# VLP - Very Low Profile

## Absolute position, rotary Electric Encoder™

The standard **DS** series of Netzer Electric Encoder™ offers a range of diameters with very low profile and a floating hollow-shaft rotor. Despite of the resulting mechanical design flexibility there are situations where the mechanical constraints are such that the standard encoders cannot fit.

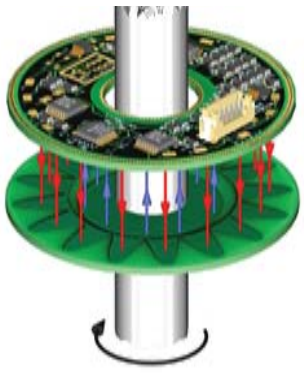
The **VLP** type of Electric Encoder™ has an open, simplified, construction. It comprises a PCB stator and a (passive) PCB based rotor that are typically attached to the host system by means of standard screws. The resulting encoder has an extremely low profile which enables it to fit very demanding mechanical constraints. The electrical interface and output formats are identical to those of the standard DS Electric Encoder™.

Because of their open construction the **VLP** Electric Encoder™ encoders may in some situations require a grounded conductive shield depending on the host system and the environment.

The customized **VLP** Electric Encoder™ offers many advantages:

- Very low profile (down to 5 mm)
- Very low weight
- Mechanically and electrically floating rotor
- High precision
- High tolerance to temperature, shock, moisture and magnetic fields
- Analog or multiple digital interface options.
- Extremely low power options

The **VLP** Electric Encoder™ is suited to demanding application such as: aerospace, medical, instrumentation, automotive, etc.



Like in standard Electric Encoder™ the holistic structure[(1)] of the **VLP** series of Netzer Electric Encoder™ provides generous mounting tolerance, thus obviating the need for internal ball bearings.

The absence of bearings and components such as flexible couplers, glass disc, light sources and detectors, along with very low power consumption makes the **VLP** Electric Encoder™ virtually failure free.

The DC operated Electric Encoder™ includes a stator and rotor. The stator includes an electric field transceiver and processing electronics. The rotor is electrically floating and passive.

The output signals of the **VLP** Electric Encoder™ are analog Sine / Cosine representing the rotation angle. The digital outputs are obtained by further processing which may be either on board or external to the encoder.

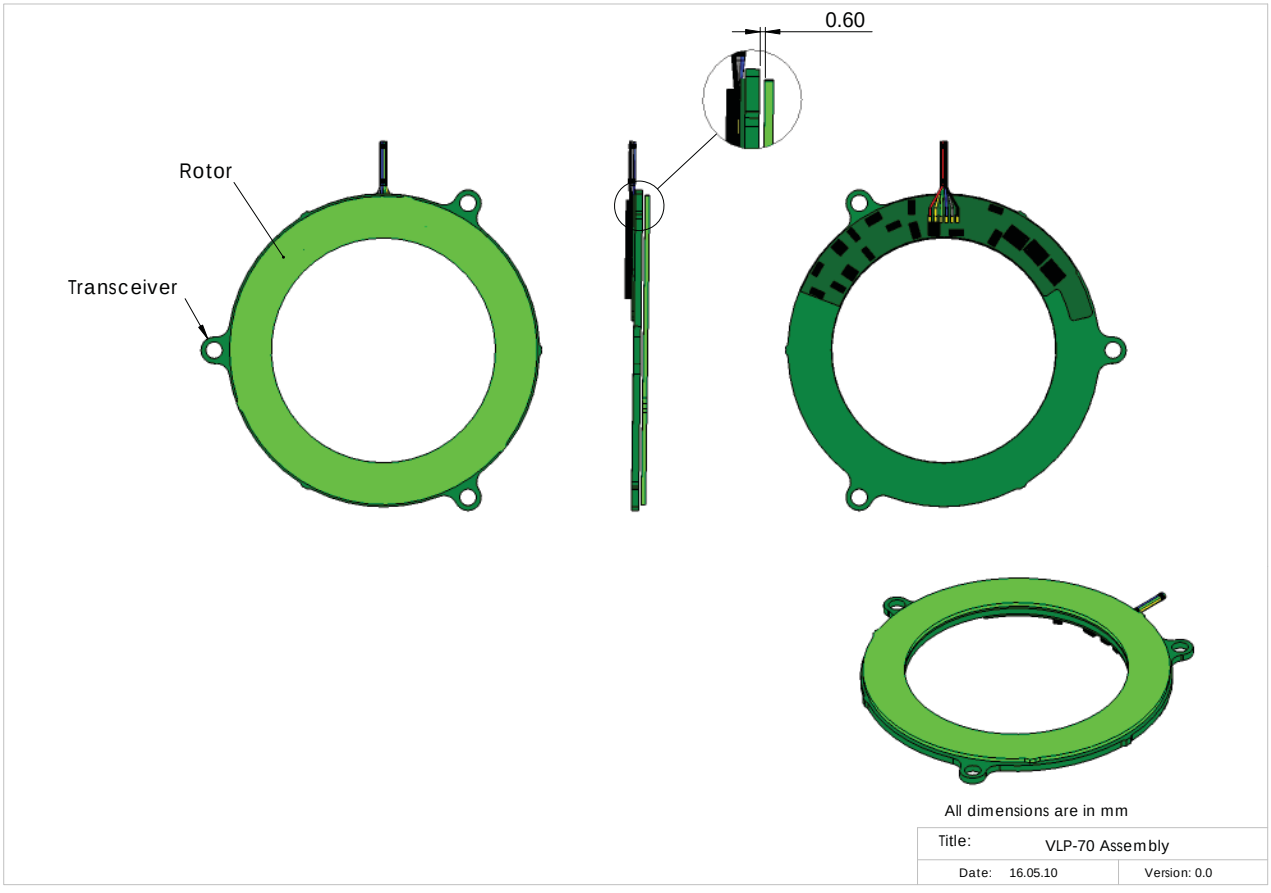
| Electrical parameters - common to all types | | |
|---|---|---|
| Supply voltage | 5V ± 5% [3] | |
| Interconnection | 250 mm Teflon - insulated, flying AWG-32 leads | |
| **Environment - common to all types** | | |
| EMC [4] | IEC 6100-6-2, IEC 6100-6-4 | |
| Operating temperature range | Analog | -55°C to +125°C [5] |
| | Digital | -55°C to +85°C [5] |
| Relative humidity | <98 % - non condensing | |
| Shock endurance | IEC 60068-2-27 ; 100 g for 11 ms | |
| Vibration endurance | IEC 60068-2-6 ;20 g 10 – 2000 Hz | |
| Protection [6] | IP 40 | |

| Output options - Table 1 | | |
|---|---|---|
| | Analog | Digital |
| Absolute | Sine/Cosine | SSi |
| Incremental | | AqB + Index |

