PETERMANN TECHNIK
Excellence in clocking

PETERMANN-TECHNIK GmbH
Lechwiesenstr. 13 • D-86899 • Landsberg am Lech
Tel: +49/8191/305395 • Fax: +49/8191/305397
info@petermann-technik.com • www.petermann-technik.com

ULTRA-LOW POWER OSCILLATOR 32.768 kHz

SERIES „ULPO-RB1“

FEATURES

- Ultra-Low Power Oscillator for Low Cost
- Excellent long time reliability
- Smallest footprint 1.5 x 0.8 mm
- Ultra-low power: <1 µA
- Directly interfaces to XTAL inputs
- Supports coin-cell or super-cap battery backup voltages
- Oscillator output eliminates external load caps
- Internal filtering eliminates external V_{DD} bypass cap
- Programmable output swing to reduce power
- Pb-free, RoHS and REACH compliant / MSL1@260°

APPLICATIONS

- Smart Phones
- Tablets
- Health and Wellness Monitors
- Fitness Watches
- Sport Video Cams
- Wireless Keypads
- Ultra-Small Notebook PC
- Pulse-per-Second (pps) Timekeeping
- RTC Reference Clock
- Battery Management Timekeeping
- Wearables
- IoT
- GPS
- Smart Metering
- Home Automation

GENERAL DATA

PARAMETER AND CONDITIONS	SYMBOL	MIN.	TYP.	MAX.	UNIT	CONDITION
FREQUENCY						
Fixed Output Frequency	F_out		32.768		kHz	
FREQUENCY STABILITY						
Frequency Tolerance[1]	F_tol			10	PPM	T_A = 25°C, post reflow, Vdd: 1.5V – 3.63V.
				20	PPM	T_A = 25°C, post reflow with board-level underfill, Vdd: 1.5V – 3.63V.
Frequency Stability[2])	F_stab			75	PPM	T_A = -10°C to +70°C, V_{DD}: 1.5V – 3.63V.
				100	PPM	T_A = -40°C to +85°C, V_{DD}: 1.5V – 3.63V.
				250	PPM	T_A = -10°C to +70°C, V_{DD}: 1.2V – 1.5V.
25°C Aging	F_aging	-1.0		1.0	PPM	1st Year
OPERATING TEMPERATURE RANGE						
Operating Temperature Range	T_use	-10	–	+70	°C	Commercial
		-40	–	+85	°C	Industrial
Storage Temperature Range	T_stor	-55	–	+125	°C	Storage
SUPPLY VOLTAGE AND CURRENT CONSUMPTION						
Operating Supply Voltage	V_{DD}	1.2		3.63	V	T_A = -10°C to +70°C
		1.5		3.63	V	T_A = -40°C to +85°C
Core Operating Current [3]	I_{DD}		0.90		µA	T_A = 25°C, V_{DD} = 1.8V. No Load
				1.3	µA	T_A = -10°C to +70°C, V_{DD} max: =3.63V. No load
				1.4	µA	T_A = -40°C to +85°C, V_{DD} max:=3.63V. No load
Output Stage Operating Current [3]	IDD_out		0.065	0.125	µA/Vpp	T_A = -40°C to +85°C, Vdd: 1.5V – 3.63V. No load
Power-Supply Ramp	t_VDD_Ramp			100	ms	V_{DD} Ramp-Up 0 to 90% V_{DD}, T_A = -40°C to +85°C
Start-up Time at Power-up [4]	t_start		180	300	ms	T_A = 25°C ±10°C, valid output
				450	ms	T_A = -40°C to +70°C, valid output
				500	ms	T_A = +85°C, valid output

Notes: 1.No board level underfill. Measured as peak-to-peak/2. Inclusive of 3x-reflow and ±20% load variation. Tested with Agilent 53132A frequency counter. Due to the low operating frequency, the gate time must be ≥100 ms to ensure an accurate frequency measurement.
2. Initial offset is defined as the frequency deviation from the ideal 32.768 kHz at room temperature, post reflow.
3. Core operating current does not include output driver operating current or load current. To derive total operating current (no load), add core operating current + output driver operating current, which is a function of the output voltage swing. See the description titled, Calculating Load Current.
4. Measured from the time V_{DD} reaches 1.5V.

