[0016] US 6070662 A discloses a method and apparatus for establishing communication in a cased wellbore with a data sensor that has been remotely deployed, prior to the installation of casing in the wellbore, into a subsurface formation penetrated by the wellbore. Communication is established by installing an antenna in an opening in the
casing wall.

[0017] However, all of the above systems suffer from low efficiency, which becomes even more apparent in applications where two way communication is established using power harvesting on the remote side. Further, the above prior art are sensitive to alignment of the antennas to obtain the necessary connectivity, and complex completion programs have to be run to align the completion with the casing.

Short summary of the invention

[0018] Embodiments of the present invention disclose a method and a system for improving the signal transfer and energy efficiency of the signal and power transmission between wireless transmitters and receivers of wireless links inside the wellbore.

[0019] Embodiments of the present invention disclose a wellbore E-field wireless communication system where the signal transfer and energy efficiency is improved compared to systems described in prior art.

[0020] According to a first aspect, there is provided a wellbore wireless communication system, said communication system comprising: a first E-field antenna; and a second E-field antenna, wherein said first E-field antenna, and said second E-field antenna are both arranged in a common compartment of a wellbore and further arranged for transferring a signal between said first E-field antenna and said second E-field antenna, wherein said first E-field antenna comprises a first dipole antenna, and wherein a first leg of said first dipole antenna is a tubing, liner or casing of said wellbore, and said system further comprises a layer of dielectric insulation between said first leg and a second leg of said first dipole antenna, such that said tubing, liner or casing is an active element of said first dipole antenna.

[0020a] According to a second aspect, there is provided a wellbore wireless communication system, said communication system comprising: a first E-field antenna; and a second E-field antenna, wherein said first E-field antenna, and said second E-field antenna are both arranged in a common compartment of a wellbore and further arranged for transferring a signal between said first E-field antenna and said second E-field antenna, wherein said first E-field antenna comprises a first toroidal inductor, and wherein said first toroidal inductor is arranged about a tubing, liner or casing of said wellbore, such that said tubing, liner or casing is acting as a waveguide for an electric field.

[0020b] According to a third aspect, there is provided a wellbore wireless communication system, said communication system comprising: a first E-field antenna; a second E-field antenna, and a resonator surrounding said first E-field antenna and said second a second E-field antenna, wherein said resonator extends into a lateral wellbore, wherein said first E-field antenna, and said second E-field antenna are both arranged in a common compartment of said wellbore and further arranged for transferring a signal between said first E-field antenna and said second E-field antenna, and

wherein said resonator comprises a metallic packer arranged to delimit the size of the compartment.

[0021] The first and second E-field antennas are electric dipoles. Electric dipoles set up an electric field that will propagate through a medium as waves, e.g. radio waves. While the electric field as disclosed by the invention is created around an electrically charged particle, i.e. the electric dipole, the magnetic field used for the wireless link in prior art is created around the coil involved by the modulated magnetic field. Although the electric and magnetic fields are interrelated as known from Maxwell's equations, efficiency of the wireless link can be significantly improved by using the E-field for communication. However, to take advantage of the properties of the E-field, at least the sender antenna has to be an electric dipole, as discussed later in the document.

[0022] The metallic resonator further improves the efficiency of the system over the prior art. In an embodiment the metallic resonator comprises existing casing and tubing inside the wellbore, where the resonator extends into a lateral wellbore with an E-field
antenna. An electric field set up by one of the antennas in the resonator will then propagate inside the resonator and reach the other antenna.

[0023] A further advantage of embodiments of the invention is that the requirements for alignment and proximity between the sender and receiver pair of couplers are less strict than for prior art inductive couplers. As long as the antennas are located inside the resonator, their alignment is not critical. In this way superior connectivity can be established between a mother wellbore and a lateral wellbore without spacing out or similar techniques known from prior art.

[0024] According to prior art, alignment of the wellbore completion inside a casing of a wellbore requires specific procedures for spacing out the completion so that the downhole magnetic dipoles are properly aligned to establish wireless connectivity, as the wellbore completion is set and the tubing hanger is landed inside the wellhead housing of the well. Magnetic dipoles have to be aligned so that the B-field from a sender can penetrate the coil of the receiver. It is well known that the strength of the B-field around a magnetic dipole has a certain propagation, and that the field is strongest in specific directions relative the coil.

[0025] Space out can be understood as the process required to add exactly the necessary tubings to the top of the wellbore completion as this is lowered into the wellbore casing. At the end of the wellbore completion program the wellbore completion is landed and terminated in a tubing hanger in a wellhead housing. If the wellbore completion is to long the tubing has to be lifted up to remove some of the tubing. If it is to short, more tubing has to be added.

[0026] If however, an embodiment of the present invention is used, the completion program may be simplified since the alignment is less critical, which in turn can reduce the time both for planning and conducting the wellbore completion program.

[0027] Another advantage of embodiments of the invention is that the pair of electric dipoles according to the invention can be placed a longer distance away from each other than for magnetic dipoles according to prior art.

[0028] A further advantage is that the electric dipoles can communicate even when there are intermediate obstacles, as long as they are in the same annulus.