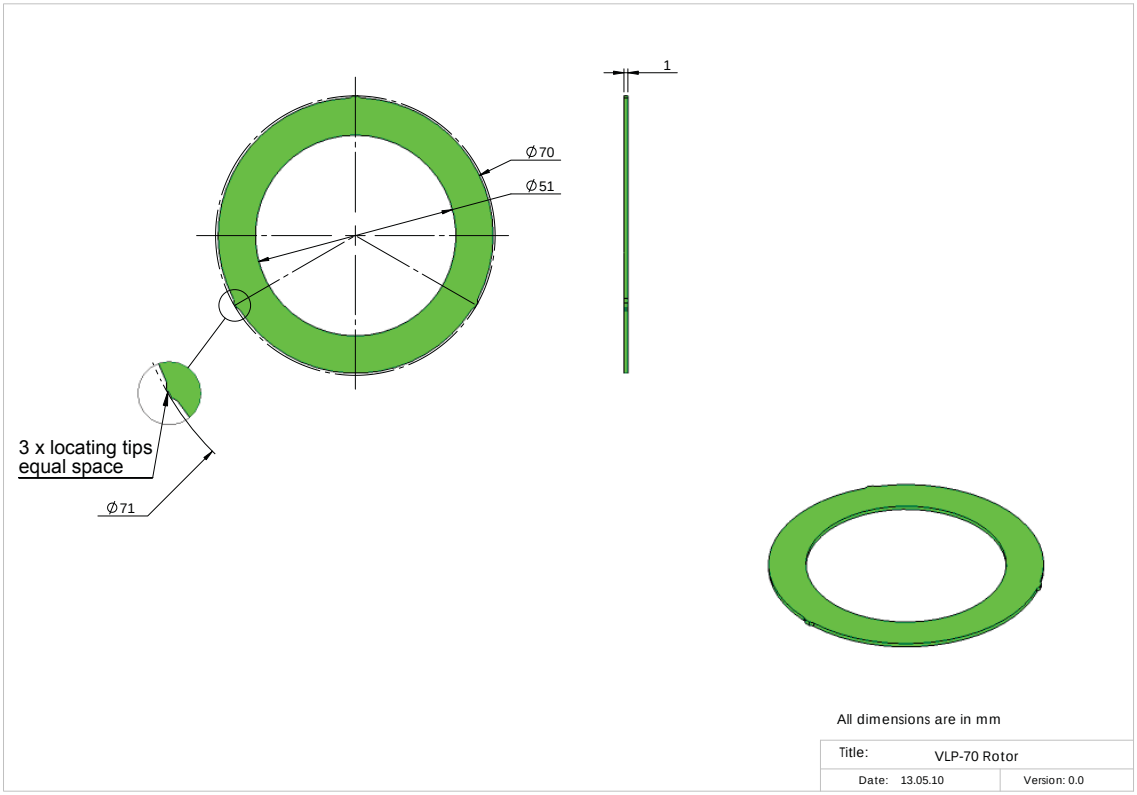
# VLP - 70

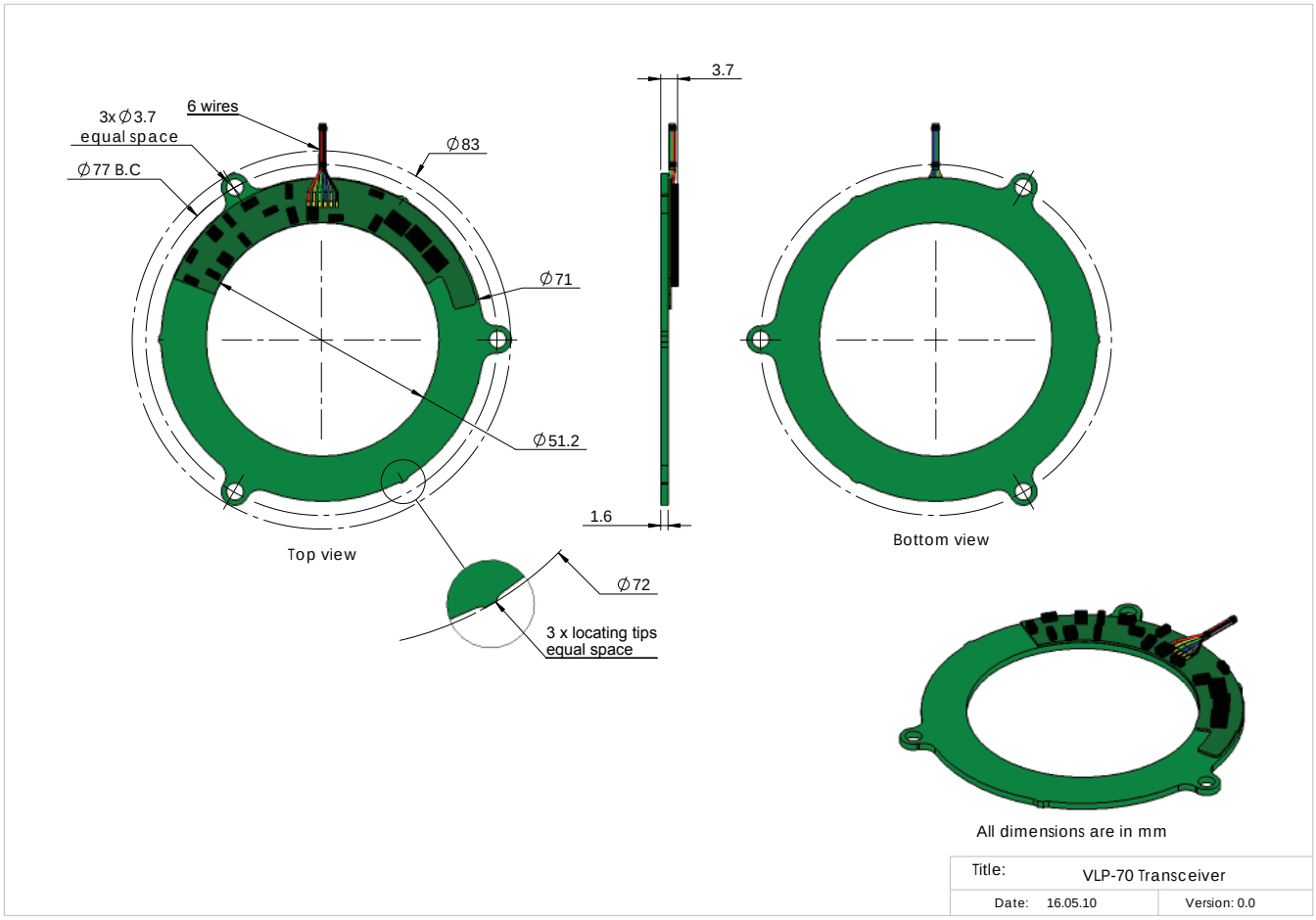
| Mechanical parameters | |
|---|---|
| Allowable mounting eccentricity [2] | ±0.1 mm |
| Allowable rotor axial position tolerance [2] | ±0.1 mm |
| Rotor inertia | 3100 gr · mm² |
| Weight | Rotor 3.1 gr<br>Stator 8.5 gr |
| Outer diameter / Inner diameter / Profile | Rotor 70/ 51/ 1.6 mm<br>Stator 72/ 51/ 2 mm |
| Nominal air gap | 0.6 mm |
| Material (stator, rotor) | FR-4 printed circuit board |

| Operational parameters | | |
|---|---|---|
| Electrical Cycles/Revolution – Fine/Coarse channels [7] | 16 / 3 | 3 / 16 |
| Angular resolution (using 12 bit A/D conversion) [8] | 17 bits | 14 bits |
| Static error (with offset compensation) [9] | < 40 mDeg | < 1 Deg |
| Maximum operational speed [10] | 3,000 rpm | 20,000 rpm |
| Measurement range | Unlimited rotation | |
| Applicable outputs | Standard options - see table #1 | Analog Sine/Cosine<br>Incremental AqB |

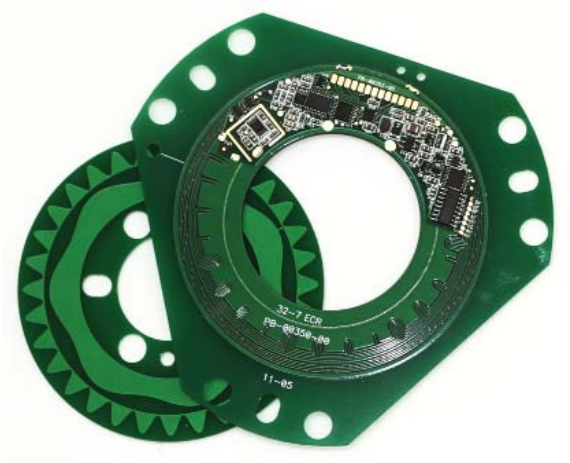


# VLP - 70


1
Ø70
Ø51
3 x locating tips
equal space
Ø71
All dimensions are in mm
Title: VLP-70 Rotor
Date: 13.05.10
Version: 0.0

