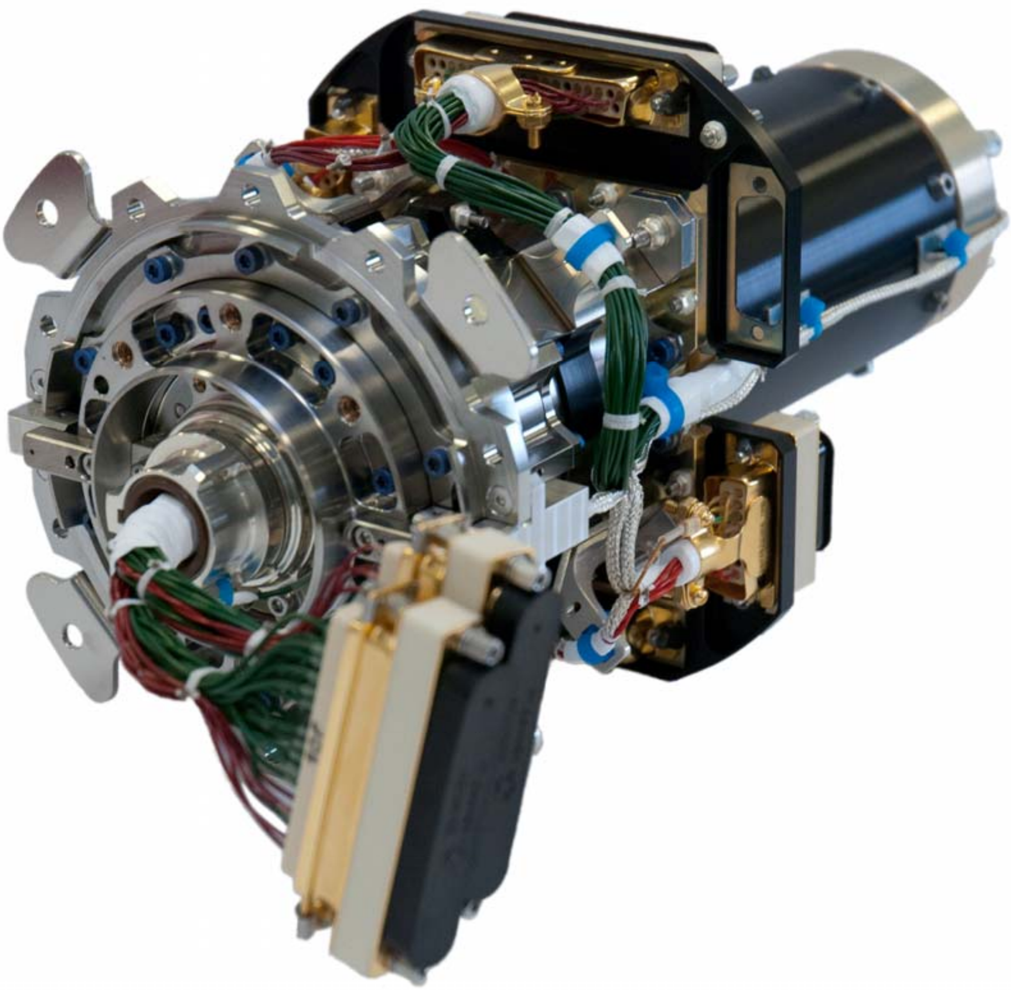
SEPTA® 33
Solar Array Drive Assembly



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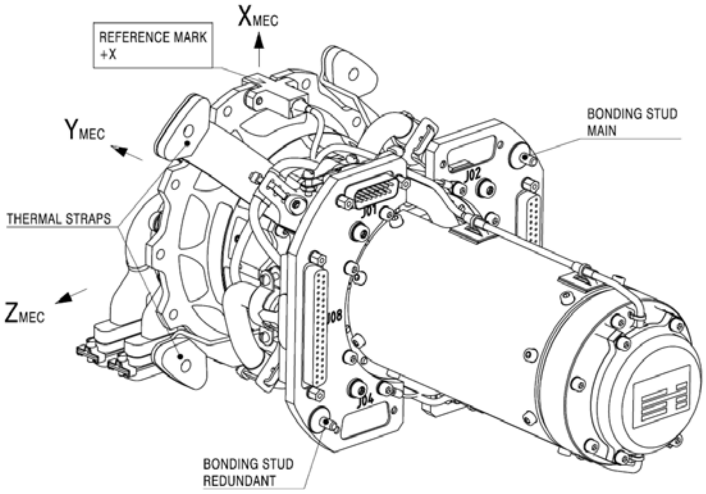
GENERAL DESCRIPTION

