ZikoDrive ZDBL Series UART Operating Manual

Introduction

OverView

This manual is intended to be used with the ZikoDrive ZDBL SERIES UART compatible Motor controllers running standard firmware (1.2) and includes the following UART Commands that can also be used over RS232 or RS485 using the relevant Break Out Boards:

- Setting up standard running features such as Speeds, Output enable, Direction, braking and running current.
- Setting up the start-up parameters including Hold torque, Hold time, Starting torque and the starting speed.
- Setting up the motor running parameters such as the Phase Advance Angle, Rotor Positional Proportional Gain, Rotor Positional Integral Gain, PWM frequency etc.…
- PI Closed loop control settings
- Additional Mode settings

Specifications

- Up to 35Vdc.
- Up to 20A.
- Sensorless BLDC trapezoidal/Block commutation control
- Modular design, connects to many Break Out Boards that can provide options such as 4-20mA, 0-10Vdc, Optically Isolated inputs etc...
- Over temperature protections and stall detection.
- 16bit high speed Microcontroller controlled.

Contents

Important NOTE:

It is critically important to not exceed the recommended input voltages as this may cause un-repairable damage to the ZikoDrive ZD SERIES UART Motor Driver. The max voltage recommended for any digital or analogue inputs is 5Vdc. DO NOT APPLY Higher Voltage PWM as this will damage the board.

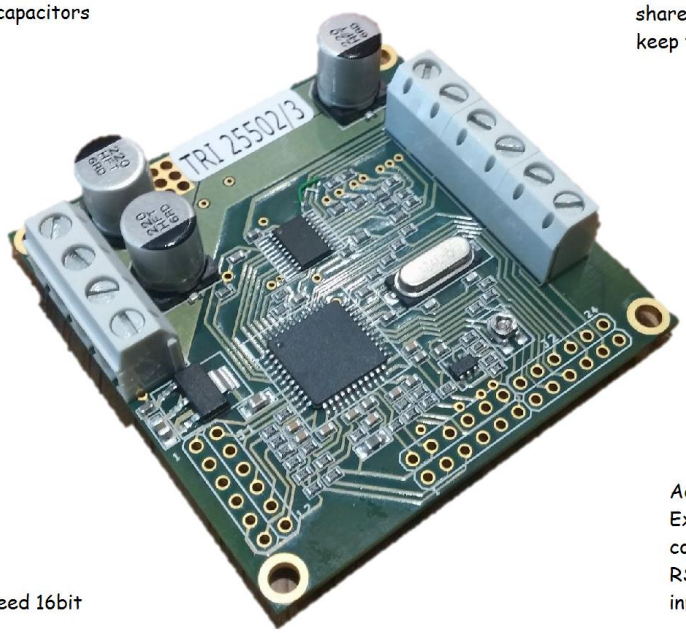
All wires must be kept as short as possible to reduce EMC emissions from the motor phase cables and to reduce noise on both the analogue and digital inputs. If you require more information regarding good wiring practice please contact ZikoDrive enquiries@zikodrive.com.

Components

Board View

Large Very low ESR capacitors

Connections doubled up to evenly share high current loads, as well as keep the total board hight Very low.



Additional IO that can support External break out boards or connectors. Options include RS232/RS485 CanBUS, Isolated inputs etc...

Powerfull high speed 16bit microcontroller

Thick, heavy copper traces to reduce power loss and improve heat dissapation.

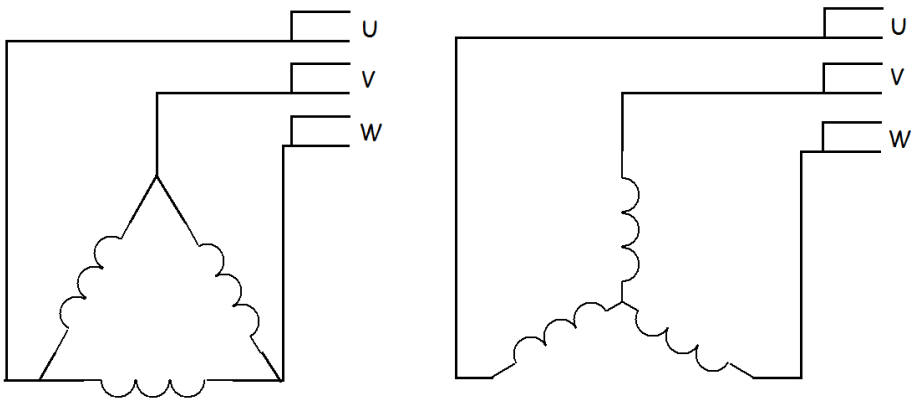
Reverse Poilarity Protected

Power Mosfets mounted to the bottom for easy heat sinking and heat dissapation.

