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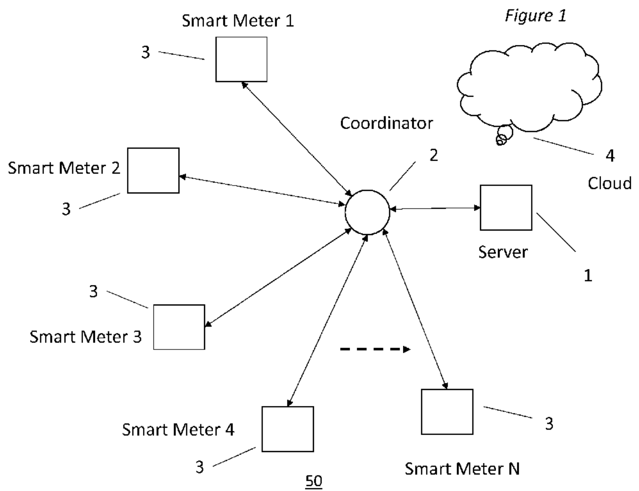
**Published**:
— *with international search report (Art. 21(3))*

**(54) Title**: SMART METER SYSTEM COMMUNICATION METHODS




**(57) Abstract**: An improved data packet design that can be used in a variety of data communication standards used in smart meter systems is disclosed. In an embodiment a smart meter system that comprises of a local server, a coordinator and a plurality of smart meters in the many-to-one data communication system configuration. The smart meter uses a variety of types of radio frequency data packets. The data packets contain the commands, parameters, and data for system control and data transmission. The data packet designs are disclosed for a route discovery command, a get parameter command, a set parameter command, a get data command, a reset command, a relay command, a start command, and a calibration command that are used in the smart meter system.

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# SMART METER SYSTEM COMMUNICATION METHODS

## FIELD OF THE INVENTION

[0001] The present invention is related generally to meters for measuring power and more particularly to a smart meter system.

## BACKGROUND

[0002] A smart meter system is an interconnected system comprises a local server connected to a coordinator that is linked to many smart meters. The voltage, current, power, and energy data measured by the smart meters are typically sent to the coordinator for determining power usage. The data received at the coordinator is stored in a database in either the local server or in a public network such as the Internet cloud. Commands used in the smart meter system for controlling the data transmission are sent from the local server and transmitted by the coordinator to the smart meters. There is a need to enhance system performance, reliability, testability and manufacturability of the overall system during the product production and prototyping. Accordingly, what is needed is a system and method that addresses such needs. The system and method must be easily implemented, cost effective and adaptable to existing systems. The present invention addresses such a need.

## SUMMARY

[0003] An improved data packet design that can be used in a variety of data communication standards used in smart meter systems is disclosed. In an embodiment

a smart meter system that comprises of a local server, a coordinator and a plurality of smart meters in the many-to-one data communication system configuration. The smart meter system uses a variety of types of data packets. The data packets contain the commands, parameters, and data for system control and data transmission. The data packet designs are disclosed for a route discovery command, a get parameter command, a set parameter command, a get data command, a reset command, a relay command, a start command, and a calibration command that are used in the smart meter system.

## BRIEF DESCRIPTION OF THE DRAWINGS

[0004] Fig. 1 is an illustration of a smart meter system according to a preferred embodiment of the invention.

[0005] Fig. 2 is an illustration of the route discovery command, showing the route discovery command, route discovery response message, and route discovery acknowledgment message.

[0006] Fig. 3 is an illustration of the get parameter command, showing the get parameter command and get parameter response message.

[0007] Fig. 4 is an illustration of the set parameter command, showing the set parameter command and set parameter response message.

[0008] Fig. 5 is an illustration of the get data command, showing the get data command and get data response message.

[0009] Fig. 6 is an illustration of the reset command, showing the reset command and reset response message.

[0010] Fig. 7 is an illustration of the relay command, showing the relay command and relay response message.

[0011] Fig. 8 is an illustration of the start command, showing the start command and start response message.

[0012] Fig. 9 is an illustration of the calibration command, showing the calibration command and calibration response message.

DETAILED DESCRIPTION

[0013] The present invention is related generally to meters for measuring power and more particularly to a smart meter system. The following description is presented to enable one of ordinary skill in the art to make and use the invention and is provided in the context of a patent application and its requirements. Various modifications to the preferred embodiments and the generic principles and features described herein will be readily apparent to those skilled in the art. Thus, the present invention is not intended to be limited to the embodiments shown, but is to be accorded the widest scope consistent with the principles and features described herein.

[0014] Fig. 1 is an illustration of a smart meter system 50 according to an embodiment of the invention in a radio frequency (RF) data communication system e.g. Zig Bee that may or may not support an industry standard such as IEEE 802.14.5. Although in a preferred embodiment the data packets are transmitted over the communication system wirelessly via a standardized protocol, one of ordinary skill in the art readily recognizes the data packets could be transmitted over wires and/or using any type of protocol and that use would be within the spirit and scope of the present invention.