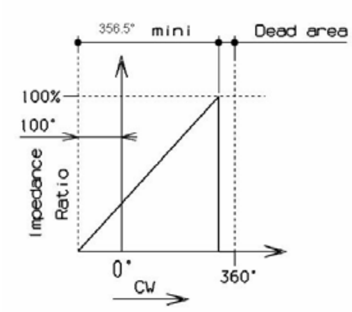
The SEPTA 33 Solar Array Drive Mechanism (SADM) is designed to fulfil a wide range of applications on satellites with a mass of approximately 1000 kg in various orbits that are used for scientific, navigation or telecommunications purposes by using a standard product. The Septa 33 is designed with a focus on robustness and for a lifetime of more than 12 years. The SEPTA 33 is fully space qualified and is used in both GALILEO IOV (33CS) and FOC (33P) programme. The SADM consists of an actuator, a slip ring assembly (composed of a collector for power and signal transfer) and sensors for position feedback. Within the qualification campaign of SEPTA 33 a total of 21 000 cycles were performed during the life time test. The SADM has >100 yrs of accumulated component flight heritage (C.F.H.) since 2003, and is flying since 2011. The SEPTA 33 is an alternative to the Septa 31 or 32.



The SADM provides the direct interface with the Solar Array Yoke and the Spacecraft structure. Due to the inherent stiffness of the actuator, this is an advantage over other designs of SADM as the actuator carries all the launch loads from the Solar Arrays, while the slip ring Assembly has to carry only the loads introduced from the position sensor and the self-weight of the assembly. The SEPTA®33 has a very precise rotational resolution (step size) of 0.002055° and a maximum speed of 0.4°/s (one rotation per 15 minutes). A variant with 0.0054° step size is also available. The position of the Solar Array is measured using two redundant potentiometers delivering an accuracy of ±0.5°.

Overall SRA configuration considers ten power lines rated at 4.0 A_{RMS} each, with five groups of 'twin' returns, two pairs of separate and redundant ground connections, and eight multi-purpose signal lines. Full double insulation as well as margin wrt current and power has been included in the design.

Position measurement is achieved using main and redundant potentiometers with an overall resistance of 10 kΩ, which feedback an analogue 0 V to 5 V signal, delivering a continuous angular position of the SADA with a full measurement scale of 360°. The actual linearity of the individual potentiometers is better than ±0.35°. An independent and fully redundant highly repeatable reference position sensor is included in addition delivering an OC signal on passing the mechanical reference position.

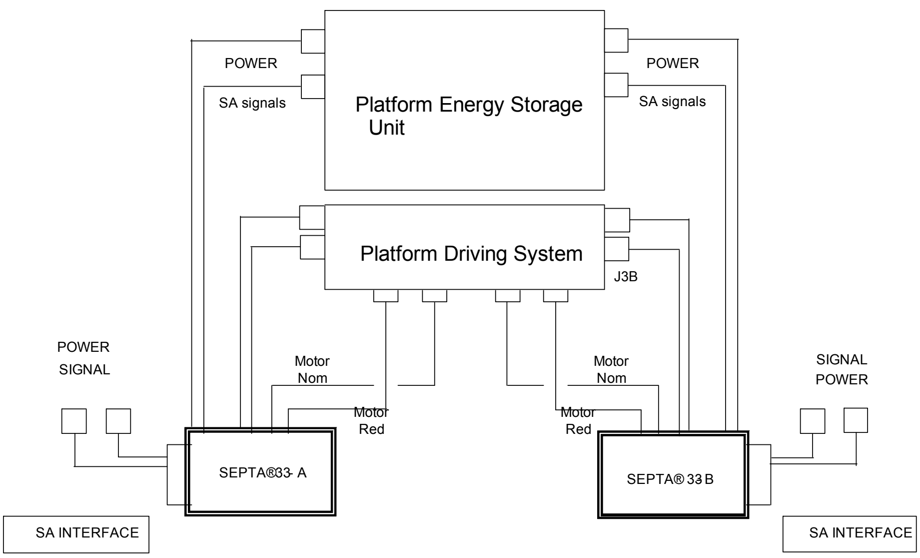


The SADA is powered using a two phase hybrid stepper motor with redundant windings giving 175 200 or 66 240, resp. stable (un-powered) positions of the output shaft over one revolution.

