1. SCOPE

The Doppler Wind Experiment (DWE) Ultra-Stable-Oscillator (USO) is a compact, atomic resonance-controlled oscillator, which provides an extremely stable sinusoidal output signal at 10 MHz.
Next the detailed description of DWE USO, the manual provides transportation-, handling- and storage information, as well as installation-, operation- and test instructions.

2. APPLICABLE DOCUMENTS

The Applicable Documents listed below form part of this document.

AD 01 HUYGENS PROBE CRAF/CASSINI PROGRAMME
EXPERIMENT INTERFACE DOCUMENT PART A

AD 02 HUYGENS PROBE CRAF/CASSINI
DOPPLER WIND EXPERIMENT - DWE
EXPERIMENT INTERFACE DOCUMENT PART B

AD 03 HUYGENS PROBE CRAF/CASSINI PROGRAMME
EXPERIMENT INTERFACE DOCUMENT PART C

AD 04 HUYGENS
EXPERIMENT DOCUMENT REQUIREMENTS DESCRIPTION

AD 05 HUYGENS PROBE CRAF/CASSINI
DOPPLER WIND EXPERIMENT - DWE
PRODUCT ASSURANCE PLAN

AD 06 CASSINI MISSION: HUYGENS PROBE
TECHNICAL SPECIFICATION
ULTRASTABLE OSCILLATOR - USO for the
DOPPLER WIND EXPERIMENT - DWE

In the event of conflict between the content of this document and the content of applicable documents, the following order of precedence shall apply:
AD 02 - AD 01 - AD 03 - AD 04 - AD 05 - AD 06 - this document

3. DWE USO DESCRIPTION

3.1. Experiment Objectives

The primary scientific goal of the Doppler Wind Experiment (DWE) on the Huygens Probe of the Cassini Mission is a determination of the direction and strength of the zonal winds in the Titan atmosphere. A height profile of wind velocity will be derived from the Doppler shift of the Radio Relay Link signal from the Huygens Probe to the Saturn Orbiter with an accuracy at the ±1 m/s level.

Further scientific objectives of the experiment are
- to monitor Probe descent dynamics like spin and parachute swing,
- to establish position and orientation of the Huygens Probe at and after impact on Titan
- and to determine strength and spatial scales of turbulences in the Titan atmosphere by measurement of Doppler modulation, Doppler variations and fluctuations.

For implementation of the DWE
- an Ultrastable Oscillator within the Transmitter (TUSO) chain of the Huygens Probe is required to assure Doppler stability of the Probe Relay Link
- and a further Ultrastable Oscillator is required within the Receiver (RUSO) on the Saturn Orbiter to guarantee frequency stability of the receiver.

The DWE USOs are compact, atomic resonance frequency-controlled oscillators. The USOs highly frequency-stable output signal is obtained from a 10 MHz Voltage Controlled Crystal Oscillator (VCXO), whose frequency is referenced and locked to the atomic resonance frequency $f_{rb} \approx 6.834$ GHz provided by the ground-state hyperfine transition of the 87Rb.

A photograph of the USO is shown in Figure 3.1-1.

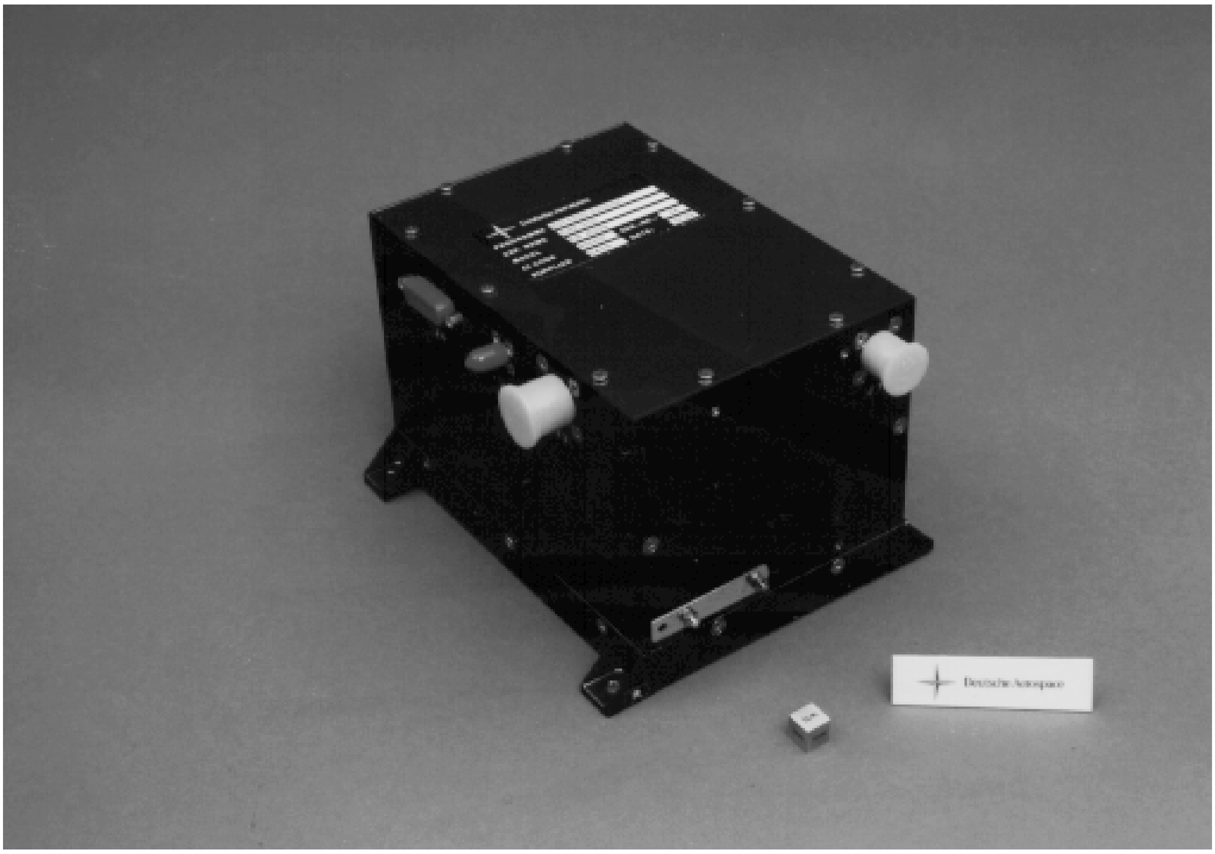


Figure 3.1-1: DWE - USO

3.2. USO Functional Design and Operating Principles

3.2.1. Functional principle

Figure 3.2-1 illustrates the functional principle of a Rb USO:

- The VCXO is locked to the hyperfine transition by synthesizing a microwave signal that is derived from the 10 MHz VCXO output.
- This microwave signal is used to excite the Rubidium atoms that are contained within a glass cell in a microwave cavity.
- The frequency synthesis scheme is designed so that the VCXO frequency is exactly 10 MHz when the microwave frequency equals the hyperfine transition frequency.
- A comparison of the synthesized microwave signal and of the atomic resonance generates an error signal to servo the VCXO through its control voltage.

