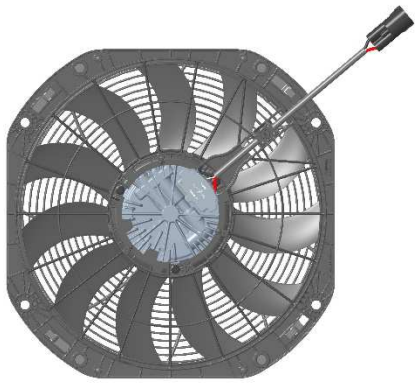
## 1 General

Fan diameter Ø: 465 mm
Nominal voltage: 24 V
Drive family SBL HT 1000

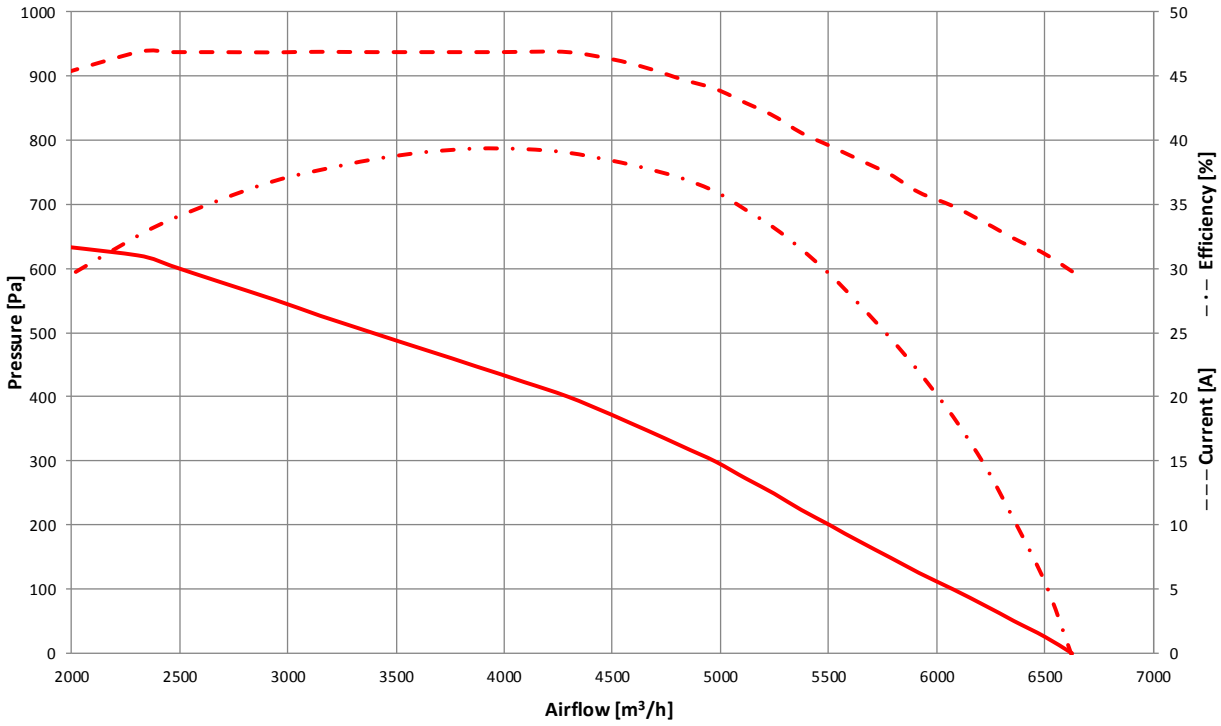
Part number: 30107271A



## 2 Features

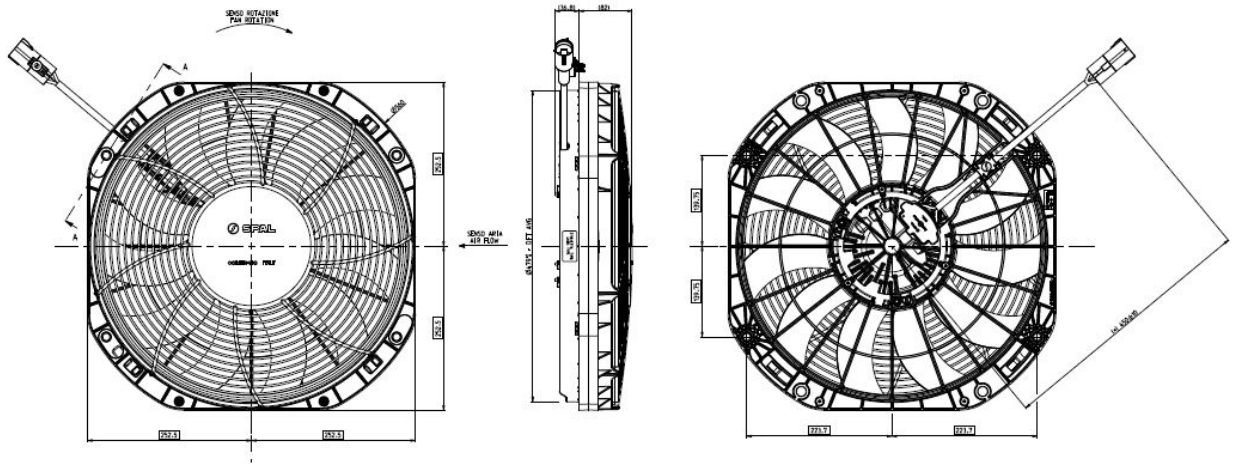
| | | |
|---|---|---|
| Max fan speed forward | rpm | 3050 |
| Max fan speed reverse | rpm | 3050 |
| Min fan speed | rpm | 1020 |
| Sound pressure level at max speed | dBA | 87.5 – at 1 m from the fan module - lateral side |
| Weight | kg | 5.8 |
| Operating supply voltage range | V | 16.0 .. 32.0 at the Drive connector |
| Supply voltage to reach max speed | V | 26.0 .. 32.0 at the Drive connector |
| Operating ambient temperature range | ℃ | -40 .. +120 |
| Max operating ambient temperature @ max fan speed | ℃ | +95 (1) |
| Storage temperature range | ℃ | -40 .. +125 |
| Lifetime | h | up to 40000 hours depending on mission profile |
