Application Manual

MCSO2

Clock Oscillator
10 kHz – 225 MHz

TABLE OF CONTENTS

MCSO2

Clock Oscillator 10 kHz – 225 MHz

1. OVERVIEW

- Oscillator with built-in AT-cut crystal, operating in fundamental mode
- Overall frequency stability over temperature range: ≤ ±50 ppm or ≤ ±100 ppm
- Very fast start-up: typ.1 ms at 25°C
- Output signal HCMOS compatible
- High shock and vibration resistance
- Operating voltage: 1.8 V, 2.5 V, 3.3 V or 5.0 V
- Power consumption:
  - < 110 µA at V_{DD} = 3.3 V, F = 32.768 kHz
  - < 5 mA at V_{DD} = 3.3 V, F ≤ 20 MHz
- Operating temperature range:
  - A = 0 to +70°C
  - B = -40 to +85°C
  - C = -55 to +125°C
  - X = Custom
- Enable/Disable function (option 1)
- Low aging rate
- Ceramic SMD package (5.0 x 3.2 mm), RoHS-compliant and 100% lead-free

1.1. GENERAL DESCRIPTION

The MCSO2 combines a High Frequency HCMOS oscillator circuitry together with an AT-cut quartz crystal in a hermetically sealed ceramic package with ceramic or metal lid. No external components are required.
The frequency output 10 kHz – 225 MHz on F_{OUT} pin can be enabled / disabled by the E/D pin (option 1). The F_{OUT} frequency is enabled when E/D pin is connected to V_{DD} or when it is left open (not connected). When the E/D pin is tied to GND the frequency is disabled and the F_{OUT} pin is in high impedance state (Hi-Z).

1.2. APPLICATIONS

The MCSO2 clock oscillator module combines outstanding performance and robustness in a standard ceramic package:

- Oscillator module (embedded XTAL) in a standard 5.0 x 3.2 mm lead-free ceramic package
- High shock and vibration resistant

The robust construction and high performances make this product perfectly suitable for many high reliability applications:

- Avionics / Aerospace: Airborne Equipment / Engine Control / Actuator Controller / Temperature Controller / Instrumentation / Navigation and Guidance Systems
- Instrumentation: Field Test Instrument / Automotive Test Equipment
- Communication: Optical Network / Wireless Communication System
- Security / Safety: Survival and Protection System / Railway Security System / Fire Fighter Equipment
- Industrial: Telemetry / A/C Controller / Hydraulic Sensor

1.3. ORDERING INFORMATION

Example: MCSO2 F K H V T – C 40.000 MHz E/D T3 XXX

Code	Package Size
MCSO2	5.0 x 3.2 mm

Code	Jitter
F	Low jitter *
Blank	Standard

Code	Lid
K	Kovar lid
Blank	Ceramic lid

Code	Frequency range
H	> 20 MHz
Blank	≤ 20 MHz

Code	Supply voltage
Z	V_{DD} = 1.8 V
W	V_{DD} = 2.5 V
V	V_{DD} = 3.3 V
Blank	V_{DD} = 5.0 V **

Code	Frequency stability
T	±50 ppm
Blank	±100 ppm

Code	Temperature range
A	0 to +70°C
B	-40 to +85°C
C	-55 to +125°C
X	Custom

Code	Frequency
40.000 MHz	40.000 MHz

Code	Option 1
E/D	Enable/Disable
Blank	No function

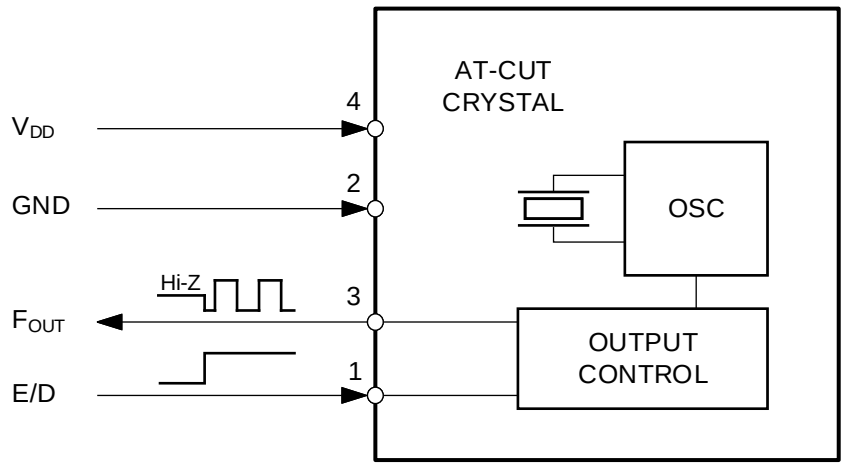
Code	Option 2
T3	SnAgCu solder dipped pads
Blank	Au flashed pads

Code	Customer specification N°
XXX	XXX

* One-sigma jitter for low jitter version (F):
t_{RMS} < 2 ps for F ≤ 20 MHz
t_{RMS} < 10 ps for F > 20 MHz

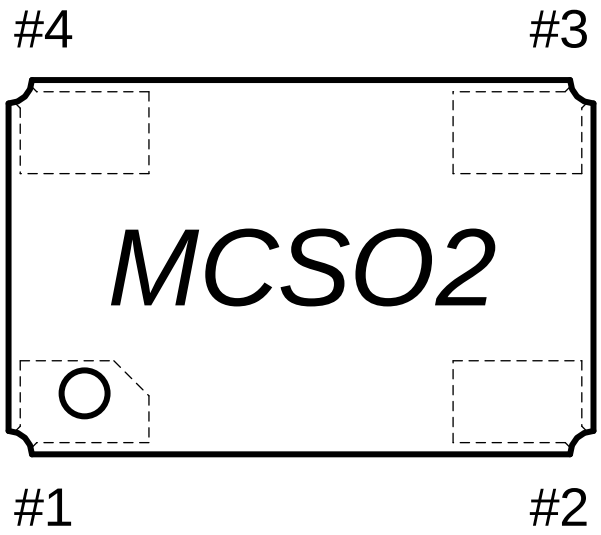
** 5.0 V version not available for low jitter version (F)

