Guidelines for use of Mercury Miniature OCXOs in Network Timing Applications

This application note gives best practice advice on how to optimise the performance of Rakon's miniature Mercury OCXOs in network timing and synchronisation applications – date of issue: 2014-11-12.

Introduction

In a conventional OCXO, to improve frequency stability, the effect of ambient temperature is virtually eliminated by enclosing the entire oscillator within an 'oven' maintained at a constant high temperature. As conventional OCXOs tend to be bulky, high in price and power-hungry, Rakon developed the Mercury series of miniature OCXOs.

In a miniature OCXO a miniature oven keeps a crystal oscillator at an approximately constant temperature slightly above the specified operating temperature range, for example at ≈ 92° for a device with an operating temperature range of –40° to +85°C. The whole assembly is then treated as a TCXO and a temperature sweep is performed at the factory and each device is programmed with a correction curve. This results in an oscillator with a typical stability of better than ±50ppb over –40° to +85°C. This means that every device has been tested over the full operating temperature range in a temperature chamber. The operating temperature specified in our data sheets is that of the air in the vicinity of the OCXO. Because the oven does not have the strict temperature requirements demanded by a conventional OCXO, it can be implemented at lower cost and in a smaller package.

Please note that heat sources near the OCXO may lift the board temperature above that of the air. If the internal temperature of the OCXO rises above its specified maximum operating temperature as a result of convection heating within the customer's module, the OCXO will no longer maintain its stability. This can occur even if the air temperature external to the OCXO is still below the OCXO's maximum operating temperature.

It is important to realise that heat, although usually considered an unwanted by-product, is what gives an OCXO its stability. Provided the board temperature stays below the maximum operating temperature there is no need to cool the device – in fact cooling can be detrimental to its short and medium term stability.

General Guidelines

Consult the manufacturer from the start of the program and continue the engagement throughout the development. An evaluation board is available to assist with bench testing of the Mercury OCXO. This board can accommodate the various package format options.

Power Supply Considerations

It is recommended to use a local power supply regulator to isolate the device from external power noise sources. The local supply must be dimensioned in such a way that it can handle the warm-up current of the device. The warm-up power consumption of the Miniature OCXOs is limited as per the following table:

	Warm-up	Steady-state at 25°C
Mercury, -20° to +70°C	800 mW	350 mW
Mercury, -40° to +85°C	1000 mW	400 mW

It is recommended to decouple the supply of the OCXO with a 10 uF capacitor close to the device.

Voltage Control

In case voltage control has been specified it is important to realise that typical sensitivity is +8 ppm/V and a small error in the control voltage may result in a considerable frequency error. Because of this the ground of the control voltage needs to be connected close to the ground of the OCXO as ground lead impedance may introduce a voltage (= frequency) error caused by the relatively large current flowing through it.

Thermal Guidelines

Under steady state conditions the OCXOs will perform as per the specification. A steady state is reached after a "warm-up" period which includes the oscillator and the circuit board on which it is mounted, under conditions of constant temperature and airflow. For wander compliance testing it is recommended to power-up the board for at least 24 hours (48 hours if parts were soldered recently) before commencing the measurements and to keep the temperature variation within ±1°C (unless otherwise stated in relevant standard).

A change in the temperature external to the OCXO will result in an increase or decrease of current to the heater as the oven is trying to maintain its temperature. This is a critically damped closed loop system and its response will lag the external stimulus resulting in phase and frequency variations (i.e. frequency wander).

For this reason it is best to keep the external temperature fluctuations to a minimum. The main cause of temperature fluctuation is variation in the amount of airflow when fans run at varying speeds or are used intermittently.

Another source of temperature variation is when circuitry in the vicinity of the OCXO is switched on intermittently. This can generate enough heat to disturb the thermal balance. It is best to keep such circuitry away from the oscillator.

As there is no need to cool the OCXO, its short and medium term stability can be greatly improved by thermally isolating it from the environment. Two important factors are board layout and airflow.

