Mobile Hydraulic Control Training
Hydraulic Control 101
Hydraulic Control 101

- **Hydraulic, mechanical, electrical, and pneumatic** are the four methods of energy transmission.

- Each method has advantages and disadvantages so a combination of these energy transmissions may be used on mobile equipment.

- Hydraulic fluid provides force like a solid object (fluid molecules don’t compress like gas molecules).

- Flow (GPM “gallons per minute”) = hydraulic actuator speed.

- Pressure (PSI) = hydraulic actuator force. Most mobile systems are less than 3000 psi.
A basic hydraulic control system consists of the following components:

1. Power Supply
2. Hydraulic Pump
3. Valve
4. Cylinder

(Diesel Engine or Electric Motor)
Hydraulic System Components

- **System Pump**
  - Delivers constant flow of fluid and pressure
  - The pump shaft is driven by an engine or electric motor
  - Pumps have an inlet port and outlet port.

Example: (4) inline pumps connected to a motor for a mobile application
Hydraulic System Components
Hydraulic Actuators

- **Cylinder or RAM**
  - Converts hydraulic energy to mechanical energy
  - Cylinders provide linear mechanical energy

Hydraulic Cylinder Example

Pressure

To Tank

Hydraulic Cylinder Example
Hydraulic System Components
Hydraulic Actuators (continued)

- **Hydraulic Motors** provide rotary mechanical energy
  
  Example: Shows two motors (middle) for cat-track movement
Directional Valve Actuator:

- Moves the valve spool position by, electrical, hydraulic, pneumatic, or by a mechanical interface
  - Manual lever
  - Pilot: air or hydraulic pressure is used to shift the spool
  - Solenoid: electromechanical device that converts electric power into linear mechanical force and motion.
Hydraulic System Components
Directional Valves

- **Directional Valves**
  - Internal spool directs fluid flow from the pump to a hydraulic actuator
  - 4-way (*4 ports*): Commonly called bi-directional valves. Used for FWD/REV motion of a hydraulic actuator. See cross-section below.
  - 2-way (2 ports): Used for on-off (bang-bang) functions
Hydraulic System Components
Solenoids

Solenoid Types
A radio receiver will control the solenoid part of the hydraulic system. Solenoids come in different types and shapes. The two show below are very common. One is a valve type and the other is a coil type.

The left picture shows a valve type. This adjusts fluid flow to move the internal valve spool. The right picture shows a coil type. When energized it has rod that pushes the valve spool.
Here are some common types of radio output signals to control a valve:

- Digital Outputs are very common for all hydraulics. These are typically found on lower cost machines where proportional control is not needed.

- For proportional control, the most common type of proportional control signal for valves is the PWM signal. This is a similar signal used for controlling servo motors, and linear actuators.

- Some other common electrical output signals for valve control are:
  - Analog Output, (0-5VDC, 0-10VDC) “electronic driver cards”
  - Ratio Metric Analog (3-6-9VDC, where 6VDC is a neutral position) “Danfoss PVG”
  - Current Output (similar to a PWM) or current compensated “closed loop”
The most common is the PWM, so what is a PWM signal?

A PWM output is an unregulated output proportional to a command. This is an efficient technique to control current. A PWM output provides an apparent proportional output by driving a digital (on/off) output at high frequencies for proportionally longer or shorter periods of time. PWM can be low (25Hz to 400Hz) or a high 1000Hz. High frequencies produces a more constant ripple free amperage output. Here is a picture of a 100Hz PWM signal that one would see on a meter.
Example of an “open loop” PWM

Example: Valve has a solenoid valve controlling hydraulic fluid (blue area) to move the internal valve spool. The yellow area is pressurized fluid going to either a hydraulic actuator, or back to the fluid tank/reservoir.
What is a Current Output?

A current output is a regulated PWM output proportional to a command.

What is the difference between a Current Output signal and a PWM signal?
The “open loop” PWM is an unregulated output affected by changes in load, plus operating temperatures. The current output provides a regulated current source, that will not vary due to the changes in the load or temperature. Also, the valve electronics have a transducer that measures spool movement in relation to the input signal from the receiver and by means of a solenoid valve, controls the direction, velocity, and position of the internal valve spool.
PWM Signals (continued)

Here is an example of a PWM solenoid information that we will need in order to setup the radio receiver to drive the outputs properly for proportional control:

Example:

Solenoid Brand: Hydraforce
Initial Value: 400mA  (this is the threshold current)
Final Value: 1200mA  (this is the maximum current)
Frequency: 100Hz    (this is the PWM frequency)

Threshold Current: The amount of current required to reach the point where increasing current input causes flow from the valve to begin to increase (normally closed valve) or decrease (normally open valve).

