ELECTRICAL TEST METHODS FOR CRYSTAL CONTROLLED OSCILLATORS

ESCC Basic Specification No. 24200

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DCR No.	CHANGE DESCRIPTION

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1 PURPOSE

This specification defines the basic electrical test methods applicable to Crystal Controlled Oscillators. The requirements for measurements (i.e. which measurements are to be performed and how) shall be given in the Detail Specification.

1.1 APPLICABITY

This specification is applicable to all crystal controlled oscillators. The types covered by this specification include the following:

- XO: The simplest and most general-purpose-type of crystal controlled oscillator where the principal control element is the crystal unit. Because the XO employs no means of temperature control or compensation, it exhibits a frequency-temperature characteristic determined mainly by the crystal unit employed.

2 RELATED DOCUMENTS

2.1 APPLICABLE DOCUMENTS

The following ESCC specifications form part of, and shall be read in conjunction with, this specification. The relevant issues shall be those in effect on the date of commencement of the testing of the component.

- ESCC Basic Specification No. 21300, Terms, Definitions, Abbreviations, Symbols and Units.
- NIST Technical Note 1337, National Institute of Standards and Technology, Characterisation of Clocks and Oscillators

3 TERMS, DEFINITIONS, ABBREVIATIONS, SYMBOLS AND UNITS

The terms, definitions, abbreviations, symbols and units as specified in ESCC Basic Specification No. 21300 shall apply. Other symbols and abbreviations are defined, as applicable, within the document referenced in Related Documents herein and in the text of this document.

4 REQUIREMENTS

4.1 INPUT CURRENT-POWER

When measured (or calculated for the power: P = EI), the oscillator input current-power shall not exceed the value specified.

4.2 OUTPUT WAVEFORM

The type of output waveform shall be verified when the oscillator is operated as specified, using suitable test equipment.

4.3 VOLTAGE PROOF

The oscillator shall be subjected to an overvoltage of 20% above the maximum specified supply voltage, for a duration of 1 minute, unless otherwise specified.

The applied overvoltage for oscillators employing CMOS devices shall not exceed 16.5 volts.

The application of the overvoltage at the supply terminals shall not impair performance of the oscillator as verified by the subsequent electrical measurements.

4.4 OUTPUT VOLTAGE-POWER

4.4.1 Output voltage

The RMS or peak-to-peak output voltage of the oscillator shall be measured across the specified load. When measured, the output voltage of the output waveform shall not exceed the limits specified.

4.4.2 Output power (sinusoidal waveform)

The output power of the oscillator shall be measured across the specified load. The output power is calculated from the RMS output voltage and the load impedance or, alternately, it may be read directly from an appropriate power meter. When measured, the output power shall not exceed the limits specified.

4.4.3 Output logic voltage levels (square wave output waveform)

The output logic voltage levels of the oscillator (see Figure 1) shall be measured across the specified load. When measured, the output logic voltage levels of the output waveform shall not exceed the limits specified.

NOTE: The measurements shall be referenced from ground (0Vdc) to the flat portion of each level, disregarding overshoot, undershoot or ringing, as shown on Figure 1.