Printed Circuit Board Layout Considerations

Apply standard RF practice, keep tracks short and place the oscillator near the timing circuitry. Use the recommended pad layout as detailed in the specification. Whilst the use of ground and power supply planes is generally a good practice, to avoid thermal energy loss, these planes (copper pours) should not be used underneath the OCXO in any of the layers. For the same reason do not route any tracks underneath the OCXO area. It is recommended to widen this exclusion zone beyond the size of the oscillator by at least an amount equivalent to the thickness of the board used. E.g. if an oscillator with 9.7 x 7.5 mm footprint is used on a 2 mm thick multi-layer board, the track and plane exclusion zone should be at least 13.7 x 11.5 mm. Tracks connecting to the pads should have a width of less than 1 mm to avoid conducting heat away from the OCXO and should not connect to any layer inside the exclusion zone. To further minimise heat transfer between OCXO and the board it is recommended to cut 1-2mm wide slots in the board around the OCXO. If it is not possible to implement these recommendations please contact Rakon to discuss potential alternative solutions.

Airflow Considerations

In order to meet the specification the OCXO must be shielded from airflow. Place the oscillator where air flow is low. It may be possible to use tall components or mechanical parts to shield the oscillator locally.

If this is not possible or shielding is not sufficient a plastic or metal cover may be placed over the OCXO. It is recommended that the cover leaves an air-gap of a least several mm above and around the oscillator. The following graphs show the effect of airflow (at 1m/s) when switched off and on intermittently. Figure 1 shows Mercury performance without shielding and figure 2 shows the same device with a draught cover in place.

Figure 1

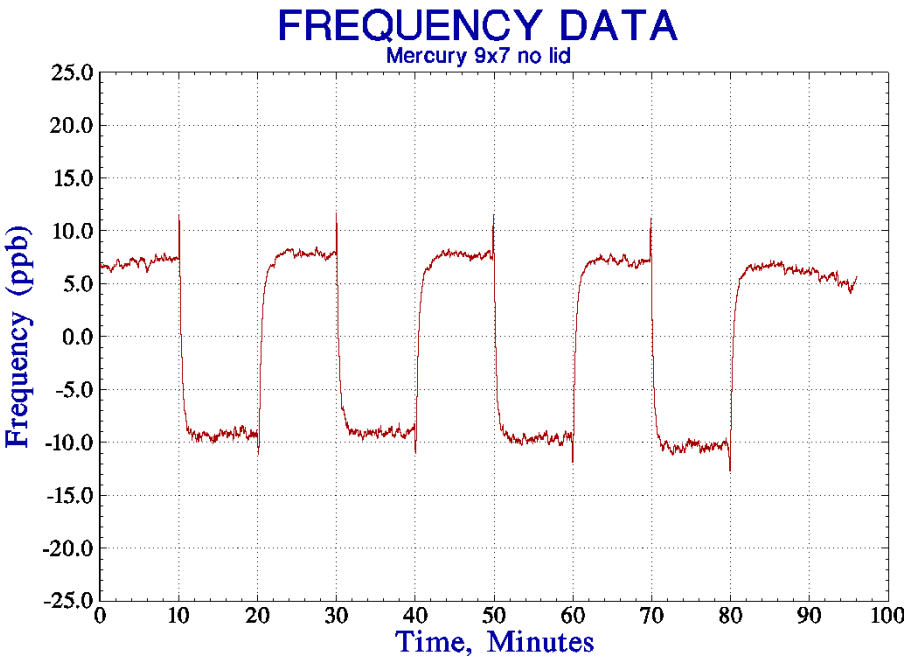
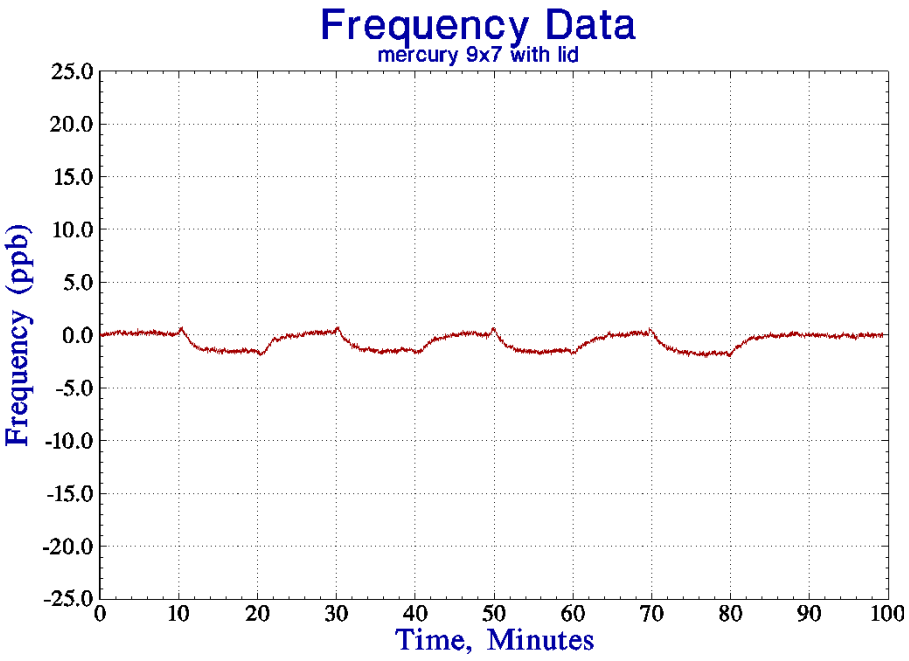