The SEPTA 33 is only available without embedded electronics and shall be powered directly with a dual phase, bipolar 25 V to 30 V input with minimum step duration of 10 ms. For full torque performance in this mode, the maximal step frequency shall not exceed 100 Hz. Constant current and microstepping operation is also possible.

OPTIONS

The SEPTA 33 is available with an optical position sensor (33CS version) with a resolution of 10 bit and an RS422 interface.



MOTOR INTERFACE

- Supply Voltage: 28 V +2/-3 V
- No. of Phases: 2
- Min. Step duration : 10 ms
- Rise time per step: < 0.5 ms
- Step Frequency: 100 Hz max.
- Nominal Power: 4.7 W
- Peak Power: 13 W (TBC)

In slow drive mode, with steps following at 205 ms (average) repetition rate, the motor shall be left unpowered in the pauses. Doing so, the lines must be left open (a high resistance termination is acceptable) to avoid an inductive short on the powered winding.

ESD

SEPTA 33 are ESD (electrostatic discharge) sensitive device. Electrostatic charges as high as 4000 V readily accumulates on the human body and test equipment and can discharge without detection. Although the SADM features proprietary ESD protection circuitry, permanent damage may occur on devices subjected to high energy electrostatic discharges. Therefore, proper ESD precautions are recommended to avoid performance degradation or loss of functionality.

SPECIFIC DESIGN FEATURES

Double insulation and separation of potential is a specific concern in the SADM as a failure may significantly affect the power available to the S/C. As a consequence, different potentials have been physically separated, and specific isolation means are included to prevent unwanted contact.

All bearings feature labyrinth seals to prevent debris from entering the mechanism, and to retain the lubricant. Design of these labyrinths follows standard design rules and practice and their function has been tested.

PACKAGING AND STORAGE

As delivered by RUAG SPACE the SEPTA®33 is mounted on a handling tool equipped with shock detectors.

The SEPTA 33 must be kept in a clean room class 8 (100 000) environment and shall be protected from direct UV light. If moved out of a clean environment, it has to be double bagged and sealed in antistatic protective foil (ESD) under dry nitrogen.

DELIVERABLES

- FM- or PFM-Units
- Transport and Handling Jigs (temporary only)
- EIDP (CD-ROM):
    - Certificate of Conformity
    - CIDL & ABCL
    - Logbook
    - Interface Control Document
    - User's Manual
    - RfD's / RfW's
    - NCR's
    - Minutes of Meetings
    - Acceptance Test Plan
    - Acceptance Test Report

FM ACCEPTANCE PROGRAMME

The flight model acceptance programme includes the following tests:

- Inspection and control
- Mass measurement
- Functional characteristics measurement
- Vibration tests (FM-level)
- Thermal vacuum cycling with performance tests
- Inspection and Control

DESIGN CHARACTERISTICS

Mechanism	
Drive direction	Forward and reverse rotation (endless rotation)
Speed range	0 to 1 rev / 15 min
Maximum rotation speed	0.4°/s
Qualified life span	12 years in orbit + 5 year storage (2 years integrated on Satellite)
Qualification sequence	21000 sweeps

Actuator	
Winding resistance (at 20°C)	82.9 Ω±5%
Number of steps per revolution of motor	360
Gear ratio options	1:486.667 or 1:184
Stabile positions (motor is unpowered)	175200 or 66240 steps
1 step corresponds to (at output)	0.002055° or 0.0054°
SA holding torque (unpowered motor)	≥ 20 Nm
SA average torque (powered motor)	≥ 10 Nm
SA repeated peak torque (powered motor)	≥ 14 Nm (starting and stop)
SA momentary peak torque (powered motor)	≥ 20 Nm (exceptional peak torque)

Power Transfer (forward and reverse line)	
Number of power transfers	10 (with 5 ‚twin' returns)
Current	4.0 A_{RMS}
Voltage	Nom. 55 V
Power transfer	2.2 kW
Insulation	≥ 10 MΩ
Noise	10 mV_{RMS}/A