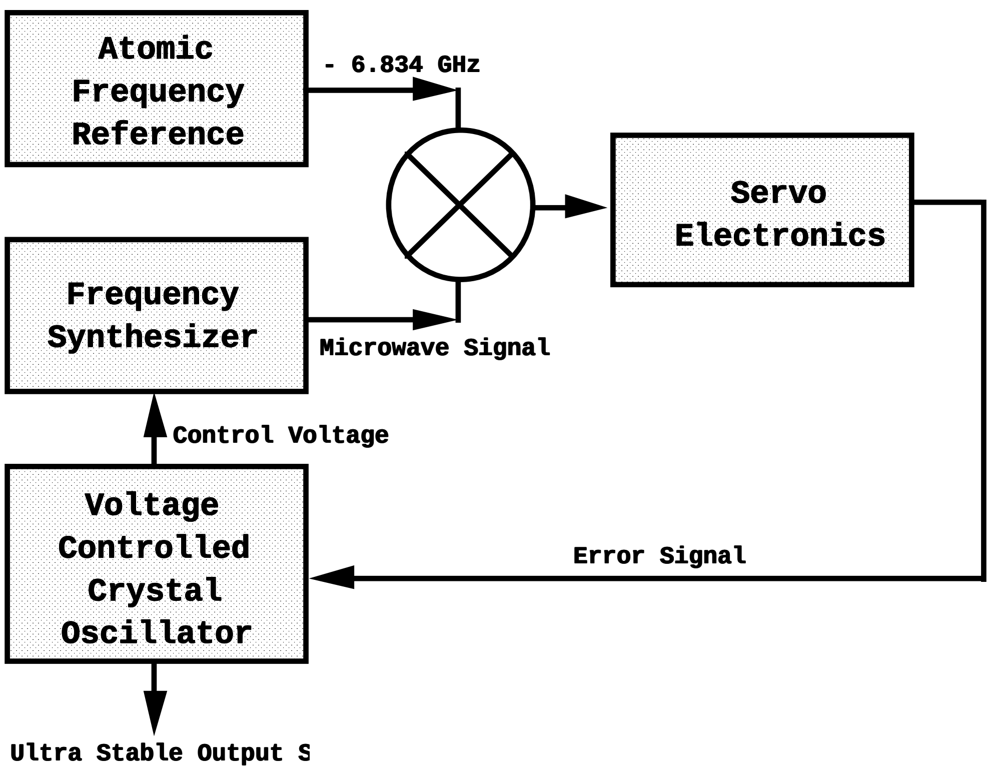


Figure 3.2-1: Rb USO Functional Principle

3.2.2. Physics Package and Detection of the Atomic Resonance

Light, generated by an RF excited plasma discharge within a Rubidium lamp, is injected to the resonance cell, where it interacts with the Rubidium atoms vaporized in the cell at an elevated temperature. Some of the light is incident upon a photo detector cell within the microwave cavity. These components form the so-called Physics Package. A schematic of the Physics Package indicating the optical signal processing is shown in Figure 3.2-2.

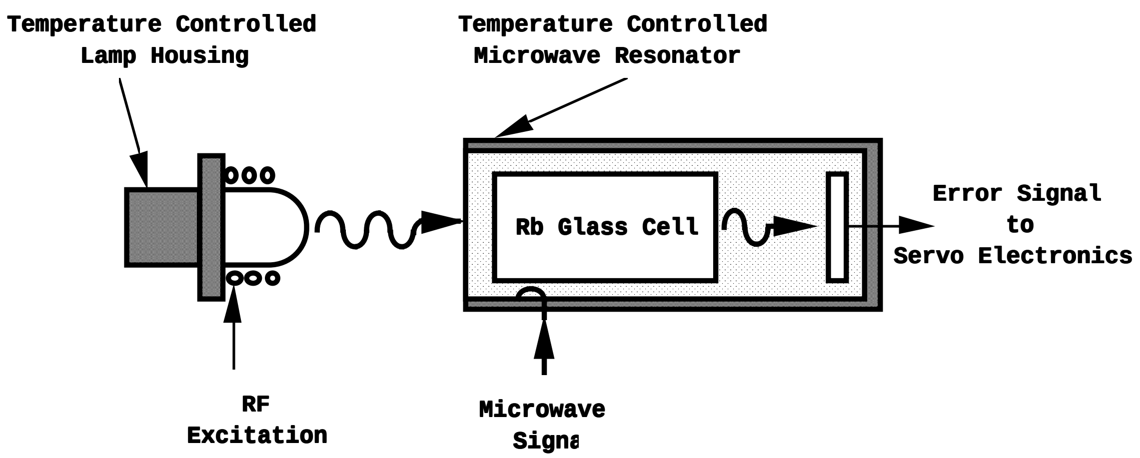


Figure 3.2-2: Optical Signal Processing

When the applied microwave frequency is equal to the Rubidium resonance frequency f_{rb}, the rubidium atoms resonate within the microwave field in the cavity. The resonance causes the light reaching the photo detector to decrease. This behaviour is illustrated by the dip in the uppermost curve in Figure 3.2-3.

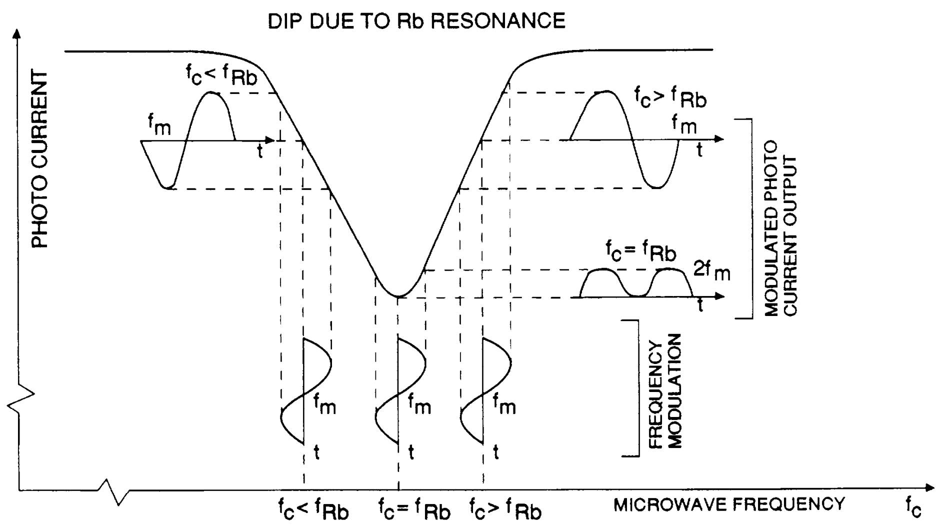


Figure 3.2-3: Derivation of Modulation Signal (Courtesy of Ball Efratom)

3.2.3. Atomic Resonance and Optical Pumping

The atomic resonance is detected by optical means and involves a process known as optical pumping. Figure 3.2-4 shows the energy levels and transitions of ^{87}Rb Atoms during optical pumping.

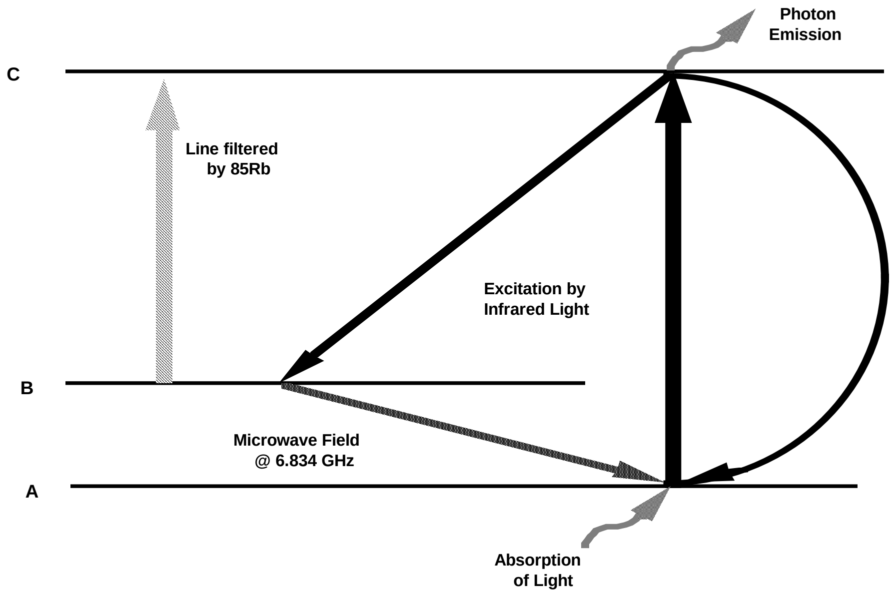


Figure 3.2-4: Illustration of Optical Pumping Process

The two lower levels, A and B, are the ground state hyperfine levels. In the absence of external stimuli, the Rubidium atoms are equally distributed between these two levels.

Through the absorption of light energy, the atoms are raised to a higher state that is referred to as level C. Level C is an optically excited state of the atom that is normally vacant. In general, transitions to level C can occur from either of the two hyperfine energy levels, A or B. To ensure that only the atoms of hyperfine level A will make the transition to level C, the light is filtered by means of a vapour in the cell, which contains 85Rb and 87Rb isotopes and a buffer gas. The 85Rb atoms have an overlap with the 87Rb resonance transition line B and thus can absorb the level B atoms. The remaining infrared light offers the proper wavelength to be absorbed by the Rb atoms in level A. After being raised to level C, the atoms emit a photon and again redistribute to levels A and B.

The buffer gas is used to keep the Rb atoms away from the cell walls and to freeze them in place for interaction with the microwave field, which causes the circle to be closed by the transition of atoms from level B to level A.

