

INTEGRATED PRODUCTION SERVICES
**PRODUCTION
OPTIMIZATION**



Pacemaker Controller User's Manual

Version 4.6.0

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1 Overview of the Pacemaker Controller

The Pacemaker Controller is designed to automate the production cycle of an oil or gas well equipped with a plunger lift system. It can also be used for other well hook-ups that do not have a plunger lift system. Configuration data and well data are stored by the controller and can be reviewed through the set and read commands. The data needed most often can be read quickly using the scroll keys. The controller is normally used with a plunger detector switch. The plunger detector is used to detect when the plunger arrives at the surface and signals the controller when Sales Time (Afterflow) should start. Note that sales time and afterflow are used interchangeably in this manual. They both mean the time the motor valve is open after the plunger arrives. There are certain well hook-ups that do not require a plunger detector, for example, when the controller is being used as a Hi-Lo controller or an intermitter. The controller is normally connected to the tubing and sales line via pressure transducers. It also can be connected to the casing pressure using a third pressure transducer. The tubing and casing pressure are for monitoring only. The line pressure is used for the high and low kill functionality. The controller has optimization built in that will automatically adjust the sales time and off time based on the plunger travel speed. This type of optimization is designed specifically for the pacemaker plunger and works well with conventional plungers. It can also be used in a manual non-adjusting mode. The controller comes standard with a Modbus interface. This allows all Well and Configuration data to be polled by a host computer. This is useful if the controller is being used as part of an automation system.

1.1 Pacemaker Control Cycle

The Pacemaker Controller operates using six timers. The following is a list of the timers: On, Bon, Sales, Shut-In, Off and Battery Off. All the timers, except the battery off timer, are settable by the user. When the controller is powered on, it starts up in shut-in time to ensure the safest possible starting state. The off time is used to get the plunger on the bottom of the well and is the minimum time the well is off. Once the off time expires, the controller will go into on time. During on time, the controller is waiting for the plunger to arrive. If it does, the controller will go to sales time (afterflow). If the controller does not get the plunger during the on time, it will go to shut-in time (backup time). If the plunger arrives or on time expires, the controller will make adjustments to the on and off timers depending on the plunger travel speed. If the plunger is too slow or does not arrive, it will reduce the sales time and increase the off time. If the plunger is too fast, it will increase the sales time and decrease the off time. If the controller received the plunger arrival signal and went to sales time, it will stay there until the sales time expires and then go to off time. Once back in off time, the cycle starts over again. The battery off timer is used to shut the controller off if the battery falls below 5.4 volts. It will stay in this timer until the battery has recovered to 5.8 volts. The controller then goes to shut-in time and continues the normal cycle. The battery off timer will count up and not down to show how long the controller has been off.

1.1.1 B Valve

In this set up the controller can be programmed to offer a B valve or "tank" valve. It will operate the same as the plunger mode however after the A valve open time expires (On Time) it will then go to a B valve open time (BOn Time) in which it opens the well to the atmosphere in an attempt to surface the plunger. If the plunger arrives during the B valve open time the controller will then enter the sales (afterflow) cycle. This mode can be helpful in keeping a plunger running that has to be vented to the tank on occasion in order to surface.

1.2 Hi and Lo Pressure Kill

The controller has a built in Hi-Lo feature for controlling high and low sales line pressures on the well. This allows the controller to monitor the line pressure and go to shut-in time if the pressure is too high or too low. If the High-Pressure Limit is set and the line pressure goes above the set limit, the controller will start the Hi Kill Timer. This timer will wait for a given amount of time before it will activate the Hi Kill.

This allows the limit to be set closer to the wells operating pressure and avoid the pressure spike from packing the line when the well is first turned on and allows the selling of the head gas. The Low Kill does not have a timer associated with it. It will act immediately when the line pressure drops below the low limit. This can be used to shut the well in if the sales line breaks or starts to leak. The High Kill can be disabled by entering 9999 as the limit. The low kill can be disabled by entering 0000 as the limit. Set commands 16, 34 and 35 are used to configure this option.

1.3 On and Off (Kill) Switches

The controller has both a “on” and “off (Kill)” switch inputs. This allows connection to external devices to turn the well on and off. If the well has a tank level switch, it could be connected to the kill switch and would close the motor valve if the tank became full. This can be used during well testing.

1.4 Battery Save Display Feature

In order to conserve the battery in the controller, the display will be powered off after two minutes if there has been no keypad activity. Pressing any keypad button will reactivate the display. The controller will ignore the key pressed to turn the display on and display the current well information.

1.5 Purge Operation

The controller can be configured to purge the fluid from the latching valve plumbing while the motor valve is closed. This can be used during cold weather to keep the latching valve plumbing from freezing which can cause the motor valve to operate incorrectly. It can also be used to supply gas to a well head compressor. If the well head compressor is using gas from the sales line, it could stall during the plunger fall or off time when no gas is flowing. The function will allow some gas to flow while the well is shut-in. The set 22 and set 23 commands are used to configure this function. Setting them both to “00” will disable the function. If this function is configured, the valve counts will continue to increase during plunger fall of off time and the valve counts will not match the plunger arrival counts.

The controller is capable of a number of types of configuration to accommodate the most challenging well hoop-up. The following list is the factory default options for the controller and will be programmed to one of them when leaving the factory. The SET 50 command, discussed later, is used to program the controller to the selected operation. In addition, the SET 51 command, also discussed later, is used to configure the controller once the mode is selected.



2 Timers (States)

The Pacemaker Controller uses five operating timers to control the well cycle. The timers are On, Bon, Sales, Shut-in, and Off. It also uses a Battery Off Timer for low battery conditions. The timers are sometimes referred to as states.

2.1 On Time (Set 10)

The On Time is the state that opens the motor valve to produce product. The On Timer counts down from the setting in "Set 10". If the On Time value expires, without receiving a plunger arrival the controller will go to Mandatory Shut-In (Backup) Time or B On Time bypassing the Sales Time (Afterflow). If a plunger arrival is detected during the On Time the controller will go to Sales Time (Afterflow).