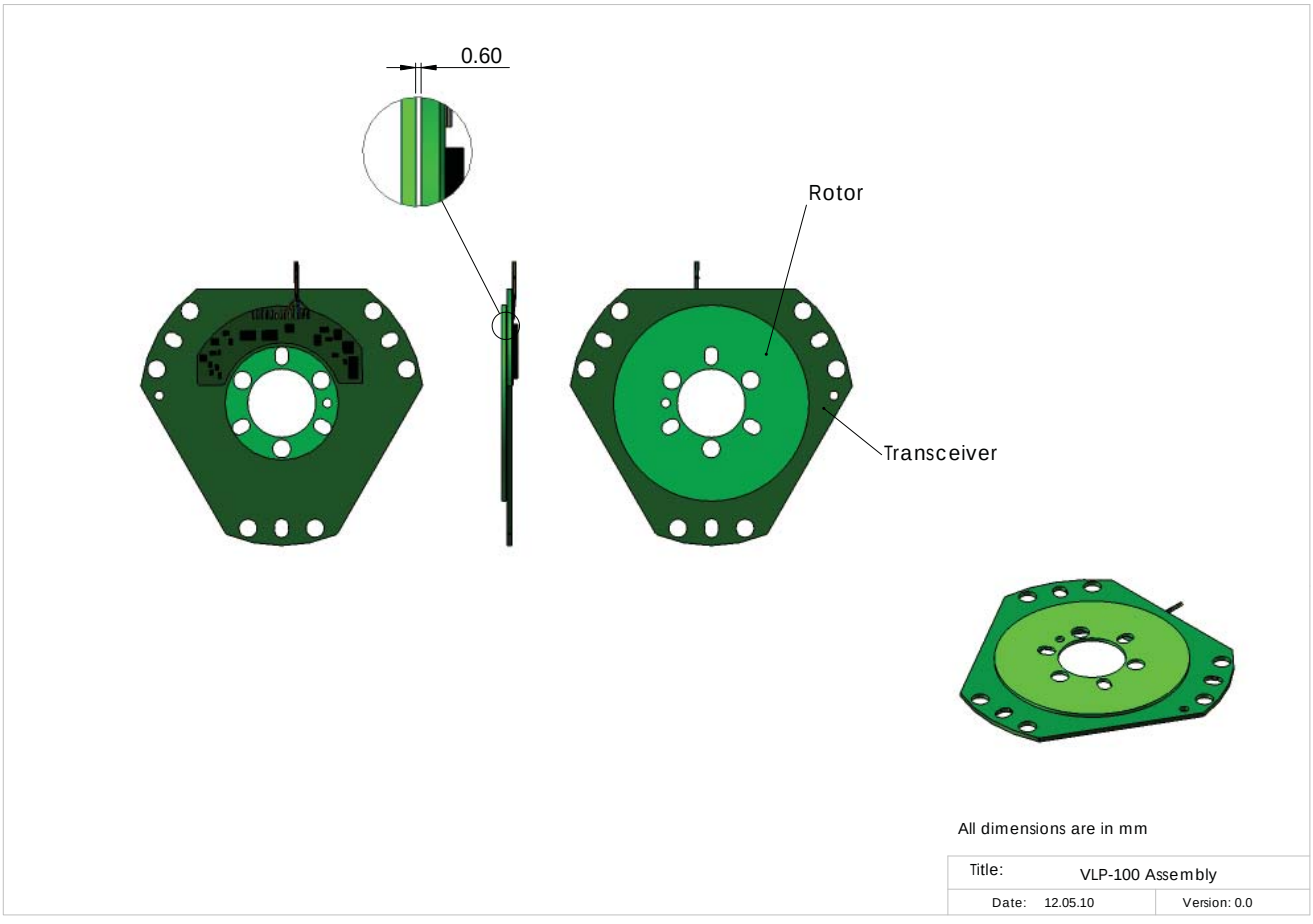

3.7
6 wires
3x Ø3.7
equal space
Ø77 B.C
Ø83
Ø71
Ø51.2
1.6
Top view
Bottom view
Ø72
3 x locating tips
equal space
All dimensions are in mm
Title: VLP-70 Transceiver
Date: 16.05.10
Version: 0.0

# VLP - 100

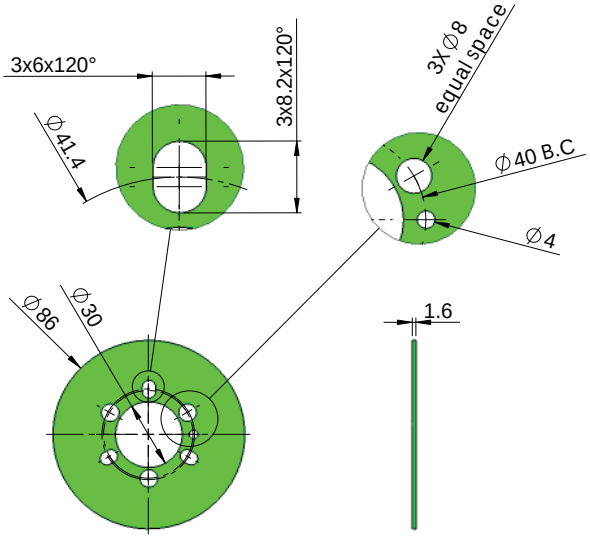


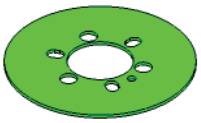
| Mechanical parameters | |
|---|---|
| Allowable mounting eccentricity (2) | ±0.1 mm |
| Allowable rotor axial position tolerance (2) | ±0.1 mm |
| Rotor inertia | 15300 gr · mm$^2$ |
| Weight | Rotor 15.2 gr<br>Stator 34.3 gr |
| Outer diameter / Inner diameter / Profile | Rotor 70 / 51/ 2 mm<br>Stator 125/ 50 / 5 mm |
| Nominal air gap | 0.6 mm |
| Material (stator, rotor) | FR-4 printed circuit board |

| Operational parameters | |
|---|---|
| Electrical Cycles/Revolution – Fine/Coarse channels (7) | 32 / 7 |
| Angular resolution (using 12 bit A/D conversion) (8) | 18 bits |
| Static error (with offset compensation) (9) | < 40 mDeg |
| Maximum operational speed (10) | 1,500 rpm |
| Measurement range | Unlimited rotation |