2. BLOCK DIAGRAM



2.1. PINOUT

MCSO2 Package: (top view)



#1	E/D
#2	GND
#3	F_{OUT}
#4	V_{DD}

2.2. PIN DESCRIPTION

Symbol	Pin #	Description
E/D	1	Input to enable/disable the F_{OUT} pin (option 1). If E/D is HIGH or floating (V_{IH} or open), the F_{OUT} pin is in output mode. When E/D is tied to Ground (V_{IL}), the F_{OUT} pin is disabled (Hi-Z).
GND	2	Ground.
F_{OUT}	3	Clock Output; three-state; controlled by E/D. If E/D is HIGH (V_{DD}) or floating, the F_{OUT} pin drives the square wave of the frequency. When E/D is tied to Ground, the F_{OUT} pin is disabled (Hi-Z).
V_{DD}	4	Power Supply Voltage.

3. ELECTRICAL SPECIFICATIONS

3.1. ABSOLUTE MAXIMUM RATINGS

Absolute Maximum Ratings according to IEC 60134:

SYMBOL	PARAMETER	CONDITIONS	MIN	MAX	UNIT
V_{DD}	Power supply voltage	Nominal V_{DD} = 1.8 V	-0.3	2.3	V
		Nominal V_{DD} = 2.5 V	-0.3	3	
		Nominal V_{DD} = 3.3 V	-0.3	3.8	
		Nominal V_{DD} = 5.0 V	-0.3	5.5	
V_I	Input voltage		-0.3	V_{DD}	V
V_O	Output voltage		-0.3	V_{DD}	V
V_{ESD}	ESD voltage	HBM (1)		±2000	V
		MM (2)		±200	
T_A	Operating temperature range A		0	70	°C
T_B	Operating temperature range B		-40	85	°C
T_C	Operating temperature range C		-55	125	°C
T_{STO}	Storage temperature	Stored as bare product	-65	125	°C
T_{PEAK}	Maximum reflow condition	JEDEC J-STD-020C		265	°C

(1) HBM: Human Body Model, according to JESD22-A114.
(2) MM: Machine Model, according to JESD22-A115.

3.2. OPERATING PARAMETERS

For this Table, V_{DD} = nominal voltage; GND = 0 V; T_A = 25 °C; unless otherwise indicated.

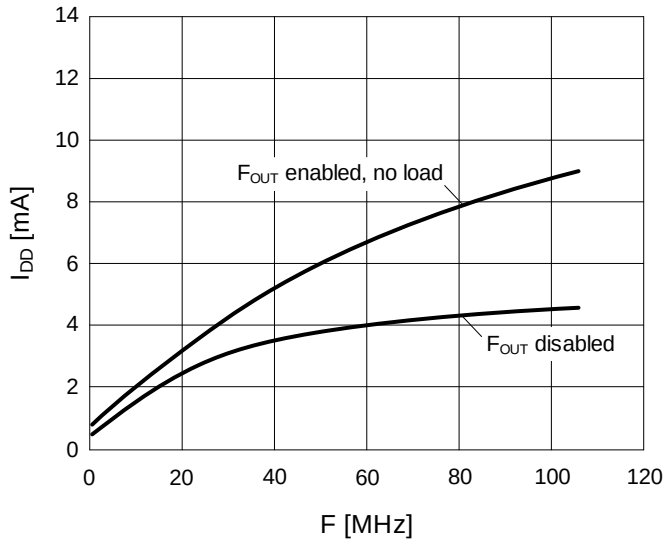
Operating Parameters:

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
Supply						
V_{DD}	Power supply voltage (1) (2)	Nominal V_{DD} = 1.8 V	1.71		1.89	V
		Nominal V_{DD} = 2.5 V	2.375		2.625	
		Nominal V_{DD} = 3.3 V	3.135		3.465	
		Nominal V_{DD} = 5.0 V	4.75		5.25	
I_{DD}	Input current. V_{DD} = 2.5 V F_{OUT} enabled, no load	10 kHz ≤ F ≤ 32.768 kHz			0.1	mA
		32.768 kHz < F ≤ 10 MHz			2	
		10 MHz < F ≤ 20 MHz			3	
		20 MHz < F ≤ 225 MHz			25	
	Input current. V_{DD} = 3.3 V F_{OUT} enabled, no load	10 kHz ≤ F ≤ 32.768 kHz			0.11	
		32.768 kHz < F ≤ 10 MHz			4	
		10 MHz < F ≤ 20 MHz			5	
		20 MHz < F ≤ 225 MHz			30	
	Input current. V_{DD} = 5.0 V F_{OUT} enabled, no load	10 kHz ≤ F ≤ 32.768 kHz			0.12	
		32.768 kHz < F ≤ 10 MHz			6	
		10 MHz < F ≤ 20 MHz			7	
		20 MHz < F ≤ 225 MHz			40	
Input E/D						
V_I	Input voltage		GND -0.3		V_{DD} +0.3	V
V_{IL}	LOW level input voltage		GND		0.3 V_{DD}	V
V_{IH}	HIGH level input voltage		0.7 V_{DD}		V_{DD}	V
t	Reaction time				1	µs
Output F_{OUT} (HCMOS compatible)						
V_{OH}	HIGH level output voltage		V_{DD} -0.5			V
V_{OL}	LOW level output voltage				0.4	V
C_L	Output load capacitance	HCMOS	3	15	47	pF
t_r / t_f	Rise & fall time	F = 32.768 kHz, C_L = 15 pF, 20% to 80% V_{DD}			150	ns
		F ≤ 20 MHz, C_L = 15 pF, 20% to 80% V_{DD}			7	
		F > 20 MHz, C_L = 15 pF, 10% to 90% V_{DD}			3	