The absorption of light by the Rb atoms when raised to level C can be detected by a small (less than 1%) dip in the light intensity when sweeping the microwave field over the resonance. For this reason a DC detection of the dip is not advisable. An AC method where the microwave signal is phase modulated with an audio frequency signal of about 135 Hz performs well. As can be seen from Figure 3.2-3 modulation of the microwave signal copies to a modulation of the photo detector output current. Using this signal as an error signal to servo the VCXO will result in a photo detector current being modulated at twice the modulation frequency when the microwave signal is exactly equal to the rubidium hyperfine frequency. In other words, the presence of the doubled modulation frequency indicates that the 10 MHz output signal of the VCXO is locked to the ultra stable atomic resonance frequency of Rubidium.

3.3. USO Description

Figure 3.3-1 represents a detailed block diagram of the DWE USO. The figure also shows the arrangement of the USO functional blocks on circuit boards.

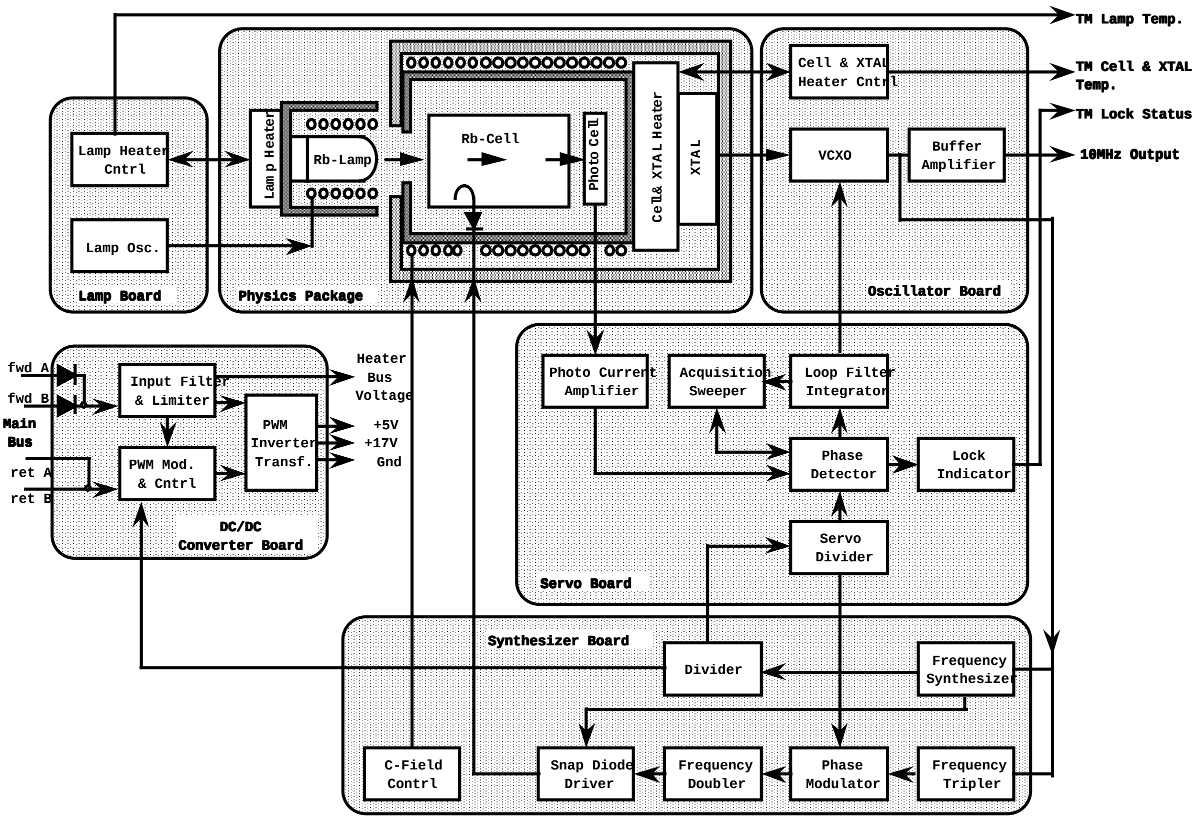


Figure 3.3-1: DWE-USO Functional Blockdiagram

3.3.1. Lamp Board

The Lamp Heater Control electronics and the Lamp 0scillator circuit (with the exception of the tank coil) are located on the lamp board. The Lamp Oscillator operating at a frequency of about 83 MHz provides the energy to ignite and maintain ignition of the Rubidium lamp.

3.3.2. Physics Package

Core of the USO is the Physics Package with the functional elements
- Rb lamp with lamp coil and heater
- Resonator containing Rb cell, step recovery diode, microwave couple loop and photo detector
- Magnetic-field coil
- Common heater for resonator and crystal (XTAL)
- and the XTAL itself all mounted in a common magnetic shield made from Mu-metal.

The Rb lamp, which provides light by an RF-excited plasma discharge, is mounted in a temperature-controlled (≈113°C) housing. The coil located around the lamp is part of the RF exciter circuit. As already mentioned, the remaining elements of the lamp oscillator are part of the Lamp Board.

The function of the resonator is
- to filter the light from the Rb lamp and to perform interaction of the light with the Rubidium atoms of the cell
- to adapt an input signal from the Synthesizer Board, which represents the frequency of the USOs crystal oscillator output signal
- and to generate an error signal to the servo board in order to stabilize the frequency of the crystal oscillator.

In order to do this, a 60 MHz and a 5.3125 MHz signal mixed on the Synthesizer Board are applied to the step recovery diode, which produces harmonics of the signals. The couple loop and the resonator cavity are tuned to select the spectral component equal to $114 \cdot 60$ MHz - $1 \cdot 5.3125$ MHz, which corresponds to the resonant frequency (6.834... GHz) of Rubidium. In order to find the Rubidium resonance by the AC method described in section 3.2, the 60 MHz signal is phase modulated by a 135.6 Hz signal. The response of the Rubidium atoms is detected by the photocell, which provides the error signal to the servo board. The resonator is operated at a fixed temperature of about 78°C.

The magnetic-field coil, which is wound on the resonance cell, generates a magnetic field that provides optimum field strength for the hyperfine transition (so-called 2nd order Zeeman effect).

Separate heater transistors are used for the temperature-controlled housings of lamp and cell. Dedicated thermistors for lamp and cell form part of the respective feedback branch of the thermal control circuits.

In the USO a special mechanical stress compensated (SC-cut) crystal oscillator is used. The crystal can be operated at the same nominal temperature as the resonator cell (=78°C). Therefore, the crystals thermal control circuit is slaved to the control circuit of the cell. An additional thermistor is provided to monitor the actual crystal temperature.

3.3.3. Servo Board

The Servo Board provides the control voltage for the Voltage Controlled Crystal Oscillator (VCXO). Two reference signals at audio frequencies of 135.6 Hz and 271.2 Hz are generated by dividing the 138.9 kHz signal derived from the Synthesizer Board by 1024 and 512, respectively.

The inversion in phase of the modulated photo current, which happens exactly at the Rubidium resonance frequency (refer to Figure 3.2-3), is synchronously demodulated by a phase detector using the 135.6 Hz reference signal. The demodulator output signal is processed in the Loop Filter Integrator. The integrator output voltage is non-zero until the VCXO output frequency is locked to the Rubidium atomic resonance frequency f_{rb} and can for that reason be used as the control voltage for the VCXO.

In a second loop the doubled modulation frequency can be detected using the 271.2 Hz reference signal. This demodulator output signal is used to indicate lock to f_{rb}. The lock signal is also used to stop the acquisition sweep, which is activated after switch on of the USO. During acquisition the VCXO is detuned such that the microwave signal in the resonator sweeps around the Rubidium hyperfine frequency with a peak deviation of ¦ 10 Hz.

3.3.4. Synthesizer Board

On the Synthesizer Board all frequencies required for signal processing within the USO are generated from the VCXO output signal.

The 60 MHz signal applied to the step recovery diode via a driver circuit is generated using a frequency tripler and a doubler in series. The 5.3125 MHz signal also required by the snap diode is produced by a frequency synthesizer, which divides the XTAL-signal by 32 and adds up the halved signal frequency. A further signal at 138.9 kHz is synthesized by dividing the 10 MHz signal by 72. As already mentioned, this signal is used as an input for the servo electronics and additional to synchronize the DC/DC converter switching frequency to the USO output.

A further task performed by the electronics on the Synthesizer Board is to phase modulate the input signal to the step recovery diode using the 135.6 Hz signal.