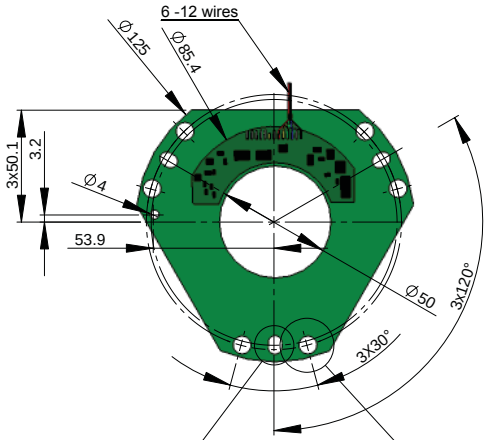
# VLP - 100



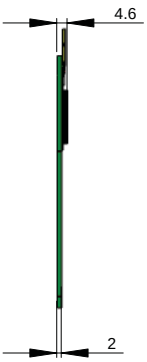



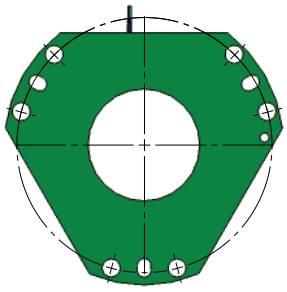
All dimensions are in mm

| Title: | VLP-100 Rotor | |
|---|---|---|
| Date: | 16.05.10 | Version: 0.0 |

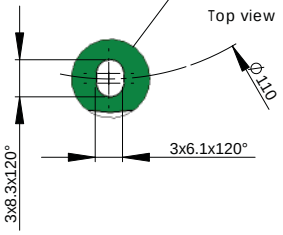


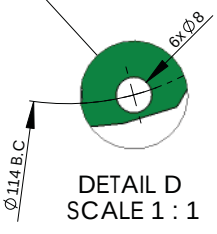

Top view



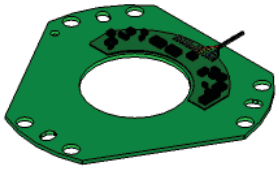



Bottom view




DETAIL D
SCALE 1 : 1



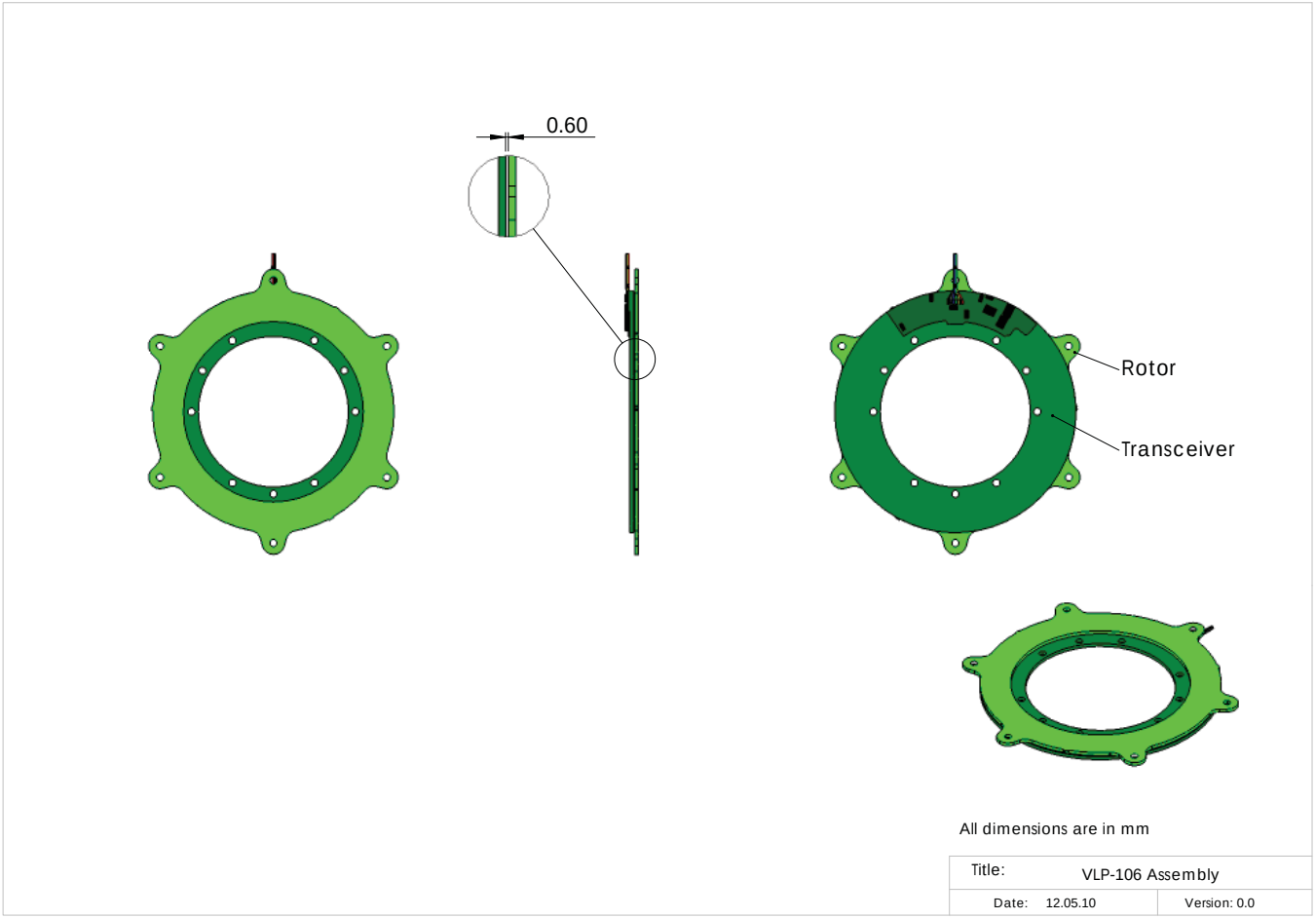
All dimensions are in mm

| Title: | VLP-100 Transceiver | |
|---|---|---|
| Date: | 12.05.10 | Version: 0.0 |