Figure 2



Rakon can provide the following draught covers to shield the device from air flow:

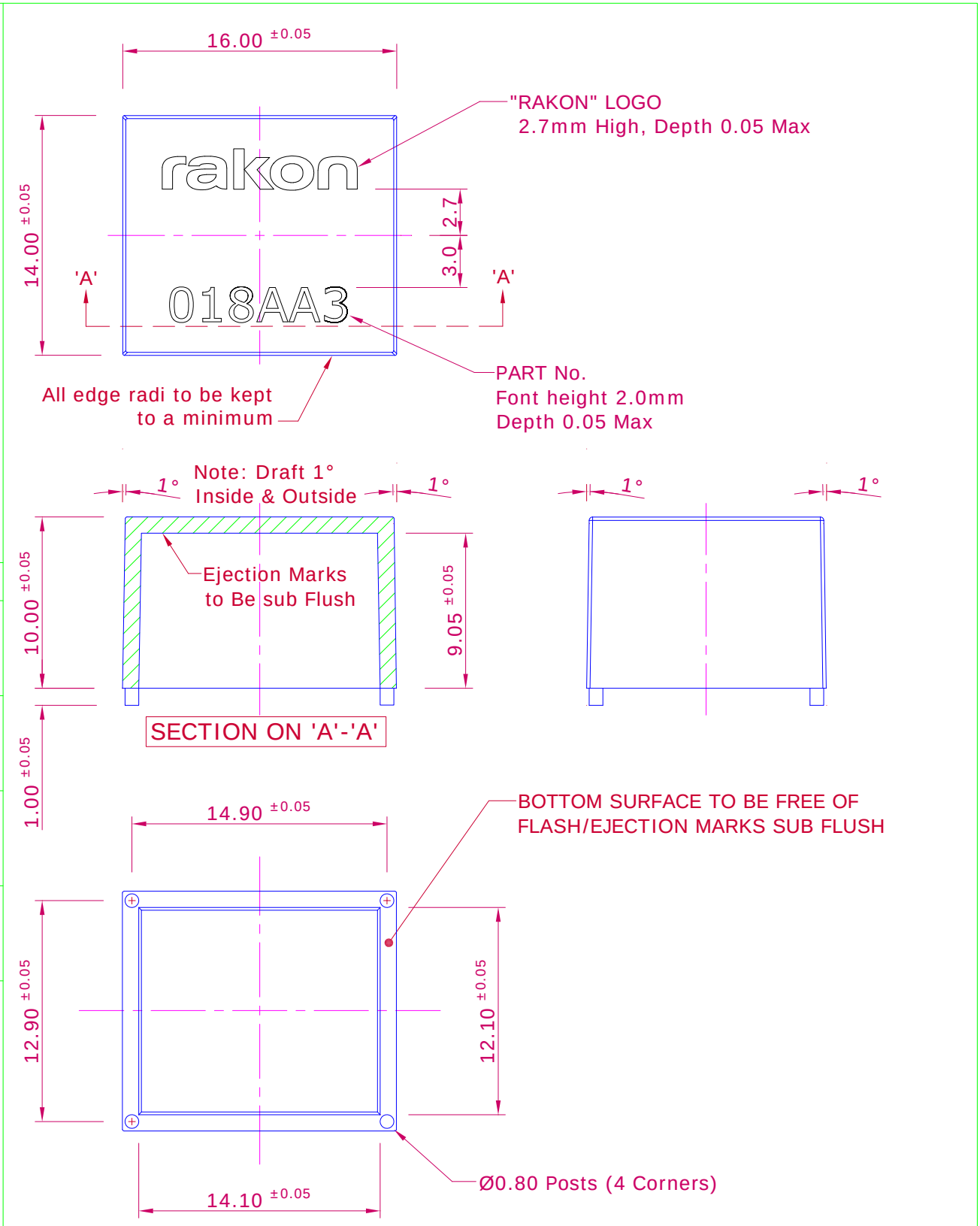
Description	Part Number	Outline Drawing	Assembly Drawing
COVER (16 x 14 x 11) FOR MERCURY 9 x 7	82PCV00018AA3	Figure 3	Figure 4
COVER (21 x 16 x 11) FOR MERCURY 14 x 9	82PCV00018AA4	Figure 5	Figure 6