[0015] The smart meter system 50 comprises a local server 1 connected to a coordinator 2 and smart meters 3 (smart meter 1-N). In one embodiment, the local server 1 is connected to the coordinator 2 via wires. In another embodiment, the local server 1 is connected to the coordinator 2 wirelessly.

[0016] The smart meter system 50 is a many-to-one data communication topology. In this embodiment, the local server 1 issues a command to the coordinator 2 which executes the command by sending a corresponding data packet wirelessly to the smart meters 3 by a RF link. Then the smart meters 3 send an appropriate response back to the coordinator 2 by the same RF link. Power usage data sent by the smart meters 3 can be stored in a database hosted in the local server 1 or an internet cloud 4.

[0017] The smart meter system 50 uses a variety of types of data packets to improve the functionality of the smart meter system. The data packets contain the commands, parameters, and data for system control and data transmission. The data packets are categorized into three command types, command type 1, command type 2 and command type 3. Data packets in accordance with command type 1 comprise special commands such as for example a route discovery command. Data packets in accordance with command type 2 comprise normal commands including but not limited to a get parameter command, set parameter and get data command. . Data packets in accordance with command type 3 comprise control commands including but not limited to a reset command, a relay command, a start command, and a calibrate command that are used in the smart meter system.

[0018] Each of the above described data packets have a plurality of fields therein. One of ordinary skill in the art readily recognizes there could be more or less fields in any of the data packets and those data packets use would be within the spirit and scope of the present invention. In addition the fields could be in any order or could of different types and that would also be within the spirit and scope of the present invention.

[0019] The power usage can be accessed for example by displaying web pages using any device that is connected to the local server or the internet. The database can be analyzed to determine optimal power usage and distribution. The power usage can also be analyzed to enable system control, e.g. cut off the power if necessary.

[0020] To set up the smart meter system 50, the local server 1 sends a route discovery command to the coordinator 2. Fig. 2 is an illustration of a packet of the route discovery command, showing the route discovery command in accordance with an embodiment, showing a route discovery response message, and a route discovery acknowledgment message. The data packet 60 comprises a communication type identification field (USR_RX_GET) 5, a command type identification field (COM_ADD) 6, and a coordinator address identification field 7, that comprises as a 4-word address, ADD_3, ADD_2, ADD_1, ADD_0.

[0021] When the route discovery broadcast command is received by the plurality of smart meters, a route discovery response message is sent out after a random delay. Such delay is necessary to minimize the chance of collisions from transmissions of route discovery response messages from all the smart meters. The route discovery response message comprises of a communication type identification field (USR_TX_GET) 8, a command type identification field (COM_ADD) 9, and a smart meter address field 10, that comprises of a 4-word address, ADD_3, ADD_2, ADD_1, ADD_0.

[0022] When the route discovery response message is received by the coordinator, a route discovery acknowledge message is sent from the coordinator back to the smart meter. The route discovery acknowledge message comprises of a communication type identification field (USR_RX_GET) 11, a command type identification field (COM_ADD) 12, and a coordinator address field 13 that comprises of a 4-word address, ADD_3, ADD_2, ADD_1, ADD_0.

[0023] Fig. 3 is an illustration of the get parameter command, showing the get parameter command and get parameter response message. The coordinator can obtain the set of parameters that a smart meter uses to calculate power and energy by transmitting the get parameter command. The get parameter command comprises a communication type identification field (USR_RX_GET) 14, a command type identification field (COM_PARAM) 15.

[0024] When the get parameter command is received by the smart meter being addressed, the smart meter transmits a get parameter response message back to the coordinator. The get parameter response message comprises of a communication type identification field (USR_TX_GET) 16, a command type identification field (COM_PARAM) 17, and a plurality of parameters 18, that includes words MIN_ADC, MAX_ADC, SAMPLE_INT, SAMPLE_WIN, MAG_I, MAG_V, MIN_V, MAX_V, MIN_I, MAX_I, and T_EFF.

[0025] Fig. 4 is an illustration of the set parameter command, showing the set parameter command and set parameter response message. The coordinator 2 can set the parameters that a smart meter 3 uses to calculate power and energy by transmitting the set parameter command. The set parameter command comprises of a communication type identification field (USR_TX_SET) 19, a command type identification field (COM_PARAM) 20, and a plurality of parameters 21, that includes of words MIN_ADC, MAX_ADC, SAMPLE_INT, SAMPLE_WIN, MAG_I, MAG_V, MIN_V, MAX_V, MIN_I, MAX_I, and T_EFF.

[0026] When the set parameter command is received by the smart meter being addressed, the smart meter transmits a obtain parameter response message back to the coordinator. The set parameter response message comprises of a communication type identification field (USR_TX_SET) 22, a command type identification field (COM_PARAM) 23, and a plurality of parameters 24, that includes of words MIN_ADC, MAX_ADC, SAMPLE_INT, SAMPLE_WIN, MAG_I, MAG_V, MIN_V, MAX_V, MIN_I, MAX_I, and T_EFF.

[0027] Fig. 5 is an illustration of the get data command, showing the get data command and get data response message. The get data command comprises of a communication type identification field (USR_RX_GET) 25, command type identification field (COM_DATA) 26.