2.2 B On Time (Set 11)

The B On Time opens the B motor valve to try to get the plunger to the surface. The B On Timer counts down from the setting in "Set 11". The controller will go to B On Timer after the On Time has expired without a plunger arrival. If the B On Time value expires, without receiving a plunger arrival the controller will go to Mandatory Shut-In (Backup) Time bypassing the Sales Time (Afterflow). If a plunger arrival is detected during the B On Time the controller will go to Sales Time (Afterflow).

2.3 Off Time (Set 12)

During the Off Time the motor valves remains closed. When the controller goes to Off Time, the timer value begins to count down from the setting in Set 12. The On switch (Murphy Switch) can interrupt the off time and send the controller to On Time.

2.4 Sales Time, Afterflow (Set 13)

Sales Time (afterflow) starts when a plunger arrival is detected during On Time. During the Sales Time, the motor valve remains open. Sales Time starts with the time that was entered with the Set 13 command and will be adjusted up or down depending on the plunger travel speed. When sales time expires, the controller will go to Off Time and repeat the cycle once more. The Pacemaker Controller automatically adjusts Sales Time and Off Time based on the plunger travel time. The plunger travel time is the time it takes the plunger to travel to the surface after the motor valve is opened. The plunger arrival is detected with the plunger detector or plunger sensor.

2.5 Mandatory Shut-In, Backup Time (Set 14)

The Mandatory Shut-In Time closes the motor valve and lets the well recover. It cannot be interrupted except by the On or Off key. The Mandatory Shut-In time is entered at the end of On Time or B On Time if no plunger arrival was detected. This time is used to allow the well to recover if the plunger did not arrive. This time needs to be long enough to get the plunger on the bottom.

2.6 Hi Kill Delay Timer (Set 16)

This timer is activated when the line pressure exceeds the high-pressure limit. The timer allows the compressor time to pull the line pressure back down before the Hi Kill sends the controller to fall time. If the controller is being used as a Hi-Lo Only controller the Hi Kill delay is not used.

2.7 Lo Kill Delay Timer (Set 17)

This timer is activated when the tubing pressure falls below the well close pressure limit in “Set 41”. The timer allows the well to die back some before it unloads without shutting it in.

2.8 Battery Off Time (Not a Settable Timer)

The timer is entered when the battery voltage falls below 5.4 volts. The controller will stay in this timer until the battery is charged back to 5.8 volts. This counter will count up and not down indicating the amount of time that the controller has been in the battery off state. During this state the controller will keep both motor valves closed and not operate the pressure transducers. It does this to preserve battery power. Once the battery reaches 5.8 volts the controller will switch to Off Time and resume normal operations.



3 Display Layout

The Differential Pressure Well Controller display is laid out in four separate sections. The top left section has the current Controller State and the time remaining of that state. The top right section displays status flags, configuration information and battery voltage. The bottom left section displays four sets of travel time information. The bottom right section displays the valve and plunger arrival counts, Sales Time and casing pressure.

3.1 On Time Display

You will see this display when the controller is waiting on the plunger. The motor valve is open during this time.

On HH:MM:SS	MHLOKS X.X
T HHH:MM:SS	AV XXX P XXX

3.2 B On Time Display

You will see this display when the controller is waiting on the plunger and the On Time has expired. The B motor valve is open during this time and the well would normally be venting to the atmosphere. The A motor valve is opened or closed depending on "Set 24".

B On HH:MM:SS	MHLOK X.X
T HHH:MM:SS	BV XXX P XXX

3.3 Sales Time (Afterflow) Display

You will see this display after the plunger has arrived. The motor valve is open during this time.

Sale HH:MM:SS	MHLOK X.X
T HHH:MM:SS	AV XXX P XXX

3.4 Off Time Display

You will see this display after the Plunger Fall Time has timed out. During this On Time, the motor valve is closed and the controller is waiting on the Differential Setpoint to be met. The timer will be counting up indicating how long the controller has been waiting on the Differential Setpoint to be met.

Off HH:MM:SS	MHLOKS	X.X
T HHH:MM:SS	V XXX P XXX	

3.5 Mandatory Shut-In Time, Backup Display

You will see this display if the plunger did not arrive during the On Time or the B On Time. Both the motor vales will be closed and pressure cannot bring the well on.

Shut HH:MM:SS	MHLOK	X.X
T HHH:MM:SS	AV XXX P XXX	

3.6 Battery Off Time Display

You will see this display if the battery voltage drops below 5.4 volts. The time will be counting up indicating how long the controller has been in this state. Once the battery voltage is above 5.7 volts the controller will go to Plunger Fall Time. The motor valve will be closed during this time.

Batt HH:MM:SS	MHLOKS	X.X
T HHH:MM:SS	AV XXX P XXX	

4 Controller Status Flags

As shown in the examples above, the controller status flags are displayed in the top right section of the display next to the battery voltage. They are only visible when their corresponding condition is active.

4.1 “M” Manual Mode Flag

The letter “M” on the screen indicates the controller is in manual mode. Manual mode is enabled and disabled through the set 77 command. Manual mode will stop the On and Off cycles from running. The motor valve can be held open during a swabbing operation using the On key or the motor valve can be held closed using the Off key overnight to allow the well to build pressure.

4.2 “H” Hi Kill Flag

The letter “H” indicates the line pressure has exceeded the High Limit Setpoint. See set command 34. When this occurs, the controller will start the high kill delay timer, Set 16. If the high condition is present when the timer expires, the controller will go to Fall Time and remain there until the high condition goes away.

4.3 “L” Lo Kill Flag

The letter “L” indicates the line pressure has dropped below the Low Limit Setpoint. See set command 35. When this occurs, the controller will go to Plunger Fall Time and remain there until the high condition goes away.

4.4 “O” On Switch Flag

The letter “O” indicates the On Switch is made and the controller will go to On Time if the controller is in Off Time.

4.5 “K” Kill (Off) Switch Flag

The letter “K” indicates the Kill (Off) Switch is made. When this occurs, the controller will go to Plunger Fall Time and remain there until the kill switch is reset.

5 Scroll Data

The differential has two sets of scroll keys. They are the '7', '8' and '9'. They are used to scroll data on the display. The following sections describe the information in detail.

5.1 '7' Key Scroll Data

5.1.1 Total Sales Time

The Total Sales Time has the following format: Total Sale HHH:MM:SS. The Total Sales Time is the total time the motor valve has been open since last being cleared.