The covers need to be secured with adhesive. Any adhesive suitable for bonding components to printed circuit boards can be used. Examples are Loctite 3220 and Epotek TJ1104-LH (formerly known as Epotek 102-104). These examples are provided for information only – users remain responsible for assessing suitability. For proper use of the adhesive please consult the manufacturer's Technical Data sheet and Material Safety Data sheet.

Reflow Soldering

The parts are suitable for reflow soldering with a process compatible with the profile as included in the specification. Note the product is non-hermetic and cleaning liquid may become trapped after cleaning. We do not recommend cleaning this product as trapped moisture and/or residue may degrade the performance.

Figure 3



ISSUE 1
28OCT11

APPROVALS

DESIGN ENG.: R.W.

INDUSTRIAL ENG.: S.N.

Q.A.: D.W.

MATL. CONTROL: J.G.

MATERIAL:	FINISH:	TOLERANCES:
VECTRA LCP	COLOUR : GREEN (20 VDI)	1 Decimal Place ±0.1 2 Decimal Places ±0.05

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DRAWN BY:	DIMENSIONS:	SCALE:	3rd Angle	APPROVED BY:
G.W.	mm	3:1		G.W. 03NOV11

TITLE: COVER (16.0 x 14.0 x 11.0) FOR MERCURY 9x7

CODE: 82P CV00 018 AA3

SHEET: 1of1

Figure 4

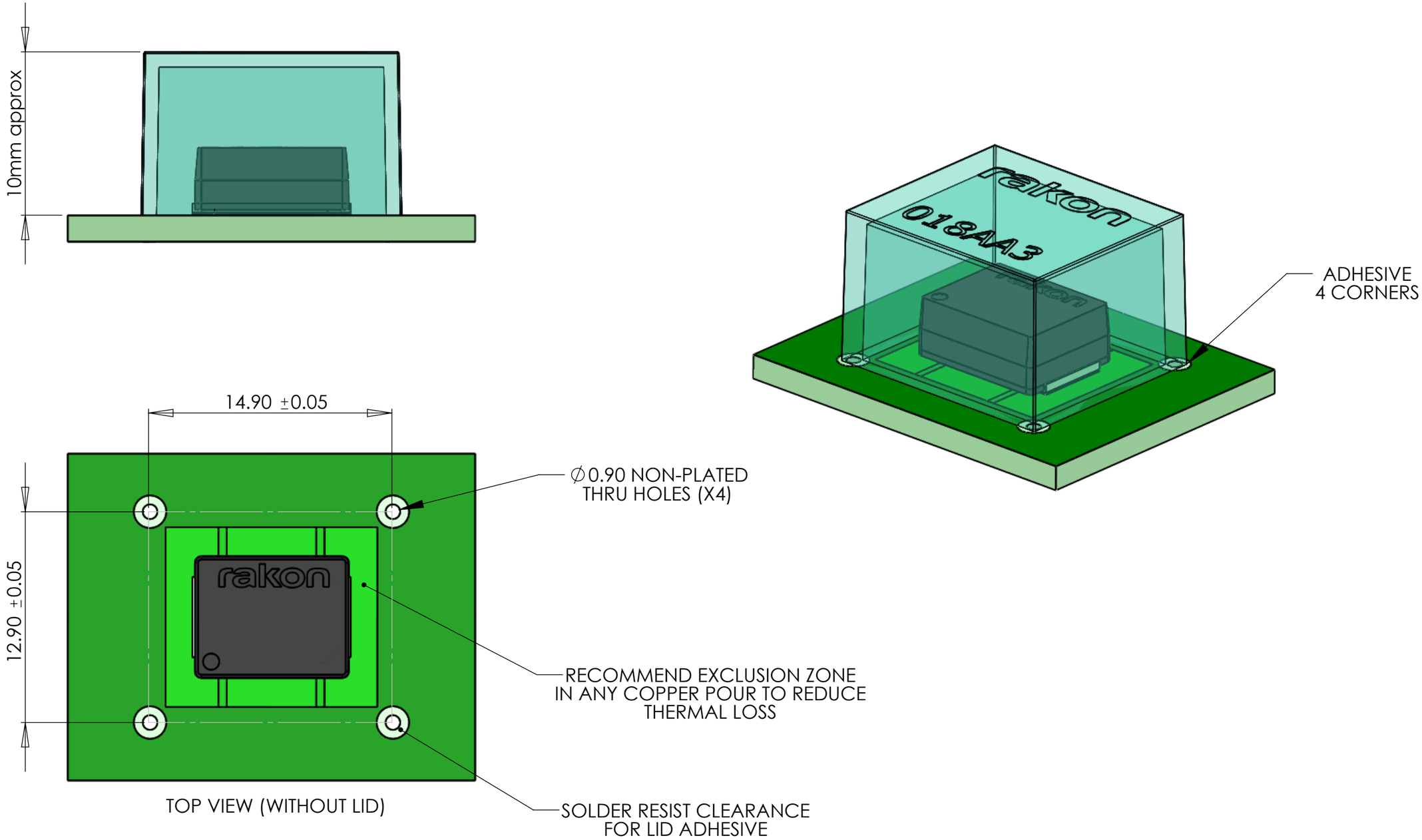
10mm approx
14.90 ±0.05
12.90 ±0.05
rakon
rakon
018AA3
ADHESIVE
4 CORNERS
∅0.90 NON-PLATED
THRU HOLES (X4)
RECOMMEND EXCLUSION ZONE
IN ANY COPPER POUR TO REDUCE
THERMAL LOSS
SOLDER RESIST CLEARANCE
FOR LID ADHESIVE
TOP VIEW (WITHOUT LID)