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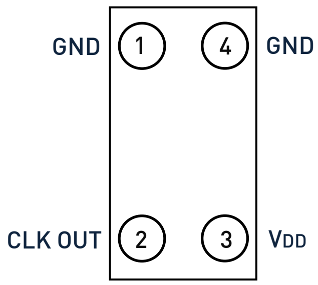
GENERAL DATA (continued)

PARAMETER AND CONDITIONS	SYMBOL	MIN.	TYP.	MAX.	UNIT	CONDITION
JITTER PERFORMANCE (T_A = OVER TEMP)						
Period Jitter	T_jitt		35		ns_{RMS}	Cycles = 10,000, T_A = 25°C, V_{DD} = 1.5V – 3.63V
LVCMOS OUTPUT (STANDARD VERSION T_A = –40/+85°C, TYPICAL VALUES ARE AT T_A = 25°C)						
Output Rise/Fall Time	tf, tf		100	200	ns	10-90% (V_{DD}), 15 pF Load VDD= 1.5V to 3.63V
Output Clock Duty Cycle	DC	48		52	%	
Output Voltage High	VOH	90%			V	V_{DD}: 1.5V – 3.63V. I_{OH} = -10µA, 15 pF Load
Output Voltage Low	VOL			10%	V	V_{DD}: 1.5V – 3.63V. I_{OL} = 10µA, 15 pF Load
PROGRAMMABLE, REDUCED SWING OUTPUT (ADAPTABLE ACCORDING TO CUSTOMERS REQUIREMENT)						
Output Rise/Fall Time	tf, tf			200	ns	30-70% (V_{OL}/V_{OH}), 10 pF Load
Output Clock Duty Cycle	DC	48		52	%	
AC-coupled Programmable Output Swing	V_sw		0.20 to 0.80		V	ULPO-RB1 does not internally AC-couple. This output description is intended for a receiver that is AC-coupled. VDD: 1.5V – 3.63V, 10 pF Load, I_{OH} / I_{OL} = ±0.2 µA.
DC-Biased Programmable Output Voltage High Range	VOH		0.6 to 1.225		V	VDD: 1.5V – 3.63V. IOH = -0.2 µA, 10 pF Load.
DC-Biased Programmable Output Voltage Low Range	VOL		0.35 to 0.80		V	VDD: 1.5V – 3.63V. IOL = 0.2 µA, 10 pF Load.
Programmable Output Voltage Swing Tolerance		-0.055		0.055	V	TA = -40°C to +85°C, VDD = 1.5V to 3.63V.
EXCELLENT RELIABILITY DATA						
MTBF				500 million hours		
Shock Resistance				10.000 g		
Vibration Resistance				70 g		

PIN DESCRIPTION

Pin	Symbol	I/O	Functionality
1,4	GND	Power Supply Ground	Connect to ground. Acceptable to connect pin 1 and 4 together. Both pins must be connected to GND.
2	CLK Out	OUT	Oscillator clock output. The CLK can drive into a Ref CLK input or into an ASIC or chip-set's 32kHz XTAL input. When driving into an ASIC or chip-set oscillator input (X IN and X Out), the CLK Out is typically connected directly to the XTAL IN pin. No need for load capacitors. The output driver is intended to be insensitive to capacitive loading.
3	V_{DD}	Power Supply	Connect to power supply 1.5V ≤ Vdd ≤ 3.63V. Under normal operating conditions, V_{DD} does not require external bypass/decoupling capacitor(s). For more information about the internal power-supply filtering, see Power-Supply Noise Immunity section in the detailed description. Contact factory for applications that require a wider operating supply voltage range.

FIGURE 1. 1.5X0.8 MM PACKAGE (TOP VIEW)



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DESCRIPTION

The ULPO-RB1 is the smallest, lowest power 32.768 kHz oscillator optimized for mobile and other battery powered applications. The silicon oscillator technology enables the smallest footprint with 1.5x0.8mm packaging. This device reduces the 32.768 kHz footprint by as much as 85% compared to existing 2.0 x 1.2 mm SMD - XTAL package. Unlike XTALs, the ULPO-RB1 oscillator output enables greater component placement flexibility and eliminates external load capacitors, thus saving additional component count and board space. And unlike standard oscillators, the ULPO-RB1 features programmable output swing, a factory programmable output that reduces the voltage swing to minimize power.

The 1.2V to 3.63V operating supply voltage range makes it an ideal solution for mobile applications that incorporate a low-voltage, battery-back-up source such as a coin-cell or super-cap.

The ULPO-RB1 oscillators consist of a silicon resonators and a programmable analog circuit using a key sealing process ensuring best performance and reliability.