| Time from 0 rpm to max speed | s | 15 |
| Load dump protection (Pulse 5b) | V | 65 - Pulse peak voltage ($U_S$*) - ISO16750-2:2010 |
| Reverse polarity protection | | ISO 16750-1 functional status class D - device fully functional after the test, after replacing all blown fuse links and after correcting the polarity |
| Notes: (1) Few minutes ambient temperature transients do not engage the derating owing to the thermal inertia of the system. Overloads may anticipate derating. | | |

## 3 Air performance at maximum speed



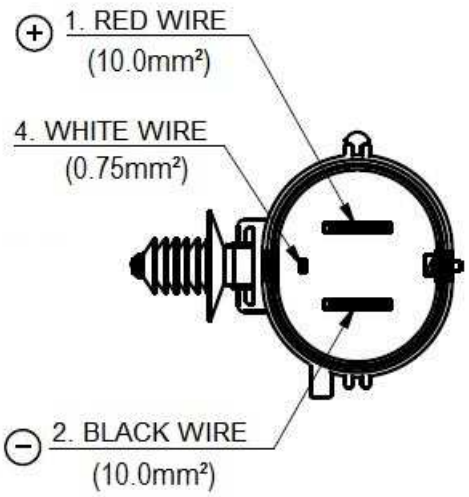

Air density 1.17 kg / m3 - Test number: #16156 – Test bench compliant to ANSI AMCA 210
TAMB = 20 ℃ ± 5 ℃ - UB = 26.0 V at the Drive conn ector

## 4 Mechanical data



Fixing recommendation: use M8 bolts for fixing. Nominal tightening torque 15 ±3 Nm
Nominal torque defined for brand new, clean and lubricant-free bolts.

