JDLink Communications Controller

Operational Description

Phoenix International Corporation

A John Deere Company

1. Introduction

The John Deere JDLink product is a stand-alone device that can be installed on various types of John Deere agricultural equipment. JDLink consists of a Communications Controller in an aluminum enclosure, an installation harness, GPS and cell phone antennas, and an antenna mounting bracket. The unit runs off of vehicle power (alternator / battery).

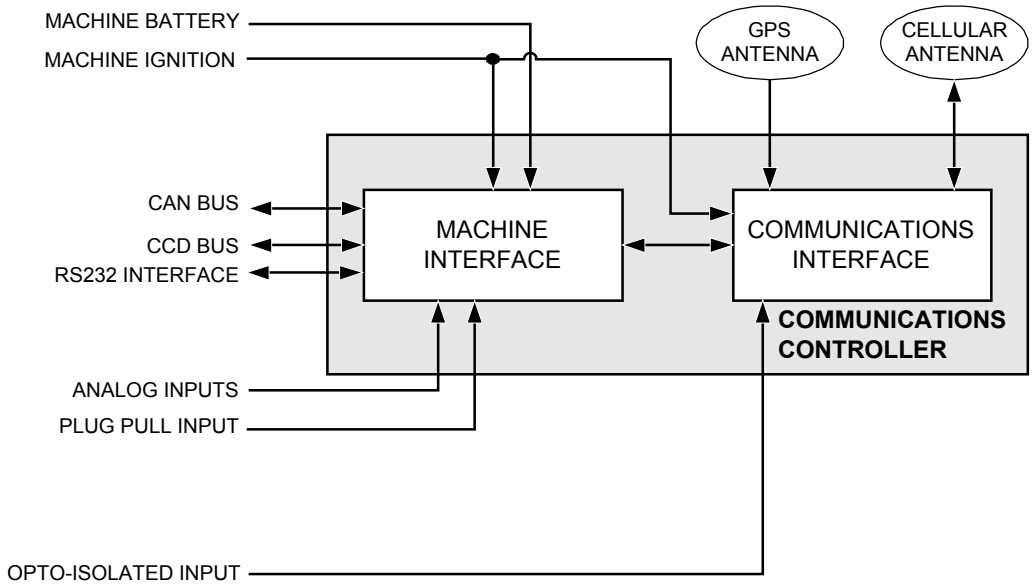
JDLink provides the operator/owner with a way to remotely monitor machine status. This is accomplished by the Communications Controller monitoring CAN (Controller Area Network), CCD (Chrysler Collision Detection), and / or RS-232 serial busses on the equipment. The Communications Controller also has various digital and analog inputs that can be configured for specific tasks. The Communications Controller gathers the following types of vehicle information:

- Location information via GPS
- Vehicle engine hours
- Three types of machine alerts (up to 499 total alerts)
  - "Red" or Stop Engine alerts, which can be configured to generate an immediate call-in if the user desires,
  - "Yellow" or Caution alerts, which are alerts that do not require immediate action,
  - "Signal" alerts, which are specific to the JDLink Communications Controller unit.

This information is sent back to a centralized server (called the Communications Server) via a cell phone modem. The user can then access this information via the World Wide Web using a web browser. The user also configures the Communications Controller using the same web interface – the Communications Controller has no operating controls on the unit. The Communications Server can also initiate a call to the Communications Controller. This is done for two reasons - retrieving the current vehicle status and updating configuration information.

2. Communications Controller Architecture

The Communications Controller consists of two main components, the Communications Interface and the Machine Interface. The Communications Interface is an off-the-shelf AMPS (Advanced Mobile Phone System) cellular modem operating at 824 - 849 MHz, and an integrated GPS (Global Positioning System) receiver. It is responsible for initiating and receiving calls from the Communications Server and obtaining GPS position information. The Machine Interface is responsible for gathering information from the vehicle via CAN, CCD, RS-232, and/or discrete inputs, providing regulated power to the Communications Controller, and packaging all data appropriately for over-the-air transmission. The Machine Interface and the Communications Interface communicate via an RS-232 serial interface. A block diagram of the Communications Controller is shown below.