Setting Up

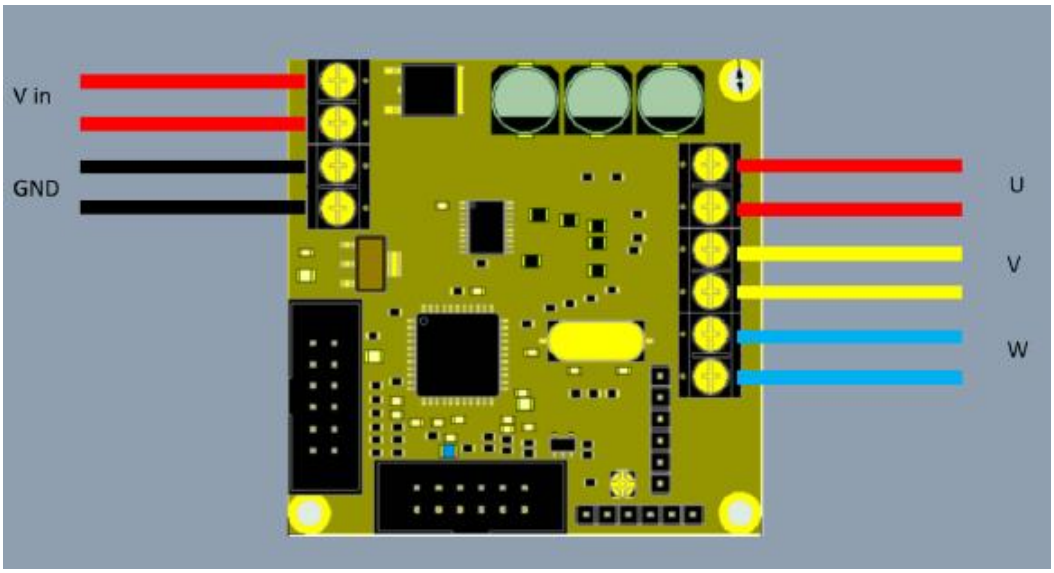
Wiring Motor Phase Wires

Wire up the Motor phase wiring according to the motor manufactures data sheet. The exact order the wires are inserted in not critically important. If the wiring order is incorrect the motor direction will change.

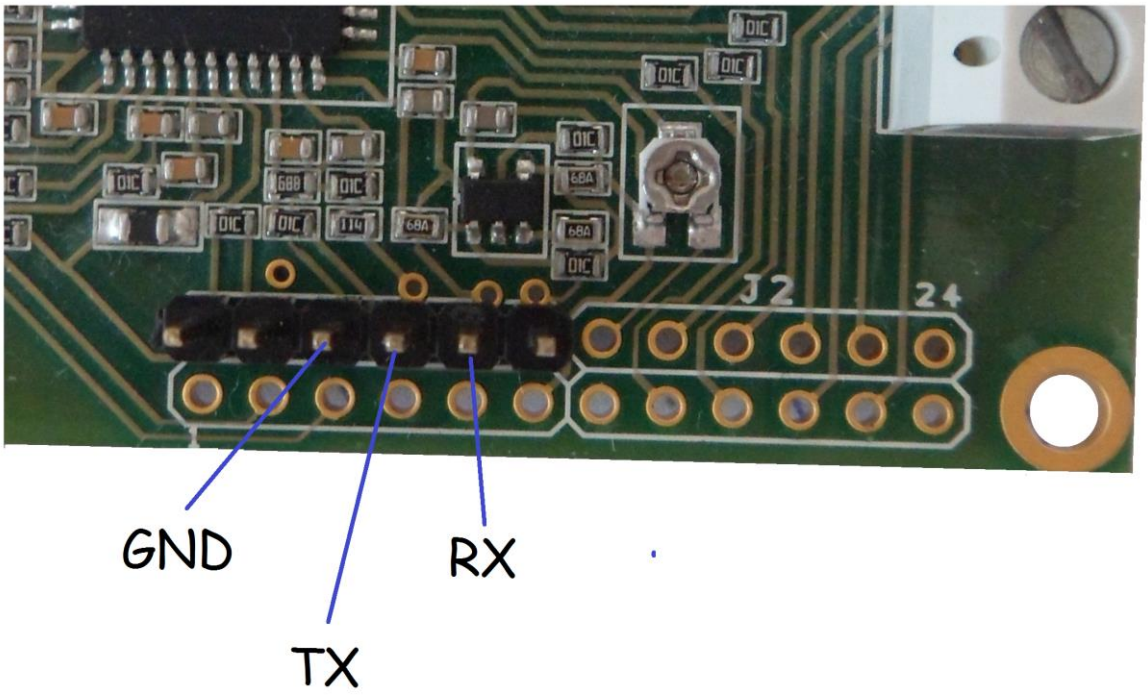


Power Wires

12-35Vdc must be applied to the board on at least two terminals of the terminal Block Marked GND & Vin (on the rear of the board). Although the board is protected against reverse polarity, care should be taken to ensure the wires are not reversed.
Note – Please ensure that the DC power supply has the proper current supply capability. Care should be taken to ensure the DC supply is clean (keep wires as short as possible, and shield where required).