Figure 5

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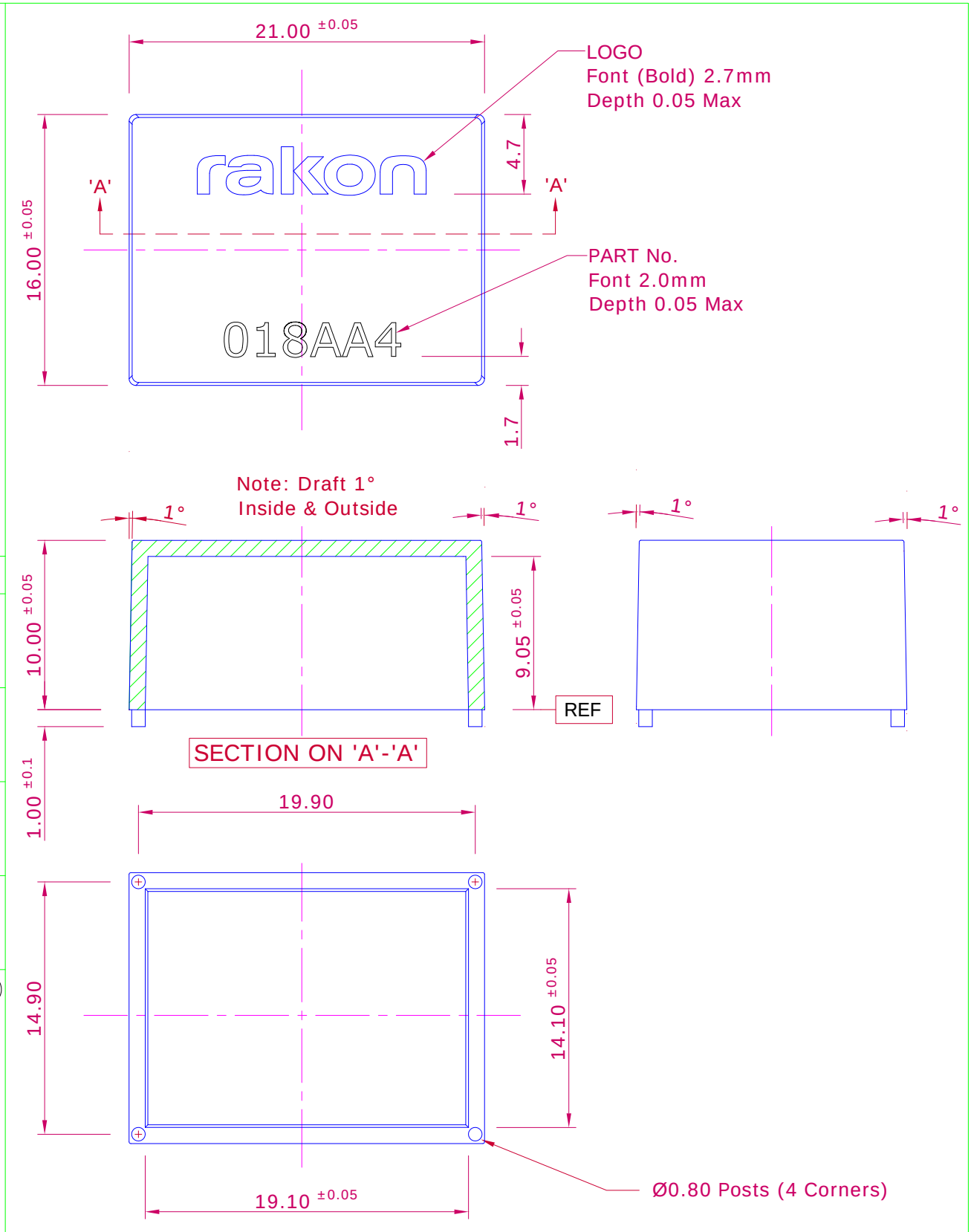

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