5.1.2 Longest Travel Time

The Longest Travel Time has the following format: Long Travel MM:SS. The Longest Travel Time is the slowest run the plunger has made.

5.1.3 Shortest Travel Time

The Shortest Travel Time has the following format: Short Travel MM:SS. The Shortest Travel Time is the quickest run the plunger has made.

5.1.4 Average Travel Time

The Average Travel Time has the following format: Ave Travel MM:SS. The Average Travel Time is calculated using an 25-value weighted-average. This weighted-average calculation uses the last Travel Time average in 24 of the 25 travel times to calculate a new average. The 25th travel time is the newest or last travel time that is detected. The total of the 25 travel times is determined. The total is then divided by 25, with the result reduced to the nearest whole number.

5.1.5 Total Off Time

The "Total Off Time" has the following format: Off Time HH:MM:SS. It is the total time the motor valve has been closed since the controller was last cleared.

5.1.6 Longest Off Time

The "Longest Off Time" has the following format: Long Off Time HH:MM:SS. It is the longest time the motor valve has been closed during a well cycle since the controller was last cleared. If looking at the timers, it would be the longest time viewed in the Off Time state. When looking at the display, it would be the longest time during the "OFF HH:MM:SS" time.

5.1.7 Shortest Off Time

The "Shortest Off Time" has the following format: Short Off Time HH:MM:SS. It is the shortest time the motor valve has been closed during a well cycle since the controller was last cleared. If looking at the timers, it would be the shortest time viewed in the Off Time state. When looking at the display, it would be the shortest time during the "OFF HH:MM:SS" time.

5.1.8 Average Off Time

The "Average Off Time" has the following format: Ave Off Time HH:MM:SS. The Average Off Time is calculated using an 8-value weighted-average. This weighted-average calculation uses the last Off Time average in seven of the eight travel times to calculate a new average. The eighth Off Time is the newest or

last Off Time that is calculated. The total of the eight off times is determined. The total is then divided by eight, with the result always reduced to the nearest whole number.

5.2 '8' Key Pressure Scroll Data

5.2.1 Tubing Pressure

The tubing pressure is displayed in the following format: Tube Pres:XXXX PSI. If tubing pressure is needed, the controller must be equipped with a pressure transducer that is connected to the tubing of the well. It is for display purposes and available through the Modbus interface.

5.2.2 Line Pressure

The line pressure is displayed in the following format: Line Pres:XXXX PSI. If line pressure is needed, the controller must be equipped with a pressure transducer that is connected to the sales line of the well. It is used for the hi-lo functionality and available through the Modbus interface.

5.2.3 Casing Pressure

The Casing Pressure is displayed in the following format: Casing Pres:XXXX PSI. If casing pressure is needed, the controller must be equipped with a third transducer that is connected to the casing of the well. It is for display purposes and available through the Modbus interface.

5.2.4 Pressure Limit Count

The total number of times the high pressure limit was reached and the total number of times the low pressure limit was reached is displayed in the following format: Limit Hi:XXXX Lo:XXXX.

5.2.5 Switch Count

The total number of times the on switch was seen and the total number of times the off switch was seen is displayed in the following format: Switch Hi:XXXX Lo:XXXX.

5.3 '9' Key Scroll Data

5.3.1 Valve and Plunger Counts

The Valve and Plunger Counts have the following format: A Valve C:XXX A:XXX and B Valve C:XXX A:XXX. C:XXX" is the number of times the valve has been operated or cycled. The A:XXX is the number of times the plunger has arrived. The maximum number for both is 999; after 999 it will roll back to zero.

6 Keypad Operation

The SMI Differential Pressure Controller is equipped with a 4 x 4 keypad. In an effort to keep the keypad as simple as possible it was necessary to have some keys provide more than one function. While the 'ON' and 'OFF' keys will always turn the well on and off, the 'C', 'S' and 'R' keys perform multiple functions. Also, the '7' & '4' and the '9' & '6' are used for the quick data scroll. While this may seem a little confusing at first, it does not take long to get used to.

CURRENT 7 STATUS	PRESSURE 8 STATUS	VALVE 9 COUNTS	ON
4	CURRENT 5 TIME	6	OFF
TRAVEL 1 TIME	YES 2	SETUP 3	 SET
CANCEL C CLEAR	NO 0	ENTER E EXIT	 READ

6.1 'ON' Key

This key will turn the well on and change the timer to the On Timer and open the motor valve. This is the only function this key will perform and it cannot be overridden. When the controller is turned on with the 'ON' key, the tubing and line pressure will not be recorded in the history.

6.2 'OFF' Key

This key will turn the well OFF and change the timer to the Plunger Fall Time and close the motor valve. This is the only function this key will perform and it cannot be overridden.

6.3 'C' Key

The 'C' key is the clear or cancel key. It will backspace on "Set" and "Read" commands, clear the values in certain "Read" commands, and cancel out of a "Set" command once it is backspaced to the beginning. To cancel out of a command, you use the 'C' key to backspace to the beginning and then press the 'C' key again to cancel out of the command. This works for both the command entry and the data entry. It is also used to clear any message the controller may display. For example, the keypad locked and unlocked messages.

6.4 'E' Key

The 'E' key is the enter key. It is used to save the data that is entered in the "Set" commands and exit out of the "Set" and "Read" commands. If you do not want to save the data that is in the "Set" command, you can use the 'C' key to backspace to the beginning and then press the 'C' key again to cancel out of the command.

6.5 ↑ 'S' Key

The 'S' key is the Set key. It has two functions. One is to start a set command operation and the second is to scroll commands and scroll history data. If the controller is in the normal mode displaying one of the timers and the 'S' key is pressed, the controller will change the display to read "Set". You now would enter the number for the set command you wanted to view and press the 'E' key. This would bring up that command.

The key has a secondary use, which is scrolling the set and read commands and the Travel Time history data. The scrolling is used with the read 13 command. When you have a set or read command on the display, you can use the 'S' key to go to the next command. For example, if you are viewing the set 10 command and you press the 'S' key, the set 11 command will be displayed. When viewing the Travel Time history entries, the set key is used as an upward directional key when scrolling through the history entries. (Example: If the #5 entry is shown on the display, pressing the 'S' key will move the history entries to the #4 entry.) Note on the read 13 command: when you first enter the command it will show the current Travel Time. If you scroll from the current Travel Time, entry '0', you will go to the next "Read" command. If you want to scroll the history data you will need to hit enter again, and then scroll.