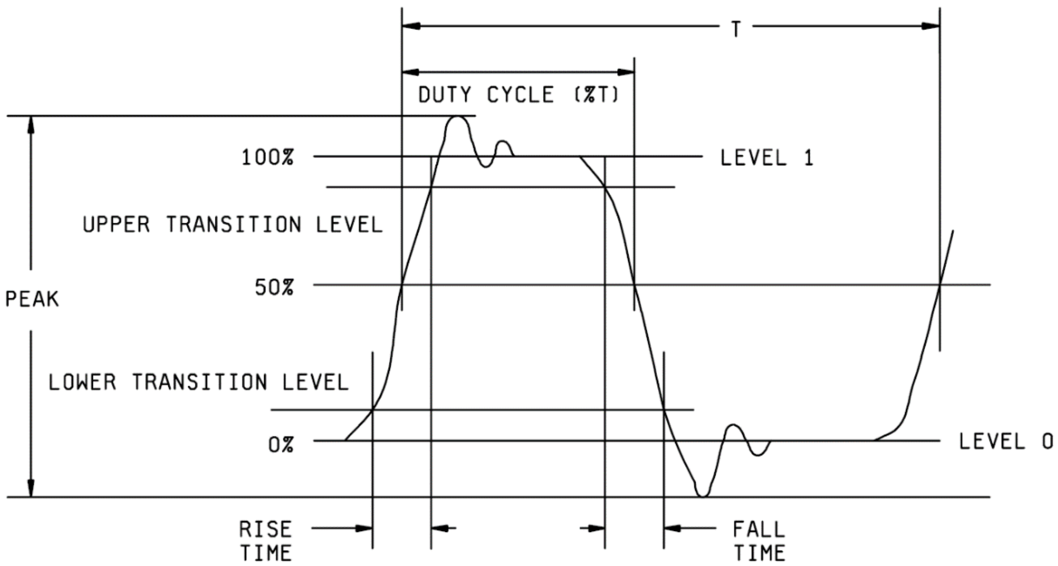

FIGURE 1 - RECTANGULAR OUTPUT WAVEFORM

4.4.4 Rise and Fall Times (Square Wave Output Waveform)

The Rise and Fall Time measurements of the oscillator output between the specified voltage levels shall be made. See figure 1 and as follows:

- Rise time: The time observed for a logic "0" to logic "1" transition, when measured on the leading edge of a rectangular waveform pulse, between two specified voltage transition levels.
- Fall time: The time observed for a logic "1" to logic "0" transition, when measured on the trailing edge of a rectangular waveform pulse, between two specified voltage transition levels.

Unless otherwise specified, the Rise and Fall Time measurement transition levels shall be at 10% of the output voltage for the lower level and at 90% of the output voltage for the upper level.

When tested, the Rise and Fall Times of the output waveform shall not exceed the limits specified.

4.4.5 Duty Cycle (Square Wave Output Waveform)

Unless otherwise specified, the Duty Cycle of the oscillator output shall be measured at the 50% voltage level. See figure 1 and as follows:

- Duty Cycle: The percentage of time above a specified reference level with respect to the waveform period (also called symmetry).

NOTE: The measurements shall be referenced from ground (0Vdc) to the flat portion of each level, disregarding overshoot, undershoot or ringing, as shown on Figure 1.

When tested, the duty cycle of the output waveform shall not exceed the limits specified.

4.5 FREQUENCY ACCURACY (AT REFERENCE TEMPERATURE)

Unless otherwise specified, the output frequency of the oscillator shall be measured referenced to nominal frequency, with nominal supply voltage and nominal load. Output frequency shall be measured immediately following stabilization at the reference temperature. Unless otherwise specified, the following details shall apply:

- Reference temperature: T_{amb} = +25ºC ±1ºC
- Stabilization time: 8 minutes ±5 minutes

When measured, the Frequency Accuracy shall not exceed the limits specified.

The Frequency Accuracy shall be determined by:

- f Accuracy = δf

  where δf is computed as follows:
  - $\delta f = |(f - f_{Nom}) / f_{Nom}|$

    where f is the measured output frequency and f_{Nom} is the nominal frequency.

4.6 FREQUENCY-VOLTAGE TOLERANCE.

This is the maximum permissible deviation of the oscillator output frequency from the output frequency at specified nominal supply voltage due to changes in supply voltage over the specified range, other conditions remaining constant.

When measured, the Frequency-Voltage Tolerance referenced to output frequency at nominal supply voltage shall not exceed the limits specified.

Unless otherwise specified, the frequency-voltage tolerance shall be determined from measurements of output frequency when the oscillator supply voltage is adjusted to its specified nominal value, to its minimum value and to its maximum value. Sufficient stabilization time shall be allowed between adjustment of supply voltage and measurement of output frequency. Unless otherwise specified, measurements shall be performed at the specified temperature with a tolerance of ±1ºC and supply voltage with a tolerance of ±0.05V.

The Frequency-Voltage Tolerance shall be determined by:

- f-V Tolerance = ±MAX [δf_{Max}, δf_{Min}]
  where MAX [ ] is the maximum value among δf_{Max} and δf_{Min}.
- δf_{Max} and δf_{Min} are computed as follows:
  - $\delta f_{Max} = |(f_{Max} – f_{Vnom}) / f_{Vnom}|$
  - $\delta f_{Min} = |(f_{Min} – f_{Vnom}) / f_{Vnom}|$

    where f_{Max} is the maximum measured output frequency, f_{Min} is the minimum measured output frequency and f_{Vnom} is the measured frequency at the nominal supply voltage.

