ROD2522S2

The ROD2522S2 is a 0.5 ppb pk-pk PPS OCXO for telecommunications applications. Taking advantage of Rakon's proprietary smart compensation techniques and unique circuitry design, the ROD2522S2 delivers a 24-hour holdover (1.5 µs) across 4°C temperature windows.

The ROD2522S2 is the first 25 x 22 mm SMD oscillator that is able to provide 24-hour holdover performance.

The device accepts a primary reference traceable clock and, using advanced compensation algorithms, compensates for ageing related frequency variations dynamically. Taking advantage of the thermo-mechanical construction, the advanced package design extends the product's operating temperature range from -40°C up to 95°C. Its compensated frequency ageing is as low as 0.02 ppb/day. These unique features make the ROD2522S2 an ideal solution where 24-hour holdover, highly accurate and precise frequency stability are critical.

Key specifications

- Frequency (Fn): 10, 12.8 or 20 MHz
- Holdover: 24-hour (≤1.5 µs, 4°C external temperature variation)
- Frequency stability (FvT): 0.5 ppb pk-pk
- Operating temperature: -40 to 85°C
- Compensated ageing: ±0.02 ppb/day
- Voltage supply: 3.3 V
- I²C bus device status and commands

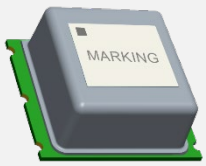
Applications

- Edge grandmasters
- DU/CU/servers
- Cell-site routers
- Front-haul switches
- NIC time cards
- Test equipment
- GNSS modules

25.4 x 22.0 x 12.1 mm

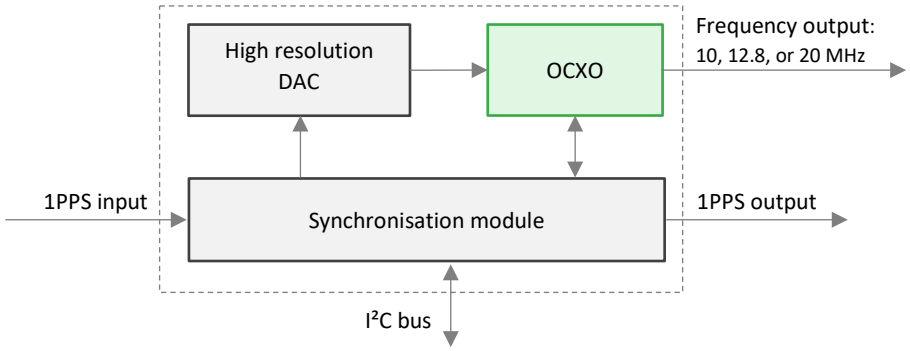
Pb FREE

RoHS COMPLIANT



Block Diagram – 1PPS Input and Free-running Frequency 10, 12.8 or 20 MHz

- 1PPS input and output
- Free-running frequency output



ROD2522S2

1.0 Absolute Maximum Rating[1]

Parameter	Min.	Max.	Unit	Note
a. Storage temperature	-40	+85	°C	
b. Supply voltage (V_{CC})	-0.3	3.6	V	
c. Voltage on PPS input	-0.3	V_{CC} +0.3	V	
d. Voltage at any digital interface pin with respect to GND	-0.3	V_{CC} +0.3	V	
e. Load for HCMOS RF Output		45	pF	
f. Continuous output current for HCMOS RF output		±40	mA	

2.0 Power Supply

Parameter	Min.	Typ.	Max.	Unit	Test Condition / Description
a. Supply voltage (V_{CC})	3.135	3.30	3.465	V	
b. Current consumption			1	A	During warm-up time
c. Current consumption			300	mA	In steady-state & still air at +25°C
d. Power-on recall voltage	2.2			V	Minimum V_{CC} at which memory recall occurs
e. V_{CC} ramp rate	0.2		100	V/ms	

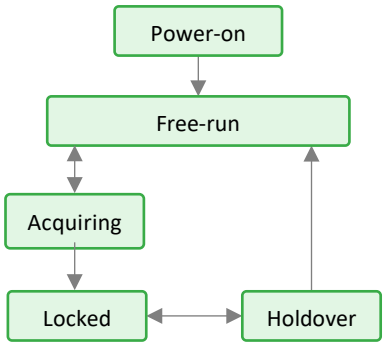
3.0 RF Signal Output – HCMOS

Parameter	Min.	Typ.	Max.	Unit	Test Condition / Description
a. Low level output voltage (V_{OL})			0.4	V	
b. High level output voltage (V_{OH})	2.4			V	
c. Rise and fall times			5	ns	from 10% to 90% output levels, 15pF load
d. Duty cycle	45		55	%	At 50% level
e. Load		15	45	pF	
f. Spurious			-80	dBc	
g. Sub-harmonics			-40	dBc	
h. Start-up time			1	Sec	

[1] Operating beyond this limit may result in change or permanent damage to the device.

4.0 Device Operating States

- Workflow diagram



State	Condition/Description
a. Power-on	This state corresponds to the initial operating state of the device. Stabilisation steps and order of magnitude: • Start-up time: 1 second after powering on the device; frequency signal output is delivered (valid clock pulses), within ppm of final frequency. • Power consumption will stabilise within 3 minutes after powering on at +25°C; that stabilisation is dependent on ambient temperature at the start. • Ageing slope will reach its final performance after recovery time (see 'Recovery' specification section)
b. Free-run	No 1PPS input is available Similar to a stand-alone OCXO delivering its intrinsic performances (no ageing compensation in this state).
c. Acquiring	1pps input must be available to initiate the learning phase 1pps signal input must be present over: • the first 40 seconds and, • 70% minimum of the remaining time, at any time; if those conditions are not met, then back to free-run mode. 1pps output is enabled as soon as 4s after the 1pps input is available. Short time loop. Able to handle system stabilisation. Start computing data for the locked mode. On Hot system (after warm-up time), phase & frequency are tuned within a few minutes (typical 4 minutes). Cold start requires more time for the system to be stable enough (up to 30 minutes maximum at -40°C). When acquisition process is successful: • frequency accuracy is guaranteed within less than 1ppb; • phase is aligned to the 1pps input signal. • Upgrades to 'locked' mode
d. Locked	1pps input available - 1pps output signal enabled. Optimized time loop. Get the best of the GNSS stability and the performances of the OCXO. Acquiring ageing information. Phase is locked, frequency is locked & guaranteed.
e. Holdover	From 'locked' mode, if PPS input becomes unavailable then the device goes into 'holdover' mode • Frequency stability over operating temperature is guaranteed. • After initial warm-up, the system requires 3 days of continuous operation to meet specified long holdover stability. • The compensation mechanism continuously corrects the frequency up to half of the cumulated locked time, with a limit of 12 hours. After which a constant compensation value is applied to the frequency and the OCXO module is in 'free run' mode. • The remaining computed holdover duration value can be checked through the OCXO status register (see § 14.0, register 0x42) In 'holdover' mode, if PPS signal becomes available again then module reverts into 'locked' mode.