Additionally, the synthesizer board provides the DC input signal to control the magnetic field of the resonator coil in the Physics Package.

3.3.5. Oscillator Board

This board provides the ultra-stable 10 MHz signal via a buffer amplifier to the USO output connector and to the Synthesizer Board. With the exception of the SC-cut crystal, which is located in its oven within the Physics Package (see section 3.3.2), the board incorporates all elements of the VCXO. The crystal has no separate heater circuitry. The XTAL is mounted with excellent thermal contact to the resonator cell, and is heated in slave mode by the cell heater. Nevertheless, separate thermistors are used to measure the temperature of the cell and of the crystal oven.

3.3.6. DC/DC Converter Board

The DC/DC Converter, a schematic diagram is shown in Figure 3.3-2, has two redundant input lines A & B. Both input lines, forward and return, are floating above chassis and are insulated from secondary signal ground. The converter limits the maximum input current to 1 A for any USO internal short circuit scenario. The DC supply voltage range is +26 V to +32 V. The USO heater elements, which are also floating above chassis and insulated from secondary signal ground, are supplied by the converter directly after input filtering and current limitation. The regulated supply voltages (+5V and +17V) for the USO electronics are galvanically insulated by transformers from the converter input. The switching frequency is synchronized to the 10 MHz output signal (refer to section 3.3.4).

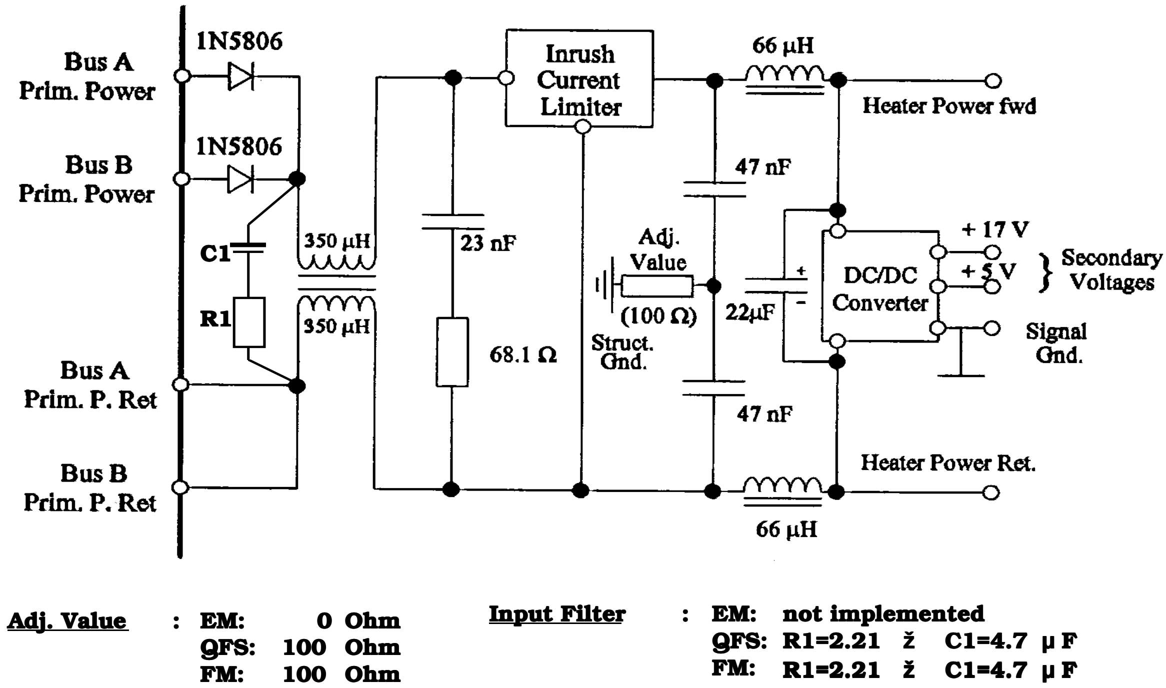


Figure 3.3-2: DC/DC Converter Schematic Diagram

3.4 Mechanical and Thermal Design

The small volume, low mass and low power consuming USO has been realized by the application of advanced technological concepts.

The Physics Package shown in Figure 3.4-1 is configured from two subassemblies:

- The Rb lamp together with the oscillator coil and the lamp heater mounted in a cylindrically shaped assembly made from a high temperature resistive and low thermal conductive plastic material

- The metallic microwave resonator containing the step recovery diode, the microwave couple loop, the Rb cell and the photo detector, all mounted together with the magnetic-field coil, the SC-cut crystal and the heater elements in a cylindrically shaped magnetic shield made from Mu-metal.

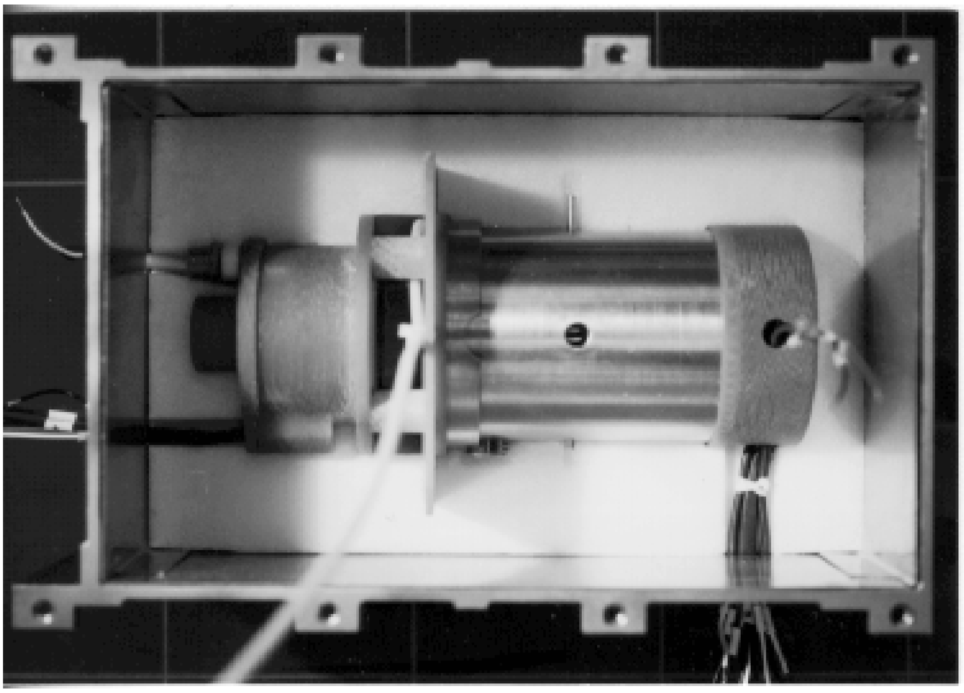


Figure 3.4-1: Physics Package embedded in Foam within Inner Housing

The Physics Package is encapsulated by a low thermal conductive foam within a two-layer inner housing of the USO (see Figure 3.4-1). The inner housing forms the second magnetic shield required for the Physics Package. To ensure proper stiffness of the inner housing and simultaneously achieving low mass, only a thin Mu-metal layer that provides the required magnetic shielding is used. This thin Mu-metal layer is mechanically supported by a second layer made from aluminium.