[0028] When the get data command is received by the smart meter being addressed, the smart meter transmits a get data response message back to the coordinator. The get data response message comprises of a communication type identification field (USR_TX_GET) 27, a command type identification field (COM_DATA) 28, and a plurality of data 29, that includes of words RMS_V, RMS_I, POWER_1, POWER_0, ENERGY_1, ENERGY_0, SM_V, SM_I, and STATUS.

[0029] Fig. 6 is an illustration of the reset command, showing the reset command and reset response message. The reset command comprises of a communication type identification field (RESET) 30, a command value field (flagreset) 31, and the reset energy value 32 that includes words ENERGY_RESET_VALUE1 and ENERGY_RESET_VALUE0.

[0030] When the reset command is received by the smart meter being addressed, the smart meter transmits a reset response message back to the coordinator. The reset response message comprises of a communication type identification field (USR_TX_GET) 33, status of the reset 34 given by SUCCESS or FAILURE, a command value field (flag) 35, and the energy reset value to 36 that comprises words, ENERGY_RESET_VALUE1 and ENERGY_RESET_VALUE0.

[0031] Fig. 7 is an illustration of the relay command, showing the relay command and relay response message. The coordinator can control a relay to cut off the power line from the power line source by transmitting the relay command. The relay command comprises a communication type identification field (RELAY) 37 and a command value field (flag) 38.

[0032] When the relay command is received by the smart meter 3 being addressed, the smart meter 3 transmits a relay response message back to the coordinator 2. The relay response message comprises a communication type identification field (RELAY) 39, status of the reset 40 given by SUCCESS or FAILURE, a command value field (relay) 41.

[0033] Fig. 8 is an illustration of the start command, showing the start command and start response message. The start command comprises of a communication type identification field (START) 42, and a command value field (flaginc) 43.

[0034] When the start command is received by the smart meter being addressed, the smart meter transmits a start response message back to the coordinator. The start response message comprises of a communication type identification field (START) 44, status of the reset 45 given by SUCCESS or FAILURE, a command value field (flaginc) 46.

[0035] Fig. 9 is an illustration of the calibration command, showing the calibration command and calibration response message. The coordinator 2 can start a voltage, current, power, and energy calibrations in the smart meter being addressed by transmitting the calibration command. The calibration command comprises a communication type identification field (CALIBRATE) 47, and a command value field includes of words V_CAL 48, I_CAL 49, and T_CAL 50.

[0036] When the start command is received by the smart meter being addressed, the smart meter transmits a calibration response message back to the coordinator. The calibration response message comprises of a communication type identification field (CALIBRATE) 51, status of the calibration 52 given by SUCCESS or FAILURE, a command value field includes of words MAG_V 53, MAG_I 54, and T_EFF 55.

[0037] Embodiments described herein can take the form of an entirely hardware implementation, an entirely software implementation, or an implementation containing both hardware and software elements. Embodiments may be implemented in software, which includes, but is not limited to, application software, firmware, resident software, microcode, etc.

[0038] The steps described herein may be implemented using any suitable controller or processor, and software application, which may be stored on any suitable storage location or computer-readable medium. The software application provides instructions that enable the processor to cause the receiver to perform the functions described herein.

[0039] Furthermore, embodiments may take the form of a computer program product accessible from a computer-usable or computer-readable medium providing program code for use by or in connection with a computer or any instruction execution system. For the purposes of this description, a computer-usable or computer-readable medium can be any apparatus that can contain, store, communicate, propagate, or transport the program for use by or in connection with the instruction execution system, apparatus, or device.

[0040] The medium may be an electronic, magnetic, optical, electromagnetic, infrared, semiconductor system (or apparatus or device), or a propagation medium. Examples of a computer-readable medium include a semiconductor or solid state memory, magnetic tape, a removable computer diskette, a random access memory (RAM), a read-only memory (ROM), a rigid magnetic disk, and an optical disk. Current examples of optical disks include DVD, compact disk-read-only memory (CD-ROM), and compact disk – read/write (CD-R/W). To describe the features of the present disclosure in more detail refer now to the following description in conjunction with the accompanying Figures.

[0041] Although the present invention has been described in accordance with the embodiments shown, one of ordinary skill in the art will readily recognize that there could be variations to the embodiments and those variations would be within the spirit and scope of the present invention. Accordingly, many modifications may be made by one of ordinary skill in the art without departing from the spirit and scope of the present invention.

# CLAIMS

What is claimed is:

1. A data communication method within a smart meter system, the smart meter system comprising a local server, a coordinator coupled to the local server; and a plurality of smart meters coupled to the coordinator; the method comprising;

issuing by the local server a command type 1 to the coordinator; and

sending a broadcast command by the coordinator to the plurality of smart meters based upon the command type 1; wherein the command type 1 comprises a communication type identification field, a command type identification field, and a coordinator address identification field.

2. The data communication method of claim 1 which includes sending one or more response messages from the plurality of smart meters after a random delay after the broadcast command has been received.

3. The data communication method of claim 2, wherein the one or more response messages comprises a communication type identification field, a command type identification field, and a smart meter address identification field.