Maximum Control Current: The point where increasing current input no longer results in an increase in valve flow.

Most distributors / integrators should know this information, but some may not, so we may need to get a solenoid part number or specification sheet to look this information up.
So, what radio receivers provide what type of outputs?

Model Flex EM/EX Series Receivers
- mechanical relay type digital output
- Fused at 5A
- No PWM or analog outputs available

Model CAN-6 radio receiver
- 8 solid state digital outputs (3A)
- 8 analog (0-5, 0-10, or 3-6-9VDC)
- No PWM outputs

Model MHR radio receiver
- 16 solid state digital on-off outputs (3A)
- 16 PWM “open loop” outputs
- 16 Current PWM or current compensated “closed loop” outputs
- No analog outputs
Mobile Hydraulic Radio Control
ON-OFF systems

For most simple on-off “bang-bang hydraulic valves” we will use the Flex EM/EX radio products to control the valves directly. The EM systems will be stock 12-24VDC systems with single speed operation that provide a digital output to the solenoid coil.
The model CAN-6 radio receiver can provide a 0-5VDC, or 0-10VDC output to an electronic driver module. The electronic driver module then provides a PWM output to the valves.
The model CAN-6 radio receiver can be paired up with a transmitter to drive any hydraulic valve directly that has solenoids requiring a digital on-off, or analog signal. The model CAN-6 can also provide CAN communications to CAN-bus controlled equipment.
CAN-Bus Control System with Radio
Benefits of radio control and CAN-Bus technology for mobile equipment:

- Radio control is easily added as an interface module to the system
- All hydraulic system adjustments are removed from the radio system
- Can-Bus self diagnostics can help determine radio problems
- Two way radio control provides data feedback for machine adjustments. (ex. rpm, temp, press, errors, etc.)
- Radio control + electronic hydraulic control offers smooth machine control, which extends the life of the machine and hydraulic components
Two model CAN-6 units setup in a transceiver mode will make up the model WIC-2400 wireless CAN radio system providing a wireless link of CAN data between two modules. This system is meant to replace CAN system cables that are prone to breaking or wire isolation is needed.

Example showing CAN engine data being transmitted and then displayed on a CAN based gauge.
Mobile Hydraulic Radio Control
PWM Output Example

The new model MHR radio receiver can be combined with a transmitter to provide CAN communications, digital, and PWM outputs for driving hydraulic valves directly. This radio receiver can provide the same precise control as a CAN-bus system, and includes inputs for getting feedback from external machine sensors, thus providing an intelligent direct drive valve control package.
The new model MHR receiver

Model MHR “mobile hydraulic” radio receiver

Outputs
- Drives up to eight bi-directional (fwd/rev) 16 functions
- Provides PWM, current PWM outputs (25 to 1000Hz)
- Provides on-off outputs rated at 3A. (total output max 21A)
- Two separate E-Stop outputs (double redundancy)

Inputs
- Six analog or digital inputs (0-12VDC)

