



1. Introduction

The mRO-Series Evaluation Kit allows users to quickly interface an mRO-50 or mRO-50 Ruggedized miniaturized Rubidium Oscillator. Through the RS232 serial interface, the user can communicate with the mRO.

1.1. Designer Kit Serial

The mRO can connect to a PC via the RS232 port. During warmup time, which takes about 70 seconds, the mRO delivers data in calibration mode. The PC interrogates the mRO, which sends back data, allowing for evaluation of the system.

2. Board Description



Evaluation board with mRO

- A. Power supply with stabilized power unit +7Volts
- B. Power selector: give the ability to supply the mRO with a stabilized power supply unit(A) or from an USB PORT (C) coming from a personal computer
- C. USB power to supply the mRO with a personal computer (USB voltage is around +5V)
- D. Voltage frequency shift (from 0.5V min to 2.5V max) allows a +/- 8 ppb shift
- E. Frequency adjust selector (Mechanical trimming (F) or external voltage frequency shift input (D))
- F. Mechanical frequency trimming allows a +/- 10 ppb shift
- G. CMOS OUTPUT (0Vmin-5Vmax)
- H. SINE WAVE OUTPUT (+5 dBm)
- I. RS232 9600 Bauds
- J. B.I.T.E OUTPUT (TTL logic)
- K. B.I.T.E OUTPUT LIGHT: light off when lock
- L. PPS IN (OV-5V): not used
- M. PPS OUT (0V-3V not loaded): not used
- N. POWER SUPPLY LIGHT



3. Operating & Hardware System Requirements

The following supplies are required:

- 1. Microsoft Windows operating systems requirements:
 - Windows 10-64 Bits or Windows 11-64 Bits
 - Screen Resolution: at least 1680x1050
 - A free serial port (RS232, 9 pin Sub-D)
- 2. A 7V/0.5A properly filtered power supply, and a power cable with two wires of different colors.
- 3. USB socket coming from the PC is strong enough to supply the mRO even during warmup time if there is no power supply available.
- 4. A serial cable with 9 pin Sub-D connectors. One connector male, the other female.
 - Pin 2 connected to pin 2.
 - Pin 3 connected to pin 3.
 - Pin 5 connected to pin 5.
- 5. A frequency counter with an external reference input.

4. Installation Procedure

4.1. Safety

Warning: Use proper ESD precautions.

Warning: Ensure that all cables are properly connected.

The equipment contains small quantities of rubidium metal hermetically sealed inside the glass lamp and cell assemblies, hence, any dangers arising from ionizing radiation are caused for human health (exemption set in article 3 to Council directive 96/29/Euratom).

Handling the product in reasonably foreseeable conditions does not cause any risk for human health, exposure to the SVHC (substances of very high concern) would require grinding the component up.

4.2. Environmental Responsibility

The equipment contains materials, which can be either re-used or recycled.

Do not deposit the equipment as unsorted municipal waste. Leave it at an authorized local WEEE collection point or return to Safran to ensure proper disposal. In case of disposal by Safran, the costs related to return freight will be charged to the sender.

To return the appliance:

Submit a support ticket at https://safran-navigation-timing.com/support-hub/

We will contact you for more information and/or with shipment process details.



5. Safran mRO application control software

5.1. Setup

Start the executable **SpectraMon v3.0.0.exe** (can take up to 20s to execute) and open the **Settings** window.

- A/-	Settings			•	Connect
Monitor AC Calibrate	Serial communication COM Pert Bead rate Record	COM3 V 9660 V	mRO parameters. Path	Saie	
Control Farmware Update	Path	Broow			
	Power supply Votage	[š. ∨] v	PLL settings Fractional HGH Fractional LGW Modulater Barre	H2 H2	
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	Sended		Писелен		Send
छ Settings					Clear Data

Settings window

Select the available COM port connected to the evaluation board and press Connect:



Connect button

The software will automatically detect the type of mRO (mRO-50 or mRO-50 Ruggedized). The type of the mRO and the serial number will be display at the left of **Connection** button.





To record data coming from the mRO, select the filename path, and check the **Record** box.

