Tillett and Hague Technology Guidance and Control System

Reference manual for implement manufacturers

Inter-row and In-row

Disclaimer:
Considerable effort has gone into making Tillett and Hague guidance and control systems reliable under normal commercial conditions. However, it is possible that under some adverse circumstances the guidance system will be unable to operate reliably. We recommend that it is made clear to operator's that it is their responsibility to ensure that the machine is operating in a satisfactory manner. Should a fault develop, or excessive crop damage occur, operation should cease, and users should be encouraged to contact their dealer or implement manufacturer for advice.

Manual V10.4 Feb 2025

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1. Introduction to this manual

This manual has been written to provide implement manufacturers incorporating Tillett and Hague guidance and control systems into their products with the technical information they need.

This manual is not intended for use by implement operators. However, Tillett and Hague Technology Ltd do give permission for extracts from this manual to be used by their customers in the production of implement operator manuals. Tillett and Hague also produce a simplified in-row operators guide.

It is the responsibility of the implement manufacturer to ensure that all implements are sold with the information necessary for safe and effective operation. Tillett and Hague Technology Ltd will on request provide reasonable assistance in the development of English language operator manuals and other training material.

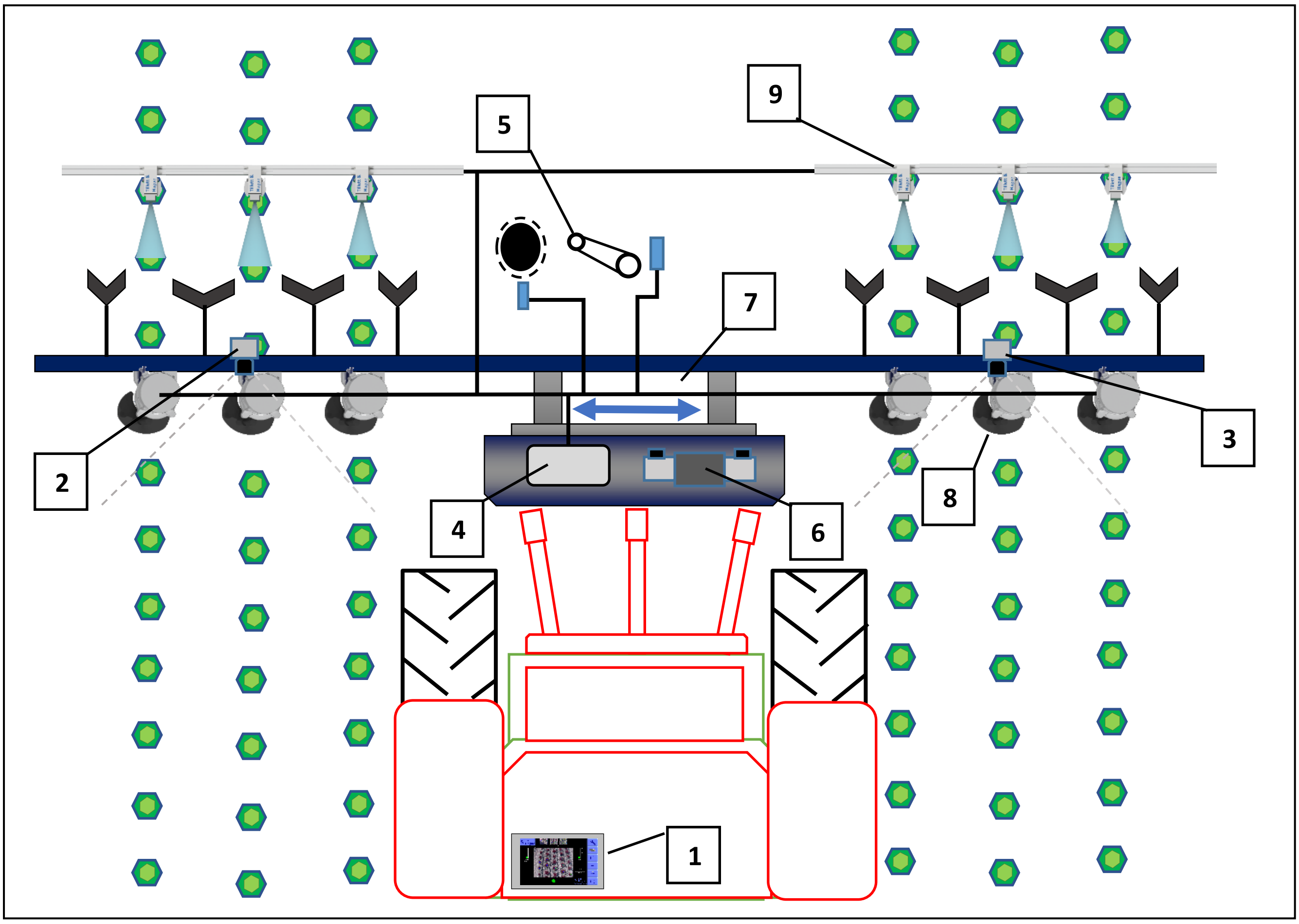
2. Product description

This vision guidance system analyses data from digital cameras to identify crop rows. Rows are tracked over successive images and their position be used to steer an implement laterally relative to those crop rows. When running in in-row mode individual crop plants are also tracked so that in-row cultivators or spray nozzles can be synchronised with plants as they pass under the implement.

Tillett and Hague's software has been refined over 20 years of commercial use and development and has to date been used to guide over 3000 vision guided implements around the world. The very latest version of this software has been loaded onto a new hardware system incorporating touch screen technology with a bright high contrast display. This provides operators with highly visible user-friendly information including live images with graphical overlay. Highly efficient processors and CMOS imagers produce world leading row tracking performance from a robust purpose designed package that is simple and cost effective to install.

There are 4 main components to the system.

- A digital camera **(2)** or cameras **(2/3)** mounted on the implement looking ahead at a wide area of crop normally taking in several rows each.
- A cab mounted console **(1)** containing a computer to analyses camera images and find exact row/plant centres.
- An implement mounted control box **(4)** housing an electronic board that controls hydraulic valves **(6)** for side shift or disc steering. That board also accepts input from position and proximity sensors **(5/7)** necessary for closed loop control.
- In-row cultivators **(8)** and/or nozzles **(9)** connected to implement module **(4)** via CAN.

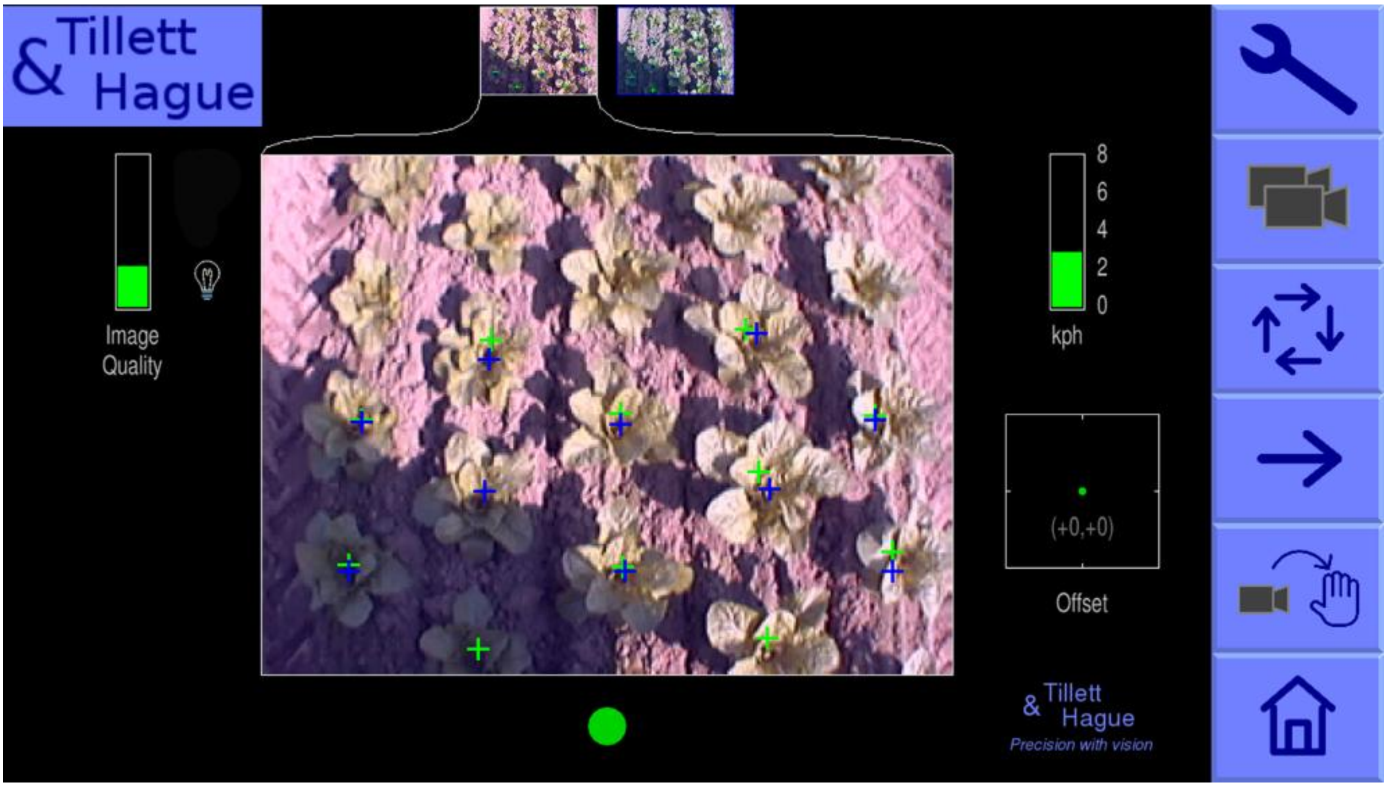


Schematic of a rear mounted in-row guidance system with side shift

The system uses a colour camera to pick out green crop and weed from backgrounds containing soil, stones and trash. (Systems can also be configured to work in crops of other colours.) Crop plants are located within a scene by matching a template corresponding to the known planting pattern with crop plants as they appear in the camera image. That image is displayed live on the console with crop plants overlaid with blue and green crosses for in-row and overlaid with green lines for inter-row.

Matching a template to a broad area of crop improves reliability especially when parts of rows are not present or partially obscured by weeds. Template shape is determined by a configuration pre-programmed to suit a particular crop planting geometry and implement configuration. Different configurations can be created for different crops and implement configurations.

Live video allows users to check for a good match between template and actual crop geometry, which is important for accurate row following.



Console working screen showing a typical live video image for a 2-camera in-row machine with the template superimposed as blue and green crosses over individual crop plants.

12 V Electrical system

The system is designed to operate from a tractor nominal 12V supply fused at no more than 20A for short circuit protection. The power consumption for electronic parts including the console is only 25W, but solenoid valves driven by the system will increase that substantially when they are activated particularly larger hydraulic valves used by in-row machines. The system is tolerant to voltage surges up to 27 V and will continue to operate for short periods down to 6V providing continuity during tractor starts.

42V Electrical system

Electrically powered rotors require an adequately regulated 42V power supply. For tractor mounted implements this can be supplied from a battery pack (e.g. 3 x 12V automotive batteries) with a PTO driven alternator to maintain charge (3 x 13.8V =42V). An on-screen warning of low voltage (38V) is displayed if supply voltage drops and a safety cut off to protect rotors (36V) is also employed. Each rotor usually draws between 2A and 5A in normal operation with possible peaks of 10A.

Hydraulic system

The hydraulic requirements for in-row machines with electrically driven rotors are similar to that of an inter-row machine and the reader is referred to the inter-row reference manual for system requirements, although extra hydraulic functions such as levelling may need to be considered.

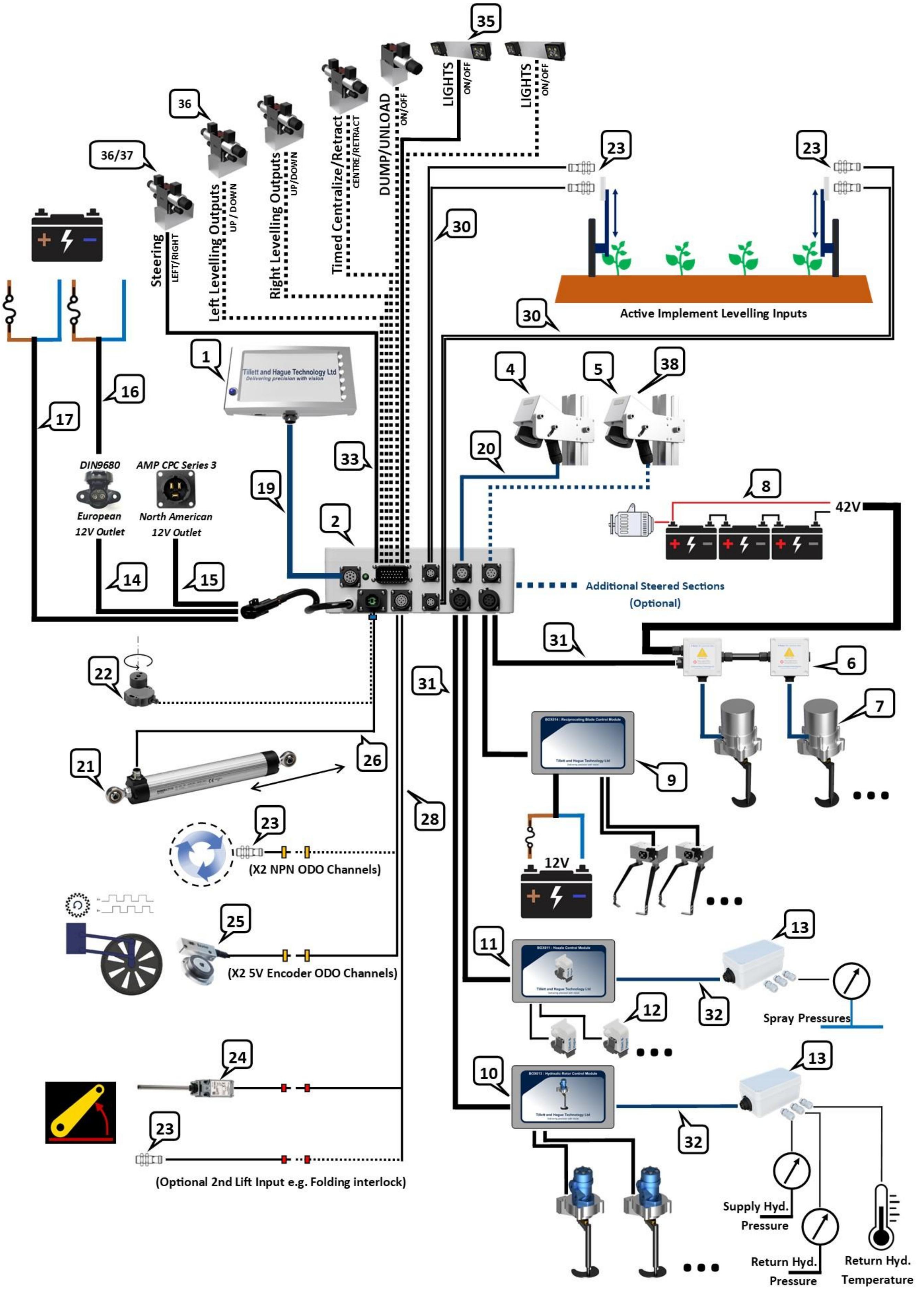
Hydraulically driven rotors require large volumes of oil, up to 11l/min/rotor. Check your tractor hydraulic system/transmission specification bearing in mind that flow rates are often quoted at engine rpms that might not allow adequately slow forward speeds. Additional oil filtration and heat management may also be required.

For further discussion of hydraulic systems including the use of proportional valves see Annex.

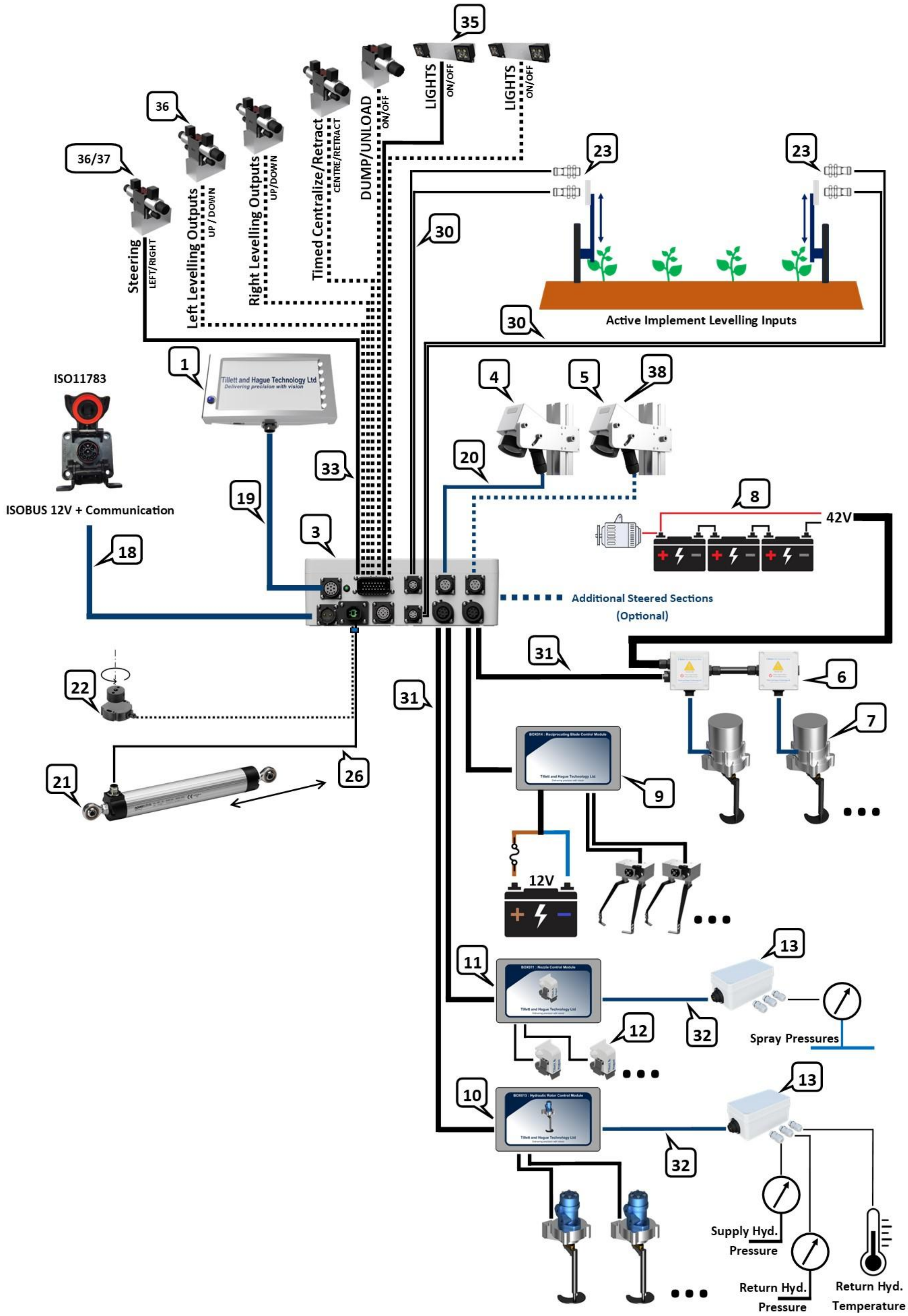
Spray system

Where nozzles are fitted an appropriate spray tank, pump and filter system must be provided.

3. System overview - with optional additional equipment (broken lines)



ISOBUS system overview - with optional additional equipment (broken lines)



	Part Name	Part number
1	Console/Cab mounted terminal	BOX001-HS
2	Inrow implement control module	BOX006
3	Optional ISOBUS power and data connection to tractor for Lift and Odometer inputs	BOX006-ISO
4	Camera 1	BOX003
5	Camera 2 (optional)	BOX003
	CAN Devices	
6	Electric Rotor 42V, 12V and CAN Junction Box	BOX009
	Electric Rotor 42V, 12V and CAN Junction PCB	PCB016
7	Electric Rotor Assembly	ROT001-E
8	Electric Rotor 42V Power Supply	BOX017
9	Reciprocating Blade Control Module	BOX014
	Reciprocating Blade PCB	PCB010
10	Hydraulic Rotor Control Module	BOX013
	Hydraulic Rotor PCB	PCB004
11	Nozzle Control Module	BOX011
	Nozzle Controller PCB	PCB005
12	Nozzle Assembly	NOZ001
13	Condition Monitoring Module (Spray or Hydraulic Monitoring)	BOX012
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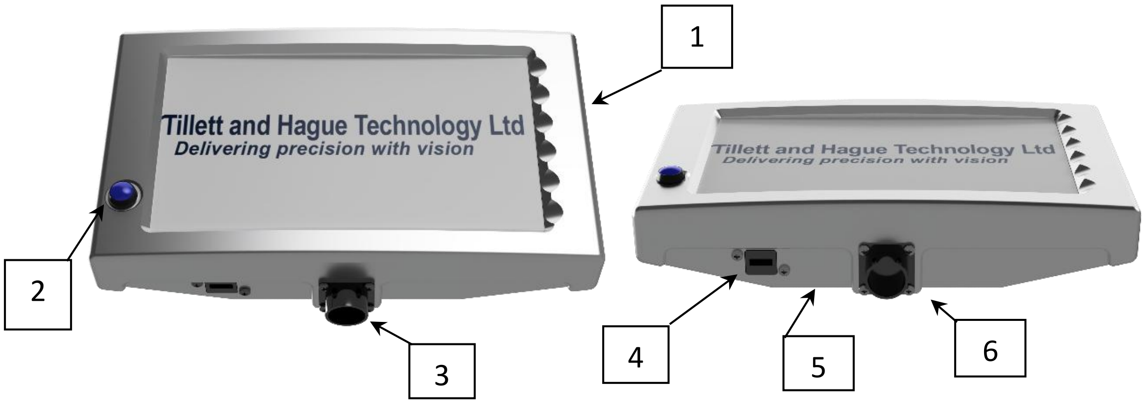
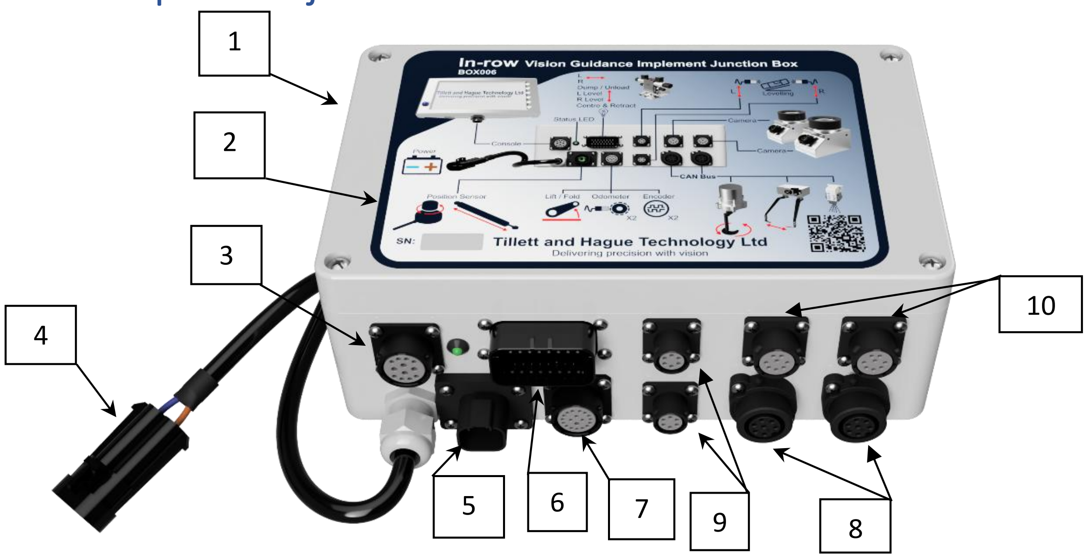
14	Euro “D” plug power cable	CBL004
15	North American power cable	CBL004-USA
16	Euro “D” plug receptacle to battery cable (optional)	CBL007
17	Direct to battery power cable (optional)	CBL020
18	ISOBUS implement module to tractor cable	CBL051
19	Console to implement module cable	CBL001
20	Implement module to camera cable	CBL002
21	Linear potentiometer position sensor	SEN002
22	Rotary potentiometer position sensor for disc steering applications (optional)	SEN005
23	NPN Proximity sensor (Lift, NPN ODO, Levelling inputs)	SEN001
24	Snap action finger switch (Lift)	SEN004
25	Incremental encoder input to system	SEN006
26	Single Potentiometer sensor cable	CBL003
27	Dual potentiometer sensor cable	CBL010
28	15 way Lift/Odometer cable	CBL011
29	12 way Lift/Odometer cable	CBL048
30	6 way levelling input cable	CBL012/CBL045
31	CAN/Power cable (High Power Version)	CBL022,CBL008
32	CAN/Power cable (Low Power Version)	CBL019
33	23 way valve output loom - Steer Left/Right - Timed Centralise/Retract - Levelling (Left up/down, Right up/down) - Night Operation Light - Dump/Unloader valve	CBL009
34	8 way valve output loom - Steer Left/Right - Night Operation Light - Dump/Unloader valve	CBL006
35	Night Operation Light Assembly	BKT002-2LED
36	Hydraulic control valve block assembly (optional) used for steering, levelling, centralising etc. functions	HYD001
37	Proportional hydraulic control valve block assembly with filter (optional) used for steering.	HYD004
38	Universal camera bracket (optional)	BKT001

3.1 HS Console (cab mounted terminal.) PN: BOX001-HS



	Features
1	Cab mounted Console.
2	Power button
3	12-way Console cable connection.
4	USB socket (For system updating/backup via USB stick & keyboard connection)
5	ISO mounting holes (100x100mm)
6	Optional RAM mounting plate. (1'' ball).

3.2 In-row implement junction box PN: BOX006



	Features
1	Implement junction box.
2	Junction box connection label.
3	Main Console cable connector.
4	Power supply cable (12V non-switched should be externally fused to 20 amp)
5	Slide/side shift/disc steer position sensor connector **(Blue)**
6	23 Way Valve cable connector
7	15 Way Odometry/lift/fold sensor connector
8	CAN connectors
9	Levelling left and right sensor connectors
10	Ethernet Camera Connectors

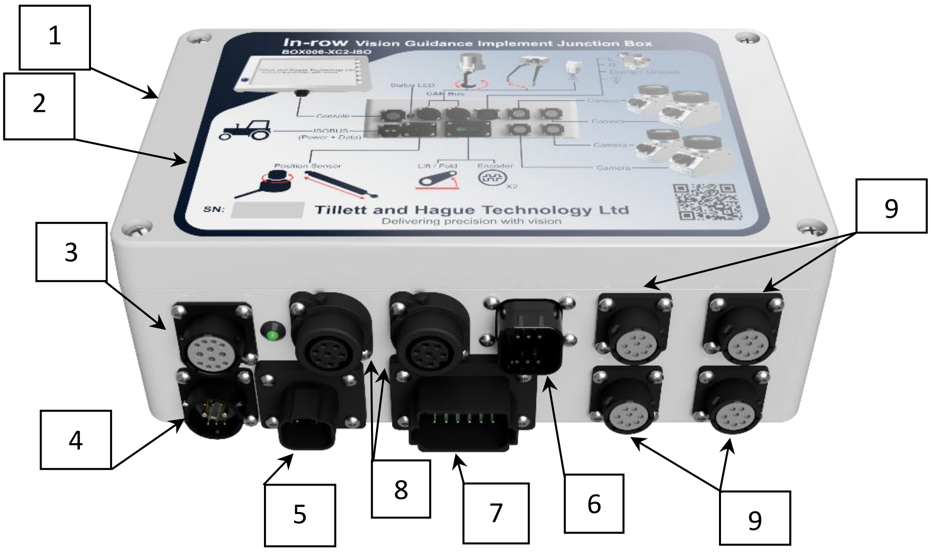
3.3 In-row implement junction box with ISOBUS Tractor Connection PN: BOX006-ISO

	Features
1	Implement junction box.
2	Junction box connection label.
3	Main Console cable connector.
4	ISOBUS Connection to tractor, 12V and ISOBUS via CBL051
5	Slide/side shift/disc steer position sensor connector **(Blue)**
6	23 Way Valve cable connector
7	15 Way Odometry/lift/fold sensor connector (Not used if ISOBUS Lift and Odometer inputs utilized)
8	CAN connectors
9	Levelling left and right sensor connectors
10	Ethernet Camera Connectors

3.4 Alternate 4 camera In-row implement junction box PN: BOX006-XC2

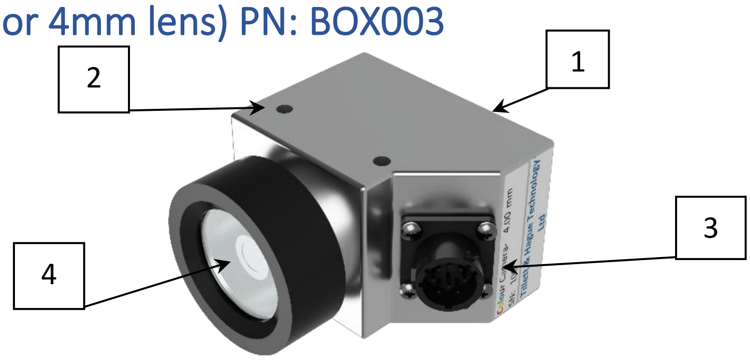
	Features
1	Implement junction box.
2	Junction box connection label.
3	Main Console cable connector.
4	Power supply cable (12V non-switched should be externally fused to 20 amp)
5	Slide/side shift/disc steer position sensor connector **(Blue)**
6	8 Way Valve cable connector
7	12 Way Odometry/lift/fold sensor connector
8	CAN connectors
9	X4 Ethernet Camera Connectors

3.5 Alternate 4 camera In-row implement junction box PN: BOX006-XC2-ISO



	Features
1	Implement junction box.
2	Junction box connection label.
3	Main Console cable connector.
4	ISOBUS Connection to tractor, 12V and ISOBUS via CBL051
5	Slide/side shift/disc steer position sensor connector **(Blue)**
6	8 Way Valve cable connector
7	12 Way Odometry/lift/fold sensor connector (Not used if ISOBUS Lift and Odometer inputs utilized)
8	CAN connectors
9	X4 Ethernet Camera Connectors

3.6 Camera (6mm or 4mm lens) PN: BOX003



	Features
1	Ethernet camera
2	2 x M6 mounting threads each side
3	8-way camera cable connection.
4	6mm (narrow angle) lens BOX003-6 and 4mm (wide angle) lens BOX003-4 options

NB Cameras serial number 4470 onwards (September 2022) are a MK2 version which is both mechanically and electrically identical to the original cameras. However, MK2 cameras use different software making it impossible to mix camera types on the same machine. Furthermore, implement modules serial numbers lower than 2230 (December 2021) contain firmware that is not compatible with MK2 cameras. Please contact us for solutions if these limitations are an issue.

3.7 Console cable 6m PN : CBL001-6, CBL018-6, CBL029-6, CBL039-6

NB Minimum bend radius 45mm

	Features
1	12-way console cable [Female-Male] 6m and 10m lengths as standard CBL001-“L”
2	12-way console extension loom [Male–Female] 6m length as standard CBL018-“L”
3	12-way console extension loom [Female–Male] 6m length as standard CBL029-“L”
4	12-way console extension loom inline [Male-Female] 6m length as standard CBL039-“L”

3.8 Camera cable 5m PN: CBL002-5

NB Minimum bend radius 28mm

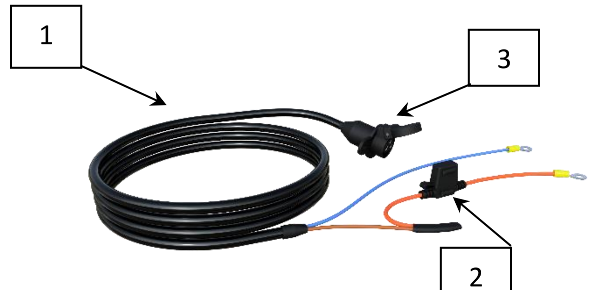
	Features
1	Camera cable, 2m, 5m, 7m and 10m lengths as standard CBL002-“L”
2	8-way female plug. (To Camera)
3	8-way Male plug. (To Implement junction box)

3.9 Camera disconnect at headstock extension cable PN: CBL013

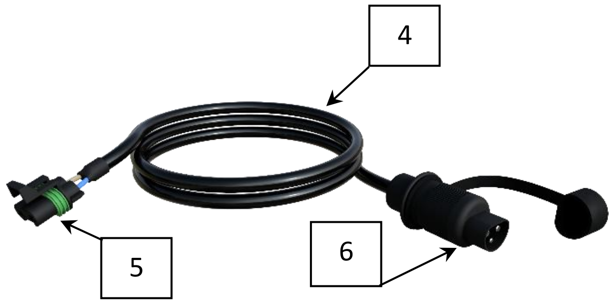
NB Minimum bend radius 28mm

	Features
1	Camera cable, 1.5, 2, 2.5m lengths available CBL013-“L”
2	8-way female plug (mounted box towards camera/toolbar), ideal for quick hitch toolbar applications
3	8-way Male plug. (To Implement junction box)

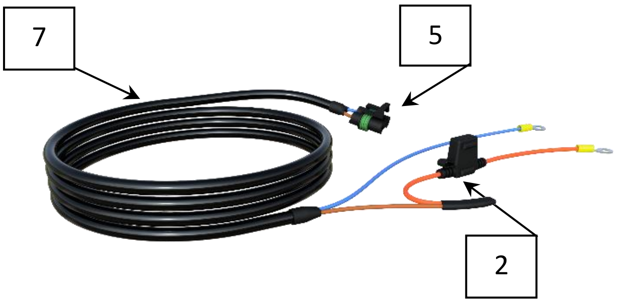
3.10 Tractor/implement power cable



CBL007



CBL004

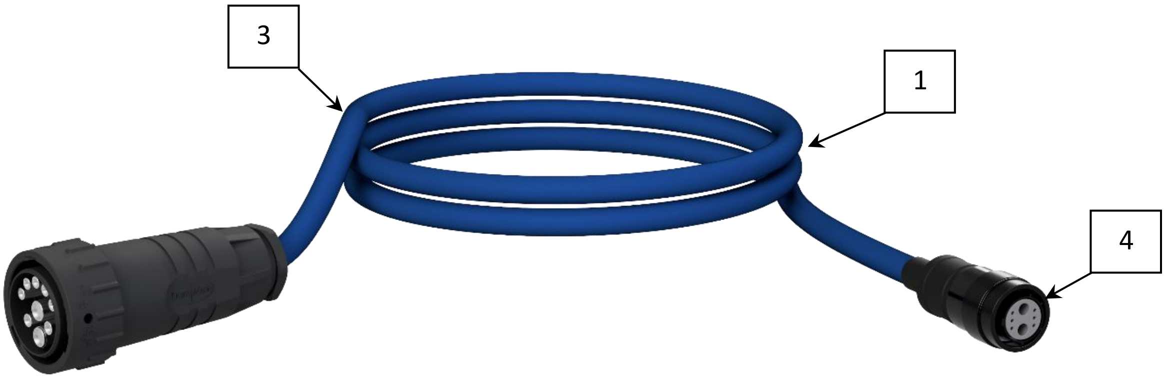


CBL020

CBL028

	Features
1	Optional tractor power cable (3 Meters long as standard) CBL007-“L”
2	Fuse holder (20-amp MAX)
3	3-way Female ‘D’ plug/socket
4	European Implement junction box power cable (3 and 5 Meters long as standard) CBL004-“L” North American 3 pin 12V plug variant available too (CBL004-“L”-USA)
5	2-way power connector.
6	3-way Male ‘D’ plug.
7	Optional direct to battery power cable (5m and 8m variants) CBL020-“L”
8	Power extension cable CBL028-“L”

3.11 ISOBUS 12V and Communication cable PN: CBL051-3

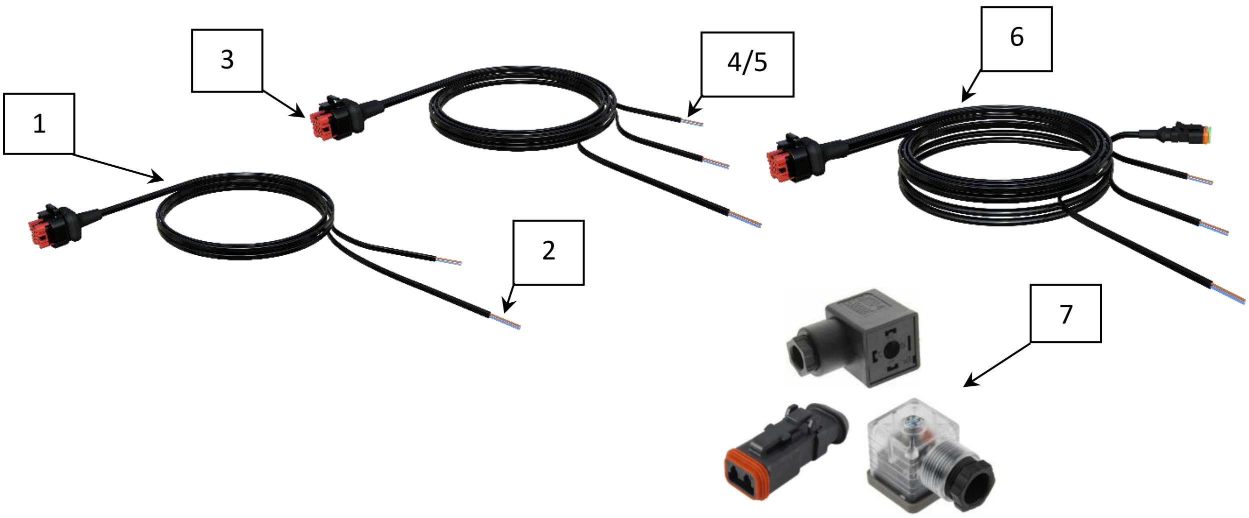


	Features
1	ISOBUS to Implement Module Cable 3m
2	ISOBUS Connector to tractor
3	12V and Communication cable 3m, other cable lengths available on request CBL051-“L”
4	Connector to Implement Module, only compatible with a BOX006-ISO

3.12 23 Way Valve cable connector PN: CBL009

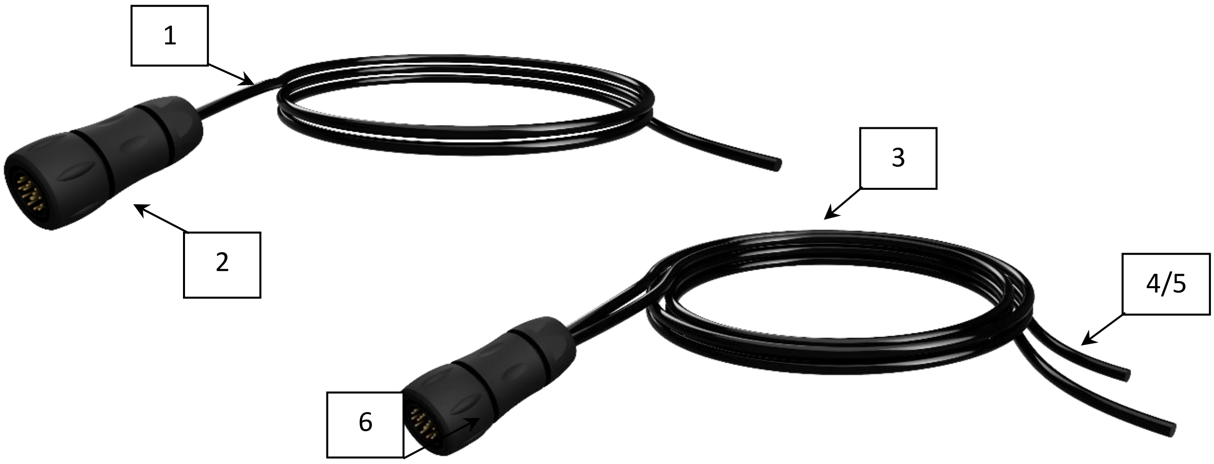
	Features
1	Valve connection loom.
2	23-way valve connector to implement module plug 6 (BOX006 only)
3	Bare wire tails for connection to solenoid valves, Connector options available, e.g. DIN, Deutsch DT etc.
4	Solenoid connections for the following functions Steering Left/Right Centralising/Retract Left levelling Up/Down Right levelling Up/Down Dump/Unloader valve Night Operation Lights

3.13 8 Way Valve cable connector 2m. PN: CBL006-2



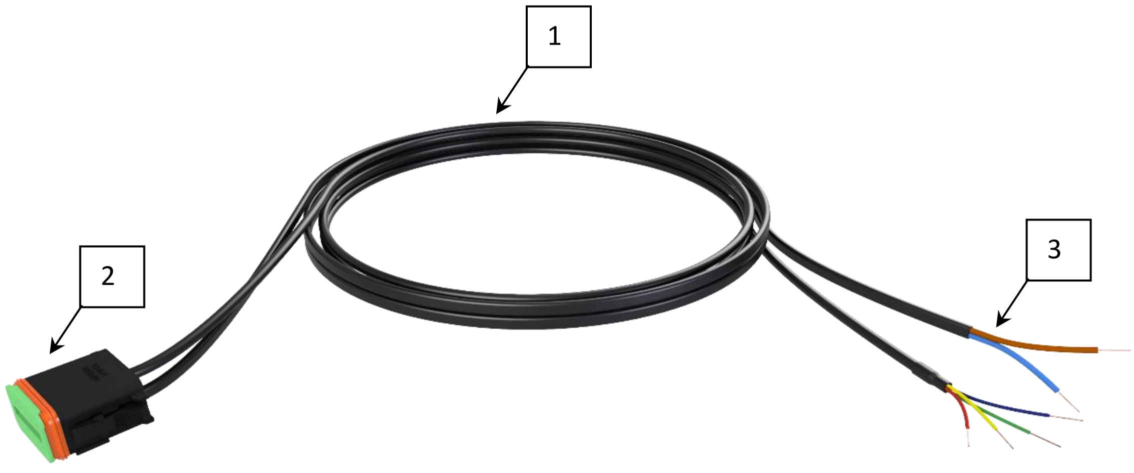
	Features
1	Basic hydraulic solenoid valve loom.
2	2m Open wire tails to take 2-way valve connector plugs.
3	8-way Male plug to implement module plug 6 (BOX002 or BOX006-XC2 only)
4	Basic loom with additional output for hydraulic dump valve CBL006-2-WD-2
5	Basic loom with additional output for night lights CBL006-2-WL-2
6	CBL006-2-WD-2-WL-2 integrates both 2m dump valve and 2m night operation lights into valve loom
7	Various connector options available e.g. DIN, Deutsch DT etc. e.g. 2m valve loom with valve DIN connectors and 2m lights cable to DT connector CBL006-2-DIN-WL-2-DT

3.14 15 way Lift/Odometry sensor cable PN: CBL011-8



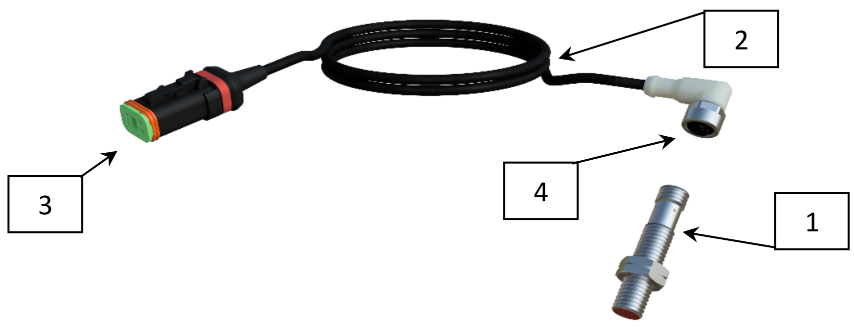
	Features
1	Lift/Odometry sensor cable 8m length, other lengths available on request e.g. CBL011-"L"
2	15-way connector to implement module plug 7 (BOX006 only)
3	Bare wire tails for connection to proximity detectors for lift input and encoders for odometric input, DT connection to proximity and odometer sensors also available e.g. CBL011-"L"-DT for connection to CBL005+SEN001 (Lift) and SEN006 (Odometer) etc
4	More than one encoder input can be used in conjunction for higher accuracy odometric readings across machine. e.g 8m dual encoder odometer, single lift cable, CBL011-8-DO-8
5	A second/dual lift input (either NO or NC operation) for safety interlock etc. e.g. 8m single encoder and 8m dual lift odometer cable, CBL011-8-DL-8
6	Odometer input using Proximity sensor inputs (CBL005+SEN001) is possible with this connection

3.15 12 way Lift/Odometry sensor cable PN: CBL048-8



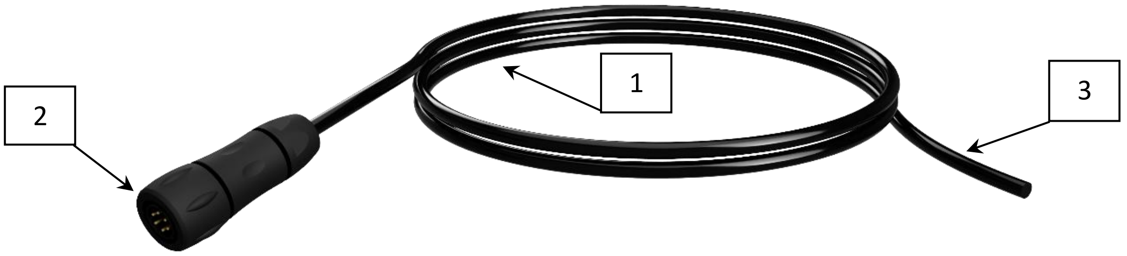
	Features
1	Lift/Odometry sensor cable 8m length, other lengths available on request e.g. CBL048-"L"
2	12-way connector to implement module plug 7 (BOX006-XC2 only)
3	Bare wire tails for connection to proximity detectors for lift input and encoders for odometric input, DT connection to proximity and odometer sensors also available e.g. CBL048-8-DT for connection to CBL005+SEN001 (Lift) and SEN006 (Odometer) etc.
4	More than one encoder input can be used in conjunction for higher accuracy odometric readings across machine, CBL048-8-DO-8
5	A second lift input (either NO or NC operation) for safety interlock etc, CBL048-8-DL-8

3.16 Proximity sensor and Lift/Speed sensor lead 5m PN: SEN001 & CBL005



	Features
1	Ferrous metal sensing NPN proximity sensor
2	5m sensor lead, other lengths available on request, e.g. CBL005-"L"
3	4-way Female plug (To connect to CBL011-8-DT or CBL048-8-DT)
4	M12 connector to sensor
5	12mm mounting hole required for NPN proximity sensor

3.17 6 Way Levelling sensor cables (left and right) PN: CBL012-6

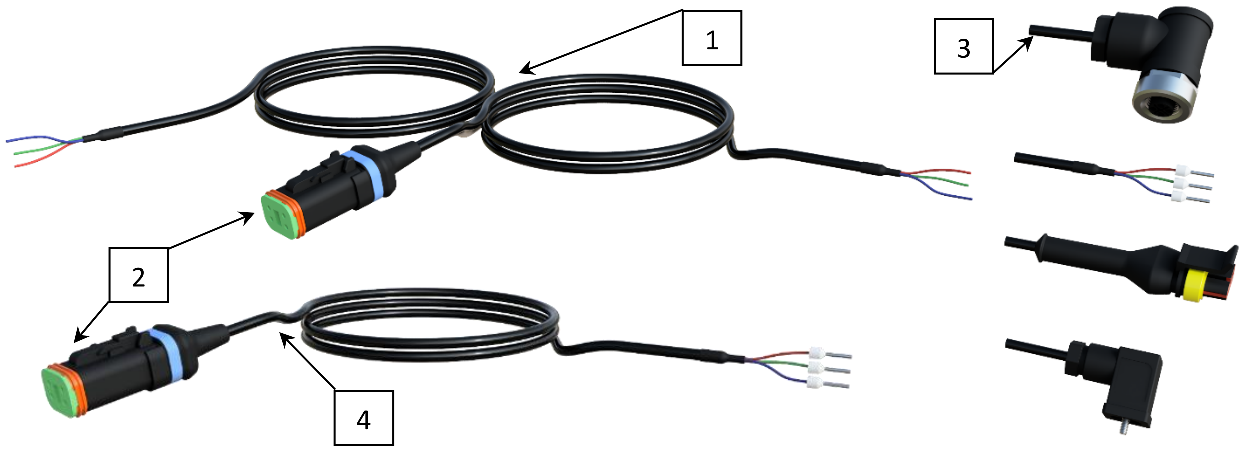


	Features
1	Levelling proximity sensor cable (two required per machine), 6m and 3m versions available as standard
2	6-way connector to implement module plug 9 (BOX006 only)
3	Bare wire tails for connection to proximity detectors, NPN operation sensor inputs required

3.18 6 Way Levelling sensor cables (left and right) PN: CBL045-5

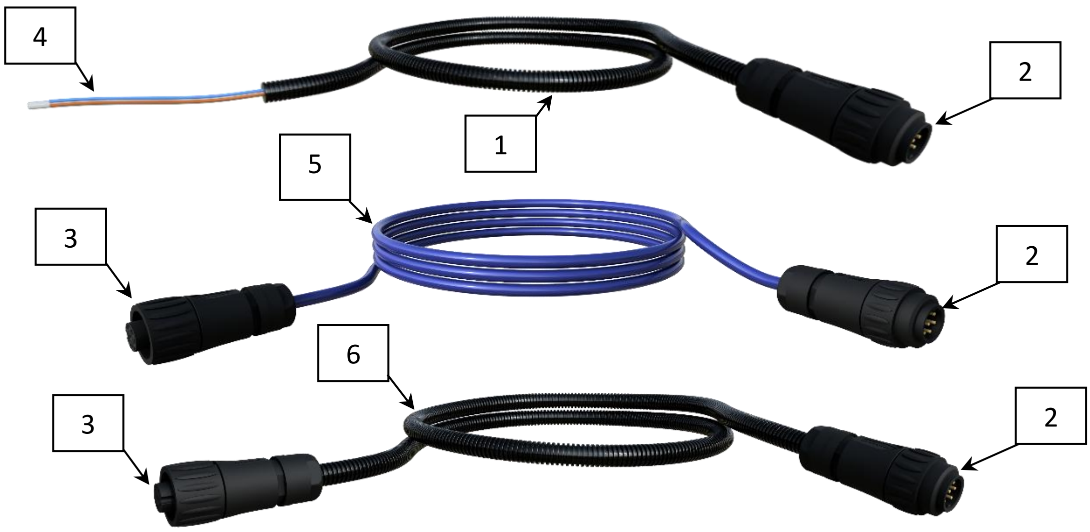
	Features
1	Levelling proximity sensor cable (two required per machine), 5m versions available as standard
2	6-way connector to implement module plug 9 (BOX006 only)
3	M12 connectors to SEN001 NPN proximity sensors