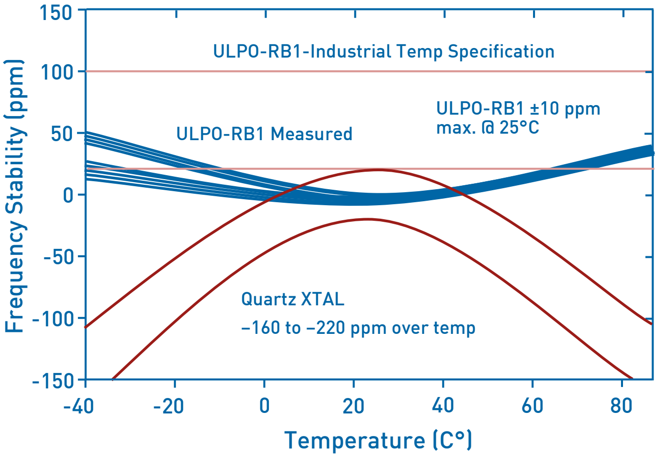
FREQUENCY STABILITY

The ULPO-RB1 is factory calibrated to guarantee frequency stability to be less than ±10 ppm at room temperature and less than ±100 ppm over the full -40°C to +85°C temperature range. Unlike quartz crystals that have a classic tuning fork parabola temperature curve with a 25°C turnover point, the ULPO-RB1 temperature coefficient is extremely flat across temperature. The device maintains less than ± 100 ppm frequency stability over the full operating temperature range of –40/+85°C when the operating voltage is between 1.5 and 3.63V as shown in Figure 2.

Functionality is guaranteed over the 1.2V - 3.63V operating supply voltage range. However, frequency stability degrades below 1.5V and steadily degrades as it approaches the 1.2V minimum supply due to the internal regulator limitations. Between 1.2V and 1.5V, the frequency stability is ± 250 ppm max. over temperature.

When measuring the ULPO-RB1 output frequency with a frequency counter, it is important to make sure the counter's gate time is ≥100ms. The slow frequency of a 32.768 kHz clock will give false readings with faster gate times.
Contact Petermann-Technik for applications that require a wider supply voltage range >3.63V or lower frequency options as low as 1Hz.

FIGURE 2. PETERMANN-TECHNIK vs. QUARTZ



POWER SUPPLY NOISE IMMUNITY

In addition to eliminating external output load capacitors common with standard XTALs, this device includes special power supply filtering and thus, eliminates the need for an external V_{DD} bypass-decoupling capacitor to keep the footprint as small as possible. Internal power supply filtering is designed to reject more than ±150 mV noise and frequency components from low frequency to more than 10 MHz.

OUTPUT VOLTAGE

The ULPO-RB1 has two output voltage options. One option is a standard LVCMOS rail-to-rail DC-coupled output swing, which is mostly used. The second option is the programmable reduced swing output for reducing current consumption. Output swing is customer specific and factory programmed between 200 mV and 800 mV. For DC-coupled applications, output VOH and VOL are individually factory programmed to the customers' requirement. VOH programming range is between 600 mV and 1.225V in 100 mV increments. Similarly, VOL programming range is between 350 mV and 800 mV. For example; an IC or µP is internally 1.8V logic compatible and requires a 1.2V VIH and a 0.6V VIL. Simply select ULPO-RB1 programmable output swing factory programming code to be "D14" and the correct output thresholds will match the downstream IC or µP input requirements. Interface logic will vary by manufacturer and we recommend that you review the input voltage requirements for the input interface. For DC -biased output configuration, the minimum VOL is limited to 350mV and the maximum allowable swing VOH - VOL) is 750mV. For example, 1.1V VOH and 400mV VOL is acceptable, but 1.2V VOH and 400 mV VOL is not acceptable.

When the Output is interfacing to an XTAL input that is internally AC-coupled, the ULPO-RB1 output can be factory programmed to match the input swing requirements. For example, if a PMIC or MCU input is internally AC-coupled and requires an 800mV swing, then simply choose the ULPO-RB1 programming code "AA8" in the part number. It is important to note that the ULPO-RB1 does not include internal AC-coupling capacitors. Please see the *Part Number Ordering* section at the end of the datasheet for more information about the part number ordering scheme.

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POWER-UP

The ULPO-RB1 starts-up to a valid output frequency within 300 ms (150ms typ). To ensure the device starts-up within the specified limit, make sure the power-supply ramps-up in approximately 10 - 20ms (to within 90% of V_{DD}). Start-up time is measured from the time V_{DD} reaches 1.5V. For applications that operate between 1.2V and 1.5V, the start-up time will be longer.