~	Settings				RUG-mRO 🔒 Serial number : SN08700X 🕒 Disconnect.
Monitor Calibrate	Serial communication COM Port Baud rate	COM9 ~	٥	mRO parameters Path	Save
Control	Path	C:Record	Browse		
G Ferrinware Update	Power supply vatase	5 ~	V Statestionnes un domini ← → → + ⊕ + C + PC → T Orgenser → Nouveau domini Remes Code, suisce (TestFee) Code, suisce (Te	Aque loci I(C) > Record v C	C Reclescher dans Hacood IIII ← ● Tate
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0 Settings	FNHI MONITORI SN			00324485 0550208210CC09600955885207850787077800C5088608AB09C5093442 9 5805708X	Data

Data record

All data parameters coming from the mRO can be recorded inside a dedicated "record file" according to the timegate. The software records 27 parameters:

- 1. Unix_Timestamp: System (PC) time in seconds
- 2. IPhot(int): Photodiode data measured by the mRO, this is an int value
- 3. Atomic_SIGNAL_MIDDLE_RANGE (int) Satom 15: signal level data on the first side of the Rubidium line
- 4. Atomic_SIGNAL_UPPER_RANGE (int) Satom 31: signal level data on the second side of the Rubidium line
- 5. Heating_Power_Laser (int): heating power dissipated in order to warm the laser diode
- 6. Heating_Power_Rb_cell (int): heating power dissipated in order to warm the Rb cell.
- 7. Laser_source (int): voltage supply of the unit powering the laser diode of the mRO
- 8. Laser_Voltage (int): laser voltage, measured by the mRO
- 9. MiniRb_Temperature (int): temperature signal of the mRO
- 10. Voltage_control_TCXO (int): DAC value connected to the 10 MHz TCXO voltage control input
- 11. CFIELD (micro-Amp): current flowing through the magnetic coil in micro-Amp
- 12. Temperature cell setting (int): temperature setting point of the Rb Cell
- 13. Temperature laser setting (int): temperature setting point of the laser
- 14. Pil Laser (int): polarization of the power amplifier which drive the laser
- 15. PIL_CFIELD (int): polarization of the power stage which drive the current flowing through the magnetic coil
- 16. PIL Polar AOP (int): pre-polarization of the power stage which drive the laser
- 17. PIL VC: TCXO voltage control input
- 18. Status: mRO status
- 19. Rb_cell_temperature_setting point (°C): temperature of the rubidium cell
- 20. Laser_temperature_setting point (°C): temperature of the laser
- 21. MiniRb_Temperature (°C): temperature of the mRO
- 22. Laser_current (micro-Amp): current flowing through the laser diode.
- 23. Photodiode current (nano-Amp): current flowing through the photodiode.
- 24. Heating_Power_Rb_cell (mWatt): heating power dissipated to warm the Rubidium cell
- 25. Heating_Power_Laser (mWatt): heating power dissipated in order to warm the Laser
- 26. Cell heating current (mA): Current in milliAmp flowing through the heating system of the Rb cell
- 27. Laser heating current (mA): Current in milliAmp flowing through the laser heating system.



The **Power supply** of the mRO can be selected, it gives the ability to the software to compute the right power dissipated by the Rb-cell heating system and laser heating system.

Power supply		
Voltage	5	~
	3.3	
	5	

Power supply selection

The mRO will be contacted according to the Timegate parameter (configured in seconds).

	- Company - Comp	
Timegate	10	5

Timegate selection

The mRO memory can be recorded inside a dedicated "mRO parameters" file. Select **Save** to record these parameters.

~	Settings			RU	K3-mRO 🔒 Serial number : SN08700X 💿 Disconnect
Monitor	Serial communication			mRO parameters	
42	COM Part	COM9 V D		Pan	
Calibrate	Baud rate	9600 ~			
0	Record	P			
Control	Path	C:Record Browse			
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Memory record

When the software is executed, an **ApplicationControlSettings.ini** file is created in the same path as the executable. This file saves the settings in the **Settings** window, so that when you restart the software, the settings configured will be the last settings used.



5.2. Safran mRO series application control monitor

To begin monitoring the mRO, open the Monitor window and select Start Measurement.

- \/-	Monitor						RUG mRO 🔒 Sensi number : SM06700X 🥚	Disconnect
Monitor	Cell temperature			VCSEL temperatu	e			
~	Temperature	84	°C	Temperature	95	*0	Rutid	am 35 °C
Calbrate	PITHON	2390		Pil HLaser	3518		Measure	
	Photodiode	9448	nA	Current	1435	In A		
0	Heating current	26	mA	Heating current	16	mA	1.6	1.0
Control	Heating power	105	mW	Heating power	45	mW		
G Firmware Update				Serve loop	Closed	₿	198-1 1980 -	- 0.8
	Leser lock control			átom lock control				frequence
	Laser lock control	1205		Atom lock control				- 0.4
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	Sended						Received	Send
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Monitor window

When the start button has been selected, data monitoring will plot to a graph in the **Measure** window.