3.19 Slide/side shift/disc steer position sensor cable PN: CBL003, CBL010



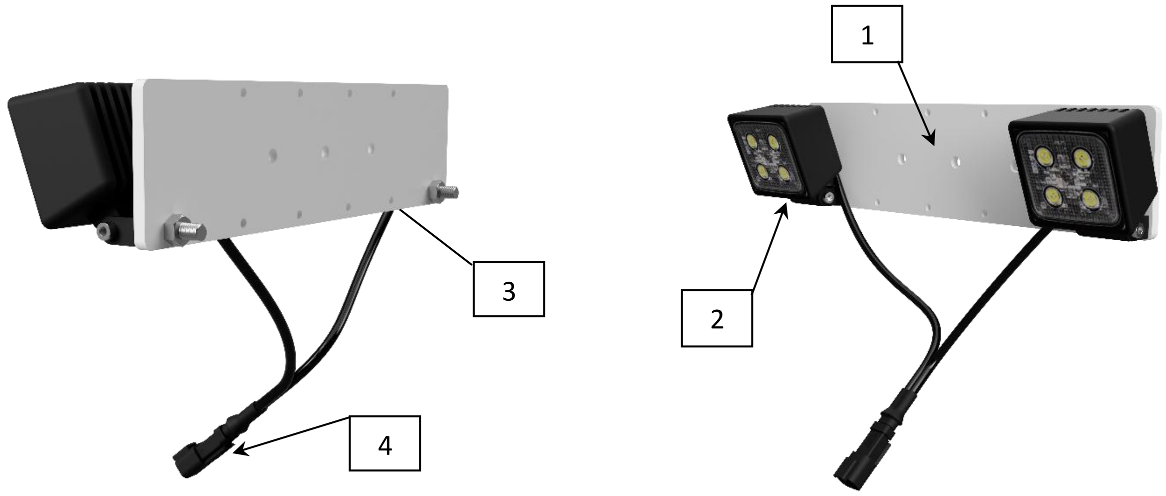
	Features
1	Dual input position sensor cable (CBL010)
2	4-way connector to implement module plug 5 **(Blue)**
3	Bare wire tails for connection to position sensors e.g. potentiometers, connector options available e.g. DIN, M12, TE3, Ferrules etc. e.g. CBL003-2-M12
4	Single position sensor cable can be utilised if only one position feedback device is used (CBL003)

3.20 CAN/Power connector loom PN:CBL008-L, CBL019-L, CBL022-L



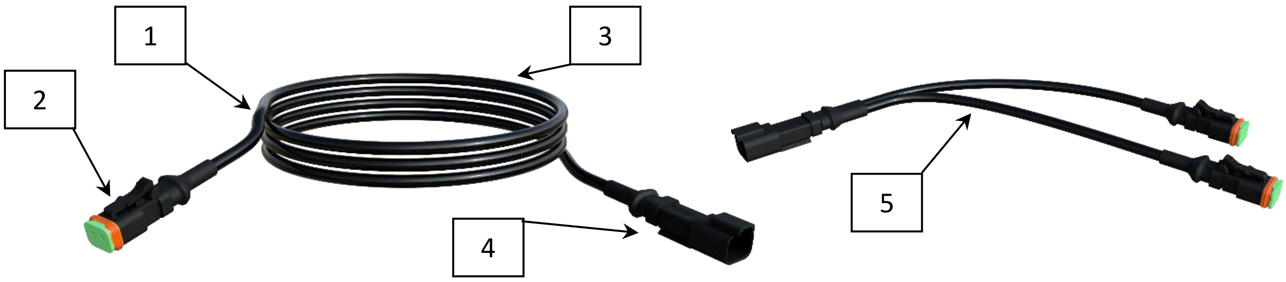
	Features
1	CAN/12V power loom, various lengths possible upon request
2	7 way Male connector to implement module plug 8
3	7 way Female connector to CAN device(s)
4	Bare wire tails for connection to bare board CANbus devices (CBL008-L)
5	Connection cable to enclosed low power junction box CANbus devices (CBL019-L) *For low powered CAN devices such as condition monitoring, manual/feeler
6	Connection cable to enclosed high power junction box CANbus devices (CBL022-L) *For higher power draw CAN devices such as rotors, reciprocating blades, nozzles

3.21 Night operation lights and mounting bracket assembly PN: BKT002-2LED



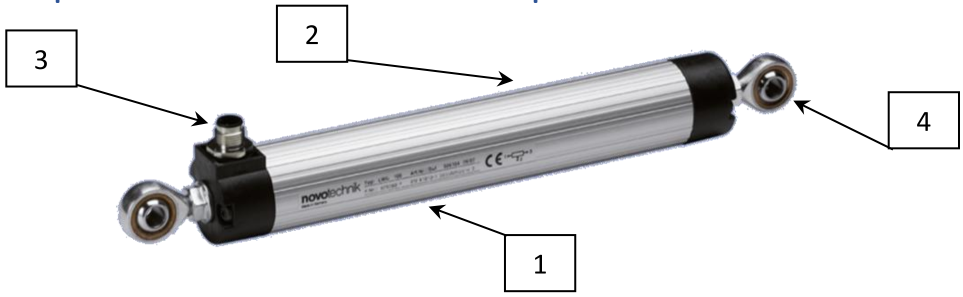
	Features
1	Night operation lights activated by touch screen display
2	x2 12W 1080 Lumen LED worklamps
3	Universal mounting bracket to camera pole
4	2-way Deutsch DT connector

3.22 Night operation light extension and "Y" adaptor cable PN: CBL017-L, CBL027-0.25



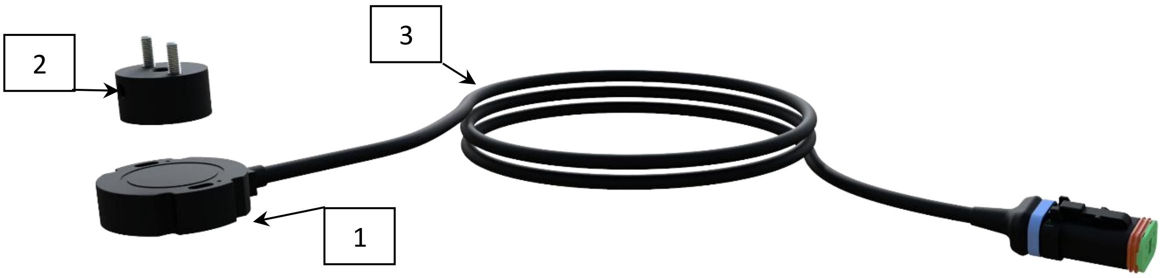
	Features
1	Night operation light extension cable
2	2-way Deutsch DT connector female
3	2 core cable available in various lengths (3m, 4m, 5m, 6m) CBL017-"L"
4	2-way Deutsch DT connector Male
5	"Y" adaptor cable enabling connection to multiple lights CBL027-0.25

3.23 Linear potentiometer for machine position PN: SEN002-L



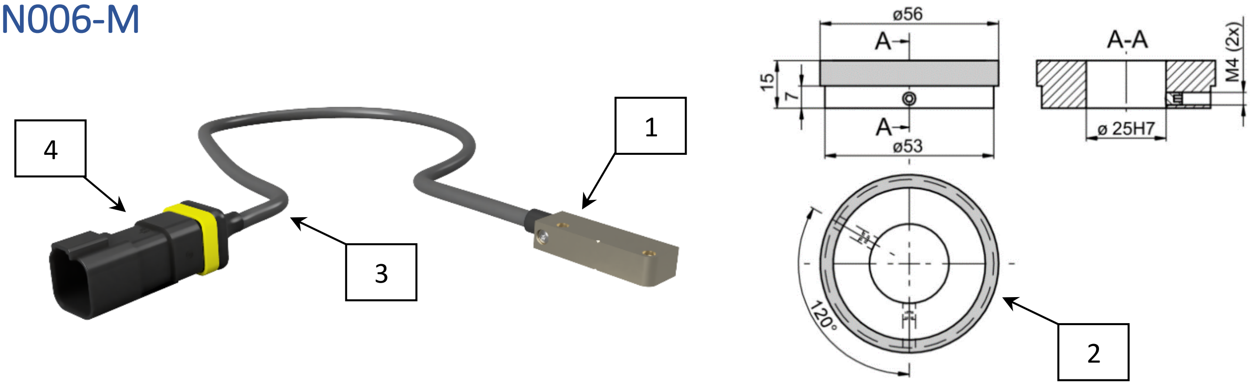
	Features
1	5K Linear potentiometer
2	Available in three variants depending on required stroke 300mm, 500mm, 600mm
3	M12 connector to sensor lead
4	8mm mounting points

3.24 Non-contact rotary position sensor PN: SEN005-L + SEN005-M



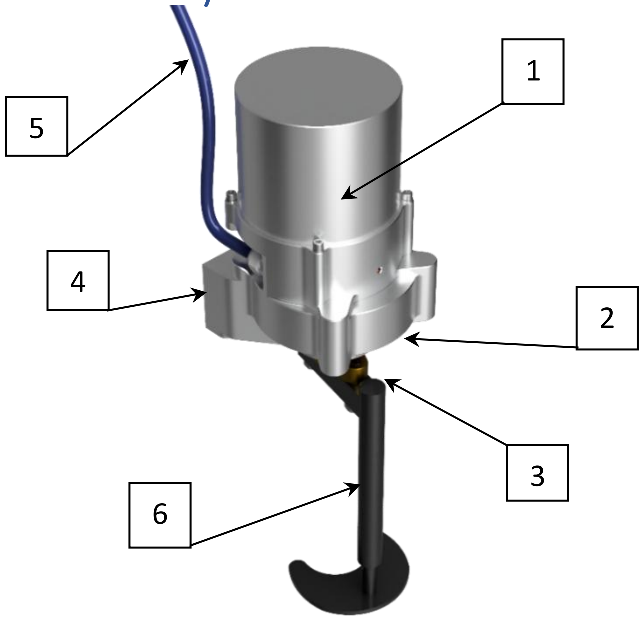
	Features
1	5V non-contact position sensor with cable SEN005-"L"
2	Position sensor magnet SEN005-M
3	2.5m cable length maximum
4	Can be connected directly to implement module plug 5 **(Blue)** using Deutsch DT connector

3.25 Non-contact Incremental Encoder Odometer sensor PN: SEN006-0.5-DT + SEN006-M



	Features
1	5V non-contact odometer encoder sensor with cable SEN006-0.5-DT
2	Encoder sensor magnet wheel SEN006-M
3	0.5m cable length, various cable lengths available on request
4	6-way Deutsch DT connector Male **(Yellow)**
5	Can be connected to implement module via CBL011-"L"-DT or CBL048-"L"-DT

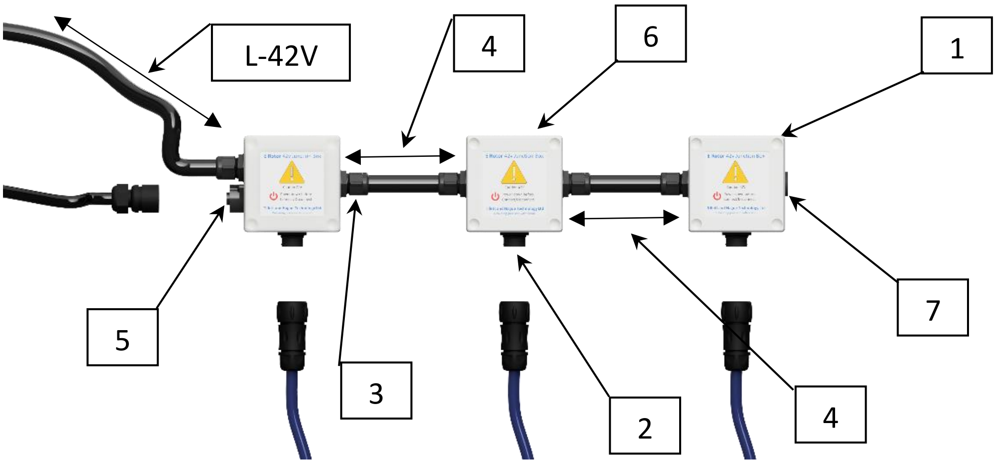
3.26 42V Electric Rotor Assembly PN: ROT001-E



	Features
1	Brushless electric motor drive
2	Planetary Gearbox
3	M12x1.75 @ 80mm centres rotary disc mounting bracket
4	M12x1.75 @ 110mm x 50mm centres rotor mounting holes
5	42V, 12V CANBUS communication lead
6	Various disc sizes available for manufacture from 16cm* through to 45cm plant spacings. (CAD profiles available upon request)

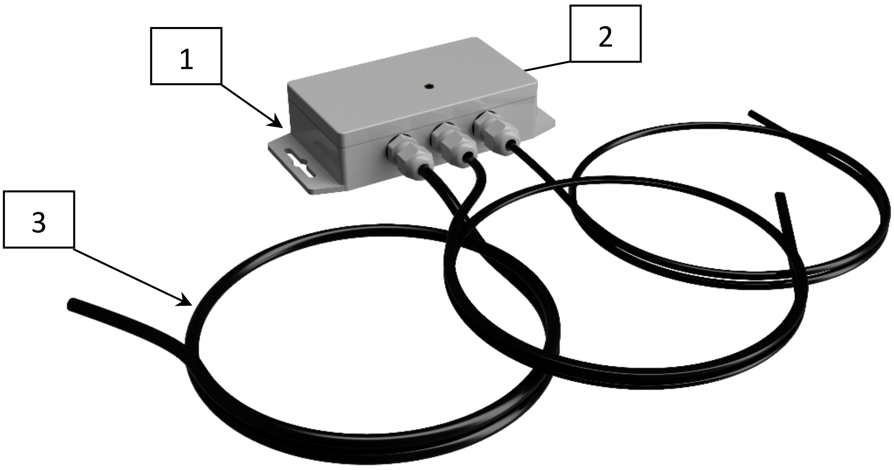
*16cm disc size requires two passes or a dual rotor setup to achieve compete cultivation coverage

3.27 Electric Rotor CAN, 12V, 42V distribution junction boxes PN: BOX009 Contains PCB016)



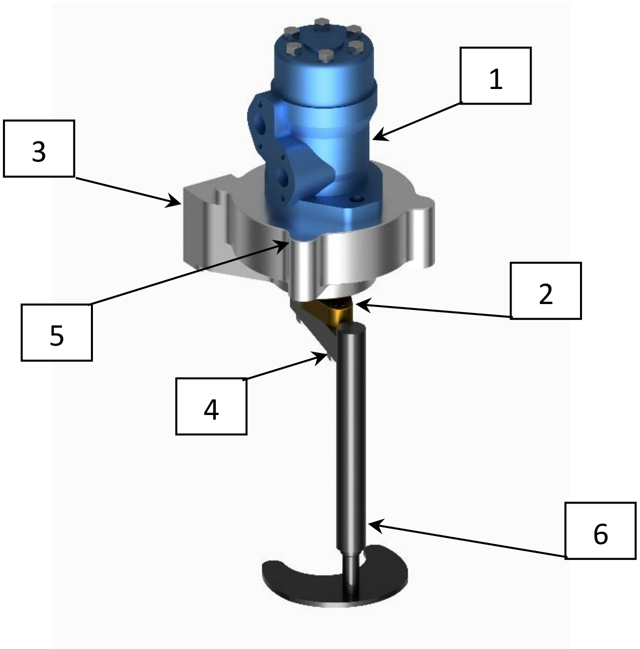
	Features
1	100mm x 100mm junction box
2	Panel mount connector to rotor
3	CAN, 12V 42V connection IN/OUT
4	Length of loom L depending on requirements
5	First box has flying lead connection for 42V supply of length “L” and a connector for a CAN/12V cable to implement module (BOX009-A-“L”-42V)
6	Intermediate boxes allow extra rotors to be added to network (BOX009-B-“L”)
7	Last box must be terminated with end cap and a 120Ω Term resistor, (BOX009-C-“L”)

3.28 42V Alternator Regulator BOX010



	Features
1	42V Alternator Regulator for use with Mahle Z1660 48V 100A IA1627 AAN5920 48V 100A IA1464 / MG1 72735000 Alternator
2	Regulator Status LED
3	Trailing wires to 12V supply and Alternator feedback

3.29 Hydraulic Rotor Assembly PN: ROT002-H



	Features
1	Hydraulic motor (11 litres per minute requirement per row, Closed Circuit hydraulic design required)
2	Direct drive to rotary disc
3	M12x1.75 @ 80mm centres rotary disc mounting bracket
4	M12x1.75 @ 110mm x 50mm centres rotor mounting holes
5	Sensor feedback to hydraulic rotor board
6	Various disc sizes available for manufacture from 16cm* through to 45cm plant spacings available. Effective cultivation will only be possible with THT designed disc profiles (CAD profiles available upon request)

*two passes or a dual rotor setup is required for effective cultivation due to smaller plant spacing

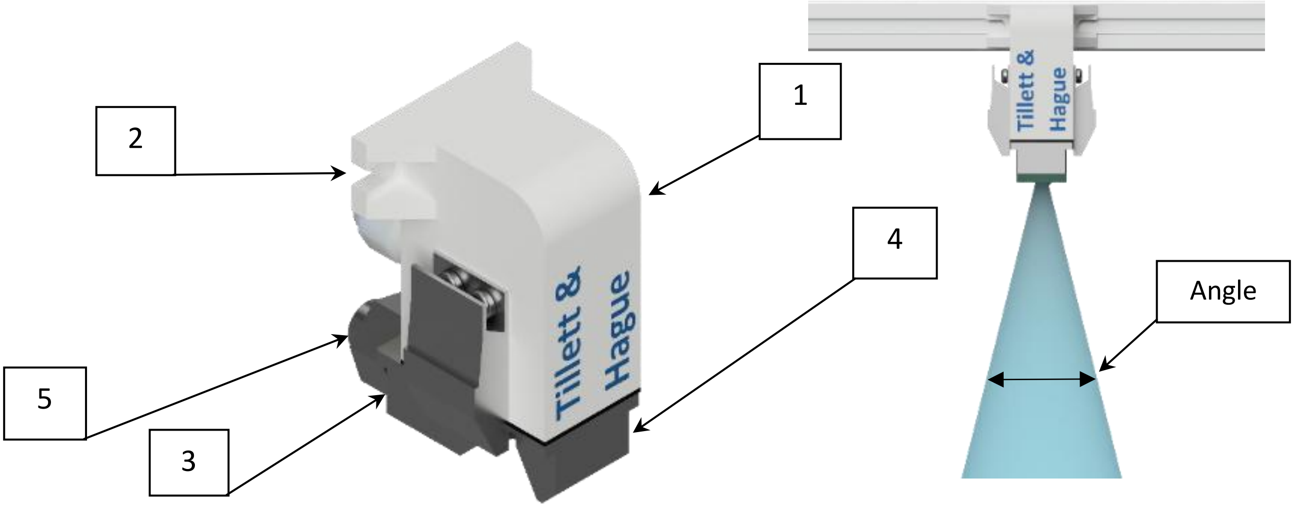
3.30 Hydraulic Rotor Control Module PN: BOX013 (Contains PCB004)

	Features
1	6 channel hydraulic rotor controller module
2	X12 M12 cable glands x6 rotor valve connection, x6 rotor sensor feedback connection
3	Male panel mount CAN/12V connector (for use with CBL022 only)
4	Optional female panel mount CAN/12V for connection to other CANbus devices (BOX013-EC)

3.31 Hydraulic Rotor Control Board PN: PCB004

	Features
1	6 rotor channel controller PCB
2	Proportional valve control
3	Encoder and index sensor feedback inputs
4	160mm x 100mm x 42mm board dimensions
5	3mm x 152.5mm x 91.5mm mounting holes
6	CANbus and 12V connection to implement module
7	Extra rotor boards and functionality can be added to CAN network

3.32 Nozzle Assembly PN: NOZ001

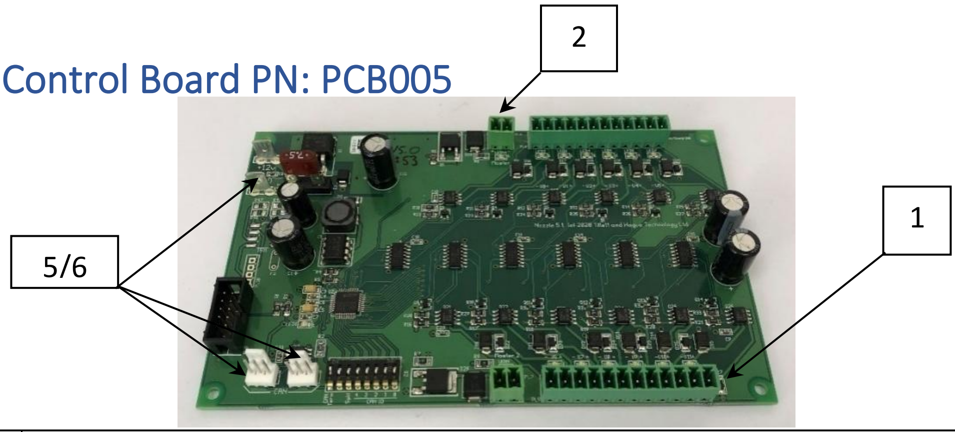


	Features
1	Nozzle Assembly with removable valve element
2	M5 mounting slots
3	Integrated fine mesh filter
4	Multiple nozzle tip options depending on application Sprinkler part number = Angle-Number of orifices – orifice size e.g. 14-6-40 Atomizing part number = Angle -A- Effective orifice size e.g. 14-A-50
5	4mm push fit quick connector

3.33 Nozzle Control Module PN: BOX011 (Contains PCB005)

	Features
1	12 channel nozzle controller module
2	X12 M12 cable glands for outputs
3	Male panel mount CAN/12V connector (for use with CBL022 only)
4	Optional female panel mount CAN/12V for connection to other CANbus devices (BOX011-EC)

3.34 Nozzle Control Board PN: PCB005



	Features
1	12 nozzle output channels
2	2 “Master” valve outputs
3	160mm x 100mm x 20mm board dimensions
4	3mm x 152.5mm x 91.5mm mounting holes
5	CANbus and 12V connection to implement module
6	CANbus connector for secondary CAN/12V device

3.35 Condition Monitoring Microcontroller Module PN: BOX012 (Contains PCB006)

	Features
1	Hydraulic and Spray condition monitoring options
2	X2 Hydraulic Pressure, x1 Temperature, x1 Filter blockage inputs (BOX012-H)
3	X3 Spray pressure, x1 Master pressure inputs (BOX012-S)
4	Panel Mount CANbus connector for use with CBL019

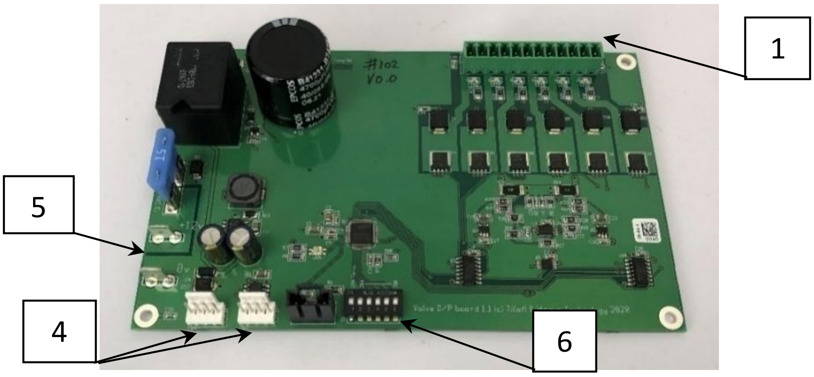
3.36 Condition Monitoring Microcontroller PN: PCB006

	Features
1	Hydraulic and Spray condition monitoring options
2	X2 Hydraulic Pressure, x1 Temperature, x1 Filter blockage inputs
3	X3 Spray pressure, x1 Master pressure inputs
4	100mm x 70mm x 20mm board dimensions
5	3.5mm x 91.5mm x 61.5mm or 6mm x 75mm mounting holes
6	CANbus and 12V connection to implement module
7	CANbus connector for secondary CAN/12V device

3.37 Reciprocating Blade Controller Module PN: BOX014 (Contains PCB010)

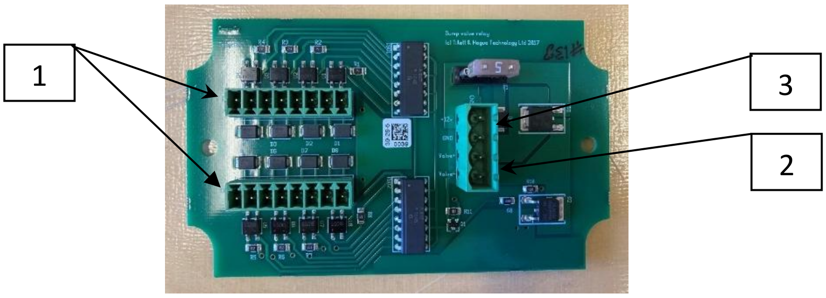
	Features
1	6 channel reciprocating blade controller module
2	X6 M12 cable glands for valve outputs
3	X1 M16 gland, raw 12V power input (Power supply for output valves)
4	Male panel mount CAN/12V connector (for use with CBL022 only)
5	Optional female panel mount CAN/12V for connection to other CANbus devices (BOX014-EC)

3.38 Reciprocating In-Row Cultivator Controller PN: PCB010



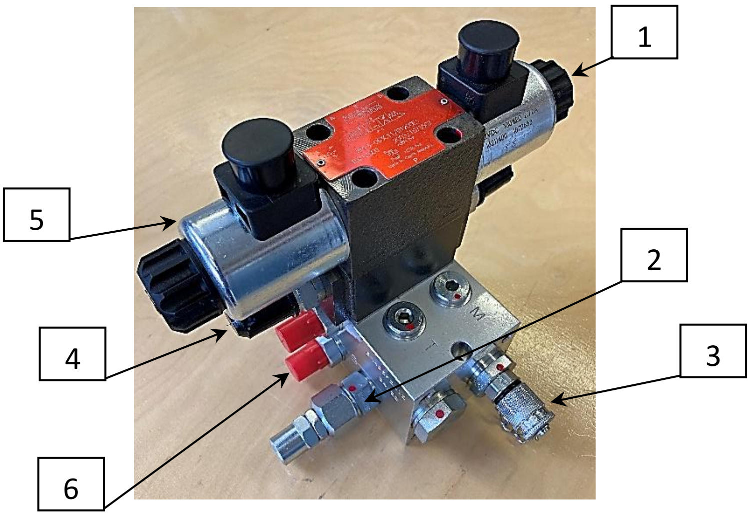
	Features
1	6 output channels
2	160mm x 100mm x 30mm board dimensions
3	3mm x 152.5mm x 91.5mm mounting holes
4	CANbus and 12V connection to implement module
5	Raw 12V supply for powering solenoids
6	Extra in-row blade control boards and functionality can be added to CAN network

3.39 Opto-isolated input/output board PN: PCB008



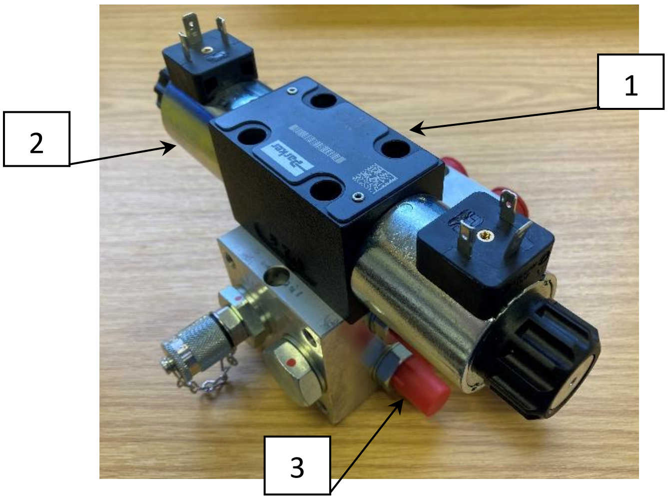
	Features
1	12 opto-isolated input channels
2	Electrically isolated inputs to trigger a single output
3	12V supply and single valve output channel
4	107mm x 70mm x 20mm board dimensions
5	4mm x 104.5mm mounting holes

3.40 Hydraulic steering control valve PN: HYD001



	Features
1	Open centre directional control valve (not suitable for hydraulic rotor operations)
2	Pressure reducer integrated into manifold block
3	Test point fitting for setting circuit pressure (gauge available HYD003)
4	Flow control for metering steering speed
5	12V solenoid coils
6	BSPP fittings, Hydraulic piping kit available if required PN: HYD002

3.41 Proportional hydraulic steering control valve PN: HYD004



	Features
1	Closed centre proportional directional control valve
2	Proportional solenoid coils
3	BSPP fittings, Hydraulic piping kit available if required PN: HYD002
4	Pressure line filter

4. Safety

1. These guidelines only cover aspects of safety specific to this guidance product. Machines should be operated under general safety and accident prevention regulations.

2. The operator is responsible for safe operation of the machine even when automatic steering is operating.

3. The guidance system is only intended to guide agricultural implements within agricultural fields.

4. When carrying out repairs or adjustments to an implement, ensure that that the hydraulic supply is off, and pressure is zero. If electric rotors are fitted ensure the 42V supply is turned off.

   Be aware that spurious speed signals can be generated potentially causing the side shift/steering discs to move unexpectedly. This is most likely if odometry is generated via GPS, which is inclined to drift, or via computer vision, particularly if people are moving in the camera field of view. These modes of speed estimation should only be used in inter-row mode.

5. Never conduct maintenance work on a side shift/slide mechanism while it is supporting the implement.

6. Side shift and steered disc mechanisms form pinch, trap and shear points. Be aware of these when carrying out maintenance.

7. Regularly check the condition of electrical cables, hydraulic hoses and fittings.

8. Do not allow other persons to ride on or work near an implement when it is in operation.

9. The optional tractor power supply cable has a 20Amp fuse fitted near to the battery terminals. This is for short circuit protection and must not be omitted. If connecting to an existing 12V power outlet, ensure that it is appropriately fused.

10. When routing the loom and power supply cables ensure that they do not cause a restriction or trip point in the cab.

5. Assembly

5.1 General assembly

It is assumed here that the implement is fitted with a hydraulic side shift or disc steered system actuated by **12V** solenoid operated directional valves taking less than **3 amps** when operated. It is further assumed that the hydraulic circuit includes the means to regulate the flow of oil and thus the rate of side shift or steering, unless a proportional steering valve option has been chosen.

Step 1 – Mounting the implement control box

The implement control box is best mounted centrally on the implement to reduce cable lengths. The metal box is water resistant to IP67, but we recommend providing a cover to protect against mechanical damage and direct rain. The box measures 260mm x 160mm x 91mm with 6.67mm diameter fixing holes at 240mm x 110mm centres. Minimum bend radius is 28mm for camera and CAN cables, 45mm for console cables.

Step 2 – Mounting a side shift or steering sensor

Ensure the sensor has a stroke greater than implement movement and is mounted symmetrically so that mid stroke of the sensor represents mid stroke of the implement. (Offset configurations are possible, but best avoided in the interests of simplicity). Potentiometers should have a resistance of between **3KΩ** and **10KΩ.** Our standard linear potentiometers have a maximum resistance of **5KΩ**. It is also possible to use Hall effect-based position sensors (12V or 5V supply, 0 - 5V output signal).

Step 3 – Odometry

In-row weeding requires high precision odometry. Odometry sources used for inter-row guidance based on GPS or vision are not adequately accurate. Instead, a ground wheel preferably incorporating an incremental encoder that offers between 8000 and 3000 pulses per meter travelled should be fitted. For example, a 0.4m diameter wheel fitted with a 4000 (2000 A+ and 2000 B+) pulse per revolution encoder to give 3183 pulse per meter would be acceptable. (NB Configurations takes the reciprocal e.g. 3.14 e^{-4} m/pulse). It is also possible to derive a sufficiently accurate odometry signal from a ground wheel fitted with teeth detected by a NPN proximity detector. Our standard proximity sensor picks up ferrous metals up to a gap of 4mm. However, an accurate speed cannot be established until two pulses have been received and so this method can lead to crop damage when starting from stationary mid-field.
If an ISOBUS connection is available and the ISOBUS version of our implement module is installed our system can take lift and odometer data from the tractor's ISOBUS. Subject to accuracy testing, use of ISOBUS wheel speed may avoid the need to install an odometer sensor.

Step 4 – Mounting the lift and fold (optional) proximity sensor/microswitch

Lift and fold movements can be detected using either NPN type proximity detectors or microswitches. Lift sensors should be mounted on a depth wheel unit or adjacent to the tractor top link such that they are triggered when the implement is lifted. It is important that the lift sensor cannot be triggered spuriously, by passing over a wheel rut for example. Refer to Annex for lift and secondary lift input operation options that are available.

In the case of using an ISO 11786 socket or ISOBUS for hitch position, installation of a lift switch can be omitted. ISOBUS hitch lift trigger point can be set from the "Advanced settings and diagnostics" screen described in Section 6.3.

Step 5 – Mounting the camera(s)

Under normal operating conditions cameras should be mounted on a vertical pole approximately 1.6m above soil level at an angle of approximately 40 degrees to the vertical for interrow guidance and 24 degrees for in-row operation (though both these can be refined during the commissioning process). It is important that the camera is held rigidly and square to the implement. It should be mounted centrally over the crop rows to be followed with at least half a row width visible outside the outer rows at the bottom of the image. Additional cameras may be fitted to ensure that all rows can be viewed adequately, two camera sockets are provided as standard, additional sockets (maximum of four per module) are available on request. Camera cable minimum bend radius is 28mm.

Step 6 – Connecting hydraulic valve solenoids and sensors

Route cables carefully ensuring they cannot become trapped or chaffed making allowance for normal movement such as side shift or implement lift, steering, levelling movements.

Step 7 - Mounting the console

Mount the console in the tractor cab in a position where it can be clearly seen, but does not obscure operator's visibility. Four M6 mounting holes on a square 100mm pitch at the console rear are designed to accept VESA standard brackets. We recommend “RAM” type ball and socket style mounting brackets, but other mounting methods are available.

Caution

- The console should be protected from severe vibration.
- The console is water resistant but should not be mounted where it will be exposed to direct rain.
- Minimum bend radius 45mm for console cables.

Step 8 – Hitching to the tractor

Position the tractor and implement on a level surface. Check that the tractor’s lower link arms are evenly adjusted and hitch to the 3-point linkage points on the implement frame.

Caution

- Once the 3-point linkage is correctly fitted stop the tractor and apply the handbrake.

Step 9 – Reducing free lateral movement

Adjust the stabiliser links to prevent lateral movement of the lower link arms to give the implement a rigid reference to steer against.

Caution

- For side shifting front mounted systems it is particularly important that there is no lateral movement in the linkage.
- For large rear mounted side shifting implements it is beneficial to use fixed discs attached to the non-side shifting part of the frame so that the moving section has a firm reference to push against. This also reduces lateral loads on the tractor. When using such fixed discs for stability, it is acceptable to have a small amount of lateral movement in the tractor lower link arms.

Step 10 – Levelling the implement

With the implement on the ground, adjust the top link so that the frame is level, front to rear and the camera pole(s) are vertical. If automatic levelling is fitted, it may be necessary to repeat this step once the machine’s automatic levelling has engaged and is in it’s working position.

Step 11 – Connecting the implement cable to the console

The cable from the implement should be routed into the tractor cab and through to the console.

Caution

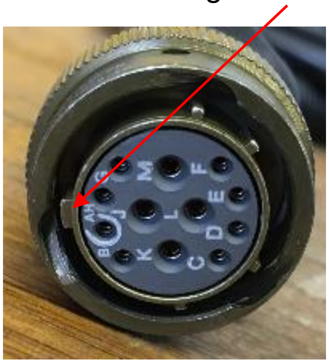
- Do not to allow the cable to restrict access to or exit from the cab or act as a trip point.

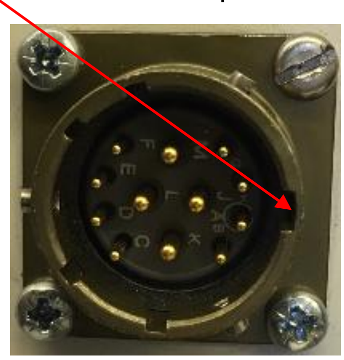
Plug the multi pin plug into the socket in the bottom of the console.

Caution

- Note the correct alignment of the tabs in the plug and socket and avoid excessive force in pushing the connector together.

Ensure alignment tab and slot are lined up when inserting the plug into the socket





Caution

- Clipping the loom and hoses to the top link should help keep them clear of catch points.
- Make sure that the linkage can be operated over its full range without stretching or chaffing cables or hoses.

Step 12 – Connecting the power supply cable

The implement control box power supply cable should be connected to the tractors 12V battery. For small or inter-row machines it may be possible to use the tractors auxiliary 3 pin power sockets. However, it is normally preferable to connect direct to the battery via the cable provided. It is important that this cable includes a 20amp fuse at the battery end for short circuit protection. Cigarette lighter sockets are definitely not suitable!

Caution

- Check polarity of power connections if fitting direct to the battery!
  - **BROWN = +12V**
  - **BLUE = 0V**

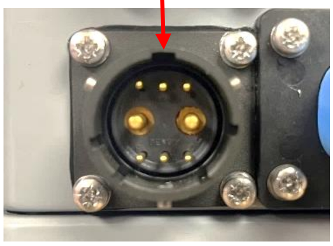
When the system is connected to 12V supply the console power button will flash every 5 seconds, indicating the console is ready to boot. If no flash occurs, please check connections for breaks.

Step 13 – Connecting the ISOBUS 12V power and data cable (ISOBUS Implements)

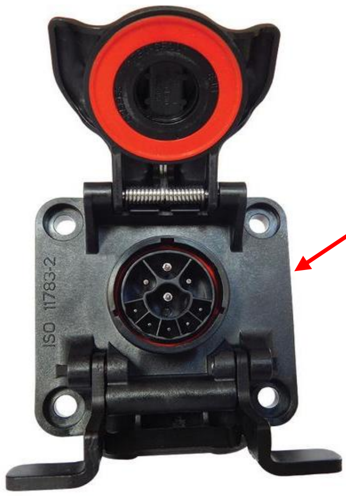
Route the cable from the implement module to the tractor's ISOBUS socket.

Caution

- Do not to allow the cable to restrict access to or exit from the cab or act as a trip point.
- Note the correct alignment of the tabs in the plug and socket and avoid excessive force in pushing the connector together.



From Implement



Tractor Socket

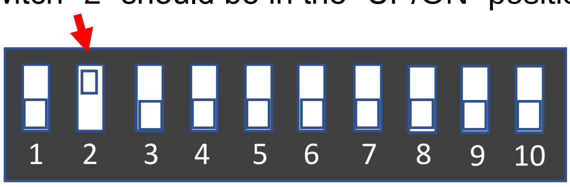
Step 14 – Connect the hydraulic supply hoses

Connect the hydraulic supply hoses in such a way that they are not chaffed or over extended with full link movement. Attaching hoses to the top link is sometimes helpful.

Step 15 – Activating night operation lights or the ON while moving output

In addition to valve outputs the module is equipped with an extra output that can drive up to 3 amps that can be configured to either switch on when moving, potentially useful for band spraying, or on when switched on from the console. The latter being intended for activating night lights. Which mode the module operates in is determined by a DIP switch on the module PCB as outlined below.

The Function DIP switches are located on the right-hand side of the implement microcontroller PCB. To turn on the light option switch "2" should be in the "UP/ON" position.



5.2 CANbus and Accessories

All CAN devices on the network must have separate CAN IDs which are set via a PCB mounted DIP switch. There is a different method available for electric rotors that avoids the need to open the waterproof seal. That utility is available from the service tools menu described in Section 11.

It is convenient to arrange multiples of the same CAN device type on the bus in ascending identification address from left to right across the machine.

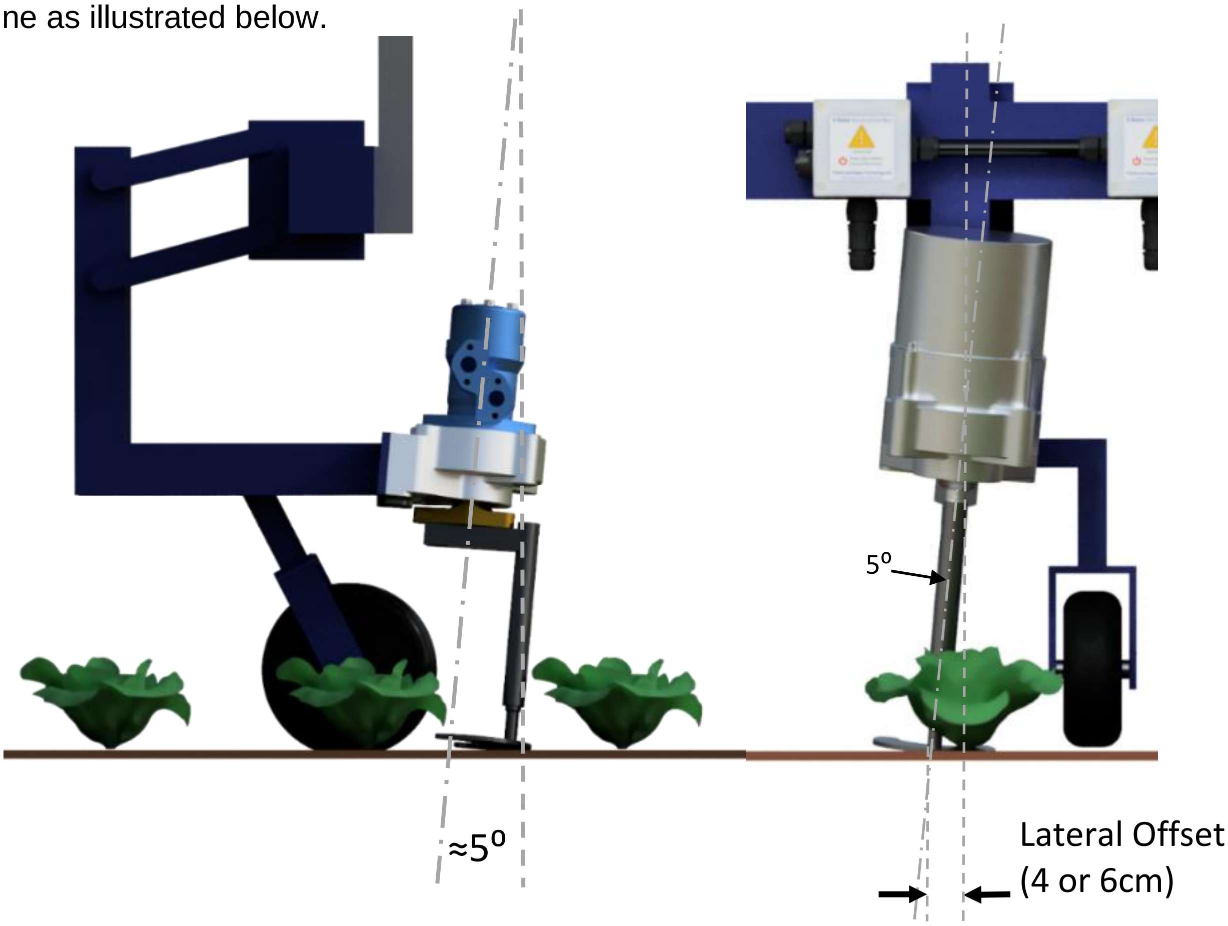
The end of the CAN bus must be terminated correctly. This can be achieved by setting the CAN Terminator DIP switch turned "ON" at the last PCB on the bus. For electric rotors, termination is fitted in the last junction box.

5.2.1 In-row Rotors

Step 1 – Mounting rotors

Rotors should be mounted as far forward as possible to minimise the distance between the bottom of the camera field of view and the cultivator blades. The longer plants are out of sight and not tracked visually the greater the reliance on odometry leading to reduced accuracy.

Mount rotors using the four M12 mounting holes located at 110mm x 50mm centres. It is advised to employ a break back mounting system to ensure that the rotor is protected mechanically against being forced into the ground with excessive force. A mechanism for fine adjustment of individual rotor cultivator depth is required to achieve best cultivation results. The rotor should be inclined forward approximately 5º to minimise draught. The rotor should also be inclined laterally at an angle of approximately 5º. The rotor assembly should also be laterally offset so that the point at which the axis of rotation meets soil level should be 4 or 6 cm (depending on disc type) from the crop row centre line as illustrated below.



For Electric Rotors

Step 2 – Mounting CAN/42V/12V distribution junction boxes

CANbus, 12V and 42V supplies are run into junction boxes at intervals along the implement frame. Each box allows connection of a single electric rotor. While rotors junction boxes are water resistant to IP65 we recommend providing a cover to protect against mechanical damage and direct rain.

Step 3 – Connecting rotors to junction boxes

Each rotor is connected to its junction box by a short (<1m) spur. Route the rotor cable to allow for full movement of the rotor free from chaffs and snags. Ensure that the connector alignment tabs align when inserting the connector into the plug.

Step 4 – Connecting rotor junction boxes to implement module

The CANbus and 12V supply are connected to the implement module. For larger networks it is advisable to use both CAN/12V plugs on the implement module to avoid overloading a single outlet. Typically, the left side from one outlet and the right from the other. To complete the CANbus network connection ensure that a 120Ω terminator resistor plug has been installed to the end of the bus, contact THT if you are unsure of bus termination requirements for your application.

Step 5 – Connecting to 42V supply

A fused and regulated 42V must be supplied. For safety reasons it should be possible to isolate that supply for maintenance. It is important that the 42V supply can both source current for normal operation and sink current for short periods during braking. This is most conveniently achieved by using a battery pack and PTO driven alternator. Typically, an alternator shaft speed of approx. 2500rpm is required so an appropriate mechanical drive must be provided.

Double check 42V polarity before connecting.

For Hydraulic Rotors

Step 2 – Connecting hydraulic hoses to rotor

Hydraulic rotor proportional valves are not directional and so attention must be paid to pressure and tank line polarity. It is good practice to use rigid hydraulic pipe as far as possible, minimising flexible hose whose lack of stiffness degrades dynamic control performance. The maximum length of flexible pipe should be 1.6m and preferably shorter.

Step 3 – Mounting hydraulic rotor controller

Rotor boards must be mounted securely via the provided mounting holes in an IP65 or better enclosure to protect from mechanical damage and water ingress. Our BOX013 meets this requirement. It is also advised to provide a cover for this enclosure to protect from mechanical damage and direct rain.

Step 4 – Wiring proportional valve outputs

Valves should be wired channel 0 (left of machine) to channel 5 (right of machine) sequentially. Due to current draw of each proportional valve appropriate wire gauge should be 0.75mm²/20AWG or greater.

Step 5 – Wiring sensor feedback

Encoder and index sensor feedback from the rotor itself must be routed appropriately to ensure that cable damage does not occur. Sensor feedback channels should be wired to match the rotor valve output channel. For further information on hydraulic rotor board connections and setting see Annex.

Step 6 – Connecting rotor board to implement module

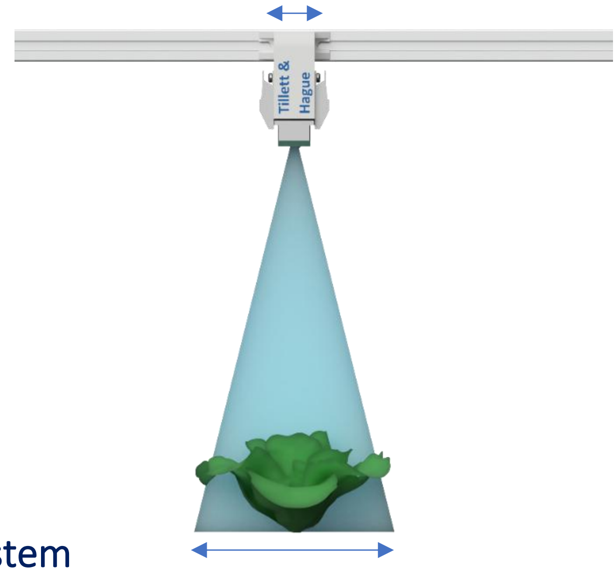
Rotor boards must be connected to the implement module via the CANbus using CBL022. For larger networks of multiple hydraulic rotor boards requiring higher currents, it is advisable to use both CAN/12V plugs on the implement module rather than a single outlet. The DIP switches for CAN termination and identification address need to be set appropriately on PCB004. See Annex.

5.2.2 Nozzles

Step 1 – Mounting nozzles

Nozzles should be mounted as far forward as possible to minimise the distance between the bottom of the camera field of view and the cultivator blades. The longer plants are out of sight and not tracked visually the greater the reliance on odometry leading to reduced accuracy.

Nozzles can be mounted using the two 5mm x 35mm mounting slots. They should be mounted in an appropriate position and height, depending on application and spray angle.



Step 2 – Connecting nozzle spray system

Nozzles can be connected to the spray circuit via 4mm push fit connectors. Appropriate spray circuit materials and filtration should be integrated depending on chemical to be used.

Step 3 – Mounting nozzle board

Nozzle board must be mounted securely via the provided mounting holes in an IP65 or better enclosure to protect from mechanical damage and water ingress. Our BOX011 meets this requirement. It is also advised to provide a cover for this enclosure to protect from mechanical damage and direct rain.

Step 4 – Wiring nozzle outputs

Nozzles should be wired channel 0 (left of machine) to channel 11 (right of machine) sequentially. Larger alternative nozzle types may require larger gauge wire but standard Tillett and Hague spot spray nozzles can be wired with 0.22mm/24AWG wire.

Step 5 – Connecting nozzle board to implement module

Nozzle board must be connected to the implement module via CANbus using CBL022.

DIP switches on PCB005 inside the box need to be set for CAN termination and identification address. See Annex.

5.2.3 Condition Monitoring

Our condition monitoring board has four analogue and one digital input that can be used for monitoring spray system pressures and filter blockages. The same board with appropriate sensor selection and DIP switch settings can be used to monitor hydraulic systems.

It must be mounted securely via the provided mounting holes in an IP65 or better enclosure to protect from mechanical damage and water ingress. Our BOX012 meets this requirement. It is also advised to provide a cover for this enclosure to protect from mechanical damage and direct rain.

It is connected to the implement module via CANbus using CBL019. See Annex for DIP switch settings, CAN termination and identification address.

Sensor supply voltage from the board is 15V.

Hydraulic sensors

Hydraulic sensors measure supply and return pressure, return temperature and blocked filter parameters. Sensor recommendations as follows:

Pressure sensor – 0-250bar gauge pressure, 0-5V output

Pressure and temperature sensors – 0-250bar gauge pressure, 0-5V pressure output, -50ºC to +150ºC temperature range with 0.25V-4.75V linear output

Filter blockage sensor – Normally open blockage sensor

Spray pressure sensors

Spray pressure transducers can be integrated into the system to monitor master/supply pressure and three banks of spray pressure. Sensor recommendations as follows:

Spray pressure sensor - 0-4bar range, 4-20mA output

5.2.4 Reciprocating In-row Blade Controller Board Integration

This six channel board provides a similar function to the nozzle board but the outputs are sized to drive more powerful solenoid valves.