UART Connections



GND is the common digital GND for the PCB. The RX and the TX pins must be connected to the Master Controller. I.e., TX (transmitting) from the Master controller must be connected to the RX (receiving) pin on the ZDBL board. The TX (transmitting) from the ZD SERIES UART must be connected to the RX (receiving) of the Master Controller.

Connections for any serial Break Out Board (RS485 & RS232)

Connecting to the Break Out Boards are simple.

A	=	Non-inverting receiver input and non-inverting driver output
B	=	Inverting receiver input and inverting driver output
GND	=	Ground

Note - If shielded cables are used between the Master Controller and the ZikoDrive please ensure only one end of the shielding is grounded to ensure no Ground loops.

Programming Manual

The UART Protocol

The protocol used is non-standard and derived by the ZikoDrive engineers to provide fast and efficient data transfer.
The Data is transmitted and received in 8bit binary Bytes. To easily transition between binary, decimal, and hexadecimal you can either use the programmer mode on the PC calculator, or I find using this website very efficient (https://www.mathsisfun.com/binary-decimal-hexadecimal-converter.html).

Protocol Setup

BAUD RATE	=	19200
START BITS	=	One
STOP BITS	=	One
PARITY	=	None

Recommended hardware

TTL-232R-3V3

Recommended Software

Realterm serial/TCP Terminal that can be *downloaded here* from sourceforge
There is ongoing development for ZikoDrive own software ZDSoft to incorporate the ZDBL series of controllers in the near future.

The ZikoDrive Protocol

All commands are initiated with a two byte header, one byte address code, one byte register address, a data byte and then followed with a CheckSum byte.
To ensure the correct data is being transferred, the protocol will send either a confirm (0x06) or a reject (0x15) for a good, or a bad command. If the ZD SERIES UART has accepted the command, the confirmation will then be sent to the Master Controller and then process the given command. If the command was rejected, all data will be disregarded and a new command must be sent.

Example 1 – Basic Send

From Master		0x7A 0x64 0x01 0x02 0x00 0xFC
0x7A & 0x64	=	Header, ASCII code ZD
0x01	=	ZikoDrive Address, Set as 0x01 as default
0x02	=	Register Address, Enable outputs
0xFC	=	CheckSum

CheckSum formula

Each command sent to the ZikoDrive controller must be followed with a CheckSum byte or the data will be rejected.

CHECKSUM = ((ADDRESS + REGISTER + DATA) XOR 0xFF) & 0xFF;

1. The Address, the required register and the data bytes are added together.
2. Command is run through an XOR with 0xFF
3. Command is then run through & with 0xFF

We have available a EXCEL spreadsheet to help calculate the CheckSum byte if required.
Please note that the Header and the CheckSum bytes are not included in the CheckSum Formula.

Shortlist of Commands

Register	Name	Length	Default
RUN			
0x01	Control	8bits	0x00
0x02	Enable Outputs	1bit	0x1
0x03	Direction	1bit	0x0
0x04	Brake	1bit	0x0
0x05	Running Current	4bits	0x3
START UP			
0x10	Hold torque	4bits	0x2
0x11	Hold Time	4bits	0x2
0x12	Start Torque	4bits	0x2
0x13	Start Speed	4bits	0x8
Motor Run			
0x20	Phase Advance	4bits	0x8
0x21	POS Prop GAIN	4bits	0x7
0x22	POS Intg GAIN	4bits	0x8
0x23	Recirculation	2bits	0x0
0x24	Blank Time	4Bits	0xC
0x25	Decay	1bit	0x0
0x26	PWM Frequency	5bits	0x13
Closed Loop			
0x30	Speed Prop Gain	4bits	0x7
0x31	Speed Intg Gain	4bits	0x6
0x32	Max Speed	3bits	0x4
0x33	Overspeed Limit	2bits	0x2
SETTINGS			
0x40	Mode	2bits	0x0
0x41	Restart(loss)	1bit	0x1
0x42	Stop on Fail	1bit	0x0
0x43	Control	2bit	0x0

RUN Registers

These registers are used to control the motor in real time, or let the controller only how to control the motor once UART has been disconnected.

Control Register (0x01)

The control is used to control the motor. The function of this control register depends on which mode the driver is set to run in. More information on the various modes can be found in the MODE register of this manual.

When the UART is not connected, either an external potentiometer/analogue voltage/current loop/PWM etc. can be used as the control signal.