4. The data communication method of claim 2, wherein when the one or more response messages is received by the coordinator an acknowledge message is sent from the coordinator to the plurality of smart meters.

5. The data communication method of claim 4, wherein the acknowledge message comprises a communication type identification field, an operation status field, and an address field.

6. The data communication method of claim 1, wherein the command type 1 comprises a network discovery command.

7. A data communication method within a smart meter system, the smart meter system comprising a local server,  a coordinator coupled to the local server; and a plurality of smart meters coupled to the coordinator; the method comprising;

issuing by the local server a command type 2; and

sending by the coordinator the command type 2 to one or more addressed smart meters; wherein the command type 2 comprises a communication type identification field, a command type identification field, and a parameter field comprising plurality of parameters.

8. The data communication method of claim 7, wherein when the command type 2 is received by the one or more addressed smart meters at least one message is sent in response.

9. The data communication method of claim 8, wherein the at least one message comprises a communication type identification field, an operation status field, and a parameter field comprising a plurality of parameters.

10. The data communication of claim 7, wherein the command type 2 comprises any of a get parameter command, a set parameter command, and a get data command.

11. The data communication of claim 10, wherein the at least one message comprises any of a get parameter response message, a set parameter response message, and a get data response message.

12. A data communication method within a smart meter system, the smart meter system comprising a local server, a coordinator coupled to the local server; and a plurality of smart meters coupled to the coordinator; the method comprising;

issuing by the local server a command type 3 to the coordinator; and

sending by the coordinator the command type to one or more addressed smart meters; wherein the reset command comprises a command identification field, a command value field, and a parameter field comprising a plurality of parameters.

13. The data communication method of claim 12, wherein when the command type 3 is received by the one or more addressed smart meters at least one message is sent in response.

14. The data communication method of claim 13, wherein the at least one message, comprises a command identification field, an operation status field, a command value field, and a parameter field comprising a plurality of parameters.

15. The data communication method of claim 12, wherein the command type 3 comprises any of a reset command, a relay command, a start command and a calibrate command.

16. The data communication of claim 15, wherein the at least one message comprises any of a reset response message, a relay response message, a start response message and a calibrate response message.