5.0 Operating States

Parameter	Free-run	Learning	Learning	Holdover
a. Frequency calibration	Table 1	NA	NA	NA
b. 10 years stability (overall)	Table 1	NA	NA	NA
c. Ageing	Table 1	NA	NA	NA
d. Frequency stability over operating temperature range	Table 1	NA	NA	Table 4
e. Supply voltage stability	Table 1	NA	NA	Table 4
f. Load sensitivity	Table 1	NA	NA	Table 4
g. Acceleration sensitivity	Table 1	NA	NA	Table 4
h. Warm-up time	Table 1	NA	NA	NA
i. Retrace	Table 1	NA	NA	NA
j. Phase noise	Table 1	NA	Table 3	Table 4
k. Short term stability	Table 1	NA	Table 3	Table 4
l. 1PPS input	NA	Table 2	Table 3	NA
m. 1PPS output	NA	Table 2	Table 3	Table 4
n. TIE	NA	NA	NA	Table 4

6.0 Free-run State – Table 1

Parameter	Min.	Typ.	Max.	Unit	Test Condition / Description
a. Nominal frequency		10, 12.8, 20		MHz	
b. Frequency calibration (at +25°C ±2°C)			±100	ppb	At time of shipment, reference to nominal frequency [2]
c. 10 years overall stability			±350	ppb	After stabilisation of the device (14 days of continuous operation)
d. Ageing (at shipment/after recovery time)					See § Recovery
per day			±0.2	ppb	Measured before shipment
per year			±50	ppb	Cumulated (extrapolation)
10 years			±250	ppb	Cumulated (extrapolation)
e. Frequency stability over operating temperature range			0.5	ppb	Peak-to-peak
f. Hysteresis effect			0.3	ppb	Over -40 to +85°C, gradient 1°C/minute
g. Supply voltage stability			±0.5	ppb	Nominal V_{CC} ± 5% variation
h. Load sensitivity			±0.5	ppb	HCMOS: 15pF to 30pF load variation
i. Acceleration sensitivity			±3	ppb/*g*	Vs. static orientation
j. Warm-up time (to ± 10ppb) at +25°C			3	Minutes	Reference to frequency after 1 hour of continuous operation
k. Retrace vs. operating at ambient			±5	ppb	24h on, 24h off, 1h on

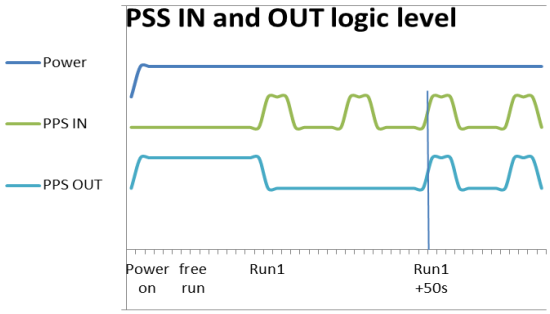
[2] The characteristics of the OCXO may be temporarily affected by the processes of assembly, soldering & powered-off time. The frequency specifications apply 48 hours after assembly. Nominal conditions apply unless otherwise stated.

l. SSB phase noise (offsets, 20MHz)						Static conditions
	1Hz		-94	-84	dBc/Hz	
	10Hz		-120	-114	dBc/Hz	
	100Hz		-140	-134	dBc/Hz	
	1kHz		-145	-139	dBc/Hz	
	10kHz		-150	-144	dBc/Hz	
m. Short term stability (ADEV)						Static conditions
	1s to 100s			3 to 5	ppt	
	1,000s			3 to 7	ppt	
	10,000s			10 to 20	ppt	

7.0 Free-run State – Table 2

Parameter	Min.	Typ.	Max.	Unit	Test Condition / Description
a. Nominal frequency		10, 12.8, 20		MHz	
b. 1PPS input					
Waveform compatibility					HCMOS
Low level input voltage (VIL)	0		1.0	V	
High-level input voltage (VIH)	2.2		V_{CC}	V	
Pulse width	10		10000	µs	
Time deviation (TDEV)		20	90	ns	Tau = 100s to 10,000s
c. 1PPS output (available 30s max. after locking on 1PPS input & over 24h in holdover mode)					
Waveform compatibility					HCMOS
Low level input voltage (VIL)			0.4	V	Load 15pF // 10kΩ min
High level input voltage (VIH)	2.4			V	Load 15pF // 10kΩ min
Pulse width		25		ms	
Rise and fall time		5	10	ns	10% to 90% level, 15pF load

- The phase alignment is done on the positive edge of both pps in and out signals.



8.0 Free-run State – Table 3

Parameter	Min.	Typ.	Max.	Unit	Test Condition / Description
a. Nominal frequency		10, 12.8, 20		MHz	
b. SSB phase noise					Static conditions
1Hz		-100	-90	dBc/Hz	
10Hz		-130	-120	dBc/Hz	
100Hz		-145	-140	dBc/Hz	
1kHz		-150	-145	dBc/Hz	
10kHz		-155	-150	dBc/Hz	
c. Short term stability (ADEV)					Static conditions
Tau = 1,000s			6 to 10	ppt	
Tau = 10,000s			4 to 7	ppt	
d. 1PPS input - Waveform compatibility					HCMOS
Low level input voltage (VIL)	0		1.0	V	
High level input voltage (VIH)	2.2		Vcc	V	
Pulse width	10		10000	µs	
Time deviation (TDEV)					
e. 1PPS output - Waveform compatibility					HCMOS
Low level output voltage (VOL)			0.4	V	Load 15pF // 10kΩ min
High level output voltage (VOH)	2.4			V	Load 15pF // 10kΩ min
Pulse Width		25		ms	
Rise and fall time		5	10	ns	10% to 90% level, 15pF load
PLL accuracy	-50		50	ns	

- Phase alignment is done on the positive edge of both pps in and out signals.

9.0 Free-run State – Table 4

	Parameter	Min.	Typ.	Max.	Unit	Test Condition / Description
a.	Nominal frequency		10, 12.8, 20		MHz	
b.	Frequency stability over -40°C to +85°C			0.5	ppb	Reference to (Fmax - Fmin)
c.	1.5µs holdover performance Constant temperature with 10°C variation (asymmetrical) with 20°C variation (asymmetrical)	 >12 8 6			hours	with gradient of 0.5°C/minute See Figure 1 to Figure 6 for illustration and details.
d.	Supply voltage stability			±0.5	ppb	Nominal VCC ± 5% variation
e.	Load sensitivity			±0.5	ppb	HCMOS: 1 to 2 loads (15pF)
f.	Acceleration sensitivity			±3	ppb/g	Vs static orientation
g.	SSB phase noise					Static conditions
	1Hz		-100	-90	dBc/Hz	
	10Hz		-130	-120	dBc/Hz	
	100Hz		-145	-140	dBc/Hz	
	1kHz		-150	-145	dBc/Hz	
	10kHz		-155	-150	dBc/Hz	
h.	Short term stability (ADEV)					Static conditions
	Tau = 1s to 1,000s			3 to 7	ppt	
	Tau = 10,000s			6 to 10	ppt	
i.	1PPS output					Available over 24 hours max. from holdover mode start
	Waveform compatibility					HCMOS
	Low level output voltage (V_{OL})			0.4	V	Load 15pF // 10kΩ min
	High level output voltage (V_{OH})	2.4			V	Load 15pF // 10kΩ min
	Pulse Width		50		ms	
	Rise and fall time		5	10	ns	10% to 90% level, 15pF load

Holdover Mode Continued

TIE (Time Interval Error):	All following plots show TIE assuming frequency error is nil at the start of the holdover sequence, since this error is corrected at system level. Figure 1 to Figure 6 show expected performance with baseline ROD2522S2 module. ROD2522S2's holdover duration is limited to 12 hours.

