Digital Load Control

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Introduction

The main application of the HED® Digital Load Control is to provide protection for an engine, and to allow the application to run at peak efficiency.

The type of engine protection intended is to keep the hydraulic function from overloading and perhaps stalling the engine. To do this, the Load Control monitors the engine RPM. The Load Control's outputs are then used to effect the hydraulic function, either by driving a flow control valve, or a dump valve. When the engine's RPM drops below a set point, the Load Control decreases the hydraulic function, thus lightening the load on the engine.

All of the Load Control's parameters can be adjusted via a serial link to a computer. This serial link can interface with HED® Load Link software, or any Terminal type program.

Notices and Warnings

This Manual

This manual is intended to help explain the features and the operation of the HED® Digital Load Control. Be sure to read this manual fully, before installing or setting up your new Load Control.

Warranties

All warranty and service should be handled through your supplier or installer.

Notice of Changes

The information and specifications in this manual are those in effect at the time of printing. HED® reserves the right to change specifications or design at any time without notice.

Specifications

The following are the specifications for the standard configuration of the HED Digital Load Control.

Supply Voltage:	10 – 45VDC.
Operating Temperature:	-45 to 85°C
Output Current:	2A.
Output Type:	Sourcing.
Input Frequency (pin 12):	0 – 15KHz.
Digital Input Type:	Switch-To-Ground.
Analog Input:	0-5VDC.
Input Impedance:	
Pin 9	10KΩ pull-up to about 10V.
Pin 10	10KΩ pull-up to about 10V.
Pin 11	100KΩ pull-down to ground.
Pin 12	3.3KΩ pull-up to about 10V.
Regulated Supply (pin 4):	5VDC @ 20mA.
Serial Link (pins 7 & 8):	RS232, at 9600 baud.
Enclosure:	NEMA 4 (if properly closed)
Mating Connector:	Deutsch DTM06-12SA (plug) - 1 needed WM-12S (wedges) - 1 needed 0462-201-20141 (sockets) – up to 12 needed

Pinout

Pin	Function	Pin	Function
1	BATTERY	7	RS232 Out – to PC
2	GROUND	8	RS232 In – From PC
3	GROUND	9	Digital In – Low RPM Set
4	5V Supply - Out	10	Digital In – High RPM Set
5	Output #1	11	Analog In
6	Output #2	12	Frequency In

Outputs

The Digital Load Control has two pulse width modulated (PWM) outputs. Both of the outputs put out the same value. This allows the Digital Valve Driver to drive dual valves, or it has a built in spare output. **NOTE: Connecting the two outputs together, externally, DOES NOT increase the current capability of the outputs.** In other words, two 2A outputs connected together make one 2A output.

The control algorithm that determines the output duty cycle has two main parts. These are the Proportional control, and the Integral control parts. Each can be independently adjusted, or even disabled. Note that if both the Proportional and the Integral algorithms are turned off, the Load Control will just sit there and look pretty.

Proportional Control:

Proportional control provides very fast reactions to any change in error. It works well for transient, or momentary disturbances, like hitting a rock. The drawback with proportional controllers are that if the disturbance persists, the machine will run at an RPM less than the **High RPM** point. For example a ditcher might run at 4000rpm in dry sand, 3900rpm in wet sand, 3600rpm in dirt, 3000rpm in clay and so on.

The proportional control algorithm uses a two-point proportional control profile. The two points are set by the **High RPM** and the **Low RPM** parameters, along with the **Pulses** parameter. If the input RPM is above the **High RPM** the outputs are equal to the **Max** setting. If the input RPM is equal to the **Low RPM** the outputs are equal to the **Threshold** setting. In between these two points, the outputs are adjusted linearly between **Threshold** and **Max**.

While all parameters can be set via a serial link, the **Low** and **High RPM** settings can be set by grounding certain pins. That is, if the input RPM is held where you want the **High RPM** to be, Pin 9 can be grounded to store this value. The Load Control will send a message over its serial port, indicating that the parameter has been changed. If it is attached to a PC, this message can be displayed. Similarly, if the input RPM is held where you want the **Low RPM** to be, Pin 10 can be grounded to store this value. Again, the Load Control will send a message over its serial port, indicating that the parameter has been changed.

To disable the Proportional control part, simply set the **Low RPM** parameter higher than the **High RPM** point.

Integral Control:

Integral controllers work well to compensate for any persistent disturbances, or loads. After the integral controller has time to compensate for the disturbance, it should maintain the engine operating at the **High RPM** point. Thus achieving optimal performance. One example of an application that could use an integral controller is a ditcher. It might be digging through sandy soil for a while, then hit clay, then gravel. In each type of soil, the engine should run at the High RPM point or higher. Note that at the transitions, this might not be the case.