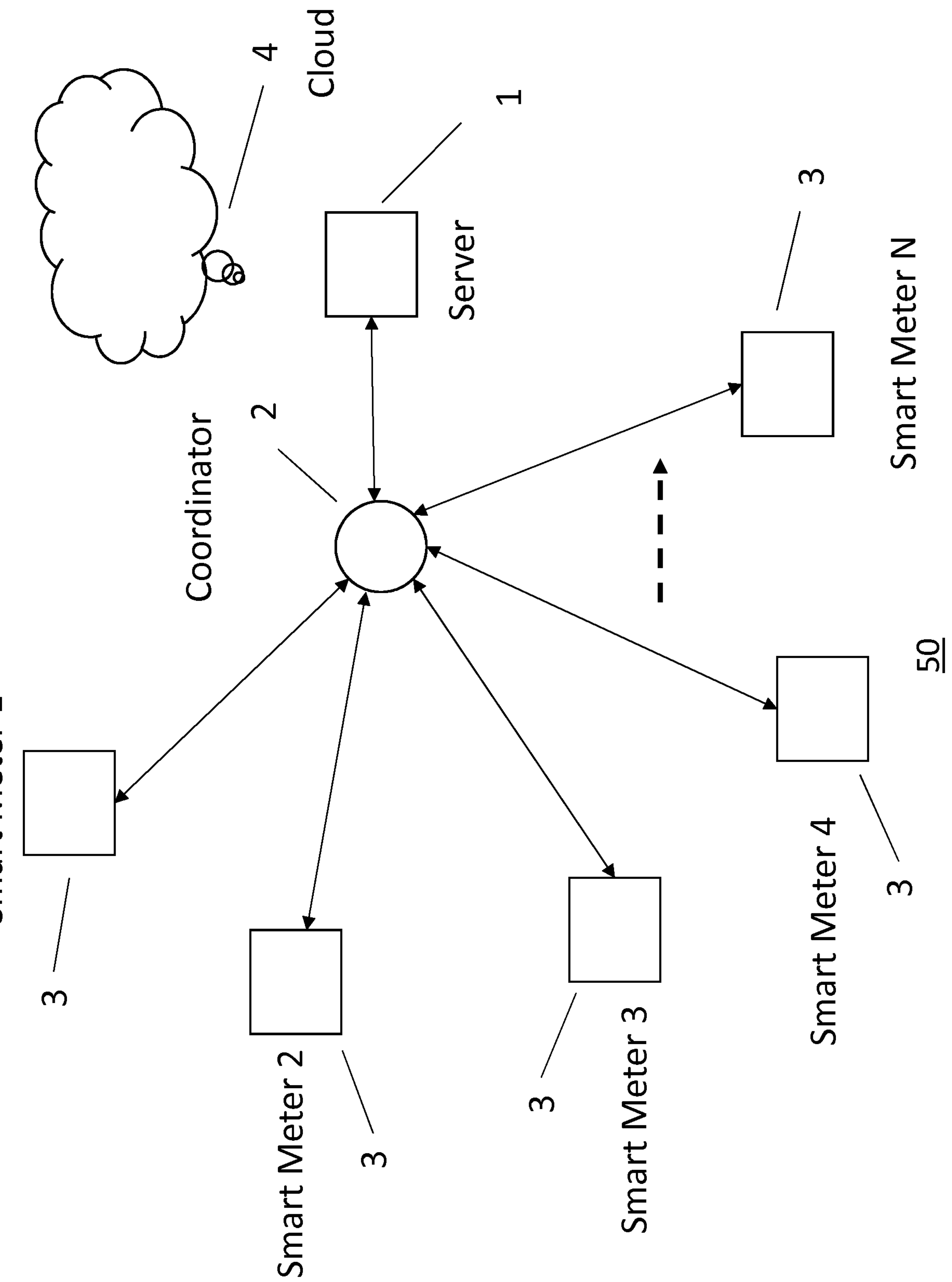

Cloud
4
1
Server
Coordinator
2
3
Smart Meter N
Smart Meter 1
3
Smart Meter 2
3
3
Smart Meter 3
Smart Meter 4
3
50

*Figure 1*

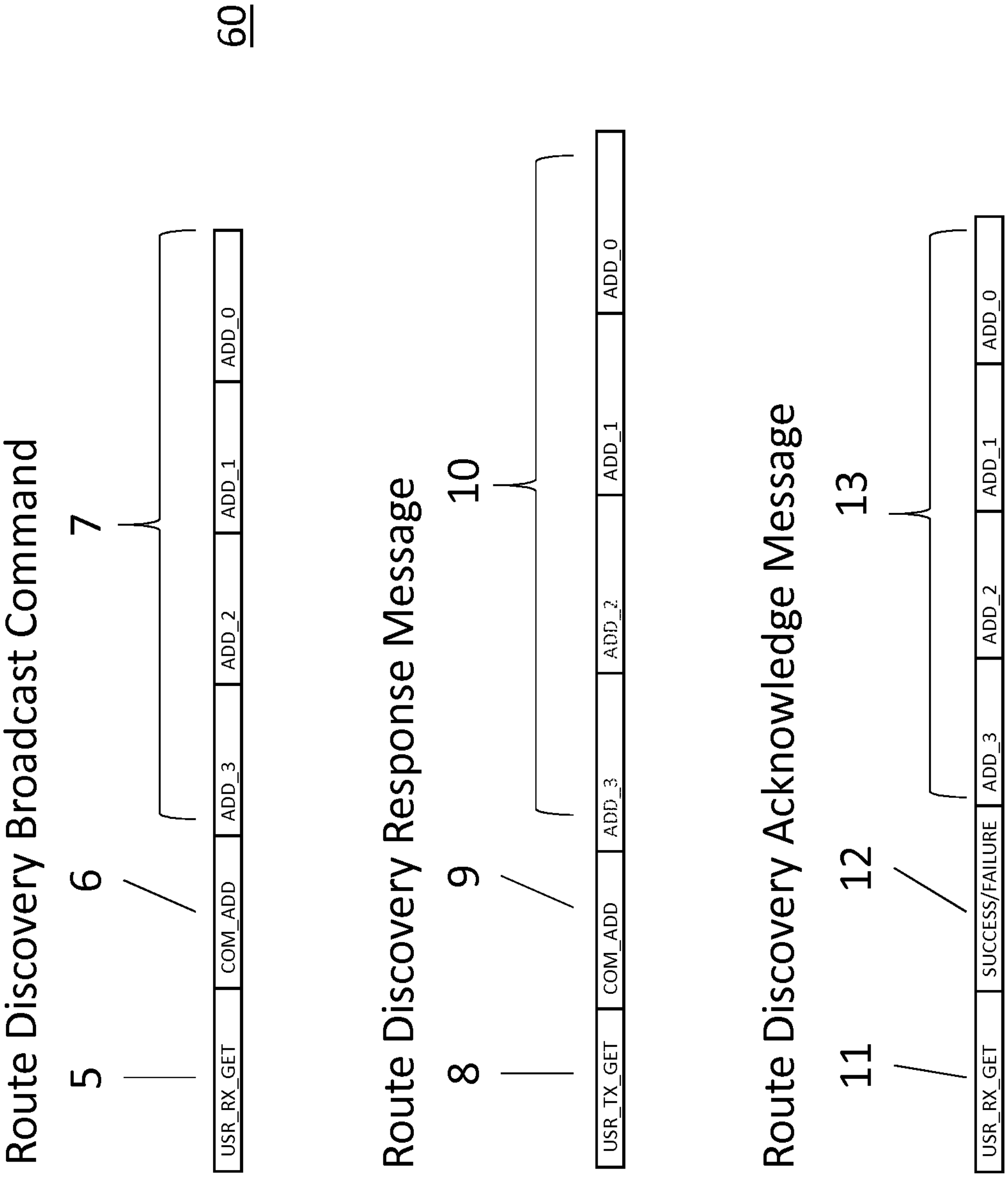

60
Route Discovery Broadcast Command
5
6
7
USR_RX_GET
COM_ADD
ADD_3
ADD_2
ADD_1
ADD_0
Route Discovery Response Message
8
9
10
USR_TX_GET
COM_ADD
ADD_3
ADD_2
ADD_1
ADD_0
Route Discovery Acknowledge Message
11
12
13
USR_RX_GET
SUCCESS/FAILURE
ADD_3
ADD_2
ADD_1
ADD_0