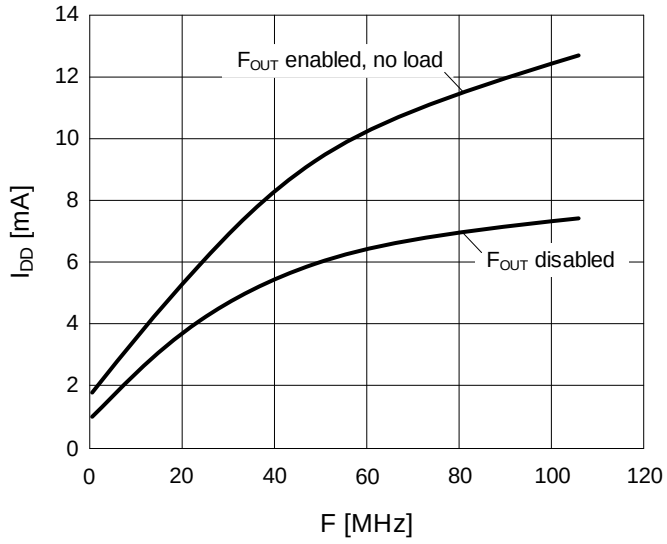
(1) A 47 nF decoupling capacitor has to be connected between V_{DD} and GND.
(2) 5.0 V version not available for low jitter version (F).

3.3. TYPICAL CHARACTERISTICS

Supply current I_{DD} vs. Frequency F: T_A = 25°C, V_{DD} = 3.3 V



Supply current I_{DD} vs. Frequency F: T_A = 25°C, V_{DD} = 5.0 V



3.4. OSCILLATOR PARAMETERS

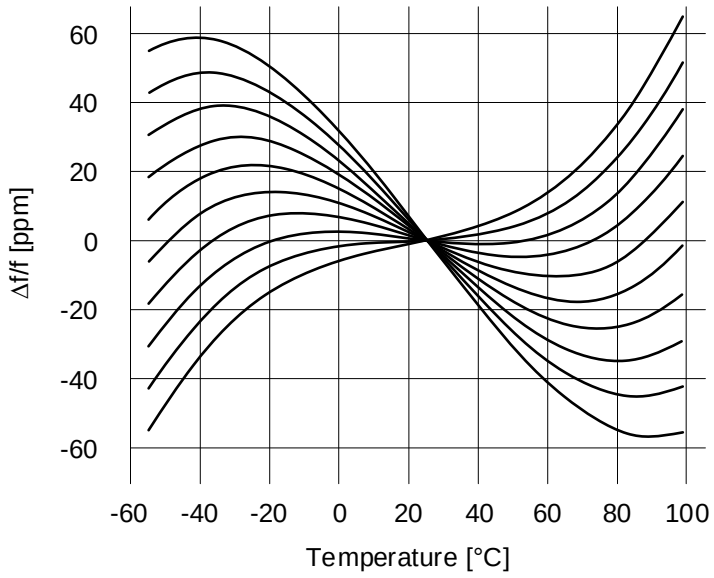
For this Table, V_{DD} = nominal voltage; GND = 0 V; T_A = 25 °C; unless otherwise indicated.

Oscillator Parameters:

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
General						
F	Frequency range		0.01		225	MHz
t_{START}	Oscillator start-up time			1	5	ms
δ_{FOUT}	F_{OUT} duty cycle @ $V_{DD}/2$		40		60	%
Frequency Characteristics						
ΔF/F	**Overall frequency stability over temperature range** (see ORDERING INFORMATION) Standard version (1) T version (2)	Including adjustment at +25°C, V_{DD} variations ±5% and C_L variations min. to max.			 ±100 ±50	ppm
Low jitter version F						
t_{RMS}	One-sigma jitter	F ≤ 20 MHz			2	ps RMS
		F > 20 MHz			10	ps RMS

(1) Including long term aging 10 years.
(2) Including long term aging 1 year.