Step 1 – Mounting cultivator blade modules

Mechanical cultivator modules should be mounted as far forward as possible to minimise the distance between the bottom of the camera field of view and the cultivator blades. The longer plants are out of sight and not tracked visually the greater the reliance on odometry leading to reduced accuracy.

Step 2 – Mounting in-row reciprocating cultivator controller board

The board must be mounted securely via the provided mounting holes in an IP65 or better enclosure to protect from mechanical damage and water ingress. Our BOX014 meets this requirement. It is also advised to provide a cover for this enclosure to protect from mechanical damage and direct rain.

Step 3 – Wiring outputs

Modules should be wired channel 0 (left of machine) to channel 5 (right of machine) sequentially. Appropriate wire gauge should be used for potential current draw of output modules.

Step 4 – Connecting cultivator controller board to implement module

For larger networks of multiple controller boards, it may be advisable to use both CAN/12V plugs on the implement module rather than a single outlet. The relevant DIP switches for CAN termination and identification need to be set appropriately, see Annex.

5.2.5 Opto-isolated Input/Output Relay Board Installation

This board takes up to eight inputs and provides an output that turns on when any of the inputs are activated. This is normally used to drive a dump/unloader valve to unload a hydraulic system when no hydraulic services are required. It is not CANbus connected.

Step 1 – Mounting input/output board

Mount securely via the provided mounting holes in an IP65 or better enclosure to protect from mechanical damage and water ingress. It is also advised to provide a cover for this enclosure to protect from mechanical damage and direct rain.

Step 2 – Wiring multiple inputs to board

Inputs are opto-isolated so current draws are low requiring only a light wire gauge. Channels are not polarity dependant.

Step 3 – Wiring supply voltage and output device

Supply voltage and output device should be wired according to silk screen of board. Appropriate wire gauge should be used. Board is fused to 5A so output function should not exceed this.

Before proceeding it is worth familiarising yourself with the working screen

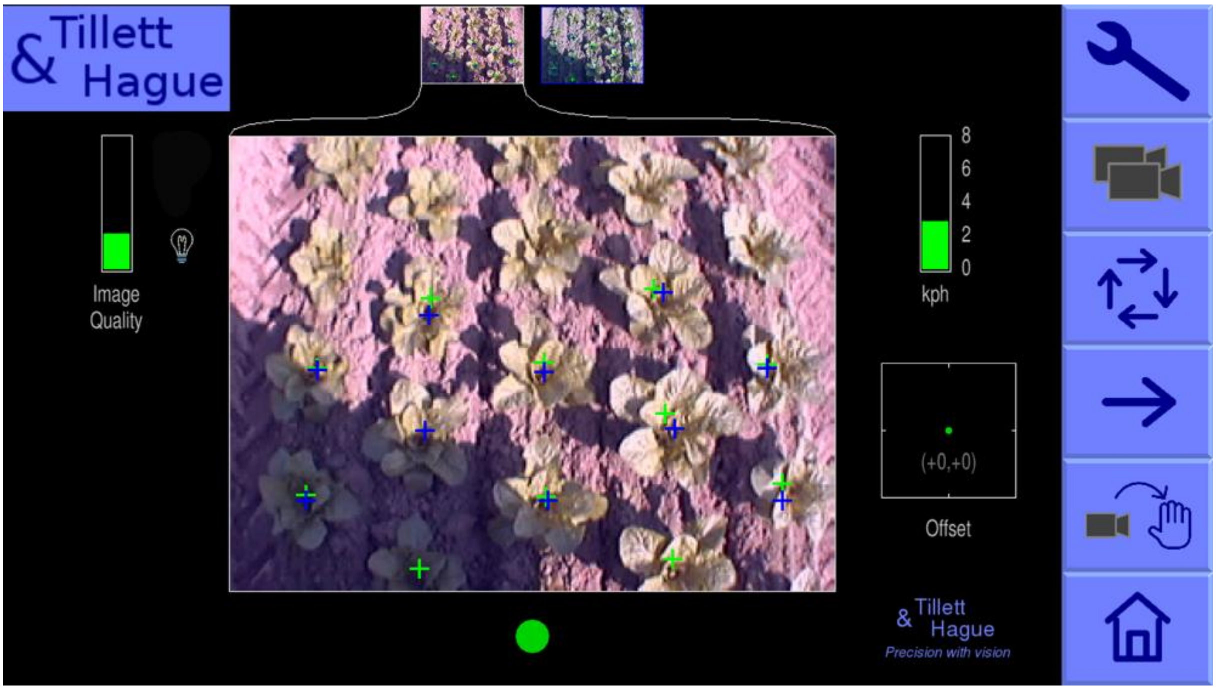
6. User Screens

Start-up screen

Turn the system on by pressing the console button for a second or two until the button is illuminated. After some PC start-up text, the user is presented with a start-up screen offering the choice between starting the inter-row or in-row guidance systems, going directly to the configuration editor, opening the service tools menu, or shutting down.

6.1 Working Screen

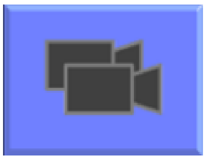
To get to the in-row working screen press the touch screen button with the graphic of 9 discrete plants. When a press has been detected the touch screen button will become darker, though the function is only activated when your finger is released.



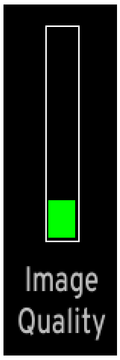
Working screen in work

The working screen has the following features:

- A live camera video image in the centre of the screen. Superimposed over the live video image are two arrays of crosses **Green** and **Blue**.
- **Green** crosses represent the estimated position of individual crop plants. They are initially placed near the top of the image according to nominal plant spacing and estimated position of previous plants in that row. They should therefore be close to, but not necessarily exactly aligned with actual plants in the video image.
- As they progress down the image, observations of individual plant position from each successive image, depicted by **blue** crosses, are used to refine this initial estimate so that by the time they reach the bottom of the image green crosses should accurately reflect plant position. It is the last estimate of plant position as they leave the bottom of the image that is used synchronise in-row cultivator units or nozzles.
- **Yellow** and **Red** crosses indicate poor template. An image with a high proportion of red or yellow crosses is likely to lead to poor tracking. Steps should be taken to improve the situation and cultivation should only proceed with caution.



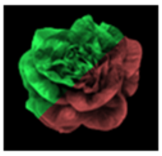
- Systems operating with multiple cameras will display live thumbnail video along the top of the display. Briefly touching on a thumbnail selects that image for the main display and other parameters such as offsets relate to the section that camera is fitted to. Alternatively, the button labelled with a multiple camera graphic toggles between thumbnails for full size display.



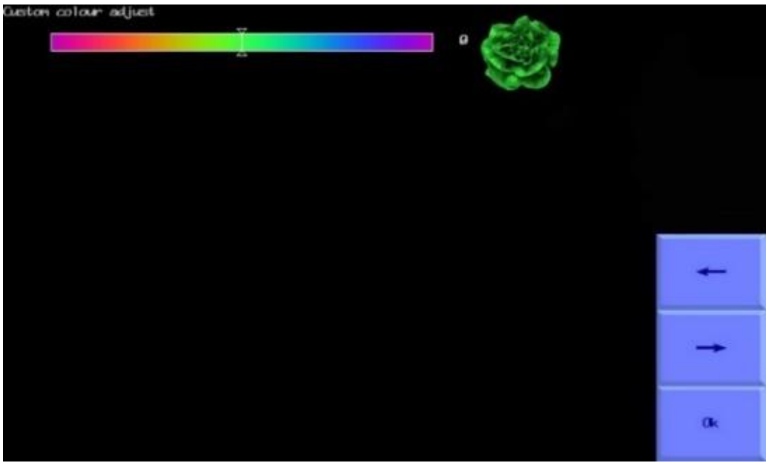
- Briefly touching on the main video images switches to a full screen video mode. Guidance continues in this mode, but the information symbols, speed, position indicator etc are obscured. Touching again reverts to the normal size image.

- An image quality gauge to the left of the screen giving relative indication of likely tracking performance. The higher the green bar the better. A low bar indicates either a poor template match or poorly defined crop plants. Guidance will, under most circumstances, operate down to an indication of approximately 20% albeit at reduced accuracy.

- If any of the crop colour options are enabled a plant symbol will be shown at the top and to the right of the image quality gauge. The colour of the symbol gives an indication of the colour selection. In general use of colour options is discouraged as it offers more scope to degrade performance than enhance it. However, there are specific exceptions:

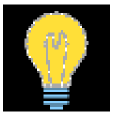


  - Red lettuce varieties benefit from the red option.
  - Red lettuce varieties showing a green growing centre sometimes benefit from the red and green (R&G) option.
  - If allium and brassica crops grow sightly blue as they mature custom colour can improve performance. If custom colour is enabled, touching on the plant symbol will pop up a colour adjustment tool. A maximum adjustment of 30 is recommended.



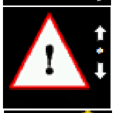
Custom colour adjustment tool.

- If lights are configured a light bulb symbol is shown at the bottom right of the image quality bar. Touching the symbol turns lights on and the bulb yellow. To activate the lights option see Section 5.1 Step 15.

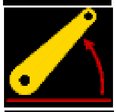


- Information symbols at the lower left of the display:
  - A warning triangle indicates poor tracking. If it is displayed with a horizontal double headed arrow lateral implement position error is estimated to exceeds 25mm. If the arrow is vertical phase angle error of at least one of the rotor units exceeds 15°. On seeing this warning users should check performance on the ground.

  - A vertical direction warning triangle may also be displayed if an odometry discrepancy between measured speed and visual odometry occurs. If enabled the warning triangle will be accompanied by an audible warning.



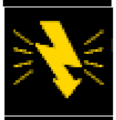
  - An implement lift symbol is displayed if the lift sensor detects the implement is lifted.



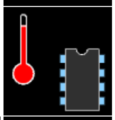
  - A circular red braked symbol is displayed if the implement is down but not moving.

  - A lightning bolt within brackets indicates a steer valve in an open circuit state.

  - A lightning bolt with lines radiating indicates a steer valve direct short.

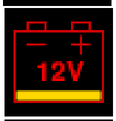


  - Thermometer and computer chip indicates the console processor is overheating.

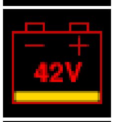


  - A CAN warning triangle with a "?" or "!" indicated unknown, conflicting, or dropped CANbus messages suggesting CAN connection issues.

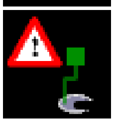
  - A 12V battery symbol indicates low voltage on the 12V supply



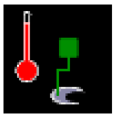
  - A 42V battery symbol indicates low voltage on the 42V supply for electric rotors



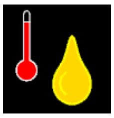
- A warning triangle with a "!" and rotor graphic indicates an electric rotor overload. **Stop operation** & run a rotor test. A system shut down and restart may be required.



- A thermometer and rotor graphic indicates an electric rotor overheat. **Stop operation** and turn off system to allow rotor(s) to cool.
  Note:
  Rotor overheat can be caused by running rotary cultivators too deep.



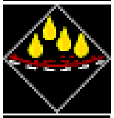
- A thermometer and oil drop indicates high oil temperature >70°C if condition monitoring is fitted. **Operation should be stopped immediately to prevent irreversible valve damage.**



- A low reading pressure gauge and “P” indicates low hydraulic supply pressure <100 bar if hydraulic condition monitoring is fitted.

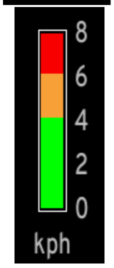
- A high reading pressure gauge and “T” indicates pressure in the hydraulic tank/return line if hydraulic condition monitoring is fitted.

- An oil filter graphic indicates a blocked oil filter if hydraulic condition monitoring is fitted. **Stop operation immediately and change filter.**

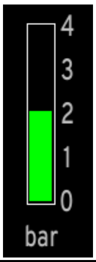


- A leaking pipe indicates a leak or blockage within the spray system if spray condition monitoring is fitted. **Stop operation** & perform nozzle tests to locate leak/blockages.

- A speed gauge on the right shows forward speed and should match tractor speed. The speed bar is normally green, an amber section indicates the machine is operating at over 75% of maximum speed and a red section indicates over speeding. For in-row machines maximum speed is a function of rotor type and the disc size entered in the selected configuration. Electric rotors can rotate faster, and larger discs enable higher forward speeds.

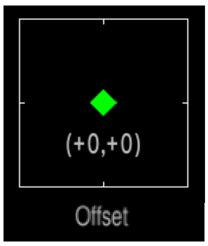


- A spray pressure gauge displays system pressure if spray nozzles are configured.



- A green dot and red/green chevrons below the image indicate side shift or slide position. A red chevron with a vertical bar indicates the limit of travel has been reached. This should not be allowed to occur for extended periods.

- The fine offset gauge shows the amount of left, right, forward or backward bias set by the user. This is used to compensate for minor lateral camera misalignment, but the lateral fine offset can also be useful on side slopes. By default, fine offset has six 1cm steps in each direction, though the number and size of steps is configurable.



- It is possible to reverse applied lateral fine offset in a single press, using the fine offset flip tool that can be activated from the System information & diagnostics screen.

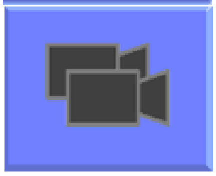
- The fore and aft fine offset alters the phase relationship between the rotary units (and nozzle timing) and the crop plants. It applies equally to all rotary units (and nozzles) in that view. See Section 8 for how to adjust the fine offset.

Note:
For multi camera systems fore and aft fine offset relates to the rows associated with the image selected for full size display.

For independently steered multi section systems the lateral fine offset is also associated with the image selected.

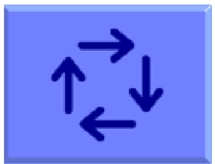
Touch screen buttons located along the right have the following functions:

- Spanner symbol, this button accesses the setup screen (Section 6.2).

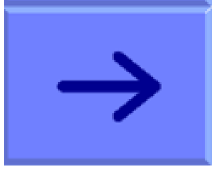


- Double camera symbol on multi camera systems only. This touch screen button toggles between cameras affecting the main image displayed and fine offset context. Alternatively, pressing on a thumbnail image will also select it for full size display.

  Additional cameras are normally used to provide extra guidance information, but it is possible to configure the system so that an additional camera, or cameras, provide a CCTV function. See "Additional settings available from the advanced editor" for instructions on how to achieve this.

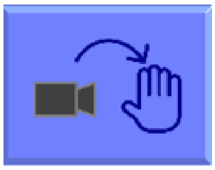


- A button with four arrows arranged in a square, cycles the direction of the arrow button below.



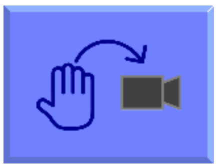
- In normal running the arrow button moves fine offset by 1cm in the direction that the arrow is pointing. A left or right arrow effects lateral offset and up and down arrows effects cultivator or nozzle phase.

- In manual mode, thick left and right arrows replace fine offset adjustment buttons and allow manual operation of side shift or steering discs moving 7% to the left or right with each button press.

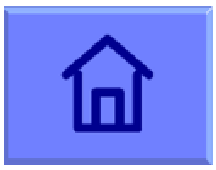


- Touch screen button labelled Camera → Hand icon disables vision steering allowing the user to move left or right manually in 7% steps for each press of the arrow buttons. For disc steered machines with a slide position sensor fitted this is achieved by automatically steering discs to maintain the desired slide position. To prevent mechanical damage these functions only operate when lifted or moving.

  In manual mode green lines representing the template and purple cross hairs are locked on the screen whilst retaining a live video image. These are useful when adjusting cameras (Section 8 Step 2).



  Return to vision guidance by pressing same button, now with a Hand → Camera icon, again. By default, the side shift/discs remain in the position they were placed manually until forward movement under vision guidance is commenced, or an implement lift is detected. The later will centralise the side shift/discs. Alternatively, systems can be configured such that side shift/discs centralise on entry into manual mode (Section 6.3)
  In-row machines will automatically jump into camera guidance as soon as motion is detected.



- Pressing the touch screen button with the house logo returns you to the start-up screen.

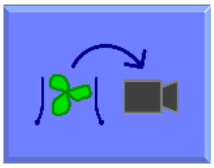
- From the start-up screen pressing the touch screen button with the power switch logo enters a shutdown screen from which you can confirm shutdown.

Inter-row working screen

This screen is very similar to the in-row working screen but omits functions relating to individual plant tracking and the control of rotors. Fine offset offers only lateral adjustment. The live video image has superimposed solid green lines representing the expected row position. The line of green crosses up the centre indicate the quality of the template match at that level. Blue is a good match. Yellow and red are poor matches.

Touching and holding on an image, or its thumbnail, stops images from that camera being used for guidance, making guidance solely reliant on any remaining cameras. When a camera is disabled in this way a red cross is superimposed over the image which remains live. Touching and holding again restores normal function. The ability to switch cameras off in this way is not available when running in-row software.

- For machines with mechanical guidance feelers fitted the guidance mode button cycles between manual mode, feeler mode and vision guidance. In manual or feeler guidance mode the fine offset slide bar is replaced by a graphic symbol indicating the mode in use.

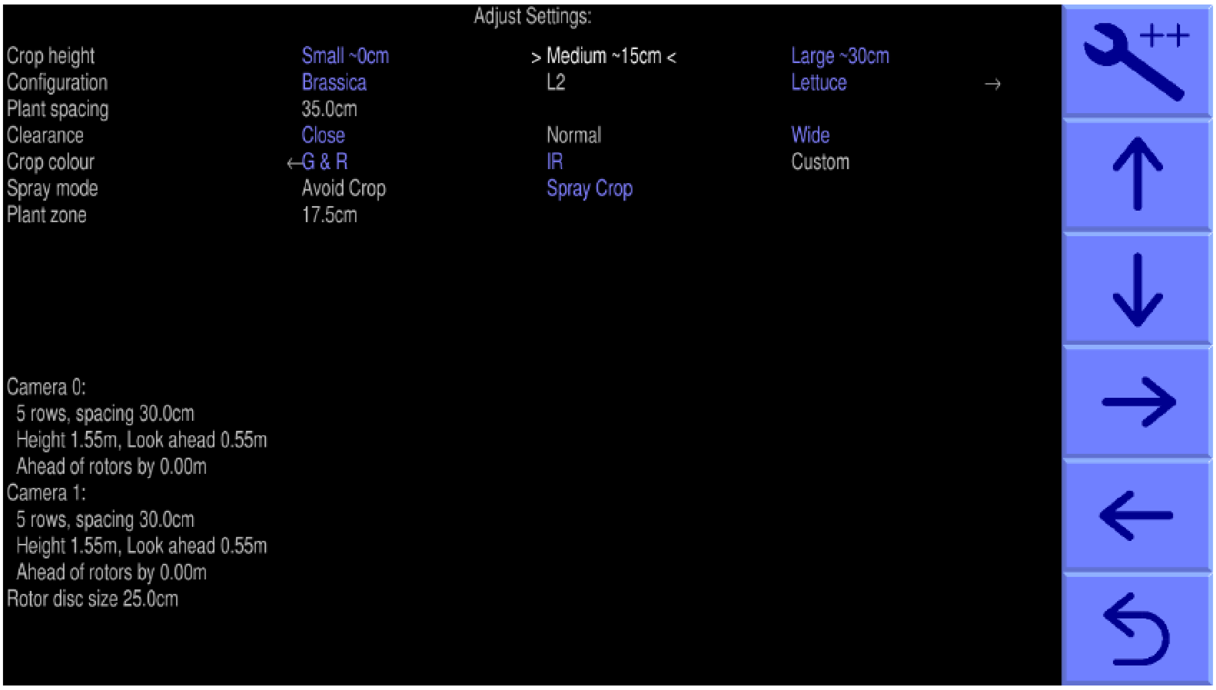


- If a manual box is fitted switching the box to manual overrides the console and a manual hand graphic replaces the fine offset slide bar.

6.2 The Setup Screen

The setup screen can be reached from the top right “spanner” touch screen button in the working screen.

Navigation within the setup screen is achieved by moving the cursor over options using touch screen buttons labelled with arrows. When the cursor is over a setting it’s text changes in colour or brightness, indicating it is selected.



The settings *"Crop height"*, *"Configuration"*, *"Clearance"* (Rotor only), *"Crop Colour"* (optional facility), *"Spray mode"* (Nozzles only) and *"Plant zone"* (Nozzles and Reciprocating Blade only) can be altered in the setup screen. Settings will be stored from your previous session running the selected configuration.

Crop Height

Increases template size to compensate for the crop canopy getting closer to the camera as it grows. This avoids the need to physically adjust camera height when moving between crops of different heights. There are settings for small, medium and large crops. The definition of small, medium and large is approximately scaled according to camera height in accordance with this table.

Camera Height	***"Small"***	***"Medium"***	***"Large"***
< 0.5m	0	5cm (2")	>10 (4")
0.5m – 1m	0	10cm (4")	>20cm (8")
>1m	<5cm (2")	15cm (6")	>30cm (12")

On initial set up the default will be medium, though crop height is saved from the previous session regardless of which configuration was last used.

Configuration

Allows users to select between alternative pre-programmed configurations for different crop planting geometries requiring different templates. The main parameters of the chosen configuration are displayed at the bottom of the setup screen, they are:

Camera #

Viewing - Number of rows being used for tracking.

"Spacing" - The row spacing between the rows being viewed.

"Height" - Distance vertically from lens to ground when in work

"Look ahead" – Horizontal distance along the ground from a point vertically below the lens to the centreline of sight (marked by cross hairs in manual mode).

"Ahead of rotors" by - Horizontal distance between a point vertically below the camera lens back to the rotors. (If the camera is mounted behind the rotors this figure is negative)

Disc size – A parameter relating to rotor disc geometry as described in Section 8

Plant spacing

Nominal spacing between plants within-the-row. With the cursor over this value the spacing can be incremented or decremented in steps of 2.5cm (1")

Clearance

An optional rotor facility - Enables rotor discs to cut slightly closer or further from the plant than normal, through changing the entry and departure points of the disc when rotating around a plant. IT is also possible to change physical clearance around crop plants by changing to a disc selection for one designed for a different uncultivated zone around the crop plant.

Crop colour

An optional facility – For green crops select "Green". Selecting "Red" inverts colour segmentation so that plants that are completely red are tracked.

Where crops have red outer leaves and a green centre, users should select "R & G".

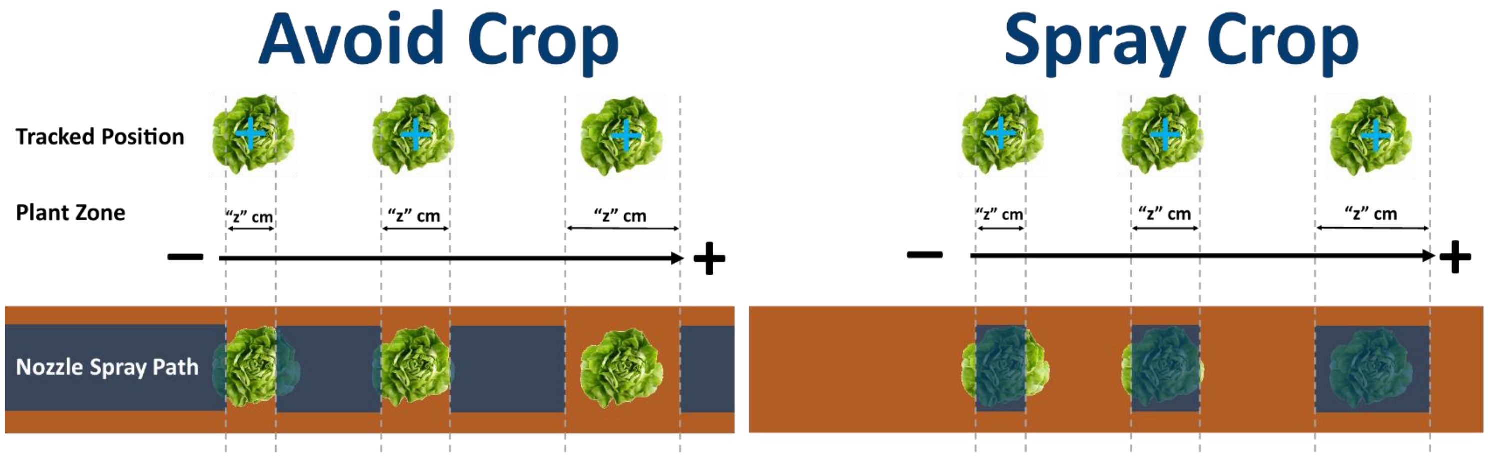
It is also possible to select “Custom” colour which can bias the colour used by the system to search for foliage. This can be advantageous on crops such as brassicas or alliums with a blue/green colour (a value of about 30 has often be found to be satisfactory). Where custom colour is enabled, it can be adjusted by touching on the plant icon in the working screen. **We discourage the enabling of custom colour unless it is absolutely necessary as it adds complexity and can, if not set correctly, dramatically reduce performance.**

For plants with particularly unusual colours that cannot be tracked using any of the normal colour options a camera that uses Infra-Red can be fitted. These cameras are automatically detected.

If a suitable configuration is not available, it can be created using the configuration editor (Section 10).

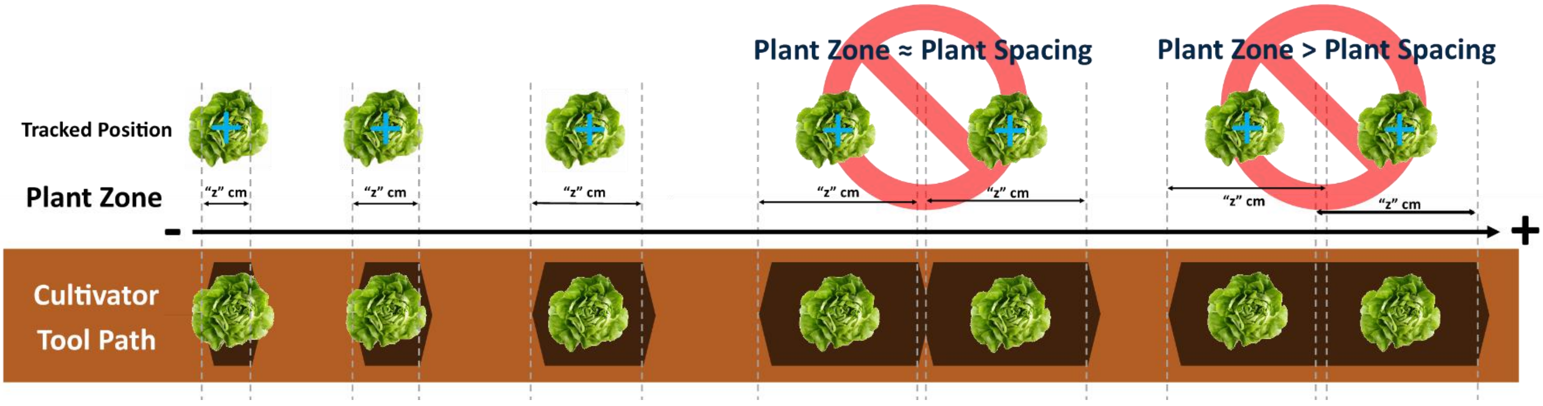
Spray mode

Used for nozzle operation only – Sets the nozzles to either spray on the crop or avoiding the crop.



Plant zone

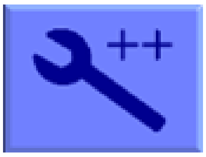
This setting is applicable to both nozzles and reciprocating blade cultivator implements. It adjusts the start and end point of nozzles or reciprocating blades symmetrically around the located plant



Note

Care should be taken to not increase plant zone too high as cultivators/nozzles may not operate if plant zone exceeds plant spacing.

6.3 Advanced Settings & Diagnostics screen



This screen is reached from the setup screen by pressing the top right touch screen button labelled with a spanner ++ symbol. Navigation within this screen is similar to the setup screen.

The first three items on this screen are for information only and cannot be changed by the user. Area worked is based on distance x width.

The remaining items on this screen are as follows:

Current Job

Provides resettable counters for elapsed time, area covered, plants located/plants treated.

Job Stats (for current job)

Displays the number of plants cultivated around/ number of plants detected. The second plant number is likely to be slightly higher than the first as when two plants are so close that the rotary blade will not fit between them then the machine deliberately removes one to avoid damaging both. Selection of “View Details” produces further job details including:

- *“Plant Population”* expressed as the number of plants per unit area (plants/ha or plants/acre)
- *“Plant Spacing”* is the average plant spacing and variability expressed as a standard deviation e.g. 37.8 +/- 3.4 cm
- *“Plant Size”* is the average linear distance across the crop foliage and size variability expressed as a standard deviation e.g. 18.6 +/- 3.1 cm

Units

Selecting toggles between metric and imperial units. This change affects all user screens and the configuration editor.

Camera skew

A measure of camera angular misalignment in the horizontal plane. This angle is automatically estimated during field running. Rate of change is highest during initial runs and after resetting to zero. It stabilizes after approximately 100m. During this initial learning phase, it is sometimes necessary to readjust the fine offset (Section 8 Step 3).

As camera skew relates to a particular camera poise it is necessary to reset it to zero manually and allow it to estimate a new value each time the camera is moved. Small lateral camera adjustments by sliding within the stroke of a camera bracket should not however require a reset, as camera poise should not be significantly affected. A reset to zero is achieved by highlighting reset and pressing the return button.

Caution
After resetting camera skew it will probably be necessary to adjust fine offset.

Camera skews more than 3 degrees indicate poor alignment requiring improvement.

Camera Offset (only present with multiple cameras on the same section)

Camera Offset is the lateral error between two or more cameras fitted to the same section. Like skew it is estimated during field operations. Rate of change of this estimated displacement is highest during initial runs and after resetting to zero. There are as many offsets as there are cameras on a section. The first camera is master/datum from which offsets are derived and so it always has zero offset.

The purpose of estimating lateral misalignment and automatically compensating is to avoid the need for very accurate mechanical setting up.

Camera skew influences camera offset so that resetting skew resets both figures for all cameras fitted. However, resetting offset does not automatically reset skew.

Test Steering

This function checks a number of components and settings relating to side shift or steering angle movement. Included are micro-controller communication with the main computer, direction of hydraulic flow, rate of flow, side shift/disc potentiometer connection polarity and continuity over the stroke. A successful steering test should return a message of ***"OK"***. The test also detects mechanical obstructions preventing the expected full travel which result in the message ***"Hit stop"***. This is achieved by exercising the hydraulic cylinder and recording the response. It is therefore necessary to turn the hydraulic supply on. For multi section machines you are prompted to select which section to test. This test also serves as an initial calibration of steering direction (when viewed in the direction of travel) through a series of questions on screen.

If the module DIP switch settings indicate a proportional valve is fitted it will calibrate the side shift to the target rate entered in the configuration (0.1m/s default).

Caution
Ensure steering mechanism is clear of obstructions and people before running.

Note: In-row cultivator (rotor and reciprocating) related tests - Check all personnel are clear of moving parts before performing any of the tests listed below:

Hydraulic flow test (hydraulic rotors only)

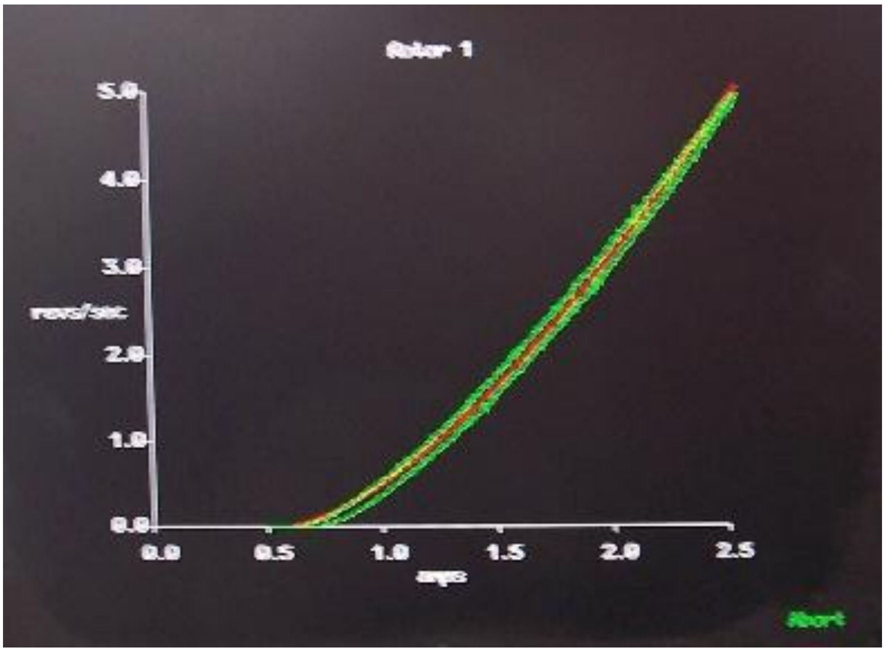
This test runs all configured rotors up to maximum speed (4 Rev/s) to ensure sufficient oil flow is available. Tractor engine revs should be set to a normal operating speed. A graph plotting both oil supply pressure in green (if condition monitoring is fitted) and flow in red (calculated from actual rotor speed) against demanded rotor speed is displayed. If pressure drops significantly during this test a warning will be displayed indicating that tractor engine revs need to be increased or alternative higher capacity oil supply sought. If the pressure only drops close to maximum speed it may be possible to continue operation but with a reduced maximum speed.

Calibrate Rotors (hydraulic rotors only)

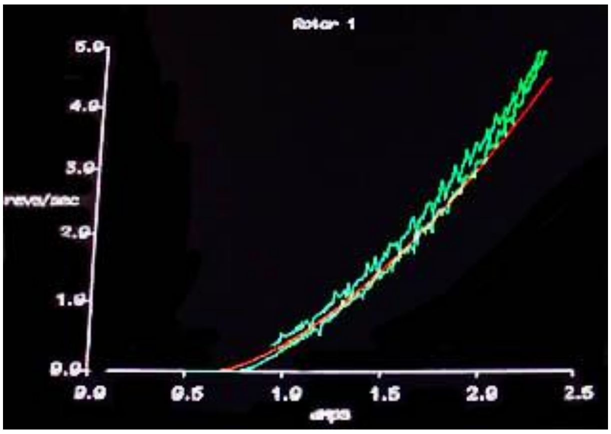
This option goes through a similar process to the rotor test except that rotor speed (revs/s) is displayed on the vertical axis and demanded solenoid current (amps) on the horizontal axis. The red line represents the systems stored calibration for that particular unit and the green line shows actual performance during the test. Due to hysteresis effects one should expect the rising green line to follow the red line displaced slightly to the right as the rotor accelerates and as it decelerates the falling green line should be displaced slightly to the left. The green line should be relatively smooth, though a small amount of ripple is acceptable. Sizable spikes in the green plot may be symptomatic of component faults. A green line smoothly ramping up and down that does not follow the red calibration plot suggests that the unit needs recalibrating.
If the calibration process was successful the message ***"Calibrated OK"*** is displayed and the user is given the option to save the calibration, discard it, or use defaults. Once one of these options is selected the user is returned to the advanced set up and diagnostics screen.
Problems detected during calibration produce similar diagnostic messages to the test process. It is sometimes possible to refine a diagnosis by inspection of the calibration plot. For example:

- A spikey trace that roughly follows the calibration line might indicate faulty encoder feedback.
- A trace that simply followed the zero line on the horizontal axis would indicate that the encoder is not working at all or has become disconnected.
- A trace that produced a rectangular series of spikes to a limited number of values would indicate that one of the encoder signal lines has become disconnected.
- An apparently normal trace with very short breaks once every full rotation would indicate that the index sensor is not working.
- A trace that starts by running along the zero line further than normal (>1 amp) and then jumps steeply up to follow the red line might indicate a sticking valve or possibly a motor that is leaking internally. Oil temperatures above 70° will cause proportional valves to stick.
  If diagnosis is proving difficult it is possible to photograph the screen and e-mail it for expert interpretation. To return to the advanced set up and diagnostics screen press "done".

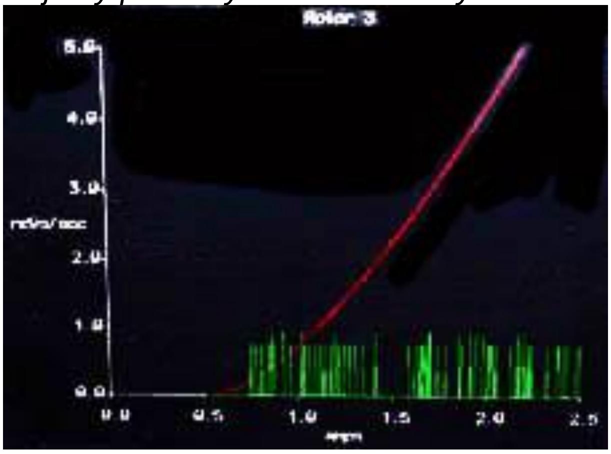
Examples of calibration traces



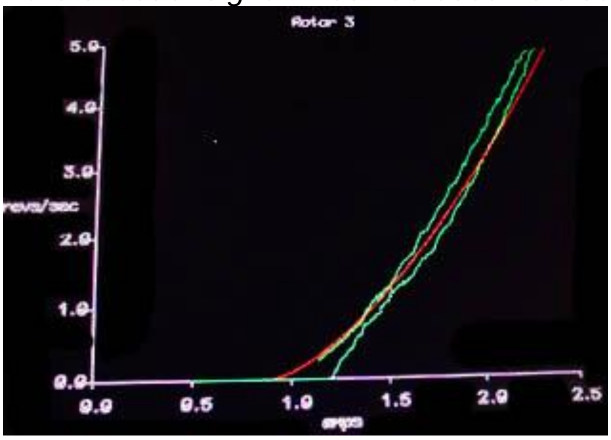
Typical graphical representation of a successful calibration



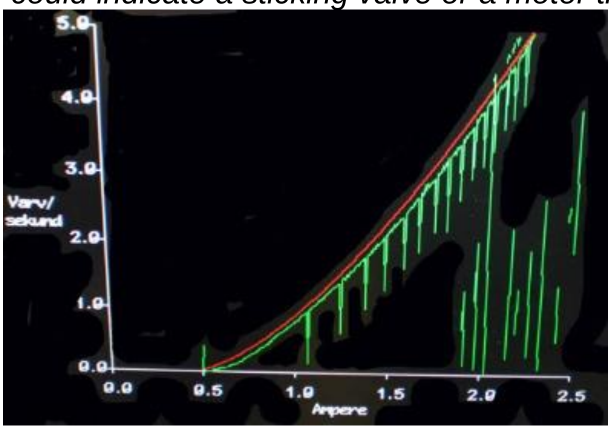
A jerky plot may indicate a faulty encoder



A trace that produced a rectangular series of spikes to a limited number of values would indicate that one of the encoder signal lines has become disconnected



>1amp to start rotation could indicate a sticking valve or a motor that is leaking internally



Discontinuity once per revolution could indicate an index sensor fault

Test Rotors (both electric and hydraulic rotors)

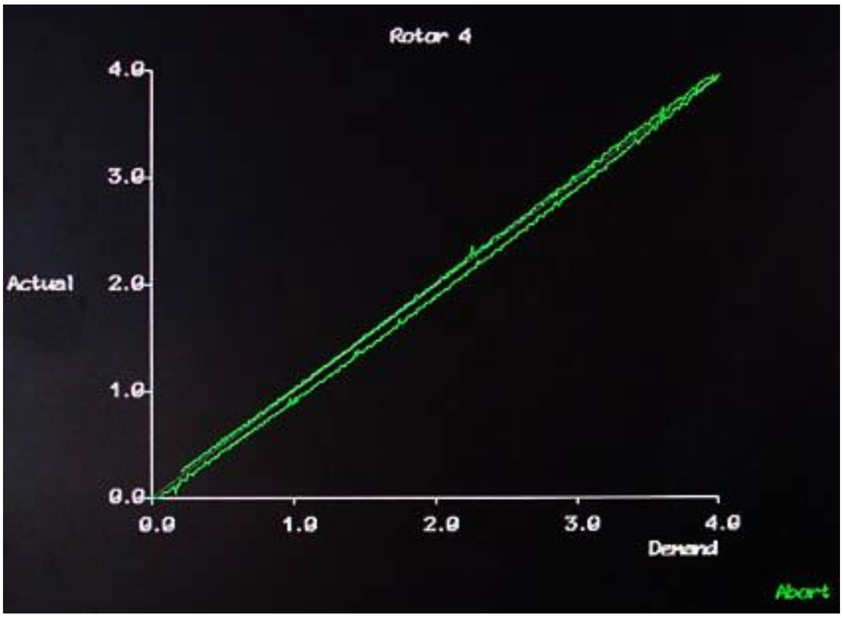
This tests control of rotary cultivators, providing a more rigorous test that that routinely conducted at start up. It is necessary to turn on rotor power (hydraulic or electric). You will be prompted to lift the implement and select ***"Begin"***. The screen will display a blank graph with actual rotor speed (revs/s) on the vertical axis and demanded rotor speed (revs/s) on the horizontal axis. The first rotor will start to rotate and as it does so two lines are plotted on the graph. The straight red line represents an ideal 1 to 1 relationship and the green line shows actual performance during the test.

Due to hysteresis effects, one should expect the rising green line to follow the red line displaced slightly to the right as the rotor accelerates and as it decelerates the falling green line should be displaced slightly to the left. The green line should be relatively smooth, though a small amount of ripple is acceptable. Sizable spikes in the green plot may be symptomatic of component faults. The test sequence lasts approximately 20 seconds per rotor. Users are prompted to select which rotor is to be tested. If ***"All"*** is selected, the system tests each rotor in turn refreshing the graph on each occasion.
If the test was passed without problem the user is given the message "***Test passed***".

If one or more rotors ran but with larger than expected average errors the user may be advised to recalibrate (see procedure above). Recalibration should only be necessary if components (motors, valves or microcontroller) have been changed. Please seek advice from your dealer if recalibration is advised with any regularity. Electric rotors do not require calibration and so a "***Recalibration required***" message would indicate a fault.

If an error is detected a diagnostic message is displayed.

"Rotor too slow" would suggest that insufficient hydraulic oil was available.
"***No rotation***" would indicate that the hydraulic supply might not be switched on (electric supply for electric rotors) or connections have not been made.
"***Reverse rotation (Rotor No.)***" suggests that the hydraulic pipes to the identified units are fitted the wrong way round. Electric rotors should not produce the "reverse rotation" message as that would indicate a wiring error.
"Comms fail" indicates a communication error between the main computer and the micro controller. To return to the advanced set up and diagnostics screen press "done" and if necessary repeat the test once the cause of any fault has been addressed.



Typical graphical representation of a successful hydraulic rotor test

Test Nozzles

This test presents three options from a pop up menu. (Leakage and blockage tests require condition monitoring to be installed):

Visual Test – Turns all nozzles ON individually in mapped order for one second each in a continuous cycle.

Leakage Test –Spray lines are pressurised and pressures monitored to identify drops in pressure that could indicate leaks or nozzles stuck in the open position. If leakages are detected, spray bar address information on the detected leak will be displayed.

Blockage Test –Spray lines are pressurised, and nozzles individually opened. Pressure decay monitored is to check for blockage or incomplete opening. If blockages are identified, affected nozzle channels will be displayed.

Flush Nozzles

Activates alternate nozzle channels for one second then switches to the other half for one second in a continuous cycle.

Note
A weak spray during a flush nozzles test could indicate insufficient pump flow capacity.

Test Cultivators (for reciprocating in-row cultivators only)

Energises reciprocating in-row cultivators in mapped order for one second each in a continuous cycle.

Test all Cultivators (for reciprocating in-row cultivators only)

Activates alternate reciprocating in-row cultivators for one second then switches to the other half for one second in a continuous cycle.

Note
Reduced cultivator insertion and retraction speeds could indicate insufficient hydraulic flow.

Audible Warnings

When selected “Yes” a buzzer inside the console sounds when warning symbols such as the poor tracking symbol appear on the working screen. The default is “Yes”.

Leave manual on moving

When selected “Yes” automatic camera control takes over when motion is detected. The default is “No”. When running in inter-row mode a number of options are available regarding behaviour in marginal conditions.

Go to manual if lost (Inter-row only)

When selected “Yes” control will be switched to manual if the system is unsure of row position and the buzzer will sound for four seconds. If “No” is selected it will attempt to relocate the rows and continue vision guidance. The default is “No”.

Uncertainty Threshold (Inter-row only)

This setting is only applicable if “Go to manual if lost” is set to “Yes” and allows the user to adjust the level of guidance uncertainty to be reached before entering *“Lost”* mode whereby the guidance is set to manual mode.
When in this *“Lost”* manual mode, guidance uncertainty is still monitored, and guidance can be automatically resumed if the setting of “Auto-resume” is set to “Yes”.

Larger uncertainty threshold values result lower sensitivity of guidance doubt before entering *“Lost”* mode.

Lower uncertainty threshold values result in greater sensitivity meaning that *“Lost”* mode is entered more easily.

Note:
As default an uncertainty threshold of 25mm is set, it is not advised to set uncertainty threshold below 10mm or above 40mm.

Auto-resume (Inter-row only)

When set to “Yes” allows for automatic reengagement of camera guidance when the guidance enters “Lost” manual mode. Auto-resume monitors uncertainty while in *“Lost”* manual mode and once the level of uncertainty drops below the threshold for long enough that camera guidance can be carried out the system will reengage camera guidance automatically.

Centre when entering manual

When selected “Yes” the side shift or steering discs will centralise whenever manual is selected. If “No” is selected the side shift or discs will stay in their current position until a manual steering input is made. The default is “No”.

Auto select feelers (Inter-row only)

This setting is only shown if mechanical crop guidance feelers are fitted. When selected “Yes” automatically drops from vision guidance to feeler guidance when one of the feelers is deflected. The default is “No”.

Side slope compensation (an optional experimental feature)

This experimental function is intended to automatically apply a lateral offset to compensate for sides slopes. Please contact us if you wish to try this feature.

Enable fine offset flip

Selecting “Yes” adds a touch button on the working screen below the fine offset bar with opposing arrows which when touched flips fine offset direction. The default is “No” and should only be changed for work on side slopes or in cross winds.

Error log

Is a log of automatically generated error messages (e.g. camera connections, microcontroller connections and excessive camera skew). Selecting “view log” displays single line messages that can be helpful with diagnostics. Not all messages indicate serious faults. On exit you have the option to select “clear” which erases messages or close which returns to the advanced set up & diagnostics screen without erasing. These messages are saved between sessions.
Tip
When seeking advice over the telephone it is very useful to have an exact word for word record of any error messages and to make a note of numeric error codes.

µC version

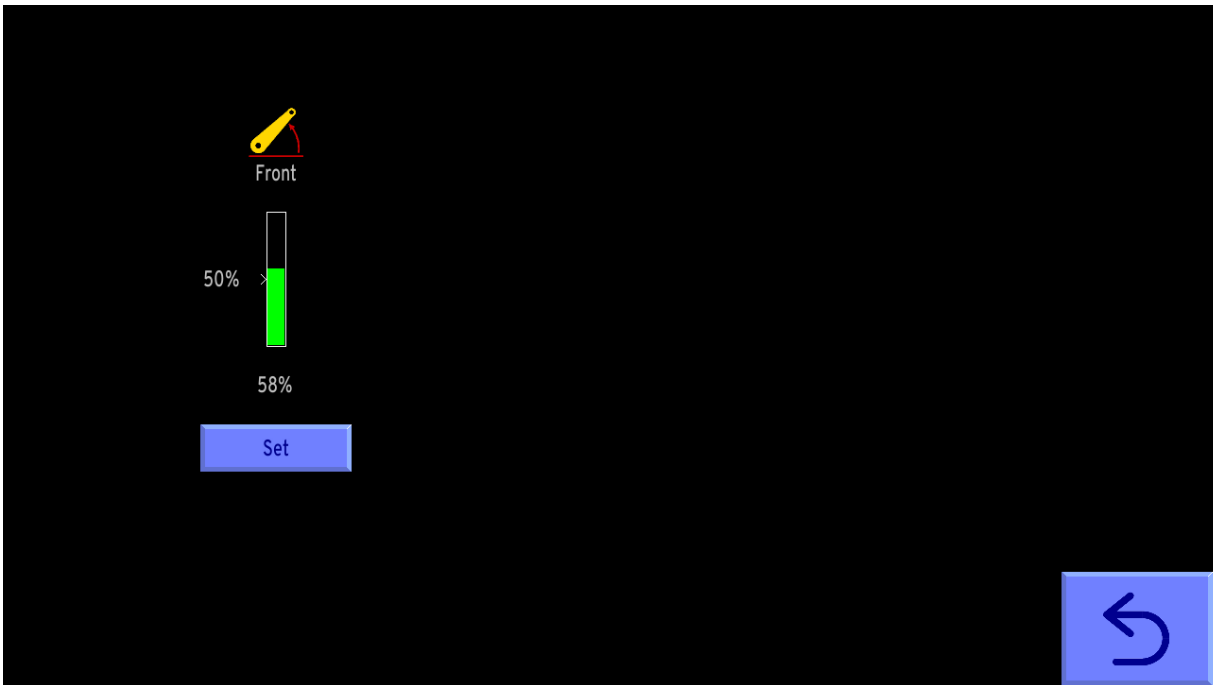
Displays the version numbers and allocated CAN address IDs of any microcontroller boards fitted.

To exit the status and diagnostics screen press the bottom right touch screen button labelled with a loop back arrow.