Figure 1 – Simulated worst case TIE in holdover – 3°C ramp, 0.83°C/hour

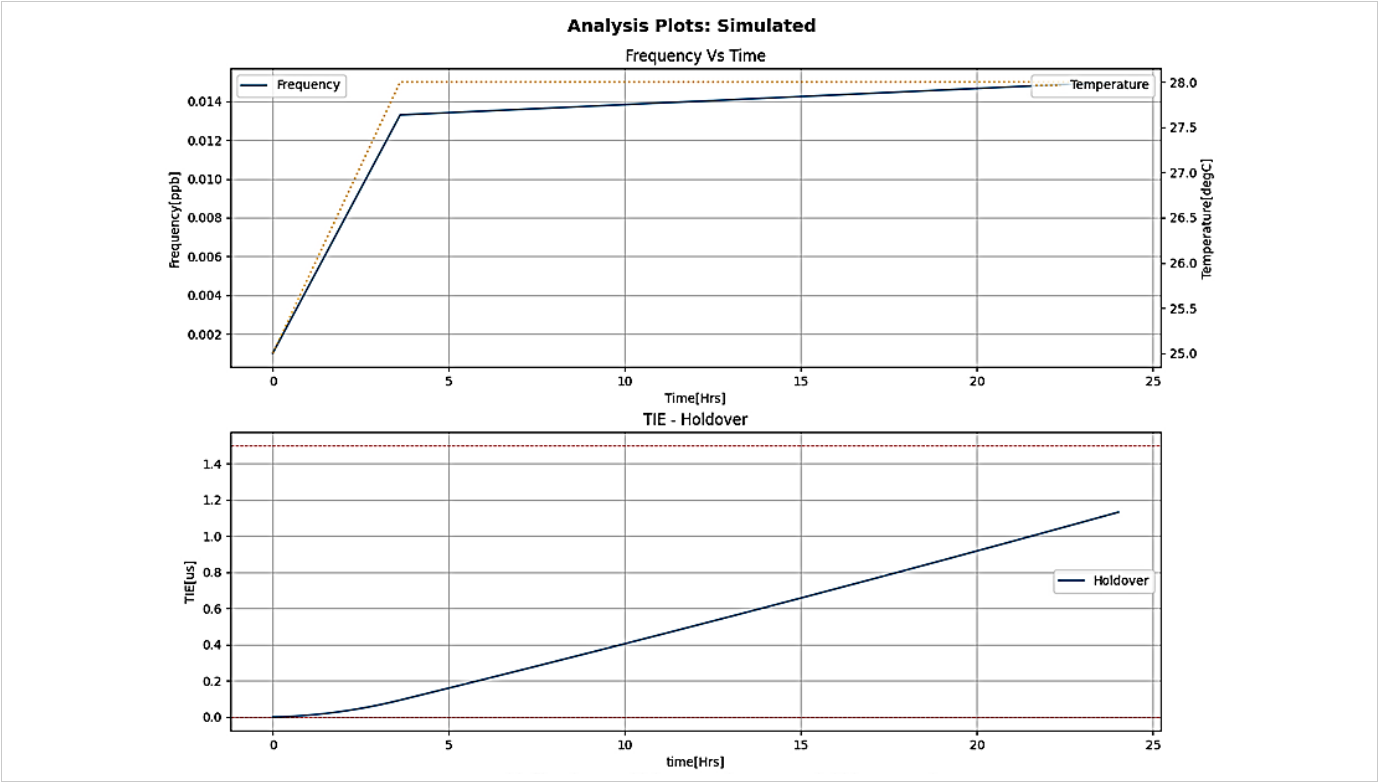


Figure 2 – Simulated worst case TIE in holdover – 4°C ramp, 0.83°C/hour

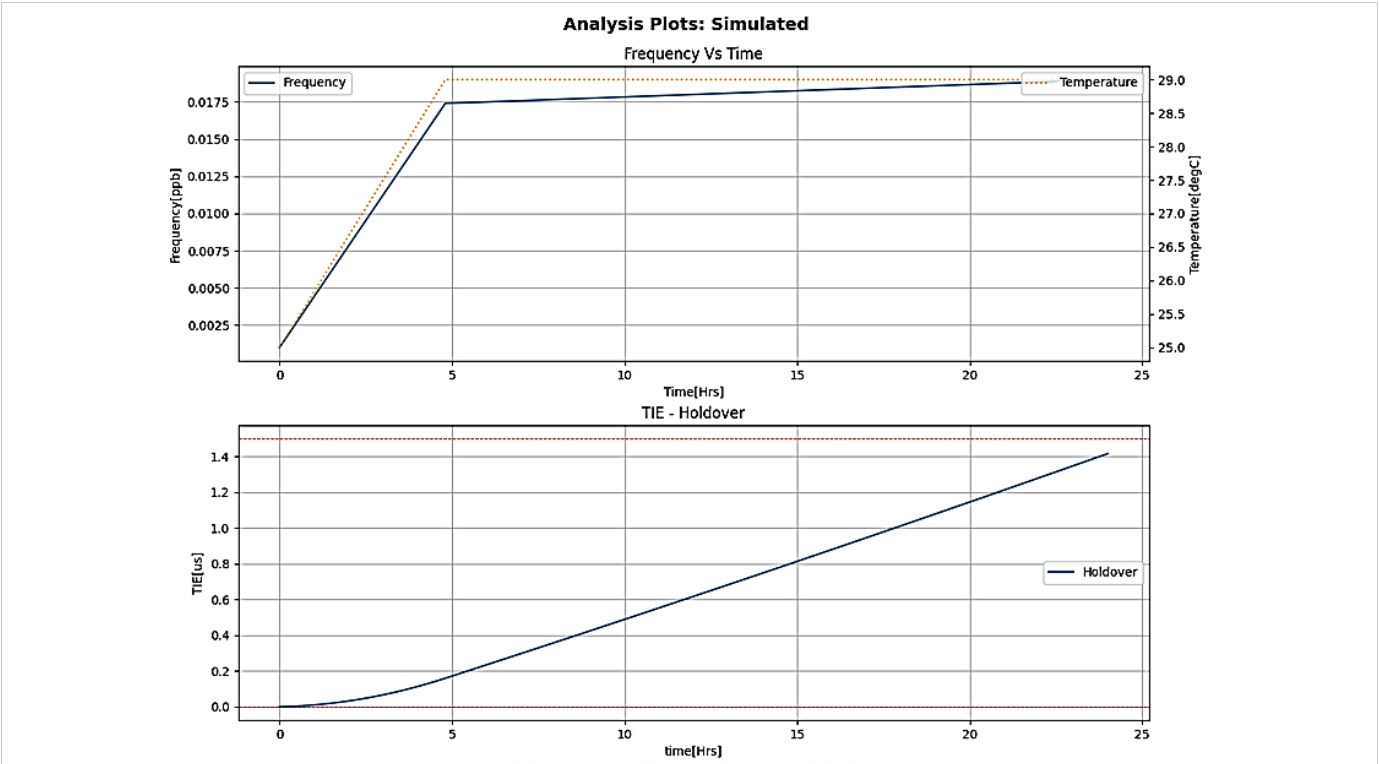