3.4.1.FREQUENCY VS. TEMPERATURE CHARACTERISTICS



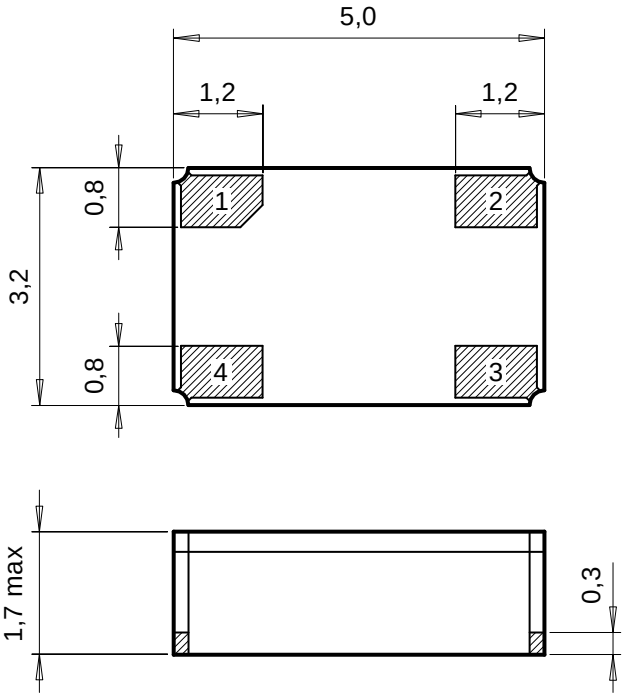
4. PACKAGE

4.1. DIMENSIONS AND SOLDER PAD LAYOUT

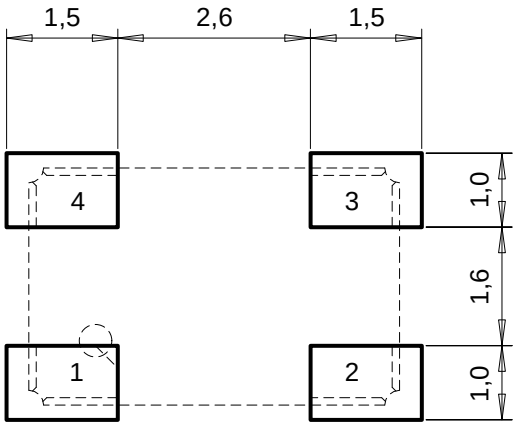
4.1.1.PACKAGE WITH CERAMIC LID

MCSO2 Package with Ceramic lid (Blank):

Package dimensions (bottom view):



Recommended solder pad layout:



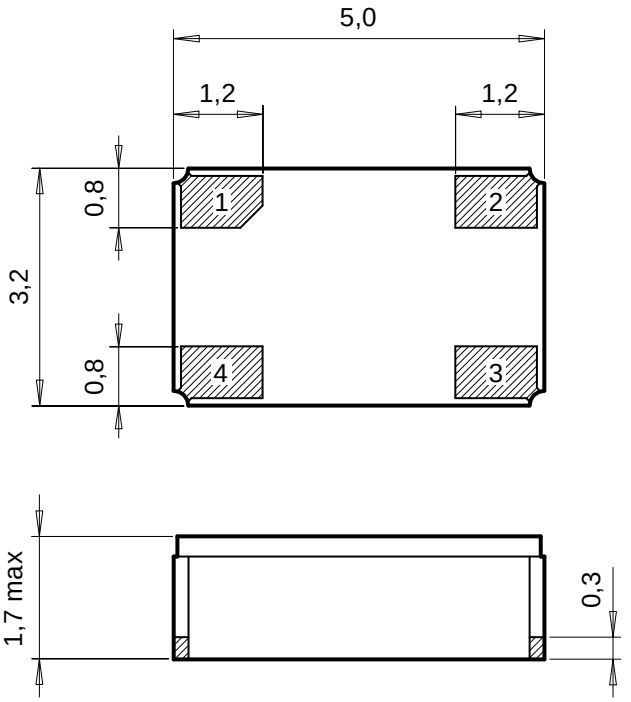
Tolerances: unless otherwise specified ±0.1 mm
Drawing: MCSO2_Ceramic_Pack-drw_20210608

All dimensions in mm typical.

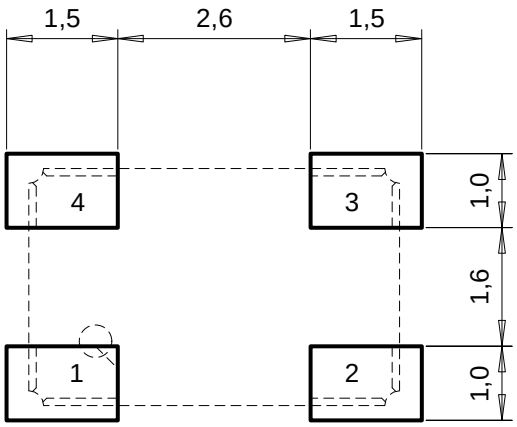
4.1.2.PACKAGE WITH METAL LID

MCSO2 Package with Metal lid (K):

Package dimensions (bottom view):



Recommended solder pad layout:

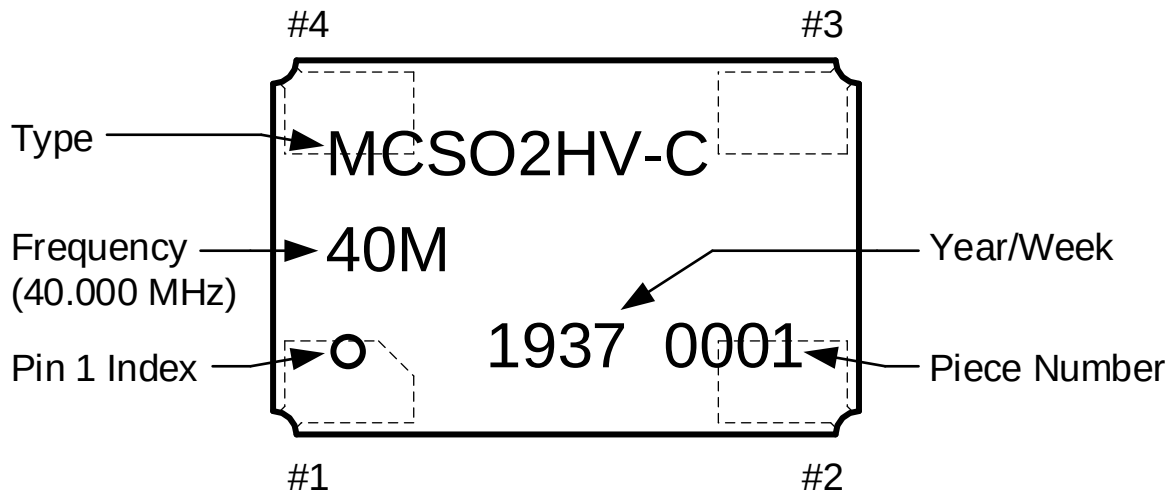


Tolerances: unless otherwise specified ±0.1 mm
Drawing: MCSO2_Metal_Pack-drw_20210608

All dimensions in mm typical.