For the integral control algorithm, if the input RPM is above the **High RPM** point, the outputs will increase until it reaches the **Max** setting. If the input RPM is below the **High RPM** point,

the outputs will be decreased at a rate determined by the RPM error and the **Integral Gain** parameter. The outputs will decrease continuously until either the input RPM equals or surpasses the **High RPM** value, or the outputs reach **Threshold**. The outputs will recover (grow to "**Max**") if the input RPM is above the **High RPM** point.

To disable the Integral control part, simply set the **Integral Gain** to zero.

Algorithm Setup

The following is a suggested procedure to set up the proportional and integral control algorithm.

1. Set the High RPM point at the engine speed that the Load Control should try to maintain, during operation.
2. Set the Low RPM point at the minimum operational engine speed.
3. Adjust the Integral Gain to achieve the desired response. Increasing the Integral Gain speeds up the response, but increases the likelihood of instability.

Adjustment Modes

There are two adjustment modes of operation of the Load Control. The modes determine what effect the analog input (pin 11) has on the outputs. In the first mode the analog input effects the sensitivity of the Load Control. In the other mode, the analog input effects the output level.

Sensitivity Mode (default)

Proportional Adjustment:

The Proportional Band is the RPM band that separates the **Threshold** and **Max** points. The analog input (pin 11) can be used to adjust the Proportional Band. The smaller the Proportional Band, the more sensitive the controller is to RPM changes. If there is 0VDC on pin 11, or nothing is attached, then the Proportional Band is unaffected, or full sized. That is, it is from **Low RPM** up to **High RPM**. If 5VDC is applied to pin 11, the Proportional Band is reduced 'fully'. 'Fully' is a percentage of reduction that is set by the **Range** parameter. If the **Range** parameter is set at 100%, then the Proportional Band can be reduced all the way to 0rpm. If the **Range** parameter is set at 0, the analog input has no effect on the Proportional Band.

Integral Adjustment:

The analog input (pin 11) can be used to adjust the integration rate, or speed. If there is 0VDC on pin 11, or nothing is attached, then the integration rate is determined solely by the **Integral Rate** setting. If 5VDC is applied to pin 11, the integration rate is 'fully' increased. 'Fully' is a percentage of increase that is set by the **Range** parameter. If the **Range** parameter is set at 50%, the analog input will have half the effect on the integration rate as it would if the **Range** parameter was set at 100. Again, if the **Range** parameter is set at 0, the analog input has no effect on the integration rate.

Output Level Mode

In the Output Level Mode, the "**Max**" value that is used in the output algorithms can be effected by the analog input. If there is 0VDC on pin 11, or nothing is attached, then the outputs use the **Max** parameter in their algorithms. As the voltage applied to pin 11 increases, the effective "Max" value is moved from **Max** towards **Threshold**. The **Range** parameter determines the percentage of shift that a 5VDC (maximum) input can do. This means that if the **Range** parameter is set at 100%, the analog input will be able to slide the "**Max**" value all the way between **Max** and **Threshold**. If the **Range** parameter is set at 0, the analog input has no effect on the "Max" value. For example: Assume that Threshold = 5, Max = 90, and **Range** = 50. Then the maximum PWM duty cycle out of either output is 90% if the voltage on pin 11 is 0V. If the voltage on pin 11 is 5VDC, then the maximum PWM duty cycle out of either pin will be 47.5%.

Off Mode

The Load Control has another mode that can be activated, or deactivated. This is the Off Mode. The Off Mode determines if the outputs are allowed to turn off completely or not.

Deactivated:

When the Off Mode is deactivated, the outputs do not turn completely off. That is, the outputs cannot be reduced further than the **Threshold** setting.

Activated (default):

When the Off Mode is activated, the outputs can turn completely off. That is, if the input RPM is below the **Low RPM** for a proportional control, the outputs will turn off completely. Similarly, for an integral control, if the input frequency is below the **High RPM** point long enough such that the integrator "ramps up" fully, the outputs will turn off, after they first reach **Threshold**.

Parameters

The following are the PWM Output parameters that the user can change with a PC.

Frequency: This is the PWM frequency of the outputs.

Max: This is the maximum duty cycle (0-100). If it is set below the **Threshold** setting, the load control will operate as a dump valve[1].

Threshold: This is the threshold duty cycle (0-100). If it is set above the **Max** setting, the load control will operate as a dump valve[1].

Off Mode: This option determines if the outputs turn off or stay at **Threshold** (or **Max** in dump valve operation) when they are in the 'off' state.

Adjustment Mode: This option determines if the analog input can effect the sensitivity or the output levels.

Range: This selects the amount of effect that pin 10 will have on the algorithms.

The following are the Algorithm Parameters that can be set by the user.

High RPM: This is the RPM where the algorithms start acting, if the input RPM drops below this point.