Communication
- USB port, (2) CAN-Bus ports, Infrared Port

Other available Inputs…
The 16 outputs can also be configurable to be digital inputs as well.
Input types: digital inputs, and frequency inputs (encoders / RPM)
Input voltage: 9-36VDC (20ohm impedance)
The new model MHR receiver
<table>
<thead>
<tr>
<th>Con1</th>
<th>Name</th>
<th>Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>CANH1</td>
<td>CAN bus 1 Port</td>
</tr>
<tr>
<td>A2</td>
<td>USB+</td>
<td>USB Port</td>
</tr>
<tr>
<td>A3</td>
<td>USB-</td>
<td>USB Port</td>
</tr>
<tr>
<td>B1</td>
<td>CANH2</td>
<td>CAN bus 2 Port</td>
</tr>
<tr>
<td>B2</td>
<td>CANL2</td>
<td>CAN bus 2 Port</td>
</tr>
<tr>
<td>B3</td>
<td>CANL1</td>
<td>CAN bus 1 Port</td>
</tr>
<tr>
<td>C1</td>
<td>Stop 2</td>
<td>Machine Stop output/Digital Output</td>
</tr>
<tr>
<td>C2</td>
<td>Vref Com</td>
<td>Common for Voltage Supply</td>
</tr>
<tr>
<td>C3</td>
<td>+5V Vref</td>
<td>+5V Voltage Supply (100mA max)</td>
</tr>
<tr>
<td>D1</td>
<td>Stop 1</td>
<td>Machine Stop output</td>
</tr>
<tr>
<td>D2</td>
<td>-Vbattery</td>
<td>-V Bat</td>
</tr>
<tr>
<td>D3</td>
<td>+Vbattery</td>
<td>+V Bat</td>
</tr>
<tr>
<td>E1</td>
<td>ADF1</td>
<td>Analog/Digital In1</td>
</tr>
<tr>
<td>E2</td>
<td>ADF2</td>
<td>Analog/Digital In2</td>
</tr>
<tr>
<td>E3</td>
<td>ADF3</td>
<td>Analog/Digital In3</td>
</tr>
<tr>
<td>F1</td>
<td>ADF4</td>
<td>Analog/Digital In4</td>
</tr>
<tr>
<td>F2</td>
<td>ADF5</td>
<td>Analog/Digital In5</td>
</tr>
<tr>
<td>F3</td>
<td>ADF6</td>
<td>Analog/Digital In6</td>
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<table>
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<th>Name</th>
<th>Functions</th>
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<tbody>
<tr>
<td>A1</td>
<td>IO1</td>
<td>CC Out/PWM Out/Dig Out/Dig In/Freq 1</td>
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<tr>
<td>A2</td>
<td>IO2</td>
<td>CC Out/PWM Out/Dig Out/Dig In/Freq 2</td>
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<tr>
<td>A3</td>
<td>Return 1</td>
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<td>B1</td>
<td>IO3</td>
<td>CC Out/PWM Out/Dig Out/Dig In/Freq 3</td>
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<td>B2</td>
<td>IO4</td>
<td>CC Out/PWM Out/Dig Out/Dig In/Freq 4</td>
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<td>B3</td>
<td>Return 2</td>
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<td>IO5</td>
<td>CC Out/PWM Out/Dig Out/Dig In/Freq 5</td>
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<tr>
<td>C2</td>
<td>IO6</td>
<td>CC Out/PWM Out/Dig Out/Dig In/Freq 6</td>
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<tr>
<td>C3</td>
<td>Return 3</td>
<td>Return for Out 5&amp;6</td>
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<tr>
<td>D1</td>
<td>IO7</td>
<td>CC Out/PWM Out/Dig Out/Dig In/Freq 7</td>
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<td>D2</td>
<td>IO8</td>
<td>CC Out/PWM Out/Dig Out/Dig In/Freq 8</td>
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<td>D3</td>
<td>Return 4</td>
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<td>IO9</td>
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<td>IO10</td>
<td>CC Out/PWM Out/Dig Out/Dig In/Freq 10</td>
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<tr>
<td>E3</td>
<td>Return 5</td>
<td>Return for Out 9&amp;10</td>
</tr>
<tr>
<td>F1</td>
<td>IO11</td>
<td>CC Out/PWM Out/Dig Out/Dig In/Freq 11</td>
</tr>
<tr>
<td>F2</td>
<td>IO12</td>
<td>CC Out/PWM Out/Dig Out/Dig In/Freq 12</td>
</tr>
<tr>
<td>F3</td>
<td>Return 6</td>
<td>Return for Out 11&amp;12</td>
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### MHR receiver
C2 I/O continued

<table>
<thead>
<tr>
<th>Con2</th>
<th>Name</th>
<th>Functions</th>
</tr>
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<tbody>
<tr>
<td>G1</td>
<td>IO13</td>
<td>CC Out/PWM Out/Dig Out/Dig In/Freq 13</td>
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<tr>
<td>G2</td>
<td>IO14</td>
<td>CC Out/PWM Out/Dig Out/Dig In/Freq 14</td>
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<td>G3</td>
<td>Return 7</td>
<td>Return for Out 13&amp;14</td>
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<td>IO15</td>
<td>CC Out/PWM Out/Dig Out/Dig In/Freq 15</td>
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<td>H2</td>
<td>IO16</td>
<td>CC Out/PWM Out/Dig Out/Dig In/Freq 16</td>
</tr>
<tr>
<td>H3</td>
<td>Return 8</td>
<td>Return for Out 15&amp;16</td>
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<td>J1</td>
<td>-Vbattery</td>
<td>-V Bat</td>
</tr>
<tr>
<td>J2</td>
<td>-Vbattery</td>
<td>-V Bat</td>
</tr>
<tr>
<td>J3</td>
<td>-Vbattery</td>
<td>-V Bat</td>
</tr>
<tr>
<td>K1</td>
<td>Vbattery</td>
<td>+V Bat</td>
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<td>K2</td>
<td>Vbattery</td>
<td>+V Bat</td>
</tr>
<tr>
<td>K3</td>
<td>Vbattery</td>
<td>+V Bat</td>
</tr>
</tbody>
</table>
The new model MHR receiver

Model MHR “mobile hydraulic” radio receiver

Unique features:

- Graphic display and four pushbutton keypad for diagnostics and system set up.

