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: generating a first magnetic signal; detecting the first magnetic signal using at least one magnetic sensor; switching the downhole tool to a first operating mode in response to detecting the first magnetic signal; generating a second magnetic signal; detecting the second magnetic signal using the at least one magnetic sensor; and switching the downhole tool to a second operating mode in response to detecting the second magnetic signal, wherein at least one of the first magnetic signal and the second magnetic signal is generated with an electromagnetic source tool that produces varying magnetic fields by varying power supplied by a power source of the electromagnetic source tool, wherein power electronics modify a frequency and/or waveform of the power supplied to the electromagnetic source tool.

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 magnetic sensor configured to detect a first magnetic signal and a second magnetic signal that is different than the first magnetic signal; an actuator; and a controller connected to the magnetic sensor and to the actuator; wherein the actuator is configured to perform a first tool action in response to the magnetic sensor detecting the first magnetic signal, and the actuator is configured to perform a second tool action in response to the

magnetic sensor detecting the second magnetic signal; an energy source connected to at least one of the controller, the actuator, and the magnetic sensor; and at least one electromagnetic source for creating the first magnetic signal and the second magnetic signal by varying power supplied by the electromagnetic source.

According to a third aspect of the present invention, there is provided method for operating a downhole tool, comprising: generating a first magnetic signal; detecting the first magnetic signal using at least one magnetic sensor; switching the downhole tool to a twilight operating mode in response to detecting the first magnetic signal; generating a second magnetic signal; detecting the second magnetic signal using the at least one magnetic sensor; switching the downhole tool to an awake operating mode in response to detecting the second magnetic signal; generating a third magnetic signal; detecting the third magnetic signal using the at least one magnetic sensor; and switching the downhole tool to a sleep operating mode in response to detecting the third magnetic signal, wherein the first, second, and third magnetic signals are based on one of the group of a duration of a magnetic field, a frequency of a magnetic field, and a strength of a magnetic field.

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:

generating a first magnetic signal;

detecting the first magnetic signal using at least one magnetic sensor;

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

generating a second magnetic signal;

detecting the second magnetic signal using the at least one magnetic sensor; and

switching the downhole tool to a second operating mode in response to detecting the second magnetic signal, wherein at least one of the first magnetic signal and the second magnetic signal is generated with an electromagnetic source tool that produces varying magnetic fields by varying power supplied by a power source of the electromagnetic source tool, wherein power electronics modify a frequency and/or waveform of the power supplied to the electromagnetic source tool.

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

generating a third magnetic signal;

detecting the third magnetic signal using the at least one magnetic sensor;

switching the downhole tool to a third operating mode in response to detecting the third magnetic signal;

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

6. The method of claim 1, wherein the first operating mode is a sleep mode; the second operating mode is a twilight mode; and the downhole tool switches to a third operating mode from the second operating mode, wherein the third operating mode is an active mode.

7. The method of claim 5, wherein switching the downhole tool to the third operating mode in response to detecting the third magnetic signal, further comprises switching from twilight mode to the third operating mode.

8. The method of claim 1, wherein the electromagnetic source tool includes a plurality of permanent magnets or an electromagnet.

9. The method of claim 1, wherein the electromagnetic source tool includes one or more magnetic wellbore projectiles.

10. The method of claim 1 further comprising: detecting a change in temperature field.

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

a downhole tool, comprising:

a magnetic sensor configured to detect a first magnetic signal and a second magnetic signal that is different than the first magnetic signal;

an actuator; and

a controller connected to the magnetic sensor and to the actuator;

wherein the actuator is configured to perform a first tool action in response to the magnetic sensor detecting the first magnetic signal, and the actuator is configured to perform a second tool action in response to the magnetic sensor detecting the second magnetic signal;

an energy source connected to at least one of the controller, the actuator, and the magnetic sensor; and

at least one electromagnetic source for creating the first magnetic signal and the second magnetic signal by varying power supplied by the electromagnetic source.

12. The system of claim 11, wherein the first magnetic signal and the second magnetic signal comprise a predetermined change in electromagnetic field.

13. The system of claim 11, wherein the first magnetic signal and the second magnetic signal are not a same type of signal with the first magnetic signal being based on frequency and the second magnetic signal being based on a series of magnetic pulses.

14. The system of claim 11, wherein the actuator is configured to perform a second tool action in response to the magnetic sensor detecting the second magnetic signal.

15. The system of claim 14, wherein the first tool action comprises switching the downhole tool to a first operating mode, and wherein the second tool action comprises switching the downhole tool to a second operating mode.

16. The system of claim 15, wherein the first operating mode comprises a sleep mode in which the downhole tool consumes less power than in the second operating mode.

17. The system of claim 15, wherein the second operating mode comprises an awake mode in which the downhole tool consumes more power than in the first operating mode.

18. The system of claim 11, wherein the magnetic sensor is capable of detecting a change in temperature, pressure, fluid flow rate, acoustics, electromagnetic field, or any combination thereof.

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

generating a first magnetic signal;

detecting the first magnetic signal using at least one magnetic sensor;

switching the downhole tool to a twilight operating mode in response to detecting the first magnetic signal;

generating a second magnetic signal;

detecting the second magnetic signal using the at least one magnetic sensor;

switching the downhole tool to an awake operating mode in response to detecting the second magnetic signal;

generating a third magnetic signal;

detecting the third magnetic signal using the at least one magnetic sensor; and

switching the downhole tool to a sleep operating mode in response to detecting the third magnetic signal, wherein the first, second, and third magnetic signals are based on one of the group of a duration of a magnetic field, a frequency of a magnetic field, and a strength of a magnetic field.

20. The method of claim 19, wherein the downhole tool performs an active tool function in the awake operating mode, and wherein the downhole tool performs a twilight tool function in the twilight operating mode.