Example 2 - Control

From Master	0x7A	0x64	0x01	0x01	0x80	0x7D	
From ZikoDrive							0x06

0x7A & 0x64	=	Header, ASCII code ZD
0x01	=	ZikoDrive Address, Set as 0x01 as default
0x01	=	Register Address, Control register
0x7D	=	CheckSum

Enable Outputs (0x02)

If this value is set to high, all the output transistors will be disabled. This register is only a single bit large so can only be set as a “1” run as normal or a “0” disable outputs. This register can also be accessed through external IO of the Driver.

Example 3 - Enable outputs

From Master	0x7A	0x64	0x01	0x02	0x00	0xFC	
From ZikoDrive							0x06

0x7A & 0x64	=	Header, ASCII code ZD
0x01	=	ZikoDrive Address, Set as 0x01 as default
0x02	=	Register Address, Enable Register
0x00	=	Ensure Outputs enabled
0xFC	=	CheckSum

Change Direction (0x03)

Direction register is used to set the direction of the motor. As the direction is also changed with the wiring of the three motor phases the direction bit will rotate the motor in the opposite direction.

CAUTION – Please ensure the motor is stopped before changing the direction. If the motor is not fully stopped it may possible to damage the driver due to induced reverse voltages.

Example 4 - Change Direction

From Master	0x7A	0x64	0x01	0x03	0x01	0xFA	
From ZikoDrive							0x06

Brake (0x04)

When the Brake bit is enabled, the motor's phases will be shorted together when a "0" control signal is provided. If the brake is disabled the motor will freewheel to a stop.

Example 5 - Brake

From Master	0x7A	0x64	0x01	0x04	0x01	0xF9	
From ZikoDrive							0x06

Running Current (0x05)

The running current is the max current calculated in the motor phase (Not the average total current draw of the motor). The Running current is only used once the motor has entered full sensorless mode. Each incremented value will increase the phase current by 1.25A.

Motor Phase current = Register Value x 1.25A

Example 6 - Change running current

From Master	0x7A	0x64	0x01	0x05	0x03	0xF9	
From ZikoDrive							0x06

5A max phase drive current.

StartUp Registers

These registers are used to set the StartUp parameters of the motor. If these values are not set correctly to the motor specifications, the motor may be very unstable during StartUp, or may not start at all.
Firstly, to start a sensorless BLDC motor, the rotor needs to be aligned into a known position. This is done by putting a current through two motor phases for a time long enough for the rotor to align. Once the rotor has been aligned the motor will go into a forced commutation cycle where the driver will accelerate the rotor around until the rotor speed is fast enough that the Back EMF created on the spare motor phase is large enough to be detected by the driver. Only once this speed is reached will the driver exit out of forced commutation mode and enter full BLDC senseless commutation.

Alignment Torque Register (0x10)

This value changes the amount of current in the two motor phases for the rotor alignment. The larger values will allow rotors with a higher inertia associated with them to be aligned correctly, however care must be taken on smaller motors as too high currents may damage the motor.

The current is calculated as a percentage of the Max current of the motor coils and can be calculated if required.

Motor Phase resistance = 0.7Ohms (Example Motor)
Motor supply voltage = 24Vdc

Max motor phase current = 24/0.7 = 34.3A

The alignment torque has a register 4bits long which gives us 16 possible percentage values (starting with “0”). So, each increment = 34.3/16 = 2.14A (6.25%)

Example 7 - Alignment Torque

From Master	0x7A	0x64	0x01	0x10	0x05	0xE9	
From ZikoDrive							0x06

Hex 0x05 = decimal 5 giving us 5x6.25% = 31.25% = 10.7A

NOTE – this value may seem high, however the full current may not enter the motor phases due to the motor inductance and the hold time. I.e., V=L*di/dt where V = supply voltage, L = motor inductance, di = change in current and dt = change in time. This formula can be re-arranged to find the max current value.

Alignment Time Register (0x11)

This value changes the amount of time the Hold Torque is applied to the two motor phases for the rotor alignment. The larger values will allow enough time for rotors with a higher inertia associated with them to be aligned correctly, however care must be taken on smaller motors as too high currents for too long time periods may damage the motor.

The Hold time can be set from 0ms and increase in increments of 8ms up to a total of 120ms.

Example 8 - Alignment Time

From Master	0x7A	0x64	0x01	0x11	0x05	0xE8	
From ZikoDrive							0x06

40ms allowed for rotor alignment

Forced Acceleration Torque (0x12)

This value changes the amount of Current applied to the two motor phases for motor acceleration. The larger values will allow higher torque which will allow higher inertia loads to be accelerated. Care must be taken on smaller motors as too high currents for too long time periods may damage the motor.

The current is calculated as a percentage of the Max current of the motor coils and can be calculated if required.

