculated by the following formula.

$$g_{m\text{crit}} = 4 \times ESR \times (2\pi F)^2 \times (C_0 + C_L)^2$$

$ESR$ : Equivalent series resistance

$F$ : Nominal frequency

$C_0$ : Shunt capacitance

$C_L$ : Load capacitance

In this case,  $F$  (Nominal frequency) is fixed at 25Mhz, and the remaining values are specified in datasheet of crystal.

## 3 Example

### 3.1 Example of Inappropriate Crystal Selection

Is Crystal with  $ESR = 40\Omega$ ,  $C_0 = 7\text{pF}$ ,  $C_L = 16\text{pF}$  suitable?

$$\begin{aligned} g_{m\text{crit}} &= 4 \times 40 \times (2\pi \times 25 \times 10^6)^2 \times (7 \times 10^{-12} + 16 \times 10^{-12})^2 \\ &= 0.00209\text{A/V} = 2.09\text{mA/V} \end{aligned}$$

$$\text{gain margin} = \frac{8.43}{2.09} = 4.04 < 6.9897$$

Since the gain margin is less than 6.9897, this crystal may be usable but it is not suitable for W5100S and may cause unstable operation.

### 3.2 Example of Appropriate Crystal Selection

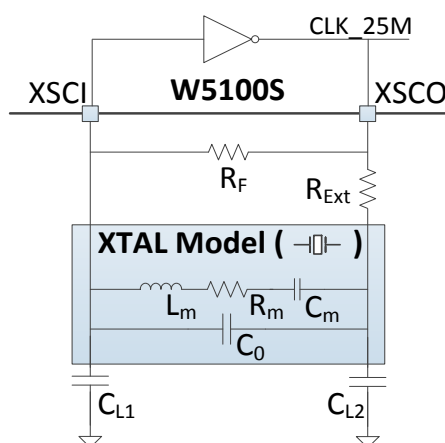
Is Crystal with ESR = 40Ω, C0 = 7pF, CL = 10pF suitable?

$$g_{m_{crit}} = 4 \times 40 \times (2\pi \times 25 \times 10^6)^2 \times (7 \times 10^{-12} + 10 \times 10^{-12})^2 = 0.00114A/V = 1.14mA/V$$

$$\text{gain margin} = \frac{8.43}{1.14} = 7.39 > 6.9897$$

Since the gain margin greater than 6.9897 this is a suitable crystal.

Then, if the crystal circuit is composed as shown below, the external load capacitor can be calculated by the following formula.



External load capacitors  $C_{L1}$  and  $C_{L2}$  are the same value. And it can be calculated by the following formula.

$$C_L = \frac{C_{L1} \times C_{L2}}{C_{L1} + C_{L2}} + C_s$$

$C_L$ : Load capacitance of crystal.

$C_{L1}, C_{L2}$ : External load capacitance.

$C_s$ : Stray capacitance of PCB trace and pad.

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In this time, Cs (Stray capacitance) is a capacitance of the PCB trace, pad, etc., normally 5 - 7pF. By the formula,  $C_{L1} = C_{L1} = 10pF$

## 4 Document Revision History

Version	Date	Descriptions
Ver. 1.0.0	1APR2018	Initial Release

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