Figure 3 – Simulated worst case TIE in holdover – 5°C ramp, 0.83°C/hour

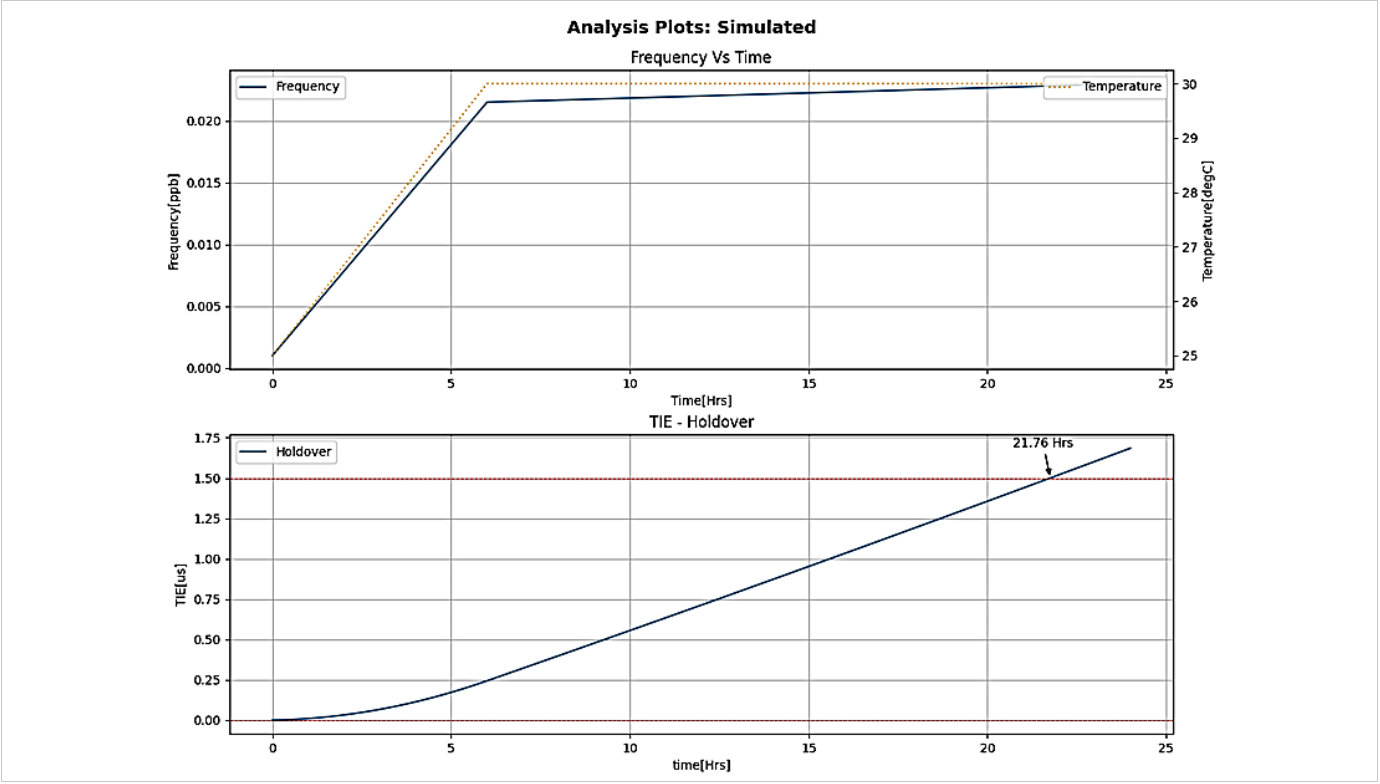


Figure 4 – Simulated worst case TIE in holdover – 10°C ramp, 0.83°C/hour