Motor Phase resistance = 0.7Ohms (Example Motor)
Motor supply voltage = 24Vdc

Max motor phase current = 24/0.7 = 34.3A

The alignment torque has a register 4bits long which gives us 16 possible percentage values (starting with “0”). So, each increment = 34.3/16 = 2.14A (6.25%)

Example 9 - Forced Acceleration Torque

From Master	0x7A	0x64	0x01	0x12	0x05	0xE7	
From ZikoDrive							0x06

Hex 0x05 = decimal 5 giving us 5x6.25% = 31.25% = 10.7A

Start Speed (0x13)

This is the speed (defined electrical cycle frequency) that the controller will accelerate the motor up to before switching to full closed loop senseless control.

Start Speed $_{(electrical\ frequency)}$ = (Data + 1) * 2Hz

Start speed RPM = (Electrical frequency * 60) / Motor Pole pairs

Please note – the Min speed of the controller is set to 25% of the start speed.

Example 10 - Start Speed

4 pole motor (2 pole pairs)

From Master	0x7A	0x64	0x01	0x13	0x05	0xE6	
From ZikoDrive							0x06

Hex 0x05 = decimal 5
Start Speed $_{(electrical\ frequency)}$ = (5 + 1) * 2Hz = 12Hz
Start Speed $_{(RPM)}$ = (12 * 60) / 2 = 360RPM

Min motor speed = 360 * 0.25 = 90RPM

Motor Run Registers

These registers are used to set the normal running parameters of the motor once full closed loop sensorless BLDC mode has been entered. If these values are not set correctly to the motor specifications, the motor may be very unstable, have reduced torque, or not even work at all.

The driver uses a 6-step program to commutate the motor phases. The timing between each electrical commutation cycle is calculated and determined through several parameters to achieve optimal dynamic response of the motor.

Phase Advance (0x20)

When the Phase advance is set to 0°, the controller will commutate the motor exactly in the middle of two back EMF positions. This is typically undesirable as by the time the controller reads the signal and reacts to it, the rotor has already progressed. The phase advance must be set at an optimal angle to ensure maximum torque at all speeds required by the application.

Example 11 - Phase Advance

From Master	0x7A	0x64	0x01	0x20	0x05	0xD9	
From ZikoDrive							0x06

Each value (starting from "0") will advance the angle by 1.875°

Position Proportional Gain (0x21)

Within a system where the speed is varying, the position of the commutation will vary as well. The ZDBL range of controllers have an integrated PI control system for a fast-dynamic response to these applications. If the value of the Proportional term on this PI controller is set too high, the controller overcompensates the required commutation position which can result in reduced torque and/or motor stall. If the value is set too low, the controller will be unable to keep up with speed variations and again produce low torque or stall.

The K_{CP} (Positional Proportional Gain term) can be calculated as follows:

$K_{CP} = 2^{(2n-7)}$

This allows for a K_{CP} range between 1/128 up to 256

Example 12 - Position Proportional Gain

From Master	0x7A	0x64	0x01	0x21	0x05	0xD8	
From ZikoDrive							0x06

Position Integral Gain (0x22)

The second part to the PI positional controller for the commutation.

The K_{CI} (Positional Integral Gain term) can be calculated as follows:

$K_{CI} = 2^{(2n-7)}$

This allows for a K_{CI} range between 1/128 up to 256

Example 13 - Position Integral Gain

From Master	0x7A	0x64	0x01	0x22	0x05	0xD7	
From ZikoDrive							0x06

Recirculation option (0x23)

Synchronous rectification is performed by the controller to control the current flows through the three-phase bridge rectifier. the circulation option allows you to choose a high side or a low side recirculation of the current, use both, or switch off completely (operating with fast decay of the current).
Changing the recirculation mode can improve, or worsen Back EMF virtual zero-point crossing reliability depending on duty cycle and motor supply voltage.

Value	Mode
0x00	Auto
0x01	High Side
0x02	Low Side
0x03	Off – No synchronous rectification

Example 14 - Recirculation

From Master	0x7A	0x64	0x01	0x23	0x00	0xDB	
From ZikoDrive							0x06

Blank Time (0x24)

Current spikes are created due to the clamp diodes integrated within the mosfets, as well as additional switching transients can cause false current trips/measurements. To overcome this issue a blank time is used to only measure the current after these transients/spikes have dispersed.

The blank time is increased from "0ns" in increments of 400ns. I.e.:

Blank Time = Data*400ns

Example 15 - Blank Time

From Master	0x7A	0x64	0x01	0x24	0x0A	0xD0	
From ZikoDrive							0x06

0x0A = 10
10 * 400ns = 4ms

Fast Decay on start (0x25)

The percentage fast decay of the current which is used during the start. The fast decay applies a reverse voltage to the motor phase winding and may reduce the out of phase Back EMF voltage.