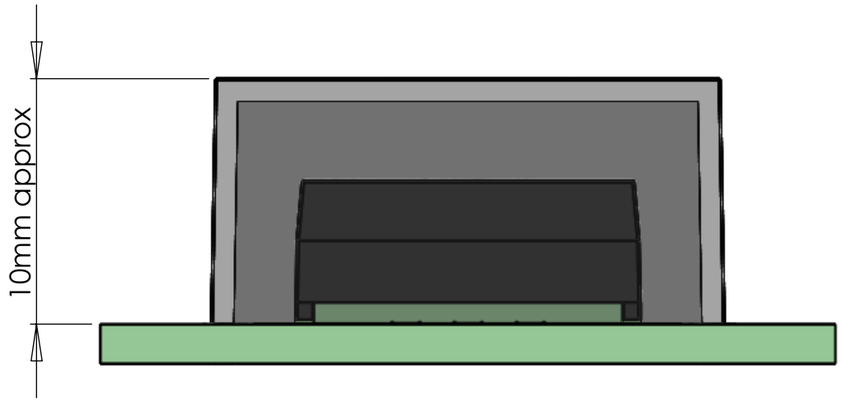
G.W	mm	3:1		G.W. 10NOV11

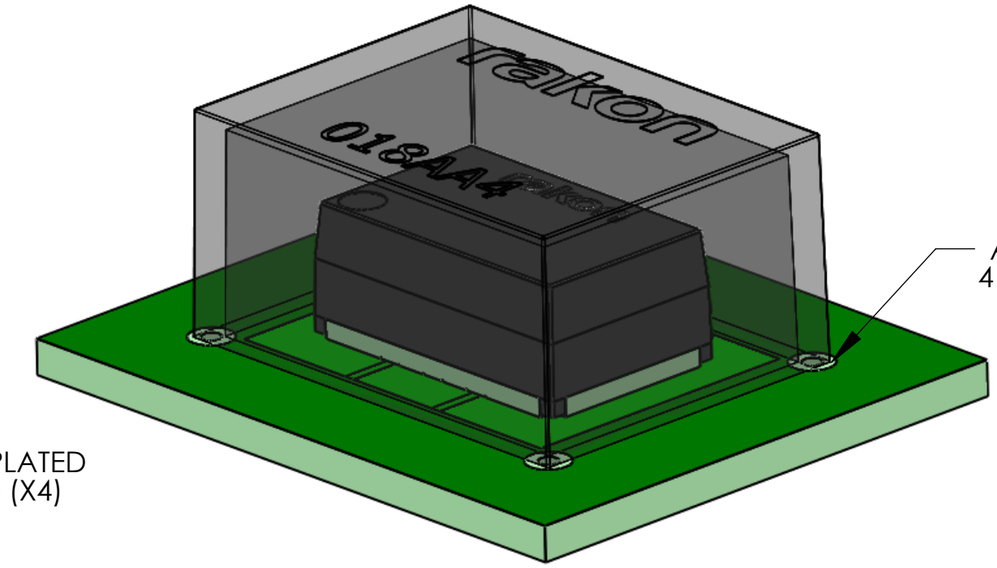
TITLE: COVER (21.0 x 16.0 x 11.0) FOR MERCURY 14x9