4.7 FREQUENCY-LOAD TOLERANCE.

This is the maximum permissible deviation of the oscillator output frequency from the output frequency at specified nominal load impedance due to changes in load impedance over the specified range, other conditions remaining constant.

When measured, the Frequency-Load Tolerance referenced to output frequency at nominal load shall not exceed the limits specified.

Unless otherwise specified, the frequency-load tolerance shall be determined from measurement of output frequency at specified nominal load conditions, minimum load conditions and maximum load conditions. Any impedance appearing across the output terminals which results from connection to the measurement system must be included in the total electrical load value. Unless otherwise specified, measurements shall be performed at the specified temperature with a tolerance of ±1ºC.

The Frequency-Load Tolerance shall be determined by:

- f-L Tolerance = ±MAX [δf_{Max}, δf_{Min}]
  where MAX [ ] is the maximum value among δf_{Max} and δf_{Min}.
- δf_{Max} and δf_{Min} are computed as follows:
  - $\delta f_{Max} = |(f_{Max} - f_{Lnom}) / f_{Lnom}|$
  - $\delta f_{Min} = |(f_{Min} - f_{Lnom}) / f_{Lnom}|$

    where f_{Max} is the maximum measured output frequency, f_{Min} is the minimum measured output frequency and f_{Lnom} is the measured output frequency at nominal load.

4.8 FREQUENCY-TEMPERATURE STABILITY.

This is the maximum permissible deviation of the oscillator output frequency from the output frequency at the specified reference temperature, due to operation over the specified operating temperature range, other conditions remaining constant.

When measured, the frequency-temperature stability referenced to the output frequency at reference temperature shall not exceed the limits specified.

Prior to this test, oscillators shall be stabilized at the specified reference temperature and the output frequency shall be measured with nominal supply voltage and nominal load. Unless otherwise specified, the reference temperature shall be T_{amb} = +25ºC ±1ºC.

Unless otherwise specified, the oscillator shall be subjected to a one-half temperature cycle from the specified minimum operating temperature to the maximum operating temperature in 10 equally spaced increments. The output frequency with nominal supply voltage and nominal load shall be measured at each temperature increment after temperature stabilization. Unless otherwise specified, measurements shall be performed at the specified temperature with a tolerance of ±1ºC and supply voltage with a tolerance of ±0.05V.

The Frequency-Temperature Stability is determined by:

- f-T Stability = ±MAX [δf_{Max}, δf_{Min}]
  where MAX [ ] is the maximum value among δf_{Max} and δf_{Min}.
- δf_{Max} and δf_{Min} are computed as follows:
  - $\delta f_{Max} = |(f_{Max} - f_{Ref}) / f_{Ref}|$
  - $\delta f_{Min} = |(f_{Min} - f_{Ref}) / f_{Ref}|$

  where f_{Max} is the maximum measured output frequency during the temperature cycle, f_{Min} is the minimum measured output frequency during the temperature cycle and f_{Ref} is the initial measured output frequency at the reference temperature.

4.9 STARTUP TIME.

Unless otherwise specified, the startup time shall be measured using an oscilloscope synchronized to the switched supply voltage. The following details shall apply:

- Test configuration: Nominal supply voltage and nominal load; see figure 2.
- Ramp rate: from 0Vdc to nominal supply voltage in 100 microseconds or less, unless otherwise specified.

When measured, the time interval for the oscillator output to achieve a continuous waveform at 90% of final output amplitude following application of power, unless otherwise specified, shall not exceed the Startup Time value specified.