4.2. MARKING AND PIN #1 INDEX

Laser marking MCSO2 Package: (top view)

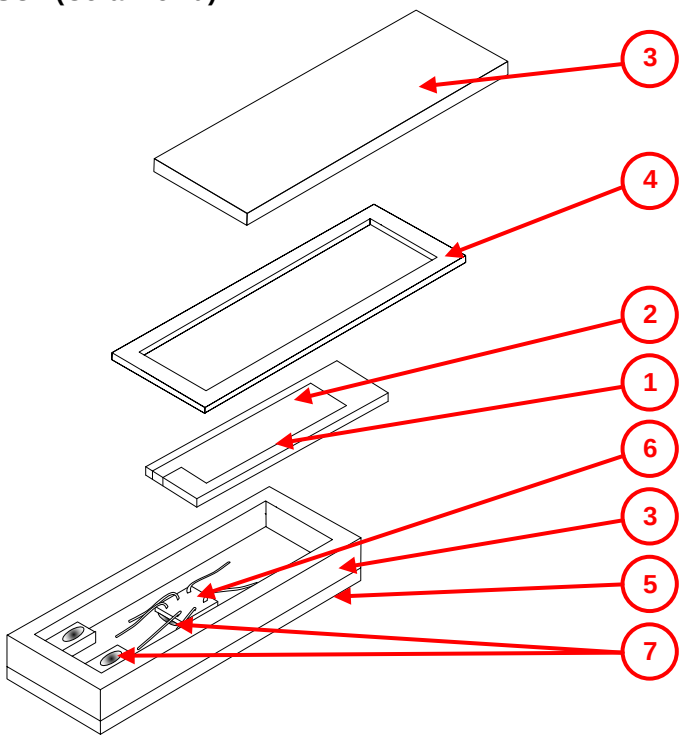


5. MATERIAL COMPOSITION DECLARATION & ENVIRONMENTAL INFORMATION

5.1. HOMOGENOUS MATERIAL COMPOSITION DECLARATION (CERAMIC LID)

Homogenous material information according to IPC-1752 standard

Material Composition MCSO2 (Ceramic lid):



(Symbolic drawing)

No.	Item Component Name	Sub Item Material Name	Material Weight (mg)	(%)	Substance Element	CAS Number	Comment
1	Resonator	Quartz Crystal	3.7	100%	SiO_2	14808-60-7	
2	Electrodes	Cr+Au	0.2	5%	Cr	Cr: 7440-47-3	
				95%	Au	Au: 7440-57-5	
3	Housing	Ceramic	63.1	100%	Al_2O_3	1344-28-1	
4	Seal	Solder Preform	3.6	80%	Au80 / Sn20	Au: 7440-57-5	
				20%		Sn: 7440-31-5	
5	Terminations	Internal and external terminals	5.1	80%	W	W: 7440-33-7	Tungsten
				15%	Ni	Ni: 7440-02-0	Nickel plating
				5%	Au 0.3 micron	Au: 7440-57-5	Gold plating
6	HCMOS IC	Silicon	1.0	95%	Si	Si: 7440-21-3	
		Die pad plating		1%	Al	Al: 7429-90-5	
		Bonding wires		4%	Al	Al: 7429-90-5	
7	Conductive adhesive	Silver filled Epoxy	1.3	70%	Ag	Ag: 7440-22-4	
				30%	EP	129915-35-1	
		Unit weight typ. ±10%	78				

5.2. RECYCLING MATERIAL INFORMATION (CERAMIC LID)

Recycling material information according to IPC-1752 standard.
Element weight is accumulated and referenced to the unit weight of 78 mg.

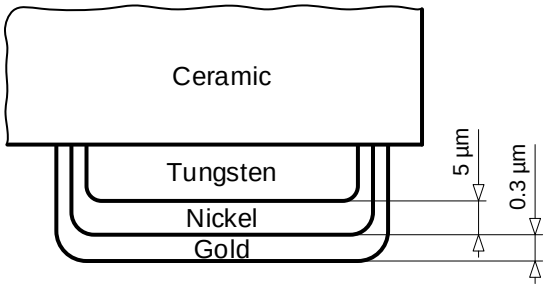
Item Material Name	No.	Item Component Name	Material Weight (mg)	Material Weight (%)	Substance Element	CAS Number	Comment
Quartz Crystal	1	Resonator	3.7	4.74	SiO_2	14808-60-7	
Chromium	2	Electrodes	0.01	0.013	Cr	Cr: 7440-47-3	
Ceramic	3	Housing	63.1	80.9	Al_2O_3	1344-28-1	
Gold	2 4 5	Electrodes Seal Terminations	3.32	4.26	Au	Au: 7440-57-5	
Tin	4	Seal	0.72	0.92	Sn	Sn: 7440-31-5	
Nickel	5	Terminations	0.77	0.98	Ni	Ni: 7440-02-0	
Tungsten	5	Terminations	4.08	5.23	W	W: 7440-33-7	
Silicon	6a	HCMOS IC	0.95	1.22	Si	Si: 7440-21-3	
Aluminum	6b 6c	HCMOS IC HCMOS IC	0.05	0.06	Al	Al: 7429-90-5	
Silver	7a	Conductive adhesive	0.91	1.17	Ag	Ag: 7440-22-4	
Epoxy	7b	Conductive adhesive	0.39	0.50	EP	129915-35-1	
	Unit weight (total) typ. ±10%		78	100			

5.3. ENVIRONMENTAL PROPERTIES & ABSOLUTE MAXIMUM RATINGS (CERAMIC LID)

Package	Description
DFN-4 ceramic package	Dual Flat No Leads (DFN), hermetically sealed ceramic package with ceramic lid.