44	Monitor												RUG	mRO 🔒 Sk	nal number : SND8/	axx 🔹 🗖	isconnest
Monitor Calbrate Calbrate Calbrate Calbrate Calbrate	Cell temperature Temperature HTTCs Protocio5 Heating connect Ilcating power	84 2390 9521 21 105	°C nA mA mW	VCSEL temperatur Temperature PLILaser Dienet Heating coment Hisating power Serve loop	10 95 3519 1434 9 46 Closed	°C mA mW	Regimesorement Measure									Butidum	35 °C
	Laser lock control VCSEL current esting DI Laser Potar AOP Servo Isop	4300 4300 2400 Closed	ß	Atom lock control Servicep	Closed	₿	- 1 2 ann ann ann 	-32	13:25:40	19-2	5:49	13-22-59 Tune	13:25:06	13:26:1	5 13-26		90 999855 2.02 2.04
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Measurement ON

At the bottom left monitor box, the status of the commands sent to the mRO appears.

On the bottom right monitor box, items received by the mRO in HEX appear.

The content of both windows can be cleared by pressing **Clear Data** on the right side.



There is a moving graph on the right of the main window, with a sliding time window equals to 3 minutes (180 seconds).

The Window size can be set between 10 and 600 seconds.

Window size	180	S	Refresh
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Window size

On this graph, nine parameters are presented. All presented data are in a range going from 0 to 4095.

- MON Satom15 and MON Satom31 are samplings taken from the output of the photodiode amplifier used to center the mRO on the Rb line. Both values must be in the same range.
- **MON IPHOT** is the signal level output coming from the photodiode.
- **MON HLASER** is the heating system's level output, which drives the laser diode temperature.
- **MON HCELL** is the heating system's level output, which drives the Rubidium Cell temperature.
- MON Laser VPIL is the power stage level output, which drives the laser diode.
- MON Laser PIL is the laser diode voltage.
- **MON TPCB** is the temperature of mRO.
- **PIL DAC VC** for the mRO-50 is the 10 MHz TCXO voltage control input, which drives the atomic clock.
- **PIL DAC VC/16** for the mRO-50 Ruggedized is the 10 MHz TCXO voltage control input, which drives the atomic clock. It is divided by 16 for correct display in the graph.

All parameters presented on the graph can be toggled on and off by clicking on the corresponding parameter label at the bottom of the graph pane, that the user needs to visualize or hide respectively.

5.2.1. Cell temperature window

This window shows 5 parameters:

- 1. **Temperature**: the setting point temperature of the Rubidium cell
- 2. Pil HCell: the hexadecimal value of Temperature
- 3. **Photodiode**: the current flowing through the Photodiode, which collects light going through the Rubidium cell.
- 4. **Heating Current**: the current used by the heating system in order to warm the Rubidium cell.
- 5. Heating Power: the total power dedicated to warm the Rubidium cell.

Cell temperature

Temperature	81	°C
Pil HCell	2250	
Photodiode	4321	nA
Heating current	45	mA
Heating power	225	mW

Cell temperature window



5.2.2. VCSEL temperature window

This box shows 5 parameters:

- 1. **Temperature**: the setting point temperature of the laser diode
- 2. Pil HLaser: the hexadecimal value of Temperature
- 3. **Current**: the current flowing through the laser diode, which emits the light going to the Rubidium cell.
- 4. Heating current: the heating used by the heating system in order to warm the laser diode.
- 5. Heating Power: the total power dedicated to warm the laser diode.
- 6. **Servo loop**: the Padlock shows the state of the laser loop.

VCSEL temperature

Temperature	88	°C
Pil HLaser	3315	
Current	1199	nA
Heating current	20	mA
Heating power	100	mW
Servo loop	Closed	Ð

VCSEL temperature window

5.2.3. Laser lock control window

This box shows the settings of the power amplifier, which is driving the laser diode. The padlock shows the state of the laser loop.

Laser lock control

VCSEL current setting	4300	
Pil ILaser	4300	
Polar AOP	2400	
Servo loop	Closed	A

Laser lock control window

5.2.4. Atom lock control window

This box shows the status of the digital loop, which drives the VCTCXO 10MHz.

Atom lock control

Servo loop



Atom lock control window



5.2.5. Coarse frequency window

This window shows the **Modulator** value of the digital PLL which drives the signal used in order to set the mRO output frequency according to the Rb line.