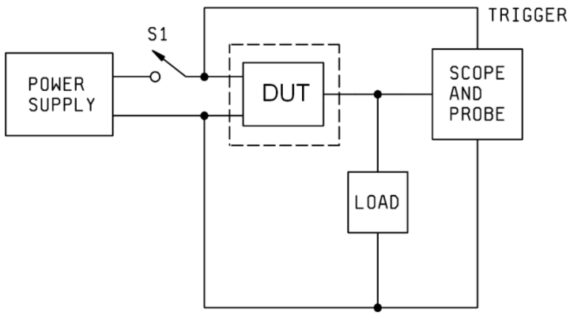

FIGURE 2 - TEST CONFIGURATION FOR STARTUP TIME MEASUREMENT

4.10 HARMONIC AND SUB-HARMONIC DISTORTION.

Harmonic distortion is a nonlinear distortion characterized by the generation of undesired spectral components harmonically related to the oscillator's nominal output frequency. In an oscillator whose output is derived by multiplying a lower frequency signal to the desired nominal output frequency, harmonics of the primary oscillator are the sub-harmonics of the nominal output frequency. Each component is expressed as a power ratio (in decibels) relative to the output power at the nominal output frequency (e.g., second harmonic is suppressed 30dB, the sub-harmonics are all below -40dBc).

The harmonic and sub-harmonic distortion referenced to the output at the nominal frequency within the frequency range as specified, shall be measured using a suitable spectrum analyzer set to display a frequency range which will embrace the appropriate harmonics and sub-harmonics of the oscillator.

NOTE: Care must be taken to ensure that the distortion is not produced in the input mixer of the spectrum analyser.

Nonlinear distortion (having the appearance of harmonic distortion) will be produced if the input mixer is overloaded. This point may be checked by placing an attenuator between the oscillator and the spectrum analyser and taking measurements at various power levels. The attenuator setting should not affect the percentage of harmonic distortion.

NOTE: In the event of high level signals in the environment in which the oscillator is being tested, care should be taken to screen the measurement system to eliminate signal picked up from the operating environment.

When measured, the harmonic and sub-harmonic distortion referenced to the output at the nominal frequency shall not exceed the values specified, within the frequency range as specified.

The various harmonic and sub-harmonic spectra shall each be measured (usually directly in decibels from the spectrum analyzer) as a power ratio with respect to the carrier power (at the nominal output frequency of the oscillator), expressed in decibels.

4.11 SPURIOUS RESPONSE.

A spurious response is a discrete frequency spectral component, non-harmonically related to the desired nominal output frequency, appearing at the output of an oscillator. These components may appear as symmetrical sidebands, or as single spectral components, depending upon the mode of generation. Spurious components in the output spectrum are usually expressed as a power ratio (in decibels) with respect to the carrier power (at the nominal output frequency of the oscillator).

Spurious Response of the oscillator shall be measured using a suitable spectrum analyzer set to display the specified frequency range.

NOTE: Care must be taken to ensure that spurious responses are not produced in the input mixer of the spectrum analyser.

Nonlinear distortion (having the appearance of spurious responses) will be produced if the input mixer is overloaded. This point may be checked by placing an attenuator between the oscillator and the spectrum analyser and taking measurements at various power levels. The attenuator setting should not affect the percentage of the spurious response.

NOTE: In the event of high level signals in the environment in which the oscillator is being tested, care should be taken to screen the measurement system to eliminate signal picked up from the operating environment.

When measured, any Spurious Responses shall be at least the specified number of decibels below the main response at the nominal output frequency, within the frequency range as specified.

4.12 OUTPUT IMPEDANCE

The output impedance shall be measured as follows:

(a) Load the oscillator output with a precision (±1% nonreactive) resistor. R_L= specified load minus 10%.
(b) Measure output voltage e_L.
(c) Load the oscillator output with a precision (±1% nonreactive) resistor. R_H= specified load plus 10%.
(d) Measure output voltage e_H.
(e) Calculate the output impedance as follows:

$$Z = \frac{R_L R_H (e_H - e_L)}{e_L R_H - e_H R_L}$$

When tested as specified, the output impedance of the oscillator shall not exceed the limits specified.

4.13 PHASE NOISE

The phase noise £(f) shall be measured under quiescent conditions in accordance with NIST Technical Note 1337. When measured, the phase noise, £(f), under steady-state (quiescent) conditions shall not exceed the values bounded by straight line segments drawn on log-log axis through specified points.

4.14 JITTER

The jitter σ(t) shall be measured under quiescent conditions in accordance with NIST Technical Note 1337. When measured, the jitter σ(t) under steady-state (quiescent) conditions shall not exceed the limits specified.