6.6 ↓ 'R' Key

The 'R' key is the set key. It has two functions. One is to start a read command operation and the second is to scroll commands and scroll history data. If the controller is in the normal mode displaying one of the timers and the 'R' key is pressed, the controller will change the display to read "Read". You now would enter the number for the read command you wanted to view and press the 'E' key. This would bring up that command.

The key has a secondary use, which is scrolling the set and read commands and the Travel Time history data. The scrolling is used with the read 13 command. When you have a set or read command on the display, you can use the 'R' key to go to the previous command. For example, if you are viewing the set 11 command and you press the 'R' key, the set 10 command will be displayed. When viewing the Travel Time history entries, the 'R' key used as a downward directional key when scrolling through the history entries. (Example: If the #5 entry is shown on the display, pressing the 'R' key will move the history entries to the #6 entry.) Note on the read 13 command: when you first enter the command it will show the current Travel Time. If you scroll from the current Travel Time, entry '0', you will go to the next read command. If you want to scroll the history data you will need to hit enter again, and then scroll.

6.7 Secondary key functions

Most of the numeric keys have a secondary function. This secondary function is accessed when the key is pressed and a numeric value is not needed for a set or read command. The name of the secondary function is printed on the key along with the numeric value of the key. When the secondary function is accessed, the name of the function of the first item on the list is displayed. The list of items can now be scrolled through using the arrow keys. To exit the secondary function the 'E' key is pressed.

6.7.1 '1' Key, Travel Time

This key brings up the travel times which are the same as the Read 13 command.

6.7.2 '3' Key, Set up

This key brings up the setup command, which is the same as the Set 50 command.

6.7.3 '7' Key, Current Status

This key brings up the current status information. The following is a list of the items: Total Sale HHH:MM:SS, Long Travel MM:SS, Short Travel MM:SS, Ave Travel MM:SS, Off Time HH:MM:SS, Long Off Time HH:MM:SS, Short Off Time HH:MM:SS, Ave Off Time HH:MM:SS, and Battery voltage.

6.7.4 '8' Key, Pressure Status

This key brings up the pressure status information.

6.7.5 '9' Key, Valve Counts

This key brings up the valve count information. The following is a list of the items: A Valve C:XXX A:XXX and B Valve C:XXX A:XXX.

6.8 '0-9' Numeric Keys

These keys are used to enter numbers into the controller during a set function. As described in the section below, a few have a dual use for scrolling quick data.

7 Set Commands

The set commands are used for configuring the controller. To enter a set command, press the 'S' key followed by the first digit of the set command you want to execute. Now press the last digit of the two-digit number of the set command you want to execute. If the display reads "Set XX" with XX being your entered command, press the 'E' key to enter the function. If you make a mistake you can use the 'C' to backspace. If the 'C' key is pressed when only "Set" is in on the screen, the controller will cancel the current set operation.

Once the values are displayed for you, the 'C' key will continue to be used as a backspace and cancel. As you enter numbers, the display will wrap the cursor for you. Also, the cursor will skip over the ':' in the timer set commands or any other formatting character you may see. You enter the data as if formatting characters were not there. Once you have the correct data entered, pressing the 'E' key will save it to memory and exit the set command. If you do not want to save the entered data or you were just viewing the value, the 'C' key will cancel the command without saving the data. You will have to backspace to the beginning of the line for the cancel to work.

7.1 Set 10, On Time

The SET 10 command is used to set the On Time. The display will show "On Time" on the top line of the display and the time "HH:MM:SS" on the bottom line of the display. The data is entered in hours, minutes and seconds. This the time the controller is waiting on the plunger. To enter a time of 30 minutes, you would enter 003000, then press 'E'.

On Time
00:30:00

Above shows the "On time" set to 30 minutes

7.2 Set 11, B On Time

The SET 11 command is used to set the B On Time. The display will show "B On Time" on the top line of the display and the time "HH:MM:SS" on the bottom line of the display. The data is entered in hours, minutes and seconds. This the time the controller is waiting on the plunger. To enter a time of one hour, you would enter 010000, then press 'E'. To disable the B On Timer, zero's should be entered in the time.

B On Time
00:30:00

Above shows the "B On time" set to 30 minutes

7.3 Set 12, Off Time

The SET 12 command is used to set the Off Time. The display shows “Off Time” on the top line of the display and the time “HH:MM:SS” on the bottom line of the display. The Off Time is automatically adjusted by the controller depending on the Travel Time. If the plunger travels to fast, time is subtracted from the current Off Time and if the plunger travels too slow time is added to the current Off Time. The adjustment is controlled by the Minimum and Maximum Off Times Command, Set 54 and Set 53. Example: To enter a time value of 2 hours, press “020000”.

Off Time
02:00:00

Above shows the “Off time” set to 2 hour.

7.4 Set 13, Sales Time, Afterflow

The SET 13 command is used to set the Sales Time. The display shows “Sales Time” on the top line of the display and the time “HH:MM:SS” on the bottom line of the display. The data is entered in hours, minutes and seconds. The Sales Time is the time the well sells gas after the plunger arrives. The Sales Time is automatically adjusted by the controller depending on the Travel Time. If the plunger travels to fast, time is added from the current Sales Time and if the plunger travels too slow time is subtracted to the current Sales Time. The adjustment is controlled by the Minimum and Maximum Sales Times Command, Set 52 and Set 51.

To enter a time of 30 minutes, you would enter 003000, then press ‘E’.

Sales Time
00:30:00

Above shows the “Sales time” set to 30 minutes.

7.5 Set 14, Mandatory Shut-In Time, Backup

SET 14 has two different modes of operation, normal timer mode and well sync mode, see 7.5.1. In normal mode this command is used to set the Shut-In, Backup Time. The display shows “Shut-In , Backup Time” on the top line of the display and the time “HH:MM:SS” on the bottom line of the display. Example: To enter a time value of 2 hours, press “020000” then “E”.