The USO electronics, described in section 3.3, is grouped into functional blocks and arranged on five printed circuit boards:

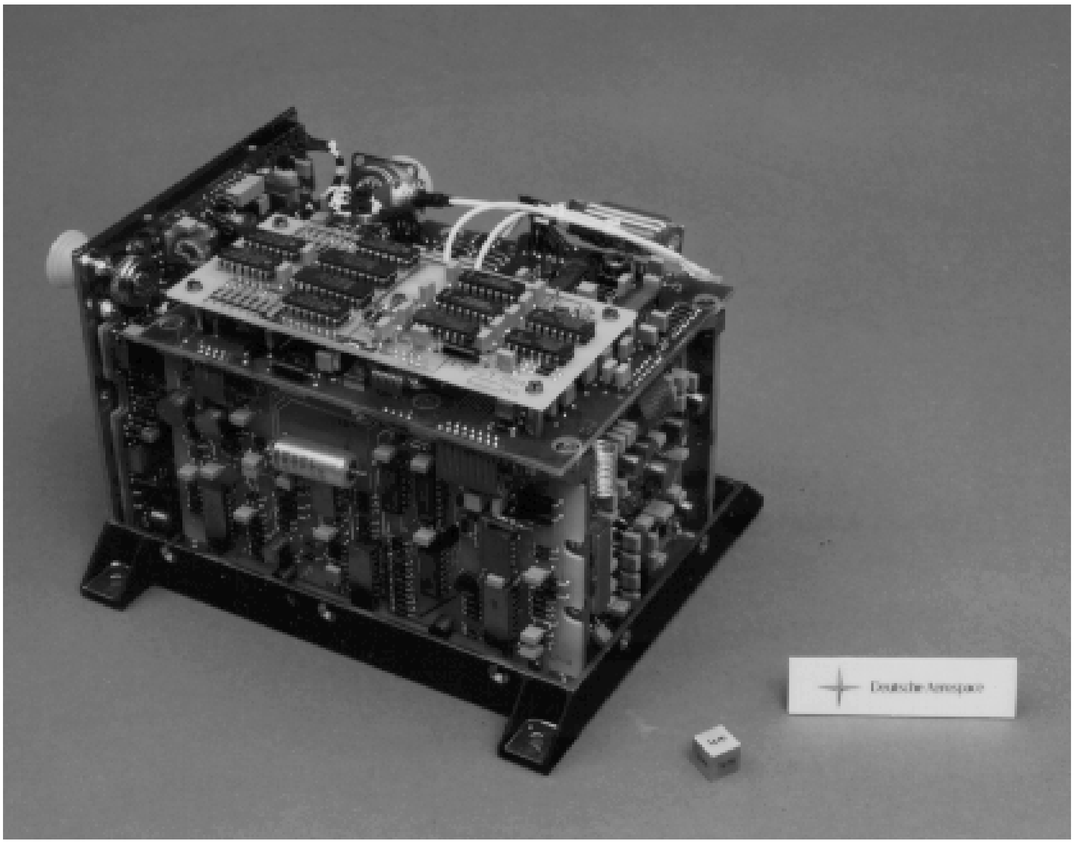
- DC/DC Converter Board
- Servo Board
- Oscillator Board
- Lamp Board

- and Synthesizer Board.

The Synthesizer Board consists of a main-board carrying the analogue synthesizer functions and a small additional board mounted on top of the main-board, which incorporates the digital synthesizer functions.

The physical arrangement with the printed circuit boards surrounding the inner housing of the USO can be seen in Figure 3.4-2. Figure 3.4-3 shows the DC/DC Converter Board.

Radiation sensitive parts like bipolar transistors and MOS-field effect transistors are encapsulated by tantalum caps that provide radiation shielding in addition to the structural elements of the USO.



3.4-2: DWE - USO Cover and Side Walls Off

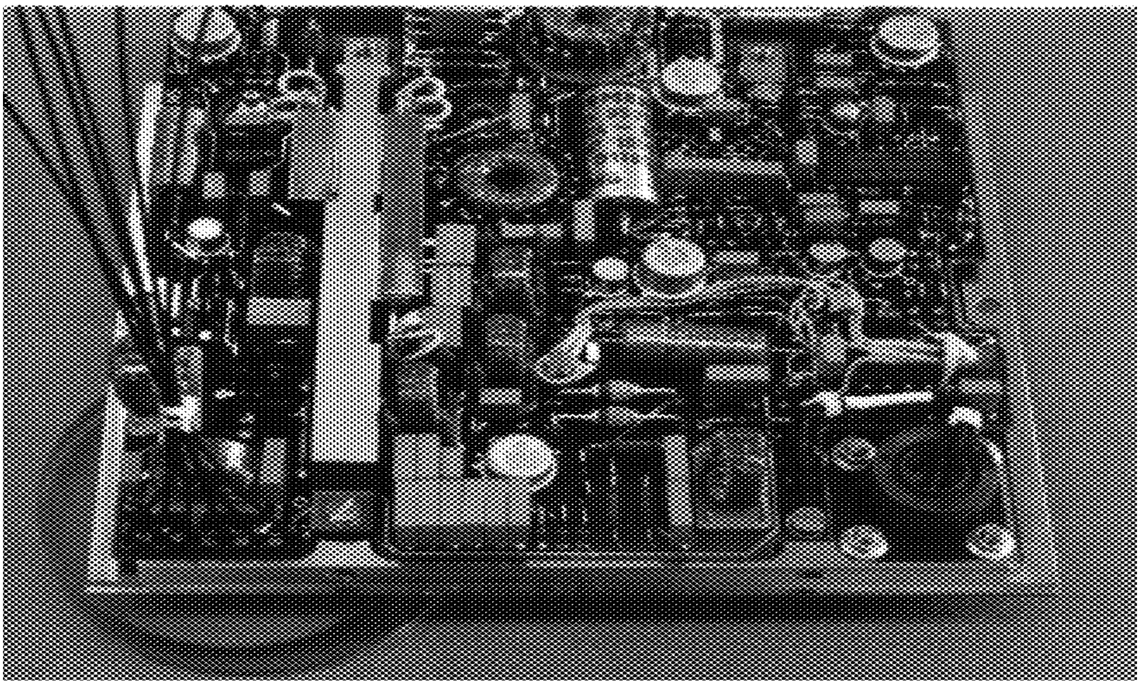


Figure 3.4-3: DC/DC Converter Board

3.5. Performance Characteristics

The pertinent performance characteristics for the Rubidium USO are listed in

- Table 3.5-1: Electrical Performance
- Table 3.5-2: Physical Performance
- Table 3.5-3: Environmental Conditions

PARAMETER	VALUE	DIMENSIONS
Frequency • Nominal Output Signal Frequency • Frequency Tolerance ∂f/fo • Warm-up Time until lock to Rubidium • Frequency Drift df/fo after lock to Rubidium • Short Time Stability for tau = 1 sec • Short Time Stability for tau = 10 sec • Frequency Variation with temperature (df/fo)/dt	10 ± 1e-8 + <±1.4 e-9 < 5e-11 < 9e-11 < 3e-11	MHz 1/K
Phase noise at Frequency Offset • -1000 Hz • -100 Hz	< -120 < -120	dBc/ Hz

• -10 Hz • -1Hz	< -95 <- 75	
Signal Level and Waveform • Output power into 50 • 2nd & 3rd Harmonic • Spurious up to 50 MHz • Output impedance • Return Loss	 0 ± 2 < -45 < -60 50 > 26	 dBm dBc dBc dB
DC Power • Supply voltage Range • DC Current • DC Power Consumption during Warm-up • Steady State DC Power Consumption	 + 26 to + 32 < 675 < 18.4 ++	 V mA W

+: $t[sec] \leq 0.0035 \cdot (T-85)^2 + 4$ at ambient pressure: T is base plate temperature in C
++: $P[W] \leq 9.93 - 0.047 \cdot T$ at ambient pressure: T is base plate temperature in C

Table 3.5-1: Electrical Performance Characteristics (to be continued)

PARAMETER	VALUE	DIMENSIONS
Telemetry Signals • Lamp Temperature + • Cell Temperature ++ • XTAL Temperature ++ • Lock Status +++	 0 to +5 0 to +5 0 to +5 0 to +5	 V V V V

\+ $T[°C] = 101.68 + 3.092 . v - 0.04594 . v^2 + 0.1125 . v^3 - 0.02409 . v^4 + 0.002227 . v^5$ with v in
++ $T[°C] = 64.42 + 3.077 . v - 0.51180 . v^2 + 0.3652 . v^3 - 0.08270 . v^4 + 0.007003 . v^5$ with v in Volt
+++ off: 0 V < v < 0.5 V ; on: 2.4 V < v < 5 V

Table 3.5-1: Electrical Performance Characteristics (continued)

PARAMETER	VALUE	DIMENSIONS
Dimensions: l x w x h	170 x 117 x 118	mm x mm x mm
Mass	1900 +0/-30	g
Centre of gravity with respect to reference whole • lx • ly • lz	 58.8 ± 1 66.7 ± 1 71.5 ± 1	 mm mm mm
Moments of Inertia • Ixx • Iyy	 7.93 ± 0.16 7.62 ± 0.15	 gm^2 gm^2

• Izz	4.60 ± 0.09	kgm^2

Table 3.5-2: Physical Characteristics

PARAMETER	VALUE	DIMENSIONS
Temperature • Operational • Storage	 -20 to +50 - 20 to +60	
Pressure	0 to 1.6	bar
Relative Humidity	< 75	%
Sine Vibration • 5-22 Hz • 22-100 Hz • Duration	 10 20 4	 mm g (peak) octave / min
Random Vibration • 20-60 Hz • 60-700 Hz • 700-2000 Hz • overall • Duration	 +6 0.2 -3 16.6 2	 dB / octave g^2 / Hz dB / octave g (rms) min/ axis
Electromagnetic Compatibility acc. to DASA reports: DWE-DASA-1000-TR-0003, -0004, -0005, -0006 and -0007		

Table 3.5-3: Environmental Conditions

3.6. Interfaces

3.6.1. Mechanical Interface

The USO is configured from a single box as shown in the Interface Control Drawing in Figure 3.6-1a and 3.6-1b.