ULPO-RB1 PROGRAMMABLE OUTPUT SWING

Figure 4 shows a typical ULPO-RB1 output waveform (into a 10 pF load) when factory programmed for a 0.70V swing and DC bias (V_{OH}/ V_{OL}) for 1.8V logic:

EXAMPLE:

+ Programmable output swing part number coding: D14. Example part number: ULPO-RB1-18-1508-75-D-32.768KHZ-T-D14
+ V_{OH} = 1.1V, V_{OL} = 0.4V (V_{SW} = 0.70V)

FIGURE 3. ULPO-RB1-33-1508-75-D-32.768KHZ-T-S OUTPUT WAVEFORM (10 PF LOAD)

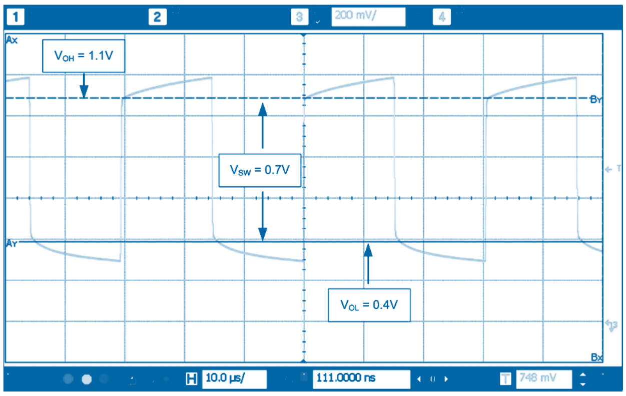


Table 1 shows the supported programmable output swing V_{OH}, V_{OL} factory programming options.

TABLE 1. ACCEPTABLE V_{OH}/V_{OL} PROGRAMMABLE OUTPUT SWING LEVELS

VOL/VOH	1.225	1.100	1.000	0.900	0.800	0.700	0.600
0.800	D28	D18	D08				
0.700	D27	D17	D07	D97			
0.525	D26	D16	D06	D96	D86		
0.500	D25	D15	D05	D95	D85	D75	
0.400		D14	D04	D94	D84	D74	D64
0.350		D13	D03	D93	D83	D73	D63

Table 2 shows the supported AC coupled Swing levels. The "AC-coupled" terminology refers to the programming description for applications where the downstream chipset includes an internal AC-coupling capacitor, and therefore, only the output swing is important and V_{OH}/V_{OL} are not relevant. For these applications, refer to Table 2 for the acceptable voltage swing options.

TABLE 2. ACCEPTABLE AC-COUPLED SWING LEVELS

SWING	0.800	0.700	0.600	0.500	0.400	0.300	0.250	0.200
Output Code	AA8	AA7	AA6	AA5	AA4	AA3	AA2	AA1

EXAMPLE:

+ Programmable output swing part number coding: AA2. Example part number: ULPO-RB1-1508-75-D-32.768KHZ-T-AA2
+ Output voltage swing: 0.250V

The values listed in Tables 1 and -2 are nominal values at 25°C and will exhibit a tolerance of ±55 mV across VDD and -40°C to 85°C operating temperature range.

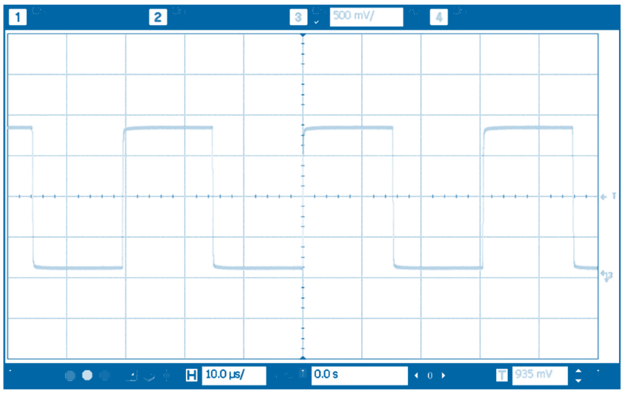
ULPO-RB1 FULL SWING LVCMOS OUTPUT

The ULPO-RB1 can be factory programmed to generate full-swing LVCMOS levels. Figure 4 shows the typical LVCMOS waveform (V_{DD} = 1.8V) at room temperature into a 15 pF load.