*Figure 2*

*Figure 3*

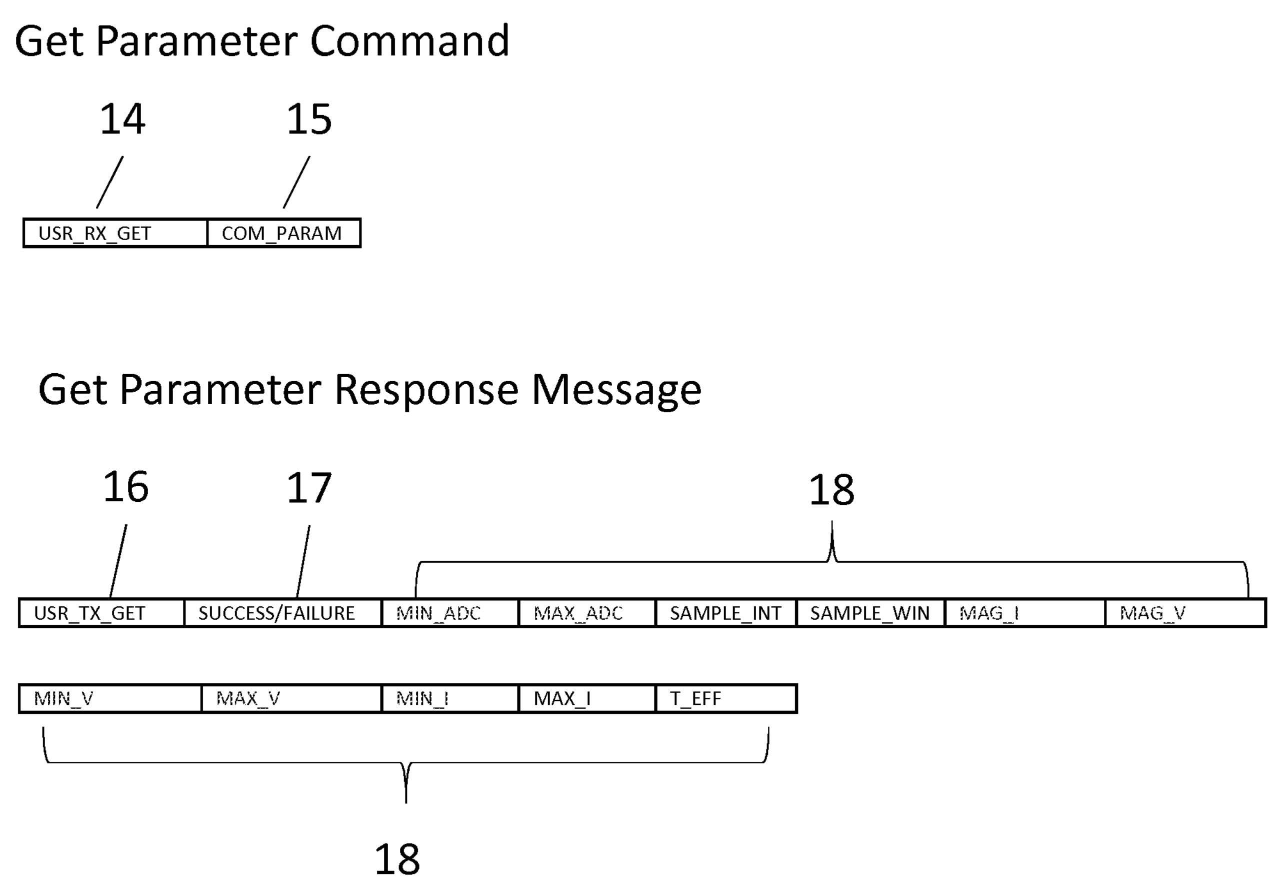

Get Parameter Command
14
15
USR_RX_GET
COM_PARAM
Get Parameter Response Message
16
17
18
USR_TX_GET
SUCCESS/FAILURE
MIN_ADC
MAX_ADC
SAMPLE_INT
SAMPLE_WIN
MAG_I
MAG_V
MIN_V
MAX_V
MIN_I
MAX_I
T_EFF
18

