W5100S Application note

Crystal Selection Guide

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1. Introduction

This document provides a crystal selection guide for the W5100S IC.

본 문서에서는 W5100S 에 적합한 Crystal 을 선택할 수 있는 Guide 를 제공합니다.

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.

$$\text{gain margin} = \frac{g_m}{g_{mcrit}}$$

g_m: Oscillator transconductance

g_{mcrit}: Oscillation loop critical gain

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

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

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 = 40Ω, C0 = 7pF, CL = 16pF suitable?

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

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

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

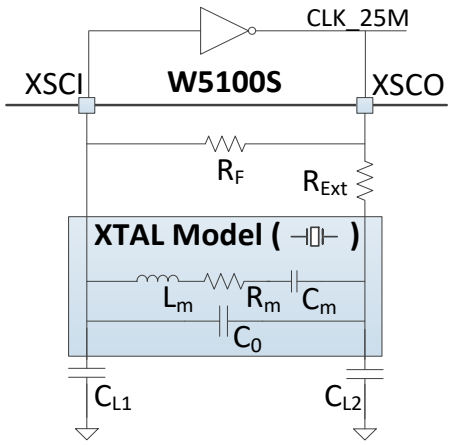
Is Crystal with ESR = 40Ω, C0 = 7pF, CL = 10pF suitable?

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

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

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.

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

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