EXAMPLE:

+Standard LVCMOS rail-to-rail output part number coding is always S
+Example part number: ULPO-RB1-33-1508-75-D-32.768KHZ-T-S

FIGURE 4. LVCMOS WAVEFORM (V_{DD} = 1.8V) INTO 15 PF LOAD



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CALCULATING LOAD CURRENT

NO LOAD SUPPLY CURRENT

When calculating no-load power for the ULPO-RB1, the core and output driver components need to be added. Since the output voltage swing can be programmed for reduced swing between 250 mV and 800 mV, the output driver current is variable. Therefore, no-load operating supply current is broken into two sections; core and output driver. The equation is as follows:

Total Supply Current (no load) = I_{DD} Core + (65nA/V)(Voutpp)

EXAMPLE 1: FULL-SWING LVCMOS

- V_{DD} = 1.8V
- I_{DD} Core = 900nA (typ)
- $Vout_{pp}$ = 1.8V

Supply Current = 900nA + (65nA/V)(1.8V) = 1017nA

EXAMPLE 2: PROGRAMMED REDUCED SWING

- V_{DD} = 1.8V
- I_{DD} Core = 900nA (typ)
- $Vout_{pp}$ (Programmable) = VOH – VOL = 1.1V - 0.6V = 500 mV

Supply Current = 900nA + (65nA/V)(0.5V) = 932nA

TOTAL SUPPLY CURRENT WITH LOAD

To calculate the total supply current, including the load, follow the equation listed below. Note the 30% reduction in power with programmable output swing.

Total Current = I_{DD} Core + I_{DD} Output Driver (65nA/V*$Vout_{pp}$) + Load Current (C*V*F)

EXAMPLE 1: FULL-SWING LVCMOS

- V_{DD} = 1.8V
- I_{DD} Core = 900nA
- Load Capacitance = 10pF
- I_{DD} Output Driver: (65nA/V)(1.8V) = 117nA
- Load Current: (10pF)(1.8V)(32.768kHz) = 590nA
- Total Current = 900nA+117nA+590nA = 1.6µA

EXAMPLE 2: PROGRAMMED REDUCED SWING

- V_{DD}= 1.8V
- I_{DD} Core = 900nA
- Load Capacitance = 10pF
- $Vout_{pp}$ (Programmable): VOH – VOL = 1.1V - 0.6V = 500mV
- Idd Output Driver: (65nA/V)(0.5V) = 33nA
- Load Current: (10pF)(0.5V)(32.768kHz) =164nA
- Total Current = 900nA + 33nA + 164nA = 1.1µA