Parameter	Directive	Conditions	Value
Product weight (total)			78 mg
Storage temperature		Store as bare product	-65 to +125°C
Moisture sensitivity level (MSL)	IPC/JEDEC J-STD-020D		MSL1
MTTF			> 100 years

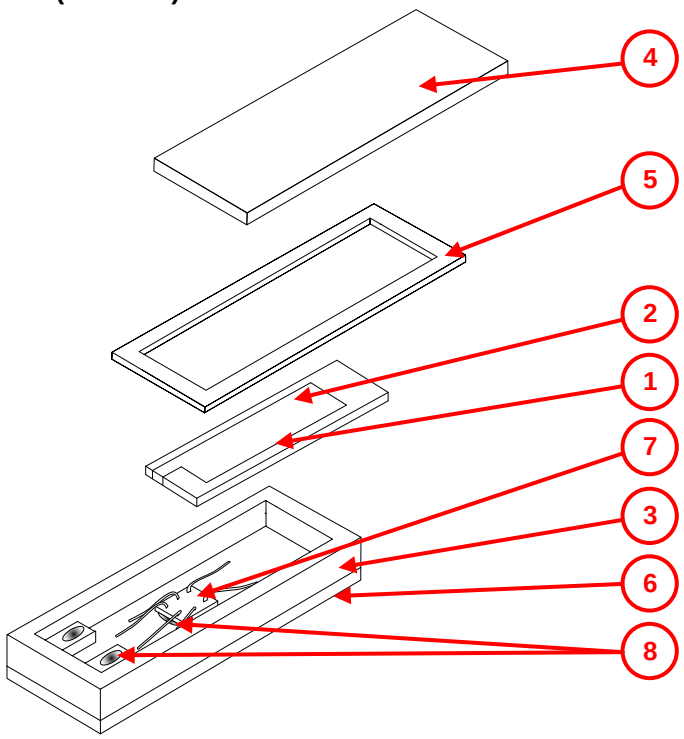
Terminal finish:



5.4. HOMOGENOUS MATERIAL COMPOSITION DECLARATION (METAL LID)

Homogenous material information according to IPC-1752 standard

Material Composition MCSO2 (Metal lid):



(Symbolic drawing)

No.	Item Component Name	Sub Item Material Name	Material Weight (mg)	Material Weight (%)	Substance Element	CAS Number	Comment
1	Resonator	Quartz Crystal	3.7	100%	SiO_2	14808-60-7	
2	Electrodes	Cr+Au	0.2	5%	Cr	Cr: 7440-47-3	
				95%	Au	Au: 7440-57-5	
3	Housing	Ceramic	48.7	100%	Al_2O_3	1344-28-1	
4	Metal Lid	Kovar Lid	32.0	90%	Fe53Ni29Co18	Fe: 7439-89-6 Ni: 7440-02-0 Co: 7440-48-4	
		Ni-plating		9%	Ni	Ni: 7440-02-0	Nickel plating
		Au-plating		1%	Au	Au: 7440-57-5	Gold plating
5	Seal	Solder Preform	3.6	80%	Au80 / Sn20	Au: 7440-57-5	
				20%		Sn: 7440-31-5	
6	Terminations	Internal and external terminals	3.5	80%	W	W: 7440-33-7	Tungsten
				15%	Ni	Ni: 7440-02-0	Nickel plating
				5%	Au 0.3 micron	Au: 7440-57-5	Gold plating
7	HCMOS IC	Silicon	1.0	95%	Si	Si: 7440-21-3	
		Die pad plating		1%	Al	Al: 7429-90-5	
		Bonding wires		4%	Al	Al: 7429-90-5	
8	Conductive adhesive	Silver filled Epoxy	1.3	70%	Ag	Ag: 7440-22-4	
				30%	EP	129915-35-1	
		Unit weight typ. ±10%	94				

5.5. RECYCLING MATERIAL INFORMATION (METAL LID)

Recycling material information according to IPC-1752 standard.
Element weight is accumulated and referenced to the unit weight of 94 mg.

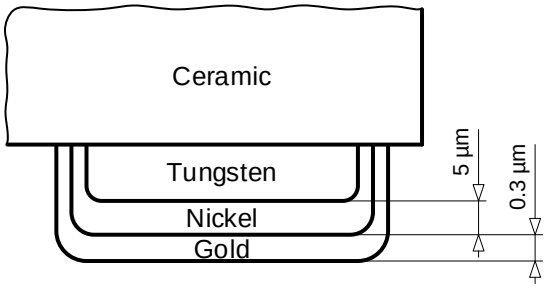
Item Material Name	No.	Item Component Name	Material Weight (mg)	Material Weight (%)	Substance Element	CAS Number	Comment
Quartz Crystal	1	Resonator	3.7	3.94	SiO_2	14808-60-7	
Chromium	2	Electrodes	0.01	0.011	Cr	Cr: 7440-47-3	
Ceramic	3	Housing	48.7	51.8	Al_2O_3	1344-28-1	
Gold	2 4 5 6	Electrodes Metal Lid Seal Terminations	3.56	3.79	Au	Au: 7440-57-5	
Tin	5	Seal	0.72	0.77	Sn	Sn: 7440-31-5	
Nickel	4 6	Metal Lid (Plating) Terminations	3.41	3.62	Ni	Ni: 7440-02-0	
Tungsten	6	Terminations	2.80	2.98	W	W: 7440-33-7	
Kovar	4	Metal Lid	28.8	30.6	Fe53Ni29Co18	Fe: 7439-89-6 Ni: 7440-02-0 Co: 7440-48-4	
Silicon	7a	HCMOS IC	0.95	1.01	Si	Si: 7440-21-3	
Aluminum	7b 7c	HCMOS IC HCMOS IC	0.05	0.05	Al	Al: 7429-90-5	
Silver	8a	Conductive adhesive	0.91	0.97	Ag	Ag: 7440-22-4	
Epoxy	8b	Conductive adhesive	0.39	0.41	EP	129915-35-1	
	Unit weight (total) typ. ±10%		94	100			