ISOBUS Hitch Setpoint

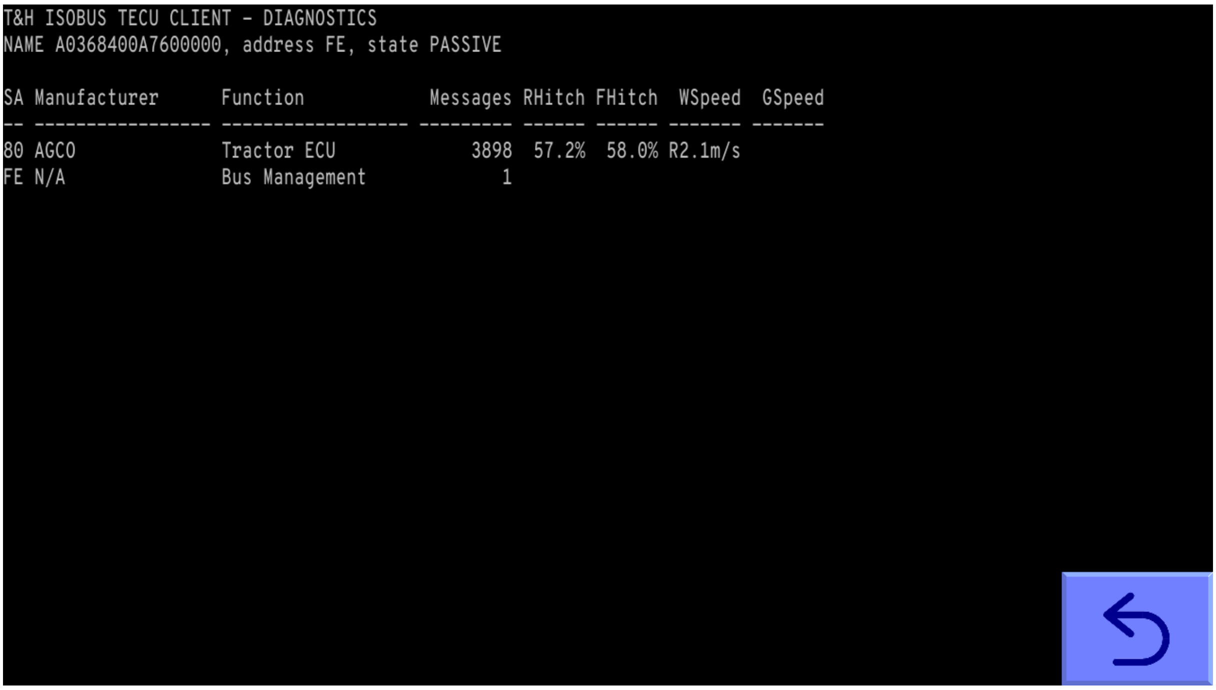
This utility provides a means of adjusting the hitch transition point between in-work and lifted out of work. The green vertical bar is a live representation of tractor hitch position read from the ISOBUS. Pressing the "Set" button changes the transition point to the current hitch position, which is then displayed as a percentage of full stroke at the base of the bar.

Hitch setpoints are retained between sessions.



ISOBUS Diagnostics

This utility allows for observation of live ISOBUS data. Useful in ensuring that connection between tractor and implement has been achieved and sensor data is available for implement operation.



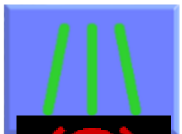
Note

Hitch setpoint and ISOBUS diagnostics are only applicable for implements fitted with ISOBUS connectivity.

7. Initial setup and testing in the factory/yard

Step 1 – Start the tractor and console

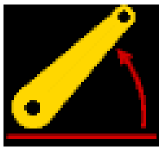
With the implement still on the ground check that hydraulic spool valves are in neutral and all persons are well clear. Start the tractor then switch on the console and wait for the system to "boot up". After about 40 seconds of PC boot up text the start-up screen should appear.



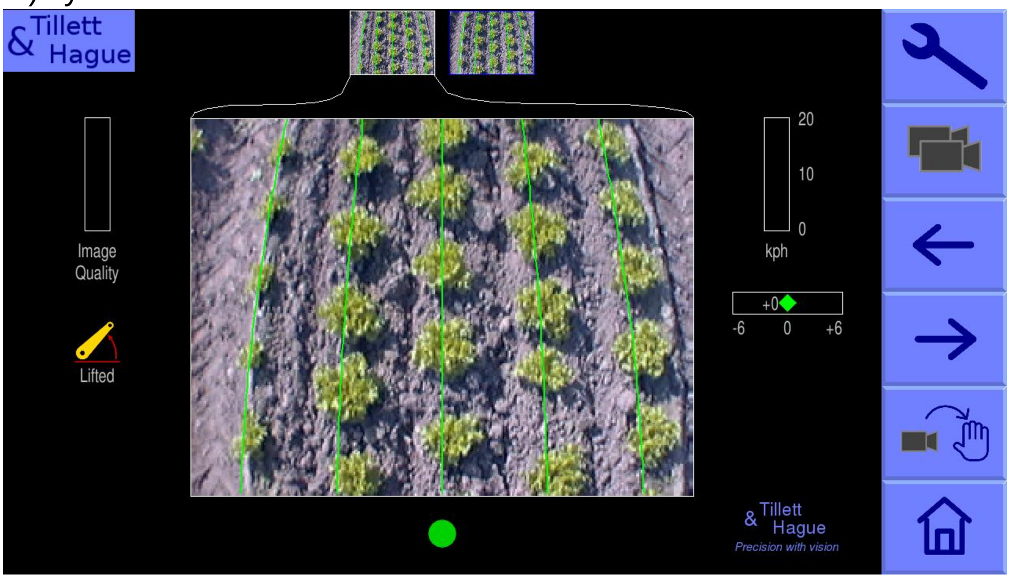
Select **inter-row** using the touch screen button with a crop row symbol. This will enter the inter-row working screen.

If the implement is lowered to its normal working position the "stopped" (red brake) symbol should be displayed and the speed bar should read zero.

Taking care to ensure that the hydraulic supply is off, spinning the odometer wheel (if fitted) should register a green speed bar.



Lifting the implement should result in the "stopped" symbol being replaced by the "lifted" (yellow lift arms) symbol.



Console inter-row working screen showing the implement is lifted and centred

Step 2 – Checking hydraulic steering operation (for non-proportional directional valves)

If adjustment is available, set the tractor's hydraulic flow rate to an appropriate level, typically 5 to 10% of full flow. (A higher flow may be needed for hydraulically driven in-row actuators.)

With the guidance system running, lift the implement clear of the ground and engage the hydraulic supply. Be ready to disengage immediately should a fault occur.

From the working screen touch the top right "spanner" touch screen button in the working screen. Touch in the same area again (this time marked by a spanner++ symbol) to reach the advanced settings and diagnostics screen. Use the arrow buttons to move the cursor down to "Test steering" and touch on the return button to start an interactive process that will set up the steering and prompt you should any adjustments be required. Left and right are defined when looking forward in the direction of travel.

At the end of the test the side shift or steered discs should centralise.

If you wish to test steering manually return to the working screen using the loop back button and touch on the button with the camera → hand icon The hydraulic side shift/steering is now in manual mode and can be operated using the touch screen buttons labelled with left and right arrows. Each press of a button steps the side shift/steering by 1cm/2°. Repeated pressing and releasing (but not holding) will result in continuous travel up to the end of the stroke denoted by a red vertical bar. This procedure can be used to check that hydraulic flow is in the correct direction and that side shift rate is correct. A normal side shift rate would be 0.1m/s (e.g. 3s to travel a 0.3m stroke). To return to normal automatic mode press the same button (now with "camera" highlighted) again. The side shift/disc will stay in the position it was placed under manual control until the implement is lowered and raised again, or the machine starts to travel forward.

Caution

- Side shift/disc travel all the way to one side on lifting the implement may indicate that the hydraulic supply is connected the wrong way.
- Rapid side shift/disc oscillations back and forth about the central position indicates that the hydraulic flow rate is too high. The tractor flow control should be turned down. Alternatively, if fitted the hydraulic flow control valve on the implement may be adjusted.
- "Reverse oil flow" message can sometimes be falsely triggered by side-shift hydraulic flow control being fully closed.
- For safety only adjust the flow control valve with the implement on the ground and the tractor engine switched off.

Step 2 – Checking hydraulic operation (for proportional directional valves)

The procedure for proportional hydraulic operation is the same as for a non-proportional valve except that sequence movements initiated by the "Test steering" function includes an additional full stroke movement to calibrate steering speed.

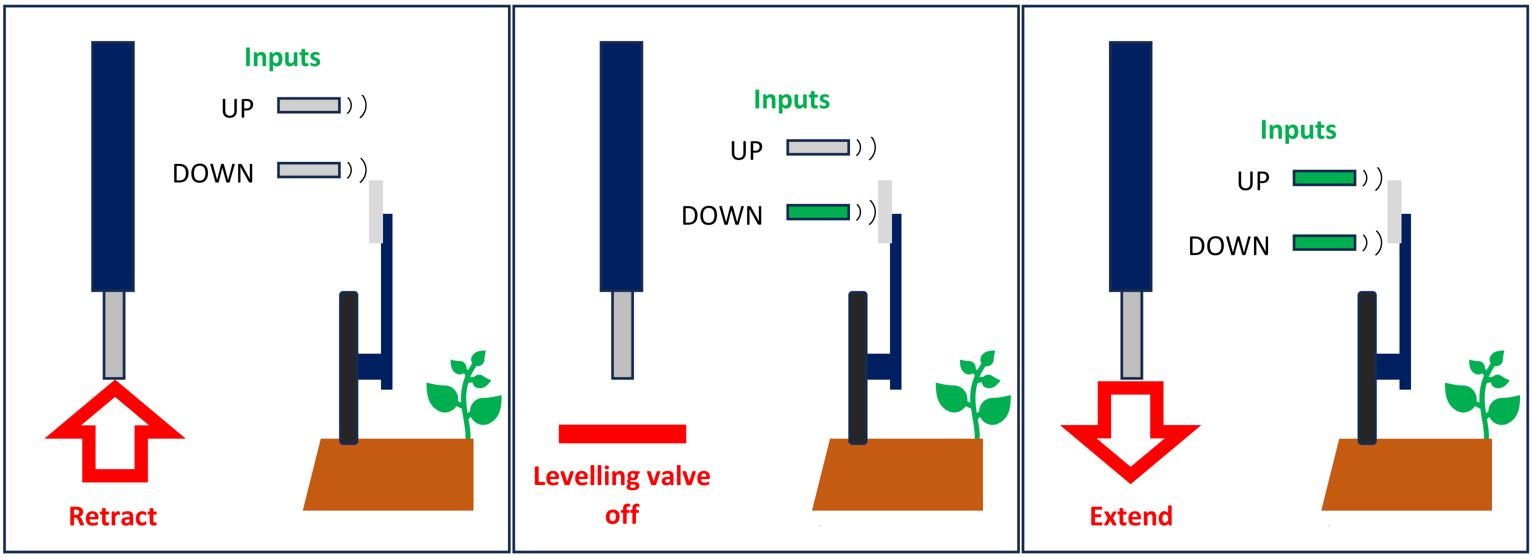
If the steering test with a proportional valve does not behave as expected check that the circuit board inside the implement module is version 1.2 or higher (see white silkscreen text at top right) and that switch No.1 of the 10-way DIP switch is ON (up position).

Step 3 – Checking hydraulic levelling operation

Two proximity detectors control levelling on each side of the machine should be arranged to “view” a metal target such that if that side is too high neither sensor is triggered. If the height is correct only one should triggered. If the implement is too low on that side both proximity detectors should be triggered by the metal target.

The position of the sensors determines the height at which that side of the implement rides and the distance between them determines the dead band.

With neither proximity detector triggered one of the levelling valve outputs will be switched on and this should be arranged to cause the levelling cylinder to retract. If only one sensor is triggered that side of the implement it is deemed to be at the correct height and both levelling valve outputs are off. If both proximity detectors are triggered the other levelling valve output will be switched on and the levelling cylinder should extend.



The machine is now ready to be taken to the field for inter-row guidance. If you wish to run in in-row mode, you first need to check in-row operation functions.

Step 4 – Rotor start-up check

If this is first time an electric rotor machine has been run it might be necessary to allocate sequential CAN addresses to each of the rotors using the “Setup Rotors” utility in the Service tool menu (see Section 11). It is also possible to use this utility to set the direction of rotation, clockwise or anti-clockwise. That direction should be set such that the rotor is travelling with the direction of travel whilst engaged between crop plants within the row and in against that direction when disengaged outside the plant row.

If this is the first time a machine fitted with hydraulic rotors has been run it is advisable to calibrate the rotors. See Section 6.3 for instructions. If no calibration is done rotors will operate with a default calibration.

Restart the system, and this time enter in-row mode by pressing the touch screen button showing an array of 9 discrete plants. A message will be displayed prompting you to lift the implement. Having done so you will see the message, “Ensure all personnel are clear of the machine”, with the option to begin the start-up testing process. For hydraulically driven rotors set the tractors hydraulic control to provide a constant flow to the implement, ensuring that you have the facility to disengage the

hydraulic supply immediately should a fault occur. For electric rotors turn on the 42V electrical supply.
To initiate the start-up test process, press the button labelled "begin" at the bottom of the display. The screen will for the next 15 seconds display the message "Synchronising encoders" during which time the rotor units should all rotate. Their speed should ramp up, holding at a constant for 5 seconds and then ramp down again. If this self-testing process has a satisfactory outcome the working screen with a live video image will be displayed and the side shift or steering discs will centralise if they were not already centred.
If the self-test process did not produce a satisfactory outcome an appropriate message will be displayed to help diagnose the problem. These potential messages include "No rotation?", "Reverse rotation *(Rotor No.)*" and "Comms fail." Users has the option via labelled touch screen buttons to "Ignore" the result and continue to the working screen, "Retry" the test process, or "Shutdown". The message "No rotation" may indicate for hydraulic rotors that the hydraulic supply is not reaching the implement, or that it is set at a very low flow rate. For electric rotors, it might mean that the electrical supply is off. "Reverse rotation" would indicate for hydraulic rotors that the pipes to the specified hydraulic motors should be reversed. If all the rotary units are specified it may be that the main hydraulic supply is connected incorrectly. Electric rotors should not produce the "reverse rotation" message as that would indicate a wiring error. The message "Comms fail" refers to an internal problem with a microcontroller connection. If you get a "Comms fail" message power the system down, check connections and try again.

Step 5 – Nozzle start-up check

If the machine is equipped with nozzles and a configuration that includes those nozzles is selected, you have the option to test their function. These nozzle test functions are accessed from the system information & diagnostics screen. Scroll down to "Test nozzles" and select "test". You will be presented with a choice of tests. The simple visual test, in which nozzles associated with each row in turn for one second, will always be offered. The more sophisticated leakage and blockage tests are only available if spray pressure monitoring is fitted. There is also a "Flush nozzles" option which if selected will turn on half (alternate) nozzles for 1 second then turns on the other half in a continuous cycle.

Step 6 – Reciprocating In-row cultivator blade start-up check

If the machine is equipped with reciprocating In-row cultivator blade modules you have the option to test their function. The cultivator module test functions are accessed from the system information & diagnostics screen. Scroll down to "Test Cultivators" and select "test", each output channel will then be activated for 1 second in sequence one at a time. If you select "test all" half the cultivators will be activated for 1 second and then the other half will be activated in a continuous cycle. This can be useful in assessing if oil flow rate is adequate.

Step 7 – Night operation lights operation check

If the implement has night operation light output activated as (see Section 5.1 Step 15) and lights have been connected. Night lights can be turned on/off via the working screen touching the light bulb icon. When the icon turns yellow the night operation lights should also illuminate. For in-row operation at night, lights should illuminate the whole treatment area and ideally mounted symmetrically either side of the camera.

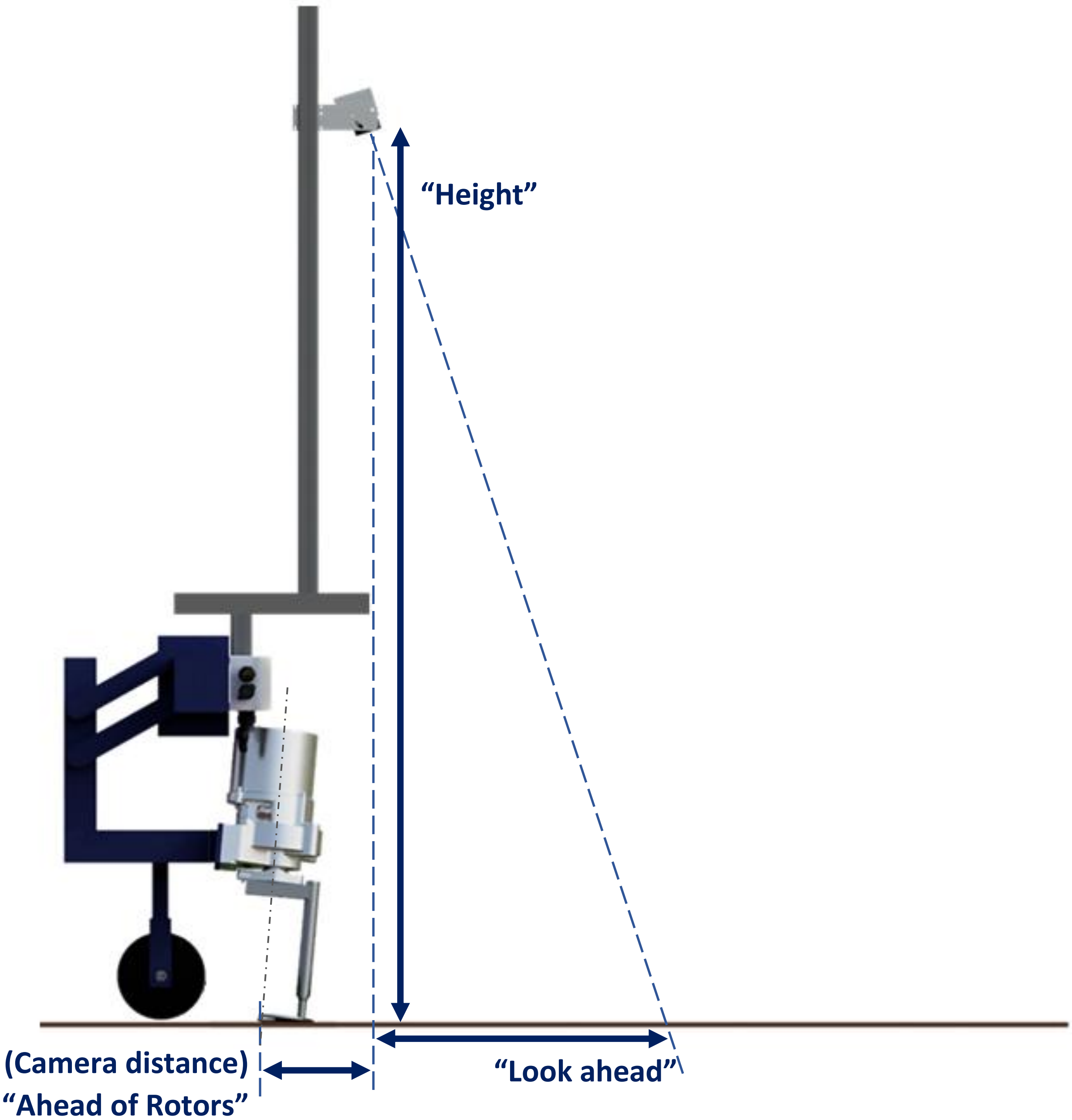
Step 8 - Camera set up by measurement

If you wish to set cameras up in the factory or yard without reference to crop rows you can do this with two simple measurements as follows:

From the working screen go into the "set up" screen by touching the spanner button. Select the configuration you require using the arrow buttons (the text will change colour or brightness when selected). Make a note of distances "look ahead" and "camera height" (see Section 8 Step 1).

Having checked that the implement is fully lowered and at its normal working depth adjust camera height so that it matches the figure given in the configuration. Now mark a point on the ground directly below the camera lens (ideally using a plumb bob). From that point measure forward along the ground and place an object at the "look ahead" distance as illustrated in the diagram below. Return to the working screen and select manual mode. Purple cross hairs will appear in the image. Adjust camera inclination so that the cross hairs align with the object placed at the "look ahead" distance.

The camera is now correctly aligned.



Note: Remember to tighten any bolts loosened in the process of adjustment.

8. Getting to work in the field

For initial running (steps 1 - 3) we advise running without in-row cultivation blades. For these first three steps you have the option to run in either in inter or in-row mode. Any adjustments such as lateral offset made in inter-row mode will also apply when running in-row using the same configuration.
To ensure good guidance it is very important to match the template representing expected planting pattern with crop plants as they appear in the live video image. The following steps outline how to get the best match and hence achieve good guidance.

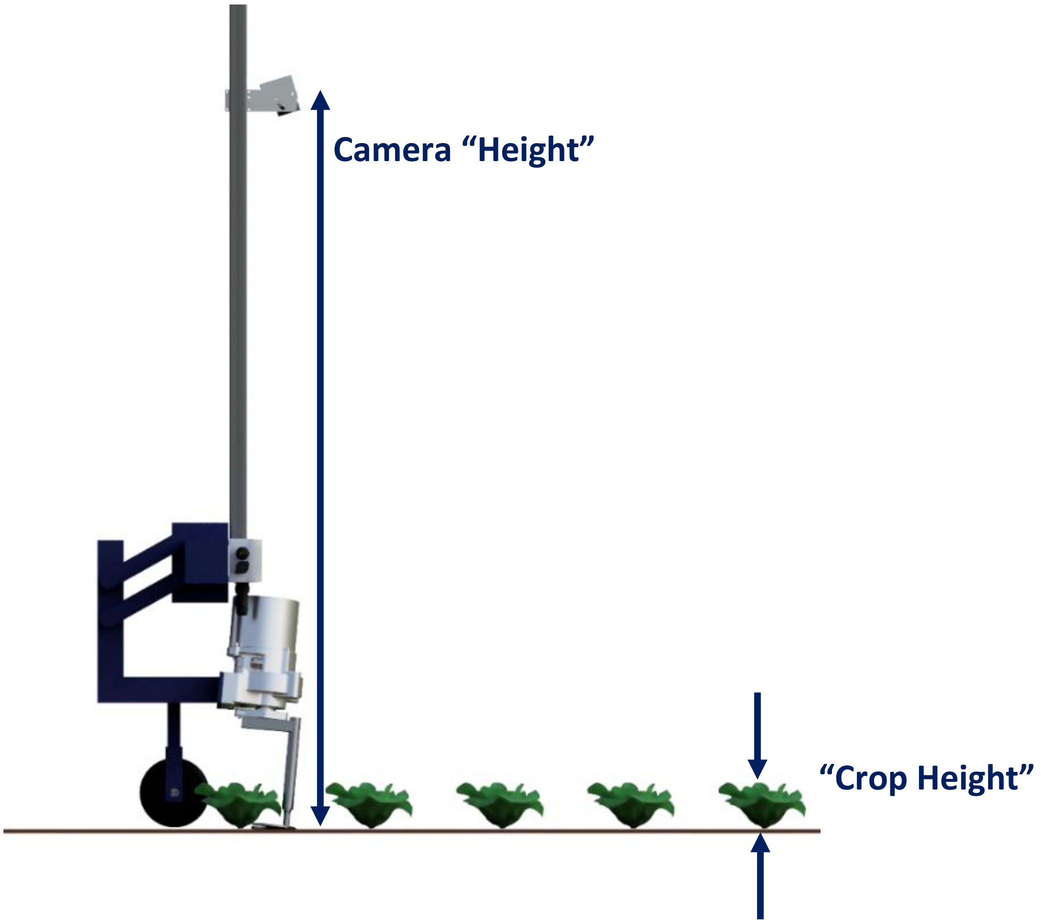
Tip: For the first few hundred meters of running after commissioning the guidance system learns a term that compensates for minor errors in camera orientation. Wherever possible we recommend that set up runs (Step 3 below) are conducted in crop showing the clearest rows available so that this term, known as camera skew, is learned as quickly and accurately as possible. High visibility rows also help manual alignment checks (Step 2). We also recommend that side slopes are avoided during initial running. Once set up is complete more challenging situations can be tackled. It is also possible to view camera skew and reset it manually (see Section 6.3).

Step 1 – Selecting configuration and crop size

From the working screen press touch screen setup button labelled with a spanner symbol. This switches the display to the setup screen.

Use the up down arrow key to move the cursor onto correct line and use the horizontal arrow keys to select an option or adjust a value.

The top line of this screen indicates crop size (height) settings under categories of small, medium and large. The heights assigned to these labels vary with camera height and are displayed. Ensure that the highlighted option corresponds to the crop you are running in.



Check selected configuration settings displayed at the bottom of the screen match crop geometry. E.g. that the number of rows viewed by the camera corresponds to the number being tracked and that row spacing on the ground correspond to the numbers on the screen. Also make a note of the three dimensions for "Height", "Look ahead" and "Ahead of cultivators/rotors by". These are particularly important parameters for in-row cultivation as they effect the timing of in-row cultivation blades.

Ensure that selected configuration settings match the number of cameras fitted.

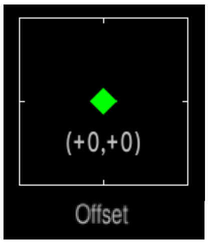
If either crop or implement geometry do not match the selected configuration settings, select an alternative configuration. If a suitable configuration does not exist refer to Section 10 for instructions to create one.

To return to the working screen press touch screen button labelled with a loop back arrow.

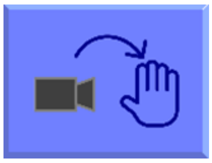
Step 2 – Checking camera height and inclination angle in the field

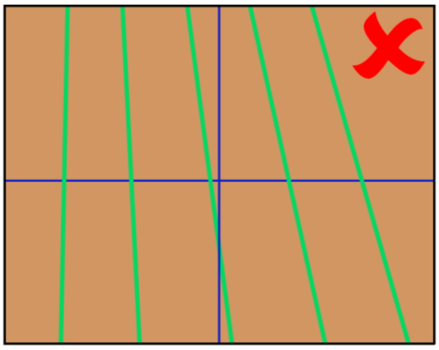
Draw into the crop and set the cultivator down onto a typical section of crop row. The cultivator should be level and set onto the rows as accurately, and as straight as possible with the camera at its normal operating height (as displayed in the "set up" screen).

Centralise the fine offset gauge so that the indicator is a diamond shape in the centre.

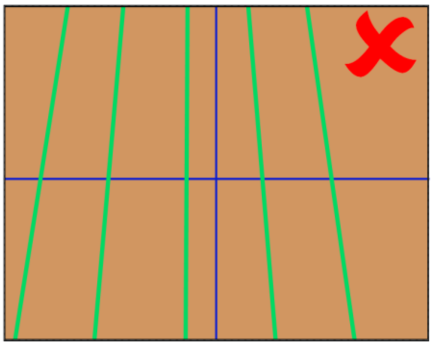


Press touch screen button with the Camera → Hand icon to enter manual mode, the overlaid green lines representing the template should lock in the centre of the screen with no tracking crosses down the centre.





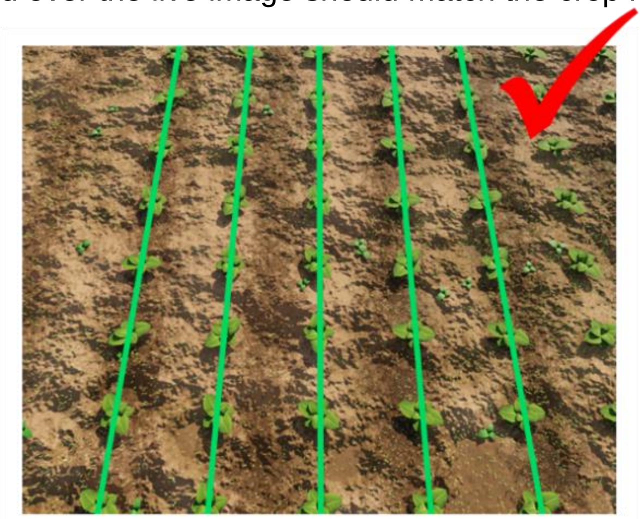
If the overlaid green lines are not symmetrical on the screen (by more than 3 degrees) the camera skew value may need resetting from the advanced set up & diagnostics screen as described in Section 6.3.



If multiple cameras are fitted and the green template lines are aligned with the blue cross hairs in the left most camera but are laterally offset in any additional camera(s), camera offset may require resetting from the advanced set up & diagnostics screen.

If the overlaid green lines are offset laterally from the real crop rows move the camera(s) laterally until they are aligned.

Green lines superimposed over the live image should match the crop rows as illustrated below.



Tip

If crop rows are difficult to see in the live video image you can enhance them by placing high visibility objects such as a strip of wood exactly over the row centre line.

If the green lines appear narrower or wider than the real crop rows check the “crop size” selected in the “set up” screen and change if appropriate. If this does not resolve the problem, it may be that the camera height (measured from centre of lens to ground level) does not match the figure displayed in the “set up” screen. The best solution is to measure the correct position and move the camera accordingly. If the discrepancy is small a less accurate, but sometimes satisfactory alternative, is to adjust camera height until the “picture” looks correct as illustrated below:

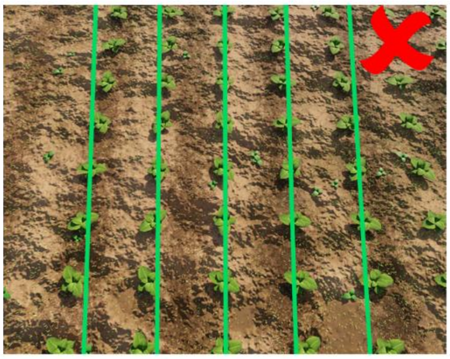
If template lines do not line up with the real crop rows in the live video image it is possible to make minor adjustments to camera orientation by eye to obtain a good match as explained below. This form of adjustment by eye is acceptable for inter-row guidance and should give good results. However, for in-row operations if you change camera orientation you will need to remeasure camera “Height” and “look ahead” as they effect the timing of in-row cultivation blades and other in-row devices such as nozzles. If those parameters no longer match those in the configuration you must edit the configuration or create a new one so that they do match.

If the camera is too low, then the template will appear narrower than crop rows. In this case raise the camera.

If the camera is too high, then the template will appear wider than crop rows. In this case lower the camera.

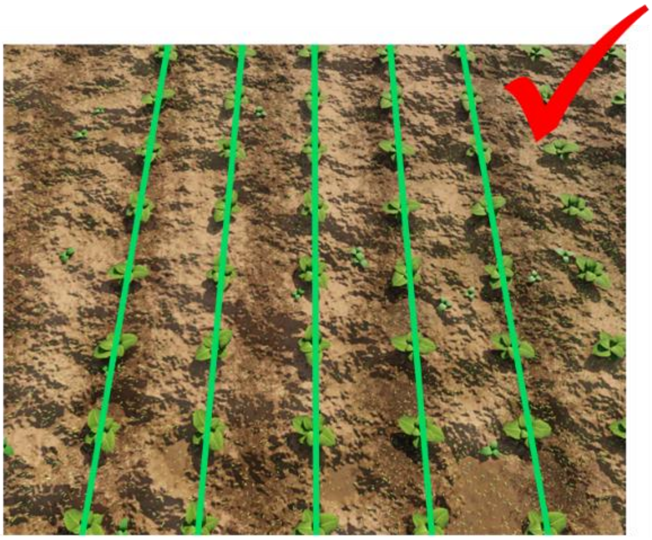
If the template matches mid screen, but not at the top or bottom, check that the implement is level. If it is, camera inclination angle may need adjusting.

If template lines appear narrower than crop rows at the top of the image but wider at the bottom, rotate the camera up so it views further ahead.



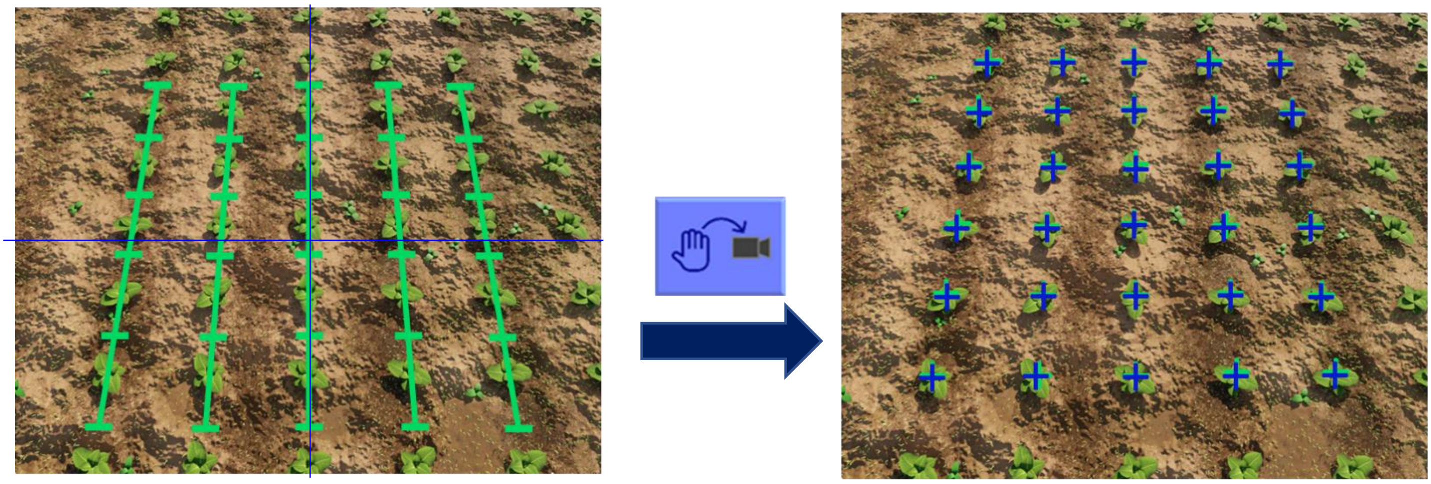
If template lines appear wider than crop rows at the top of the image but narrower at the bottom, rotate the camera down so it views less far ahead.

Best tracking will be achieved when template lines are centred on all the rows being tracked.

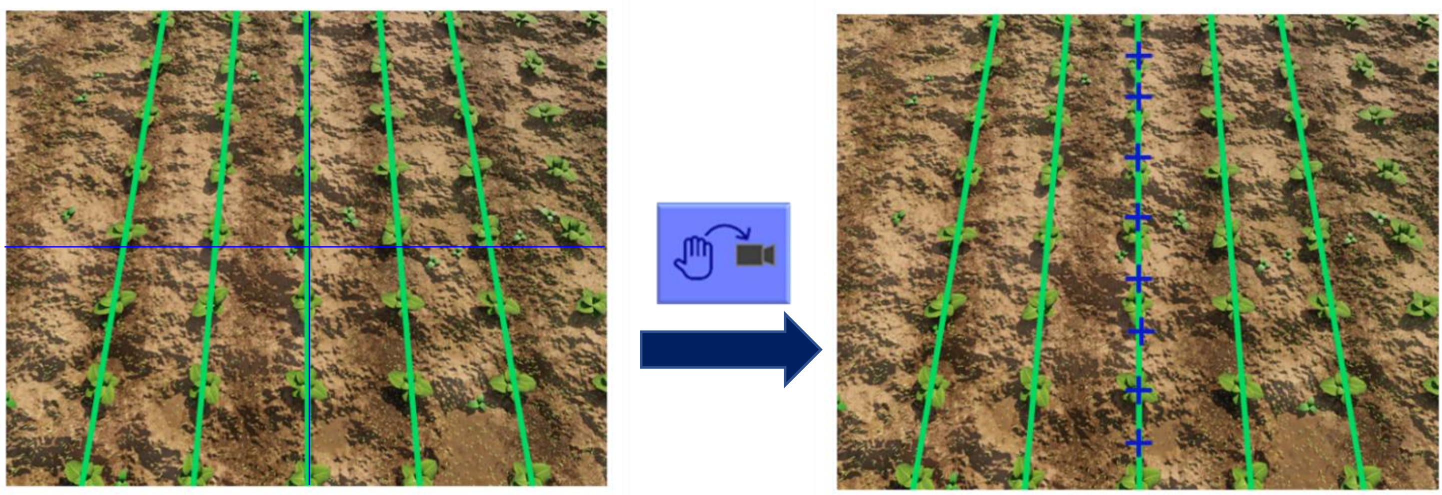


Step 3 – Initial inter-row running and adjusting camera lateral position

When you are happy you have a good template match press the touch screen button with the Hand → Camera icon to resume camera guidance. You can be sure that the machine is ready for tracking in in-row mode if an array of blue and green crosses has appeared over plants as they appear on the display.



For inter-row mode you should see a relatively straight line of blue crosses up the centre of the row pattern.



Note:
For initial set up runs almost all the crosses should be coloured green or blue and form a relatively straight lines corresponding to the crop rows. If this is not the case, or a triangular tracking warning symbol is displayed, either the machine is not correctly set up, or the crop rows are not sufficiently well defined for initial running.

Tip
In order simplify the set-up procedure it is suggested that initial running is conducted with rotary cultivation blades removed. This allows the operator to concentrate on inter-row cultivation and lateral alignment before introducing within-row cultivation.

If tracking appears good set off slowly. The implement should quickly align with crop rows. It is likely that after a short distance it will have settled at a small lateral offset. Small offsets can be corrected using the fine offset facility. Touch screen button labelled with left and right arrows adjust fine offset. Each press of an arrow key biases the side shift in steps of 1cm (3/8”). Continue down the field stopping occasionally to check lateral position. If the required fine offset exceeds the available number of steps the camera should be physically moved as described below and step 3 repeated.

It is the operator's responsibility to decide at which point the vision guidance system becomes 'lost'. If the system losses track of crop rows the operator should carefully guide the implement through to the next good reference.

Tillett & Hague Technology Ltd accept no responsibility for damage to or loss of crop whatsoever.

After approximately 100m of running alignment (“camera skew”) should have been learnt and so camera lateral bias should have stabilised. If fine offset is greater than two steps, we recommend physically moving the camera along the tool frame by the equivalent distance and resetting fine offset to zero.

Tip
If fine offset is set to the left, then the camera should be moved right as viewed from behind looking forward.

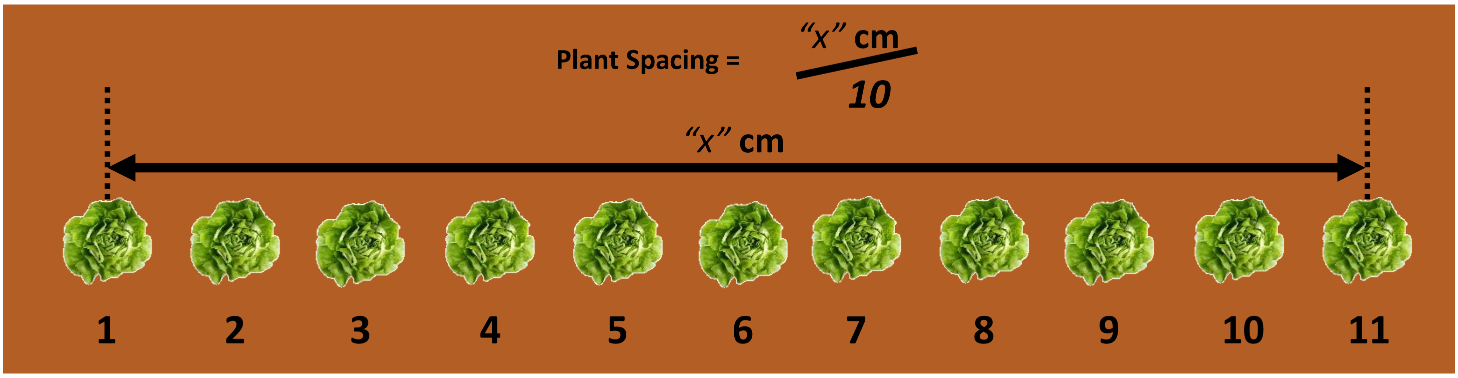
Once you are confident tracking is accurate and reliable, forward speed can be increased.

Tip
When setting up a multi-section machine it is advised to treat each section and its associated cameras as a separate machine and perform individual setup of each section in turn.

Step 4 – Adjusting Plant spacing (for in-row operation)

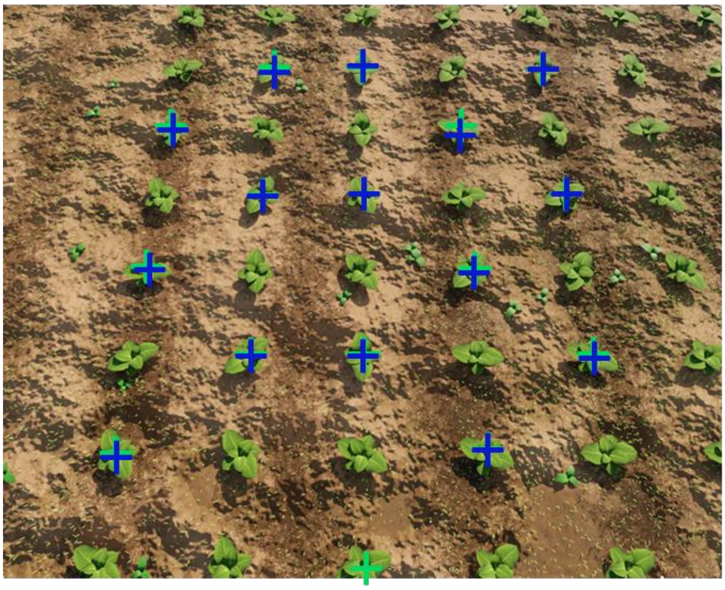
The plant spacing figure shown on the setup screen should be adjusted to be at or just below the measured average spacing in field.

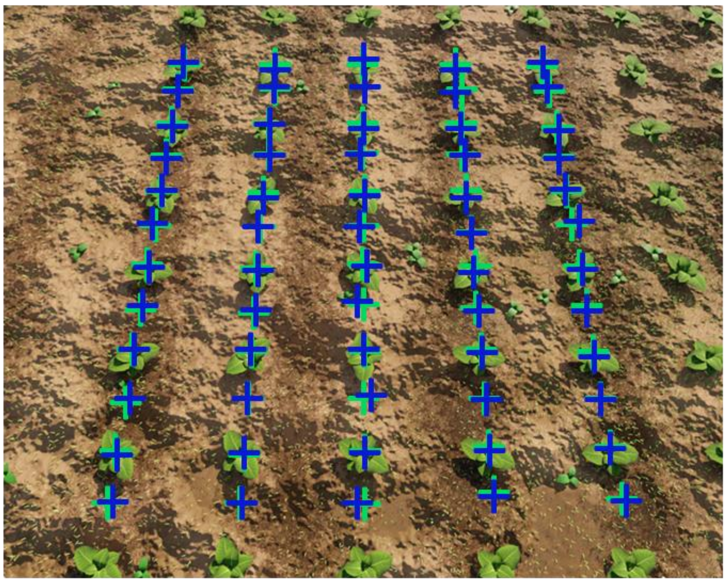
Average plant spacing in field can be calculated using a typical stretch of crop by measing the distance of 10 plant spacings or 11 plants and dividing by 10, as per the diagram below:



Observation of the live camera image tracking crosses can also provide feedback on if plant spacing has been incorrectly set by a large amount as shown below.

More plants than crosses	More crosses than plants
=	=
Plant Spacing too large	Plant Spacing too small

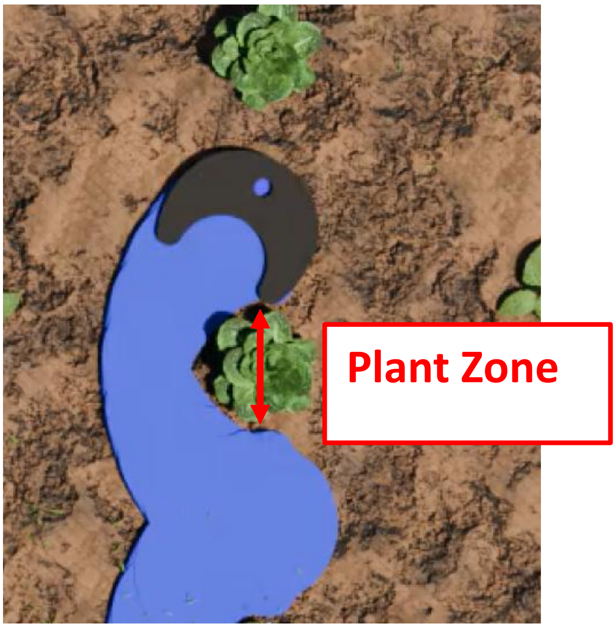




Step 5 – Running with rotary blades

Once you are confident that lateral tracking is accurate and reliable and that the plant spacing is correct, rotary blades/discs can be fitted. Discs should be selected with a “disc size” that is similar to the closest in-row plant spacing that you would like to cultivate between. This parameter cannot be easily measured from the disc itself and so it is necessary to examine the part number.

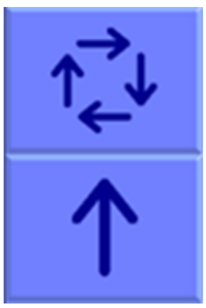
It is important that rotor units are correctly aligned laterally with respect to crop rows. In general blades designed for salad crops (part no: disc size _ 4_W_X) should be set with the centre of rotation offset 4cm from the crop row at ground level. For blades designed for larger crop plants such as brassicas (part no: disc size _ 6_W_X) lateral offset should be 6cm. X in the part number refers to the diameter of the area around a plant that should remain uncultivated, referred to as the plant zone. See Section 10 for available disc sizes.



Lateral Offset (4cm for salads, 6cm for brassicas)

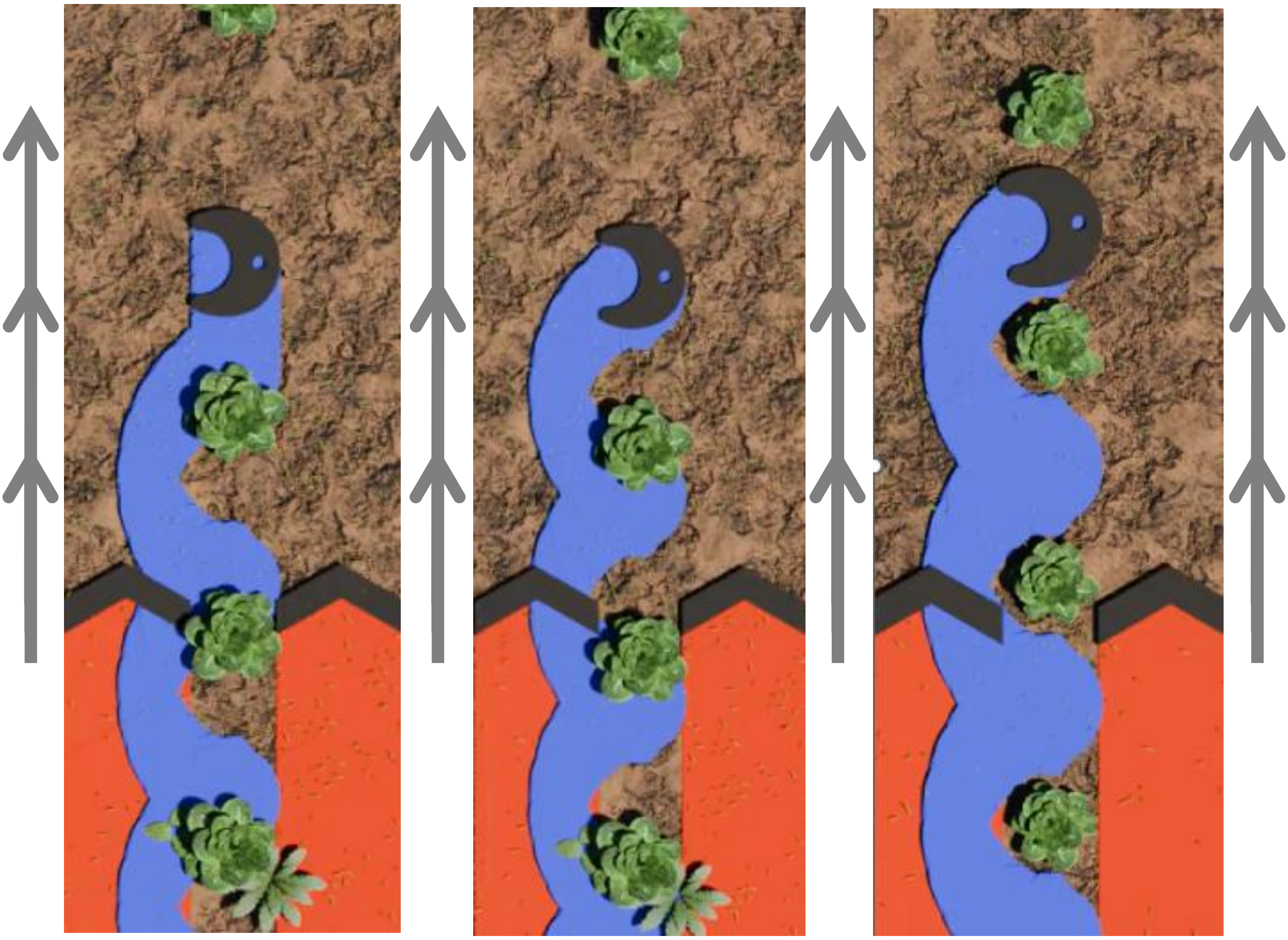
Running in in-row mode check the figure “Ahead of cultivators by” given for that configuration on the set-up screen corresponds to the distance from a point directly below the camera measured back to the centre of rotation of the rotors (see diagram in Section 7 Step 8).

Ensure that fine offset in the fore and aft direction is central. Place the implement down so that rotary blades are at least two plant pitches behind the first plant. Failure to observe this may result in damage to the first plant in each row as the system may not have time to synchronise.



Set off at low speed. After the first few plants have been passed the accuracy of cultivation around plants should be examined. If cultivators are consistently cultivating around a point that is ahead of crop plants the fine offset should be moved down using the down arrow.

Each button press corresponds to 1cm (3/8”) of phase shift. Similarly, if rotary cultivators are cultivating about a point behind the plants the up arrow should be used (see diagram below).