Shut-In Backup Time
02:00:00

Above shows the “Shut-in time” set to 2 hour.

7.6 Set 16, Hi Kill Delay Time

The SET 16 command is used to set the Hi Kill Delay Time. The display shows “Hi Kill Delay Time” on the top line of the display and the time in seconds “SSSS” on the bottom line of the display. The time is entered in seconds. To enter a time with a value of 5 minutes, press “0300” then ‘E’ on the keypad. This is the delay time before the high kill is activated. It is used to let the head gas blow down before looking for a high line condition.

Hi Kill Delay Time
0300

Above shows the “Hi Kill Delay Time” set to 300 seconds or 5 minutes.

7.7 Set 19, Current Timer

The SET 19 command is used to change the current timer. The display shows “Current Timer” on the top line of the display and the time “HH:MM:SS” on the bottom line of the display. This is the values of the current timer. The current timer is used to countdown the time of the active state. For example, if the “On Time” is active the current timer is counting down from the time that is entered in “On Time”. Set 19 allows the current timer to be modified from its normal count. This is used when more or less time is needed for a given well cycle. To enter a time of 1 minute, enter 000100, then press ‘E’.

Current Timer
00:01:00

Above shows the “Current Timer” set to 1 minute.

7.8 Set 20, Clear Command

The SET 20 command is used to clear the Sales Time, Travel Time, Valve Counts, Plunger Counts and the Travel Time history. The display will show “Clear All” on the top line and a ‘0’ on the bottom line of the display. To clear the data you will have to enter a ‘1’ then press the ‘E’ key. If you do not enter a ‘1’ and press ‘E’, the data will not be cleared.

Clear All
1

Above shows the “Clear All” set to 1 to clear data.

7.9 Set 22, Purge Cycle Command

The SET 22 command is used to set the purge cycle time. The display will show “Purge Cycle” on the top line display and “XX” on the bottom line of the display. The “XX” represents the purge cycle in minutes. The purge command allows the motor valve to open briefly on a periodic basis during Off Time and

Plunger Fall Time. This function can be used during cold weather to keep the motor valve from freezing closed due to moisture in the plumbing of the latching valve. It can also be used to supply gas to a wellhead compressor. Setting the value to 00 will disable this feature. Please note, this command will cause the plunger counts and valve counts not to match. Use set 22 and 23 together.

Purge Cycle
15

Above shows the "Purge Cycle" set to 15 minutes.

7.10 Set 23, Purge Duration Command

The SET 22 command is used to set the purge duration time. The display will show "Purge Cycle" on the top line display and "XX" on the bottom line of the display. The "XX" represents the purge cycle in seconds. Setting the value to 00 will disable this feature. Use set 22 and 23 together.

Purge Duration
10

Above shows the "Purge Duration" set to 10 seconds.

7.11 Set 30, Transducer Max Value

The SET 30 command is used to enter the Transducer Rating. This allows the controller to scale the analog channels correctly. For a 1000 PSI transducer, 1000 is entered. For a 2000 PSI transducer, 2000 is entered. The display will show "XDCR Rating" on the top line of the display and "XXXX" on the bottom line of the display. The "XXXX" represents the transducer rating in PSI. You can also use the command to scale the transducer to match a gauge on the well. If you need the controller to read a little higher you can enter 1100 for the scale instead of 1000. This will not affect the operation on the controller.

XDCR Rating
1000

Above shows the "XDCR Rating" set to a 1000 PSI transducer.

7.12 Set 31, Measured 5 Volts

The SET 31 command is used to enter the actual 5-volt reading. The controller uses the 5 volts as a reference when measuring pressures and voltages. This value will normally be entered at the factory. The value should range from 0470 to 0520. If value is outside that range, set to 0500. The display will show "Measured 5 Volts" on the top line and "XXXX" on the bottom line. The "XXXX" represents the voltage in the following format: XX.XX. To set it to 4.9 volts you would enter 0490. You must have a leading zero.

Measured 5 Volts
0500

Above shows the “Measured 5 Volts” set to 5 volts.

7.13 Set 32, Pressure Transducer On Time

The SET 32 command is used to enter the time the pressure transducer is on before the pressure is read. The display will show “XDCR On Time” on the top line of the display and “XXXX” on the bottom line of the display. The “XXXX” represents the 50mS steps. This allows the transducer to settle before a reading is taken. A normal value is 0003, which represent 150mS. This should not have to be changed unless a special transducer is used.

XDCR On Time
0003

Above shows the “XDCR On Time” set to 3 X 50mS or 150mS.

7.14 Set 33, Pressure Transducer Poll Rate

The SET 33 command is used to enter the poll rate of the pressure transducers. The display will show “XDCR Poll Rate” on the top line of the display and “XXXX” on the bottom line of the display. The “XXXX” represents the poll rate in seconds. A normal value of 0005 indicates the pressure transducer will be read every five seconds. Polling the transducer too often will cause the battery to drain faster. A poll rate of five is recommended for most applications.

XDCR Poll Rate
0005

Above shows the “XDCR Poll Rate” set to 5 seconds.

7.15 Set 34, Line Pressure High Pressure Limit

The SET 34 command is used to enter the high line pressure limit. The display will show “High Pres Kill Limit” on the top line of the display and “XXXX” on the bottom line of the display. The “XXXX” represents the high-pressure limit in PSI. When the line pressure exceeds the high-pressure limit, the controller will count down the High Kill Delay Time then go to Fall Time. The Fall Time will count down to zero and if the high pressure is still present, hold at zero. If the high pressure has passed, it will go to Off Time. Setting the high-pressure limit to 9999 will disable it.

High Pres Kill Limit

0500

Above shows the “High Pres Kill Limit” set to 500 PSI.

7.16 Set 35, Line Pressure Low Pressure Limit

The SET 35 command is used to enter the low line pressure limit. The display will show “Low Pres Kill Limit” on the top line of the display and “XXXX” on the bottom line of the display. The “XXXX” represents the low-pressure limit in PSI. When the line pressure drops below low-pressure limit, the controller will go to Fall Time. The Fall Time will count down to zero and if the low pressure is still present, hold at zero. If the low pressure has passed, it will go to Off Time. Setting the low-pressure limit to 0000 will disable it.