*Figure 4*

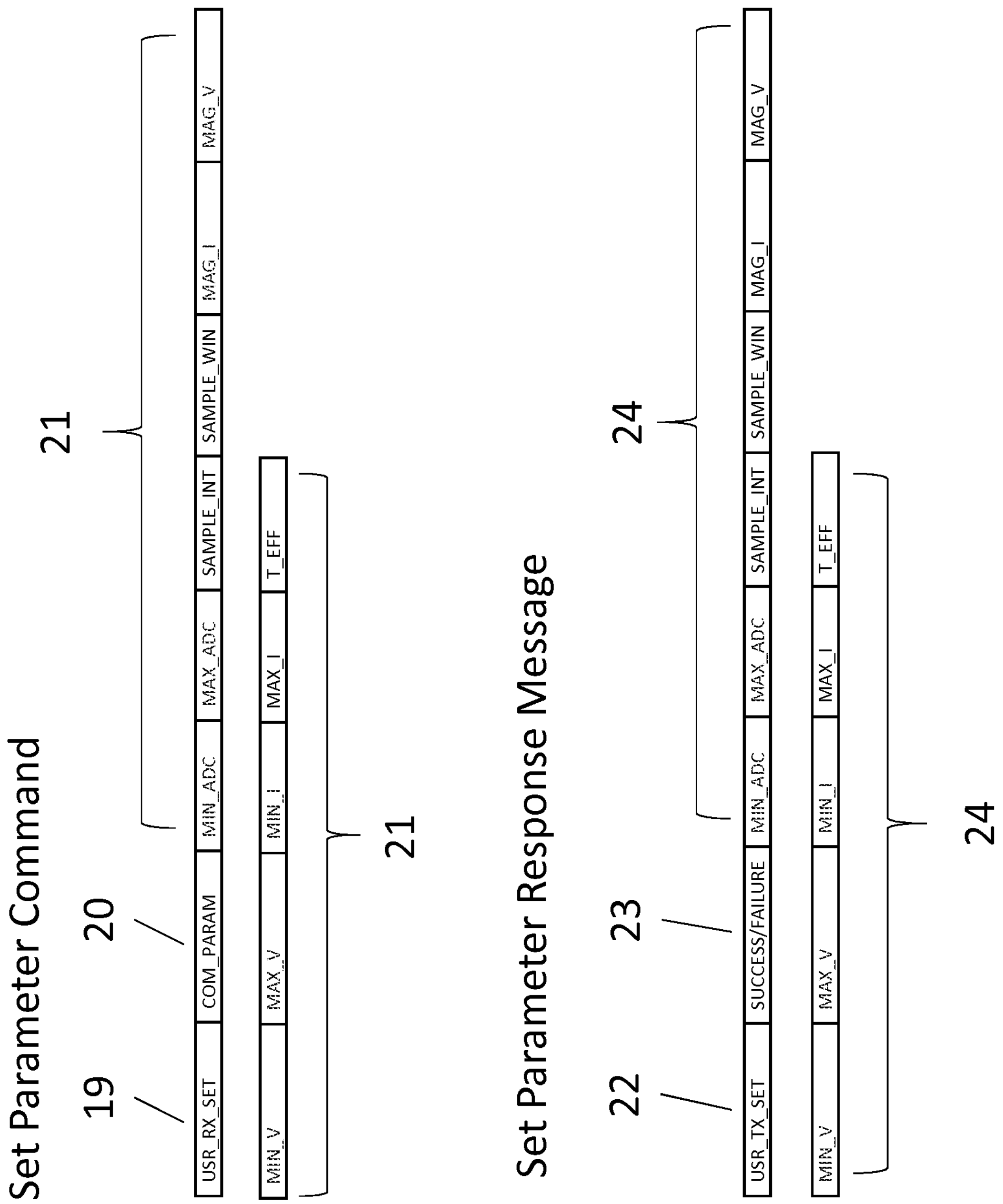

Set Parameter Command
19
20
21
USR_RX_SET
COM_PARAM
MIN_ADC
MAX_ADC
SAMPLE_INT
SAMPLE_WIN
MAG_I
MAG_V
MIN_V
MAX_V
MIN_I
MAX_I
T_EFF
21
Set Parameter Response Message
22
23
24
USR_TX_SET
SUCCESS/FAILURE
MIN_ADC
MAX_ADC
SAMPLE_INT
SAMPLE_WIN
MAG_I
MAG_V
MIN_V
MAX_V
MIN_I
MAX_I
T_EFF
24