## 5 Connector and wires




| Connector : YAZAKI YPT HYBRID (USCAR-2 compliant) - Part number: 7286-1398-10 | | | | |
|---|---|---|---|---|
| Identification (*) | +D | -D | - | PWM* / E* |

| Pin number | 1 | 2 | - | 4 |
|---|---|---|---|---|
| Wire Color | Red | Black | - | White |
| Sealing p/n | 7158-3713-70 | 7158-3713-70 | - | 7158-3031-90 |
| Pin p/n | 7114-5623-02 | 7114-5623-02 | - | 7114-4103-02 |
| Section [$mm^2$] | 10.0 | 10.0 | - | 0.75 |

For abbreviations see chapter **8.2 Drive pin functions**
NOTE: Never handle the fan module via the cable harness

## 6 Further Features

| | | |
|---|---|---|
| Compliance | | ECE Reg. 10-04 and updates - Automotive EMC directive. |
| | | 2002/95/EC RoHS - Hazardous Substances |
| | | 2000/53/EC and updates - End-of Life Vehicle |
| Ingress Protection | | IP 68 and IP6K9K design |
| Allowed power supply max ripple | rms | 1 % - contact SPAL for special needs |
| Fuse protection | | An automotive fuse according ISO8820 must be chosen and used by the customer in the application wire harness. Each drive must be protected by the unique proper fuse (e.g. in case of double fan modules, two fuses are needed) |
| | | |

## 7 Measurement conditions

The below conditions are assumed:

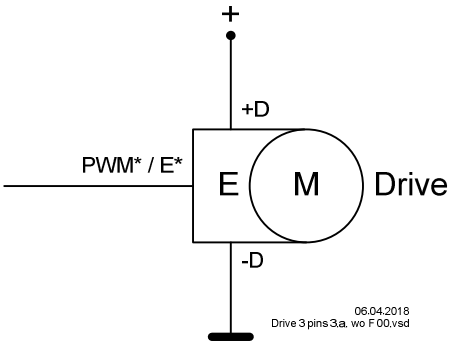
- $T_{AMB}$ = 20 ℃ ± 5 ℃ and
- Supply voltage **UB** = 26.0 V at the **Drive** connector

unless otherwise specified.

## 8 Hardware functions

### 8.1 Drive diagram

The Drive diagram is shown below.




E stands for integrated electronics. M stands for motor. Drive stands for motor with axial integrated electronics.

## 8.2 Drive pin functions

The electrical Drive interface consists of 3 pins:
Power pins:

- supply voltage plus: +D
- supply voltage minus: -D

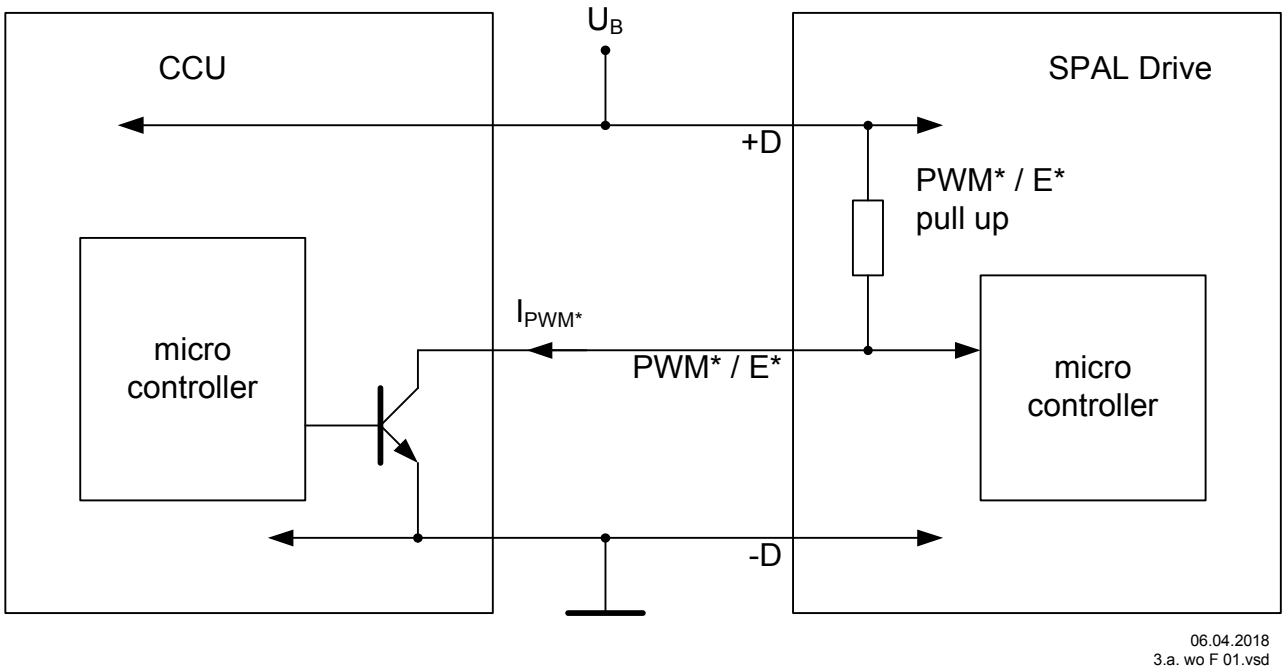
Signal pins:

1. Input: digital PWM input / active low: PWM* / E*

The signal pin PWM* / E* is used to control the Drive mode, it is the control input.

# 9 Drive interface

The Drive interface, i.e. the connections between the CCU (Custom Control Unit) and the Drive, is depicted in the following picture.




The CCU electronics and the Drive electronics are connected via one unidirectional line.

The PWM signal for the input PWM* / E* comes from the CCU electronics and uses a pull up resistor (PWM* / E* pull up) located in the Drive electronics to determine the recessive level.
This pull up resistor is connected to the supply voltage plus: +D / $U_B$.

The dominant level on the input PWM* / E* is low level, provided by the switching to ground stage depicted in above figure**.** as a bipolar npn transistor in the CCU.

## 10 Interface hardware for Digital control: pin PWM* / E*

The input PWM* / E* is used to wake up the Drive from Quiescent current mode. Any PWM duty cycle that guarantees a pulse going to the dominant level for more than $T_{wakeup}$ will wake up the Drive electronics.

| Parameters | Min | Typical | Max | Unit | Denomination |
|---|---|---|---|---|---|
| PWM* / E* frequency range | 50 | 100 | 500 | Hz | $f_{PWM}$ 1) |
| PWM* / E* duty cycle range | 0 | | 100 | % | $dc_{min}$ .. $dc_{max}$ |
| PWM* / E* high level voltage | $U_B$ * 0.65 | | | V | $U_{PWMH}$ |
| PWM* / E* low level voltage | | | $U_B$ * 0.40 | V | $U_{PWML}$ |
| PWM* / E* resolution | | 1 | | % | $dc_{resol}$ |
| PWM* / E* accuracy | | 1 | | % | $dc_{accu}$ |
| PWM* / E* current | -10 % | 5.5 | +10 % | mA | $I_{PWM*}$ |
| PWM* / E* leakage (quiescent) current | | | 200 | µA | |
| PWM* / E* wake up voltage | $U_B$ – 2 V | | | V | $U_{PWMWU}$ |
| PWM* / E* wakeup pulse | 150 | | | µs | $T_{wakeup}$ |
| PWM* pull up | | 4.7 | | kΩ | |

# 11 Software functions

## 11.1 Drive modes

The Drive has different working modes related mainly to the Drive current consumption:

1. Quiescent current mode
2. Electronics active mode
3. Run mode
4. Failure mode

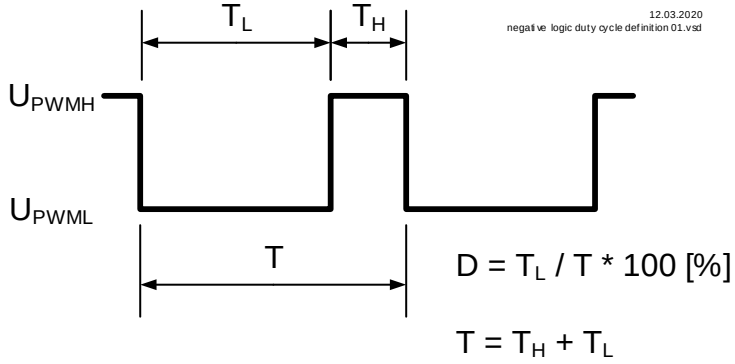
The Drive mode changes accordingly to the control input duty cycle on pin PWM* / E*.

| No. | Drive mode | Current consumption | Drive speed |
|---|---|---|---|
| 1 | Quiescent current mode | < 100 µA | 0 |
| 2 | Electronics active mode | < 40 mA | 0 |
| 3 | Run mode | depending on the requested speed and on the load | depending on the PWM duty cycle |
| 4 | Failure mode | < 40 mA | depending on the failure |