Low Pres Kill Limit
0040

Above shows the “Low Pres Kill Limit” set to 40 PSI.

7.17 Set 40, Maximum Sales Time Adjust

The SET 40 command is used to set the maximum time in minutes that can be added or subtracted from the Sales Time. The display will show “Max Sales Time Adj” on the top line of the display and “XX” on the bottom line of the display. The “XX” represents the maximum adjustment to the Sales Time in minutes. The controller will add or subtract Sales Time proportionally based on the Plunger travel time. The maximum sales adjust is the 100% value that can be added or subtracted from the Sales Time. For example, if the plunger ran in half the plunger travel set time the controller would add 50% of the maximum sales adjust to the Sales Time. With the maximum adjust set to 10 minutes, the controller would have added five minutes to the Sales Time. The opposite is also true. Also, the Sales Time can only be increased on a given well cycle if the plunger runs successfully. When the “Maximum Sales Time Adjust” is set to zero, the automatic adjustment for Sales Time will be disabled. This will lock the Sales Time, “SET 13”, at its current value.

Max Sales Time Adj
10

Above shows the “Max Sales Time Adj” set to 10 minutes.

7.18 Set 42, Plunger Travel Time

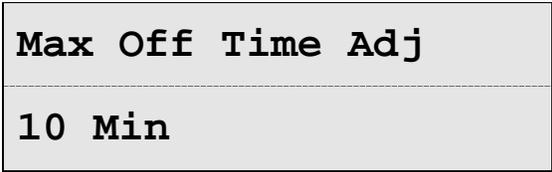
The SET 42 command is used to set the optimum plunger travel speed. When picking this number you should take into account the type of plunger you have and well depth. The display will show “Ideal Travel Time” on the top line of the display and “XX” on the bottom line of the display. The “XX” represents the Plunger Travel Time in minutes. The Plunger Travel Time is one of the main set points for the Pacemaker control process. Calculating it correctly is very important for proper well operation. If it is not entered correctly, the Sales Time and Off Time will be impacted.



Above shows the "Ideal Travel Time" set to 11 minutes.

7.19 Set 44, Maximum Off Time Adjust

The SET 44 command is used to set the maximum time in minutes that can be added or subtracted from the Off Time. The display will show "Max Off Time Adj" on the top line of the display and "XX" on the bottom line of the display. The "XX" represents the maximum adjustment to the Off Time in minutes. The controller will add or subtract Off Time proportionally based on the Plunger travel time. The maximum off adjust is the 100% value that can be added or subtracted from the off Time. For example, if the plunger ran in half the plunger travel set time the controller would subtract 50% of the maximum off adjust from the off Time. With the maximum adjust set to 10 minutes, the controller would have subtracted five minutes from the off Time. The opposite is also true. Also, the Off Time can only be increased on a given well cycle if the plunger runs successfully. When the "Maximum Off Time Adjust" is set to zero, the automatic adjustment for Sales Time will be disabled. This will lock the Sales Time, "SET 11", at its current value.



Above shows the "Max Off Time Adj" set to 10 minutes.

7.20 Set 50, Well Depth

The SET 50 command is used to configure the controller quickly. Once the well depth in feet is entered, the controller will figure out the rest of the parameters. All the parameters can still be changed manually if desired. The well depth is entered in feet with leading zeroes. The display shows "Well Depth" on the top line of the display and "XXXXXX" on the bottom line of the display. The "XXXXXX" represents the well depth in feet. This command will configure the all the timers for you. It sets up the transducers to be polled every five seconds and disable the high and low pressure kills. .



Above shows the "Well Depth" set to 7500 feet.

7.21 Set 51, Maximum Sales Time, Afterflow

The SET 51 command is used to set the maximum sales time. The display shows "Max Sales Time" on the top line of the display and the time "HH:MM:SS" on the bottom line of the display. The data is entered in hours, minutes and seconds. Set 51 is used to set the upper limit of the sales time. The controller will adjust



the sales time depending of the plunger travel time. Set 51 will limit the maximum time the controller will adjust to. To enter a time of 30 minutes, you would enter 003000, then press 'E'.

Max Sales Time
00:30:00

Above shows the "Max Sales Time" set to 1 hour.

7.22 Set 52, Minimum Sales Time, Afterflow

The SET 52 command is used to set the minimum sales time. The display shows "Min Sales Time" on the top line of the display and the time "HH:MM:SS" on the bottom line of the display. The data is entered in hours, minutes and seconds. Set 52 is used to set the lower limit of the sales time. The controller will adjust the sales time depending of the plunger travel time. Set 52 will limit the minimum time the controller will adjust to. To enter a time of 10 minutes, you would enter 001000, then press 'E'.

Min Sales Time
00:10:00

Above shows the "Min Sales Time" set to 10 minute.

7.23 Set 53, Maximum Off Time

The SET 53 command is used to set the maximum Off Time. The display shows "Max Off Time" on the top line of the display and the time "HH:MM:SS" on the bottom line of the display. The data is entered in hours, minutes and seconds. Set 53 is used to set the upper limit of the off time. The controller will adjust the off time depending of the plunger travel time. Set 53 will limit the maximum time the controller will adjust to. To enter a time of 30 minutes, you would enter 003000, then press 'E'.

Max Off Time
00:30:00

Above shows the "Max Off Time" set to 1 hour.

7.24 Set 54, Minimum Off Time

The SET 54 command is used to set the minimum off time. The display shows "Min Off Time" on the top line of the display and the time "HH:MM:SS" on the bottom line of the display. The data is entered in hours, minutes and seconds. Set 54 is used to set the lower limit of the off time. The controller will adjust the sales time depending of the plunger travel time. Set 54 will limit the minimum time the controller will adjust to. To enter a time of 10 minutes, you would enter 001000, then press 'E'.

Min Off Time
00:10:00

Above shows the “Min Off Time” set to 10 minute.

7.25 Set 61, Modbus Address Command

The SET 61 command is used to set the Modbus address. The display will show “Modbus Addr” on the top line display and “XXXX” on the bottom line of the display. The “XXXX” represents the Modbus address. The Modbus address must be between 0 and 255. General 0 will not be used since it is the broadcast address and will cause the control to take action on all Modbus commands, with no response back to the master.