Problem: Cultivation after plant
Solution: Press fine offset up arrow key

Problem: Cultivation before plant
Solution: Press fine offset down arrow key

Correct set up with cultivation symmetrically around plant

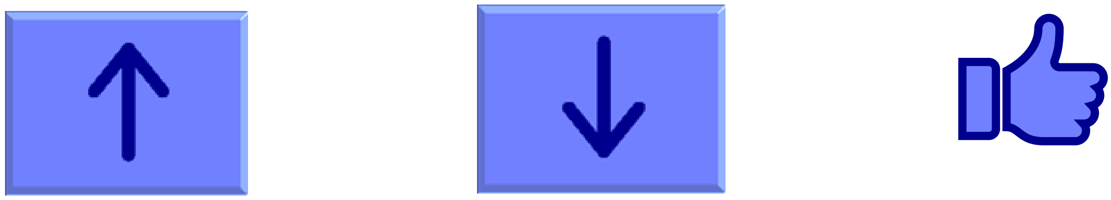


Illustration of how to use fine offset to match the centre of cultivation with crop plants

If a single cultivator is running out of phase compared to other rotors, it may require adjustment fore and aft independently, this can be achieved through mechanically moving the cultivator to achieve correct phase shift. Multiple camera systems require fore and aft offset to be checked separately for each camera and its associated rotors.
Once you are confident that tracking is accurate and reliable, both laterally and fore and aft, forward speed can be increased. The upper recommended linear speed can be obtained by multiplying the upper recommended rotary speed (3 revs/s for hydraulic rotors and 5 revs/s for electric rotors) by disc size (as displayed at the bottom of the set-up screen), thus for a hydraulic machine with a 40cm disc the nominal maximum speed is 1.2m/s (4.3kph). For an electric machine with a 20cm disc size nominal maximum is 1.0m/s (3.6kph). Rotors will rotate at higher speeds than these though accuracy will decline. In most cases the maximum forward speed will be limited by mechanical effects of

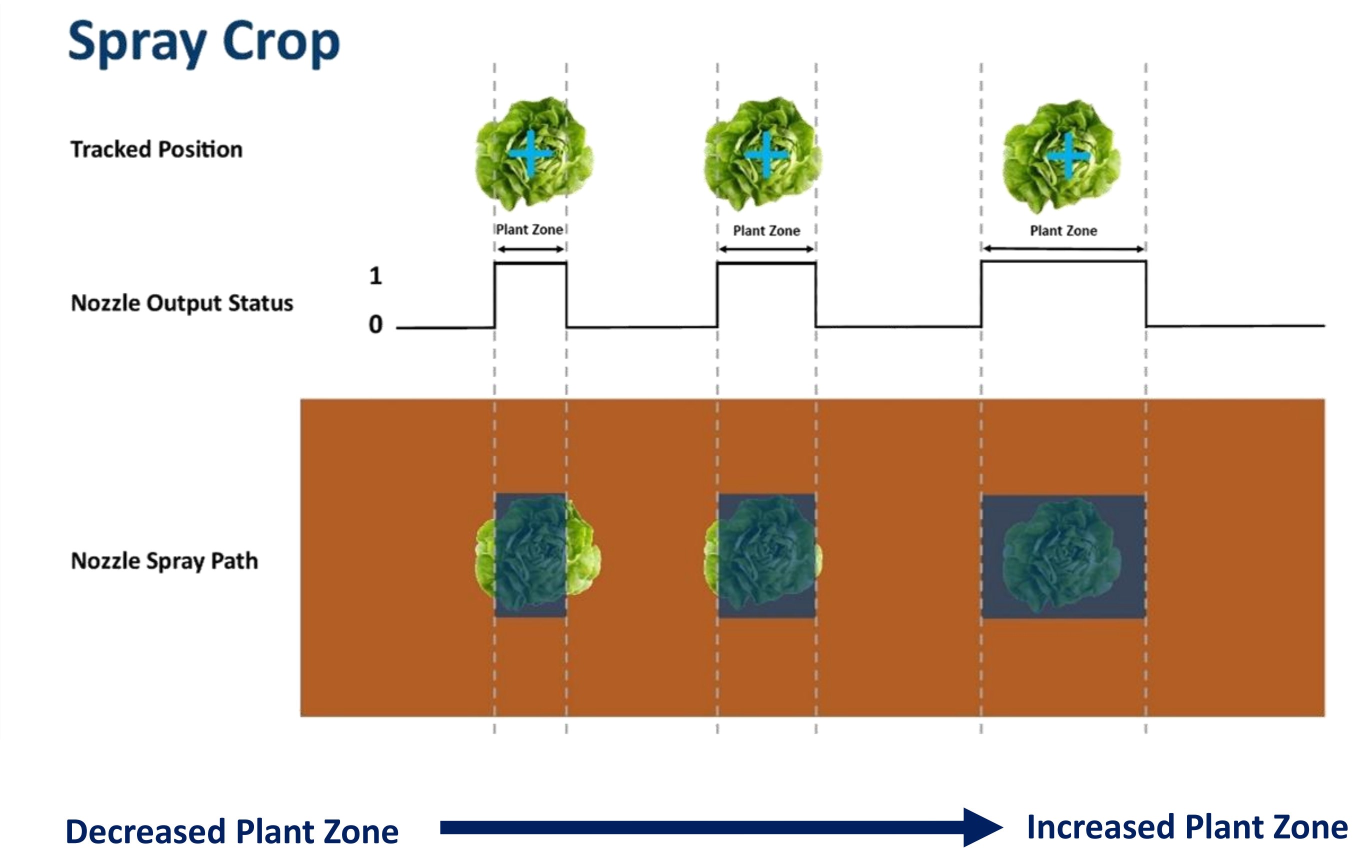
cultivators on the soil and its effect upon plants. Excessive speed will be shown as a red section on the normally green or orange speed bar and is likely to result in a tracking warning in the fore and aft direction. Should that occur, the speed should be reduced to a safe level below that at which the warning appears.
It is the operator's responsibility to decide at which point the vision guidance system becomes 'lost'. If the system losses track of crop plants the operator should cease cultivation and seek to establish the cause of the problem.

Step 6 – Running with nozzles

Nozzle operation has two key parameters:

Plant zone: sets the distance around plant centre for the nozzle to be triggered on or off.

Spray crop/avoid crop: This parameter alternates between triggering the nozzle on to spray crop or off to avoid crop when entering the plant zone.



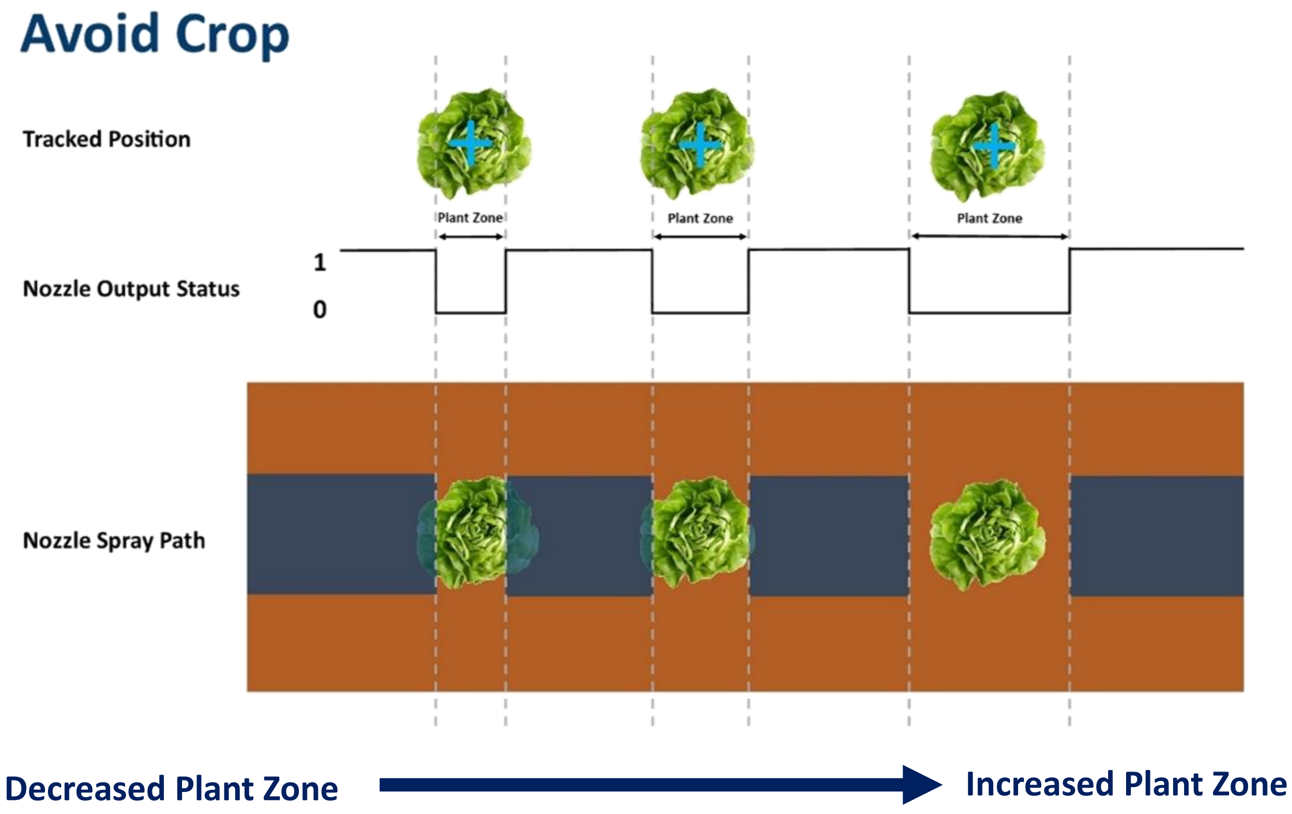
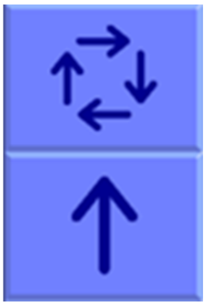


Illustration of nozzle operation parameters

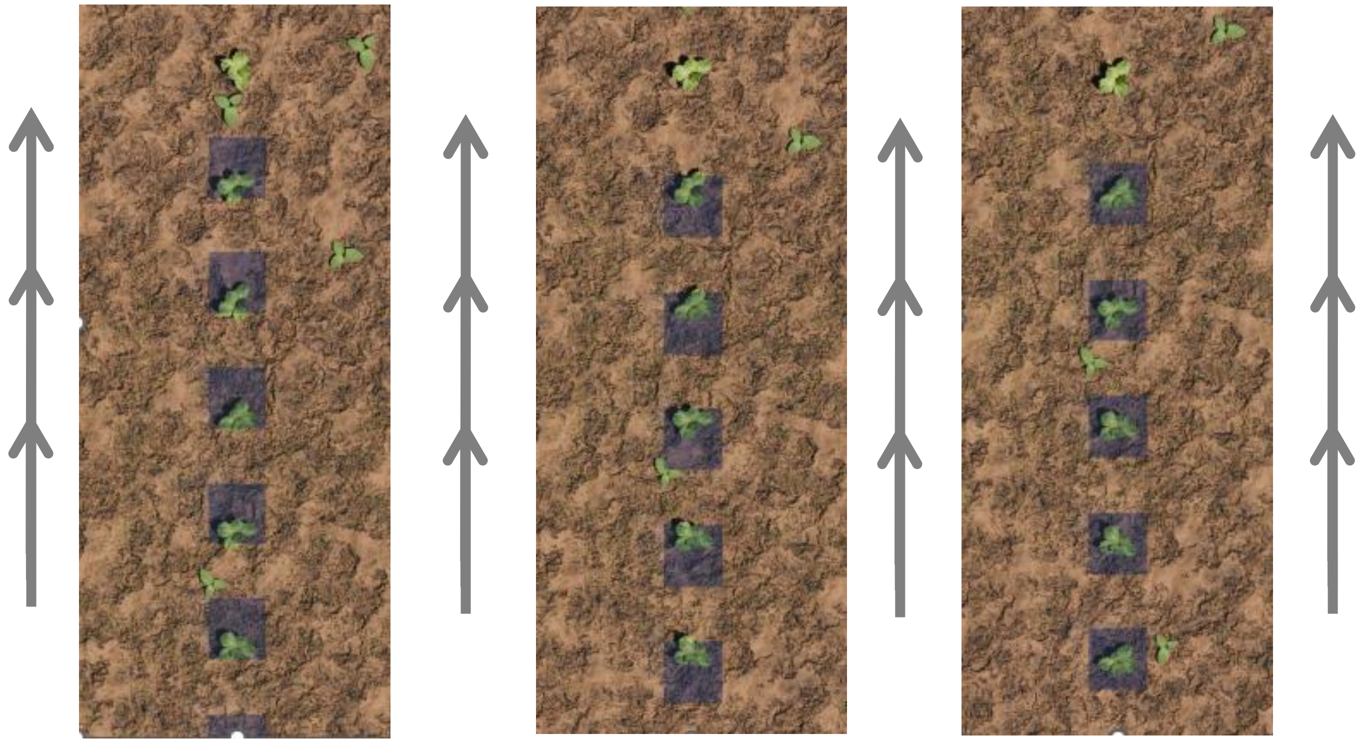
Running in in-row mode check the figure "Ahead of nozzles by" given for that configuration on the set-up screen corresponds to the distance from a point directly below the camera measured back to the centre of rotation of the nozzles.

Ensure that fine offset in the fore and aft direction is central. Place the implement down so that nozzles are at least two plant pitches behind the first plant. Failure to observe this may result in missing the first plant in each row as the system may not have time to synchronise.



Set off at low speed. After the first few plants have been passed the accuracy of spraying should be examined. If necessary, use the fine offset as described for rotors above.

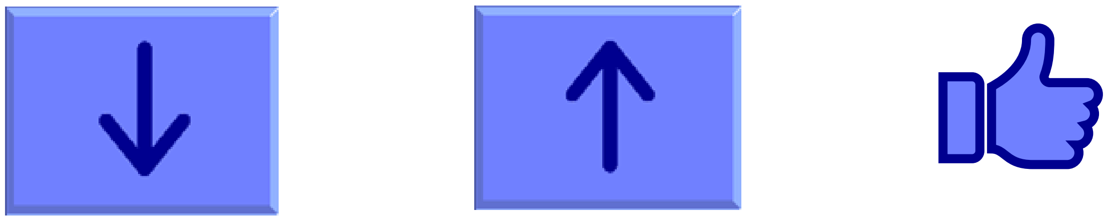
Each button press corresponds to 1cm (3/8") of phase shift.



Problem: Nozzles spraying after plant
Solution: Press fine offset down arrow key

Problem: Nozzles spraying before plant
Solution: Press fine offset up arrow key

Correct set up with nozzle spraying symmetrically around plant.



It is best practice to initially start setup of nozzles using clean water. And spray targeting can be best judged using the setting “Spray plants” with a smaller plant zone distance entered.

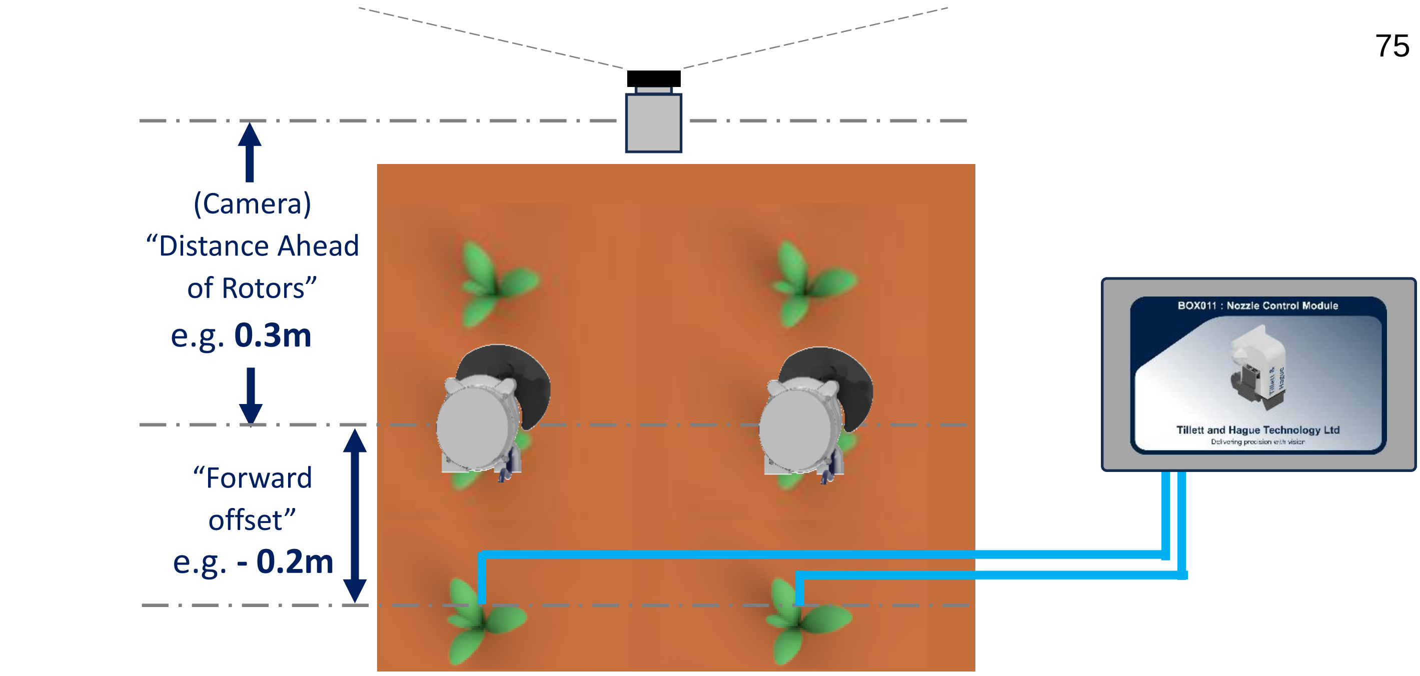
Tip
When setting up a multi-camera machine you must treat each camera view separately and perform individual fore aft fine offset setup for each camera in turn.

Step 7 – Running with both rotors and nozzles

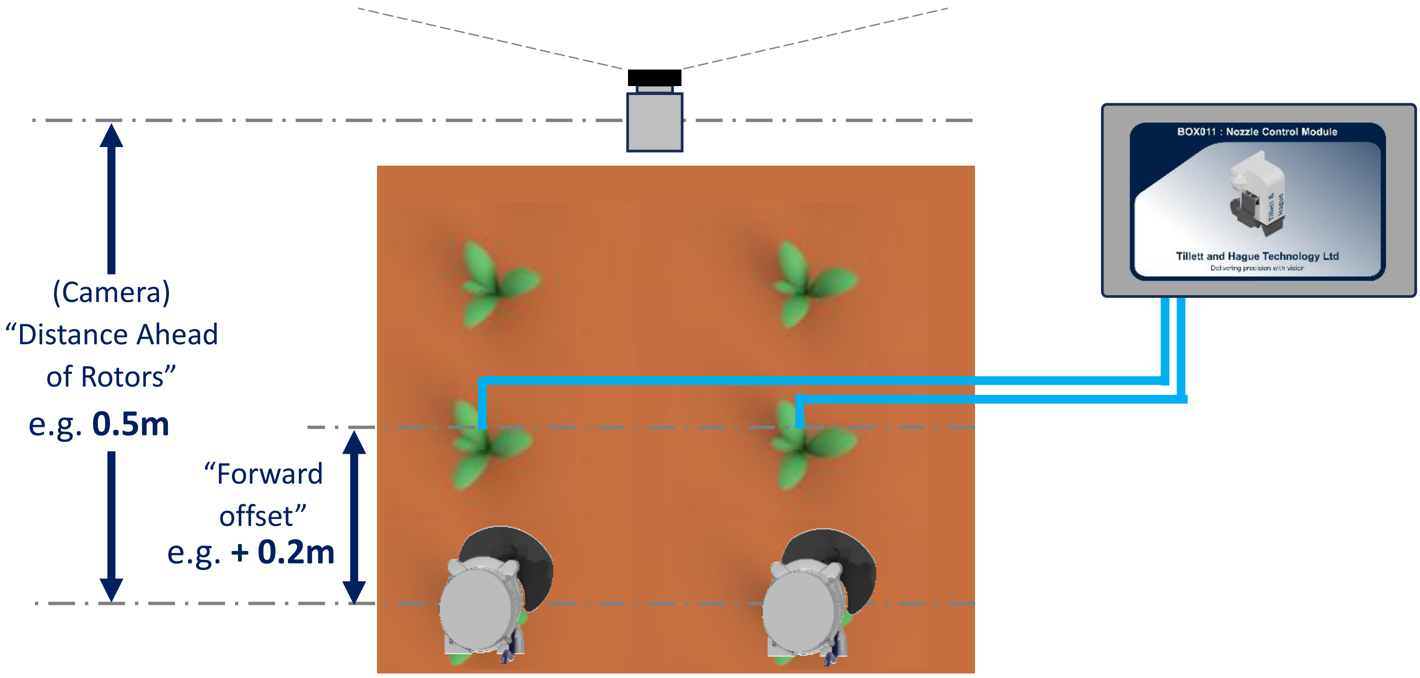
Typically, nozzles will be mounted in a staggered or offset pattern relative to rotors. Rotor offset is defined relative to the camera as “Distance ahead of rotors”. Nozzle offset is then defined relative to the rotors as “Forward offset” as illustrated below.

When fore and aft fine offset is applied in this configuration from the working screen, it is applied to both rotors and nozzles simultaneously, so it is important that their relative position is entered correctly within the configuration editor.

In the configuration editor we can set “Forward” offset for individual nozzles. A positive offset indicates the nozzle is forward of the rotor in that row, and negative offset indicates the nozzle is behind the rotor. The diagrams below show a typical camera, rotor and nozzle setups.



Negative forward offset for nozzle positions behind rotors

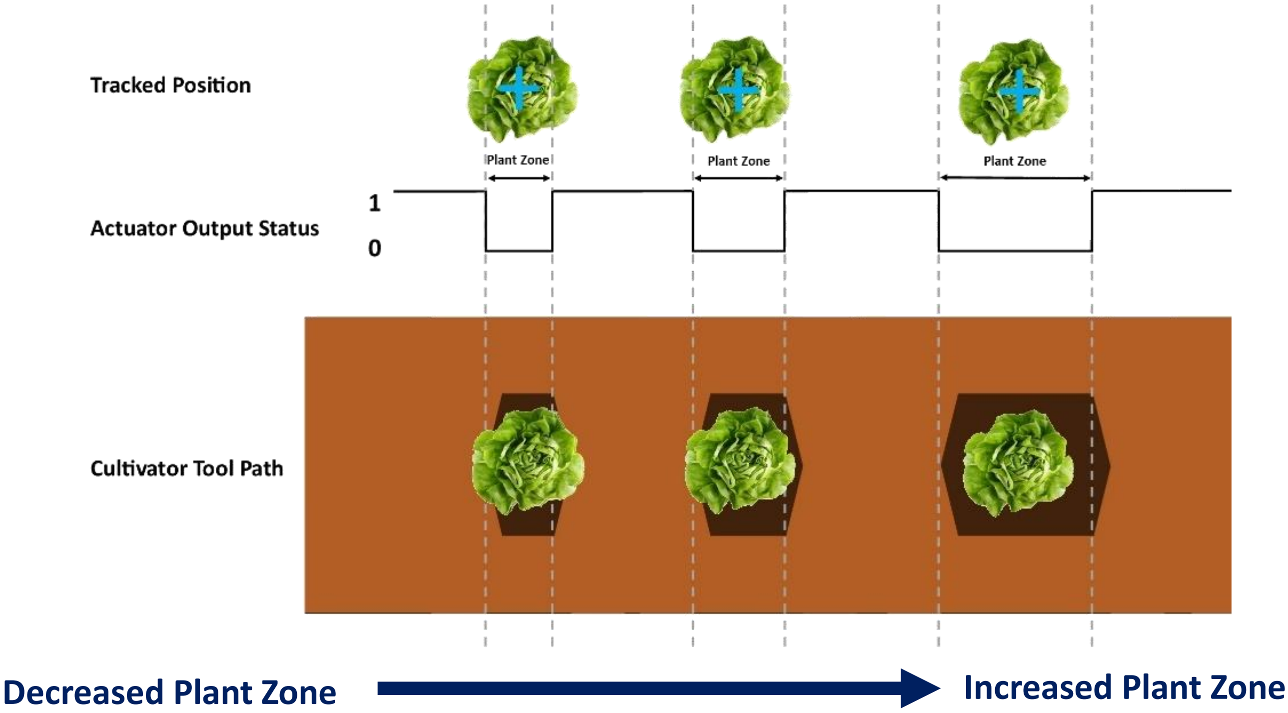


Positive forward offset for nozzle positions ahead of rotors

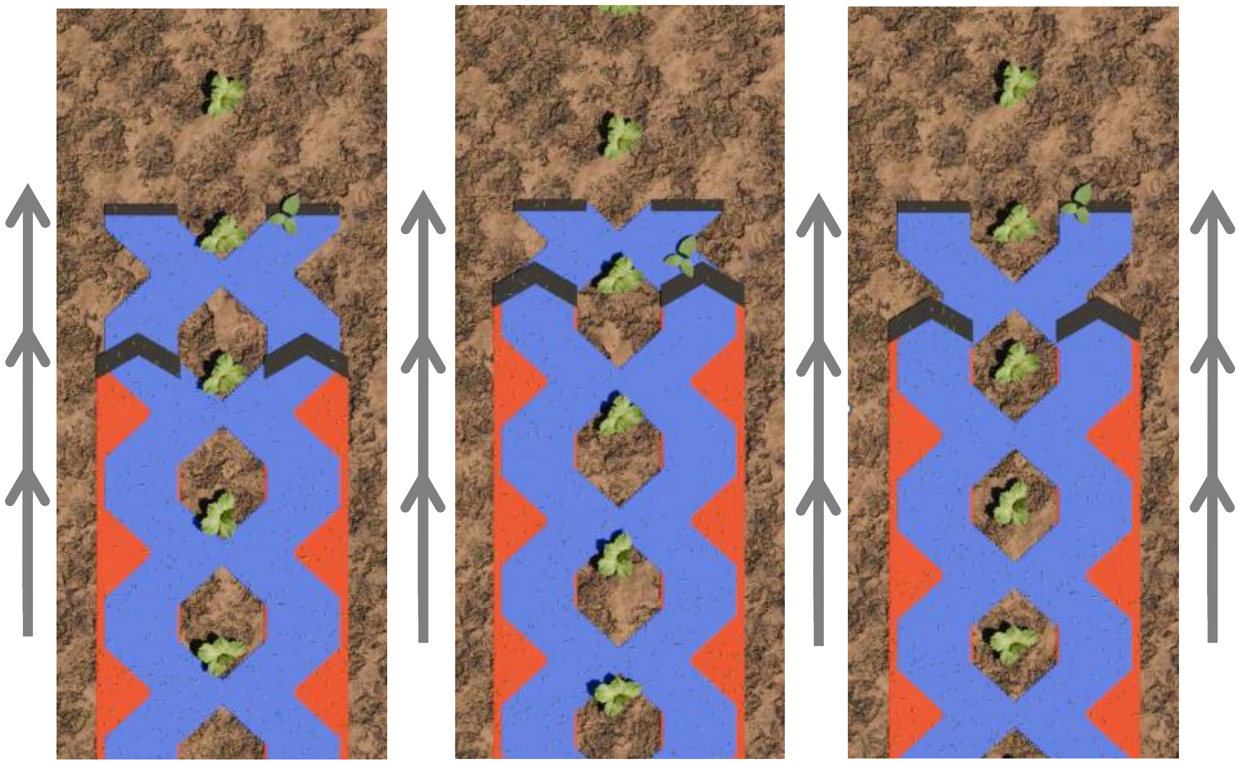
Step 8 – Running with reciprocating blades

Setting up In-row reciprocating blade cultivators is very similar to nozzles, whereby a cultivator module is activated when entering the crop zone and deactivated upon leaving the plant zone. We advise performing initial setup at a slow speed adjusting fine offset over the first 100m or so of running.

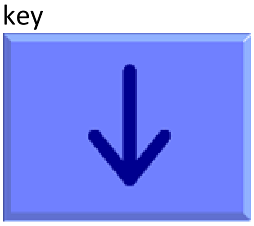
Once correct cultivator phase has been achieved it is also possible to adjust clearance of the cultivator blades from the crop itself by adjusting the plant zone. As illustrated on the next page:



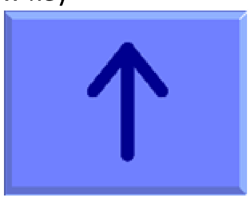
It should be noted that unlike rotary in-row cultivators the area cultivated by reciprocating cultivating blades will be influenced by the speed of the reciprocating mechanism and the forward speed of the implement. It may therefore be necessary to make adjustments to forward fine offset as forward speed changes.



Problem: Cultivation after plant
Solution: Press fine offset down arrow key



Problem: Cultivation before plant
Solution: Press fine offset up arrow key



Correct set up with cultivation symmetrically around plant.

Step 9 - Neutralising forward and backward fine offsets

Once all the devices are timed correctly you will probably find that the forward and back fine offset values are not central. It is good practice to leave the customer with these at least close to zero so that they have scope for adjustment in the future.

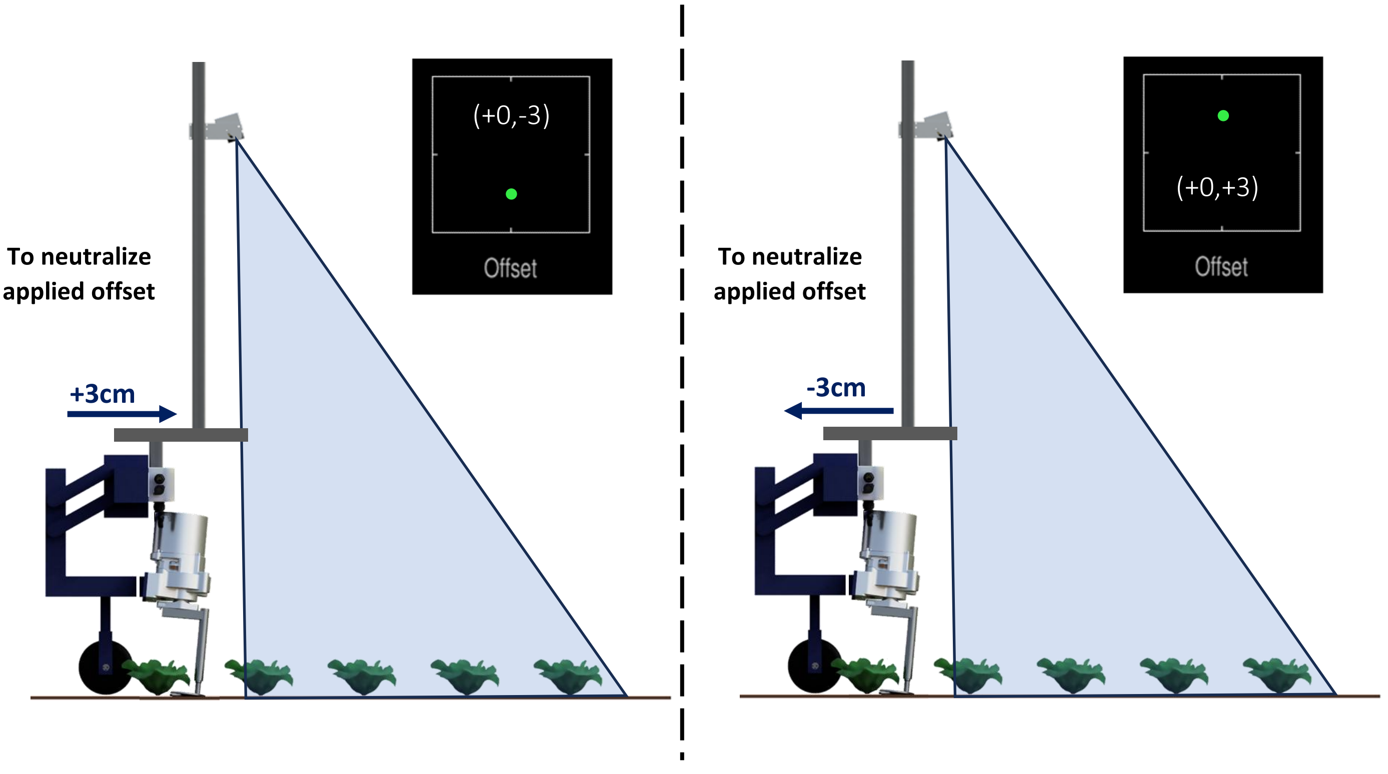
These offsets can be neutralized in two different ways. You can either physically move the camera forwards and backwards in relation to the cultivators or nozzles, or you can edit offsets in the configuration.

We will consider physical adjustment first.

It is a good idea to think of the camera and crop as a fixed datum and decide which way you want to move the cultivators or nozzles to neutralize the applied offset. If the fine offset is forward shown as upward and positive in the fine offset graphic, you would want to move the treatment devices forward closer to the camera.

In practice it is easier to move the camera so for a positive fine offset you would instead move the camera backwards by the same amount. For example, for an applied forward fine offset of + 3cm, the camera must be moved backwards by 3cm to compensate. Similarly, of course if the applied fine offset was negative, you would move the camera forward.

Note that it is important that all other aspects of camera alignment are maintained, and that this forwards and backwards movement is a pure translation.



To avoid the need for physical adjustment you can instead change the camera “distance ahead of cultivators or nozzles” number in the configuration (see Section 10, Edit Camera Settings) to have the same effect. To take the same example, for a 3cm positive fine offset you should add 3cm to the “distance ahead of rotors figure”. You can think of this as correcting for the fact that the treatment devices seem to be further behind the camera than previously thought during initial set up. You are correcting for that error that rather than physically moving the cultivators. Similarly, if the offset is negative, decrease the “distance ahead of rotors figure” by 3cm.

Once you have made an appropriate adjustment, either physical or to the configuration, you should neutralize the fine offset.

Step 10 - What to do if none of the available configurations are appropriate

If none of the available configurations are appropriate for your situation. Make a note of the relevant parameters and the name of the configuration that most closely matches your situation.

Enter the configuration editor and either edit your chosen configuration or create a copy of it to edit.

Instructions on how to edit configurations is given in Section 10.

9. Notes on daily operation with a correctly set up machine

- Before operation check that electrical and hydraulic connections are secure and that there are no obstructions to side shift/disc movement. Check also that any hydraulic filter indicators fitted do not show that the filter is blocked.

- On first setting the implement down in the field check for each camera that the green and blue crosses line up with crop plants and form relatively straight lines corresponding to crop rows. There should be few yellow or red crosses.

- Proceed with caution for first few meters checking that the speed gauge matches the tractor's and that implement alignment is good. If performance is satisfactory speed can be increased.
    - Within-row tracking should be very good at linear speeds of up to 3 (rev/s) times disc size (e.g. 3 rev/s x 0.3m = 0.9 m/s =3.2 kph) for hydraulic rotors and 5 rev/s for electric rotors.
    - Reciprocating blades are generally only effective at lower speeds. Higher speeds are possible, but blades may not have time to reach fully into the row, thus reducing efficacy.

  Soil and crop conditions may dictate maximum speeds.

- Fine offset is remembered from previous sessions and so there should not be any need to adjust this unless changes have been made to camera position.

- Setup parameters such as crop height, plant spacing, clearance etc are remembered from last operation of selected configuration.

- Operating on side slopes will result in some lateral error due to the tractor "crabbing" across the slope. Normally this is not significant, but in extreme cases it may be necessary to use the fine offset function to compensate. If operating in this way remember to reverse the bias when heading in the opposite direction and to return to a neutral setting when stopping work or moving to a flat area. A similar technique can be used to compensate for crop bent laterally by a cross wind. The offset flip tool can be useful in these circumstances.

- When the implement is lifted at row ends it will centralise ready for the next run.

- At the end of the day shut down the system by pressing the touch screen button with the power button logo and the system will shut down automatically. The power button led go out but will continue to briefly illuminate every 5 sec indicating that power is still applied via the implement. In this state the current draw is negligible.

- It is also advisable to discharge any hydraulic accumulators by reversing the tractor's hydraulic spool briefly or setting the hydraulic spool into "float" position. The implements pressure gauge indicates if this has been achieved.

10. Configuration editor

Configurations store information relating to a specific crop planting pattern and implement/tractor geometry that is necessary for row tracking. Each combination of a different crop pattern or implement geometry requires its own configuration.

The configuration editor allows experienced users to create and edit configurations. It is reached from the System information and diagnostics screen by pressing touch screen button labelled with a file and pen symbol. Users are required to enter a PIN to prevent accidental entry to the editor. The default is 1,2,3,4.

The editor is multilingual, though translations are not available in all languages. Where translations are not available, English will be displayed, though use of graphical symbols makes many functions independent of language

The editor uses the touchscreen for navigation and data entry.

Overview of screen display and how to edit configurations

On entry to the configuration editor users are presented with a list of available pre-entered configurations. Touching on a name selects that configuration, highlights it with a change in intensity or colour and prefixes it with a “>” character.

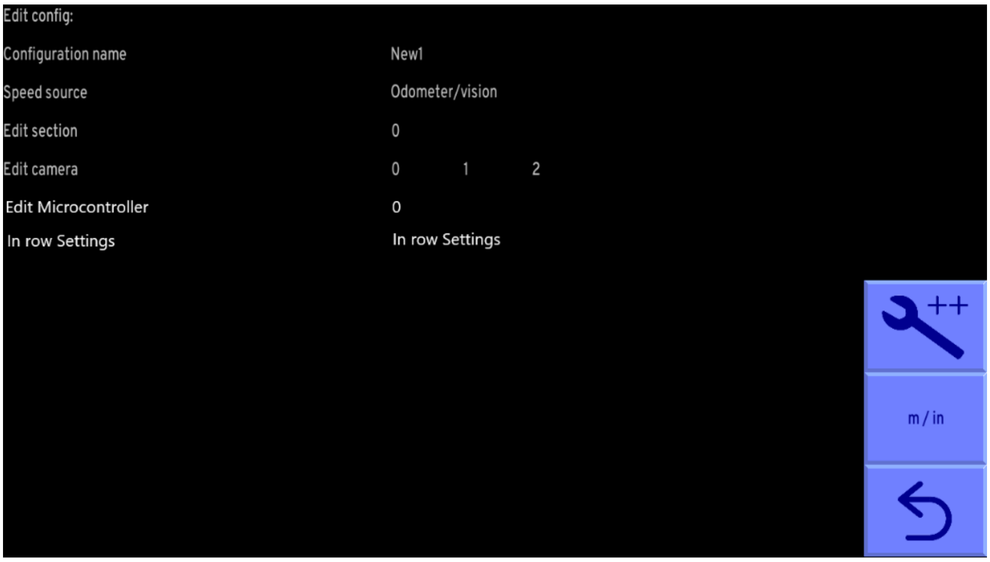
Buttons on the right-hand side of the screen perform actions on the selected configurations, create new configurations, or change language settings.

- The top right button with a drawing of a single file and a “+” symbol creates a new configuration. **NB It is very rarely advisable for users to create a new configuration from defaults in this way. It is usually easier and safer to use the copy function (see below) to create a new configuration based on one that was factory installed and is already known to work.** If pressed users are presented with a series of choices regarding the type of machine that they want to create a configuration for. Following these choices will eventually lead to a default configuration that offers the best starting point for a new configuration. The newly created configuration will be added to the list, given the name “new” and selected ready for editing.
- The second button down depicting a two file graphic copies the selected configuration and adds that copy to the list with the name “new”. It is selected and ready for editing. This is the preferred method for creating new configurations on a working machine.
- The third button down depicting a file and a pen graphic starts the editing process on the selected configuration, presenting a list of configuration parameters that are available for editing.
- The fourth button down on the top configuration editor screen depicting a bin deletes the selected configuration.

- The bottom button labelled with a loop back arrow returns to the start screen.

Note: When you next run the system you need to select the appropriate configuration as editing a configuration does not automatically select it.

Settings available from the standard editor



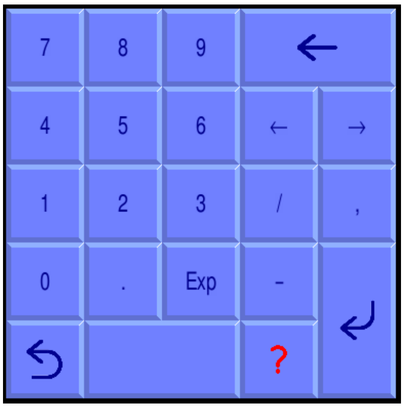
Configuration editor screen with standard settings selected

In editing mode three buttons are present at the bottom right of the screen:

- The top button marked with a spanner and two "+" symbols selects the advanced version of the editor. This offers a wider range of settings, but is rarely necessary under normal circumstances and should only be used by experts, and even then with caution. See below for the additional functions offered in the advanced editor.
- The second button from the bottom switches between metric and imperial units.
- The bottom button labelled with a loop back arrow returns users to the next level up.

Touching on an item either pops up an appropriate keyboard (Letters for editing names, numeric for entering numbers) or presents another lower level list of parameters to select from. To remove the keyboard from the screen, press it's return key.

Touching the keyboard **?** key gives context relevant help. Please make use of this facility it can be very helpful.

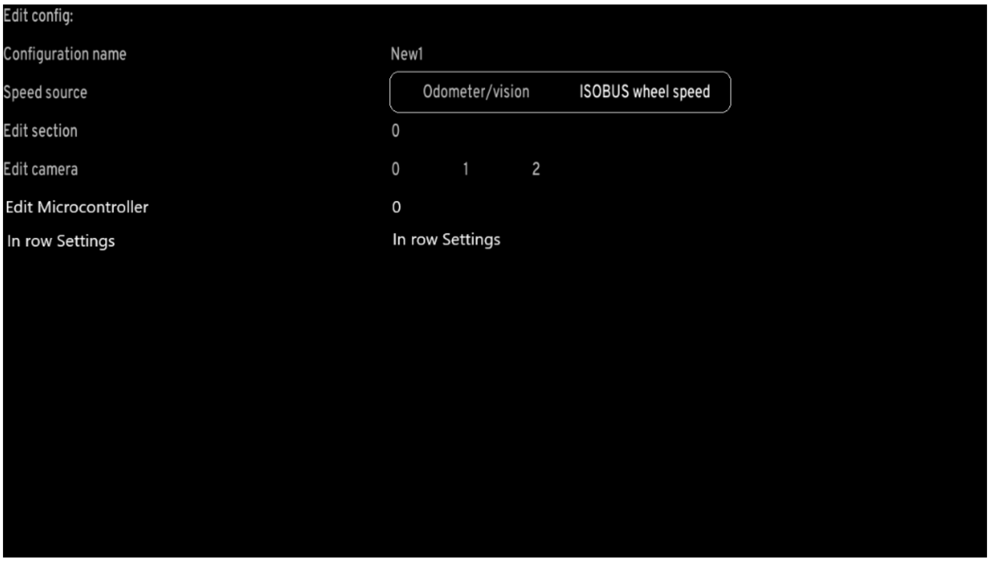


*Numeric keypad with "**?**" Help function*

General settings

The first provides an opportunity to change the configuration name. This can be up to 10 characters long and should be meaningful to the operator.

The second setting of "Speed Source" allows for selection between odometer input source to be derived from ISOBUS wheel speed or Microcontroller/Visual odometer input.



Configuration editor selection of speed source

The remaining categories of settings relate to machine subcomponents. It is possible to have more than one of these subcomponents on a single machine. For example, a machine may have two or more cameras so there will be the option to edit settings for each of these cameras independently. For reasons relating to internal computing conventions numbering of these subcomponents always starts at zero, e.g. the first camera has index number 0 and the second 1.

To edit settings for any of these subcomponents touch on the blue index number in "[_]" for the sub component that you wish to edit. This will get you into the edit screen for that particular component. Once you have completed editing that subcomponent you can return to the previous screen by pressing the button with a loop back arrow.

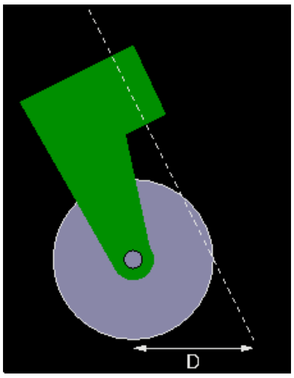
Edit Section settings

A section is defined as a frame that has independent steering. Most implements will have only one section. However, it is possible to have an implement with up to four independently steered sections. This is useful when it is required to span multiple drill/transplanter bouts.

Configuration "Section" standard editor screen

The settings are;

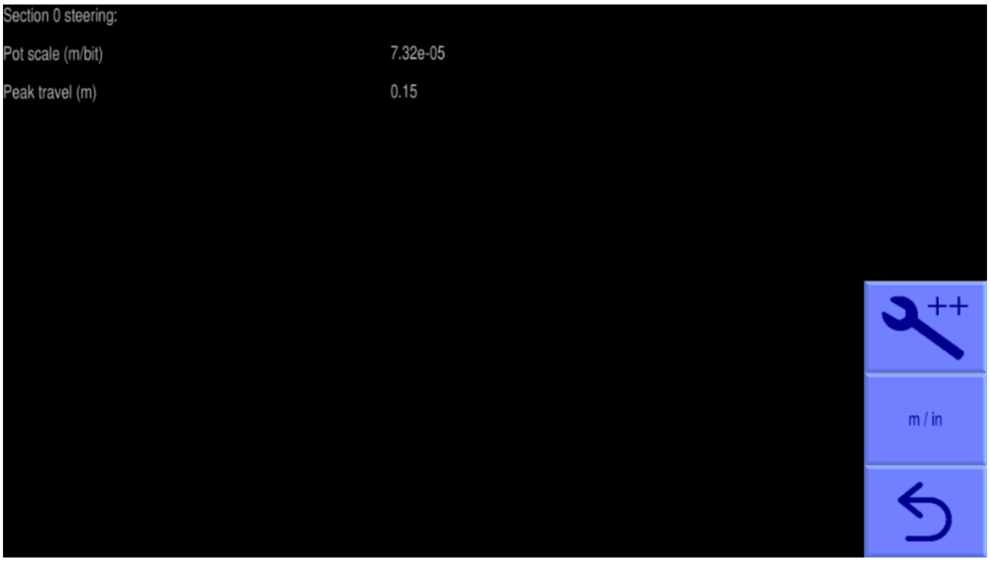
“Width” is the width of that section and is only used to calculate area worked, “Steering arm length” (distance “D” in figure below) for disc steered machines only.



“Steering arm length” D

“Cameras mounted” which allocates which cameras are fitted to that section, e.g. 0 for one camera, 0,1 if two are fitted.

It is also possible to edit further steering mechanism parameters.



Configuration “Steering parameters” standard editor screen

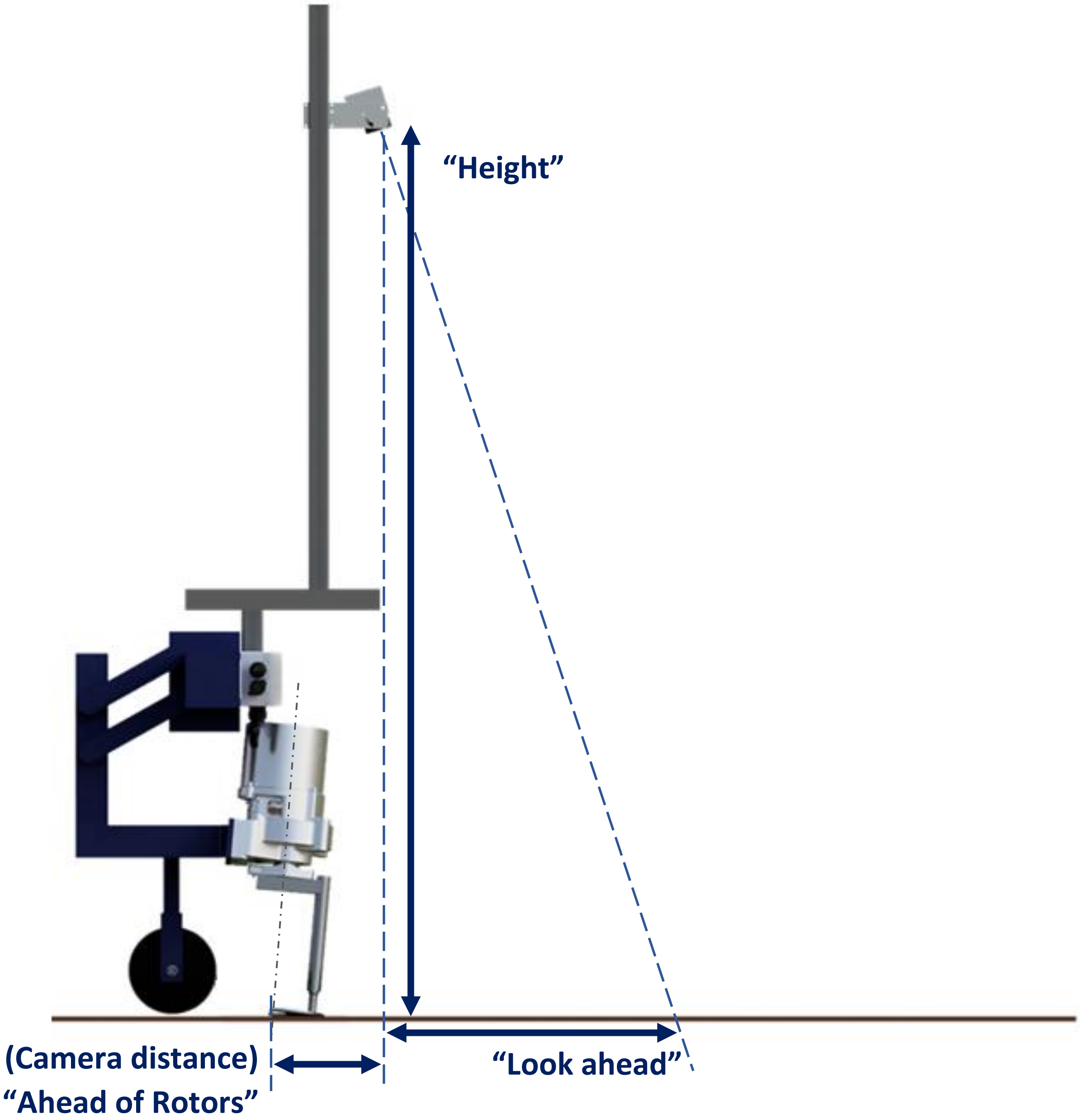
For side shift machines using a linear position sensor “Pot scale” is derived by taking full sensor stroke in m and dividing by the digital range in bits. Our electronics accepts signals from 0V to 5V and use a 12bit converter i.e., 4096 bits. A potentiometer driven by our 5V reference will provide a 0-5V output giving a 0 – 4096 digital scale. For a 0.5m potentiometer that would be 0.5m/4096 = 0.00012207 m/bit. For a within cylinder position sensor with a 0.5V to 4.5V output then the digital scale would be 409 – 3687, a range of 3278 bits, so a 0.5m stroke position sensor would have a scale 0.5m/3278= 0.00015253 m/bit.

“Peak travel” is measured from central position, usually set to be just under half total sensor stroke.

For disc steer machines peak travel becomes maximum angular deflection in degrees from the central position and Pot scale becomes the full rotary stroke of the rotary position sensor in degrees divided by 4086 (for a 0-5V output).

Edit Camera settings

The first three settings relate to camera mounting geometry as illustrated below. Camera height is the vertical distance in m (or inches with imperial units set) from ground level to the camera lens when the implement is at its normal working height. Look ahead is the horizontal distance from a point directly below the centre of the camera lens the centre of the image in the ground plane (depicted by cross hairs in manual mode). "Distance ahead of rotors/nozzles/cultivators" is the horizontal distance in m (or inches with imperial units set) that the camera is set ahead of the cultivators. It is measured from a point vertically below the camera lens back to the in-row cultivator/rotor blades or nozzles.



The next settings relate to what is seen in the image. The number of rows and their spacing.

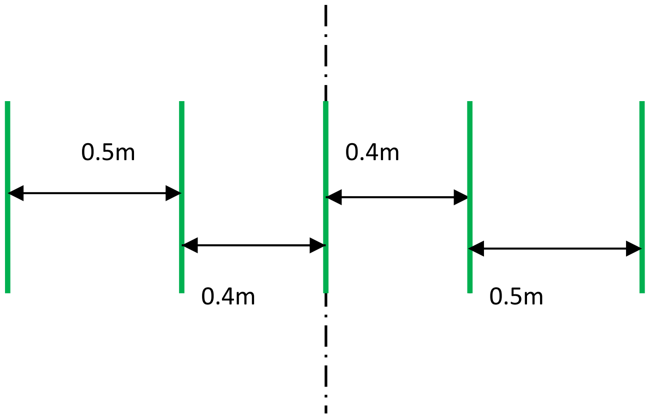
The number of rows entered here determines how many rows are used to construct the template.