Signal Transfer forward or reverse line)	
Signal transfer number	8
Current	1 A_{RMS}
Voltage	55 V
Insulation	≥ 10 MΩ
Noise	10 mV_{RMS}/A

Position Measurement	
Potentiometer resistance	10 kΩ ± 10%
Potentiometer accuracy	±0.5° resp. (±8.73 x 10^{-3} rad)
Potentiometer linearity	±0.15%
Alternative optical position sensor	10 bit, RS-422 interface, dual 5 V and 12 V supply
Reference position sensor	Active-low OC signal, 0.1° repeatability, 5…9 V supply

Dimensions	
External diameter	140 mm to 160 mm
Total length (from SA interface flange to rear part)	240 mm
Mass without external leads and connectors	M ≤ 4.0 kg
Mass with external leads and connectors	M ≤ 4.25 kg

Mechanical Interface	*PF interface*	*SA interface*
	See Figures 2 to 5	See Figures 2 to 5

Power Consumption (worst case)	V_{BUS}	P_{motor}	P_{SADE}	Total Power
Maximum conditions	28 V	4.6 W	N/A	< 4.6 W

Qualified Temperatures	T_{min}	$T_{Ambient}$	T_{max}
Ground Storage	+ 10°C	+22°C	+ 40°C
In orbit non operational	- 40°C		+ 75°C
Cold start-up limit	- 25°C		
In orbit operational (note: SA interface at -60°C/+110°C)	- 25°C	+22°C	+ 70°C

Environment conditions during operation			
Orbits	LEO	MEO	GEO
Radiation Total Dose		15 krad	

SADM Connectors	
SA Power & SA Signals (SA Interface)	D-SUB 37 P
SA Power & SA Signals (PF Interface)	D-SUB 37 S
SADM Actuator	D-SUB 15 P
SA Position Signal	D-SUB 15 P

Radiative Interface	*Slip ring housing*	*Motor housing*
External finish (nature)	Black anodizing	
Emissivity (ε)	0.85	0.5
Absorption (α)	0.80	

Interface load allowables	Qualification
Axial load (F_y)	3000 N
Radial load (F_{xz})	3000 N
Torsion moment (M_y)	25 Nm
Bending moment (M_{xz})	250 Nm

Stiffnesses	
Axial stiffness (K_y)	> $200*10^6$ N/m
Shear stiffness (K_{xz})	> $50*10^6$ N/m
Torsion angular stiffness ($K_{\theta y}$)	> 30000 Nm/rad
Bending angular stiffness ($K_{\theta xz}$)	> 130000 Nm/rad

Environment conditions during launch (qual. Level)			
		⊥ *MOUNTING PLANE*	// *MOUNTING PLANE*
Quasistatic loading		23 g	21 g
High level sine vibration:	5 Hz to 22 Hz	10 mm	10 mm
	22 Hz to 100 Hz	20 g	20 g
Sweep rate		2 oct / min	
Random vibration:	Frequency (Hz)	⊥ *MOUNTING PLANE*	// *MOUNTING PLANE*
Notching at main mode to respect	20-100 / 20 - 100	+3 dB/oct	+3 dB/oct
above interface load allowables	100 - 250 / 100-600	0.70 g²/Hz	0.160 g²/Hz
	250 - 2000 / 600-2000	-6 dB/oct	-6 dB/oct
	Global	17.1 g_{rms}	12.46 g_{rms}
Shock levels for each axes (X, Y, Z):	Frequency (Hz)	Shock input levels	
	200	100 g	
	2000	3000 g	
	10000	3000 g	