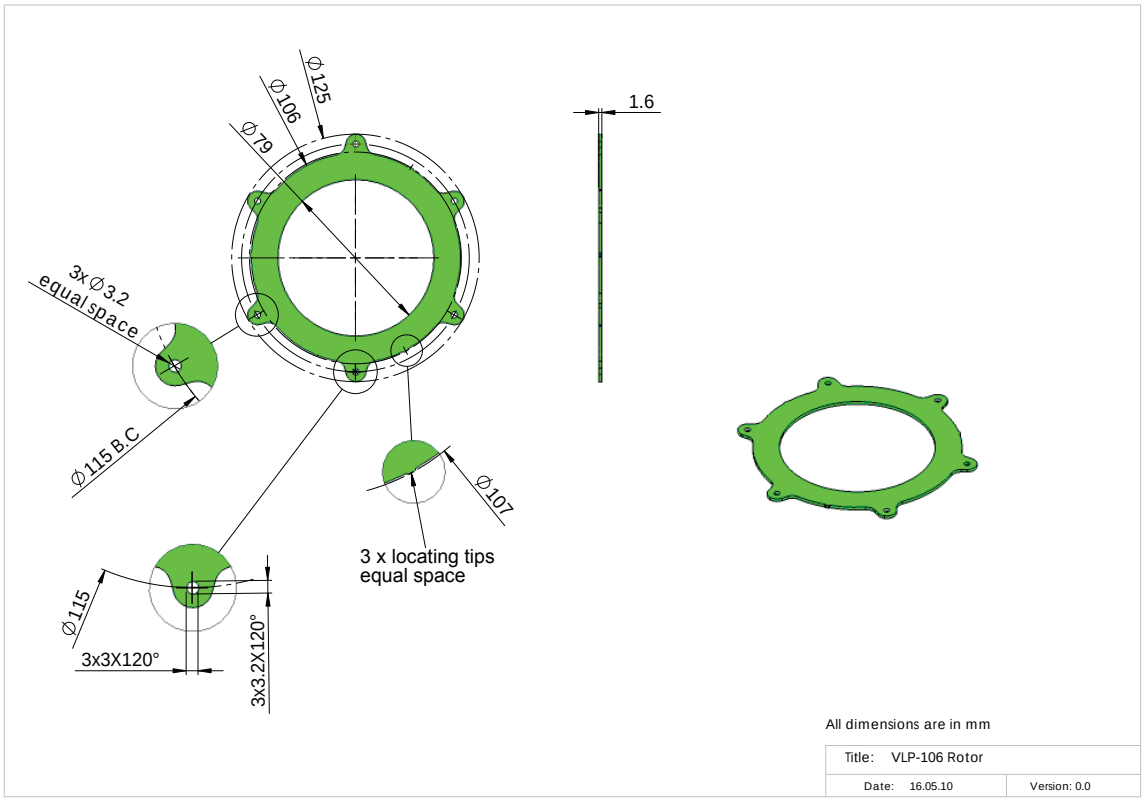
# VLP - 106

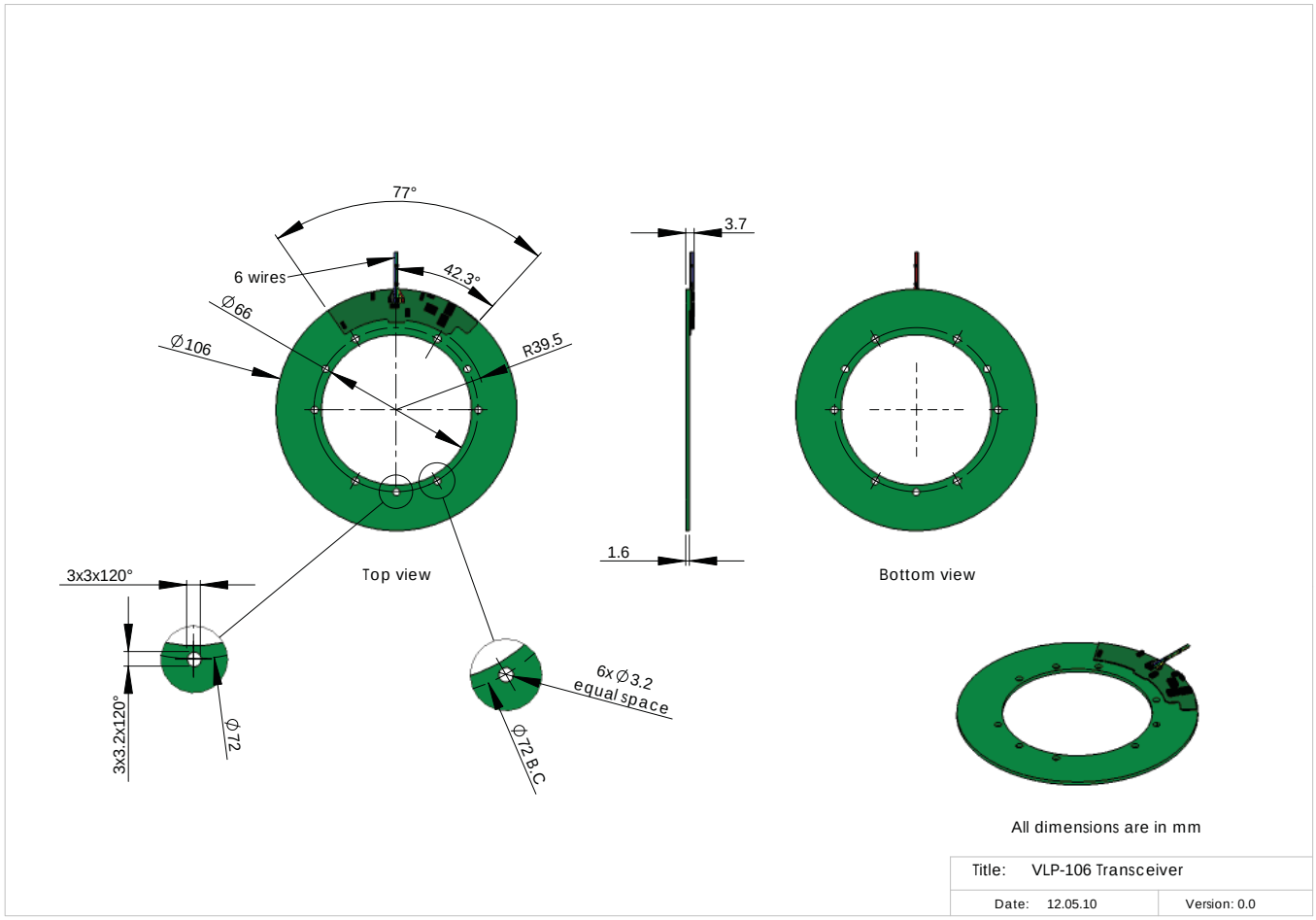
| Mechanical parameters | |
|---|---|
| Allowable mounting eccentricity [2] | ±0.1 mm |
| Allowable rotor axial position tolerance [2] | ±0.1 mm |
| Rotor inertia | 30500 gr · mm$^2$ |
| Weight | Rotor 13.9 gr<br>Stator 20 gr |
| Outer diameter / Inner diameter / Profile | Rotor 106/ 66/ 1.6 mm<br>Stator 107/ 79/ 2 mm |
| Nominal air gap | 0.6 mm |
| Material (stator, rotor) | FR-4 printed circuit board |

| Operational parameters | |
|---|---|
| Electrical Cycles/Revolution – Fine/Coarse channels [7] | 32 / 7 |
| Angular resolution (using 12 bit A/D conversion) [8] | 18 bits |
| Static error (with offset compensation) [9] | < 40 mDeg |
| Maximum operational speed [10] | 1,500 rpm |
| Measurement range | Unlimited rotation |



# VLP - 106

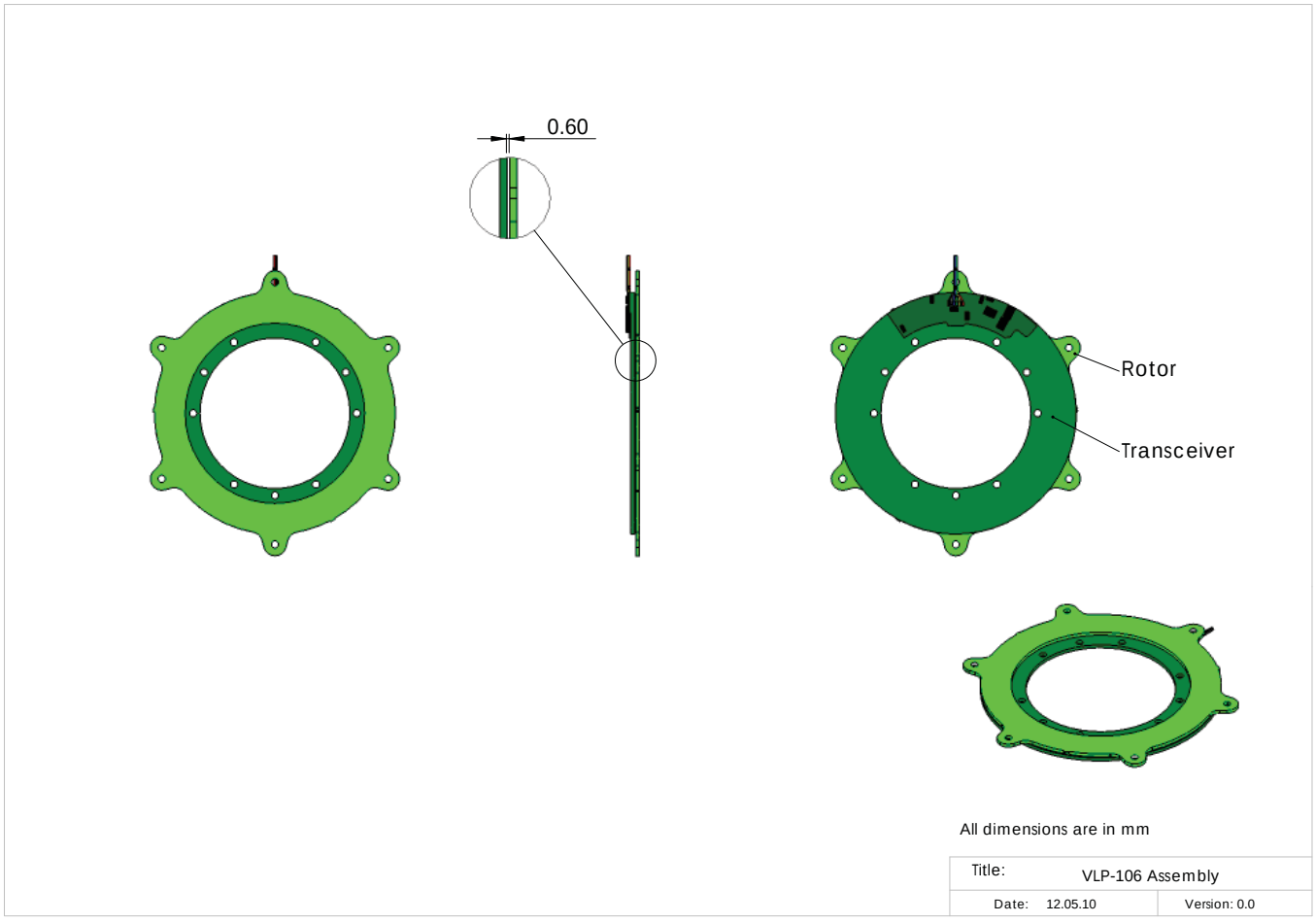

Ø125
Ø106
Ø79
3xØ3.2
equal space
Ø115 B.C
Ø107
3 x locating tips
equal space
Ø115
3x3X120°
3x3.2X120°
1.6
All dimensions are in mm
Title: VLP-106 Rotor
Date: 16.05.10
Version: 0.0