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TYPICAL OPERATING CURVES

FIGURE 5. INITIAL TOLERANCE HISTOGRAM

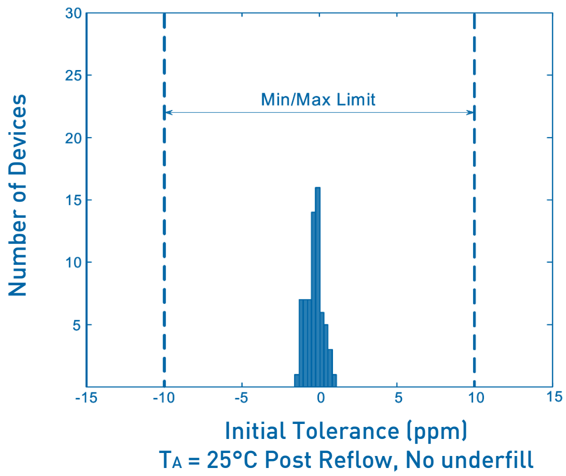


FIGURE 6. FREQUENCY STABILITY OVER TEMPERATURE

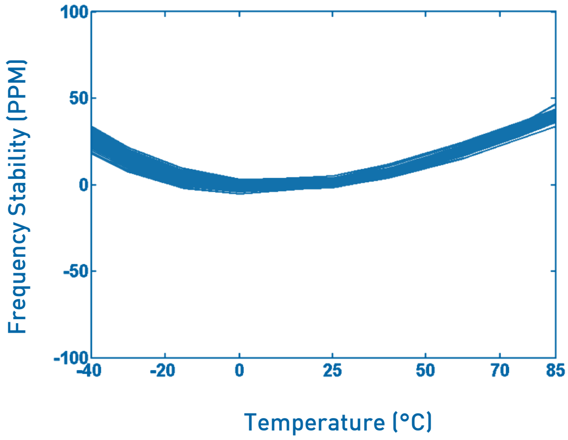


FIGURE 7. CORE CURRENT OVER TEMPERATURE

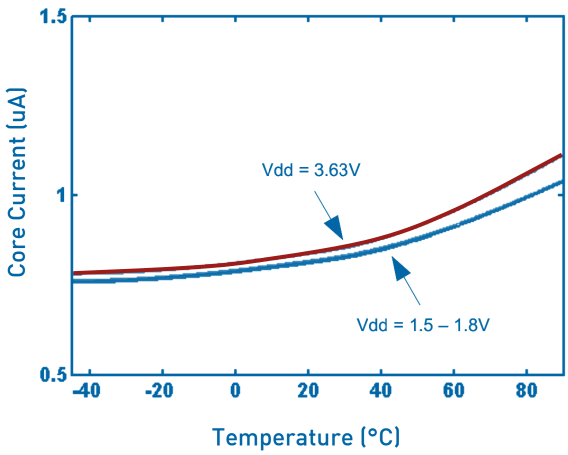


FIGURE 8. OUTPUT STAGE CURRENT OVER TEMPERATURE

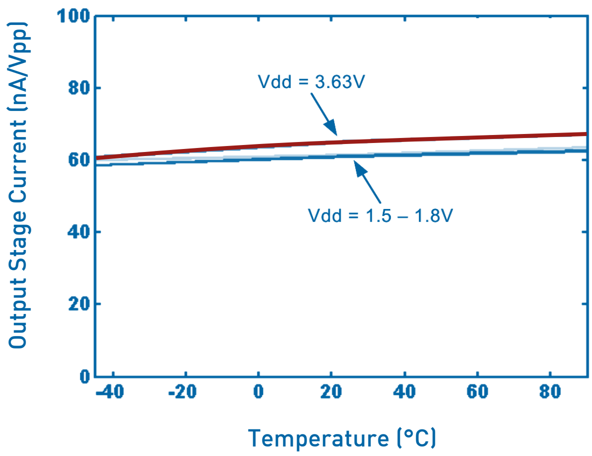
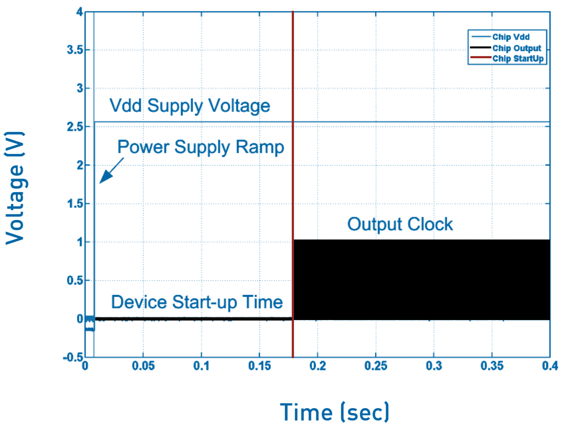


FIGURE 9. START-UP TIME



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TYPICAL OPERATING CURVES

FIGURE 10. POWER SUPPLY NOISE REJECTION (+/-150MV NOISE)

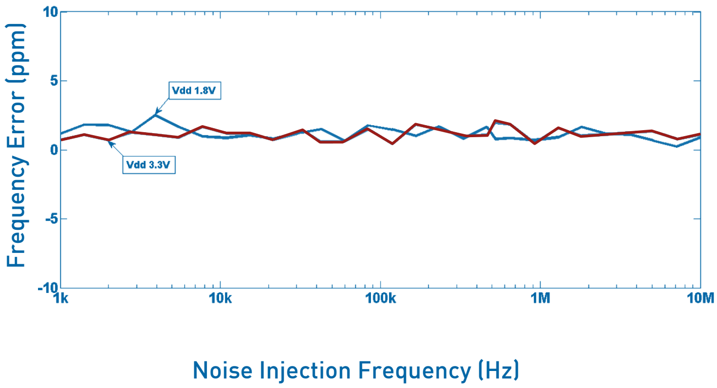


FIGURE 11. PROGRAMMABLE OUTPUT SWING WAVEFORM (V_{OH} = 1.1V, V_{OL} = 0.4V, ULPO-RB1)