5.6. ENVIRONMENTAL PROPERTIES & ABSOLUTE MAXIMUM RATINGS (METAL LID)

Package	Description
DFN-4 ceramic package	Dual Flat No Leads (DFN), hermetically sealed ceramic package with metal lid.

Parameter	Directive	Conditions	Value
Product weight (total)			94 mg
Storage temperature		Store as bare product	-65 to +125°C
Moisture sensitivity level (MSL)	IPC/JEDEC J-STD-020D		MSL1
MTTF			> 100 years

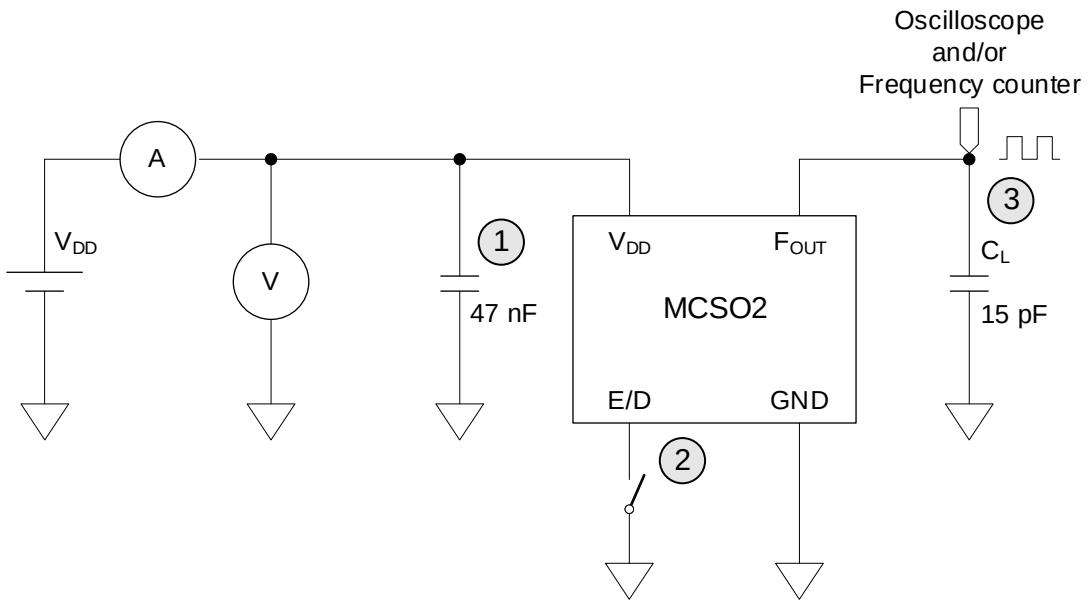
Terminal finish:



6. APPLICATION INFORMATION

6.1. TEST CIRCUIT

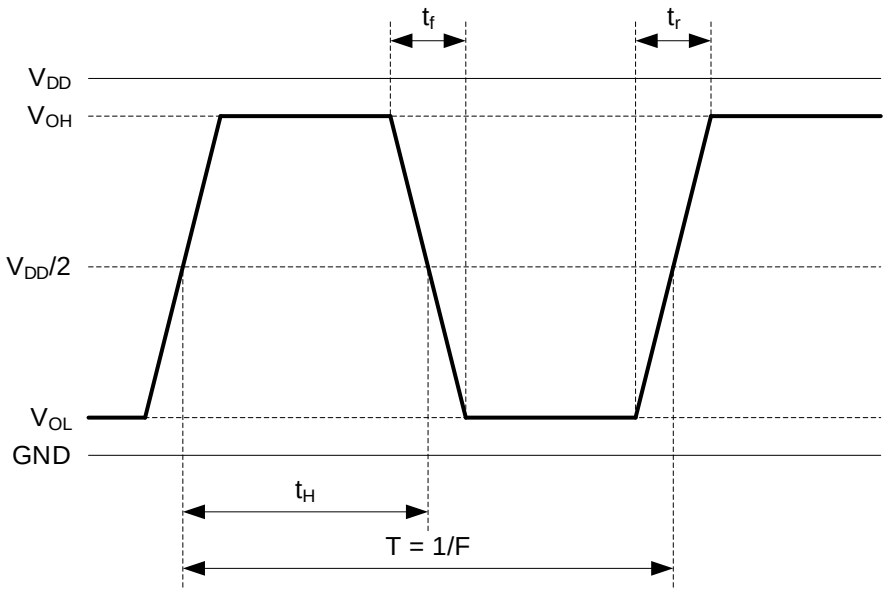
Test circuit HCMOS:



1. A 47 nF decoupling capacitor is recommended close to the device.
2. If E/D is HIGH or floating (V_{IH} or open), the F_{OUT} pin is in output mode. When E/D is tied to Ground (V_{IL}), the F_{OUT} pin is disabled (Hi-Z).
   No E/D function before V_{DD} is set.
3. C_L includes probe and fixture capacitance.