77°
6 wires
42.3°
Ø66
Ø106
R39.5
3x3x120°
Top view
3.7
1.6
Bottom view
6xØ3.2
equal space
3x3.2x120°
Ø72
Ø72 B.C
All dimensions are in mm
Title: VLP-106 Transceiver
Date: 12.05.10
Version: 0.0

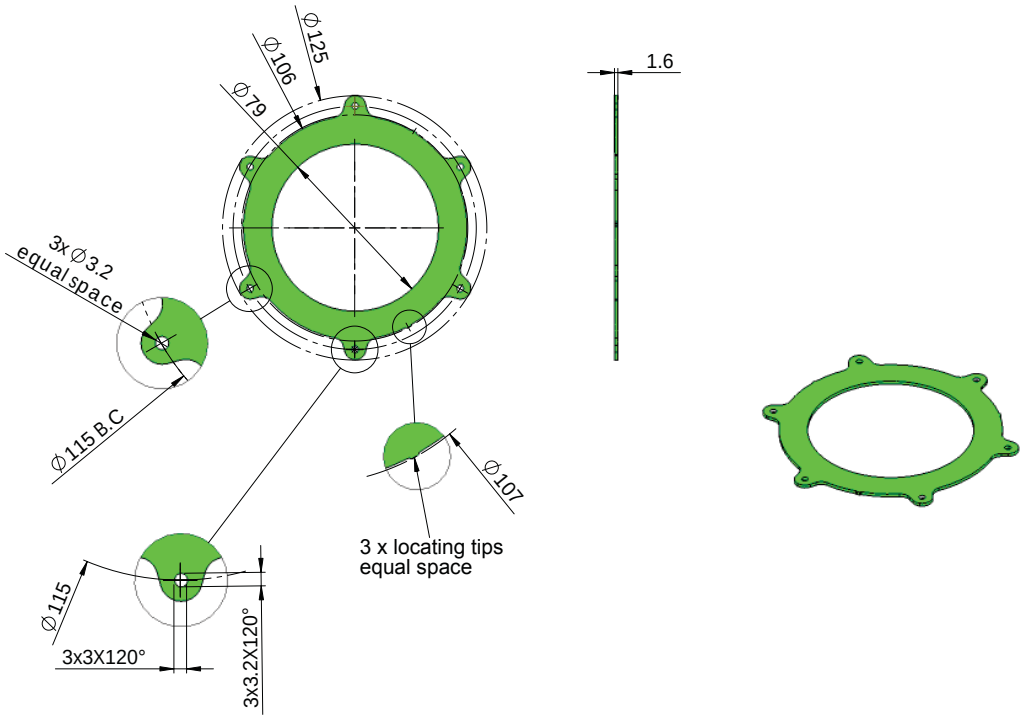
# VLP - 159

| Mechanical parameters | |
|---|---|
| Allowable mounting eccentricity [2] | ±0.1 mm |
| Allowable rotor axial position tolerance[2] | ±0.1 mm |
| Rotor inertia | 48700 gr · mm$^2$ |
| Weight | Rotor 21.4 gr<br>Stator 32 gr |
| Outer diameter / Inner diameter / Profile | Rotor 125 / 87/ 1.3 mm<br>Stator 168 / 99/ 2 mm |
| Nominal air gap | 0.6 mm |
| Material (stator, rotor) | FR-4 printed circuit board |

| Operational parameters | |
|---|---|
| Electrical Cycles/Revolution – Fine/Coarse channels [7] | 32 / 3 |
| Angular resolution (using 12 bit A/D conversion) [8] | 18 bits |
| Static error (with offset compensation) [9] | < 20 mDeg |
| Maximum operational speed [10] | 1,500 rpm |
| Measurement range | Unlimited rotation |

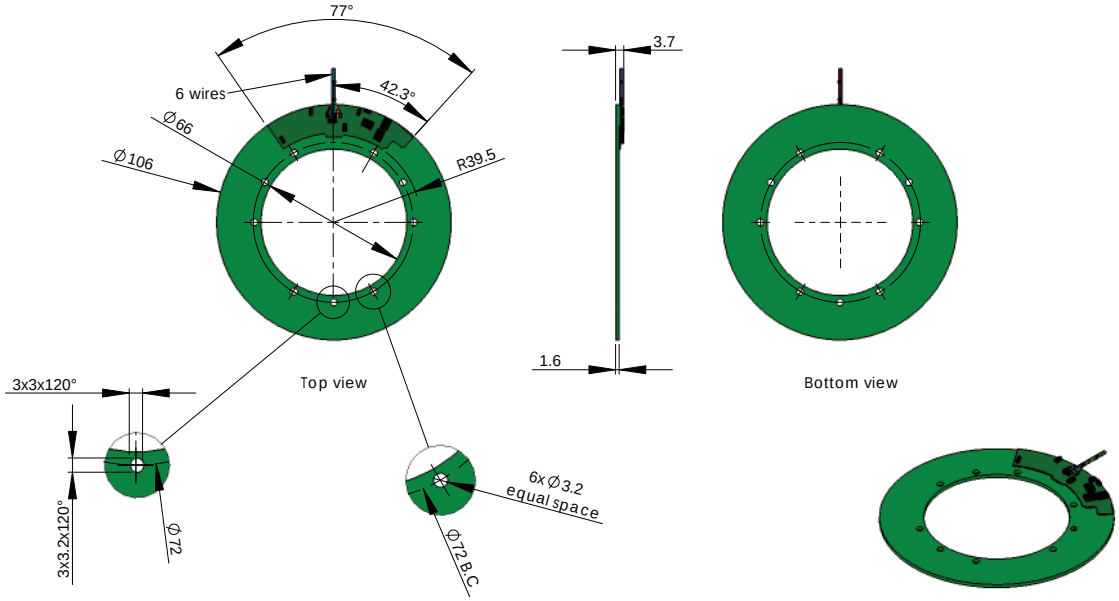


# VLP - 159




All dimensions are in mm

| Title: VLP-106 Rotor | |
|---|---|
| Date: 16.05.10 | Version: 0.0 |




All dimensions are in mm

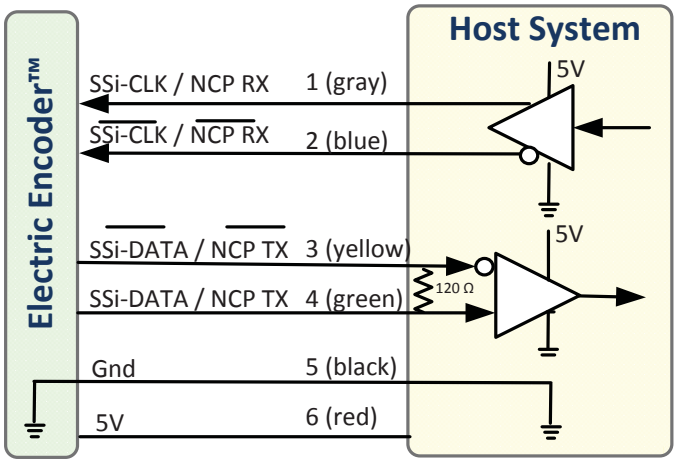
| Title: VLP-106 Transceiver | |
|---|---|
| Date: 12.05.10 | Version: 0.0 |

| Output signal parameters | |
|---|---|
| Signal latency [11] | ~250 µSec |
| Output code | Binary |
| Serial output SSi | Differential RS-422 |
| Clock SSi | Differential RS-422 |
| Monoflop time | 25 µSec |
| Clock frequency | 0.5 ÷ 2.5 MHz |
| Payload | 14 - 44 bit |