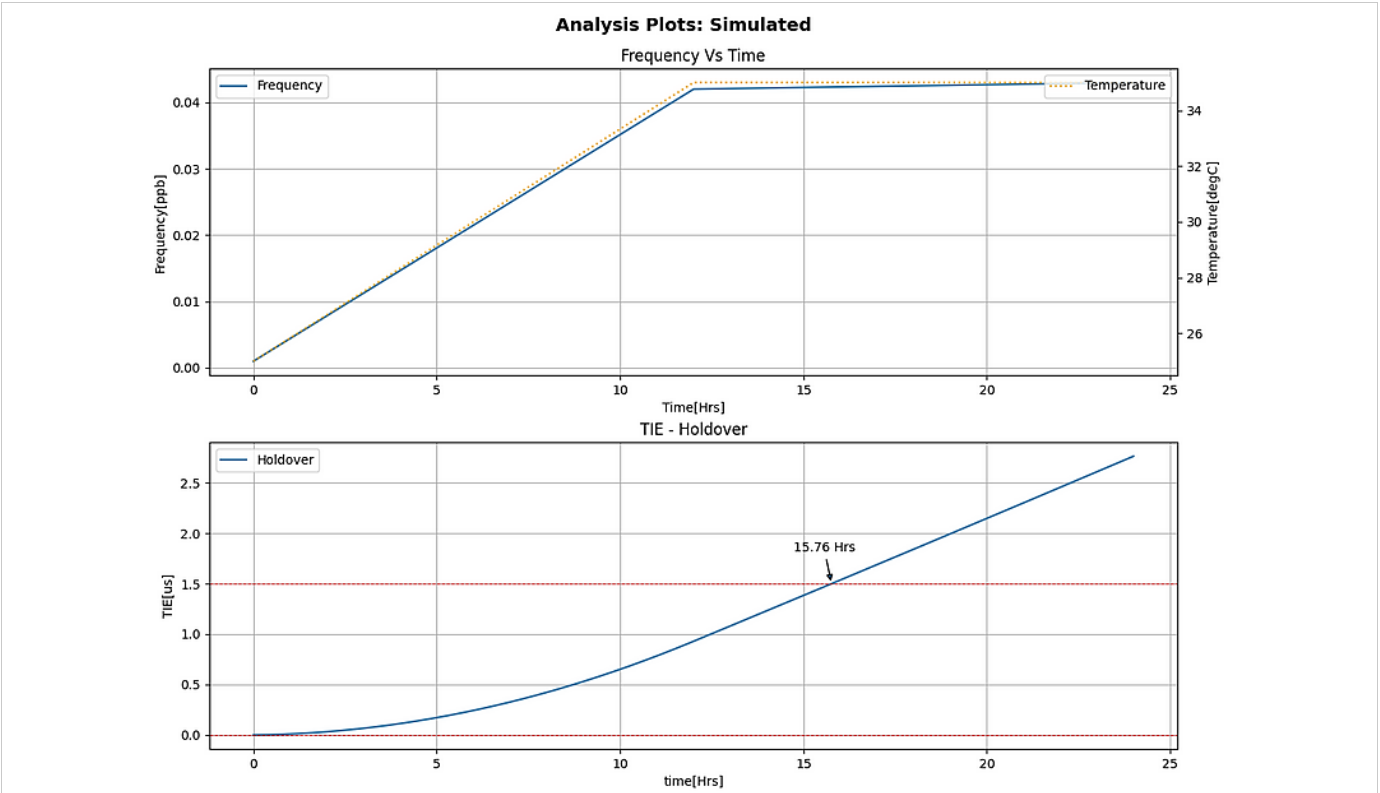


Figure 5 – Simulated worst case TIE in holdover – 5°C up/down ramps, 0.5°C/minute

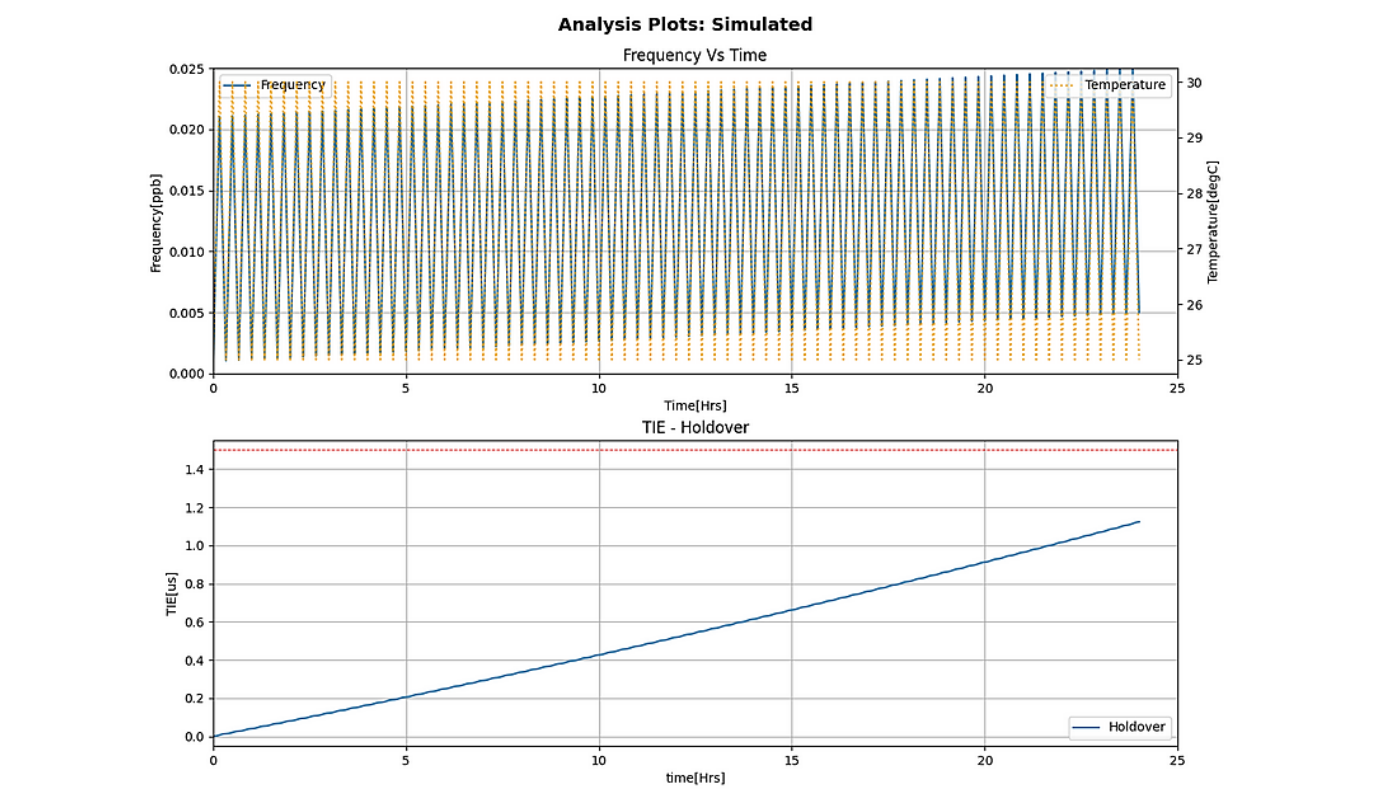
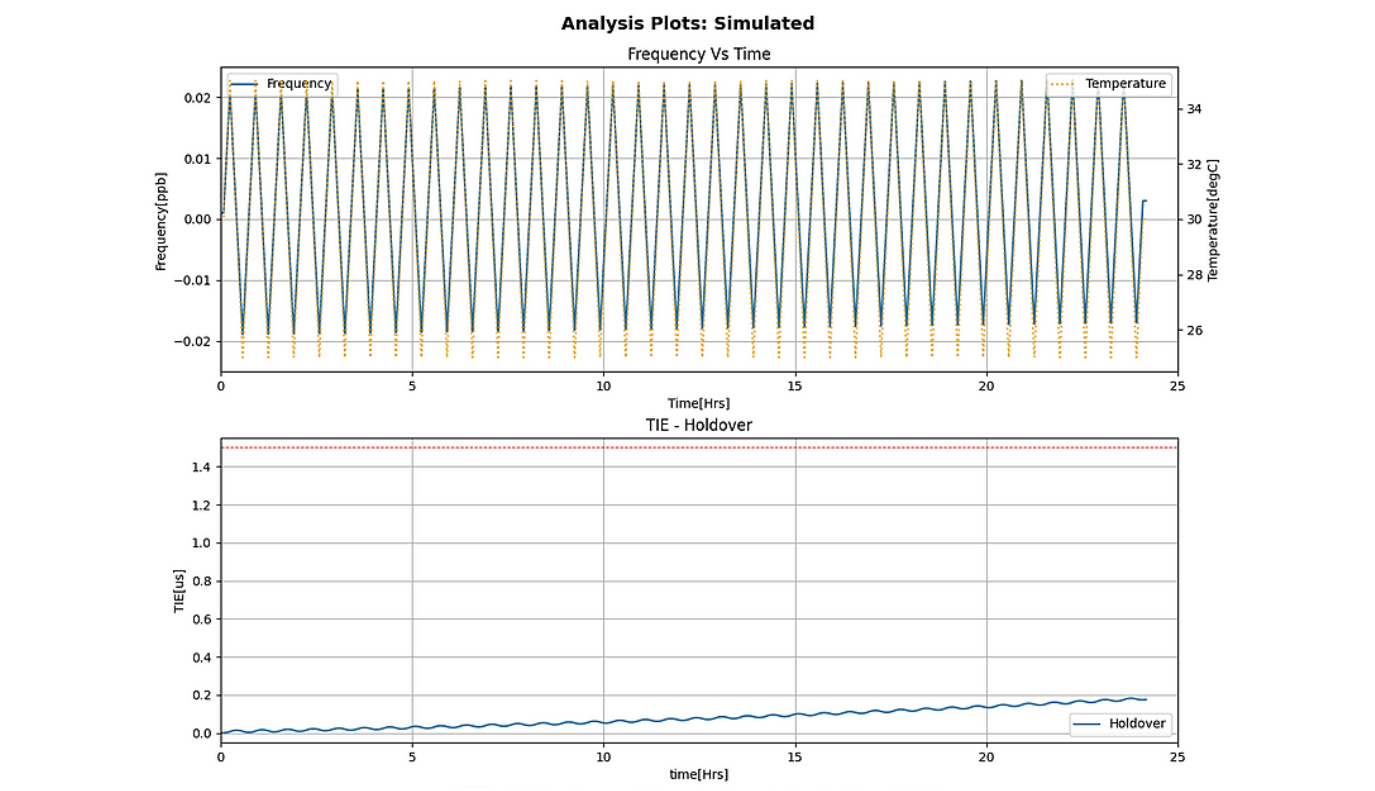