Spacing between rows is normally uniform across the field of view and is therefore a single figure. However, some crop geometries with a number of different row spacing's in the same scene require a more complex arrangement. Syntax for this is based on the assumption that the pattern is symmetrical about the centre line and starts with the central row spacing working out to the edge. Figures are comma delimited. In the case of an even number of rows the first figure is always the whole row spacing, not the distance from the centre line to the next row. The following examples cover likely configurations.

Odd no of rows irregular spacing example

Rows 5

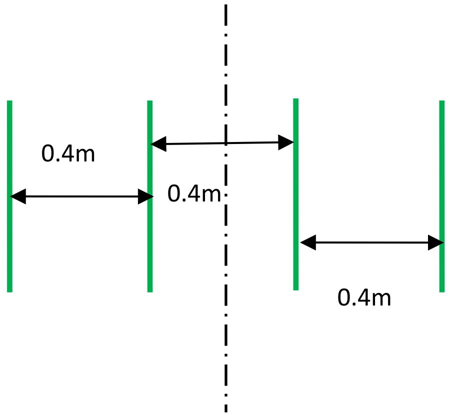
Spacing 0.4,0.5



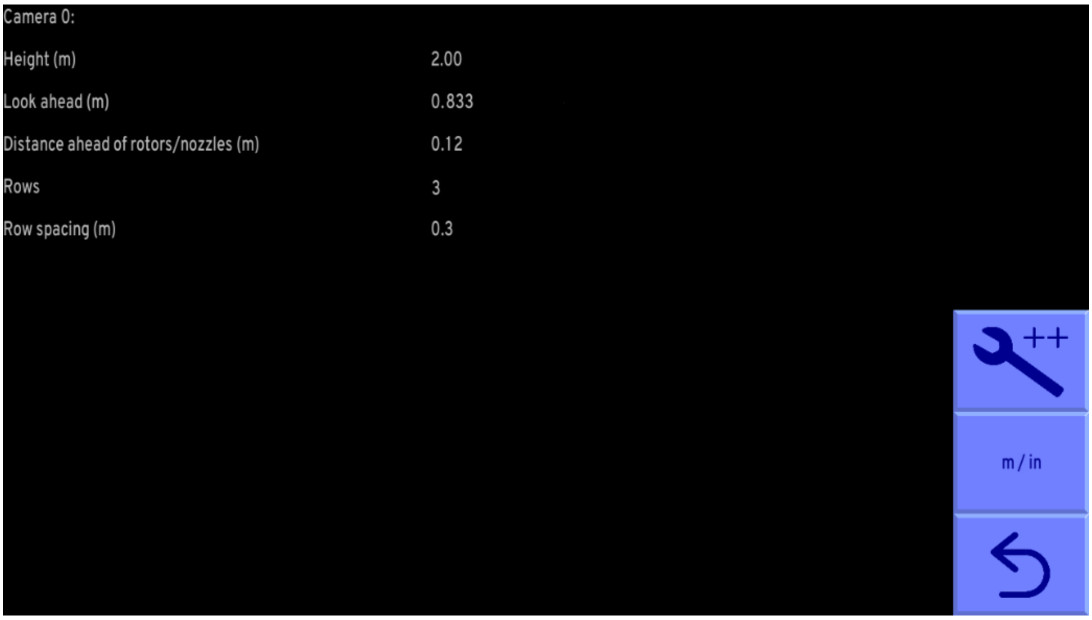
Even no of rows regular spacing example

Rows 4

Spacing 0.4



NB In the special case of following only one row the most accurate tracking will be achieved with row spacing set to between two and three times crop foliage width with an absolute minimum of 20cm.



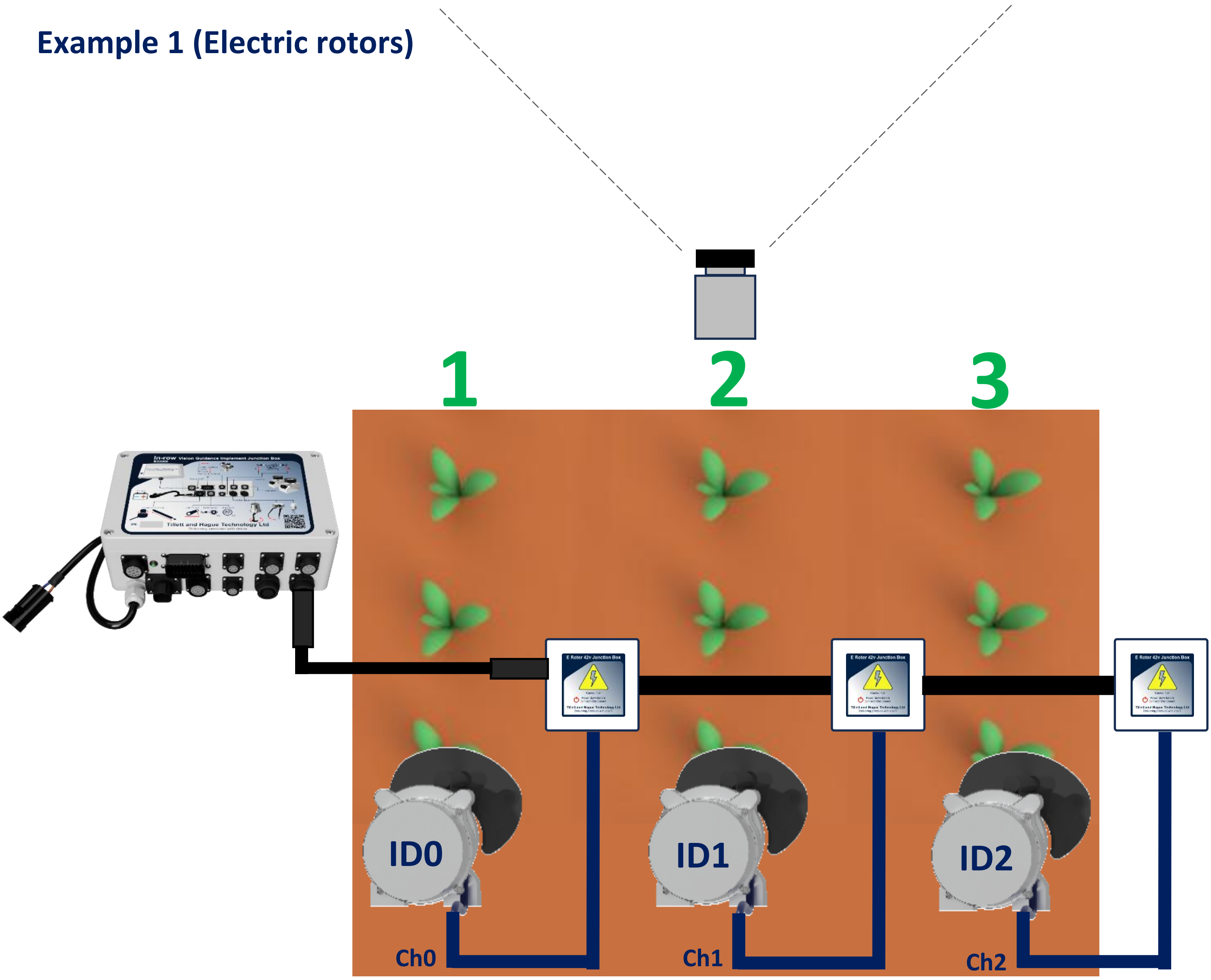
Configuration "Camera" standard editor screen

Edit Microcontroller (CANbus device settings)

This screen allows users to select which crop rows are allocated to rotor, nozzle or in-row reciprocating blade control channels associated with that implement module. For electric rotors rows are allocated to channels in ascending numeric order (defined by CAN address) (See Example 1) Hydraulic rotors are connected to implement modules via hydraulic control boards that have six channels each. Rotors connected to hydraulic board are also allocated channels in ascending numeric order. However, the first channel of a second hydraulic rotor board would be allocated channel 7, irrespective of how many channels were used on the first board. Unused channels are allocated row "0" which is a code that will cause those channels not to be used. For example, an eight row machine with one implement module that has half its rotors wired to one hydraulic control board, and the other half to a second, would have the row allocation 1, 2, 3, 4, 0, 0, 5, 6, 7, 8 (See Example 2)

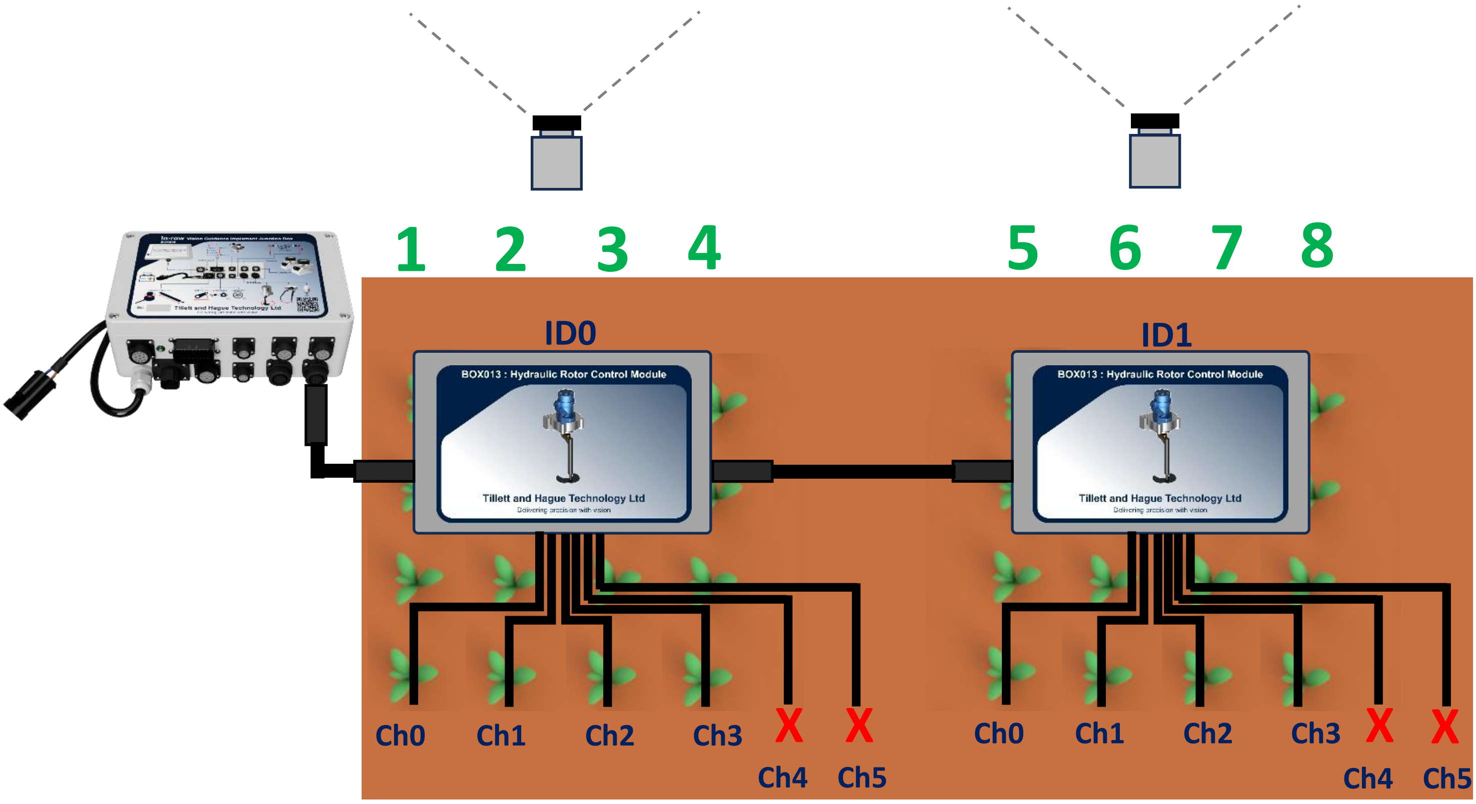
The unused rotor row "0" allocation is also used when a rotor/channel is not required for a particular crop. For example, a single camera, single implement module machine is equipped with five rotors for five rows. Under normal circumstances cultivating all five rows the row number allocation would be: 1, 2, 3, 4, 5 (See Example 3). If however, the same machine was to be used on a four row crop using the outer two rotors on each side then the allocation would be: 1, 2, 0, 3, 4 (See Example 4).

Example 1 (Electric rotors)



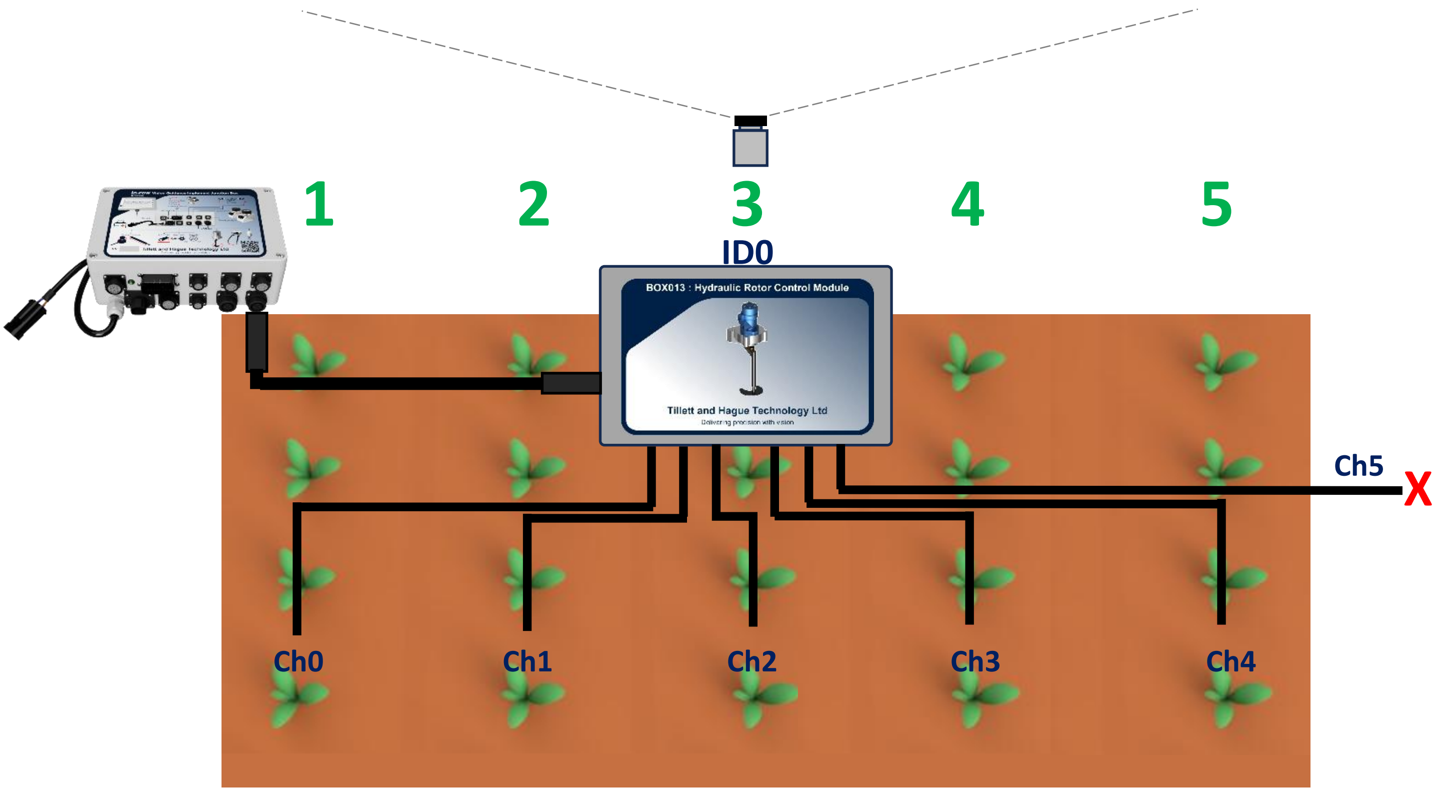
Rotor Row Numbers : 1,2,3

Example 2 (Hydraulic rotors)



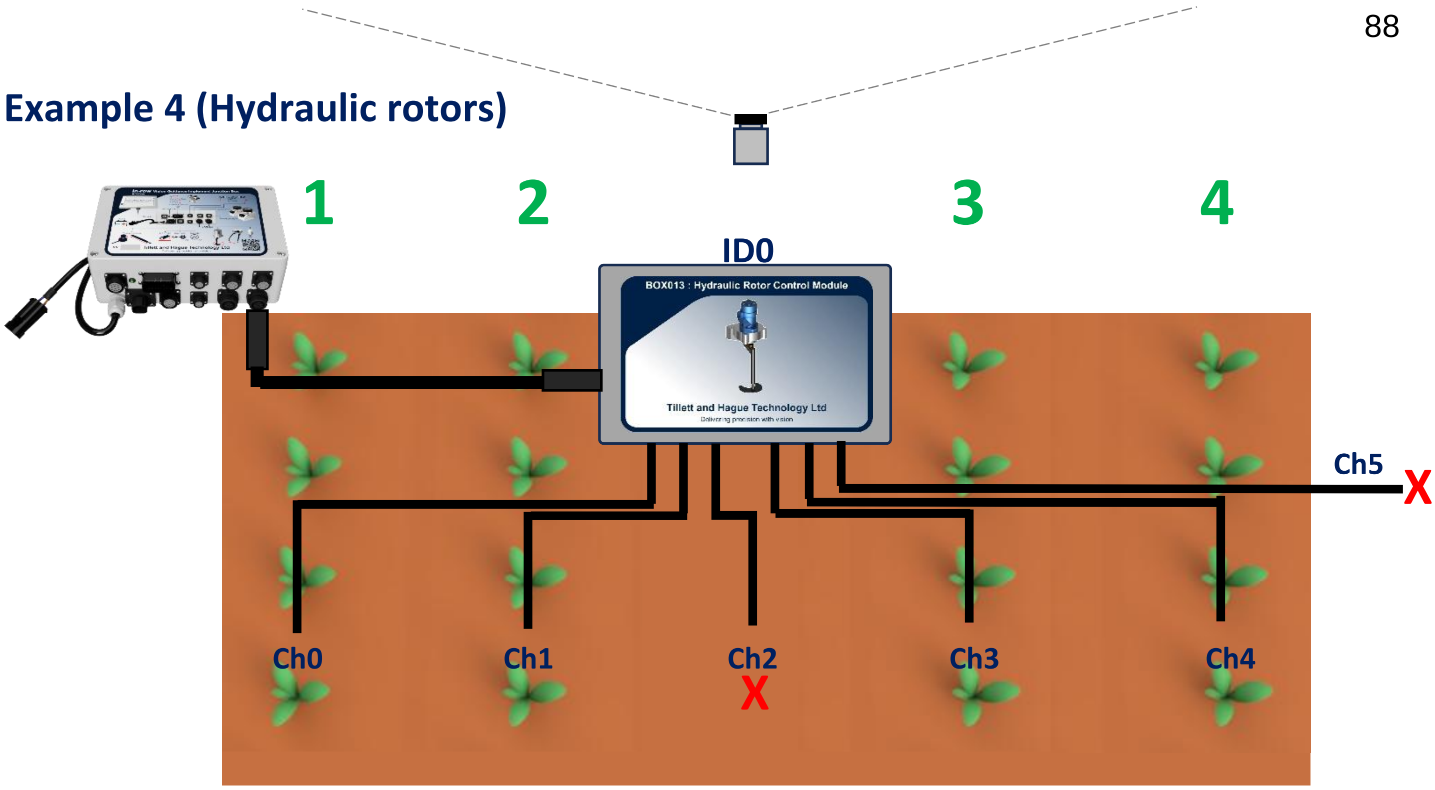
Rotor Row Numbers : 1,2,3,4,0,0,5,6,7,8

Example 3 (Hydraulic rotors)



Rotor Row Numbers : 1,2,3,4,5

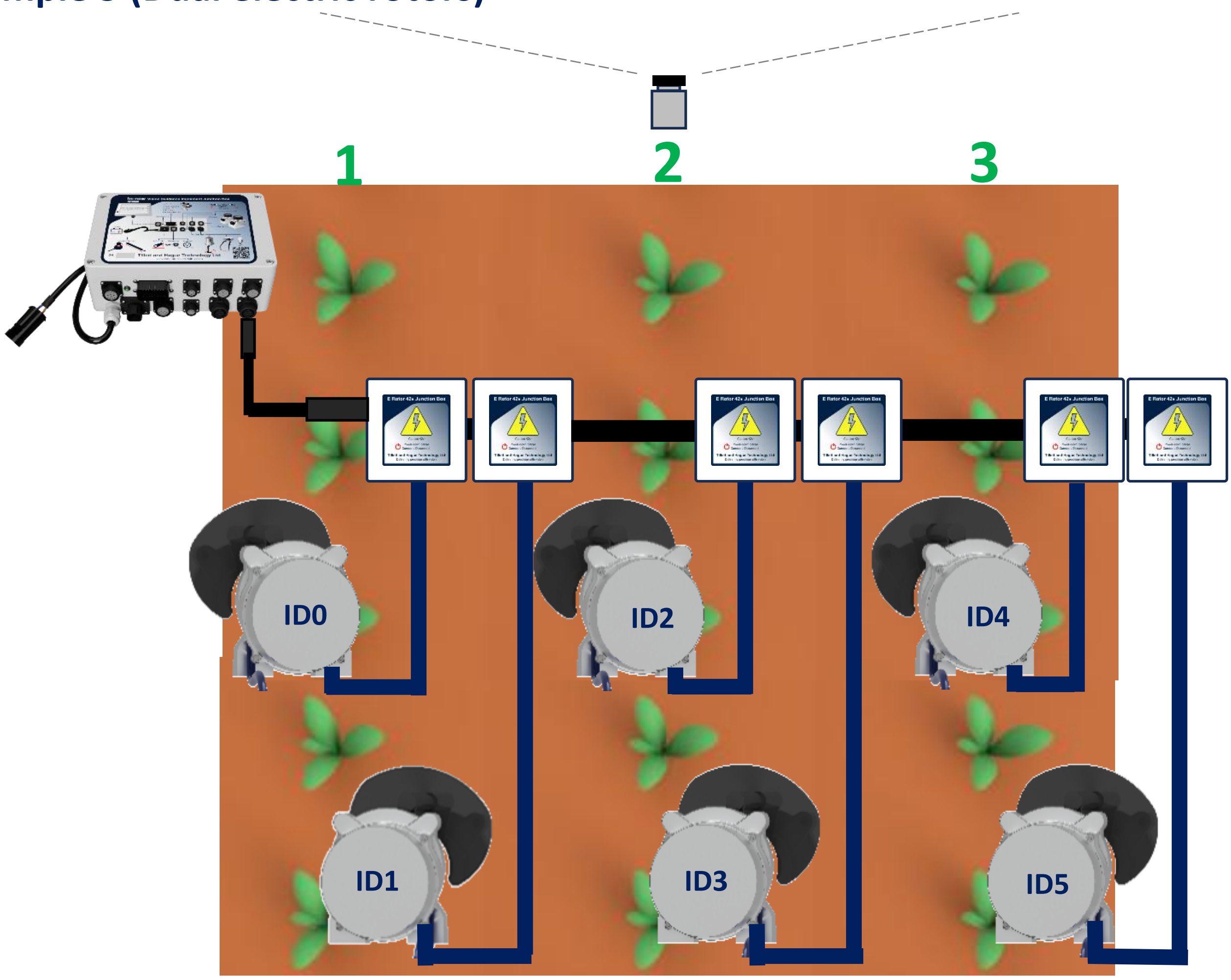
Example 4 (Hydraulic rotors)



Rotor Row Numbers : 1,2,0,3,4

In some special cases it may be beneficial to allocate more than one rotor to a row. For example, a three row machine that maximises cultivated area by fitting 2 rotors arranged either side each row would have the rotor row allocation 1, 1, 2, 2, 3, 3 (See Example 5).

Example 5 (Dual electric rotors)

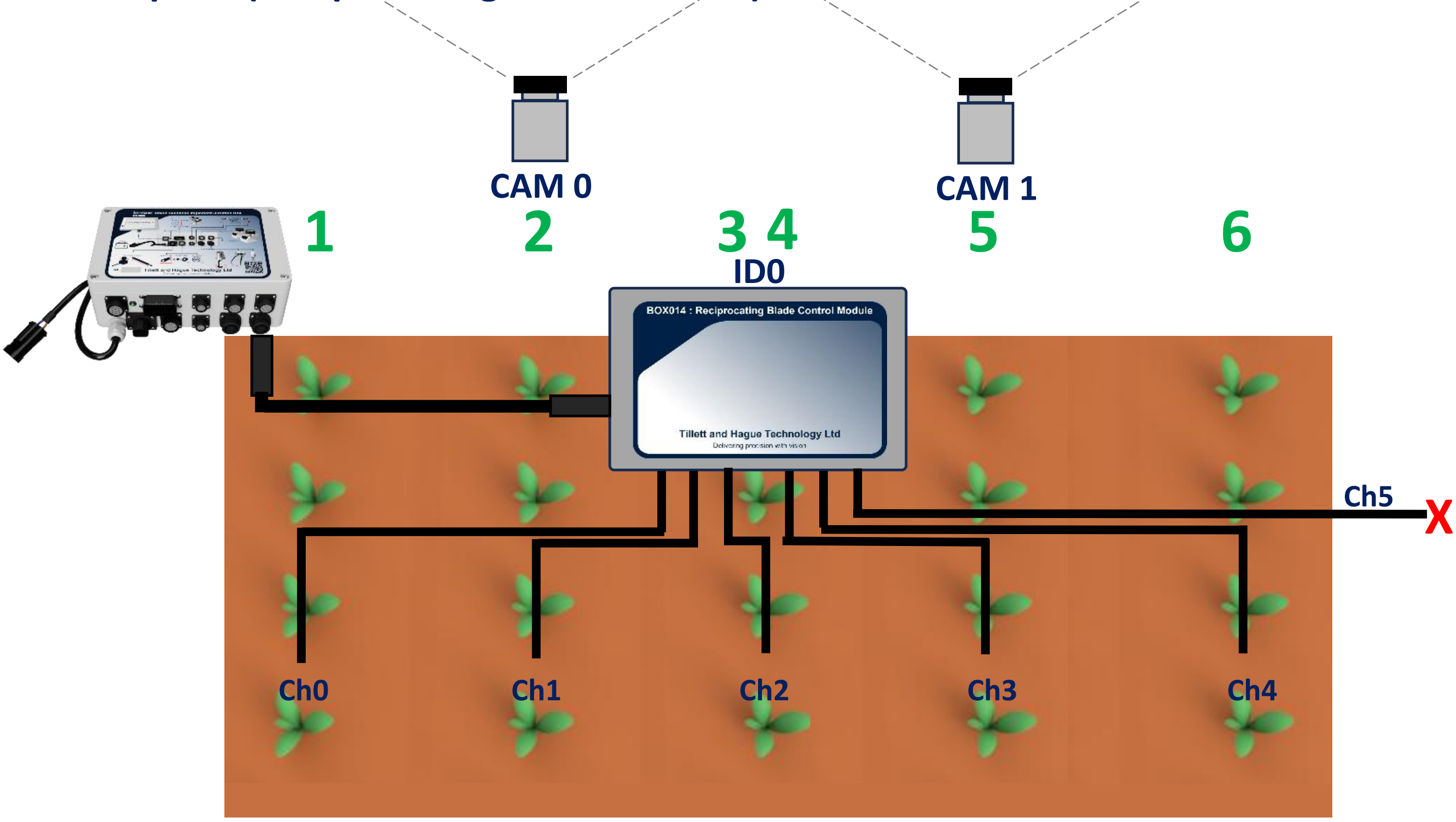


Rotor Row Numbers : 1,1,2,2,3,3

Nozzle and in-row reciprocating blade control boards are treated in exactly the same way as hydraulic rotor boards except that these boards have 12 and 6 channels respectively.

Note that row numbers unlike camera, section and CANbus device numbers start from number 1 and start from the left of view on the first connected camera and are allocated sequentially for any further connected cameras. For overlapping camera views, for example a 5 output machine with two cameras each looking at 3 rows each, with the centre number 3 row being a common feature between views, row allocation has two possible variations of 1, 2, 3, 5, 6 or 1, 2, 4, 5, 6 depending on whether tracking information from camera 0 or camera 1 is to be used to control the third output channel (See Example 6)

Example 6 (Reciprocating in-row blades)



Ch2 operated by CAM 0

In-row Knife Row Numbers : 1,2,3,5,6

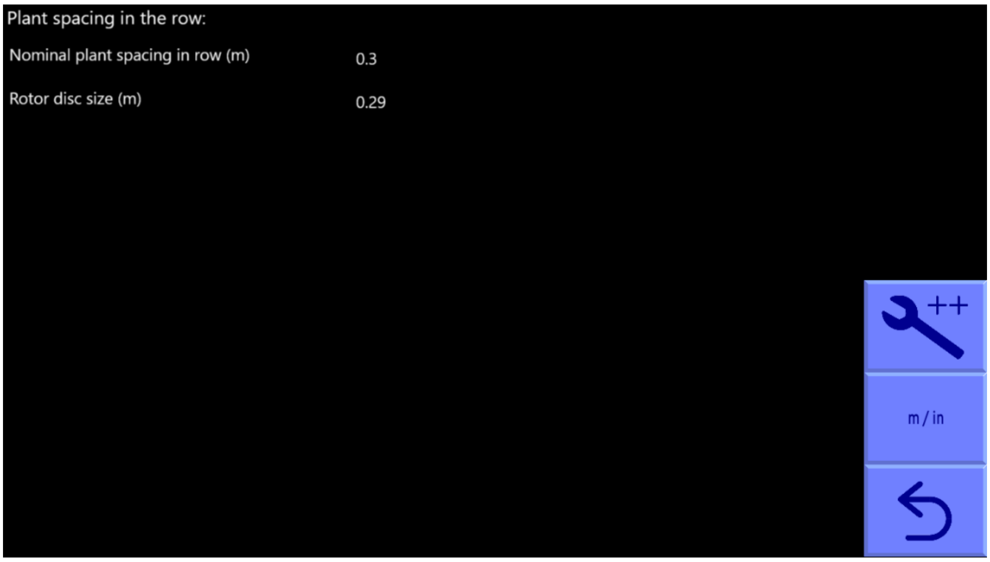
Ch2 operated by CAM 1

In-row Knife Row Numbers : 1,2,4,5,6

Configuration “Microcontroller” standard editor screen

In row settings (for rotors)

Where plant spacing is accurate "nominal plant spacing in row" should be set to average inter-plant spacing as measured in the field. However, if plant spacing is variable it should be set at a figure that reflects the closer plant spacing that you wish to cultivate between.
"Rotor disc size" is a parameter relating to disc geometry and should normally be selected to be similar to or slightly less than nominal plant spacing. It should be stamped on the disc blade, though this can be difficult to read on used blades. It may therefore be necessary to consult documentation to identify blades, though the table below may help. When using a reciprocating cultivator blade an arbitrary disc size will need to be entered into the configuration.

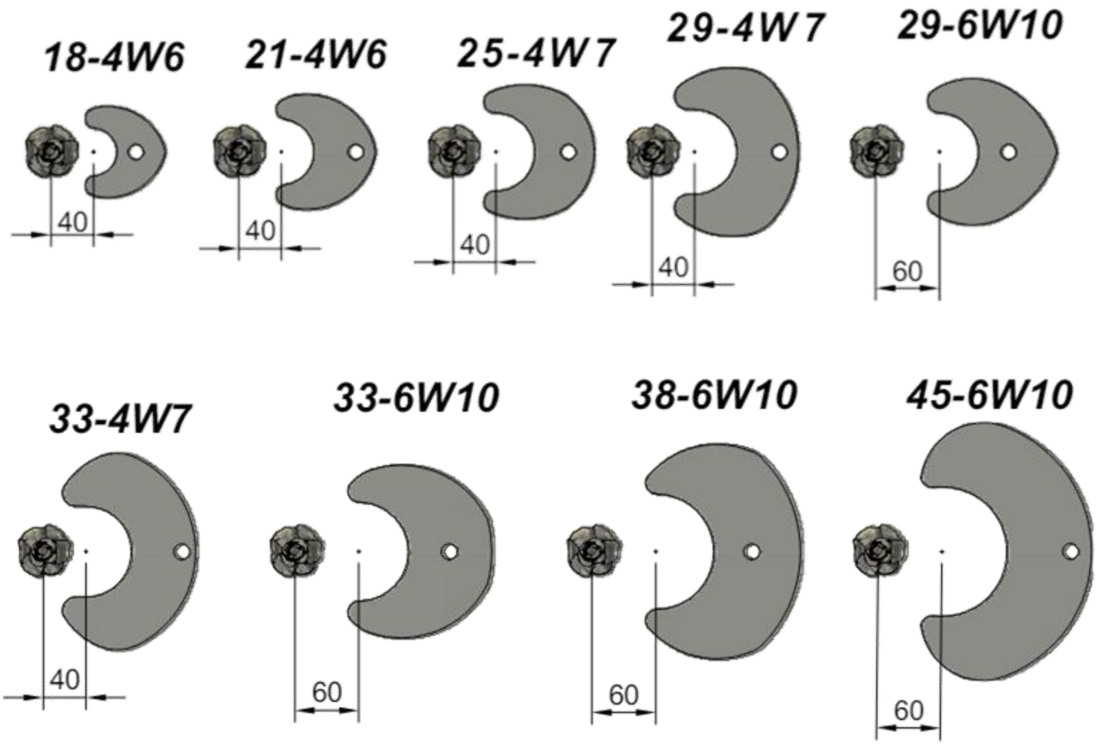


Configuration "In-row settings" standard editor screen

Disc Size	Width of Disc measured at widest point	Plant Pitch Disc is Optimised For	Minimum Plant Pitch	Offset	Plant Zone
16-4W6*	71mm	0.16m	0.12m	0.04m	0.06m
18-4W6	85mm	0.18m	0.135m	0.04m	0.06m
21-4W6	107mm	0.21m	0.1575m	0.04m	0.06m
25-4W7	126mm	0.25m	0.1875m	0.04m	0.07m
29-4W7	158mm	0.29m	0.2175m	0.04m	0.07m
33-4W7	185mm	0.33m	0.2475m	0.04m	0.07m
29-6W10	138mm	0.29m	0.2175m	0.06m	0.10m
33-6W10	163mm	0.33m	0.2475m	0.06m	0.10m
38-6W10	202mm	0.38m	0.285m	0.06m	0.10m
45-6W10	242mm	0.45m	0.3375m	0.06m	0.10m

Disc sizing chart (Most common sizes - others are available)

*Note this disc size does not allow for full cultivation within row so two passes in opposite directions, or two rotors per row, may be required.



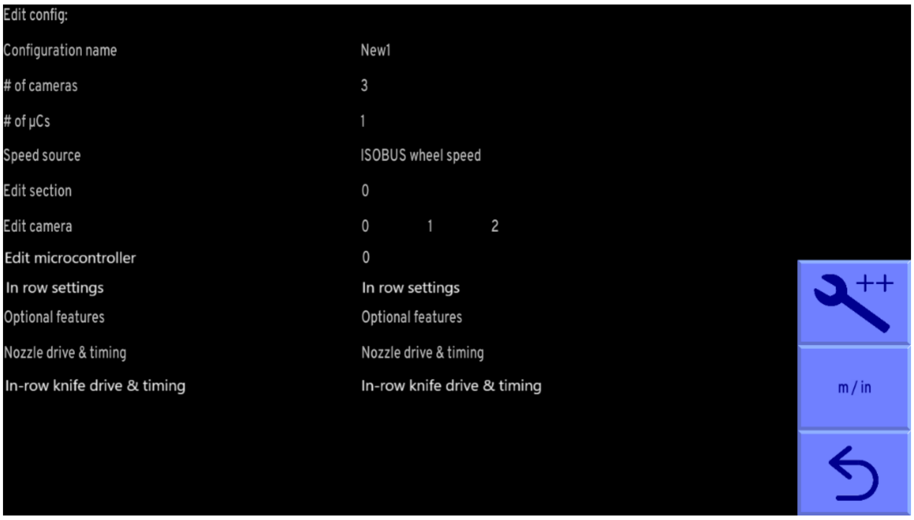
Commonly available disc sizes with required offset for each disc size illustrated

<u>Additional settings available from the advanced editor</u>

Under normal circumstances it should not be necessary to alter any of the additional parameters listed in the advanced editor. However, for those wanting to make more advanced changes they are listed here.

Additional general settings

The advanced version allows the user to enter the number of cameras and microcontrollers fitted. For example, adding an additional camera can be achieved by increasing the number of cameras fitted by one. You will then be asked if you wish to assign this camera to a section for guidance purposes. Normally you would reply “Yes”. The settings from the previous camera will be automatically copied to the new camera. However, it is also possible to configure each camera differently if required.



Configuration editor screen with advanced settings selected

It is possible to add additional cameras that are not used for guidance, but instead provide a CCTV function. To add a camera for this purpose, on the configuration editor screen (advanced) increase the number of cameras fitted by one. Do not allocate that camera to a section so the cameras mounted on the configuration edit section screen remains unchanged. On the configuration edit camera screen relating to the additional camera enter 0 rows and do not enter a row spacing. The camera will then produce an image on the working screen with no overlaid graphics that can be selected from the thumbnails in the usual way.
Odometer scale relates to distance travelled between counts from the odometer wheel encoder. It is calculated from the pulses per revolution (PPR) from the ground engaging wheel diameter according to the formula: PI x Wheel diameter / PPR.
For encoders with phase quadrature outputs PPR is the full resolution using both A and B lines. The maximum pulse rate is 256000/s.

Note

If configuration file specifies “ISOBUS wheel speed” as odometer source odometer scale will not be displayed.

Additional section settings

Distance ahead/behind rear axle is measured between the cultivators and the tractors rear axle.

Lift input setting allows selection of lift input source for the selected section. For ISOBUS enabled implements a menu allowing selection between ISOBUS/front, ISOBUS/rear and microcontroller inputs is shown when the setting is selected for configuration.

Note

In the case of multi-section implements it is possible to derive lift inputs for multiple sections from a single input.

Selection of Lift input source in configuration “Section” advanced editor screen

It is possible to define which microcontroller is used to control section steering and from which microcontroller that section should take its lift status and odometric speed. If microcontroller number for the odometer is left blank, odometric speed will be calculated from the flow of features through successive images. However, odometric speed is not sufficiently accurate for in-row operation and should only be used in inter-row mode.

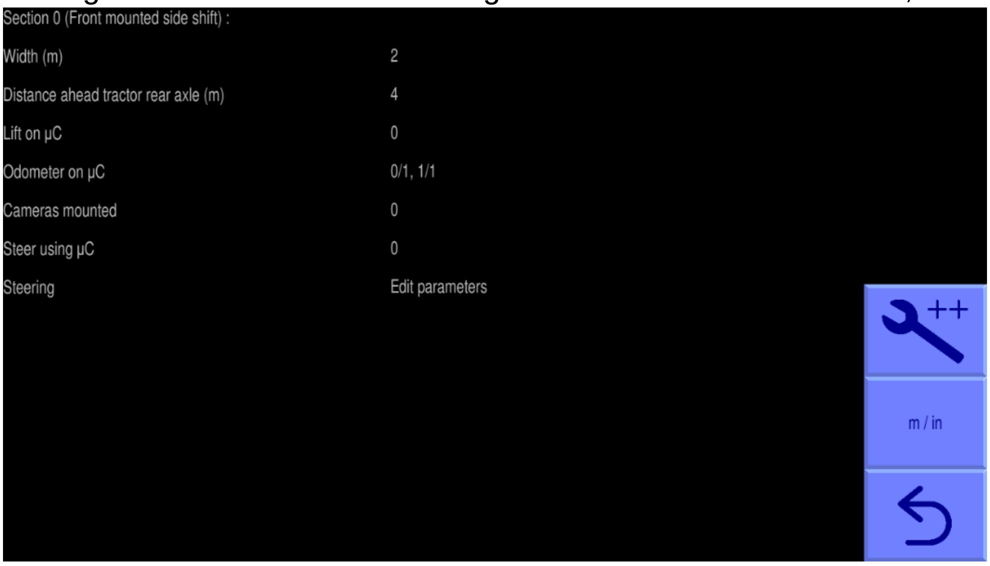
The in-row implement module (BOX006) has 4 odometer input channels and it is necessary to designate which odometer input channel(s) are to be used. Odometer channels can be specified as follows:

1st NPN pulse odometer channel	0/0
	or
	0 as first input channel will be presumed if not specified
2nd NPN pulse odometer channel	0/1
1st Encoder odometer channel	0/2
2nd Encoder odometer channel	0/3

Note
It is also possible to derive odometer input from multiple sources of the same type e.g. two NPN pulse or two encoder type through listing source channels separated by a comma.
e.g. 0/0 , 0/1 or 0/2 , 0/3

Note
If ISOBUS speed is configured for source of odometer input, under standard general settings, the setting for “Odometer on uC” will not be displayed.

Finally, the cameras mounted on that section are allocated by listing them with comma delimiting by index number. E.g. a two camera machine might have Cameras mounted 0, 1



Configuration “Section” advanced editor screen for a side shift implement

The advanced version of the steering parameters allows users to alter the value of position sensor reading that is defined as central (normally 2048).

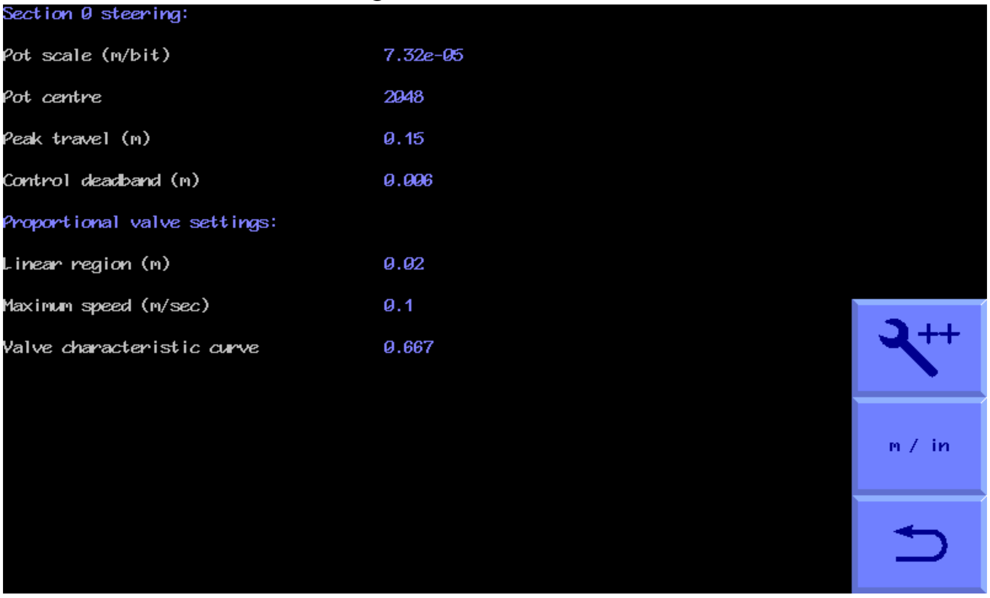
There are also a number of parameters that relate to steering control.

Deadband (the minimum steering error that results in a corrective action) can be set. Smaller values increase accuracy but can cause rapid steering oscillations if the steering rate (oil flow) is set too high. As standard this is set to 0.006m.

Linear region, maximum speed and valve characteristic curve all relate to the control of proportional hydraulic valves. And may need adjustment to suit some proportional valve setups, default values are good base to start from. Their function is explained by a diagram/graph in the help (**?**) facility.

Disc steered machines (not shown in example) can be fitted with an additional potentiometer to display linear free shifting slide position on the working screen light bar. The parameters for this additional lightbar potentiometer are derived in the same way as you would for a side shifted machine. If the lightbar peak travel is set to zero, the system assumes there is no separate lightbar position sensor, and the working screen light bar will display steering disc angle instead.

The damping term relates to disc steering.

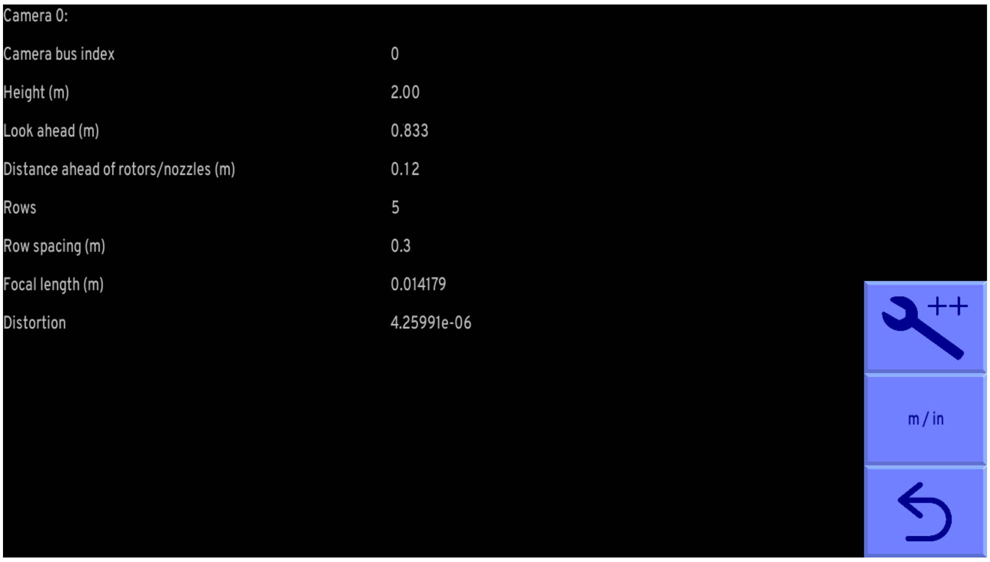


Configuration "Edit Parameters" advanced editor screen

Additional camera settings

Additional camera parameters are lens focal length and a figure relating to correcting for lens distortion. However, cameras from serial No 717 onwards have this lens data stored internally, which takes precedence over configuration data, making these figures irrelevant, except where older cameras are fitted.

It is also possible to change camera bus index though this should not be changed from the camera number in blue above without taking expert advice.

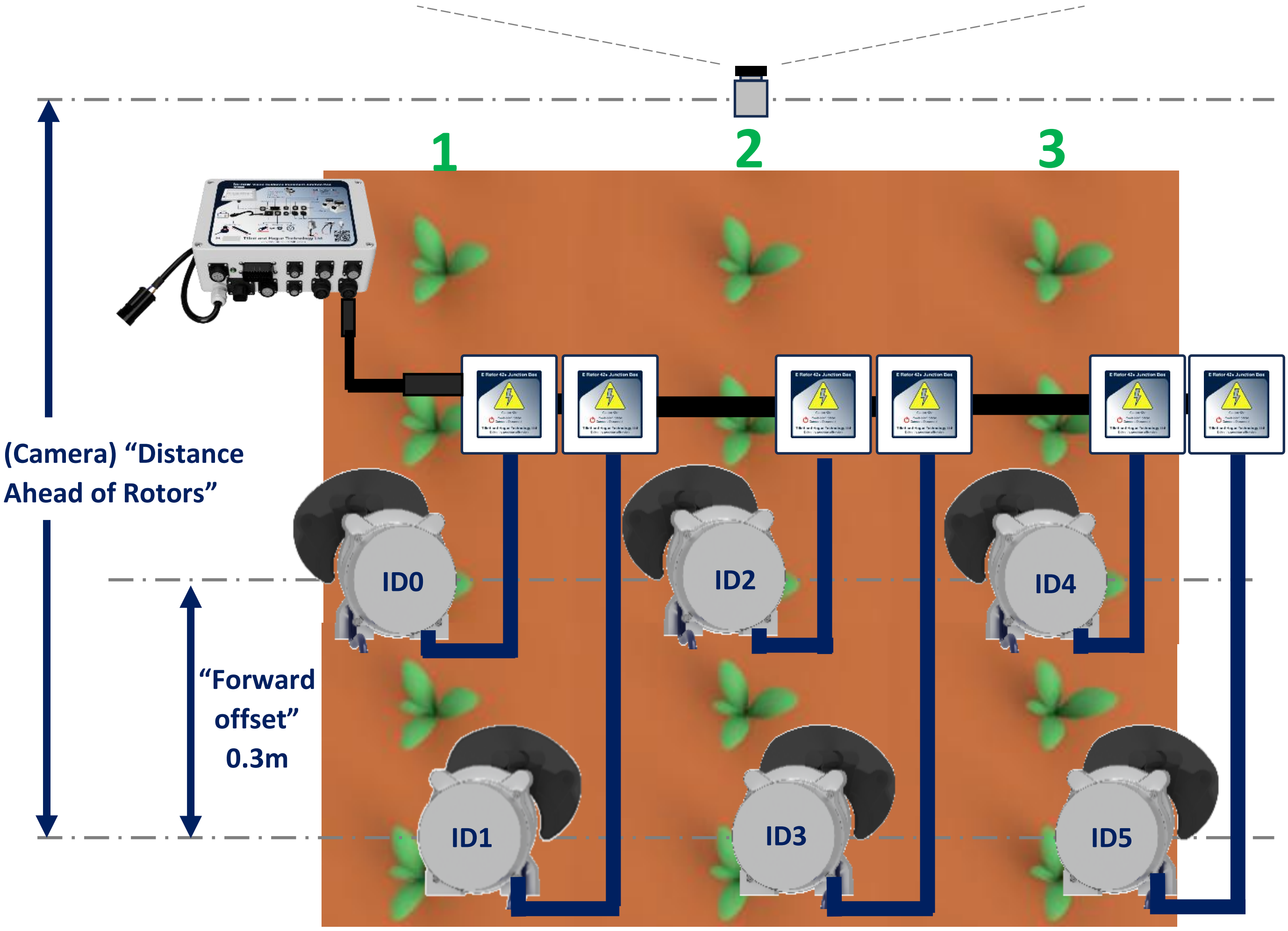


Configuration "Camera" advanced editor screen

Additional Edit Microcontroller (CANbus device settings)

In some circumstances, it may be required to have multiple within row operations of the same (Example 1) or different (Example 2) types working simultaneously on the same row. It is also possible to stagger placement of in-row devices using the forward offset tool, to position that device forward or back relative to the "distance ahead of rotors/nozzles" point using positive or negative values respectively.