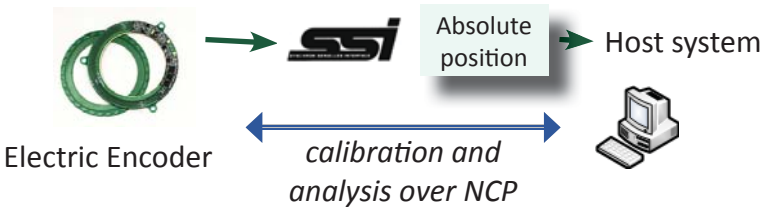
| Electrical parameters | |
|---|---|
| Current consumption | ~ 180 mA |

The native outputs signals are analog Sine / Cosine and the digital outputs are obtained by using the external module SC2SSi .
Synchronous Serial Interface (SSi) transmits the absolute position data from the Electric Encoder™ in response to controller clock pulses. The encoder and controller are linked by clock and data differential signal lines.

**Figure 1** illustrates the SSi timing diagram as implemented in the SC2SSi module. The module also provides advanced calibration and monitoring options using the **NCP** (**Netzer Communication Protocol**) and factory supplied software tools.




| SSi - Wires color code | | | |
|---|---|---|---|
| **#** | **Name** | **Color** | **Function** |
| 1 | Clock + | Grey | SSi Clock |
| 2 | Clock - | Blue | |
| 3 | Data - | Yellow | SSi Data |
| 4 | Data + | Green | |
| 5 | GND | Black | Ground |
| 6 | +5V | Red | Power supply |



**Data transmission timing diagram**

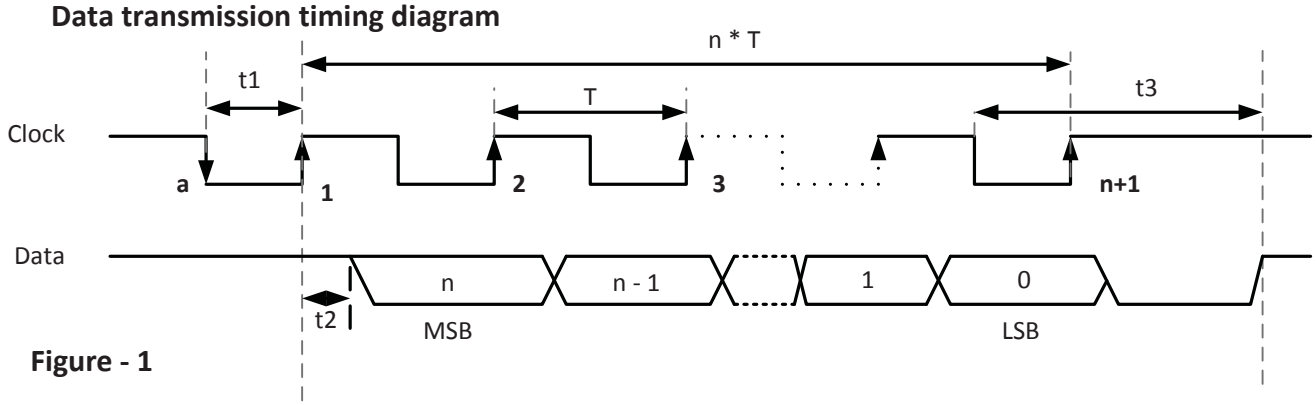


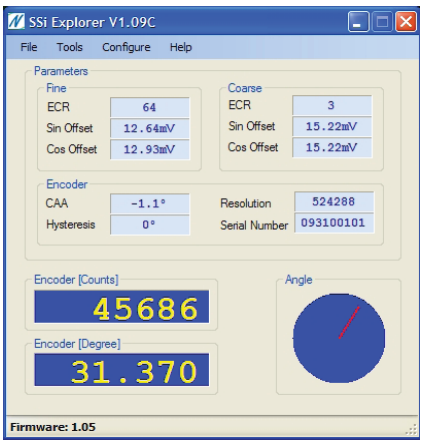

**Figure - 1**

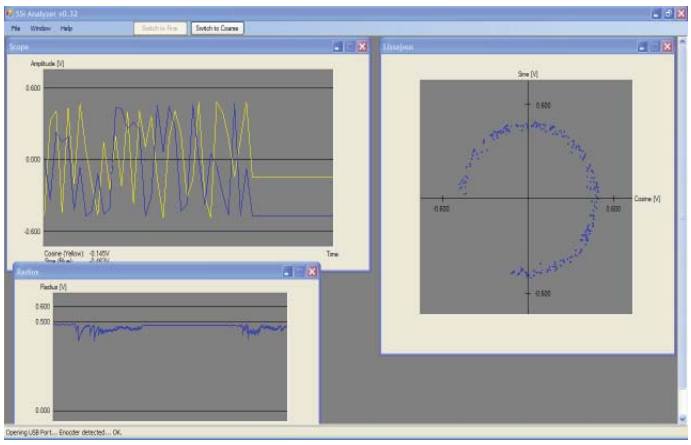
n = total number of data bits.
T = clock period (sec) - user defined.
1/T = clock frequency 0.5 ÷ 2.5 MHz (user defined).
t1 = minimum time required for the encoder to freeze data and preset the shift registers before receiving the first rising edge to prompt the MSB
t2 = data transmission delay (increases with cable length)
t3 = required delay to refresh position data between subsequent position reads.

**Position calibration & signal analysis with SSi interface:**

The Electric Encoder™ processing capabilities enable calibration, built-in tests (BIT) and advanced setup, using the available software tools, such as:

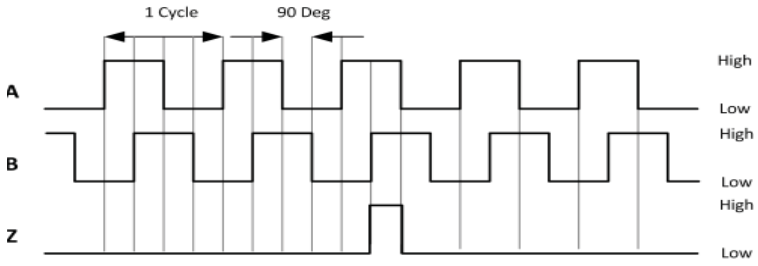
A. Simple calibration procedure using the SSi Explorer (CAA , Offsets , Zero position setting).
B. Field aid for validating proper mechanical mounting.