In addition to performing all wireless communications, the Communications Interface has the capability of monitoring two additional inputs, one dedicated to vehicle ignition and a generic opto-isolated input. The user can configure the Communications Controller to take specific actions based on the state of these inputs. Note that connection of the opto-isolated input to an external device is optional and does not apply to all installations.

The Machine Interface has three inputs in addition to buss monitoring and power regulation / distribution. Two inputs are generic analog inputs. The user can configure the Communications Controller to take specific actions based on the state of these inputs. The third input is a dedicated Plug-Pull input that can be used to initiate a call to the Communications Server. Note that connection of the analog inputs and the Plug-Pull input is optional and does not apply to all installations.

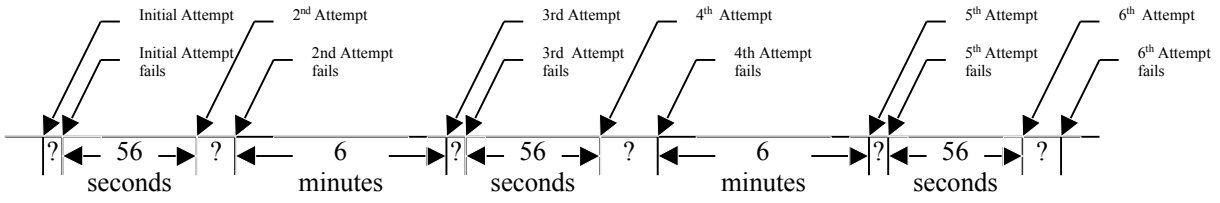
The Machine Interface also has a Real Time Clock (RTC) that is used to time-stamp bus information and for call-in scheduling.

3. Call-In Scheduling

The call-in schedule for the Communications Controller can be configured via the World Wide Web interface. Call-ins can be scheduled with a minimum interval between calls of one hour, and a maximum interval between calls of one week. The maximum transmission time per connection is 3 hours. Call-ins can occur independent of the operational state of the vehicle (vehicle ignition on or off). If there is no data to report, the Communications Controller will skip call-ins until there is new data. In the event that the Communications Controller is unable to contact the Communications Server, the Communications Controller will try to contact the Communications Server based on the retry logic shown below:

If the initial call-in is unsuccessful then:

- 2nd Attempt will be made 56 seconds after 1st attempt fails
- 3rd Attempt will be made 6 minutes after 2nd attempt fails
- 4th Attempt will be made 56 seconds after 3rd attempt fails
- 5th Attempt will be made 6 minutes after 4th attempt fails
- 6th Attempt will be made 56 seconds after 5th attempt fails



? – denotes undetermined amount of time for call attempt to fail

The Communications Controller can also be forced into a Hold mode in which no call-ins are generated.

4. Power Management

The Communications Controller has four power management modes: Full Power, Ears On, Power-Save, and Power Off. The Communications Controller is in Full Power mode when the vehicle ignition is on. In this mode, the Machine Interface is fully operational and the Communications Interface is ready to receive calls from the Communications Server. In Ears On mode, the Machine Interface is in a low power state, but the Communications Interface is still able to receive calls. Power Save mode is a reduced power mode used to prolong operation once the vehicle ignition is turned off. The maximum allowed current draw in this state is 3 amp-hours. Power Off mode is a complete power-down of the unit. The logic for transitioning from mode to mode are shown below:

- When vehicle ignition is on, the Communications Controller is in Full Power mode.
- Once vehicle ignition is off the following events occur:
  - The Communications Controller changes to Ears On mode and remains in this mode for 24 hours – during this interval it is possible for the Communications Server to contact the Communications Controller assuming good cellular coverage.
  - After 24 hours the Communications Controller will switch from Ears On mode to Power-Save mode.
    - If there is still a scheduled call-in that needs to be completed, the Communications Controller will stay in the Power-Save mode until the scheduled call-in is completed.
    - If the call cannot be completed, the Communications Controller will retry up to the maximum number of retry attempts configured or the maximum allowed 3 amp-hours of allowed current draw, whichever occurs first.
    - After the scheduled call-in occurs, the Communications Controller will enter Power Off mode.
  - If the scheduled call-in has already occurred, the Communications Controller will enter Power Off mode.
- Once the Communications Controller has entered Power Off mode the only way to turn it back on is to turn on the vehicle ignition.