Figure 6 – Simulated worst case TIE in holdover – 10°C up/down ramps, 0.5°C/minute



10.0 I²C Bus Interface

Signal Name	Type	Function	Notes	Logic Levels
a. I²C data	Open drain	Serial data	Min 2kΩ external pull-up resistor, conforms to UM10204 NXP I²C bus specification	2.1V < V_{IH} (High) < 3.3V V_{IL} (Low) < 0.4V
b. I²C clock	Open drain	Serial clock	Min 2kΩ external pull-up resistor, conforms to UM10204 NXP I²C-bus specification	2.1V < V_{IH} (High) < 3.3V V_{IL} (Low) < 0.4V
c. Frequency			100kBit/s min - 400kBit/s max	
Note:	At start up, the module performs a self-calibration process after it detects one pulse on 1PPS input. The self-calibration process may last 1 minute maximum. During this time the I²C is not available.			

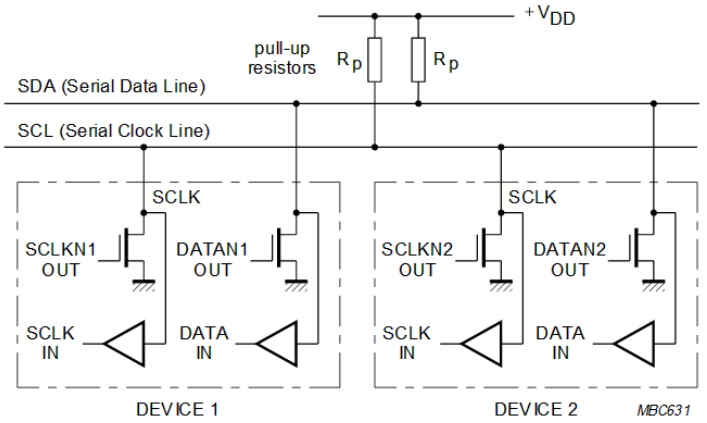
11.0 I²C Communication Conditions

I²C is not able to communicate in full-duplex mode, i.e. TX and RX are mutually exclusive. Rakon PPS Module acts as a slave in the communication setup, therefore they cannot initiate data transfers on their own. The host, which is always the master, provides the data clock (SCL), and the clock frequency is therefore not configurable on the slave.

The I²C module is compliant with the NXP Inter-IC bus (I²C bus) specification version 2.1. Fast mode up to 400 kbit/s. Fast-mode devices are downwards compatible i.e. they can be used in a 0 to 100 kbit/s Standard I²C bus system.

Only two bus lines and a ground reference are required; a serial data line (SDA) and a serial clock line (SCL). The number of ICs that can be connected to the same bus is limited only by a maximum bus capacitance of 400 pF.

The master must handle the clock stretching feature as stated in the NXP Inter-IC bus (I²C bus) specification version 2.1 as I²C data might be delayed in case of critical timing sensitive computation.

Connection of standard and fast-mode devices to the I²C bus	

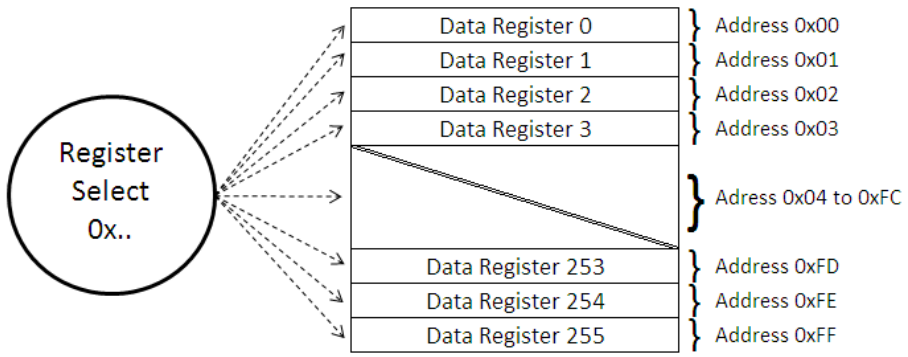
It is generally known that the I²C bus can hang if an I²C master is removed from the bus in the middle of a data read. This can occur because the I²C protocol does not mandate a minimum clock rate. Therefore, if a master is reset in the middle of a read while a slave is driving the data line low, the slave will continue driving the data line low while it waits for the next clock edge.

This prevents bus masters from initiating transfers. If this condition is detected, the following three steps will clear the bus hang condition:

1. An I²C master must generate up to 9 clock cycles.
2. After each clock cycle, the data pin must be observed to determine whether it has gone high while the clock is high.
3. As soon as the data pin is observed high, the master can initiate a start condition.

The receiver's I²C address is set to **0xE0** by default. This address can be changed on request.

The I²C interface allows 256 slave registers to be addressed. As shown in Figure *I²C Register Layout* only a few of these are currently implemented. Others are reserved for future uses or internal computation and must not be addressed.

I²C bus register layout	

Register Detail

The next section contains information about the Rakon module register.

Slave Register:	Refers to the address that has to be sent after the I²C slave address to select the desired register.
Description:	Name and function of the register.
Firmware:	Details on the firmware revision the register is supported on.
Comment:	Additional information regarding the register or the data it represents.
Message Info:	Number of bytes to be read and data type of the data register.