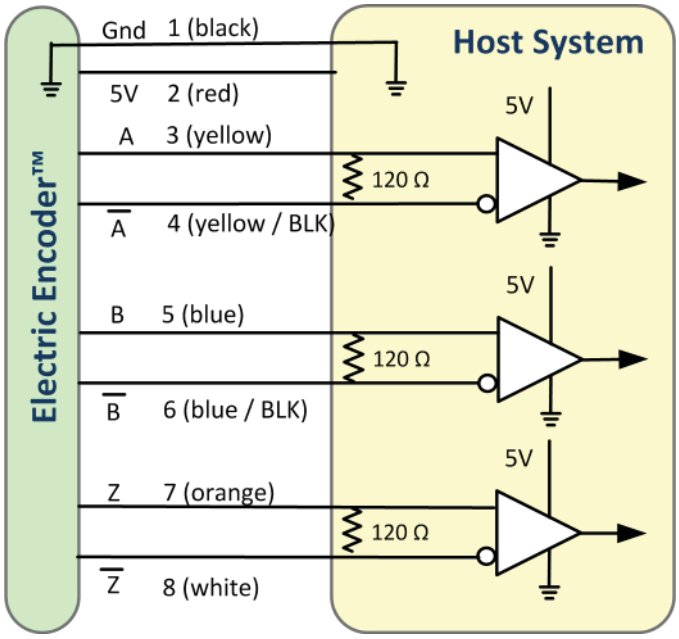


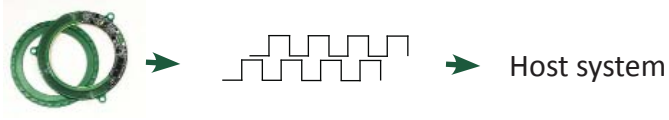
| Output signal parameters | |
|---|---|
| Signal latency [11] | 250 µSec |
| Format | Differential RS-422 |
| Phase relationship with CW shaft rotation (as seen from stator) | A leads B |
| Index pulse width | ½ A |

| Electrical parameters | |
|---|---|
| Current consumption | ~ 130 mA |



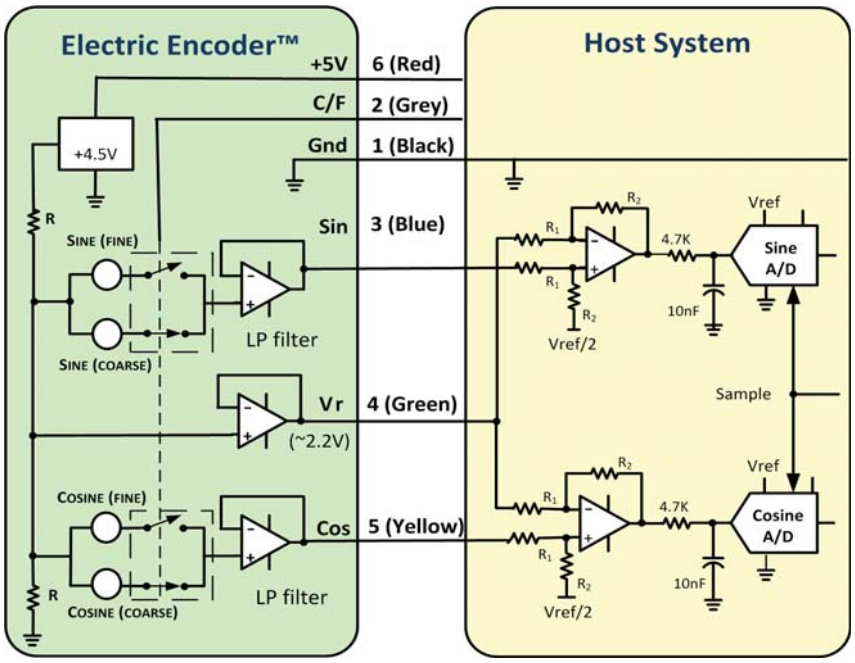

| AqB - Wires color code | | | |
|---|---|---|---|
| **#** | **Name** | **Color** | **Function** |
| 1 | GND | Black | Ground |
| 2 | +5V | Red | Supply voltage |
| 3 | A+ | Yellow | Quadrature outputs |
| 4 | A- | Yellow/Black | |
| 5 | B+ | Blue | |
| 6 | B- | Blue / Black | |
| 7 | Z+ | Orange | Index |
| 8 | Z- | White | |
| 9 | | | *Factory use* |
| 10 | | | |
| 11 | | | |
| 12 | | | |




Electric Encoder

| Output signal parameters | |
|---|---|
| Signal latency [11] | 250 µSec |
| Fine-mode output noise (DC to 1kHz)- typical [12] | 200 µV (p-p) |
| Fine-mode output amplitude - typical [13] | 0.5V ± 20% |
| Coarse-mode output amplitude - typical | 0.3V ± 10% |
| Phase relationship (CW shaft rotation - seen from the stator) | Sine leads Cosine |
| Signal bandwidth | DC to 1 kHz |

| Electrical parameters | |
|---|---|
| Output resistance | <1 Ω |
| Current consumption | ~ 10 mA [14] |




| Wires color code | | | |
|---|---|---|---|
| # | Name | Color | Function |
| 1 | GND | Black | Ground |
| 2 | C/F | Grey | Coarse / Fine |
| 3 | Sine | Blue | Sine signal |
| 4 | Vr | Green | V reference |
| 5 | Cosine | Yellow | Cosine signal |
| 6 | +5V | Red | Power supply |

**Coarse and Fine channels**

The **VLP** has two operational modes: a Coarse-mode and a Fine-mode - equivalent to two separate encoders in a common housing. The modes are selectable by a logic C/F command; logic "0" (0V to +0.5V) selects the Coarse-mode, which has M Electrical Cycle/Revolution (EC/R) while logic "1" (+3V to +5V) selects the Fine-mode which has N EC/R. The switching time is less than 1 ms.

The Coarse-mode outputs need to be read only upon system initiation after which the encoder is permanently switched to the Fine mode. Coarse and Fine sine/cosine pairs are used to calculate the initial absolute position, from that point tracking the Fine-channel outputs provides the absolute mechanical rotation angle with the specified accuracy and resolution.

All output signals are referenced to an internally generated voltage Vr (~2.25V)

**Absolute Position calculation:**

The analog Sine /Cosine outputs convey the electric angle of the Coarse or Fine signals. The absolute mechanical angle is computed by digitizing the analog signals and applying factory-supplied algorithms. Please refer to AN-02 and AN-03 .


Electric Encoder

Host system

**Notes**

1. The output signals are generated by the whole area of the rotor - see AN-01.
2. Accuracy may degrade depending on mounting tolerances and the Sine/Cosine amplitudes may exceed the A/D conversion range -see AN-02
3. The encoder includes an internal 4.5V LDO voltage regulator.
4. VLP encoders are generally insensitive to ESD and parasitic capacitive coupling from adjacent AC voltages, however, depending on the host system it may pick noise from the machine shaft if the shaft is left electrically floating, however, it is recommended to validate a resistance of no more than a few hundred ohms between the shaft and the system ground. Alternatively a non con ducting shaft may be used
5. Consult factory.
6. For higher ingress protection the encoder should be mounted inside a sealed enclosure.
7. The number of electrical sine/cosine cycles generated in one mechanical rotation.
8. The angular resolution is determined by the ratio of the Fine - channel amplitude and the encoder inherent noise – see AN-05.
9. Not including dynamic error. For higher static accuracy consult factory.
10. Determined by the Fine-channel EC/Rs and the internal low pass filters, for higher rotation speed consult factory.
11. An inherent signal delay inversely proportional to the internal filter's cut-off frequency (1 kHz, 3rd order Bessel) and resulting in a dynamic error proportional to the rotation speed - see AN-05
12. For measuring the noise and validating the interconnection see AN-02.
13. With the rotor at its nominal axial position - see AN-02.

**Resolution table**

| Resolution In bits | Steps /360° | mDeg /step | Arc-sec /step | mRad /step |
|---|---|---|---|---|
| 12 | 4,096 | 87.8906 | 316.4063 | 1.534 |
| 13 | 8,192 | 43.9453 | 158.2031 | 0.767 |
| 14 | 16,384 | 21.9727 | 79.1016 | 0.3835 |
| 15 | 32,768 | 10.9863 | 39.5508 | 0.1917 |
| 16 | 65,536 | 5.4932 | 19.7754 | 0.0959 |
| 17 | 131,072 | 2.7466 | 9.8877 | 0.0479 |
| 18 | 262,144 | 1.3733 | 4.9438 | 0.024 |
| 19 | 524,288 | 0.6866 | 2.4719 | 0.012 |
| 20 | 1,048,576 | 0.3433 | 1.236 | 0.006 |
| 21 | 2,097,152 | 0.1717 | 0.618 | 0.003 |
| 22 | 4,194,304 | 0.0858 | 0.309 | 0.0015 |