The Quiescent current mode is entered when the pin PWM* / E* is on 100 % duty cycle (dominant level). The time to go into Quiescent current mode depends on the actual PWM base frequency and the number of samples for the plausibility check (see chapter 11.3). Additionally 2 s are waited after the detection of the absence of the PWM signal before finally going into Quiescent current mode.
The Electronics active mode is entered with any PWM duty cycle value between 0 % and < 100 % if the condition from chapter 10 is fulfilled ($T_{wakeup}$).
The Run mode is entered if the PWM duty cycle on pin PWM* / E* has a value where the Drive is asked to run (see chapter 11.2)
The Failure mode is entered in case of failures of the Drive (see chapter 11.4).

## 11.2 Digital control: transfer function PWM input

The transfer function PWM input is the relation between the Drive speed and the duty cycle on the pin digital PWM input / active low: PWM* / E*.

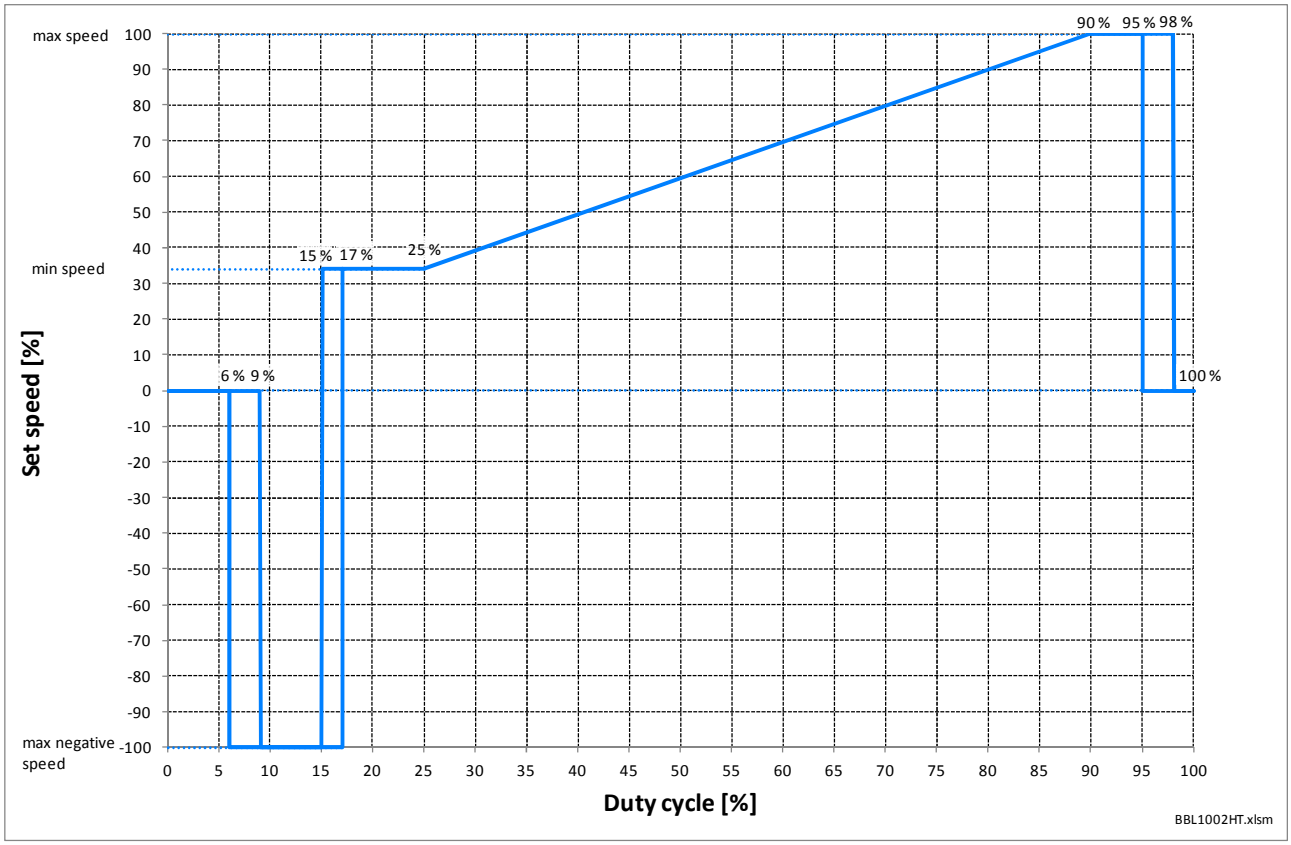



It is called ”negative logic duty cycle definition”.