0x00 = 12.5%
0x01 = 25%

Example 16 - Fast Decay

From Master	0x7A	0x64	0x01	0x25	0x00	0xD9	
From ZikoDrive							0x06

Fast Decay set to 12.5%

PWM Frequency (0x26)

This is the PWM frequency used to drive the three-phase power inverter. Faster frequencies allow for a better motor response, higher motor efficiency, lower torque ripple. However, the higher frequency's switch the mosfets more often which account for higher switching losses making the Mosfets run hotter and less efficient. Typically set around 20Khz so the frequency is out of the audible range (lower frequencies can resonate the motor) and low enough to not cause excessive mosfets inefficiencies. Typically motors with a higher inductance (slower Motors) can be run with lower frequencies, and motors with lower inductance (high speed motors) will require higher frequencies.

PWM Frequency = 1/ ((Data * 1.6 µs) +20 µs)

Example 17 - PWM frequency

From Master	0x7A	0x64	0x01	0x26	0x13	0xC5	
From ZikoDrive							0x06

0x13 = 19
19*1.6 µs = 30.4 µs
30.4 µs + 20 µs = 50.4 µs
1/50.4 µs = 19.84Khz

Closed Loop Speed Control Registers

These registers set the closed Loop PI Speed control parameters of the motor once full closed loop sensorless BLDC mode has been entered. Please see The Mode Register is used to select between the type of closed loop control required. The closed loop speed control must be entered the Mode Register.
The Speed control system measures the electrical cycle frequency to determine speed control. The control register input is used to set the desired speed for these registers.

Speed Proportional Gain (0x30)

Used to control the Proportional segment (K_{SP}) of the PI control loop. I.e., the electrical cycle difference (error) is multiplied by this data value (K_{SP}) and added to the integral term on each feedback loop. Higher values will cause very large changes where smaller values cause much more suttle changes which cause the motor to take longer to accelerate/decelerate to the control value.

$K_{SP} = 2^{(n-7)}$

Example 18 - Speed Proportional Gain

From Master	0x7A	0x64	0x01	0x30	0x08	0xC6	
From ZikoDrive							0x06

K_{SP} Value of 2

Speed Integral Gain (0x31)

Used to control the Integral segment (K_{SI}) of the PI control loop. I.e., the electrical cycle difference (error) is integrated by this data value (K_{SI}) and added to the Proportional term on each feedback loop. Higher values will cause very small changes where higher values cause much more suttle changes which cause the motor to take longer to accelerate/decelerate to the control value.

$K_{SI} = 2^{(n-7)}$

Example 19 - Speed Integral Gain

From Master	0x7A	0x64	0x01	0x31	0x08	0xC5	
From ZikoDrive							0x06

K_{SI} Value of 2

Max Speed (0x32)

The control register input is set to a percentage of this maximum speed (in electrical frequency). To set the Max speed you must know the number of motor poles and the no load speed of the motor at the motor input voltage. If this value is set too low, the motor will never reach its Max speed, if the value is set too high, control resolution is lost as the motor will run at its max speed through a larger proportion of the control register.

Max speed $_{(\text{electrical frequency})} = 0.1 * (2^{(\text{DATA} +8)} - 1)$ Hz

Max Speed $_{(\text{RPM})}$ = (Electrical frequency * 60) / No. of motor pole pairs

Note – the number of pole pairs can be found on the data sheet of the motor. Alternatively, you can count the number of poles by either looking inside the motor and counting the coils, this value gives you the number of poles so you will need to divide by 2 to get the number of pairs. If this is not possible you can apply a very low voltage through two motor phases, rotate the shaft by hand and count the number of positions the rotor settles in through a full revolution, this is the number of pole pairs.

Example 20 - Max Speed

Motor with 4 poles (2 pole pairs) and no load speed of 6000RPM.

From Master	0x7A	0x64	0x01	0x32	0x03	0xC9	
From ZikoDrive							0x06

0x03 = 3
$2^{(3+8)} = 2048$
2048-1 = 2047

Electrical frequency = 2047*0.1 = 204.7Hz

Max Speed RPM = (204.7 * 60) / 2 = 6141RPM

Overspeed ratio (0x33)

If the electrical frequency exceeds this value, the controller indicates a loss of synchronisation.

0x00 = 100% Max Speed
0x01 = 125% Max Speed
0x02 = 150% Max Speed
0x03 = 200% Max Speed

Note, the low speed limit is 25% of the Start Speed register value

Example 21 - Overspeed

From Master	0x7A	0x64	0x01	0x33	0x02	0xC9	
From ZikoDrive							0x06

Overspeed = 150% of max speed. If max speed = 6141RPM, overspeed threshold = 9211.5RPM

Settings Registers

Basic settings for various features.

Mode (0x40)

This register allows you to select the control mode of the motor by switching between open loop speed control, closed loos speed control and closed loop current control.