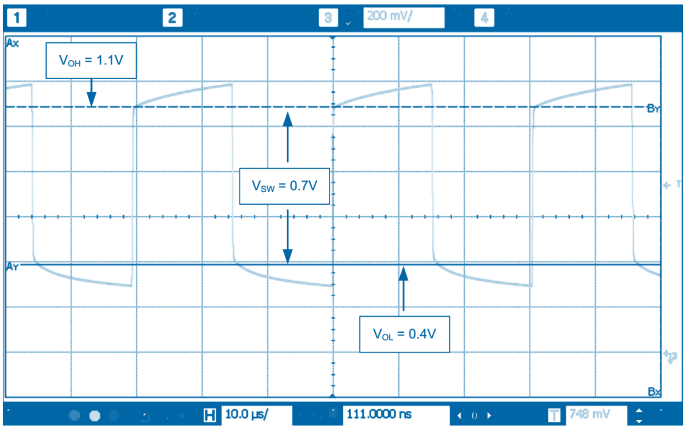
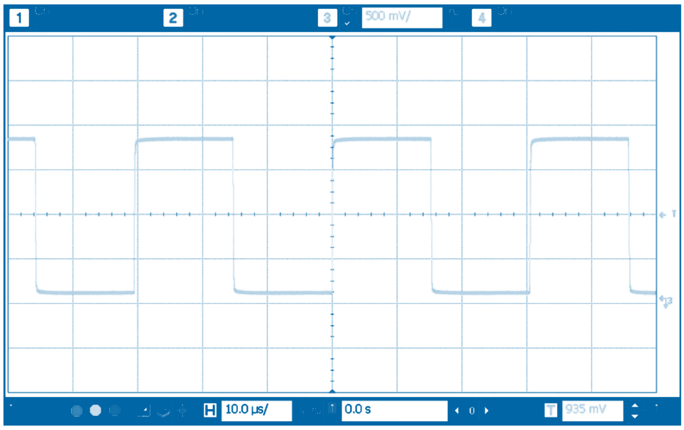


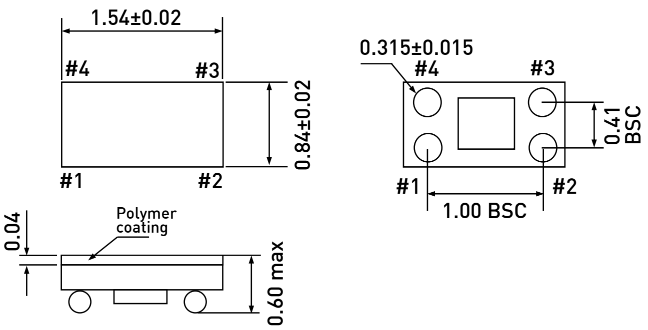
FIGURE 12. LVCMOS OUTPUT WAVEFORM (V_{SWING} = 1.8V, ULPO-RB1)



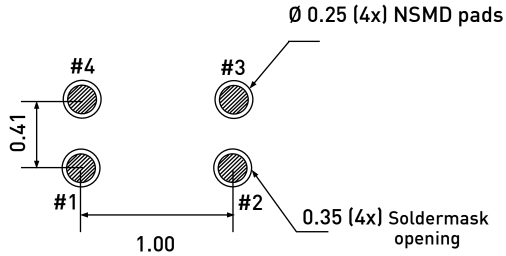
DIMENSIONS AND PATTERNS

PACKAGE SIZE – DIMENSIONS (UNIT:MM)

1.55 X 0.85 MM



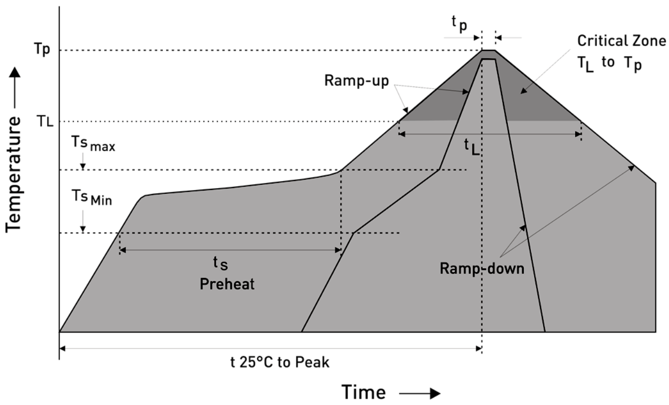
RECOMMENDED LAND PATTERN (UNIT:MM)



(soldermask openings shown with heavy dashed line)

Recommended 4-mil (0.1mm) stencil thickness

REFLOW SOLDER PROFILE



Profile Feature	Pb-Free Assembly
Average ramp-up rate (TL to TP)	3°C/second max.
Preheat:	
Temperature Min (Tsmin)	150°C
Temperature Max (Tsmax)	200°C
Time (min to max) (ts)	60-180 seconds
Time maintained above:	
Temperature (TL)	217°C
Time (tL)	60-150 seconds
Peak/Classification Temperature (Tp)	240°C
Time within 5°C of actual Peak Temperature (tp)	20-40 seconds
Ramp-down Rate	6°C/second max.
Time 25°C to Peak Temperature	8 minutes max.