Coarse frequency box

5.2.6. CField window

The mrO-50 CField window shows 4 parameters:

- 1. **CField** is the relative offset value used for the fine frequency adjustment.
- 2. **Pil CField** is the setting value of the power stage, which drives the current flowing through the magnetic coil.
- 3. Current is the current value of the magnetic coil.
- 4. Servo loop is the status of the CField loop

0	-	•	1.1
()			d
\sim			

CField	2304	
Pil CField	2285	
Current	1047	μA
Servo loop	Closed	Ð

CField box window mRO-50

The mRO-50 Ruggedized **CField** window shows 3 parameters:

- 1. **CField** is the relative offset value used for the fine frequency adjustment.
- 2. **Pil CField** is the setting value of the power stage, which drives the current flowing through the magnetic coil.
- 3. Current is the current value of the magnetic coil.

CField

oricid		
CField	2400	
Pil CField	2400	
Current	1000	μA

CField window for mRO-50 Ruggedized



5.3. Frequency setting

Open the **Calibrate** window and navigate to the **Frequency settings** tab.

Ą۶.	Calibration Laser settings Frequency settings	RUG-mHO 🔒 Sensi number: SV00/200. 🌒	Internet
Montor 43 Calibrate	Command Auto stat	Il Step modarement Rubdum Measure Rubdum	31 °C
Control Ormware Upcate	Cell temperature 2299 84 °C Apply Save Temporature 2299 84 °C Apply Save Ellowadoxte 5667 ~A 9677 ~A Save Save	959- 1599- 	D1 112
	Coarse frequency Nuddawi At8558 r - Avery PLL Sam		no diserber D.C2
	CField Current 2400 + - Appy Sise 8 2400 1000 u/	19655- 	3,04
	Servo loop Status 2 Rafeet Laser 2 Com Alom 2 Com FLEOL/RAOP Therms compensation 2 Com Vessi compensation 2 Com	Prosumery 0.0 Hz Vinition size Vinition size Vinition size Vinition size Vinition size III Vinition size Vinition size	
G. Settings	Sended Boorrool Montrool Montrool Montrool		Send Cloar Deta

Frequency settings tab

5.3.1. Command window

The **Command** window gives the ability to the mRO to lock automatically on the Rb line after power ON.

Command Auto start	Disable
	Command window

5.3.2. Cell temperature window

The **Cell temperature** window set the temperature of the Rb cell is set.



Cell temperature window

The higher is the temperature of the Rb cell, the lower is the photodiode current.

Apply: applies the value of the temperature box to the RAM of the microprocessor of the mRO.



Save: saves the value of the RAM inside the ROM of the microprocessor.

5.3.3. Coarse frequency window

This window allows the user to change the mRO frequency by 1.24 ppb step.

Coarse frequency						
Modulator		4186530	+	-	Apply	PLL Save
	0					



Warning: It is highly recommended to set the frequency adjust selector of the evaluation board on FA and to let the SMA connector (D) free of any coaxial cable when the coarse and fine frequency setting are used.

The + and – buttons increase or decrease the modulator value, and act immediately on the frequency output of the mRO.

The **Modulator** value can be written and the **Apply** button can be pressed to apply the new **Modulator** value. It is highly recommended to not exceed +/- 500 steps relative to the original default value.

Wait at least 6 seconds after each new modification, as the mRO system needs time to change the frequency output due to the high-quality factor of the atomic loop.

The PLL modulator can set the mRO frequency output in a range of 9 999 995.00 to 10 000 005.00 Hz (+/- 500 ppb) without any stability degradation.

Select the **PLL Save** button to save the **Modulator** value inside the ROM of the microprocessor.

5.3.4. CField window

This window allows the user to modify the mRO frequency by about 2.5 ppt step. (0.0025 ppb). The CField value represents the current flowing through the magnetic coil.



Warning: It is highly recommended to set the frequency adjust selector of the evaluation board on FA and to let the SMA connector (D) free of any coaxial cable when the coarse and fine frequency setting are used.

The + and – buttons increase or decrease the **CField** value, and also affect the frequency output of the mRO.

The **CField** value can be written and the **Apply** button can be pressed to apply the new **CField** value. When the frequency output is set in the appropriate range, the **Save** button is activated.

It is highly recommended to not exceed +/- 500 steps relative to the original default value.



5.3.5. Servo loop window

This box allows the user to open the 4 mains digitals loops of the mRO.