6.2. OUTPUT WAVEFORM

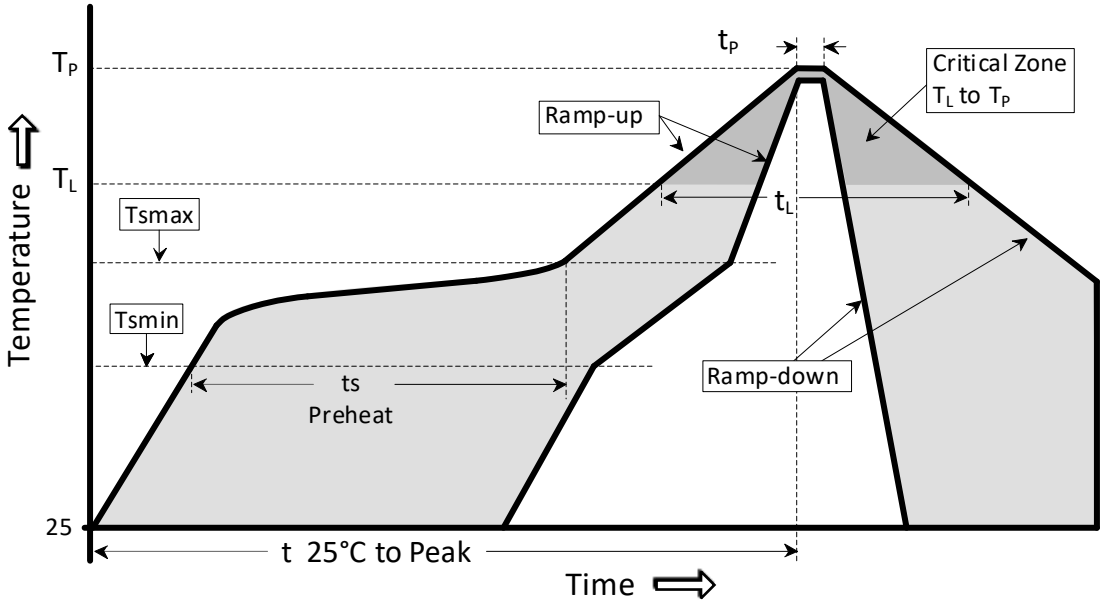
Output waveform HCMOS:



$$\text{Duty cycle} = \frac{t_H}{T} 100\ [\%]$$

6.3. SOLDERING INFORMATION

Maximum Reflow Conditions in accordance with IPC/JEDEC J-STD-020C "Pb-free"



Temperature Profile	**Symbol**	**Condition**	**Unit**
Average ramp-up rate	(Ts_{max} to T_P)	3°C / second max	°C / s
Ramp down Rate	T_{cool}	6°C / second max	°C / s
Time 25°C to Peak Temperature	$T_{to\text{-}peak}$	8 minutes max	min
Preheat			
Temperature min	Ts_{min}	150	°C
Temperature max	Ts_{max}	200	°C
Time Ts_{min} to Ts_{max}	ts	60 – 180	sec
Soldering above liquidus			
Temperature liquidus	T_L	217	°C
Time above liquidus	t_L	60 – 150	sec
Peak temperature			
Peak Temperature	Tp	260	°C
Time within 5°C of peak temperature	tp	20 – 40	sec

6.4. HANDLING PRECAUTIONS FOR MODULES WITH EMBEDDED CRYSTALS

The built-in AT-cut crystal consists of pure Silicon Dioxide in crystalline form. The cavity inside the package is evacuated and hermetically sealed in order for the crystal blank to function undisturbed from air molecules, humidity and other influences.

Shock and vibration:

Keep the crystal / module from being exposed to **excessive mechanical shock and vibration**. Micro Crystal guarantees that the crystal / module will bear a mechanical shock of 5000 g / 0.3 ms.

The following special situations may generate either shock or vibration:

Multiple PCB panels - Usually at the end of the pick & place process the single PCBs are cut out with a router. These machines sometimes generate vibrations on the PCB that have a fundamental or harmonic frequency close to the resonance frequency of the crystal unit. This might cause breakage of crystal blanks due to resonance. Router speed should be adjusted to avoid resonant vibration.

Ultrasonic cleaning - Avoid cleaning processes using ultrasonic energy. These processes can damage the crystals due to the mechanical resonance frequencies of the crystal blank.

Overheating, rework high temperature exposure:

Avoid overheating the package. The package is sealed with a seal ring consisting of 80% Gold and 20% Tin. The eutectic melting temperature of this alloy is at 280°C. Heating the seal ring up to >280°C will cause melting of the metal seal which then, due to the vacuum, is sucked into the cavity forming an air duct. This happens when using hot-air-gun set at temperatures >280°C.

Use the following methods for rework:

- Use a hot-air-gun set at 270°C.
- Use 2 temperature controlled soldering irons, set at 270°C, with special-tips to contact all solder-joints from both sides of the package at the same time, remove part with tweezers when pad solder is liquid.

7. COMPLIANCE INFORMATION

Micro Crystal confirms that the standard product Clock Oscillator MCSO2 is compliant with “EU RoHS Directive” and “EU REACh Directives”.
Please find the actual Certificate of Conformance for Environmental Regulations on our website:
CoC_Environment_MCSO-Series.pdf

8. DOCUMENT REVISION HISTORY

Date	Revision #	Revision Details
September 2016	2.0	Initial version
August 2021	3.0	New extended version

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