battery-operated downhole tools may be a concern. As a result, a reliable means for extending the useful lifetime of battery-operated downhole tools is desirable.

SUMMARY OF INVENTION

According to a first aspect of the present invention, there is provided a method for operating a downhole tool, comprising: detecting a first signal using a first sensor; switching the downhole tool from a first operating mode to a second operating mode in response to detecting the first signal; detecting a second signal using the first sensor or a second sensor; and switching the downhole tool from the second operating mode to a third operating mode in response to detecting the second signal, wherein the second operating mode comprises a twilight mode, and wherein the downhole tool in the twilight mode consumes energy at a lower rate than in the third operating mode and consumes energy at a higher rate than in the first operating mode.

According to a second aspect of the present invention, there is provided a system for operating a downhole tool, comprising: a downhole tool, comprising: a first sensor configured to detect a first signal; a second sensor configured to detect a second signal; a controller connected to the first and second sensors; and an actuator connected to the controller, wherein the actuator is configured to switch the downhole tool from a first operating mode to a second operating mode in response to the first sensor detecting the first signal, and wherein the actuator is configured to switch the downhole tool from the second operating mode to a third operating mode in response to the second sensor detecting the second signal, wherein the second operating mode comprises a twilight mode; wherein the downhole tool in the twilight mode consumes energy at a lower rate than in the third operating mode and consumes energy at a higher rate than in the first operating mode;

an energy source connected to at least one of the controller, the first sensor, and the second sensor; and at least one source for creating the first and second signals.

There is provided a method for operating a downhole tool, comprising: generating a first signal by an electromagnet of the downhole tool, wherein the first signal represents a change of one or more of a temperature, pressure, flow rate and acoustic noise; detecting the first signal using at least one sensor; switching the downhole tool to a twilight operating mode in response to detecting the first signal; generating a second signal by the electromagnet; detecting the second signal using the at least one sensor; switching the downhole tool to an awake operating mode in response to detecting the second signal; generating a third signal by the electromagnet; and detecting the third signal using the at least one sensor; switching the downhole tool to a sleep operating mode in response to detecting the third signal.

FIGURES

Some specific exemplary embodiments of the disclosure may be understood by referring, in part, to the following description and the accompanying drawings.

FIG. 1 is a schematic of a well system following a multiple-zone completion operation.

FIG. 2 is a block diagram depicting an embodiment of onboard electronics, actuators and other electronic components of a downhole tool.

FIGS. 3A, 3B, 3C and 3D are a series of graphs representing different embodiments of magnetic signals.

FIG. 4 is a schematic view of an embodiment of a magnetic source tool.

FIG. 5 is a schematic view of another embodiment of a magnetic source tool.

FIGS. 6A, 6B and 6C are schematic views of an embodiment using magnetic balls for signaling the downhole tool.

FIG. 7 is a flowchart of transitions from sleep to active modes triggered by detection of certain signals.

FIG. 8 is a graph illustrating an example mode transition when certain signals are detected.

FIG. 9 is a flowchart of transitions from sleep to twilight to active modes triggered by detection of certain signals.

FIG. 10 is a graph illustrating an example mode transition when certain signals are detected.

While embodiments of this disclosure have been depicted and described and are defined by reference to exemplary embodiments of the disclosure, such references do not imply a limitation on the disclosure, and no such limitation is to be inferred. The subject matter disclosed is capable of considerable modification, alteration, and equivalents in form and function, as will occur to those skilled in the pertinent art and having the benefit of this disclosure. The depicted and described embodiments of this disclosure are examples only, and not exhaustive of the scope of the disclosure.

What is claimed is:

1. A method for operating a downhole tool, comprising:

detecting a first signal using a first sensor;

switching the downhole tool from a first operating mode to a second operating mode in response to detecting the first signal;

detecting a second signal using the first sensor or a second sensor; and

switching the downhole tool from the second operating mode to a third operating mode in response to detecting the second signal,

wherein the second operating mode comprises a twilight mode, and wherein the downhole tool in the twilight mode consumes energy at a lower rate than in the third operating mode and consumes energy at a higher rate than in the first operating mode.

2. The method of claim 1, wherein the third operating mode comprises an awake mode, wherein the downhole tool has an increased energy consumption in the awake mode than in the second operating mode.

3. The method of claim 1, wherein the first operating mode comprises a sleep mode, wherein the downhole tool consumes less energy in the sleep mode than in the second operating mode.

4. The method of claim 3, wherein the downhole tool further comprises an actuator, wherein the actuator is disabled during sleep mode.

5. The method of claim 1, wherein the downhole tool must switch from the first operating mode to the second operating mode, before switching from the second operating mode to the third operating mode.

6. The method of claim 1, wherein switching the downhole tool to the third operating mode in response to detecting the second signal, further comprises switching from the twilight mode to the third operating mode.

7. The method of claim 1, wherein the first signal comprises a change of a temperature, pressure, fluid flow rate, acoustic, magnetic field, or any combination thereof.

8. The method of claim 1, wherein detecting the first signal comprises detecting a change in electromagnetic field.

9. The method of claim 1, wherein detecting the first signal comprises detecting a change in temperature field.

10. A system for operating a downhole tool, comprising:
a downhole tool, comprising:

a first sensor configured to detect a first signal;
a second sensor configured to detect a second signal;
a controller connected to the first and second sensors; and
an actuator connected to the controller, wherein the actuator is configured to switch the downhole tool from a first operating mode to a second operating mode in response to the first sensor detecting the first signal, and wherein the actuator is configured to switch the downhole tool from the second operating mode to a third operating mode in response to the second sensor detecting the second signal, wherein the second operating mode comprises a twilight mode; wherein the downhole tool in the twilight mode consumes energy at a lower rate than in the third operating mode and consumes energy at a higher rate than in the first operating mode;
an energy source connected to at least one of the controller, the first sensor, and the second sensor; and
at least one source for creating the first and second signals.

11. The system of claim 10, wherein the first signal comprises a predetermined change in electromagnetic field.

12. The system of claim 10, wherein the first signal comprises a predetermined change in temperature.

13. The system of claim 10, wherein the first operating mode comprises a sleep mode in which the downhole tool consumes less power than in the second operating mode.

14. The system of claim 10, wherein the third operating mode comprises an awake mode in which the downhole tool consumes more power than in the first operating mode.

15. The system of claim 10, wherein the first and second sensors are capable of detecting a change in temperature, pressure, fluid flow rate, acoustics, electromagnetic field, or any combination thereof.