Servo loop			Servo loop		
Status	\square	Refresh	Status	S	Refresh
Laser	C	Open	Laser	ß	Open
Atom	,	Open	Atom	Ð	Open
Thermal compensation	A	Open	PILPOLARAOP Thermal compensation	Ð	Open
Vcsel compensation	R	Open	Vcsel compensation	Ð	Open

Servo loop window for mRO-50 (left) and mRO-50 Ruggedized (right)

The Vcsel compensation loop can be opened without any condition, 10 minutes after power ON. The Thermal compensation and PILPOLARAOP Thermal compensation loop can be opened without any condition, 10 minutes after Power ON. The Atom loop can be opened without any condition, 10 minutes after power ON. It is not recommended to open the Laser loop.

The **Refresh** button requests the status of the 4 mains digitals loops from the mRO.

5.4. Update of the mRO firmware

It is possible to erase and load a new firmware without erasing the data relative to the operating mode of the mRO.

To do that open the **Firmware update** window and select the path to the new firmware.

	Settings New firmware path		Browse						
Control Control Firmware Update	Command Update firmware Start Status Parameters saved Frimware erased Frimware restarted	* _ Select file ← → · · · · · · · · · · · · · · · · · ·	Local Disk (C) > OROLIA		Date modified	v Ö Type S19 File	Seerch OROLIA	×	
		File name	20020201.419				Update firmware files Open Cancel		
D Settings	Sended FD FRLO FRHO FRHO FRHO FRHO SN			^	Received 003FE134 00324288 00324488 0024488 00240CF210CC095D09 SN000098	600FA207AD07B50	07C5089B0CAD0D730A2F095B4I	200	Clear Data

Firmware update window



Select a path in order to save all parameters of the mRO and press Start.

Calibrate	Settings New firmware path mRO-50 parameters path	Browse		
Control Firmware Update	Command Update firmware Start Status Parameters saved Frimware verseed Frimware restarted	*Select file ← → * ↑ > This PC > Local Disk (C) > OROLIA Organize • New folder ** Quick access This PC 30 Objects Desktop © Documents ↓ Downloads ↑ Music Pitures ¥ Videos ¥ Local Disk (C) → FiLES (D)	O Search OROLIA O	× • • • •
0	Sended TD TRLO TRNO	File name: 20020201.s19	update firmware file Open Received 0037E134 00332488	s v Cancel d Send Clear Data

Firmware update window

Firmware update ongoing, firmware is written inside the microprocessor.

It takes around 4 minutes maximum to update the mRO to new firmware.

anter more	Settings					
<i>(</i>)	New firmware path	C-JOROLIA/20020201.s19	Browse			
Calibrate	mRO-50 parameters path	C/OROLIA/2020-09-10_12-56-44_mRO50_parameters.txt	Browse			
Control	Command Update firmware	Start				
Gi Firmware Update	Status Parameters saved	~				
	Frimware erased	1				
	Frimware updated	o				
	Frimware restarted					
	Sended			Received		Send
Co Settings	S113358030405246484 S11335A0801238E35C5 S1133550F4AD3040524 S1133580A016801238E S11335708012F4AD304	33D4002053C40BC14B012DA 306200Ec69E10B012FAAD98 64233D40205S5C40AB162C 35C9304203C40AA10B01297 052444E433D4002053C404B	~	P (E)rase or (P)rogram Exased E (E)rase or (P)rogram		Clear Data

Firmware update window



After that update is done, the mRO restarts automatically.

	Settings New firmulare path mRO-50 parameters path	C 70R0UA28050211 s19 C 70R0UA282565 19_12 56-41_mR058_parameters tot	Orberte Bronze			
Source of the	Command Update fermane					
Proven	Status Paraneters saved Primare erated Primare related	* * * *	Godani formare	A dafa with summer		
0	Sended 9 390322042 31137776077647761	75677707748778877007850		Forcewed A 701 y80c-50 y82%, (0) y80c-80 y82%, (0) y80c-80), (0) y80c-80 y80c-80), (0) y80c-80), (0) y80c-80 y80c-80	0066 05.0000-000010A 20020201 00005A768	Send Ceater Defa

Firmware update window

6. Safran Technical Support

For technical support, product specifications, and additional documentation, you can visit <u>https://safran-navigation-timing.com/support-hub/mro-50-support-hub/</u> to submit a support request.

More information on standard unit behavior or any other features or functions of the mRO series can be found on our website at https://safran-navigation-timing.com/product/mro-50/



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