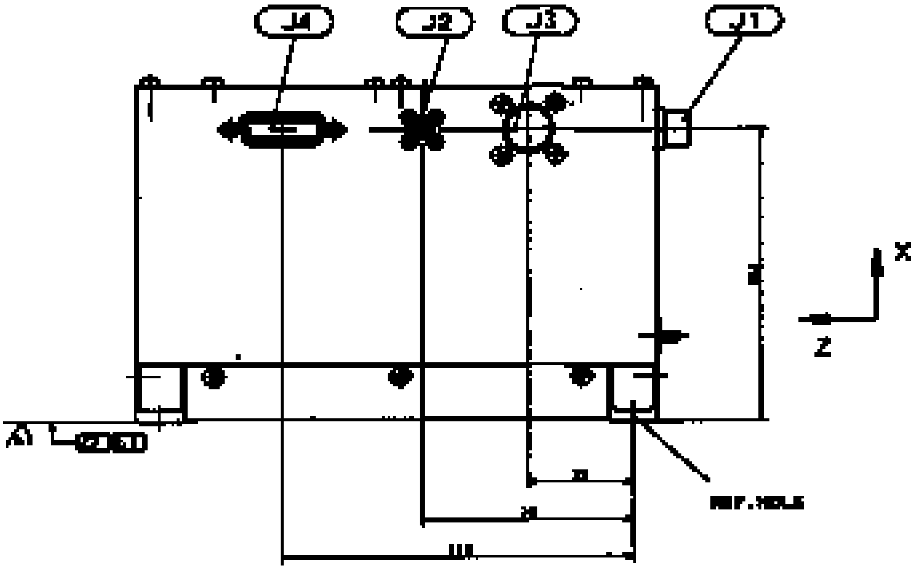


Figure 3.6-1a: Interface Control Drawing (continued)

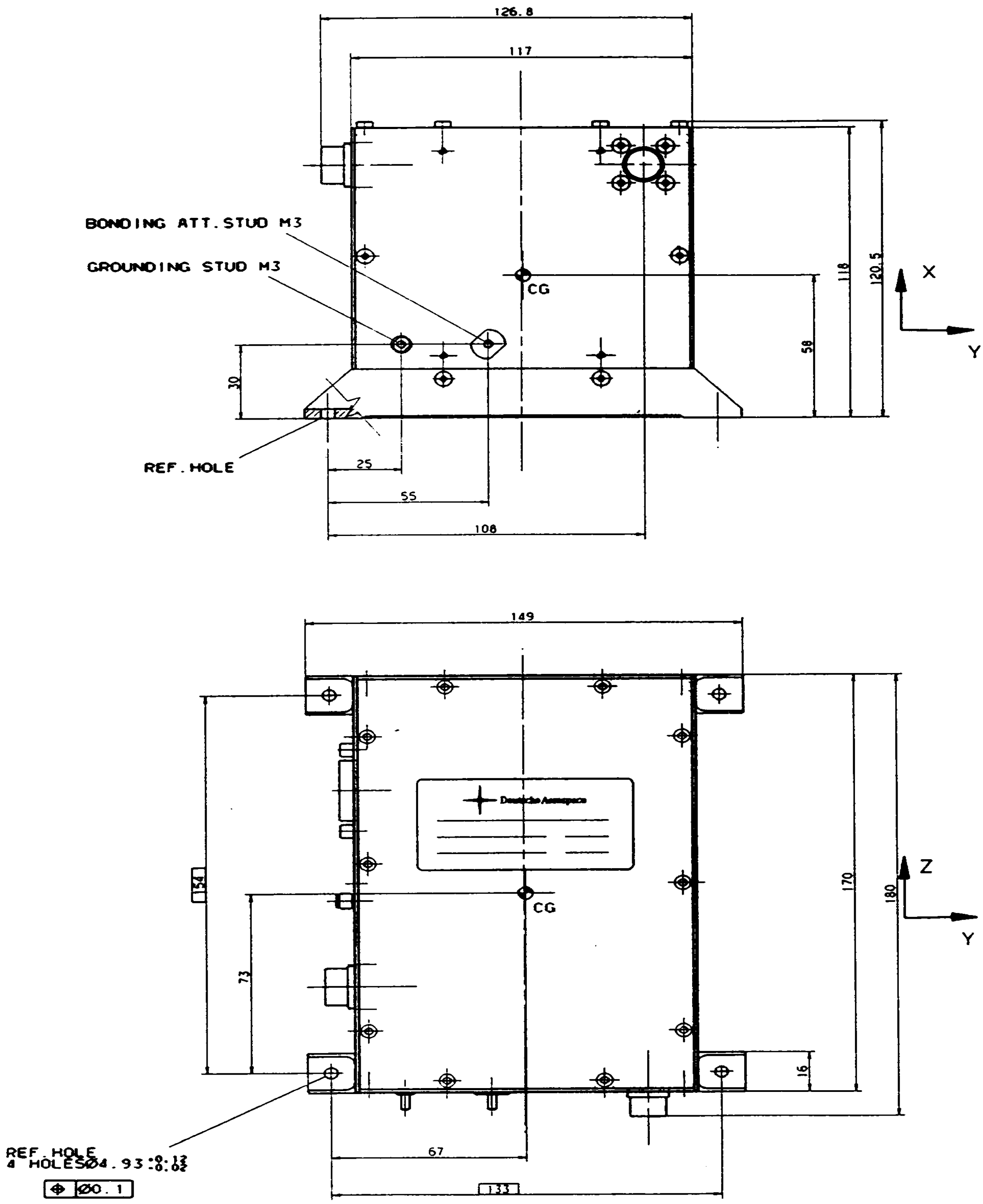


Figure 3.6-1b: Interface Control Drawing (continued)

3.6.2. Thermal Interface

The thermal interface characteristics are listed in Table 3.6-1.

Baseplate Contact Area	4 studs a' 16 x 16 mm^2
Surface Finish	Ni-plated Aluminium & Chemglaze Z306□Baseplate and Contact Areas without Chemglaze□
Surface Emissivity Surface Absorbtivity	0.85 0.85
Heat Capacity	1200 ± 60 J / K

Table 3.6-1: Thermal Interface Characteristics

3.6.3. Electrical Interface

The electrical signals are characterized in section 3.5. Location of the connectors
- J1: Power Connector
- J2: RF Connector
- J3: TM Connector
- J4: Test Connector

can be seen from the Interface Control Drawing in Figure 3.6-1a.

The connector pin allocations are given in Tables 3.6-2 to 3.6-5.

RF-, TM- and Power Interface Circuitry Diagrams are shown in Figure 3.6-2, Figure 3.6-3 and Figure 3.3-2, respectively.

Figure 3.6-4 represents the USO grounding scheme as described in section 3.3.