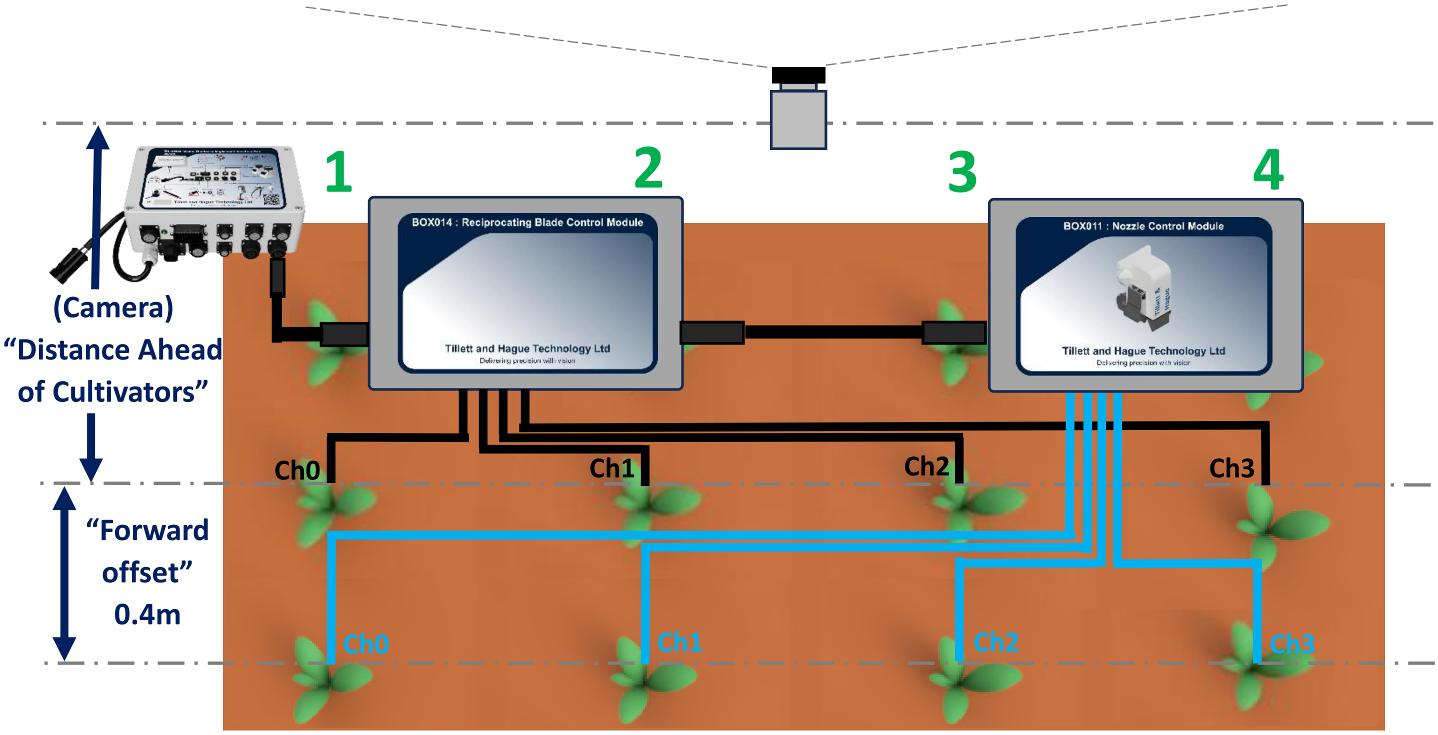
Example 1 (Dual electric rotors)



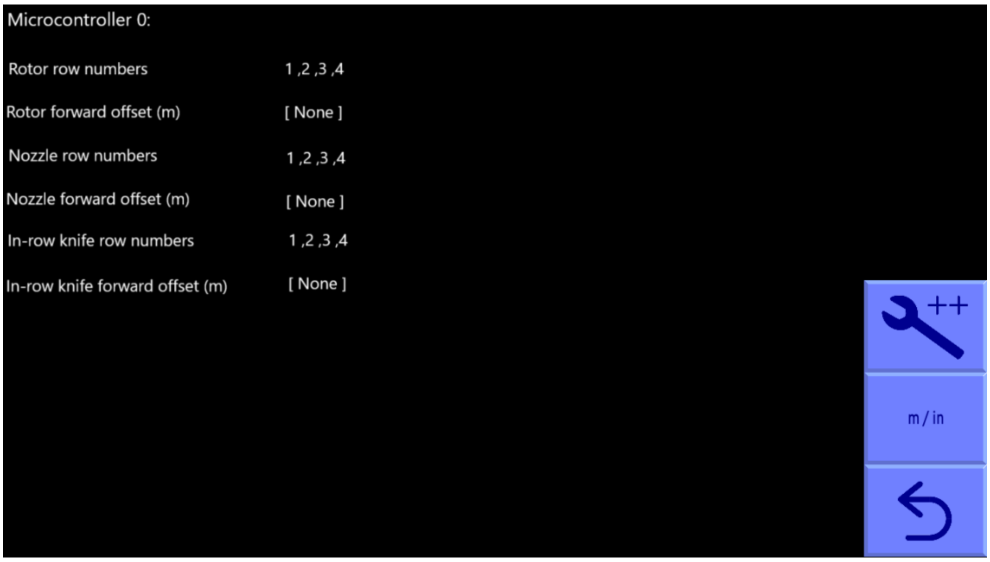
Rotor Row Numbers : 1,1,2,2,3,3

Rotor Forward Offset (m) : 0.3,0,0.3,0,0.3,0

Example 2 (Reciprocating blades and nozzles)



In-row Knife Row Numbers : 1,2,3,4
In-row Knife Forward offset (m) : [none]
Nozzle Row Numbers : 1,2,3,4
Nozzle Forward Offset (m) : - 0.4,-0.4,-0.4,-0.4



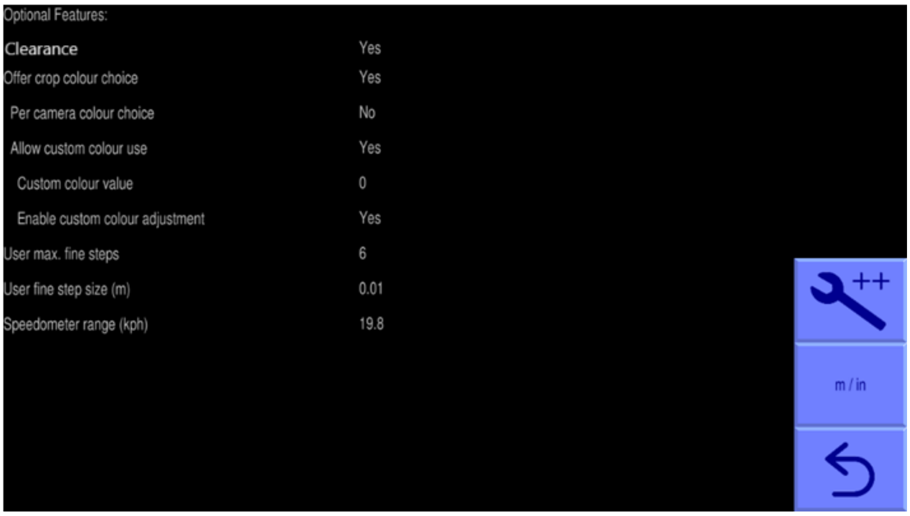
Configuration "Microcontroller" advanced editor screen

In row settings

Minimum plant spacing below which plants will be pruned out is set by default to 67% of disc size. The advanced editor allows this number to be changed, but this setting should not be set lower than the minimum plant spacing that a disc is mechanically capable of achieving, please see the in-row disc sizing chart for these values. In the case of nozzles or in-row knife actuators minimum spacing can be set to suit the minimum plant spacing to be left in the field following operation of the implement. If minimum plant spacing is set to a low value all plant spacings above the set minimum will be attempted which may not always be desirable.
Care should also be taken to ensure that minimum plant spacing is not set too close to the nominal plant spacing as this can have adverse effects on machine operation and not all plants may be tracked as a result.

Optional Features

These allow users extra facilities. The first provides an additional line on the set-up screen labelled "Clearance" which gives the option for in-row rotors to cultivate slightly (typically 5mm) tighter to crop plants, leave a normal, or provide a slightly larger gap than normal. Changing clearance in this way is best achieved by physically changing discs, but the software change is more convenient for small areas.
The second allows users to select clearance crop colour choices other than the standard green via the setup screen. As a refinement that choice can be offered per camera.
To reduce complexity, we recommend not enabling any more colour choices than are essential for good performance. The default colour choice is between "Green", "Red" (for red leafed crops) and "R & G" (for crops with a mixture of green and red leaves). A custom colour of fixed hue can be selected as an additional colour choice. A further optional graphical tool can be enabled allowing that custom hue to be varied from the advanced settings screen.
There are two options relate to customising fine offset which can be useful if extra stroke is required working across steep slopes for example. One allows the maximum number of fine offset steps to be changed (default is 6) and the other allows the size of those steps (default 10mm) to be modified.
Finally, speed bar range displayed on the working screen can be changed from the default speed which is calculated from disc size maximum achievable speed (whichever is lower will be displayed on working screen)



Configuration "Optional Features" advanced editor screen (Yes=selected No=not selected)

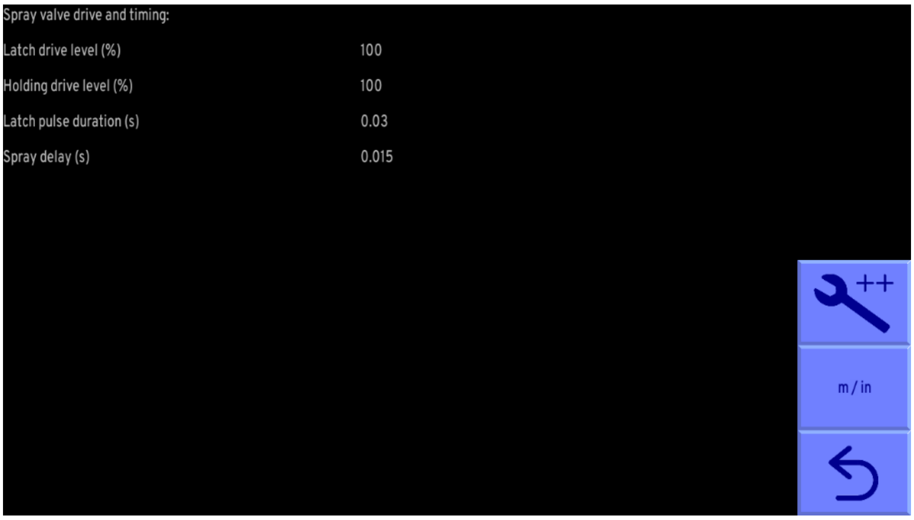
Nozzle drive and timing

Nozzle boards can be configured to drive conventional or latching solenoid valves via an on-board switch.
The levels and timing of solenoid drives can be configured in software using this option.
The first parameter allows users to select the % of full 12V drive (by PWM) applied to change solenoid valve state.

The second refers to the holding drive level required to maintain that state. That would normally be 0 for a latching valve but will be up to 100% for conventional valves. Figures around 50% might be typical if "hit and hold" techniques were being used.

The third parameter determines the time in seconds for which the latching drive level is applied before dropping down to the holding level.

The spray delay reflects the time in seconds taken between requesting a change of valve state and that change being reflected in nozzle flow rate.



Configuration "Nozzle drive and timing" advanced editor screen

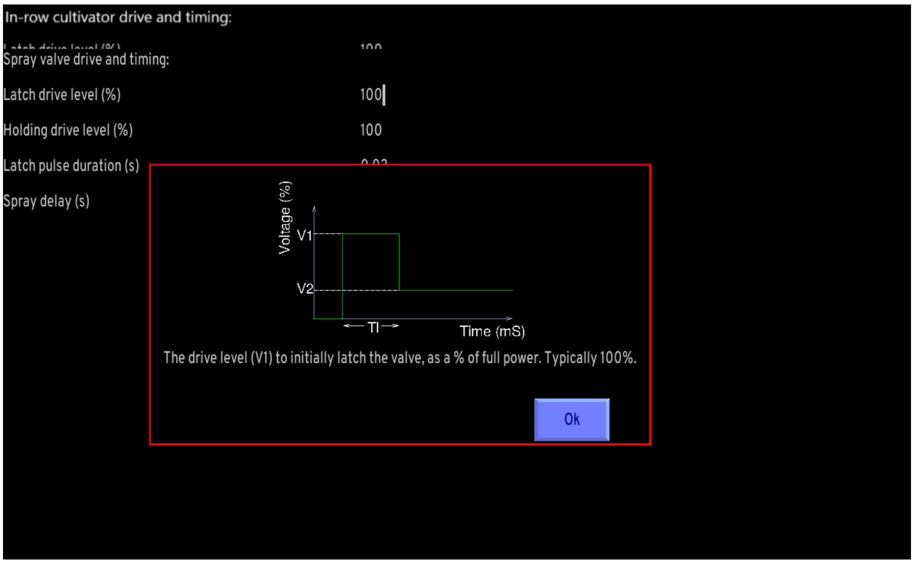
In-row cultivator drive and timing

The levels and timing of cultivator blade solenoid drives can be configured in software using this option.
The first parameter allows users to select the % of full 12V drive (by PWM) applied to change solenoid valve state.

The second refers to the holding drive level required to maintain that state. That would normally be 0 for a latching valve but will be up to 100% for conventional valves. Figures around 50% might be typical if "hit and hold" techniques were being used.

The third parameter determines the time in seconds for which the latching drive level is applied before dropping down to the holding level.

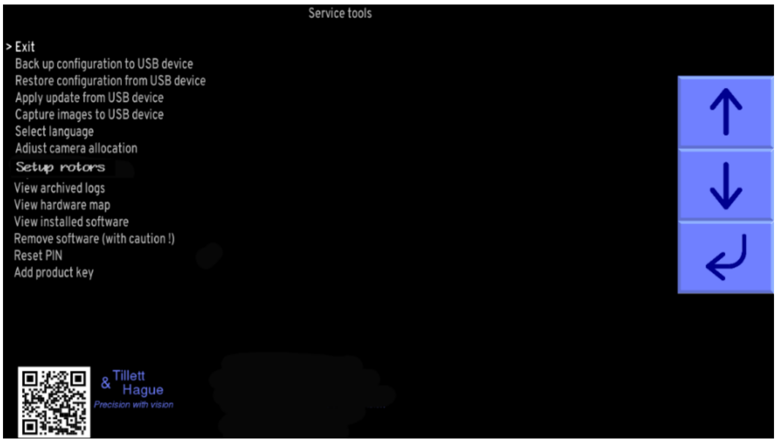
The actuation delay reflects the time in seconds taken between requesting a change of valve state and that change being reflected in cultivator blade movement.



Configuration "In-row cultivator drive and timing" advanced editor screen

Tip Context sensitive help is available within the configuration editor by pressing the red **?** touchscreen keyboard key.

11. Service menu tools (including USB Update and backup procedure)



From the start-up screen users can enter a service menu by touching the tools symbol. The service menu, illustrated above, offers a number of tools that can be useful in maintaining or fault finding a system. The QR code defaults to our web site but can be configured as part of branding.

Backup configuration to USB

Backup creates a file containing all the parameters stored in all the configurations on a console as well as information such as error logs and camera skews. It can be very helpful in diagnosing faults, restoring systems after hardware failure and as a means of quicky setting up new machines in a factory environment.

To backup to a USB device the memory stick must be inserted into the USB port of the console prior to entering the service menu. If this is not the case, or if the USB device is not formatted in the correct form, you will see a black screen with the message “No USB storage device found”. Similar messages will be received for other operations requiring a USB memory stick.

If the console has a valid USB device connected it will then save a backup of the configuration data to the first directory of the device. The file name being in the format “backup_0.tgz”. If there are already backup files stored on the device the backup will be named numerically one higher than the last backup. Backup files can be copied onto another computer and renamed but names must be in the format backup*.tgz where * can be a string of alphanumeric characters excluding spaces. Ensure that your laptop or computer does not attempt to open/unpack the file as that can corrupt the file into an unreadable format.

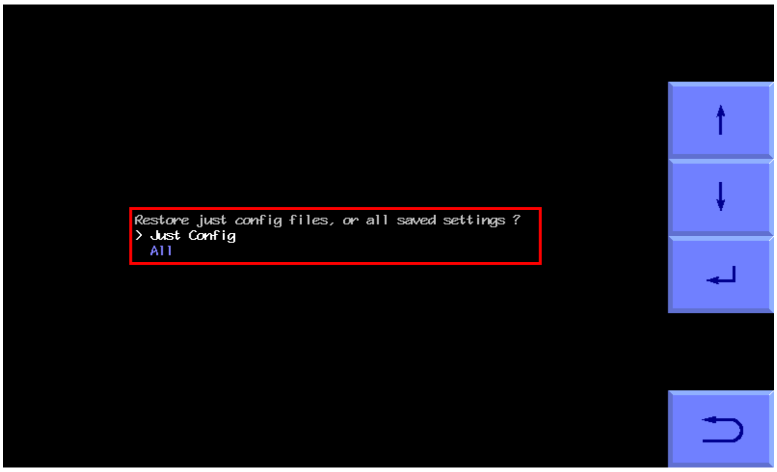
Restore configuration from USB

To restore data from a USB device the memory stick must be inserted into the USB port of the console prior to entering the service menu.

If no backup files can be found on the USB device or backup files have been corrupted, you will see a black screen with the message “Can’t open backup file”.

If more than one backup is found on a USB device a choice of which backup to restore from is given.

When restoring from a specific backup you are able to choose whether to apply the restoration to only configuration data or to all settings such as area meter, hours run, camera skews etc. In most situations only configuration data will need to be restored from. Restoring files does not delete files already stored in a console. Where configurations are duplicated the old version is overwritten.

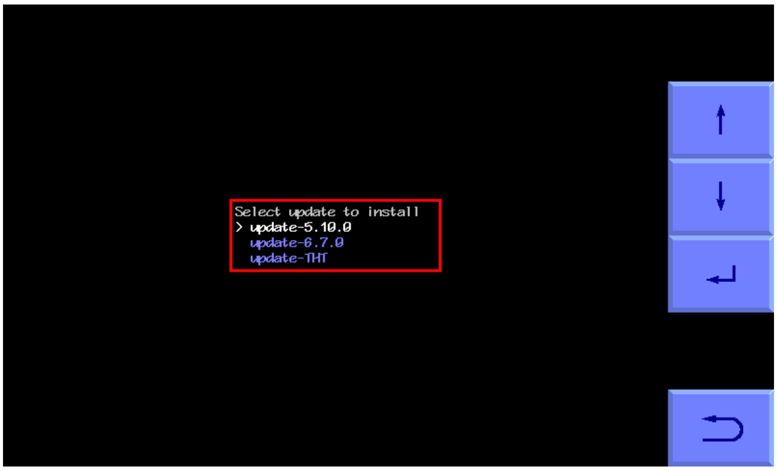


Apply update from USB Device

The update tool updates application software and can therefore be used to keep older machines up to date with the latest features.

It is important that when you are sent an update file of the format update*.tgz you ensure that your laptop/computer does not attempt to open or unpack it as this may cause corruption. When wishing to apply an update to a console it is recommended to copy and paste this file into the top directory of your USB device.

If multiple updates are stored on your USB device, you will be given a menu to decide which update you would like to select and install onto the console.



Once your update has been successfully installed you will see a black screen with the message:

“Installing update, Done”

Capture images to USB device

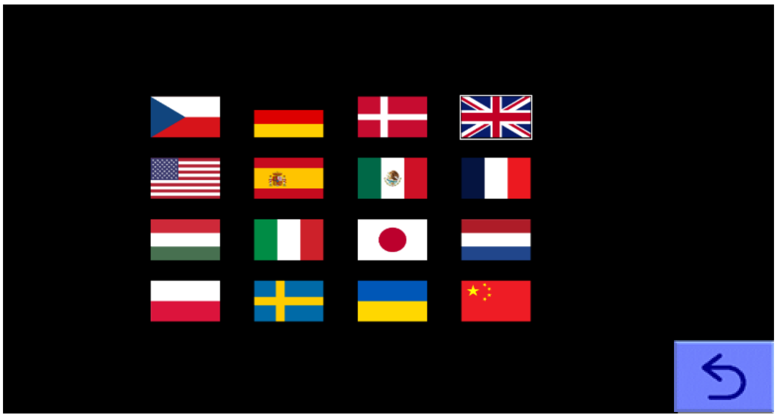
This function saves a still image which can be e-mailed to an expert for analysis. It is a particularly useful tool when used in conjunction with backup as the combined information is helpful for remote fault diagnosis.

Ensure that a USB stick is inserted and select the capture function. You will see a screen with a small live video image and touch buttons down the right-hand side. To capture an image touch on the button with the camera logo. You will hear a buzzer sound and a directory “images_0” will be created on the USB stick and an image “cam0_0.tiff” placed in that directory. You can capture more images with the same camera, and they will be numbered sequentially in the same directory.

If multiple cameras are fitted these can be selected using the left and right arrow buttons and images captured from them in the same way and named according to the camera index.

Select Language

Selecting this function brings up a screen with an array of national flags. Touching on a flag highlights it with a white border and will change the language used to that corresponding to the flag. Where translations are missing, or incomplete, language revert to English. In practice translations are mostly complete for users screens, but there are significant gaps in most languages for the configuration editor. If you would like to contribute to translations, we would be very pleased to provide you with a translations table.



Adjust camera allocation

This tool adjusts the order in which cameras appear on the working screen so that for example the left-hand thumbnail corresponds to the camera on the left of the implement. Alternatively, cameras can be swapped mechanically.

Camera order from top to bottom in the tool relates to the order in which cameras will be displayed in the working screen from left to right. The tool displays bus index, camera serial number, lens type and a live image thumbnail for camera identification.

Thin arrow buttons on the right-hand side are used to select the camera that you wish to rearrange. Thick arrows adjust the of order of the selected camera.

The bin symbol allows for the selected camera to be deleted from the list.

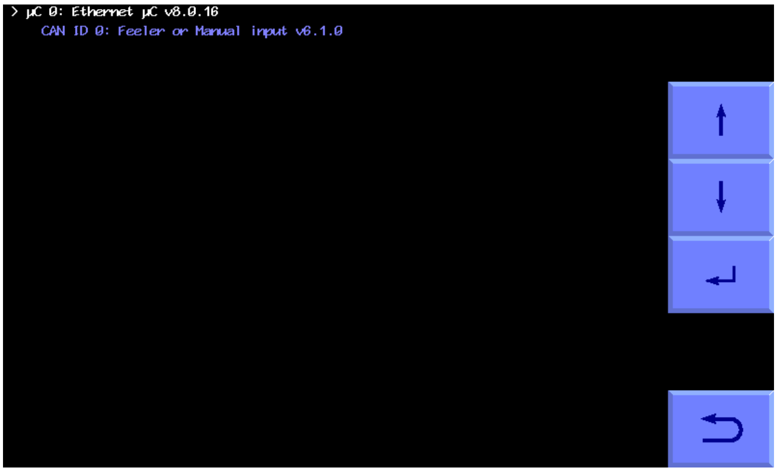
Once correct camera order has been established the return arrow can be pressed to return to the service menu.

View archived logs

This is a list of one line error messages that have been deleted or overflowed from the error log.

View Hardware map

This tool lists all connected microcontroller boards and accessory CAN devices. The address IDs for each connected component can also be viewed to ensure that the address you have intended for each component is correct.



Use the arrow keys to select a board (the text will change in colour/brightness) and then touch the return button to get live board information such as setup information, communication status and input and output values.

Setup Rotors

This is a utility for allocating CANbus identification and selecting the direction of rotation for individual electric rotors without having to open the waterproof seal.

Follow the instructions in Section 5.2.1 to mount rotors onto the machine. When it is safe to do so power up and from the working screen enter the service menu and select “Setup Rotors”. You will be required to enter the password.

If the rotors have not previously been assigned an identification no rotors will be listed and the LEDs at the front of the rotors will not be illuminated. To start the allocation process, press the button situated at the back of the left most rotor. The LED at the front of that rotor will turn red and that rotor will appear as rotor 0 as a line on the screen. Then press the LED at the back on the next rotor and its LED will turn red and the previous rotors LED will turn green. That rotor will be listed on the screen as rotor 1. Continue until all the rotors buttons have been pressed and a full set of rotors are listed on the screen. Select save and exit.

Once rotor identifications have been allocated it is possible to change the direction of rotation of each rotor individually. Go back into the Setup rotors utility. All rotors will be listed and by default set for clockwise rotation as indicated by a green circular arrow symbol. Touching on a green circular arrow symbol will turn it red indicating that the direction of rotation for that rotor is now set to anti-clockwise. Press the "Done" touch screen button to exit the utility.

View installed software

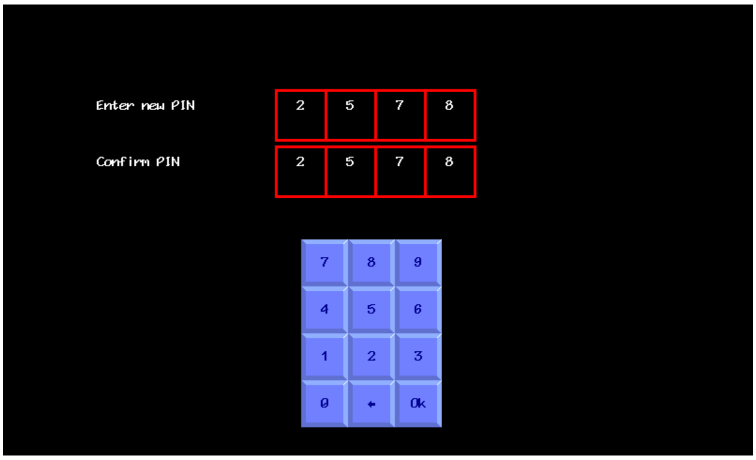
Lists software loaded e.g. inter-row guidance along with version number.

Remove software

This is a function for removing unwanted modes of operation e.g. after selling a demonstration system you may wish to remove demo mode. However, it is very rarely required and should never be selected unless you are absolutely sure you want to delete software permanently.

Reset PIN

To reset the PIN the old access code must be entered (factory default = 1,2,3,4). If the old code has been lost contact us to for reset instructions.



Add product key

This last feature in the list facilitates the activation of additional software or functions. Please contact Tillett and Hague when using this facility with your unique hardware id (shown top left) for your selected console. A unique product key for the console can then be generated by Tillett and Hague and entered to activate the additional capability.

12. Maintenance and Storage

Please follow the maintenance and storage instructions below in order to ensure your precision guided implement stays in first class working order

1. Regularly check the routing of hoses and cables and protect against chaffing.

2. Although all components are designed to be shower proof, we recommend that the console is housed in a dry environment and that the implement is not exposed to wet weather for extended periods when not in use.

3. Never pressure wash any part of the guidance system.

4. Always ensure power is supplied from a supply that is appropriately fused (10 - 20 amp).

5. Always ensure the correct supply polarity is adhered to.
   BLUE = - negative, BROWN (fused side) = + positive.

13. Trouble shooting

LED blink codes

As an aid to fault finding most system components are fitted with LEDs whose mode of illumination can provide information on system status and any error conditions.

Console front panel button LED

Under normal conditions with 12V power connected via the implement module, but with the console switched off the front panel LED gives a very brief single blink at 5 second intervals. When switched on and running normally the LED is illuminated continuously.
Other patterns of illumination indicate error conditions that use the following codes:

- Single 0.2 s blink followed by 1 s off indicates The ITX board has failed to start up
- Two three or four 0.2 s blinks followed by 1 s off indicate different touch screen errors.

Implement module

The implement module has a green LED fitted near the power lead entry gland. It is not illuminated at all when the system is powered down. For about 10 s on initial start-up it is continuously on indicating that it is waiting for CAN devices to register. It will then normally go into a period of slow blinks (1.6 s on 1.6 s off) on a continuous cycle indicating that the system is ready, but idle, with no demands coming from the console via Ethernet. This state will continue until the working screen is displayed and crop row tracking has commenced. Once demands are received from the console a rapid (0.2 s on 0.2 s off) continuous blink cycle starts indicating Ethernet data is being transferred. The LED will revert to a slow blink on entry to the set up screens or configuration editor.
Other patterns of illumination indicate error conditions that use the following codes:

- Single 0.2 s blink followed by 1 s off indicates 2 devices found with the same CAN address
- Two 0.2 s blinks (i.e. 0.2s on 0.2s off 0.2s on) followed by 1 s off indicates too many CAN errors to operate
- Three 0.2 s blinks followed by 1 s off indicates a component is connected that does not conform to known types.
- Four 0.2 s blinks followed by 1 s off indicates the valve over current trip is active, possibly due to steer valve output short circuit
- Five 0.2 s blinks followed by 1 s off indicates open circuit on a steer valve output

Electric rotor

Electric rotors are fitted with one bi-colour LED fitted centrally in the case looking forward.
On start up the LED is normally continuously green for a few seconds indicating that it is initialising or waiting for the 42V supply to be switched on. Once initialised and with 42V applied it will go into a pattern of slow blinks (1.6 s on 1.6 s off) on a continuous cycle indicates CAN bus is idle with no demands. Once CAN traffic is present this changes to a rapid (0.2 s on 0.2 s off) continuous cycle indicates data being transferred.
Other patterns of red illumination on the LED indicate error conditions that use the following codes in a 6.4 second repeating cycle:

- Single 0.2 s blink followed by a pause indicates overheat
- Two 0.2 s blinks (i.e. 0.2s on 0.2s off 0.2s on) followed by a pause indicates too overheat
- Three 0.2 s blinks followed by a pause indicates Hall effect sensors at an invalid value
- Four 0.2 s blinks followed by a pause indicates motor winding current too high
- Five 0.2 s blinks followed by a pause indicate some CAN errors but still functioning
- Six 0.2 s blinks followed by a pause indicates too many CAN errors to operate
- Seven 0.2 s blinks followed by a pause indicates Index sensor fault

Hydraulic rotor board

Hydraulic rotor boards are fitted with one green LED near the power input and 6 red LEDs corresponding to the 6 output channels near the valve outputs. To view these, it is necessary to remove the lid of the box in which the board is housed.

The green LED is lit continuously indicating that 12V power has been applied.

Once initialised the red LEDs will go into a pattern of slow blinks (1.6 s on 1.6 s off) on a continuous cycle indicates the channel corresponding to that LED is idle with no demands. Once active control starts this changes to a rapid (0.2 s on 0.2 s off) continuous cycle.

Other patterns of illumination on the red LEDs indicate error conditions that use the following codes (that are common to electric rotors):

- Five 0.2 s blink followed by 1 s off indicate some CAN errors but still functioning
- Six 0.2 s blinks followed by 1 s off indicates too many CAN errors to operate
- Seven 0.2 s blinks followed by 1 s off indicates Index sensor fault

Condition monitoring board

Condition monitoring boards are fitted with one green LED. These boards are normally housed with hydraulic rotor boards.

The green LED is continuously illuminated in an idle state and flashes 50% on 50% off at 2Hz when running normally. It blinks briefly at 2Hz indicating an error condition caused by the power supply to the proximity detectors being short circuit.

Reciprocating In-row cultivator controller board

Reciprocating cultivator blade boards are fitted with one green/red status LED located above the programming port and six red LEDs corresponding to the 6 output channels near the valve outputs. To view these, it is necessary to remove the lid of the box in which the board is housed.

On start up the status LED is normally continuously on for a few seconds indicating that it is initialising if the LED is continuously red it may be waiting for the valve 12V supply to be switched on. Once initialised and with valve 12V applied it will go into a pattern of slow green blinks (1.6 s on 1.6 s off) on a continuous cycle indicates CAN bus is idle with no demands. Once CAN traffic is present this changes to a rapid (0.2 s on 0.2 s off) continuous cycle indicates data being transferred.

When the controller board is in a fault condition the status LED will change to red and provide a series of blinks indicating the error condition

- Single 0.2 s blink followed by a pause indicates low valve supply voltage
- Two 0.2 s blinks (i.e. 0.2s on 0.2s off 0.2s on) followed by a pause indicates valve output overload
- Three 0.2 s blinks followed by a pause indicates valve output is open circuit
- Five 0.2 s blinks followed by a pause indicate some CAN errors but still functioning
- Six 0.2 s blinks followed by a pause indicates too many CAN errors to operate

Manual and Feeler modules (Inter-row only)

Both these modules contain a microcontroller board that has one green LED and four red LEDs that can be viewed by removing the lid.

The green LED is continuously illuminated in an idle state and flashes 50% on 50% off at 2Hz when running normally. It blinks briefly at 2Hz if the power supply to the proximity detectors is short circuit.

The red LEDs are illuminated with their corresponding inputs.

Fault codes (as displayed in error messages and the error log)

These numeric fault codes can provide more specific information that the written description displayed on the screen. Make a note of these codes when reporting errors.

cttnn c=class, tt= 2 digit type, nn= channel/index

0xxxx internal software error codes
00100 state/covariance dimension error
00200 variance sign error
00300 other numeric error

1xxxx camera error codes
101xx excess skew
10300 no port found
10400 no devices at all
10500 just the adaptor
106xx some devices, but no cameras found
107xx Unsupported camera
108xx Initialisation failure
109xx can't start capture
110xx can't start video transmission
111xx can't work out GUID assignments
112xx Timeout on a particular camera
11300 no data from ANY camera
11400 camera connection too slow

2xxxx Implement module uc error codes
201xx the device you want is not found
202xx timeout on data receive
203xx timeout on diag receive
204xx missing sync in packet
205xx checksum wrong
206xx received data packet not what we asked for
207xx other data format error
20800 no uCs at all
209xx Excessive number of CAN bus errors
210xx More than one device set to same ID
211xx Unrecognised CAN device
212xx Valve output overload

3xxxx Rotor error codes
301xx No rotors present
302xx Rotor index sensor fault
303xx Rotor overheat RHS
304xx Rotor overheat LHS
305xx Overheat - rotor CPU
306xx Rotor overload
307xx Rotor Hall effect sensor fault
308xx Tractor (12V) battery voltage low
309xx Rotor overload in braking.
310xx Rotor CPU timeout (Should not be seen)
311xx Lost sync, +12V power interruption?

4xxxx Other hardware error codes
40100 Odometer consistently seems wrong
40200 Pot error
40300 CPU fan alarm
40400 CPU Thermal alarm

5xxxx Operator errors
50100 Going too fast!

6xxxx Condition monitoring errors
60100 Sensor/wiring short circuit
60200 Hydraulic pressure low
60300 Hydraulic tank return pressure high
60400 Reverse oil flow
60500 Hydraulic overheat (>70C)
60600 Hydraulic filter blocked

7xxxx Spray system faults
70100 Spray pressure low
70200 No flow detected
70300 Leakage detected
70400 Missing pressure sensor / wiring fault
70500 Nozzle blocked

8xxxx Actuator board errors
80100 Low valve supply voltage
80200 Output overload
80300 Valve not connected

9xxxx CAN connect errors
90100 Can’t load dll
90200 Missing symbols in dll
90300 Can’t communicate with CAN bridge
90400 Firmware file missing
90500 Error in firmware (.ihx) file
90600 Flash write failed

Flow Charts

Problems have been divided into six categories listed below. Select the most appropriate category and work through the flow chart. Please consult your dealer for any other problems.

1. Console fails to start up correctly
2. Console shows a working screen, but the side shift/steered discs do not respond correctly
3. All systems appear to be functioning and the steering test passes, but lateral positioning performance is poor
4. Lateral positioning is good, but rotors are not rotating correctly around crop plants
5. Lateral positioning is good, and all rotors pass the rotor test but rotors are not rotating correctly around crop plants
6. Lateral positioning is good, all rotors pass the rotor test and are rotating about crop plants but their motion is jerky

1. Console fails to start up correctly

Does the working screen appear?

No

Does any text appear on the screen?

Yes

Yes

No

Does the image respond to movement in front of the camera?

Does the front panel push button light up continuously?

Yes

No

No

Yes

Power down using the bottom right touch screen button.

If screen is frozen hold illuminated front panel button down for about 3 secs until a black text screen appears.

When shut down check camera connections and restart. If problem persists, consult your dealer

Does the push button briefly flash every 5 s?

No

Yes

Is there 12v at the implement power plug?

Hold button down for 1 s. Does the light latch on and the console start?

No

No

- Check battery voltage & polarity
- Check fuse in loom near battery
- Check console connection to battery

For additional problems consult the other trouble shooting guides

Is there a message saying “Camera connection not established”?

Possible faulty console consult your dealer

No

Yes

Is there a message saying “No microcontrollers detected”?

Yes

No

Power down and check connections between tractor and implement, check connector locking rings have clicked in place. Restart. Running correctly?

Make a note of messages on the screen and consult your dealer

No

Look at green LED on the microcontroller PCB mounted in grey box

- Flashing once every 2.5 seconds = idle state, no communication?
- Flashing 3 times every seconds indicating good communication with microcontroller
- Not illuminated indicates no power or faulty

Power down, check camera cable and connections and that locking rings have clicked in place.

Restart.

Make a note of any messages on the screen and led flashing codes and consult your dealer

2. Console shows a working screen but the side shift/steered discs do not respond

Is the video image live? Check that the image responds to movement in front of the camera

Yes

Check hydraulic supply is on and correctly connected

Does the side shift mechanism centre when the implement is raised?

Yes

Switch to manual side shift/steer control and exercise the side shift/steer.

Does the manual shift work OK?

Yes

Does the console's speed indicator show a similar value to the tractors and does the stopped brake icon disappear when moving?

No

Check the odometer wheel is touching the ground and rotating. Ensure it is not damaged and correctly connected. If problems persist consult your dealer.

Yes

Follow fault finding procedure for poor crop tracking performance

No

Shut down the console check the camera connections and restart. If the problem persists consult your dealer

No

Is the implement lift icon displayed and do the crosses overlaid on the video screen disappear when the implement is lifted?

Yes

No

Check that the implement lift sensor is operating correctly. It may be out of adjustment or its cable damaged

No

Run the steering test function from the advanced diagnostics menu.

Was the steering test passed?

Yes

No

Does the test suggest no oil flow?

Yes

Check red LEDs on microcontroller board light up to indicate valves on and check connections to valves.

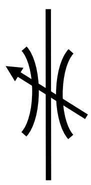
No

Does the test suggest steer rate is too fast or too slow?

No

Yes

The restrictors that control flow to steering cylinders may require slight adjustment



Does the test suggest reversing the direction of flow?

No

Does the test suggest "hit stop"?

No

For other error messages or if problems persist consult your dealer

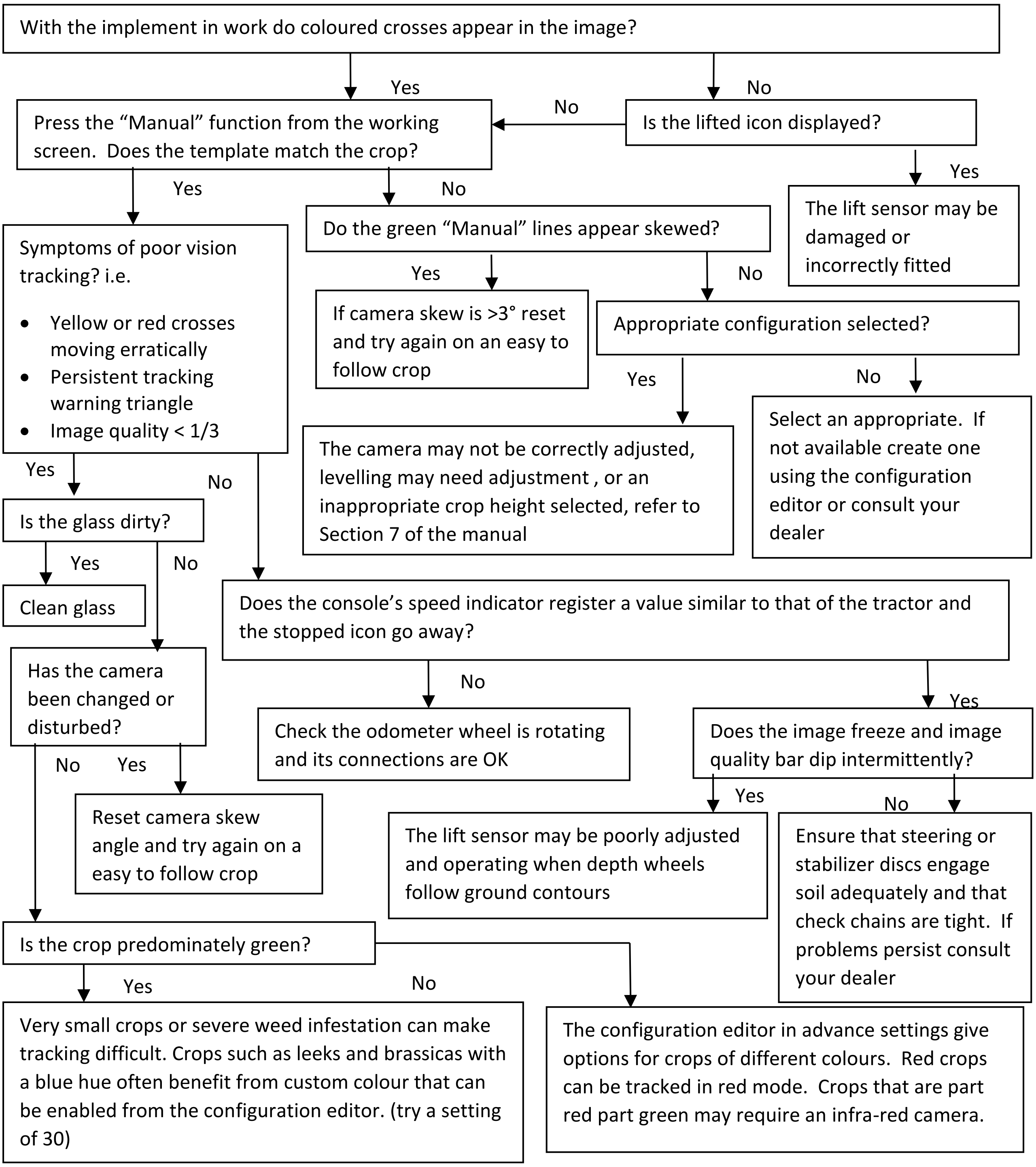
Yes

Check for mechanical obstructions, though this message may also occur if movement is too slow

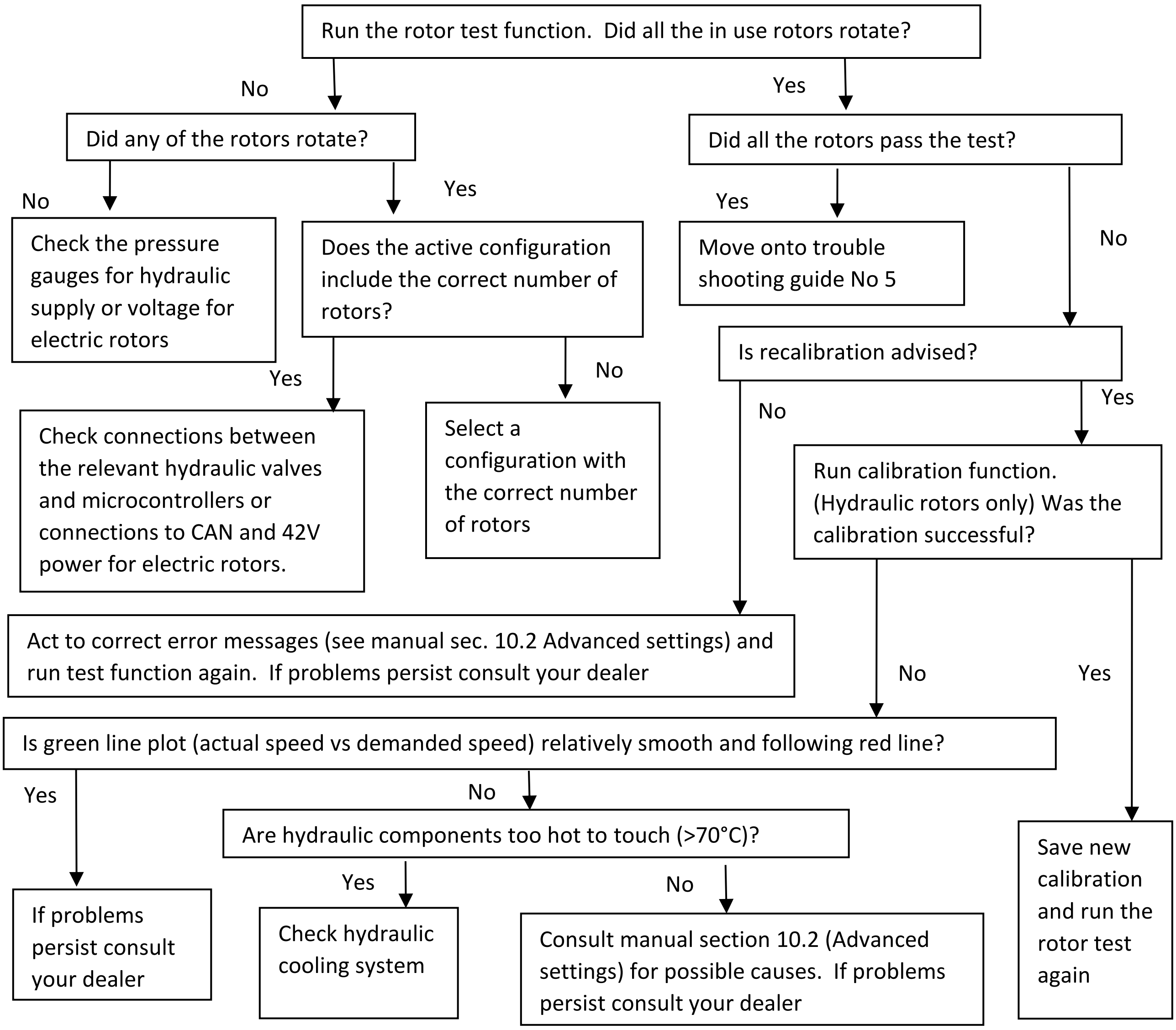
Yes

Reverse hydraulic connections to the tractor but bear in mind this will also reverse flow to other parts of the circuit.

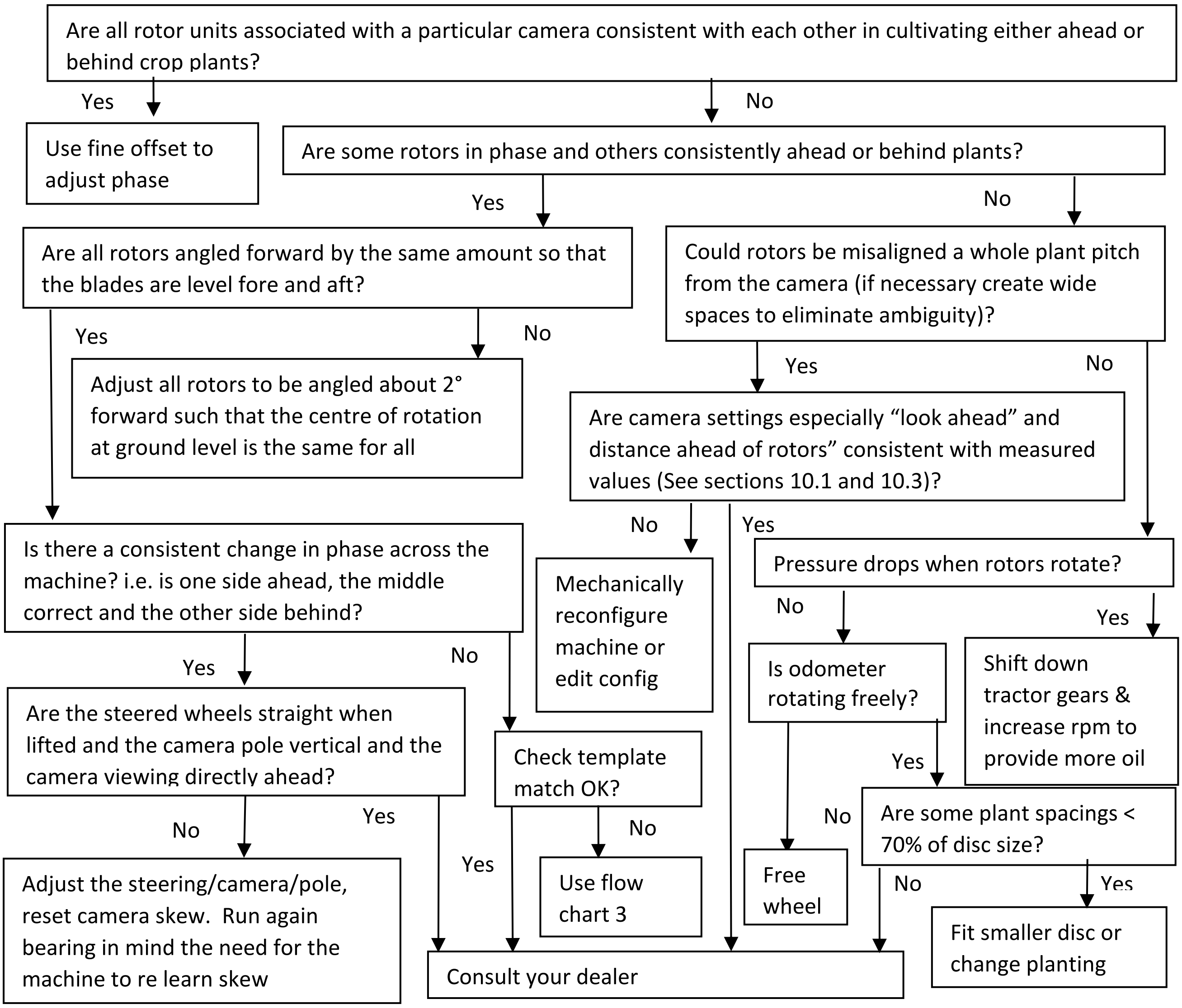
3. All systems appear to be functioning and the steering test passes but lateral positioning performance is poor



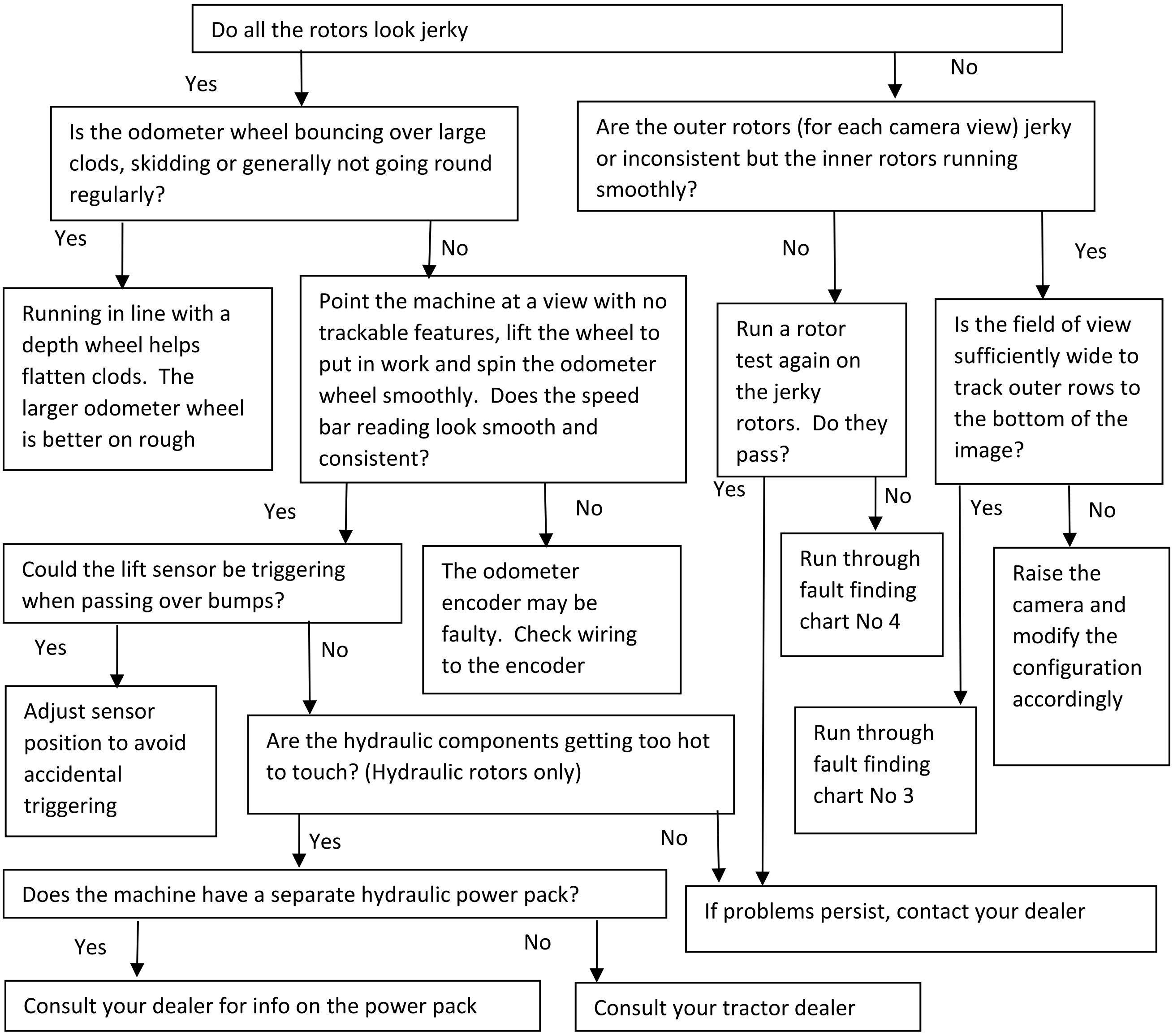
4. Lateral positioning is good but rotors are not rotating correctly around crop plants



5. Lateral positioning is good and all rotors pass the rotor test but rotors are not rotating correctly around crop plants



6. Lateral positioning is good, all rotors pass the rotor test and are rotating about crop plants but their motion is jerky



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Annex

Hydraulic systems

The hydraulic system required to operate a side shift or disc steer system is conceptually a simple one involving a single directional control valve to meter hydraulic oil into either side of a hydraulic cylinder. However, there is often a need for additional components to control the rate of oil flow such as variable restrictors and pressure regulators.