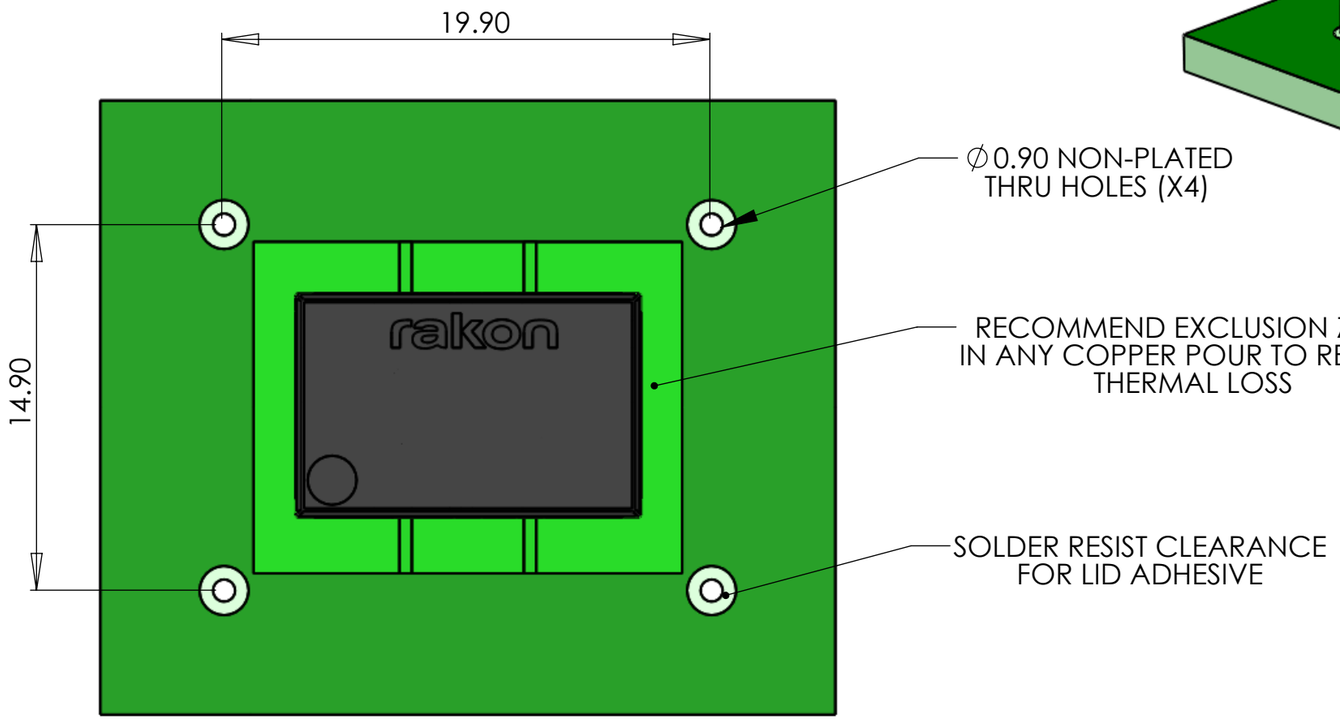
CODE: 82P CV00 018 AA4

SHEET: 1of1

Figure 6







TOP VIEW (WITHOUT LID)