Modbus Addr
0001

Above shows the “Modbus Addr” set to 1.

7.26 Set 77, Manual On/Off

The SET 77 command is used to disable the timers on the controller. The display shows “Manual ON/OFF” on the top line of the display and “0” on the bottom line of the display. This is used when the well is going to be tested. Entering a ‘1’ disables the timers and the well can only be turned on and off through the buttons on the front panel. Leaving a ‘0’ will exit and do nothing. The controller will display a ‘M’ in the status flag section of the display when in manual mode.

Manual ON/OFF
1

Above shows the “Manual ON/OFF ” set to 1 to enable.

7.27 Set 78, Password

The SET 78 command is used to enter a password into the controller. Passwords are in the range from 0000 to 9999, where 0000 is the disabled password value. The display shows "Password" on the top line of the display and "XXXX" on the bottom line of the display. When the controller is shipped from the factory it will have the password set to 0000. This disables the password feature. If you try to change a value and you get the message Keypad Locked. You will need to enter the password that was selected. The controller has a one-hour timeout for the password. If no keys are pressed in one hour, the controller will lock the keyboard.

Password
1234

Above shows the "Password" entered as 1234.

7.28 Set 79, New Password

The SET 79 command is used to enter a new password into the controller. The display shows "New Password" on the top line of the display and "XXXX" on the bottom line of the display. After the correct password is entered with SET 78, a new one can be entered in SET 79. The password can be any four-digit integer. If you get a "Keypad Locked" message, you must clear it with the 'C' key and enter the correct password.

New Password
5678

Above shows the "New Password" set to 5678.

7.29 Set 80, Lock Keypad

The SET 80 command is used to lock the keypad on the controller. The display shows "Lock Keypad" on the top line of the display and "0" on the bottom line of the display. Entering a '1' will lock the keypad when the 'E' key is pressed. Leaving a '0' and pressing 'E' will exit and do nothing. There is a one-hour auto lock function. If you have a password set and a key is not pressed in an hour the keypad will lock itself.

Lock Keypad
1

Above shows the "Lock Keypad" set to 1 for locking.

8 Read Commands

The Read commands are used for viewing well data. It should also be noted that some read commands have the option to clear the data that is being viewed. To enter a Read command, first press the 'R' key. Next press the first digit of the read command you want to execute. Now press the last digit of the two-digit number. If the display reads "Read XX" with XX being your entered command, press the 'E' key to enter the function. If you made a mistake, you can use the 'C' key to backspace. If the 'C' key is pressed while only "Read" is displayed, the controller will cancel the current read command. Pressing the 'E' key will exit the read functions.

8.1 Read 13, Travel Time History

The READ 13 command allows reading of the travel time history and the current travel time. The times are the current Plunger Travel Time and the last 25 plunger travel times with the tubing and line opening pressures. The display will show "No Trv T Tube Line" on the top line and "XX MM:SS TTTT LLLL" on the bottom line. The "XX" is a number from 0 to 25. Zero represents the current travel time and 1 to 25 are the newest to the oldest. The time is displayed in the MM:SS format minutes and seconds. The "TTTT" represents the tubing pressure in PSI and "LLLL" represents the line pressure in PSI. The travel time will read "NoArv" instead of "MM:SS" if no plunger arrival detected for that cycle. If the controller was opened with the keypad, the pressure will display "Man Open" instead of "TTTT LLLL". When the command is first entered the current travel time will be displayed. You can tell you are on the current travel time by the "No" being '0'. If you hit enter again, you cannot use the 'S' and 'R' keys to scroll through the travel times. The 'R' key moves the history entries upward in numerical order and the 'S' key moves the history entries downward. Once you start scrolling through the histories you will have to exit using the 'E' key to see the current travel time again.

No Trv T Tube Line
01 11:10 0408 0078

Above shows the travel time history display. You are looking at the newest entry "No 1". It took 11 minutes and 10 seconds for the plunger to surface and the tubing was reading 408 PSI and the line was reading 78 PSI when the motor valve was opened to surface the plunger.

8.2 Read 50, Software Version

The READ 50 command allows reading of the current software version used by the controller. The top line shows "PacMaker." on the top line and "Version 4.6.0" on the bottom line. If the version is different from 4.6.0 some of the functions may not operate as described in the manual. Pressing the 'E' key will exit this function.

PacMaker
Ver:4.6.0

Above shows the differential controller with software version 4.6.0.

9 Command Summary

Set #	Commands	Entry Description
Set 10	On Timer Value	HH:MM:SS, Time waiting to get plunger
Set 11	B On Timer Value	HH:MM:SS, Time waiting to get plunger
Set 12	Off Timer Value	HH:MM:SS, Time for plunger to reach bottom
Set 13	Sales Timer Value	HH:MM:SS, Afterflow, time after plunger arrives
Set 14	Shut-In Time	HH:MM:SS, Time for the plunger to return to bottom after failed arrival
Set 13	Maximum Off Time	HH:MM:SS, This is the maximum time the controller will be off
Set 16	Hi Kill Delay	XXXX Delay Timer in Seconds for the Hi Kill.
Set 18	B Valve Delay	XXXX Delay Timer for leaving B valve on while A is ON. In percent
Set 19	Current Time	HH:MM:SS, current timer that is running
Set 20	Clear All	X – '1' clears, '0' does not clear
Set 22	Purge Cycle Time	XX enter the desired purge cycle time in minutes
Set 23	Purge Duration Time	XX enter the desired purge duration time in seconds
Set 30	Transducer Scale	XXXX Enter the maximum pressure rating of the transducer
Set 31	Measured 5 Volts	XXXX Enter the 5 volts from the PCB. Two decimal assumed. 0500 default
Set 32	XDCR On Time	XXXX Transducer on time on 50mS steps. 0003 default
Set 33	XDCR Poll Rate	XXXX The poll rate of the transducers in seconds. 0005 default
Set 34	Hi Kill Limit	XXXX The hi pressure limit 9999 will disable
Set 35	Lo Kill Limit	XXXX The lo pressure limit 0 will disable
Set 40	Max Sales Adjust	XX enter the maximum time to adjust in minute. 10 default
Set 42	Plunger Travel Time	XX enter the desired plunger travel time in minutes
Set 44	Max Off Adjust	XX enter the maximum time to adjust in minute. 10 default
Set 50	Well Depth	XXXXXX, Enter the well depth in feet. Auto-Configures the Controller
Set 51	Max Afterflow	HH:MM:SS, maximum afterflow
Set 52	Min Afterflow	HH:MM:SS, minimum afterflow
Set 53	Max Off Time	HH:MM:SS, maximum afterflow
Set 54	Min Off Time	HH:MM:SS, minimum afterflow
Set 61	Modbus Address	XXXX enter the desired Modbus Address 0 – 255 Caution when using 0.
Set 77	Manual On/Off	X '1' Put the well in manual On/Off Mode Timers disabled
Set 78	Password	XXXX Enter the controller password, 0000 disables password
Set 79	New Password	XXXX Enter a new password 0000 disables password
Set 80	Lock Keypad	X '1' Lock keypad '0' do nothing
Read #	Commands	Description
Read 13	Travel Time History	XX, HH:MM:SS XXXX XXXX Read travel times and Pressures. When first enter entry #0 will read current travel time. Press 'E' again will allow you to scroll the history.
Read 50	Software Version	PaceMaker Ver:X.X.X