Low RPM: This is the RPM that sets the proportional band. If the input RPM is below this value, the output will be 'off', depending on the **Off Mode**. If this value is set higher than **High RPM**, the proportional control algorithm will be turned off.

Integral Gain: This determines how fast the integrator reacts. If this value is set to zero, the integral control algorithm will be turned off.

Pulses: This sets the number of pulses per revolution, for the RPM input. It is used to convert from RPM to frequency and back.

[1] To use the Load Control for dump valves, set the Threshold parameter higher than the Max parameter. This will cause the Load Control to increase its outputs as the input rpm drops below the High RPM point.

Diagnostics

LEDs:

There are two LEDs on the Load Control board. Each one indicates the status of one of the outputs. D1 indicates output #1's status (pin 5), while D2 indicates output #2's status (pin 6). Note that to help maintain the NEMA 4 rating of the enclosure, the standard HED® Digital Load Control has no windows to view the LEDs. HED® does not suggest opening the box up to view the LEDs. If you do, make sure to properly, and fully, close the enclosure when you are done.

Status	**Blink Pattern**
Okay	Very Slow, 5% On
Output Shorted	Slow 50% On/Off
Output Overheated	Quick 25% On, 75% Off

The output status is checked at startup, and then only when requested by the user, over the serial link. This is done to minimize any unnecessary 'jumps' in the outputs due to the fact that the outputs must be turned off for a while (~130ms), then turned on for a while (~65ms), before the Load Control can resume normal operation.

Queries:

The following are a few queries that the Load Control can respond to.

Software Version: This will indicate which version of software is loaded into the Load Control.

All Parameters: All the parameters can be read with one command.

Input Data: The current values of all inputs into the Load Control can be displayed.

Output Status: The output status tested, and then displayed. Note that the outputs are pulsed when the outputs are tested, as mentioned above.

Note that the normal operation of the Load Control will be temporarily suspended for these queries.

PC Interface, via Terminal or Hyper Terminal

The interface has been set up so that any terminal type program should allow the user to change or view the Load Control's parameters. This ability allows the Load Control to be operated with just about any computer system, past, present or future, as long as it has a terminal style program.

The following settings must be used:

Baud Rate = 9600

Parity = None

Stop Bits = 1

Handshaking = None.

Note Pin 7 is the Load Control-To-PC connection, and pin 8 is the PC-to-Load Control connection. These pins use RS-232.

It is suggested that Line Feeds are added/appended to incoming line ends. Local echo is also suggested.

Setting Parameters:

To change one parameter at a time, use the following (Note that letters must be upper case):

Frequency: 'F', '=', ####, < Enter >. Where #### is the number in Hz that you want the PWM frequency to be at. Example: For a 150Hz PWM output, enter "F=150" followed by hitting the <Enter> key.

Threshold: 'T', '=', ###, < Enter >. Where ### is the number in % that you want the **Threshold** duty cycle to be at. Example: For a 10% **Threshold**, enter "T=10" followed by hitting the <Enter> key.

Max: 'M', '=', ###, < Enter >. Where ### is the number in % that you want the **Max** duty cycle to be at. Example: For a 90% **Max**, enter "M=90" followed by hitting the <Enter> key.

High RPM: 'H', '=', #####, < Enter >. Where ##### is the number in rpm that you want the **High RPM** set point to be at. Example: For a 1500rpm set point, enter "H=1500" followed by hitting the <Enter> key.

Low RPM: 'L', '=', #####, < Enter >. Where ##### is the number in rpm that you want the **Low RPM** set point to be at. Example: For a 500rpm set point, enter "L=500" followed by hitting the <Enter> key.

Integral Gain: 'I', '=', #####, < Enter >. Where ##### is the number that you want the **Integral Gain** to be at. Example: For an **Integral Gain** of 100, enter "I=100" followed by hitting the <Enter> key.

Pulse: ‘P’, ‘=’, ####, < Enter >. Where #### is the number of pulses per revolution, for the RPM input. Example: For a **Pulse** of 100, enter “P=100” followed by hitting the <Enter> key.

Off Mode: ‘O’, ‘=’, #, < Enter >. Where # is 0 for off, and 1 for On.

Range: ‘R’, ‘=’, #, < Enter >. Where # is sets the range, according to the following table.

R = #	Range (%)
0	0
1	25
2	37.5
3	50
4	62.5
5	75
6	87.5
7	100

Adjustment Mode: ‘J’, ‘=’, #, < Enter >. Where # sets the adjustment mode, according to the following table.

J = #	Adjustment Mode
0	Output Level
1	Proportional Sensitivity
2	Integral Sensitivity
3	Proportional and Integral Sensitivity

Defaults: To reset all the parameters back to their factory defaults, just type “DEF” followed by hitting the <Enter> key.