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Time Measurement

The communications controller keeps track of two basic time elements in seconds. The time the engine has been running and the time the key is on.

Key-On Time

The total key-on time is represented in seconds and accumulated in Meter 4. It represents the total time the communications controller is in full power mode with power supplied from the ignition key. Key-on time is not reported to the host, but only available by direct connection with the remote communications controller and reading Meter 4.

Engine Running Time

The total engine running time is represented in seconds and accumulated in Meter 0. It represents the total time the communications controller is in full power mode (key-on) and the engine is running. Engine running time is reported with a standard position report provided during communications controller check-in.

Engine Hour Check-in Interval

The total time the engine has run since the last confirmed communication controller check-in is saved in Meter 1. A confirmed check-in maybe due the polling of the machine or a scheduled check-in. If the engine hour interval has exceeded a predetermined threshold a check-in occurs and the counter is set to zero to repeat the process.

Engine Hour Log Interval

This is a trigger point in seconds that once reached the current position and total engine running time are save to flash for latter reading during a check-in. It allows positions and hours to be saved on a defined engine hour interval to be reported when a check-in occurs. This function is disabled in the GVC Level 1A release.

Power Operation / Modes

The GVC Level 1A communications controller has 4 power modes used. They are as follows:

Full On

In full on or full power mode the GPS is powered up and doing position fixes, the cellular system is powered and capable of either checking in or being contacted (polled). All I/O are monitored continuously.

Ears On

In ears on power mode the GPS is not powered, but the cellular system is power in a minimum state and capable of either checking in or being contacted (polled). All I/O are monitored on a 5-second basis to reduce power consumption. Ears on time is configurable in seconds

Power Save

In power save mode the GPS is not powered and the cellular system is not powered. The FCP (Function Control Processor) wakes on a 5-second interval to do a house keeping check I/O and

check if a schedule must be executed. If a scheduled check-in is required the communications controller will power-up perform the check-in and then return to power save mode. This sequence is repeated until the retry configuration has been met. Power save time is only established if key-on and engine running are seen prior to key off. Power save time is configurable in seconds.

Off

In the off mode the communications controller consumes no battery power. This mode is entered with the key on only and no engine running signal and then the key is turned off, or when the power save time has expired.

The following table describes the power consumption within the different modes of operation. This information is duplicated from the power management section and describes the maximum power reserve consumption (AmpHr) once a Key-On and Engine-Running event occur.

Power reserve consumption (during Power Save from Key-Off)		
Power save mode – Ears On (8 hours)	60 mA	0.48 AmpHr
Power save mode – Sleep (70 hours)	6 mA	0. AmpHr
Failed check-in attempts – (1 min - 12 total)	500 mA	0.10 AmpHr
Total		1.00 AmpHr

Check-in Processing

The communications controller performs 3 types of check-ins. When communications are established to the host an ID and reason code for the check-in are sent. Currently 3 reason codes are used. The reason codes are a binary mask that may contain multiple reasons if a prior check-in attempt was unsuccessful. The default Level 1A Configuration will be no scheduled check-in with an engine hour interval check-in.

Scheduled Check-in (reason code 0x0001)

A scheduled check-in is based on a time schedule entered into the communications controller. In the GVC L1A application one time on each day of the week is set-up to execute a check-in. Each day of the week may be individually enabled or disabled. The actual time set in the controller to check-in is randomized over a 2-hour interval. Due to highly accurate GPS clock this is required to prevent over loading at the communications server. The scheduled-in check-in may also be disabled.

Polled Check-in (reason code 0x0002)

A polled check-in occurs when the unit is dialed from the host. Under this check-in the communications controller position and engine meter reading are read. After directly reading the current values the data stored in flash is downloaded from the unit.

Engine Hour Interval Check-in (reason code 0x1000)

An engine hour interval check-in is based on the engine hour operation reaching an accumulated threshold and that no confirmed check-in has occurred. This type of check-in is based on engine running time accumulation. For example the vehicle could report for every 8 hours of operation. Please refer to the operating time metering above.