Connector: 3401 044 01B 03 08-35 PNL		
PIN	**FUNCTION**	**TYPE OF LINE**
1	+28 V Primary Voltage A	P
2	□ Primary Voltage Return A	RP
3	□ +28 V Primary Voltage A	P
4	□Primary Voltage Return B	RP
5	□ Spare	
6	□ Spare	

Table 3.6-2: J1- Power Connector Pin Allocation

Connector: R126 - 273 SMA Female		
PIN	**FUNCTION**	**TYPE OF LINE**
inner	10 MHz Output	coaxial
outer	Output Return	coaxial

Table 3.6-3: J2 - RF Connector Pin Allocation

Connector: 3401 044 01B 03 10-35 SNL		
PIN	**FUNCTION**	**TYPE OF LINE**
1	TM Lamp Temperature A	analog
2		analog
3	TM Lamp Temperature B	analog
4	TM Resonator Temperature A	analog
5	TM Resonator Temperature B	analog
6	TM Crystal Temperature A	analog
7	TM Crystal Temperature B	digital bilevel
8	TM Lock Signal A	digital bilevel
9	TM Lock Signal B	
10	Spare Signal Ground (TM-	
11	Return) A Signal Ground	
12	(TM-Return) B Signal Ground	
13	(TM-Return) A Signal Ground	
	(TM-Return) B	

Table 3.6-4: J3 - Telemetry Connector Pin Allocation

Connector: 3401 002B DAMA 15S NMB		
PIN	**FUNCTION**	**TYPE OF LINE**
1	+17 V Secondary Voltage	analog
2		analog
5	+ 5 V Secondary Voltage	
4		analog
3	Secondary Signal Ground	analog
6	Modulation Frequency (135.6	
7	Hz) Reference Signal	analog
8	(135.6 Hz) Spare	analog
9	Video Signal	analog
10	Lock Signal	analog
11	+ 15 V	
12	+ 7.5 V	analog
13	Spare	analog
14	Lamp DC - Signal	analog
15	Loop Signal	
	VCXO Control Voltage	

	Spare	

Table 3.6-5: J4 - Test Connector Pin Allocation

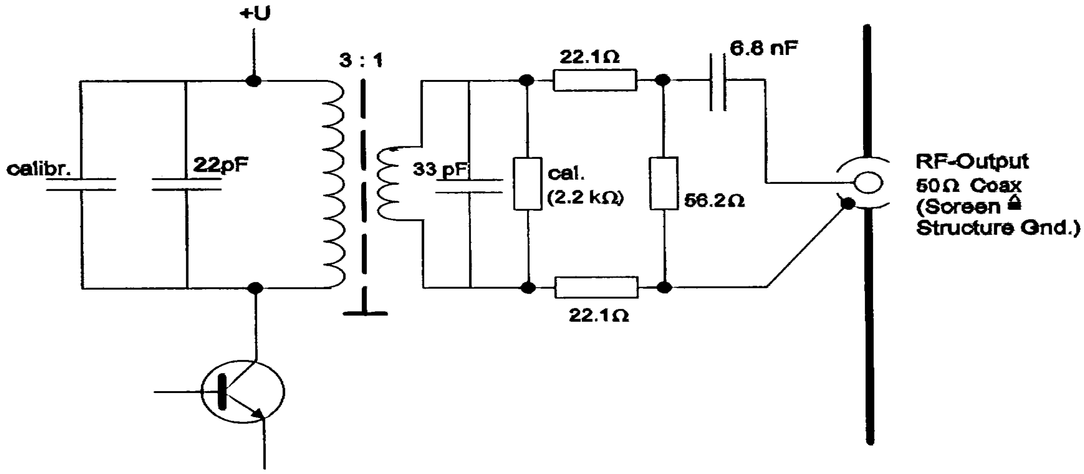
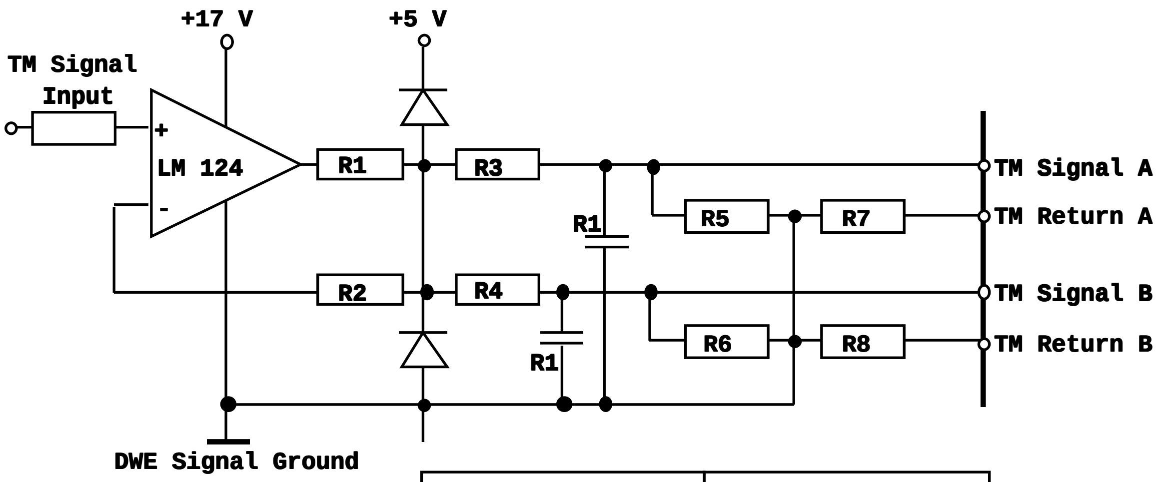


Figure 3.6-2: RF-Interface Circuitry Diagram



	Analogue TM Signal		Digital TM Signal	
Element	EMs	QFS, FMs	EMs	QFS, FMs
R1	6.8 kž	6.8 kž	6.8 kž	6.8 kž
R2	475 kž	475 kž	121 kž	121 kž
R3, R4	1.8 kž	1.8 kž	1.8 kž	1.8 kž
R5, R6	15 kž	8.25 kž	15 kž	8.25 kž
R7, R8	0	100 ž	0	100 ž

Figure 3.6-3: TM Interface Circuitry Diagram

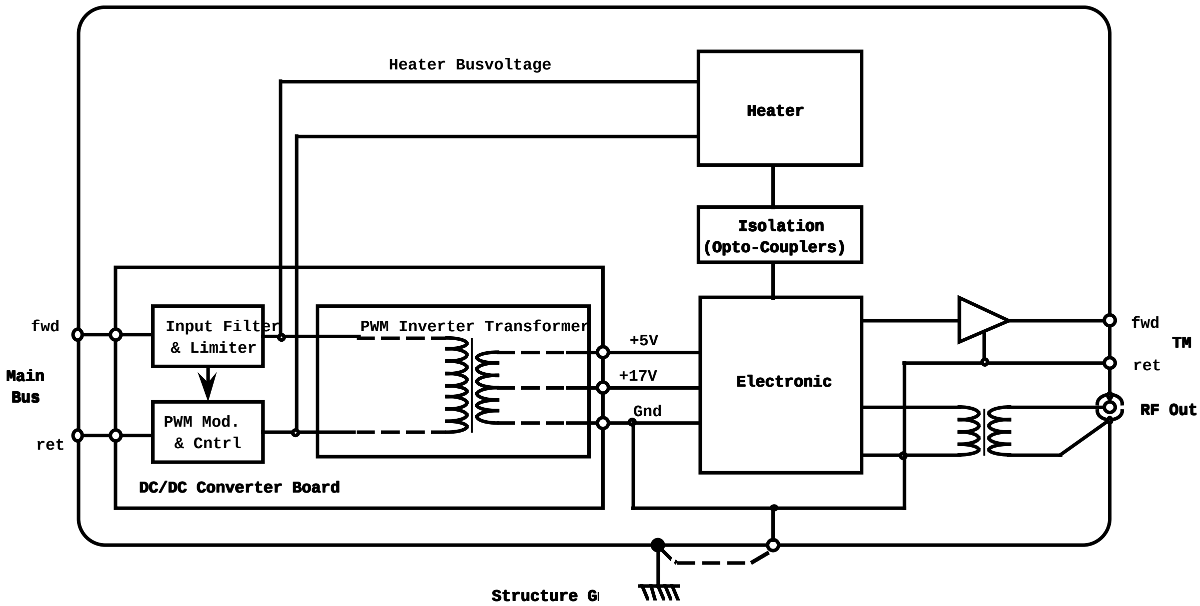


Figure 3.6-4: USO Grounding Scheme

4. TRANSPORTATION AND STORAGE

4.1. Shipping and Receiving Information

The Rubidium USO is packaged and shipped within two polyethylene bags in a foam-packed transport case. The USO was inspected mechanically and electrically prior to shipment. Upon receipt of the USO, an inspection should be made to ensure that no damage has occurred during shipping.

4.2. Handling Procedure

The USO is uncritical to handle because all sensitive parts are located inside the box. Nevertheless, the DWE-USO shall be handled with clean, lint-free gloves by authorized personnel only. The handling environment shall be not worse than lab conditions, that is:

- Temperature: 22°C ± 3 °C
- Rel. Humidity: 45% to 75%

Electrical connector pins and sockets are to be examined for contamination and damage prior to connection and disconnection. Unused connectors must be protected by dust covers.

4.3. Storage and Transport Conditions

For long-term storage and further shipment, the USO shall be put into a polyethylene bag. The opening of the bag shall be folded over, not welded. The bag containing the USO shall be packed together with at least one dust-free desiccant bag (DIN 55473) into a second polyethylene bag. After evacuation and sealing, the second bag shall be inserted together with the shock absorber material in the original transport case.