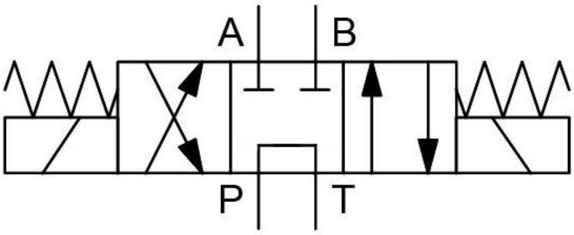
A diverse range of tractor hydraulic power systems introduces further considerations when designing implement hydraulics.

This note is not intended as a comprehensive design tutorial, rather it is a guide to the more common arrangements and a discussion of some of the issues.

It is usually cost effective for implement manufacturers to provide their own hydraulic systems suited to their own requirements. However, if required Tillett and Hague technology can supply basic hydraulic systems as part of a complete guidance and control package.

We will start by considering tractor hydraulic PTO systems. These can broadly be categorised as “open centre” or “closed centre/load sensing”. Open centre systems are generally found on older, or budget tractors, where the oil is supplied from a gear pump at a rate that is proportional only to engine RPM. For these systems an “open centre” directional control valve is preferred in which its centre position provides an unobstructed return path for the oil back to the tank.

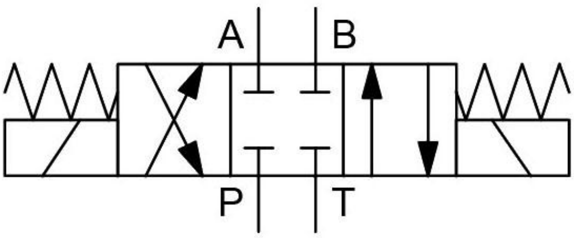
Open centre valve



If a “closed centre valve is used in which the ports are closed in the central position, then oil will be forced to return to the tank via a pressure relieve valve (the tractors own valve is normally set just above 200 bar). This is inefficient and can create large amounts of heat which may damage both tractor and implement.

Tractors with some type of load sensing system maintain a low pressure on standby and only develop full system pressure when flow is detected. These systems can use “closed centre valves”, where the pressure line is blocked in the valves centre position.

Closed centre valve



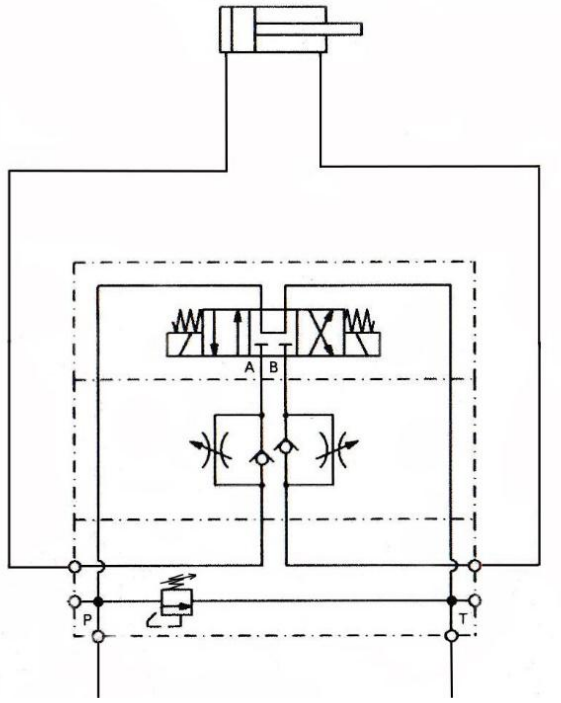
One advantage of closed centre valves is that it is possible to put additional valves in parallel on the same hydraulic circuit. This can be useful when the implement also features automatic levelling, or tine raising, but it is inconvenient to supply each of these services from its own independent tractor spool.

It is also possible to operate multiple closed centre valves with a tractor equipped only with a gear pump and no load sensing, but it requires an additional dump valve. That valve is arranged to be normally open so that tractor oil is returned to tank with little pressure drop when none of the valves are operated. The dump valve must be wired in such a way that it closes when any of the other control valve operates, leaving them with full system pressure and flow. Tillett and Hague can provide a circuit board with multiple optically isolated inputs which are logically “OR”ed to a dump valve output for this purpose.

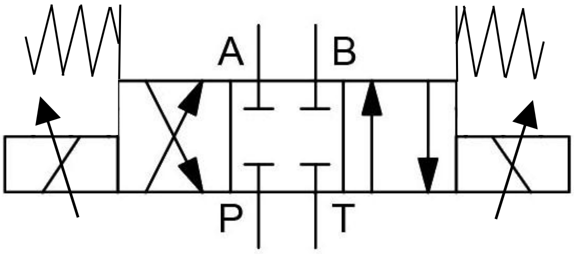
In some tractors it is possible to regulate the maximum flow on each spool independently. Exceptionally this may be sufficient to control the rate at which the steering cylinder moves to the desired target of approximately 0.1m/s. However, because the steering cylinders are normally small in diameter, the required volumetric rate is often lower than the minimum offered by the tractor. Furthermore, the two sides of the steering cylinder often have different areas requiring different flow rates in each direction to achieve the same linear speed. To regulate steering rate it is normal to fit variable restrictors on the output to each side of the cylinder.

It is not uncommon for variable restrictors to be almost fully closed to achieve the required steering rate. This makes setting very sensitive to small adjustments and to oil temperature. It can be advantageous to reduce the pressure across the restrictors with a pressure regulator, enabling them to operate with larger orifices thus reducing their sensitivity. This also has the effect of reducing the force generated by the steering cylinder, which is not normally a problem as steering forces need not be high.

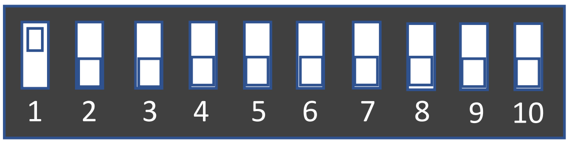
A typical circuit, as provided in the Tillett and Hague valve block assembly, is given below showing how all these components might be used in a hydraulic circuit.



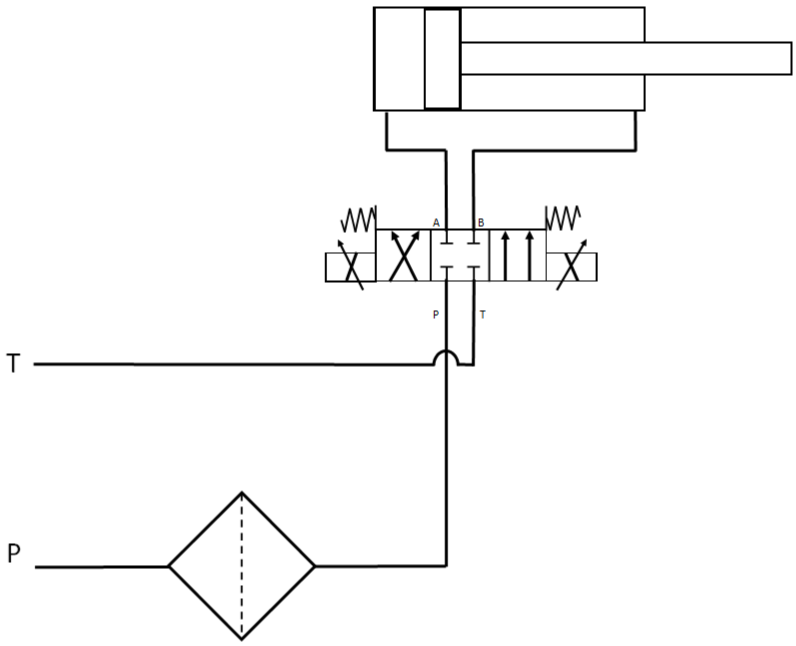
Proportional closed centre valve



For proportional steering control requires a closed centre circuit design. Fine internal tolerances in proportional control valves require an in-line pressure filter to be fitted. To activate the proportional control option DIP switch number 1 must be switched UP to the ON position, as shown below (BOX006 DIP switch show) :



Control system parameters relating to proportional control can be found in the configuration editor in Section 10. Valve characteristic curve parameter may need to be adjusted to suit chosen valve. The typical circuit for the Tillett and Hague proportional directional valve block assembly shown below. Note early guidance system did not support proportional hydraulic valves so if retrofitting please consult with Tillett and Hague Technology.

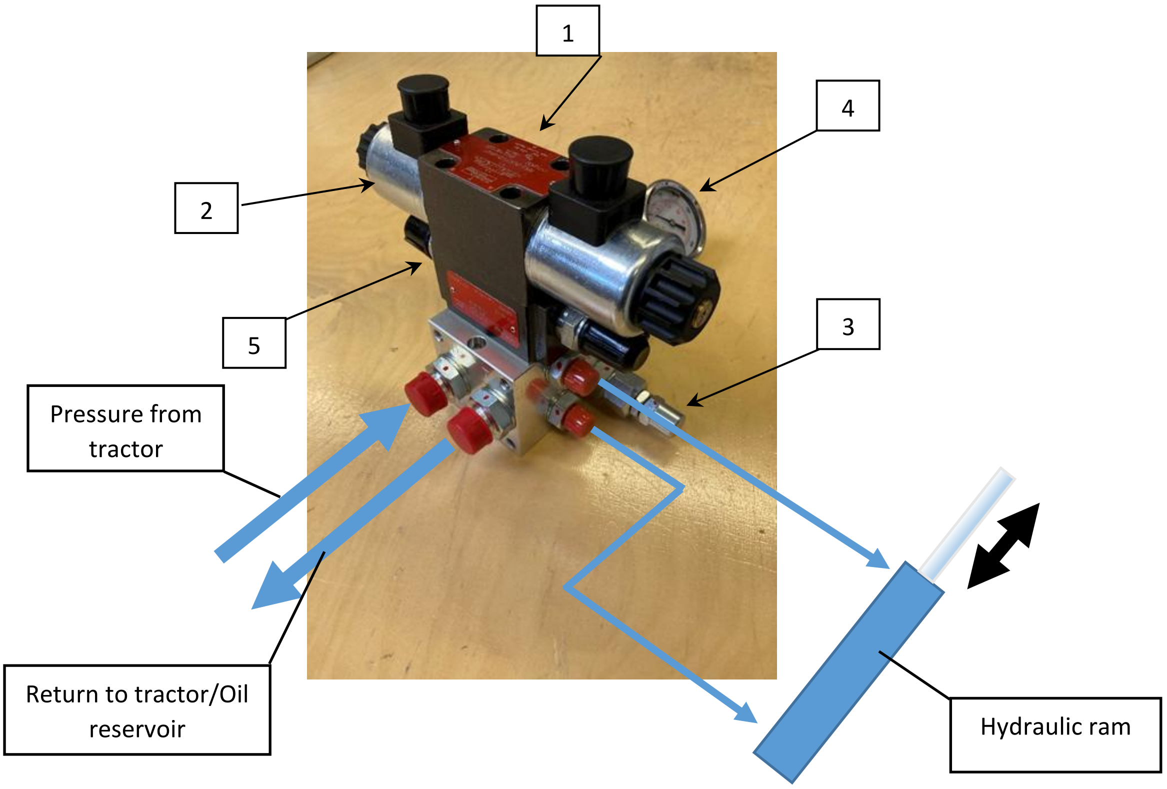


Standard directional control valve setup:

Connect the test point pressure gauge and, after checking that the hydraulic cylinder is safe to operate, turn on the tractor oil supply. The pressure gauge should read zero as the oil is passing unrestricted through the open centre directional valve. Arrange for the directional valve to operate so that the cylinder moves fully to one end of its stroke. The pressure should increase to the value set by the pressure reducer, normally 20 to 40 bar is sufficient. If required, this can be adjusted by loosening the 17mm locking nut and making the adjustment with a 4mm Allen key. If you are using the control system to operate the valve it will switch off once the desired position has been reached, so you may need an assistant to view the pressure gauge whilst the valve is operated, and the cylinder is moving.

If you reverse the direction of operation of the directional valve the cylinder will move to the other end of its stroke. Use the corresponding flow control (needle) valve knob to control the rate of movement. A speed of 0.1m/s is normally a satisfactory starting point but can be adjusted later. Keep reversing the direction of flow and adjusting the two flow control knobs until speed is satisfactory in both directions. If you find that the flow control adjustment is too sensitive, you can try further reducing operating pressure using the pressure reducing valve.

Once you are happy with the pressure you can remove the test point gauge.



	Part Name	Part Function
1	Directional control valve	Open centre directional control valve used for diverting flow of oil
2	12V solenoid coil	Activates valve to direct oil flow
3	Pressure Reducer adjuster and locking nut	Used to set operating pressure
4	Test point gauge	Used to measure operating pressure, (only required for setup and not routine running)
5	Flow control valve	Used for setting flow rate to left and right steering functions independently

Proportional hydraulic system setup:

Check that the hydraulic cylinder is safe to operate and turn on the tractor oil supply. Run the steering test from the System information & diagnostics screen and it will automatically adjust the control parameters to achieve the target side shift rate entered in the configuration. The default is 0.1 m/s.

Hydraulic fault finding:

The advanced settings and diagnostics screen include a steering test which can be helpful in diagnosing hydraulic problems. If in doubt, run this simple test. It will interactively ask you which direction is left, and which is right, show if the hydraulic supply is connected the wrong way around or is believed to be inversed, if the flow rate is too high, or too low. The test also attempts to diagnose faulty position sensors by detecting irregular output signals, or a mechanical jam for which you get the message "Hit stop". The "Hit stop" message can also be triggered by hydraulic issues such as entrapped air, or low flow rates.

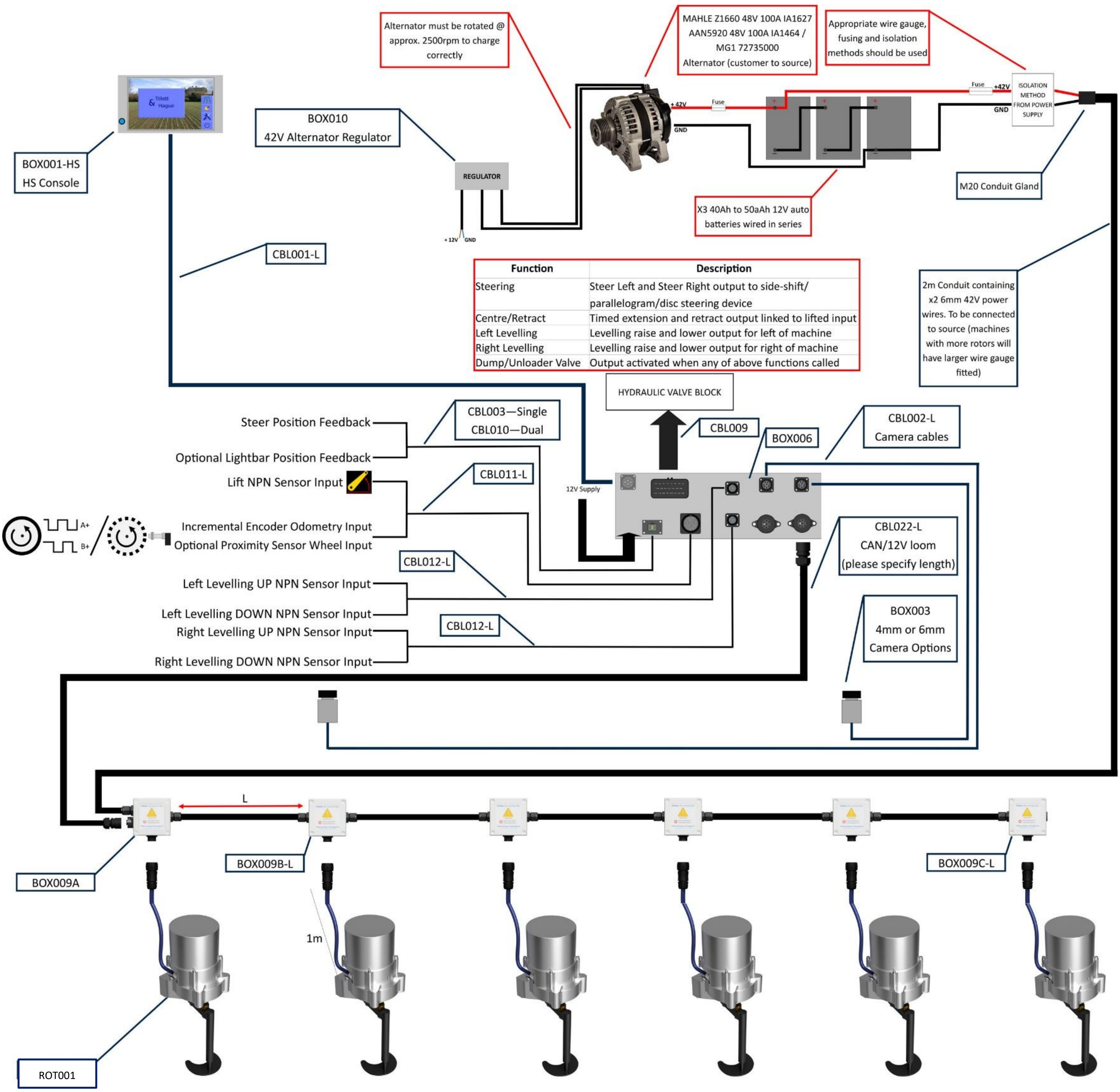
Accessory hydraulic functions:

When utilising other hydraulic functions such as machine levelling, centre/retract these can be added onto the hydraulic circuit and their flow and pressure requirements will need to be considered to ensure correct operation of all functions within the circuit. If use of an open circuit design is to be employed, the use of appropriately set flow dividers or a "dump" valve may be required.

Closed circuit design can also be used for control of services but may not be energy efficient if not combined with a closed centre supply.

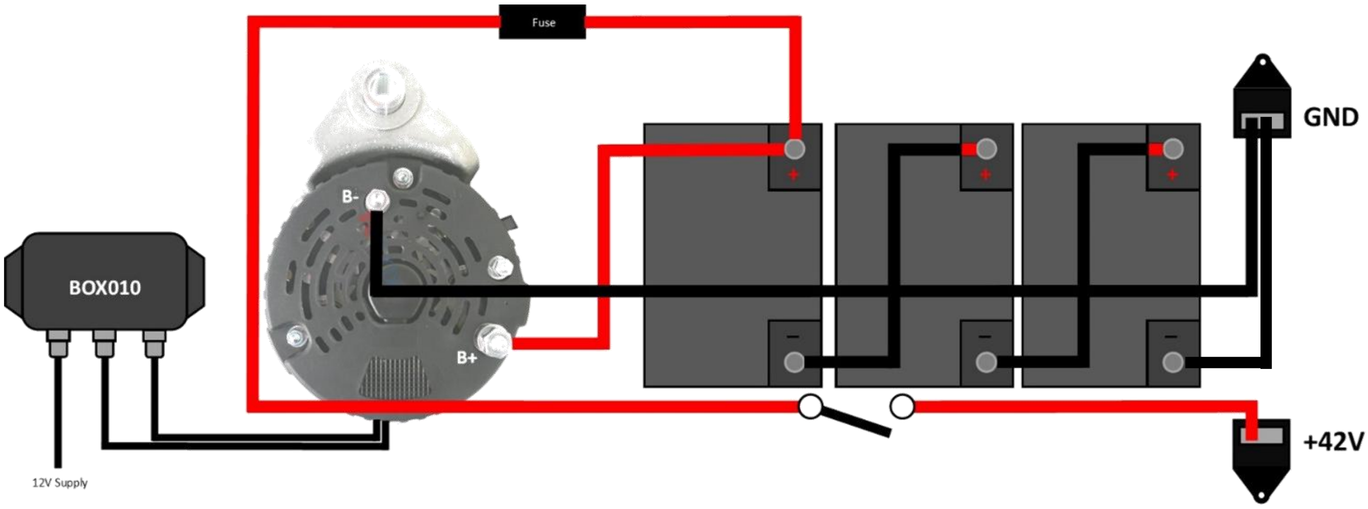
Hydraulic rotor function does require use of a closed centre hydraulic circuit design due to the proportional control required for hydraulic rotors, so a closed centre supply is recommended for efficiency and heat reasons. Variable demand of oil flow required by hydraulic rotors may require the integration of a hydraulic accumulator within the circuit design to reduce pressure fluctuations caused through changing demand of flow. Due to the tight tolerances associated with proportional control valves, adequate oil filtration methods must be employed.

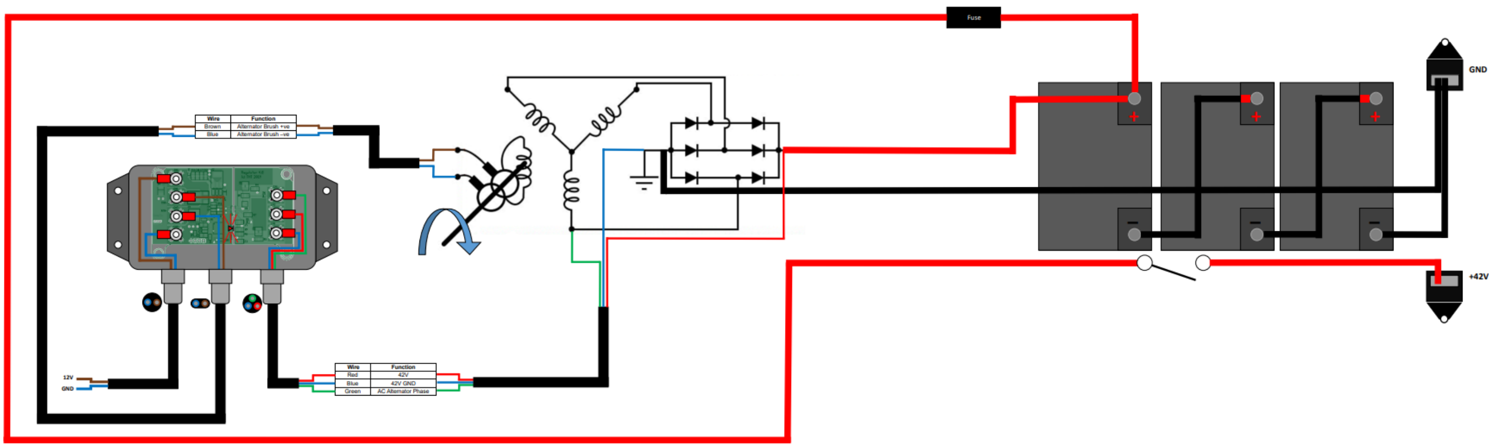
Electric Rotor In-row Implement Schematic



Function	Description
Steering	Steer Left and Steer Right output to side-shift/ parallelogram/disc steering device
Centre/Retract	Timed extension and retract output linked to lifted input
Left Levelling	Levelling raise and lower output for left of machine
Right Levelling	Levelling raise and lower output for right of machine
Dump/Unloader Valve	Output activated when any of above functions called

Alternator Charge Circuit Diagram

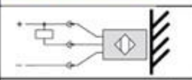
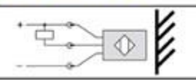
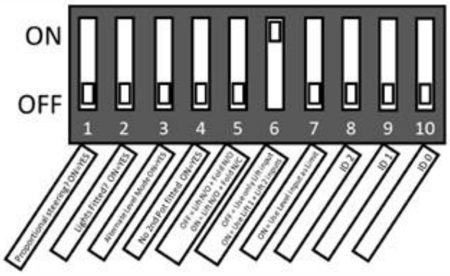
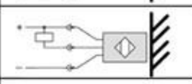
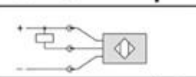
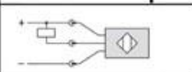
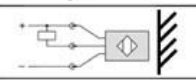
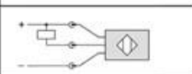
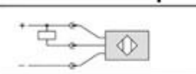
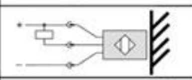
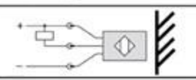
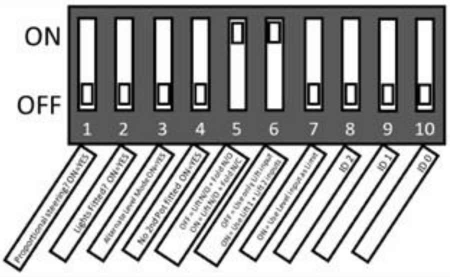
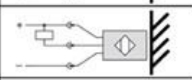
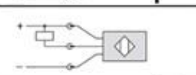
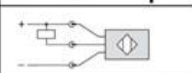
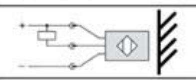
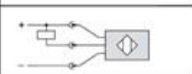
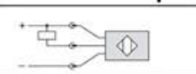


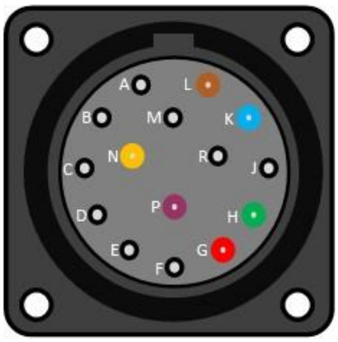


Microcontroller Board Connections and DIP Switch Settings

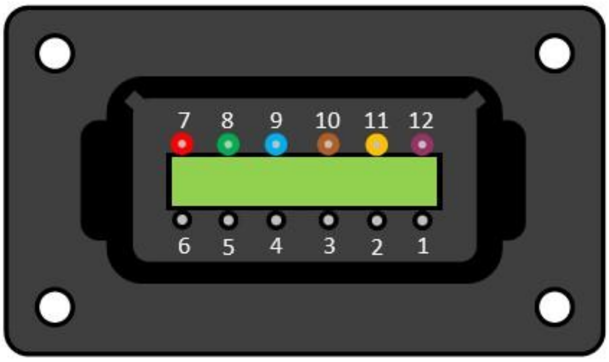
Master board 2 Lift / Lift+Fold DIP switch settings

If you wish to connect two lift inputs to BOX006 there are different modes of operation that can be set up through arrangement of the DIP switches (Switches 5 and/or 6) on the microcontroller. The lift status operation as shown in the table below:

Mode	Lift Channel 1	Lift Channel 2	Lift Status	DIP Switch Settings
2 Lift				
2 Lift				
2 Lift				
2 Lift				
Lift + Fold				
Lift + Fold				
Lift + Fold				
Lift + Fold				



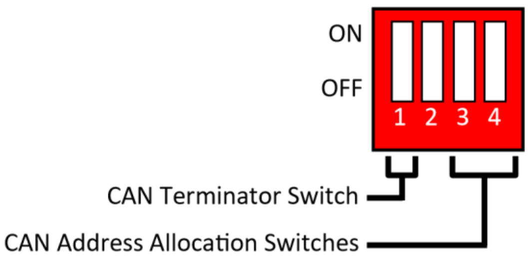
BOX006	
PIN	Function
G	12V
J	I/P Lift Channel 1
K	GND
L	12V
N	I/P Lift Channel 2
P	GND

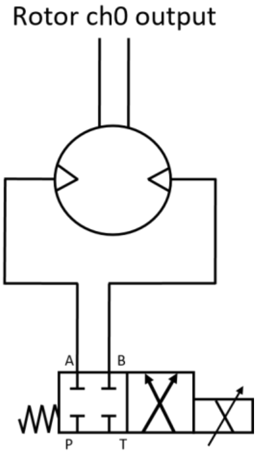


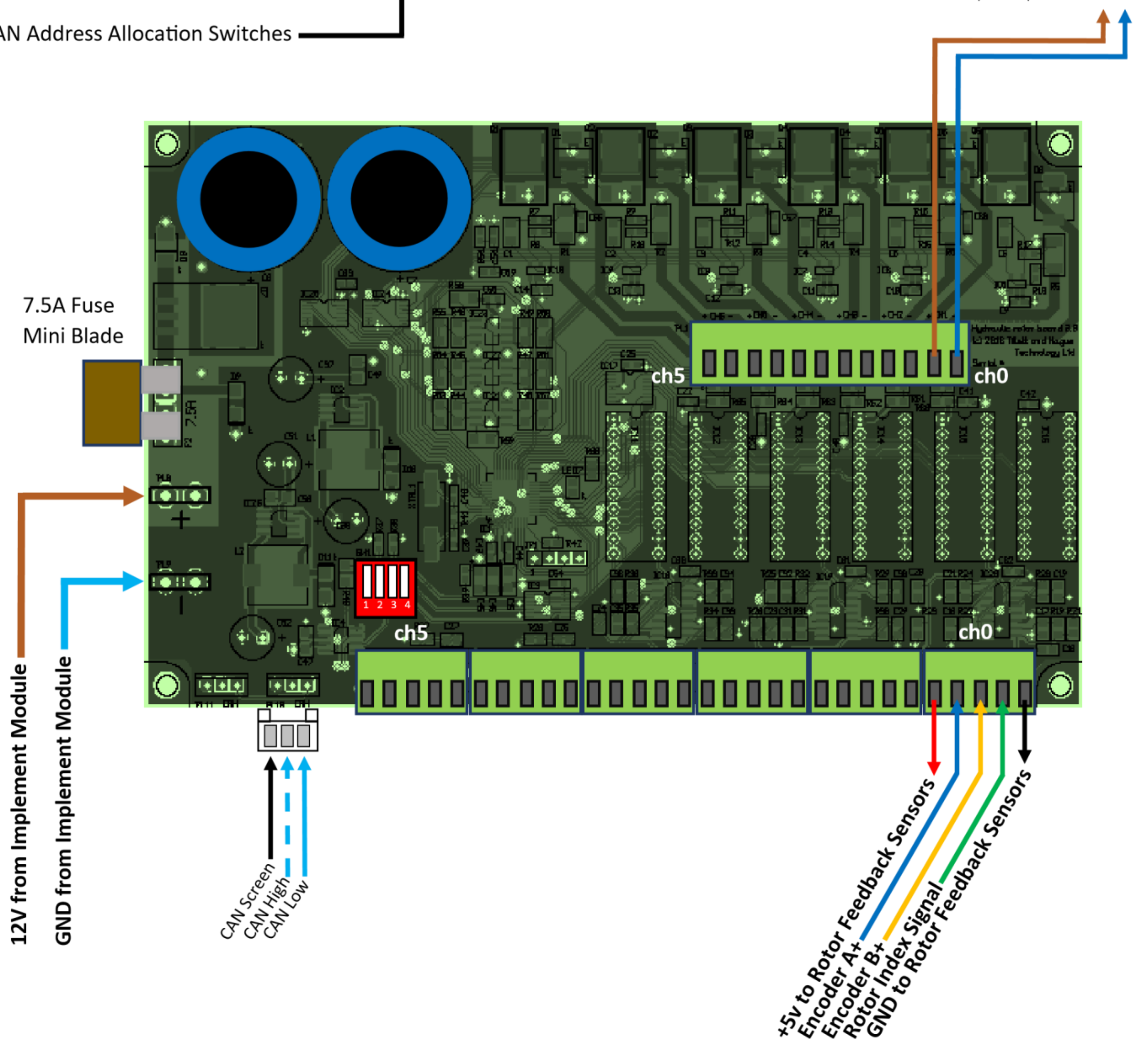
BOX006-XC2	
PIN	Function
7	12V
8	I/P Lift Channel 1
9	GND
10	12V
11	I/P Lift Channel 2
12	GND

Hydraulic Rotor Board PCB004

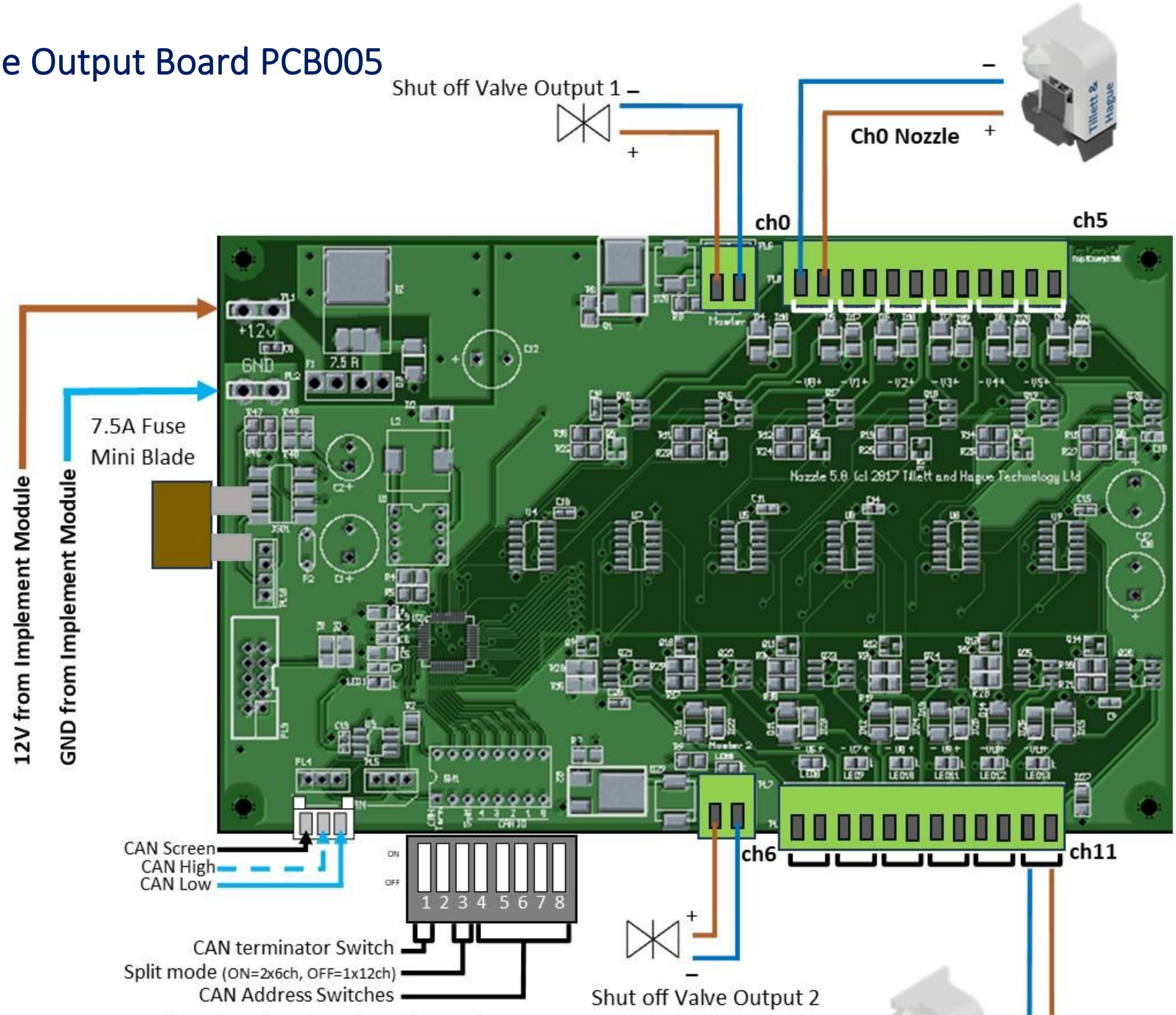
Hydraulic Rotor Board	Board DIP Switch Number 3	Board DIP Switch Number 4	
	ID Switches: ID 1	ID Switches: ID 0	CAN IDs Generated
	OFF	OFF	0->5
	OFF	ON	6->11
	ON	OFF	12->17
	ON	ON	18->23







Nozzle Output Board PCB005

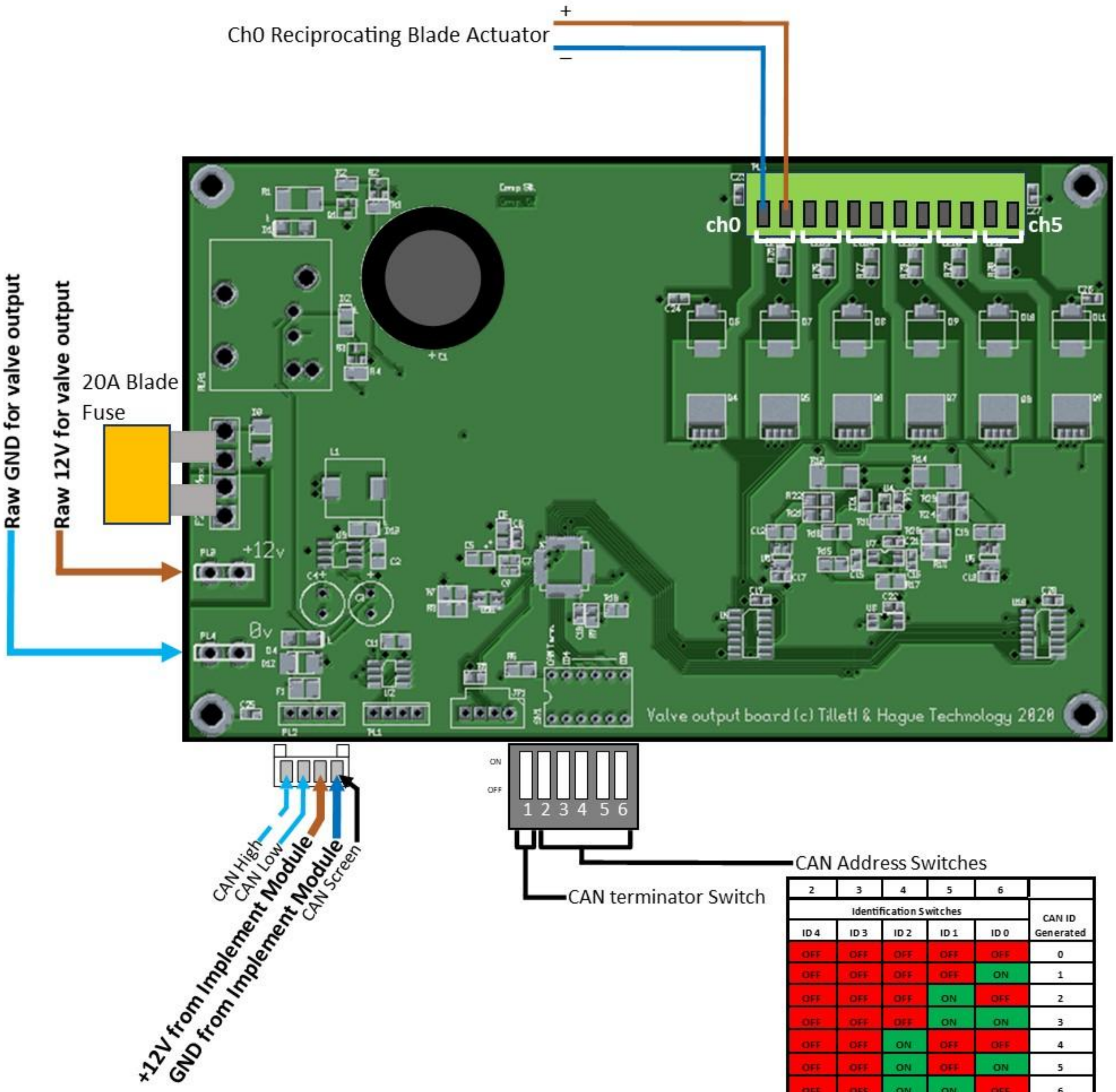


4	5	6	7	8	
Identification Switches					CAN ID Generated
ID 4	ID 3	ID 2	ID 1	ID 0	
OFF	OFF	OFF	OFF	OFF	0
OFF	OFF	OFF	OFF	ON	1
OFF	OFF	OFF	ON	OFF	2
OFF	OFF	OFF	ON	ON	3
OFF	OFF	ON	OFF	OFF	4
OFF	OFF	ON	OFF	ON	5
OFF	OFF	ON	ON	OFF	6
OFF	OFF	ON	ON	ON	7
OFF	ON	OFF	OFF	OFF	8
OFF	ON	OFF	OFF	ON	9
OFF	ON	OFF	ON	OFF	10
OFF	ON	OFF	ON	ON	11
OFF	ON	ON	OFF	OFF	12
OFF	ON	ON	OFF	ON	13
OFF	ON	ON	ON	OFF	14
OFF	ON	ON	ON	ON	15
ON	OFF	OFF	OFF	OFF	16
ON	OFF	OFF	OFF	ON	17
ON	OFF	OFF	ON	OFF	18
ON	OFF	OFF	ON	ON	19
ON	OFF	ON	OFF	OFF	20
ON	OFF	ON	OFF	ON	21
ON	OFF	ON	ON	OFF	22
ON	OFF	ON	ON	ON	23
ON	ON	OFF	OFF	OFF	24
ON	ON	OFF	OFF	ON	25
ON	ON	OFF	ON	OFF	26
ON	ON	OFF	ON	ON	27
ON	ON	ON	OFF	OFF	28
ON	ON	ON	OFF	ON	29
ON	ON	ON	ON	OFF	30
ON	ON	ON	ON	ON	31

Note:

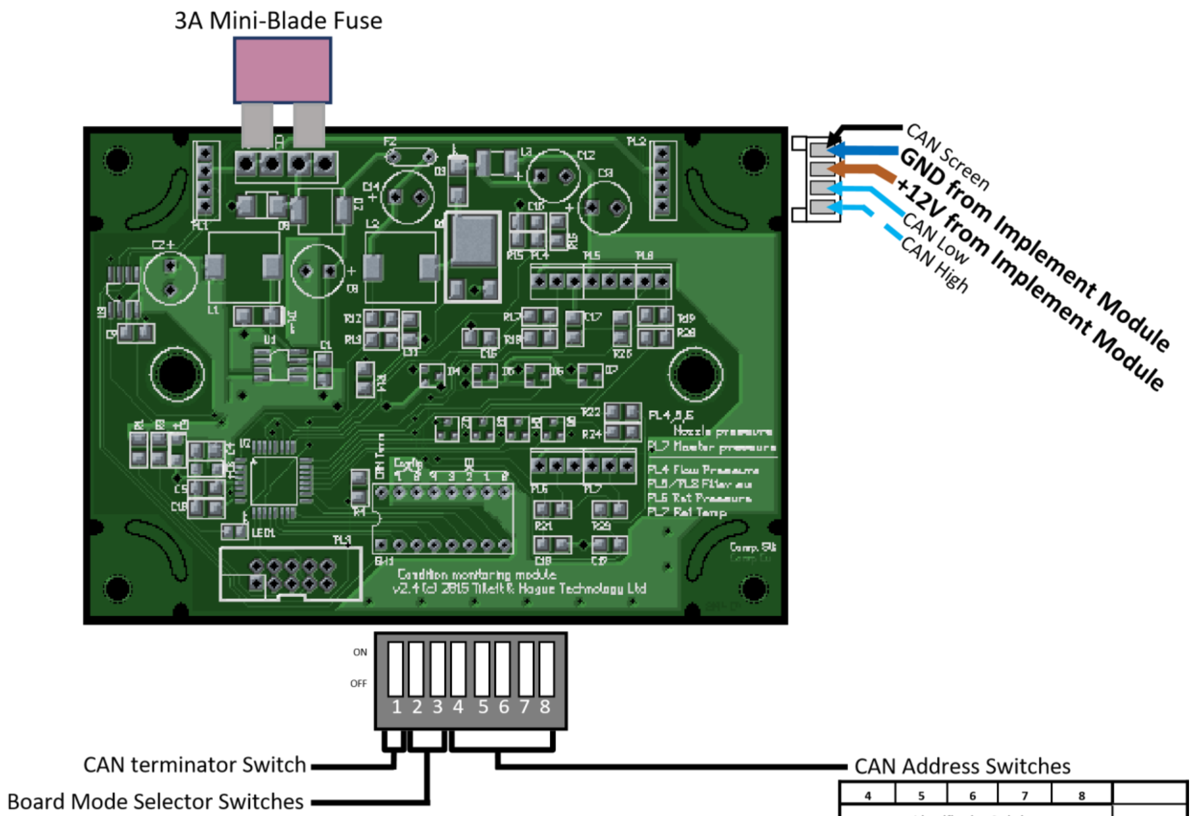
When running nozzle board in "Split" mode shutoff valve outputs will operate separately, Master 1 when channels 0->5 operate, Master 2 when channels 6-11 operate. And two successive CAN IDs are assigned to a single nozzle board.

Reciprocating Blade Controller Board PCB010



2	3	4	5	6	
Identification Switches					CAN ID Generated
ID 4	ID 3	ID 2	ID 1	ID 0	
OFF	OFF	OFF	OFF	OFF	0
OFF	OFF	OFF	OFF	ON	1
OFF	OFF	OFF	ON	OFF	2
OFF	OFF	OFF	ON	ON	3
OFF	OFF	ON	OFF	OFF	4
OFF	OFF	ON	OFF	ON	5
OFF	OFF	ON	ON	OFF	6
OFF	OFF	ON	ON	ON	7
OFF	ON	OFF	OFF	OFF	8
OFF	ON	OFF	OFF	ON	9
OFF	ON	OFF	ON	OFF	10
OFF	ON	OFF	ON	ON	11
OFF	ON	ON	OFF	OFF	12
OFF	ON	ON	OFF	ON	13
OFF	ON	ON	ON	OFF	14
OFF	ON	ON	ON	ON	15
ON	OFF	OFF	OFF	OFF	16
ON	OFF	OFF	OFF	ON	17
ON	OFF	OFF	ON	OFF	18
ON	OFF	OFF	ON	ON	19
ON	OFF	ON	OFF	OFF	20
ON	OFF	ON	OFF	ON	21
ON	OFF	ON	ON	OFF	22
ON	OFF	ON	ON	ON	23
ON	ON	OFF	OFF	OFF	24
ON	ON	OFF	OFF	ON	25
ON	ON	OFF	ON	OFF	26
ON	ON	OFF	ON	ON	27
ON	ON	ON	OFF	OFF	28
ON	ON	ON	OFF	ON	29
ON	ON	ON	ON	OFF	30
ON	ON	ON	ON	ON	31

Condition Monitoring Board PCB006



2	3			Input Functions				
Mode Switches		Mode Generated	Mode Operation	PL4	PL5	PL6	PL7	PL8
Config 1	Config 0							
OFF	OFF	0	Hydraulic Monitoring	Flow Pressure	N/C	Return Pressure	Return Temperature	Filter Blockage Sensor
OFF	ON	1	Spray Monitoring	Nozzle Pressure CH0	Nozzle Pressure CH1	Nozzle Pressure CH2	Master/Supply Pressure	N/C
ON	OFF	2	No Function	-	-	-	-	-
ON	ON	3	No Function	-	-	-	-	-

Hydraulic Sensors	Flow Pressure	0-250Bar range, 0-5V sensor output, 15V Supply
	Return Pressure	0-250Bar range, 0-5V sensor output, 15V Supply
	Filter Blockage	NO switch contact
Spray Sensors	Nozzle Pressure	0-4 bar range, 4-20mA sensor output, 15V supply
	Master Pressure	0-4 bar range, 4-20mA sensor output, 15V supply

4	5	6	7	8	
Identification Switches					CAN ID Generated
ID 4	ID 3	ID 2	ID 1	ID 0	
OFF	OFF	OFF	OFF	OFF	0
OFF	OFF	OFF	OFF	ON	1
OFF	OFF	OFF	ON	OFF	2
OFF	OFF	OFF	ON	ON	3
OFF	OFF	ON	OFF	OFF	4
OFF	OFF	ON	OFF	ON	5
OFF	OFF	ON	ON	OFF	6
OFF	OFF	ON	ON	ON	7
OFF	ON	OFF	OFF	OFF	8
OFF	ON	OFF	OFF	ON	9
OFF	ON	OFF	ON	OFF	10
OFF	ON	OFF	ON	ON	11
OFF	ON	ON	OFF	OFF	12
OFF	ON	ON	OFF	ON	13
OFF	ON	ON	ON	OFF	14
OFF	ON	ON	ON	ON	15
ON	OFF	OFF	OFF	OFF	16
ON	OFF	OFF	OFF	ON	17
ON	OFF	OFF	ON	OFF	18
ON	OFF	OFF	ON	ON	19
ON	OFF	ON	OFF	OFF	20
ON	OFF	ON	OFF	ON	21
ON	OFF	ON	ON	OFF	22
ON	OFF	ON	ON	ON	23
ON	ON	OFF	OFF	OFF	24
ON	ON	OFF	OFF	ON	25
ON	ON	OFF	ON	OFF	26
ON	ON	OFF	ON	ON	27
ON	ON	ON	OFF	OFF	28
ON	ON	ON	OFF	ON	29
ON	ON	ON	ON	OFF	30
ON	ON	ON	ON	ON	31