Query Parameters:

To query the current value of the parameters, use the above messages, without the numbers. For example, to ask what the **Threshold** is set at, type “T=” followed by <Enter>. To ask what the **High RPM** is set at, type “H=” followed by <Enter>.

Other Special Queries:

All of the parameters can be queried at once by typing: “A=” followed by <Enter>.

To see what the inputs to the Load Control currently are, type “D=” followed by <Enter>.

To check the output Status of the Load Control, type “S=” followed by <Enter>. The response will be “s=##”, where the first # is for output #1 (pin 5) and the other # is for output #2 (pin 6). A ‘0’ means that the output is OKAY. A ‘1’ means that the output is either shorted to battery, shorted to ground, or is open circuited. A ‘2’ means that the output has overheated, or the supply voltage is bad.

To check the software version, type “V=” followed by <Enter>.

PC - RS232 Wiring

This section describes the wiring connections, to attach an RS232 signal to a PC's 9 pin (DB9) serial port connector.

DB9 Pin	Description	Load Control Pin
2	PC's Receive	7
3	PC's Transmit	8
5	Ground	2, 3, or equivalent[2]

Load Control Accessories

WH-100-200

This is a "cheater" harness that is intended to "T" into the wire harness attached to the Load Control. Its function is to add the PC – serial communication wires to a harness that normally does not include them, to allow programming or diagnostics to be performed. This eliminates the need for RS232 wires to be permanently wired in the Load Control Harness. The WH-100-200 has a 3' RS232 cable.

WH-100-201

This is the same as the WH-100-200, but has a 12' RS232 cable.

HED® Load Link

HED® Load Link is a Windows based program written to interface with the Load Control. HED® thinks that it is much easier, and more user friendly than a terminal program. Load Link lets you store settings, and automate some processes.

[2] If both pins 2 and 3 are being used, then the RS232 ground can be connected to a different point on the machine, that is at the same ground as the Load Control's pin 2. That is, if the Load Control pin 2 is attached to **Battery -**, then the RS232 ground can also be attached to **Battery -**, somewhere else on the machine.

Trouble Shooting Guide

The following are a few trouble-shooting ideas. It is suggested that if any trouble is experienced with the Load Control, that a PC should be attached to the Load Control's serial link. Either Load Link or a terminal type program should be run, to allow the Load Control's diagnostic capabilities to function.

Load Control is not functioning at all:

1. Check the parameter settings with the serial link. If the Load Control answers the PC, then it has power, and is running. If the Load Control does not answer, then check the wire harness.
2. Are the parameter settings correct? If not, reset them to your desired settings, and try again.
3. Check the output diagnostics. If the output you are using is not "Okay", then check the wiring to the valve, and the valve itself.
4. Raise the Threshold setting, and make sure that the "Off Mode" is set so that the outputs do not turn off below threshold (i.e. "C=2"). If their output starts, then either the Threshold was set too low, or the input frequency is now working.
5. Check the input frequency. If it is 0, and there should be a non-zero frequency, check the wiring to the pulse/frequency sensor. If this is the initial installation on a new machine (i.e. this is the first time a HED® Digital Load Control is being used), then the pulse sensor might not be compatible with the version of Load Control you have. The standard Load Control has a pull-up resistor for its frequency input. If your sensor cannot sink enough current, then the Load Control might not see the input. If this is the case, contact whoever sold you the Load Control. HED can reconfigure the unit to have pull-down resistors, or smaller resistors, if needed. If this unit was working, or other similar machines work fine, check the sensor itself.
6. Try re-setting the parameters to their defaults.
7. If you have another Load Control, try swapping it in. If it works with the same parameter settings, and the other does not, then it probably is not the harness or valve. Return the bad unit. If neither unit operate, contact the seller of the Load Control for application assistance.

The Load Control does not operate correctly:

1. Check the parameter settings. Are the parameter settings correct? If not, reset them to your desired settings, and try again.
2. Check the input frequency. If it is 0, and there should be a non-zero frequency, check the wiring to the pulse/frequency sensor. If this is the initial installation on a new machine (i.e. this is the first time a HED® Digital Load Control is being used), then the pulse sensor might not be compatible with the version of Load Control you have. The standard Load Control has a pull-up resistor for its frequency input. If your sensor cannot sink enough current, then the Load Control might not see the input. If this is the case, contact whoever sold you the Load Control. HED can reconfigure the unit to have pull-down resistors, or smaller resistors, if needed. If this unit was working, or other similar machines work fine, check the sensor itself.

The Load Control is working Backwards:

It is possible for the Load Control to control either flow control valves, or dump valves. For flow control valves, the output drops to reduce the function, and thus the load on the engine. For dump valves the output increases to reduce the function. For a flow control valve the Maximum parameter should be larger than the Threshold setting. For dump valves, the Threshold parameter should be larger than the Maximum setting.

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