0x00 = All closed loop systems off
0x01 = Not used on current hardware – do NOT select this option
0x02 = Closed loop current control
0x03 = Closed loop speed control

Example 22 - Speed Proportional Gain

From Master	0x7A	0x64	0x01	0x40	0x03	0xBB	
From ZikoDrive							0x06

Closed loop speed control selected

Restart (0x41)

When the motor stalls or a loss of synchronisation is detected (electrical frequency smaller than low speed limit or greater than overspeed limit), this option allows the controller to automatically attempt to re-start or to remain off. To manually restart take the control register below the low speed limit and then back above it again.

The restart is a single bit, 0x00 for no restart, 0x01 for restart.

Note, the low speed limit is 25% of the Start Speed register

Example 23 - Restart

From Master	0x7A	0x64	0x01	0x41	0x00	0xBD	
From ZikoDrive							0x06

No restart on loss of synchronisation.

Stop on Fail (0x42)

If the controller acknowledges a fault, it can either ignore the fault and continue running or stop the motor until the control signal resets.

The stop on fail is a single bit, 0x00 for no stop on fail 0x01 for stop on fail.

Fail examples:
Over temperature
Loss of synchronisation
Under voltage
Mosfets over current

Example 24 - Stop on fail

From Master	0x7A	0x64	0x01	0x42	0x00	0xBC	
From ZikoDrive							0x06

No stop on fail

Control Method (0x43)

Selects the control register input

0x00 = Serial only
0x01 = Potentiometer fitted on driver
0x02 = External analogue voltage supplied

Example 25 - Control Method

From Master	0x7A	0x64	0x01	0x43	0x00	0xBB	
From ZikoDrive							0x06

Serial communication set control register

Change Address (0x44)

Not currently allowed

Quick Commands

Run (0x0)*

Control (0x01)

Control 0	0x7A 0x64 0x01 0x01 0x00 0xFD
Control 1	0x7A 0x64 0x01 0x01 0x30 0xCD
Control 2	0x7A 0x64 0x01 0x01 0x80 0x7D
Control 3	0x7A 0x64 0x01 0x01 0x0F 0xFE

Enable (0x02)

Enable 0	0x7A 0x64 0x01 0x02 0x00 0xFC
Enable 1	0x7A 0x64 0x01 0x02 0x01 0xFB

Direction (0x03)

Direction 0	0x7A 0x64 0x01 0x03 0x00 0xFB
Direction 1	0x7A 0x64 0x01 0x03 0x01 0xFA

Brake (0x04)

Brake 0	0x7A 0x64 0x01 0x04 0x00 0xFA
Brake 1	0x7A 0x64 0x01 0x04 0x01 0xF9

Running Current (0x05)

1.25A	0x7A 0x64 0x01 0x05 0x00 0xF9
2.5A	0x7A 0x64 0x01 0x05 0x01 0xF8
3.75A	0x7A 0x64 0x01 0x05 0x02 0xF7
5A	0x7A 0x64 0x01 0x05 0x03 0xF6

Start Up (0x1)*

Alignment Torque (0x10)

6.25%	0x7A 0x64 0x01 0x10 0x00 0xEE
31.25%	0x7A 0x64 0x01 0x10 0x05 0xE9
62.5%	0x7A 0x64 0x01 0x10 0x0A 0xE4
100%	0x7A 0x64 0x01 0x10 0x0F 0xDF

Alignment Time (0x11)

0ms	0x7A 0x64 0x01 0x11 0x00 0xED
40ms	0x7A 0x64 0x01 0x11 0x05 0xE8
80ms	0x7A 0x64 0x01 0x11 0x0A 0xE3
120ms	0x7A 0x64 0x01 0x11 0x0F 0xDE

Forced Acceleration Torque (0x12)

6.25%	0x7A 0x64 0x01 0x12 0x00 0xEC
31.25%	0x7A 0x64 0x01 0x12 0x05 0xE7
62.5%	0x7A 0x64 0x01 0x12 0x0A 0xE2
100%	0x7A 0x64 0x01 0x12 0x0F 0xDD

Start Speed (0x13)

2Hz	0x7A 0x64 0x01 0x13 0x00 0xEB
12Hz	0x7A 0x64 0x01 0x13 0x05 0xE6
22Hz	0x7A 0x64 0x01 0x13 0x0A 0xE1
32Hz	0x7A 0x64 0x01 0x13 0x0F 0xDC

Motor Run (0x2)*

Phase Advance (0x20)

0°	0x7A 0x64 0x01 0x20 0x00 0xDE
9.375 °	0x7A 0x64 0x01 0x20 0x05 0xD9
18.75 °	0x7A 0x64 0x01 0x20 0x0A 0xD4
28.125 °	0x7A 0x64 0x01 0x20 0x0F 0xCF

Position Proportional Gain (0x21)