Synchronize Plug Pull Check-in (reason code 0x2000)

A synchronize plug pull check-in is manually initiated by pulling the diagnostic plug and re-inserting it. This check-in is used for the synchronization of engine hours and/or diagnostics purposes. When used to calibrate vehicle hours the current engine hours and a time/date stamp of the event must be recorded. From this record a calibration valued may then later be configured at the host, via the web interface. A paper form (Deere Trak Installation Record) is inserted into the installation kit to aid in this set-up.

Retry Configurations

The retry configuration controls how a failed check-in attempt is retried. The retry configuration for check-ins is explained below.

Data Logging to Flash

The communications controller uses a process of saving information to flash memory on an event and then the information is downloaded during a check-in. This process preserves data integrity during power failures. Also with date/time stamping of data on the communication controller this preserves a vehicle time reference basis, even when the data is transmitted much later in time.

GPS Position/Velocity and Total Engine Running

Based on the check-in events both a GPS position/velocity and total engine running time records are written to flash (location – Flash 0). The information in each report is summarized below:

GPS Position/Velocity Record
Current GPS information
    Date/time, GPSStatus, GPSErrorCode
Last know GPS fix information
    TimeOfFix, EastVelocity, NorthVelocity, UpVelocity, Latitude, Longitude, Altitude, VelocityScaling, FixType, NumSys, UtcOffset
Engine Running Meter
    Meter Id=0, OperationMode, MeterValue, MeterThreshold

Cellular Diagnostic Information

The communication controller is configured to process diagnostic operations before and after each phone call attempt. The pre and post-connection action will be processed with each out going call attempt and stored in on board unit diagnostic Flash (Area 5). In this area GPS Position/Velocity, Cellular Status, FCP (Function Controller Processor) Status, General Hardware Status are stored prior to the call. After the call a Connection Log Status is stored. The diagnostic flash area saves the last 51 check-in call attempts. The diagnostic data when the unit is paged is not saved.Diagnostic LEDs

Diagnostic LEDs

On the system two diagnostic LEDs are provided. One LED provides diagnostic on availability of cellular service and positively verifies a device checked in to the host communication services. The second LED provides diagnostics for both engine running and GPS positioning.

Cellular LED

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The following table describes the operation of the Cellular LED. Please pay particular attention of the sequence of operation followed in the table.

Cellular LED	State
Cellular Service Availability Check	
Vehicle Key-Off	Off
Vehicle Key-On (0 to 7 seconds)	On
Vehicle Key-On (15 seconds to "Service Available")	Off
Vehicle Key-On ("Service Available") – steady state	On
Synchronization Check – "Service Available"	
Vehicle Key-On "Sync Plug and re-insert" => start check in	On
Vehicle Key-On (start check-in to communicating with host)	On
Vehicle Key-On communicating with host	Off
Vehicle Key-On ("Service Available") – steady state	On

Engine Running/GPS Positioning LED

The following table describes the operation of the Engine Running/GPS LED. Please pay particular attention of the sequence of operation followed in the table. The logic driving the LED is Engine Running or GPS Positioning.

Engine Running/GPS Positioning LED	State
Cellular Service Availability Check	
Vehicle Key-Off	Off
Vehicle Key-On (0 to 5 seconds)	On
Vehicle Key-On (5 seconds to "GPS Positioning")	Off
Vehicle Key-On ("GPS Positioning") – steady state	On
Synchronization Check – "GSP Input Signal Disabled"	
Vehicle Key-On / Engine Running-Off	Off
Vehicle Key-On / Engine Running-On	On

Communication Connection Parameters

Retry Configuration

1	Number of retries on each system for a single connection attempt
56	Delay between each retry in seconds
2	Total number of multiple retries
60	Delay between multiple retries in minutes

Retry configuration establishes the communications controller attempt retry sequence for completing a check-in event. The communications controller will attempt up to 6 calls for each check-in request. The retry sequence is defined as 2 attempts separated by 56 seconds, wait 60 minutes, 2 more attempts separated by 56 seconds, wait 60 minutes and a final 2 attempts separated by 56 seconds.

Automatic Redial

Automatic redial controls how the communications controller responds when contacted by the communications server. Under the current configuration the unit will answer and respond accordingly to properly formatted query and configuration messages. This allows the

communication controller to be configured and/or re-programmed over-the-air. Upon receiving a page the unit immediately answers to minimize airtime.