Slave Register	**0x3E**		
Description	Read Temperature Sensor		
Firmware	1.4+		
Comment	Represents an image of the external temperature seen by the module. The value can vary from Ox0000 to Ox0FFF, negative slope		
Message Info	# bytes	Datatype	
	2	U-Short	

Slave Register	**0x41**		
Description	Read Frequency Control		
Firmware	1.4+		
Comment	Range can swing from Ox00000000 to Ox000C8320. 8E-13 typical frequency variation per step		
Message Info	# bytes	Datatype	
	4	U-Long	

Slave Register	**0x42**		
Description	Read Status		
Firmware	1.4+		
Comment	Gives information regarding the state of the module and other parameters. Refer to Figure Status Details for more informations.		
Message Info	# bytes	Datatype	
	2	Char	

Slave Register	**0x50**		
Description	Read Product Identification		
Firmware	1.4+		
Comment	Product traceability information ASCII format		
Message Info	# bytes	Datatype	

	64	Char	

Slave Register	**0x51**		
Description	Read firmware revision		
Firmware	1.4+		
Comment	Includes the name, version revision, release date and special parameters. ASCII format		
Message Info	# bytes	Datatype	
	64	Char	

Slave Register	**0x52**		
Description	Read Relative Time Interval Error		
Firmware	1.4+		
Comment	Time Interval Error in nanosecond with an offset of +2000ns. Only available when system is locked and phase measurement is available. When there is no PPS measurement, system phase equivalent ageing is displayed. Ox0000 to Ox0FFF		
Message Info	# bytes	Datatype	
	2	U-Short	

Slave Register	**0x94**	
Description	Read ON duration	
Firmware	2.2+	
Comment	Return the actual ON time since last OCXO start-up Value in seconds	
Message Info	# bytes	Datatype
	4	U-Long

Slave Register	**0x95**	
Description	Read Holdover duration	
Firmware	2.2+	
Comment	Return the current holdover duration Value in seconds	
Message Info	# bytes	Datatype
	4	U-Long

Status Detail

The status channel is a bitfield, as shown below:

Byte MSB								Byte LSB						
0	0	0	0	0	0	0	0	**0**	/P.Out	Syst.F	**1**	HV	Lock Status	IsPPS

MSB byte is always 0x00

0	Must be 0 for normal operation.
/P.Out	0 : PPS ready and available on PPS_Out Pin 1: PPS not ready and not available on PPS_Out Pin D.
Syst.F	System Fail check. If PPS has been provided.
1	Must be 1 for normal operation.
HV	1 : Holdover state, no PPS detected. 0 : not in Holdover state, PPS detected

Lock Status	b00 : System just started (power on mode, free run mode) b01 : 30s to 30mn since system started – Stabilization (run1 mode) b10 : System ready for use (Run2 mode)
IsPPS	Is there a valid PPS input? 0: No / 1: Yes

Write Access

The receiver does not provide any write access.

12.0 Marking

Parameter	Test Condition / Description
a. Type	Label
b. Line 1	[Manufacturer identifier] RAKON
c. Line 2	[Part Number][3] SPT####LF
d. Line 3	[Nominal Frequency] E.g., 20MHz
e. Line 4	[Serial Number] 1 Letter + 5 Numerals - SN: L12345 | Batch info
f. Line 5	[Manufacturing Date Code] 4 digits for Year & Week code - DC: YyWw
QR code	[QR code] Batch information 

13.0 Environmental Specification

Parameter	Min.	Typ.	Max.	Unit	Test Condition / Description
a. Operating temperature range	-40		+85	°C	Temperature gradient ≤ ± 0.5°C/minute, airflow speed between 1m/s and 3 m/s
b. Relative Humidity	5		95	%	
c. Air Pressure	70		106	kPa	

14.0 Quality and Reliability Requirements[4]

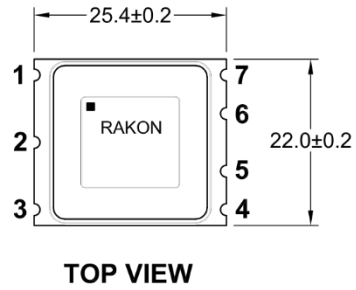
Parameter	Test Condition / Description
a. RoHS compliant	Parts are fully compliant with the European Union directives 2002/95/EC and 2011/65/EU on the restriction of the use of certain hazardous substances in electrical and electronic equipment; with exemption 7(c)-1. Note the RoHS compliant parts are suitable for assembly using both Lead-free solders and Tin/Lead solders.
b. Vibration	Mechanical vibration (JESD22-B-103B, MIL-STD-883 Cond. A) From 20Hz to 2kHz / 4 minutes per orthogonal axis with 20*g* acceleration
c. Shocks	Mechanical shocks (JESD22-B-104C, MIL-STD-202 meth 213 Cond. C) 6 shocks per direction with 100*g* acceleration - 6ms duration - 6 orthogonal directions
d. Electro-static discharge	ESD-CDM (JSESD22-C101 class C1 / 500V) ESD-HBM (JESD22-A114-F / 2000V)
e. Latch-Up Test (LUT)	JESD78 Class II Forced current limits ± 100mA

[3] Part Number Convention

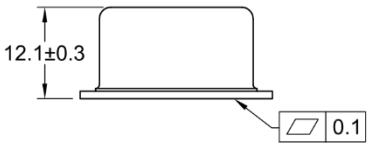
[4] Qualification, not operational

f.	High Temperature Operating Life (HTOL) test	HTOL over 1000hours at +125°C / V_{CC}=+3.5V
g.	High Temperature Storage (HTS)	HTS over 1000 hours at +125°C
h.	Low Temperature Storage (LTS)	LTS at -40°C 100 hours
i.	Temperature Cycling Test (TCT)	TCT from -40°C to +125°C (JESD22-A-104) 500 cycles - 10 minutes Soak time with 2 cycles per hour – transfer ≤ 1 minute
j.	MSL	MSL-3

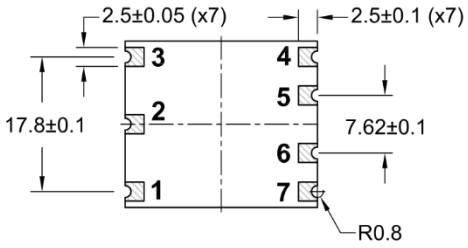
15.0 Model Outline



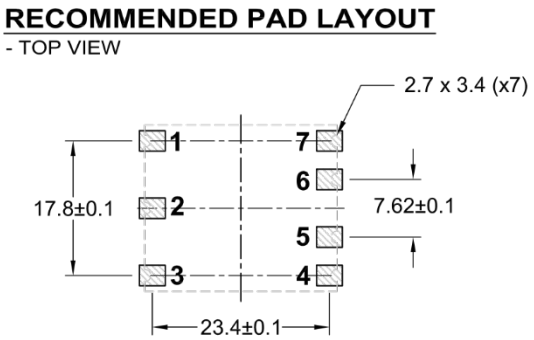
TOP VIEW



FRONT VIEW



BOTTOM VIEW



NOTE

- Planarity of the bottom PCB ≤0.15mm typicao ≤0.1mm / PCB interfacing with customer's board
- No via, no trace on bottom side
- Unit: mm. Tolerance is ±0.2 mm if it has not been indicated.