K_{CP} = 1/128	0x7A 0x64 0x01 0x21 0x00 0xDD
K_{CP} = 1/4	0x7A 0x64 0x01 0x21 0x05 0xD8
K_{CP} = 8	0x7A 0x64 0x01 0x21 0x0A 0xD3
K_{CP} = 256	0x7A 0x64 0x01 0x21 0x0F 0xCE

Position Integral Gain (0x22)

K_{CI} = 1/128	0x7A 0x64 0x01 0x22 0x00 0xDC
K_{CI} = 1/4	0x7A 0x64 0x01 0x22 0x05 0xD7
K_{CI} = 8	0x7A 0x64 0x01 0x22 0x0A 0xD2
K_{CI} = 256	0x7A 0x64 0x01 0x22 0x0F 0xCD

Recirculation (0x23)

Auto	0x7A 0x64 0x01 0x23 0x00 0xDB
High	0x7A 0x64 0x01 0x23 0x01 0xDA
Low	0x7A 0x64 0x01 0x23 0x02 0xD9
Off	0x7A 0x64 0x01 0x23 0x03 0xD8

Blank Time (0x24)

0ns	0x7A 0x64 0x01 0x24 0x00 0xDA
2ms	0x7A 0x64 0x01 0x24 0x05 0xD5
4ms	0x7A 0x64 0x01 0x24 0x0A 0xD0
6ms	0x7A 0x64 0x01 0x24 0x0F 0xCB

Percentage Fast Decay (0x25)

12.5%	0x7A 0x64 0x01 0x25 0x00 0xD9
25%	0x7A 0x64 0x01 0x25 0x01 0xD8

PWM Frequency (0x26)

50Khz	0x7A 0x64 0x01 0x26 0x00 0xD8
35.7Khz	0x7A 0x64 0x01 0x26 0x05 0xD3
27.78Khz	0x7A 0x64 0x01 0x26 0x0A 0xCE
22.73Khz	0x7A 0x64 0x01 0x26 0x0F 0xC9
14.37Khz	0x7A 0x64 0x01 0x26 0x1F 0xB9

Closed Loop Control (0x3)*

Speed Proportional Gain (0x30)

K_{SP} = 1/128	0x7A 0x64 0x01 0x30 0x00 0xCE
K_{SP} = 1/4	0x7A 0x64 0x01 0x30 0x05 0xC9
K_{SP} = 8	0x7A 0x64 0x01 0x30 0x0A 0xC4
K_{SP} = 256	0x7A 0x64 0x01 0x30 0x0F 0xBF

Speed Integral Gain (0x31)

K_{SP} = 1/128	0x7A 0x64 0x01 0x31 0x00 0xCD
K_{SP} = 1/4	0x7A 0x64 0x01 0x31 0x05 0xC8
K_{SP} = 8	0x7A 0x64 0x01 0x31 0x0A 0xC3
K_{SP} = 256	0x7A 0x64 0x01 0x31 0x0F 0xBE

Max Speed (0x32)

F_{MX} = 25.5Hz	0x7A 0x64 0x01 0x32 0x00 0xCC
F_{MX} = 204.7Hz	0x7A 0x64 0x01 0x32 0x03 0xC9
F_{MX} = 3276.7Hz	0x7A 0x64 0x01 0x32 0x07 0xC5

OverSpeed Limit Ratio (0x33)

100%	0x7A 0x64 0x01 0x33 0x00 0xCB
125%	0x7A 0x64 0x01 0x33 0x01 0xCA
150%	0x7A 0x64 0x01 0x33 0x02 0xC9
200%	0x7A 0x64 0x01 0x33 0x03 0xC8

Settings (0x4)*

Mode (0x40)

Indirect Speed (off)	0x7A 0x64 0x01 0x40 0x00 0xBE
Direct Speed	0x7A 0x64 0x01 0x40 0x01 0xBD (not used, do not select)
Closed Loop Current	0x7A 0x64 0x01 0x40 0x02 0xBC
Closed Loop Speed	0x7A 0x64 0x01 0x40 0x03 0xBB

Restart on loss of Synchronisation (0x41)

No Restart	0x7A 0x64 0x01 0x41 0x00 0xBD
Restart	0x7A 0x64 0x01 0x41 0x01 0xBC

Stop on Fail (0x42)

No Stop	0x7A 0x64 0x01 0x42 0x00 0xBC
Stop	0x7A 0x64 0x01 0x42 0x01 0xBB

Control Method (0x43)

Serial Only	0x7A 0x64 0x01 0x43 0x00 0xBB
OnBoard POT	0x7A 0x64 0x01 0x43 0x01 0xBA
External Analogue Input	0x7A 0x64 0x01 0x43 0x02 0xB9

Change Address (0x44)

New Address = 0x03	0x7A 0x64 0x01 0x44 0x03 0xB7