DIMENSIONS AND MECHANICAL INTERFACES FOR SEPTA®33

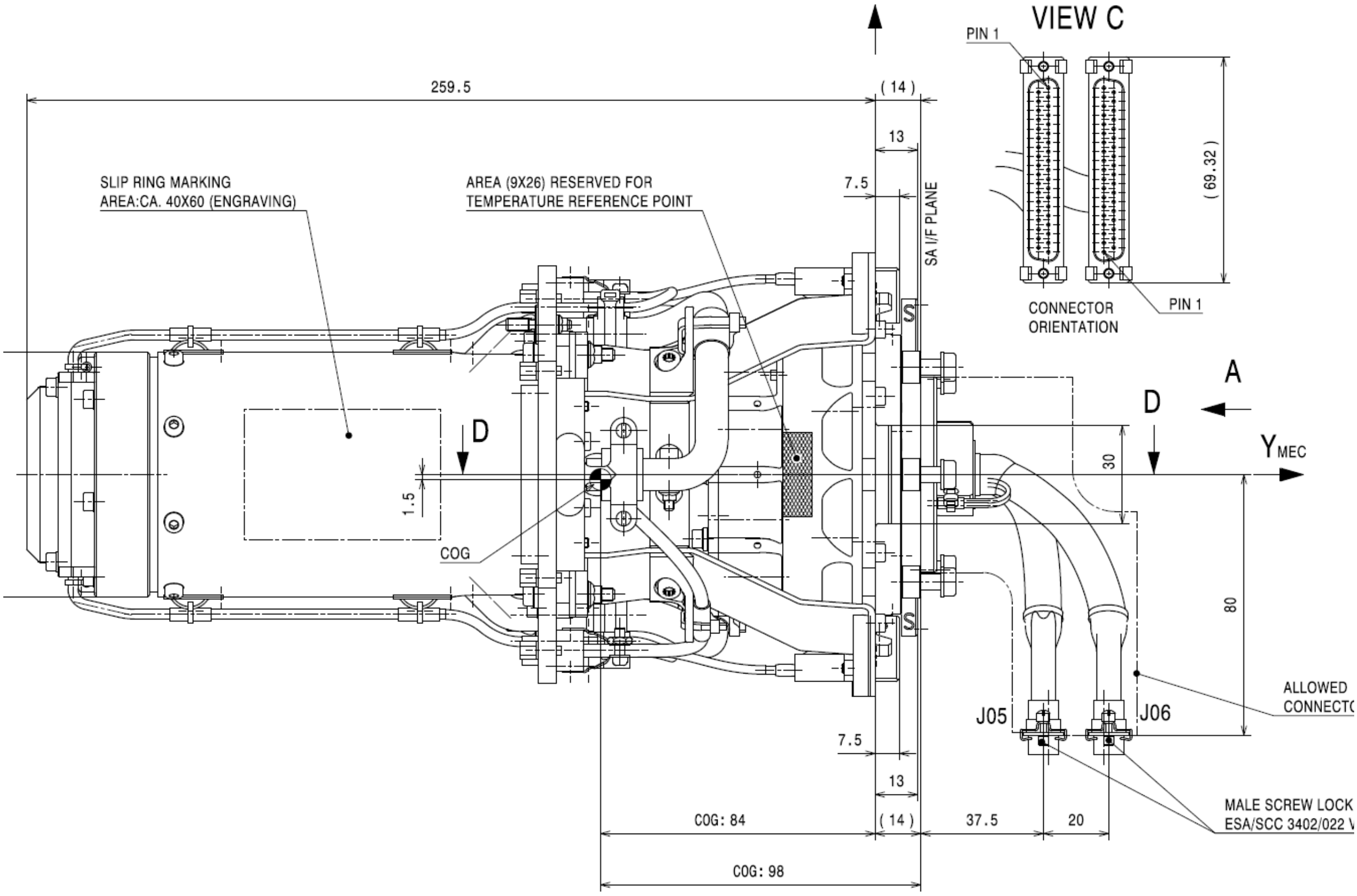
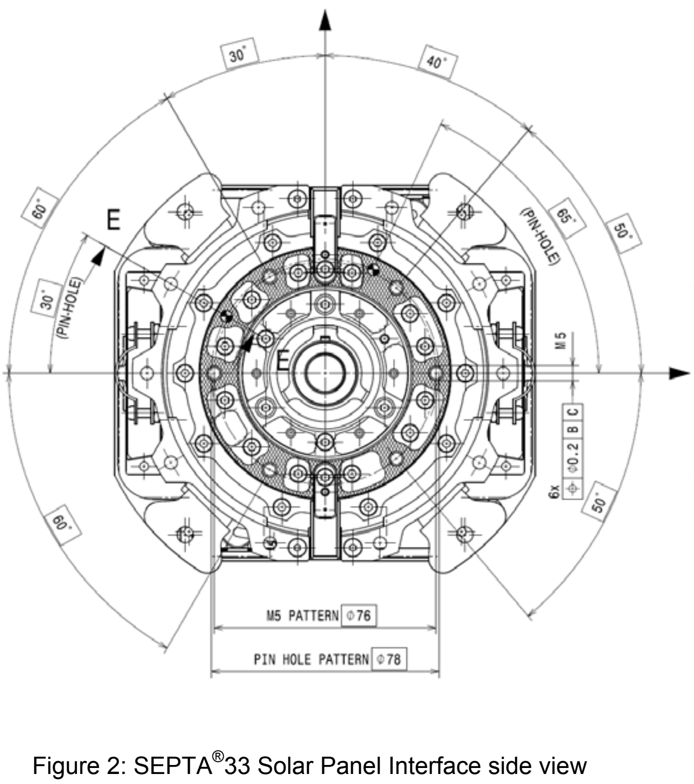


