# Reliable GreenCLK3 MHz Crystal Start-up is a Function of ESR and Crystal Package Size

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## Introduction

The GreenCLK (GCLK) family is a widely-adopted timing solution used in various industries for dozens of applications. Its unique ability to generate multiple frequency outputs from a single MHz reference gives it substantial cost and space savings. These advantages have established GCLK as the standard timing solution in the Notebook and Netbook market, as well as a competitive solution in the emerging IoT space.

## How GreenCLK3 Works

GCLK3 is the 3rd-generation of GCLK family. It boasts marketed improvements in power consumption, ppm stability, and dB levels over previous generations. Utilizing a robust reference MHz crystal, TCXO or XO, GCLK3 generates a highly stable 32.768 kHz clock output frequency, as well as a MHz output frequency.

## Purpose of Note

The purpose of this note is to help customers avoid start-up issues when integrating crystals with GCLK3 on their layout.

When selecting the reference crystal, it is important to consider equivalent series resistance (ESR), also referred to as motional resistance, in order to avoid start-up issues. The GCLK3 technology relies on the MHz crystal starting consistently as the MHz frequency is used to periodically calibrate an internal IC oscillator generating the 32.768 kHz clock. Crystals with excessive ESR may take too long to start or not start at all producing a poor calibration cycle and a 32.768 kHz clock with out-of-specification frequency error.

Each GCLK3 datasheet has recommended MHz reference crystal specifications. Please note the recommended crystal specifications for ESR.

## GreenCLK Solution

Lower motional resistance is preferable for ensuring a quick consistent crystal start-up. The recommendation is to select a crystal with an ESR near 60 Ω's if possible. Resistance values above 150 Ω's are not recommended. Please refer to the table below as a guideline when selecting the appropriate package size of the crystal to use with GCLK3 for your application.

As the table illustrates, care needs to be taken when selecting crystal's in the smallest packages, as ESR increases inversely with package size.

For example, a 2520 package would be recommended when using a 19.2 MHz crystal since its ESR is < 100 Ω's. Selecting a 1612 package at that frequency would make start-up unreliable.

However, a 1612 package with a 40 MHz crystal would work because the ESR is < 100 Ω's.

This table is only a guideline. Please refer to the manufacturer's datasheet for the exact ESR specification of the particular crystal you are using.

| MHz | EPSON | | | NDK | | | TXC | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1612 | 2016 | 2520 | 1612 | 2016 | 2520 | 1612 | 2016 | 2520 |
| 12 ~ 13 | -- | -- | 150 Ω | -- | -- | -- | -- | -- | 200 Ω |
| 13 ~ 16 | -- | -- | 150 Ω | -- | -- | -- | -- | -- | 150 Ω |
| 16 ~ 18 | -- | 200 Ω | 80 Ω | -- | -- | -- | -- | 200 Ω | 100 Ω |
| 18 ~ 19.2 | -- | 150 Ω | 80 Ω | -- | -- | -- | -- | 200 Ω | 100 Ω |
| 19.2 ~ 20 | -- | 150 Ω | 80 Ω | -- | 80 Ω | 70 Ω | -- | 100 Ω | 100 Ω |
| 20 ~ 24 | -- | 100 Ω | 80 Ω | -- | 80 Ω | 50 Ω | 150 Ω | 100 Ω | 80 Ω |
| 24 ~ 25 | 200 Ω | 80 Ω | 80 Ω | 150 Ω | 60 Ω | 50 Ω | 100 Ω | 100 Ω | 80 Ω |
| 26 ~ 27 | 200 Ω | 60 Ω | 60 Ω | 150 Ω | 60 Ω | 50 Ω | 100 Ω | 100 Ω | 80 Ω |
| 27 ~ 30 | 200 Ω | 60 Ω | 60 Ω | 150 Ω | 60 Ω | 50 Ω | 100 Ω | 100 Ω | 60 Ω |
| 30 ~ 32 | 200 Ω | 60 Ω | 50 Ω | 150 Ω | 60 Ω | 50 Ω | 80 Ω | 80 Ω | 60 Ω |
| 32 ~ 36 | 100 Ω | 60 Ω | 50 Ω | 100 Ω | 60 Ω | 50 Ω | 80 Ω | 80 Ω | 60 Ω |
| 36 ~ 38 | 80 Ω | 60 Ω | 40 Ω | 100 Ω | 60 Ω | 50 Ω | 80 Ω | 80 Ω | 60 Ω |
| 38 ~ 40 | 80 Ω | 60 Ω | 40 Ω | 80 Ω | 60 Ω | 50 Ω | 80 Ω | 80 Ω | 60 Ω |
| >40 | 80 Ω | 60 Ω | 40 Ω | 80 Ω | 60 Ω | 40 Ω | 80 Ω | 80 Ω | 60 Ω |

| Key: | Green: < 100 Ω | Yellow: = 100 – 150 Ω | Red: > 150 Ω |
|---|---|---|---|

## References:

- http://www.eea.epson.com/portal/page/portal/home/products/timing_devices/Crystals/MHz%20Surface%20Mount%20Crystals
- http://www.ndk.com/en/products/search/crystal/index.html
- http://www.txccrystal.com/crystal.html

## Related Resources:

- Determining the Correct Crystal Load Capacitance: http://www.silego.com/uploads/Products/product_230/AN-1005.zip
- http://www.silego.com/app_notes.html