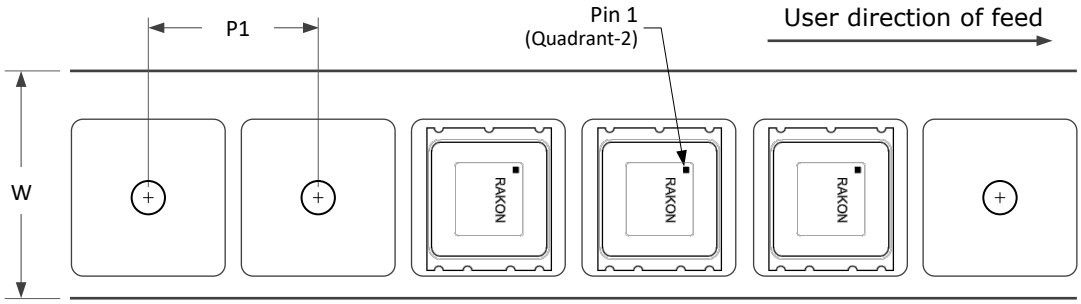
Pin	Connections
1	1PPS Input
2	PPS Output
3	Supply Voltage (V_{CC})
4	RF Output (HCMOS)
5	I^2C Bus – SCL
6	I^2C Bus – SDA
7	GND (mechanical & electrical)

16.0 3D Model

Parameter	Remarks
Package size	25.4 x 22.0 x 12.1 mm
Net weight	11 g/pc
STEP file	ROD2522S2 7-pad 3D model *To open or view the STP file, you will need to import it into one of the following software programs: Autodesk Fusion 360, CATIA, SolidWorks, Solid Edge, TurboCAD, Kubotek KeyCreator, FreeCAD, ABViewer, ShareCAD, or eMachineShop.*

17.0 Tape and Reel

Tape and reel packaging: compliant with Standard EIA-481

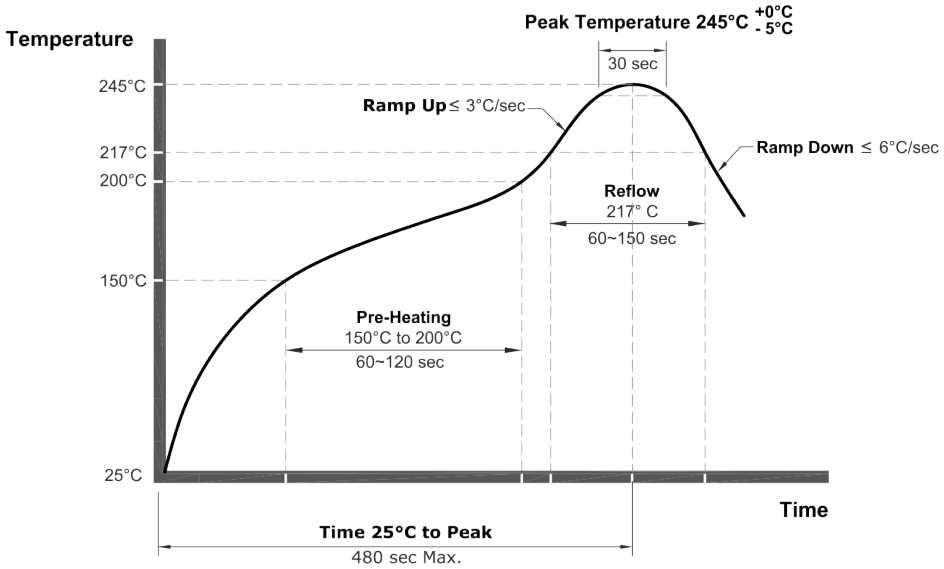


P1	W	SPQ/reel	Reel diameter	Pin 1 orientation
28 mm	44 mm	100pcs. min. 200pcs. max	Φ380 mm	Quadrant-2

18.0 Recommended Reflow Profile

Reflow profile according IPC/JEDEC J-STD-020 with classification temperature Tc 245°C.

- This product is specifically designed for pick and place reflow manufacturing process.
- The Oscillator must be always on top side during the reflow process.
- The product might be damaged or destroyed when processed top down during second reflow process.



19.0 Application Notes and Evaluation Kit

Parameter	Remarks
Application note	• RAKON EVK Hardware Installation Guide • RAKON EVK Software User Guide
Evaluation kit ref	ROD2522S2 EVK (520815)

STEP file	ROD2522S2 7-pad 3D model *To open or view the STP file, you will need to import it into one of the following software programs: Autodesk Fusion 360, CATIA, SolidWorks, Solid Edge, TurboCAD, Kubotek KeyCreator, FreeCAD, ABViewer, ShareCAD, or eMachineShop.*

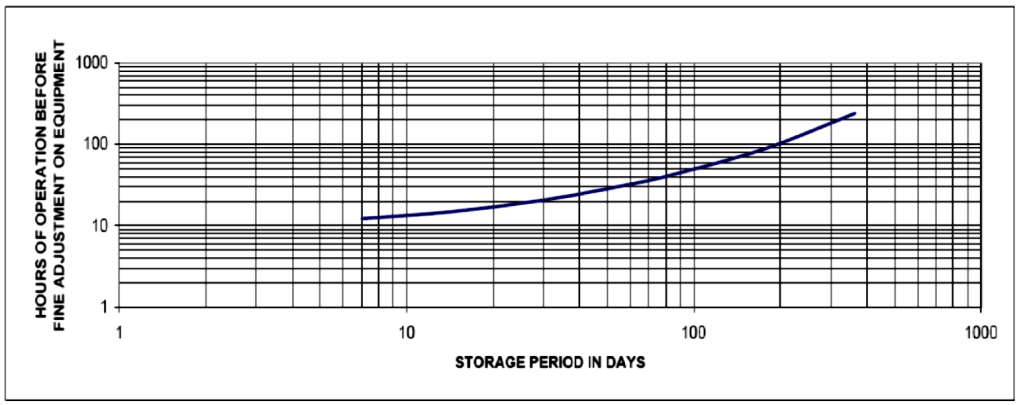
Evaluation Kit ref: ROD2522S2 EVK (520815)

- RAKON EVK Hardware Installation Guide
- RAKON EVK Software User Guide

20.0 Recovery

The stability performances of the device are measured before shipment. Then parts are shipped and could remain powered-off for an uncontrolled time, then assembled and tested over the integration process.

Parts could again remain powered off until final installation in the application when they will operate in a continuous mode.

The graph on the right shows the typical recovery time as a function of the unpowered time:	

21.0 Disclaimer

Parameter	Test Condition / Description
a. Disclaimer	"Samples supplied according to this specification are supplied from our development or pre-production programme and are not qualification approved products. No condition, warranty or representation regarding quality, suitability, performance, life or continuation of supply is given or implied, and the Warranty in clause 7 of our standard Conditions of Sale is not applicable. The right is reserved to change the design or specification or cease supply without notice." Rakon Limited