Figure 1: SEPTA®33P side view



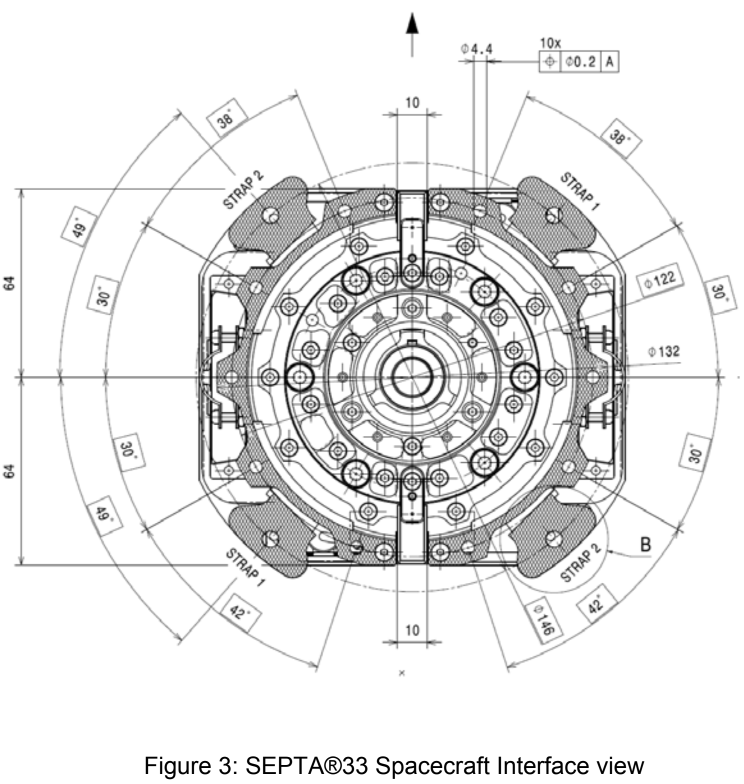


Figure 2: SEPTA®33 Solar Panel Interface side view

Figure 3: SEPTA®33 Spacecraft Interface view

ELECTRICAL INTERFACES FOR SEPTA 33