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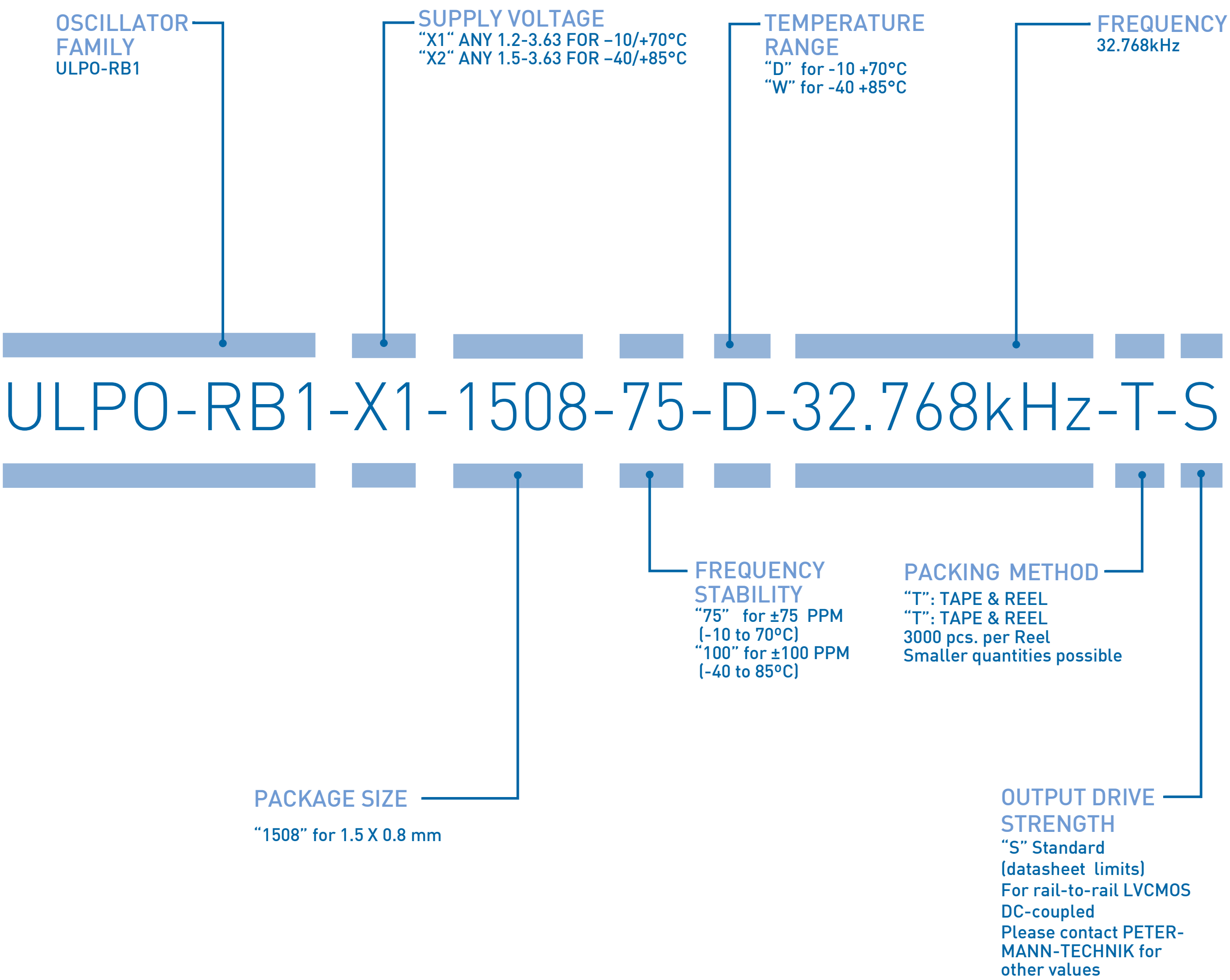
ORDERING INFORMATION



EXAMPLE: ULPO-RB1-X1-1508-75-D-32.768kHz-T-S

PLEASE INDICATE YOUR REQUIRED PARAMETERS

EXPRESS SAMPLES ARE DELIVERABLE ON THE SAME DAY IF ORDERED UNTIL 02:00 PM!

PREMIUM QUALITY BY PETERMANN-TECHNIK

OUR COMPANY IS CERTIFIED ACCORDING TO ISO 9001:2008 IN OCTOBER 2013 BY THE DMSZ CERTIFIKATION GMBH.

THIS IS FOR YOU TO ENSURE THAT THE PRINCIPLES OF QUALITY MANAGEMENT ARE FULLY IMPLEMENTED IN OUR QUALITY MANAGEMENT SYSTEM AND QUALITY CONTROL METHODS ALSO DOMINATE OUR QUALITY STANDARDS.