Diagnostic Operation

The communication controller is configured to process diagnostic operations before and after each phone call attempt. The pre and post-connection action will be processed with each out going call attempt and stored in on board unit diagnostic Flash (Area 5). In this area GPS Position/Velocity, Cellular Status, FCP (Function Controller Processor) Status, General Hardware Status are stored prior to the call. After the call a Connection Log Status is stored. The diagnostic flash area saves the last 51 check-in call attempts. The diagnostic data when the unit is paged is not saved.

During cellular operation the GPS is turned off to maximize available transmit power, reducing current draw. Just prior to the call the GPS position is saved and reported during the check-In.

Miscellaneous Configurations

A continuous communications handshake occurs when the unit is on the air. If a handshake time-out occurs of over 25 seconds the link is declared inactive and shutdown. If a handshake is present, but no command packets are processed within 120 seconds the communications channel is also declared inactive and shutdown.

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NAM Configuration

ID

The Communications Controller Asset ID is set equivalent to the ESN of the AMPS cellular module minus the leading byte. This assignment will be permanent and unique for each device produced.

Description

Within the Communications Controller the Description field is used for identification of the software loaded into the unit. There are other methods to obtain this information, but this provides a single string to identify the software loaded into the unit.

Example: GVC1A009*0316*020*043*040*100*1400*002 (50 Chars Max)

GVC Configuration Level	GVC1A009
CVDM Application Firmware	0.31.6
CVDM Boot Firmware	0.2.0
Hitachi Firmware	0.4.3
Boot Firmware	0.4.0
GPS System Firmware	1.0.0
GPS Signal Firmware	1.40.0
SID Table	002

Dial String

An 800 number is entered into the unit as the number to dial for a check-in to occur. Regardless of the setting of this number a communications controller serviced by the WIN4 network will always dial the 800 number provide by WIN4 configuration.

GPS Parameters

The GPS within the communications controller is configure to not power the GPS system while making a cellular connection or when waking up to perform a scheduled event. The position that is saved and reported when waking up to perform a scheduled event is based on the position last seen during full power mode (Key-On). This conserves power during scheduled check-ins and assumes the vehicle has not moved unless a Key-On event occurs.

Power Management

The communications controller voltage management is described below. When looking at this table it is important to remember the power supply is designed to support an external battery if required. The Asset voltage represents voltage supplied to the unit. The Battery voltage represents voltage supplied to an intermediary point through a charger (where an external battery is attached). The charger output is controlled based on the battery voltage and temperature when present. In the Level 1A no external battery is present and the temperature thermistor is internally to the unit and set at 10K. In this configuration the controller charger outputs a nominal 14volts.

Battery voltage levels (Volts)		**Asset voltage levels (Volts)**	
Low voltage off (8-12)	10.8	Low voltage off (8-24)	9.1

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Low voltage on (8-14)	12.0	Low voltage on (8-28)	9.5
Low voltage warning (8-14)	11.2	Low voltage warning (8-28)	9.5
Max voltage off (15-20)	16.2		
Max voltage on (10-20)	15.0	☐ Full On Power	

The communications controller power off monitor sets the interval at which the FCP checks and verifies voltage levels. The communications controller power save monitor sets the interval at which the FCP wakes and does house keeping duties in regards to scheduled events, external I/O, etc..

Power monitor

Power Save monitor status update interval (2-63)	5.00	Seconds
Power Off monitor status update interval (2-63)	5.00	Seconds

The following table describes the power consumption within the different modes of operation. This information is duplicated in the power management section, describing the maximum power consumption in AmpHr once a Key-On and Engine-Running event occur and then the vehicle is turned off.

Power reserve consumption (during Power Save)

Power save mode – Ears On (8 hours)	60 mA	0.48 AmpHr
Power save mode – Sleep (70 hours)	6 mA	0.42 AmpHr
Failed check-in attempts – (1 min - 12 total)	500 mA	0.10 AmpHr
Total		1.00 AmpHr

SID Table

The SID Table configuration is only used with the WIN4 service. The WIN4 Service utilizes a prioritization for the selection of either the A-side or B-side carrier. A unique feature of the service is that it is allowed to use both A/B-side carriers within the same service area based on availability of signal.