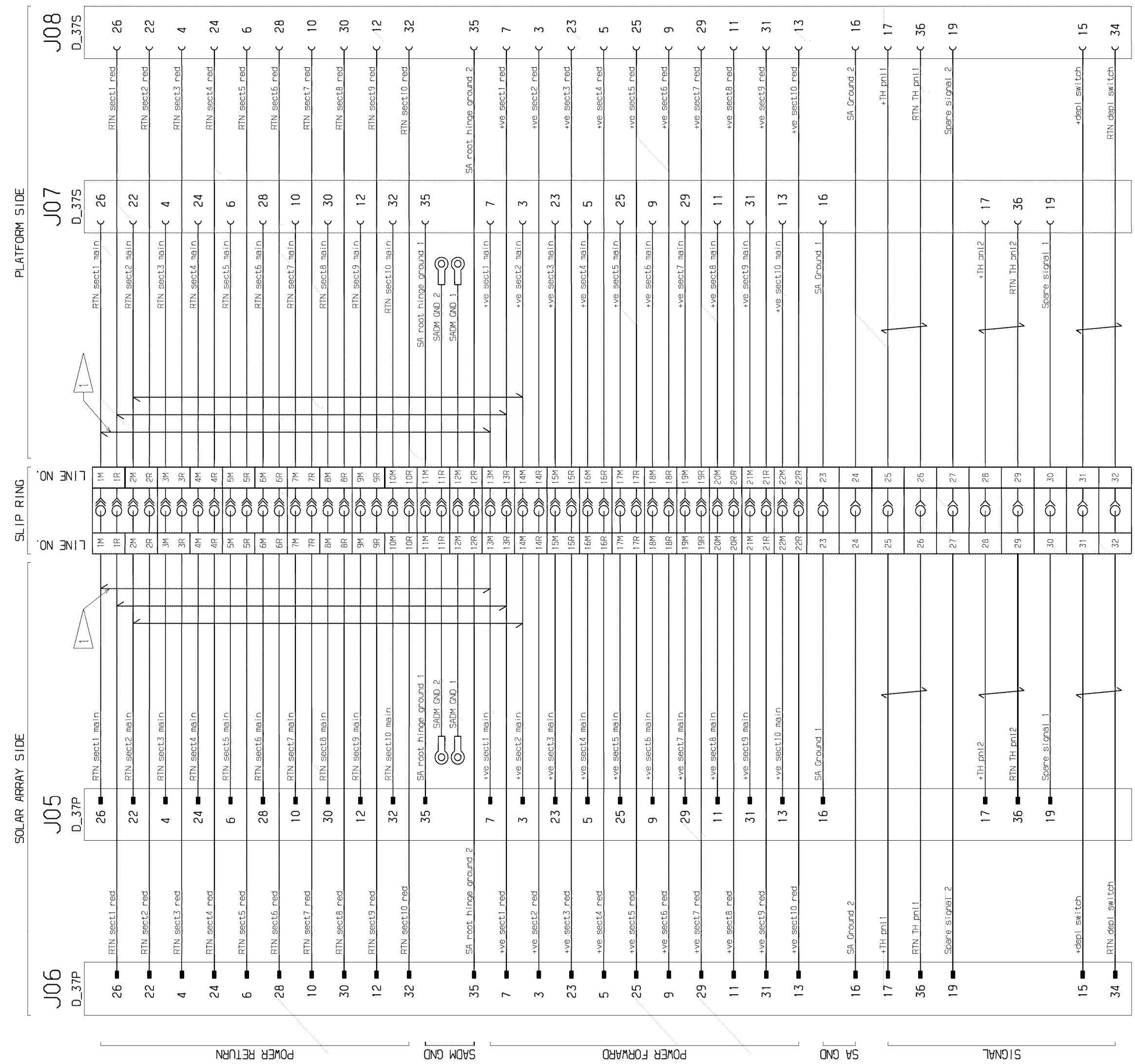


Figure 5: SEPTA®33 electrical transfer scheme

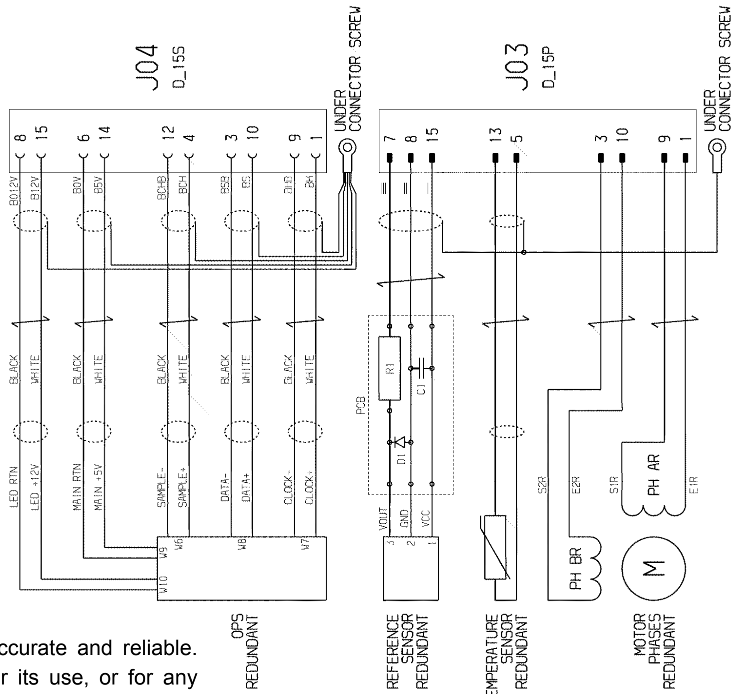


Figure 5: SEPTA®33CS Housekeeping interfaces