Considering this definition,

- continuous low voltage is 100 % duty cycle (dominant level)
- continuous high voltage is 0 % duty cycle (recessive level)

Based on this duty cycle definition the transfer function PWM input is shown in the following figure.




## 11.3 Drive speed set point with Digital control

The PWM signal on the control input PWM* / E* is measured by the Drive electronics. For improving noise to signal ratio the PWM signal becomes only valid and is only used to set the speed of the Drive when a sufficient number of consecutive duty cycle measurements are equal.
This plausibility test slightly delays the response to the change of the duty cycle PWM value. This delay is in the range of 0.2 s or less.

## 11.4 Drive mode Failure modes

There are the following cases where the Drive will go into Failure mode and stop the Drive:

| Failure modes | Handling of the failure | Notification (*) |
|---|---|---|
| Drive blocked | In case of detection of a rotor locked the following strategy is used: a delay of 5 s till the next start attempt is introduced. If this start attempt fails again a delay increased by further 5 s till the next start attempt is introduced. This delay increase is repeated till the delay between the attempts is 25 s. Then this delay is kept for ever as long a valid PWM duty cycle is detected which asks the Drive to run | n/a |
| Drive overloaded | Fan speed is reduced in case of overload detection by means of current draw measurement. | n/a |
| Over current | The Drive will stop if the over current safety threshold is reached. | |
| Drive overheated | Fan speed is reduced in case of overheating detection (derating). Over the max operating temperature, the Drive will stop. | n/a |
| Under and Over voltage | If the supply voltage is outside the specified range the Drive will stop. | n/a |
| Internal Drive failure | The Drive will stop if a failure is detected during the startup self check procedure. | n/a |

In all cases the Drive tries to recover from failures when a valid PWM signal is detected which asks the Drive to run.
(*) Notification is not available as no feedback is provided to the CCU.

## 12 Units and acronyms

| Unit | | Physical Quantity | Prefix | Dimension | |
|---|---|---|---|---|---|
| % | percent | Proportionality | M | $10^{6}$ | mega |
| Ω | Ohm | Electrical Resistance | k | $10^{3}$ | kilo |
| ℃ | degree Celsius | Temperature | m | $10^{-3}$ | milli |
| A | Ampere | Current | µ | $10^{-6}$ | micro |
| h | hours | Time | n | $10^{-9}$ | nano |
| dBA | deciBel (A-weighting) | Sound pressure level | p | $10^{-12}$ | pico |
| Hz | Hertz | Frequency | | | |
| min | minute | Time | | | |
| Pa | Pascal | Pressure | | | |
| rpm | Revolutions per minute | Rotation frequency | | | |
| s | second | Time | | | |
| V | Volt | Voltage | | | |
| W | Watt | Power | | | |

**Table 1: Units of measurements**

| Key Word | Description |
|---|---|
| AMPL_IN | Amplitude PWM input signal |
| CCU | Custom Control Unit |
| Drive | Motor with axially integrated electronics |
| IGN | Ignition (KL15) |
| PWM | Pulse Width Modulation |
| $R_i$ | Input Resistance |
| SBL | Sealed brushless |
| T | Temperature |
| $T_{AMB}$ | Ambient Temperature |
| $U_B$ | Supply voltage |
| $U_n$ | Nominal supply Voltage |
| rms | root mean square |

## 13 Document change history

Initial document author: document author
Latest revision: 000

| Document author | Date | Revision | Comment |
|---|---|---|---|
| SPAL TEAM | 03.02.2020 | 000 | Initial Version. |
| SPAL TEAM | 15.12.2020 | 001 | Update Load dump value, was 35 is 65. |

**Table 2: Document change history**

Document status: released

## 14 Sommario