10 SMI PaceMaker Well Controller Hardware Connections

10.1 Bottom Terminal Row

Terminal number	Description
1	Solar Panel Positive connection (+), Red wire on solar panel
2	Solar Panel Negative connection (-), Black wire on solar panel
3	Battery Negative connection (-), Black wire on battery lead
4	Battery Positive connection (+), Red wire on battery lead
5	Plunger Detector Power, Normally the red wire. Not used on a two-wire detector or three-wire MSO/GO switch. DO NOT SHORT TO GROUND
6	Plunger Detector Signal (+), Normally the white or blue wire.
7	Plunger Detector ground, (-), Normally the black wire on the MSO switch.
8	On Switch (+), Normally, the XXXX wire on the Murphy switch
9	On Switch (-), Normally, the XXXX wire on the Murphy switch
10	Kill Switch (+), Normally, the XXXX wire on the Murphy switch
11	Kill Switch (-), Normally, the XXXX wire on the Murphy switch
12	Valve A Power, This is the black wire on the latching valve
13	Valve A Open, This is the green wire on the latching valve
14	Valve A Close, This is the red wire on the latching valve
15	Transducer 1 Power, This is the red wire on the transducer
16	Transducer 1 Signal, This is the clear or white wire on the transducer
17	Transducer 1 Ground, This is the black wire on the transducer
18	Transducer 2 Power, This is the red wire on the transducer
19	Transducer 2 Signal, This is the clear or white wire on the transducer
20	Transducer 2 Ground, This is the black wire on the transducer
21	RS232 Receive Data, Normally Pin 3 on a D connector
22	RS232 Ground Data, Normally Pin 7 or Pin 5 on a D connector
23	RS232 Transmit Data, Normally Pin 2 on a D connector
24	Chassis Ground

10.2 Top Terminal Row

Terminal number	Description
25	Not Used
26	Not Used
27	Not Used
28	Transducer 1 Power, This is the red wire on the transducer
29	Transducer 1 Signal, This is the clear or white wire on the transducer
30	Transducer 1 Ground, This is the black wire on the transducer
31	Not Used.

11 Trouble Shooting

The most common failure in an electronics device is the connection. It is always a good idea to check them first and make sure you have the correct voltage on the battery. A good visual inspection for any mechanical or water damage is also a good first step.

11.1 Will Not See Plunger

There are a number of reasons you may not see the plunger. The following is a short list: worn plunger, high line pressure, stuck plunger, and a bad sensor. The following outlines the steps to check for a bad sensor.

1. Check sensor wiring
 - a. Two Wire - #6 White, #7 Black
 - b. Three Wire - #5 Red, #6 White, #7 Black
2. Check position of the sensor to ensure the plunger is traveling past the sensor location.
3. With the controller in On Time wave a metal object (wrench) slowly by the sensor. It should be within an inch of the sensor.
 - a. If the sensor is a three wire type. You have the ability to increase the sensitivity.
 - b. Open front of sensor by removing three of the four screws and rotating the cover out of the way.
 - c. Adjust the dial clockwise to increase the sensitivity of the sensor. A little goes a long way.
4. If the above was not successful a new sensor may be needed.

11.2 Bad Pressure Reading

Improper settings or a bad transducer can cause a bad pressure reading. It should also be noted, that the transducers have a 1% to 2% accuracy rating. A normal gauge on a well has an accuracy rating of 5% to 20%. This can cause the transducers in the controller not to match the well gauge exactly.

1. Check Transducer scale "Set 30". This should match the rating on your transducer normally 1000 PSI or 1500 PSI.
2. Check the measured 5 volt setting "Set 31". This should be set to 0500.
3. Check the transducer poll rate "Set 32". This should be set to 0005 seconds.
4. Check the transducer on time "Set 33". This should be set to 0003.

11.3 Motor Valve Failures

1. Check Supply gas to for a clean, dry, and constant supply.
2. Check the supply pressure. It should be between 28 to 48 PSI.
3. Check the supply gas going to the controller.
4. If the supply is dirty, disassemble and clean the latch valve.
5. Check the wiring of the latch valve, #12 Black, #13 Green, and #14 Red.
6. Check the battery to make sure it is above 5.5 volts.

12 Pacemaker Controller Specifications

12.1 Package Size

Fiberglass box - 7.6" x 7.6" x 4.55"

12.2 Package Rating

Designed to NEMA 4, 4X specifications

12.3 Valve Control

Solenoid Pneumatic actuator

12.4 Operating Temperature

Operating Temperature Range is -40F to +185F, excluding the LCD

12.5 Communications Port

RS232 9600 baud, No Parity, One stop bit, Modbus Protocol, Modbus Address 1

12.6 Battery

6V Lead Acid. 4.5 Ahr @ 20hrs (approximate 30 days w/o recharge – ideal conditions)

12.7 Valve Actuator

125 PSI rated, all brass ¼ pipe thread connections

12.8 Pressure Transducers

3 x 0-1000 to 0-10,000 PSI transducers. Tubing, Line, and Casing

12.9 Solar Panel

7.5V @ 300mA