For transport and short time storage temperature shall not exceed -30C to + 60C. For long term storage the lab conditions defined in para. 4.2 shall be maintained.

4.4. Safety Instructions

There are no sources of hazard identifiable. Therefore, no safety instructions are necessary.

5. INSTALLATION INSTRUCTIONS

5.1. Mounting

The USO housing has been designed to minimize the thermal conductance between USO and the mounting platform by using only four mounting studs.

We recommend using four M4 x 16 screws together with No. 4 sleeve washers. Screws should be fixed using a torque screwdriver (Ma = 100 Ncm).

5.2. Power Requirements

The DWE-USO STPM requires an external DC voltage source capable of providing a DC voltage 26 V ≤ Vdc ≤ 32 V with a maximum current of 650 mA.

6. OPERATING INSTRUCTIONS

Under normal operating conditions, when the USO is supplied by a DC voltage of 26 V ≤ Vdc ≤ 32 V and the RF output is terminated with a 50 Ohm resistive load, the unit immediately provides a 10 MHz signal from the crystal oscillator.

Until lock to the Rubidium atomic reference frequency, the 10 MHz signal is frequency modulated by the resonance search sweep signal. The frequency peak deviation is about ± 10 Hz with a corresponding sweep rate of

- ≈ 0.085 Hz / sec for QFS and FMs
- ≈ 0.8 Hz / sec for EMs.

After lock frequency accuracy is better 1.4 .10-9. Warm-up time until lock depends on the environmental temperature and is typically 16 minutes after switch-on at ambient temperature of 25°C. In general, warm-up time and steady state power consumption can be predicted from the mathematical relationships given in Table 3.5-1.

Next the RF output signal the USO provides short circuit protected telemetry- and test signals (refer to sections 3.5 and 3.6). These signals are designed for nominal operation into load impedances ¦ 10 M¢. Temperature as a function of the telemetry voltage can be calculated using the formulas given in Table 3.5-1.

7. MAINTENANCE

The Rubidium USO does not require preventive or periodic maintenance.

8. TROUBLE SHOOTING AND REPAIR

Performance of the Rubidium USO can be verified using the Unit Tester set-up shown in Figure 8-1. The test equipment required to functionally test the USO is listed in Table 8-1. Test equipment other than those items listed may also be used provided that the performance equals or exceeds the characteristics of the listed items. A copy of the measurement software and a software users manual, written in German language, are available on request.

8.1. Test Set-up and Verification of Unit Tester

The functional operation and measurement accuracy of the Unit tester has to be verified prior to the USO performance testing. The individual test-steps are:

1) Perform test set-up according to Fig. 8-1 and switch on all equipment with the exception of the USO (switch off DC Power Supply No.1). Allow for 2 hours warm-up time.

2) Adjust frequency of the synthesizer to 10 MHz + 30 Hz and the output power level to +7 dBm.

3) Connect Rb reference Frequency Standard to testport "T".

4) Call-up measurement software "USOMP" and select "Meßreihe Starten".
Set reference frequency to 10 MHz, frequency offset to 30 Hz and measurement time to 20 minutes.

5) To store measurement results, define Dateiname, e.g. "VERIFY.mes", and start measurement.

6) Start measurement of short time stability and wait 20 minutes.
Verify measurement accuracies from graphics:
- frequency drift dfo/fo < $1 . 10^{-11}$ per hour
- short term stability for integration time tau = 1 sec: $\Delta fo/fo < 3 . 10^{-12}$

7) Disconnect Rb Reference Frequency Standard from Testport "T".

The Unit Tester is now ready for performance verification.

8.2. Performance Verification

The individual test steps are:

1) Connect the USO to testport "T" and measure USO baseplate temperature

2) Call-up measurement software "USOMP" and select "Meßreihe Starten".
Set reference frequency to 10 MHz, frequency offset to 30 Hz and measurement time to 180 minutes.

3) Adjust DC power supply to 28 V and switch on supply.

4) To store measurement results, define Dateiname, e.g. "USOTEST.mes".

5) Start measurement and monitor lock status. When USO is locked (≈ 20 min. after turn-on at ≈25°C) start measurement of short time stability and wait 180 minutes.

6) Switch-off USO and evaluate measurement results for
   Ñ frequency
   Ñ short-term stability
   Ñ DC power consumption
   Ñ temperature signals
   Ñ lock status
   Ñ and test voltages
   from graphics and compare results to specified values.

8.3. Out-of-Specification Performance and Repair

The USO should not be disassembled. In case the verification tests indicates out -of - specification performance, the unit should be send back to DASA.

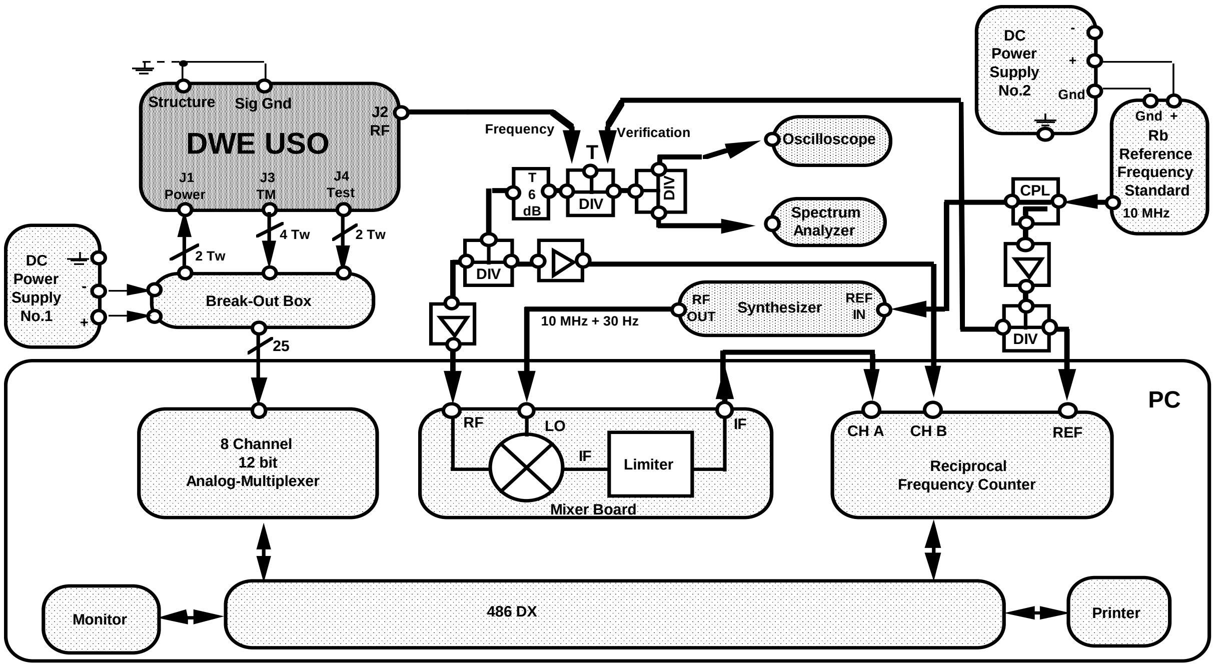


Figure 8-1: Performance Test Set-Up

	Equipment	Manufacturer	Type
-	DC-Power Supply No.1	Philips	PE1540
-	DC-Power Supply No.2	Philips	PE1540
-	Personnel Computer		486 DX
-	8 Channel 12 bit ADC	Keithley	DAS-8PGA
-	Mixer Board	Ball-Efratom	FMS-200
-	Universal Counter Board	Guide Technology	GT100
-	Monitor		
-	Printer	Kyocera	F-1010
-	RF Synthesizer	HP	Hp3335A
-	Spectrum Analyzer	HP	Hp8566A
-	Oscilloscope	Tektronix	7834
-	Dual Time Base	Tektonix	7B92A
-	Dual Trace Amplifier	Tektronix	7A26
-	Multimeter	Fluke	8000
-	Rb Ref. Freq. Standard	Ball-Efratom	FRK-L-2C6A1A
-	Break-out Box	TU Bochum	DWE01
-	Amplifier	HP	Hp8447A
-	Amplifier	HP	Hp8447A
-	Set of 10MHz Signaldividers	Minicircuits	

Table 8-1: Unit Tester Equipment List