[0029] In a number of wellbore applications, such as for e.g. establishing communication between a mother wellbore and lateral wellbores, this adds a lot of flexibility. A sender can be arranged attached or integrated to the tubing wall of the completion, and a receiver may be attached to the tubing wall of the lateral bore. Even when they are not directly opposite each other, or there are obstacles between them, such as edges of the casing where the lateral bore branches off, the sender and receiver pair will be able to establish a reliable wireless power and communication link.
[0030] Another application where the use of embodiments of the invention is advantageous, is to set up communication between sender and receiver pairs at different depths along the motherbore or a lateral bore. This can be important if measurements have to be performed at different locations, such as formation measurements at two levels.

Figure captions

[0031] The attached figures illustrate some embodiments of the claimed invention.
[0032] Fig. 1 illustrates in a sectional view a wireless electric transfer system according to an embodiment of the invention with toroidal inductor antennas arranged in an annulus of a wellbore.
[0033] Fig. 2 illustrates in the same way as in Fig. 1 a wireless electric transfer system according to an embodiment of the invention where the toroidal inductor antennas are arranged at the same height.
[0034] Fig. 3 illustrates in a simplified sectional view toroidal inductor antennas with stand-alone cores arranged in the mother wellbore and a lateral wellbore.
[0035] Fig. 4 illustrates the same as in Fig. 3, where the antennas are toroidal inductor antennas arranged about a motherbore tubing (101) and a lateral tubing (201).
[0036] Fig. 5 illustrates in a simplified sectional view a wireless electric transfer system according to an embodiment of the invention with dipole antennas arranged in an annulus of a wellbore.
[0037] Fig. 6 illustrates the same as in Fig. 5, where the tubing is used as an active element of the dipole antenna.
[0038] Fig. 7 illustrates in a sectional view a wireless electric transfer system according to an embodiment of the invention comprising a resonator wherein the antennas are arranged.
[0039] Fig. 8 illustrates in a sectional view the system according to the invention in a multi-lateral wellbore (2) with an open hole formation.

Embodiments of the invention

[0040] The invention will in the following be described and embodiments of the invention will be explained with reference to the accompanying drawings.
[0041] Figure 1 illustrates in a simplified cross sectional drawing an embodiment of the wellbore E-filed wireless communication system (1). The wellbore (2) comprises an inner tool, tubing, liner or casing (101) and an outer tubing, liner or casing (102). In between the inner tool, tubing, liner or casing (101) and an outer tubing, liner or casing (102) there is defined a compartment (210).
[0042] It will be understood from the following description of the communication system (1) that it is not important in any of the embodiments whether the compartment, or

Claims

1. A wellbore wireless communication system, said communication system comprising:

a first E-field antenna; and

a second E-field antenna,

wherein said first E-field antenna, and said second E-field antenna are both arranged in a common compartment of a wellbore and further arranged for transferring a signal between said first E-field antenna and said second E-field antenna,

wherein said first E-field antenna comprises a first dipole antenna, and

wherein a first leg of said first dipole antenna is a tubing, liner or casing of said wellbore, and said system further comprises a layer of dielectric insulation between said first leg and a second leg of said first dipole antenna, such that said tubing, liner or casing is an active element of said first dipole antenna.

2. A wellbore wireless communication system according to claim 1, comprising:

a control system;

a wellbore instrument;

a first E-field transceiver connected to said control system and said first E-field antenna; and

a second E-field transceiver connected to said wellbore instrument and said second E-field antenna,

wherein said wireless communication system is arranged for transferring a communication signal between said control system and said wellbore instrument via said first and second E-field antennas.

3. A wellbore wireless communication system, said communication system comprising:

a first E-field antenna; and

a second E-field antenna,

wherein said first E-field antenna, and said second E-field antenna are both

arranged in a common compartment of a wellbore and further arranged for transferring a signal between said first E-field antenna and said second E-field antenna,

wherein said first E-field antenna comprises a first toroidal inductor, and

wherein said first toroidal inductor is arranged about a tubing, liner or casing of said wellbore, such that said tubing, liner or casing is acting as a waveguide for an electric field.

4. A wellbore wireless communication system according to claim 3, wherein said first toroidal inductor is arranged about a stand-alone metal core within said compartment.

5. A wellbore wireless communication system according to claim 1, wherein said second E-field antenna comprises a second dipole antenna.

6. A wellbore wireless communication system according to claim 1, wherein said second E-field antenna comprises a first toroidal inductor.

7. A wellbore wireless communication system according to claim 1, wherein said second E-field antenna is arranged in a lateral wellbore.

8. A wellbore wireless communication system according to claim 1, wherein said system comprises a metallic resonator surrounding said first E-field antenna and said second E-field antenna.

9. A wellbore wireless communication system, said communication system comprising:

a first E-field antenna,

a second E-field antenna, and

a resonator surrounding said first E-field antenna and said second a second E-field antenna, wherein said resonator extends into a lateral wellbore,

wherein said first E-field antenna, and said second E-field antenna are both arranged in a common compartment of said wellbore and further arranged for transferring a signal between said first E-field antenna and said second E-field

antenna, and

wherein said resonator comprises a metallic packer arranged to delimit the size of the compartment.

10. A wellbore wireless communication system according to claim 2, comprising:

a wellbore cable between said control system and said first E-field transceiver.