- Two separate internal computer processors (double redundancy)

- Two separate E-Stop outputs (double redundancy)

- Tested to IP-66 / 67 sealing tests

- System can be expanded by adding another receiver or another module like the CAN-M1 module additional inputs or outputs.

- A PC software program will be available for setting up proportional valve parameters, with an easy to use interface
MHR receiver
LCD Graphic Display

**Fault Number**
Each fault has a number and letter indicating a System (S) or User (U) alarm which is useful in troubleshooting and installation.

**Description of Fault**
In this example, Output 11 has an Over Current Error due to a faulty solenoid.

**Input Values**
Analog or digital inputs can be displayed for monitoring purposes.

**Proportional Output Commands**
Active outputs are shown indicating the function that is on and the level of output.

**Latched Output Commands**
The status of latched functions such as Engine High/Low Idle or Pump On/Off can be displayed.

**CAN-BUS Commands**
Standard J1939 or other custom CAN-BUS values can be displayed. Example shows a custom readout for the Boom Angle and Load.

**RF-Signal Status Indicator**
RSSI provides a measure of the quality and strength of the RF communication between the transmitter and receiver. This may also be communicated over the CAN-BUS.

**Transmitter Battery Indicator**
The life of the transmitter battery is displayed to indicate when it's time to change batteries. This may also be communicated over the CAN-BUS.

**Receiver Watch Dog**
The watchdog spins to indicate the MHR is in run mode and actively monitoring all aspects of the system.
MHR receiver
LCD Graphic Display (continued)

**Header**
Indication of the current menu context

**Parameter List**
List of parameters to choose from to modify. To cycle through the list use the **UP/DOWN** buttons. To enter a submenu, use the **SELECT** button. The **BACK** button will take the user back to the Setup Mode menu.
The list of choices are:
- PWM Frequency
- Output # (There will be one for each output available on the unit)
MHR receiver
LCD Graphic Display (continued)

**Header**
Indication of the current menu context

**Parameter List**
List of parameter to choose from to modify. To cycle through the list use the *UP/DOWN* buttons. To enter a submenu, use the *SELECT* button. The *BACK* button will take the user back to the IO Config menu.
The list of choices are:
- Config Type
  - Unused
  - Digital Output
  - Current Compensated
  - Open Loop PWM
  - Digital Input
- Minimum Current (Only used for Current Comp)
- Maximum Current (Only used for Current Comp)
- Start Ramp
- Stop Ramp
- Min Duty Cycle (Only used for Open Loop PWM)
- Max Duty Cycle (Only used for Open Loop PWM)
MHR receiver
Proposed PC Setup Screen 1

This should be a list box of the outputs which is populated based on a configuration file that indicates how many IOs there are for the particular device type.

This should update with the IO name when a different one is selected.

These groups should only be active when the particular type is chosen, otherwise all of the fields should be greyed out.

These fields should only be shown in manufacturing mode.

Device picture
Just like in the current RCP

Mouseover tool tips
Just like in the current RCP
MHR receiver
Proposed PC Setup Screen 2

This list should have a scroll bar automatically show up when the list is too long to fit in the window, based on the sizing of the program.

This screen is shown when this is clicked.

Device picture
Just like in the current RCP

Mouseover tool tips
Just like in the current RCP

These are read only fields based on what is read from the unit.

RF channel will be populated based on the frequency read from the device.

If disabled is chosen, then the input field should be greyed out for these.

The MH receivers will have both of these enabled, transmitters will only have one enabled and the other greyed out.
MHR receiver versus the competition

- Provides both open and closed loop PMW signals, other systems typical just provide the open loop type.
- Takes inputs such as analog sensors, and digital switches, where others only supply outputs or would need to add other modules, thus increasing their system cost.
- Offers programmable I/O with the use of the graphic display or the PC software that will be available soon.
- Graphic display provides more system data and status versus LED lights.
- 4 button keypad can digitally adjust outputs, where others use rotary potentiometers located internally on the printed circuit board.
- Sealed and tested to IP-66/67 specifications.
- Receiver can be mounted out in the open with internal / external antenna options.
- When matched up with the list of Magnetek transmitters, the MHR can supply a number of options that will be most needed.
- The MHR will work with the following transmitters:
  - Enrange Flex EM / EX / and Pro series transmitters
  - Enrange PGT / MBT transmitters
  - Enrange MLTX transmitters
  - Enrange XLTX transmitters
  - Enrange DTX transmitters
ANY QUESTIONS?