Figure 5

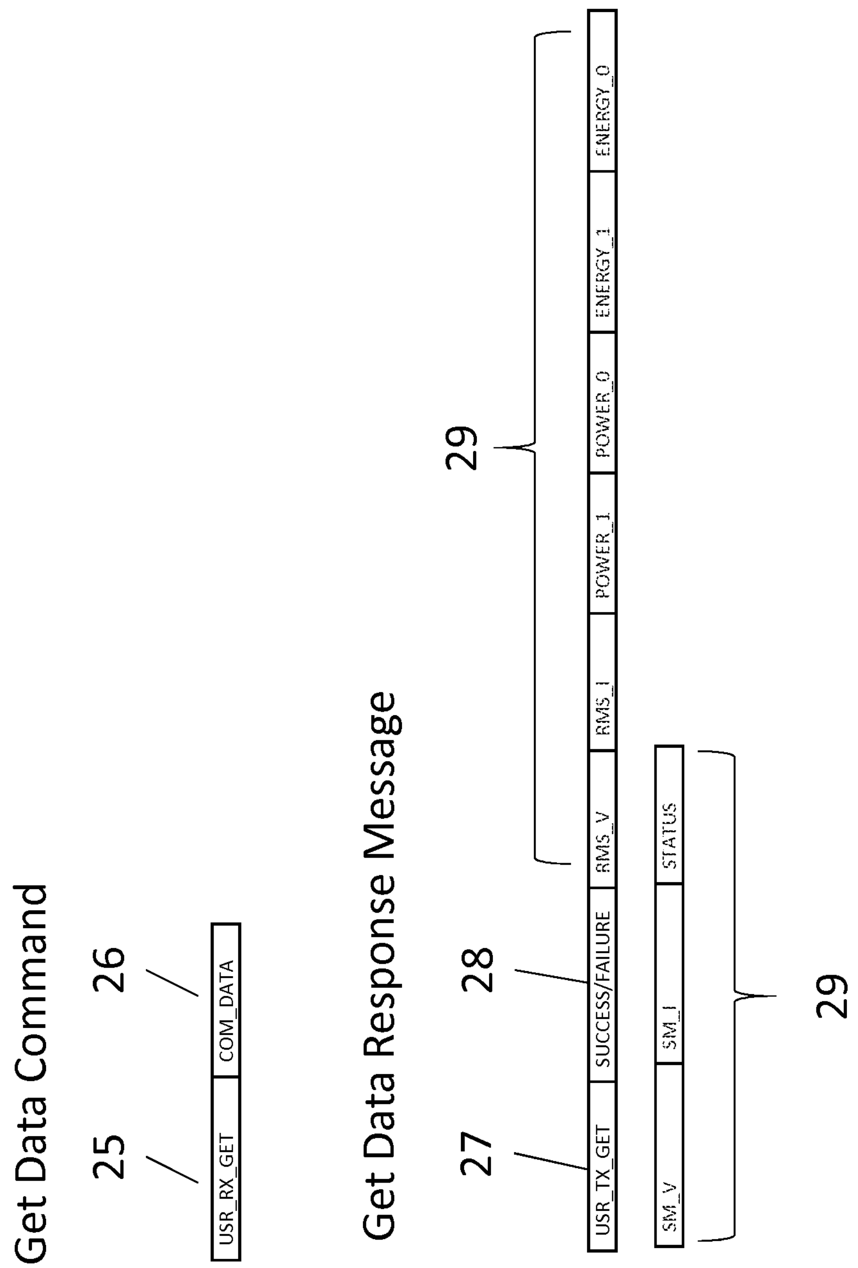

Get Data Command
25
26
USR_RX_GET
COM_DATA
Get Data Response Message
27
28
29
USR_TX_GET
SUCCESS/FAILURE
RMS_V
RMS_I
POWER_1
POWER_0
ENERGY_1
ENERGY_0
SM_V
SM_I
STATUS
29

*Figure 6*

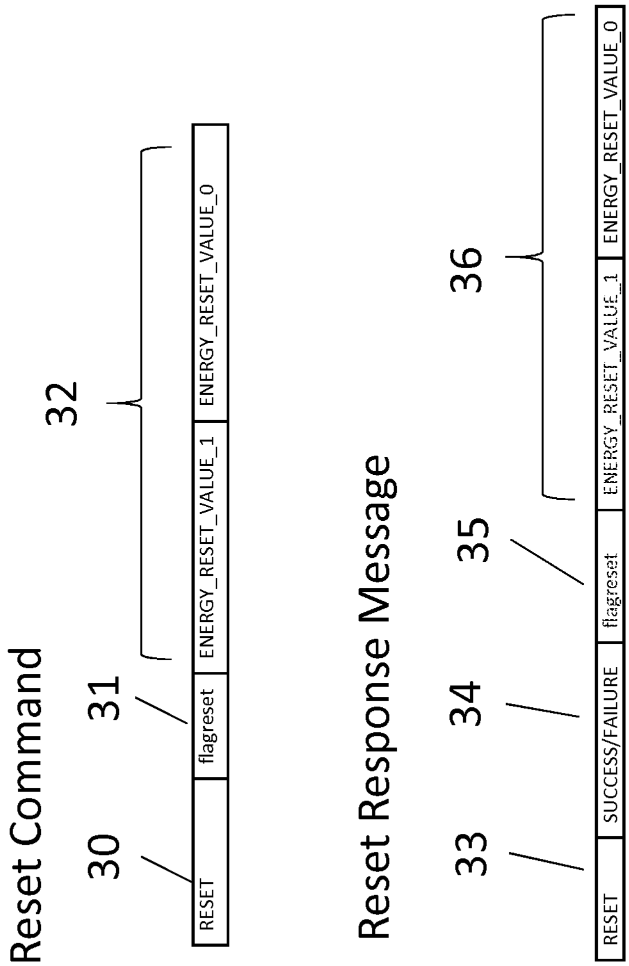

Reset Command
30
31
32
RESET
flagreset
ENERGY_RESET_VALUE_1
ENERGY_RESET_VALUE_0
Reset Response Message
33
34
35
36
RESET
SUCCESS/FAILURE
flagreset
ENERGY_RESET_VALUE_1
ENERGY_RESET_VALUE_0

*Figure 7*

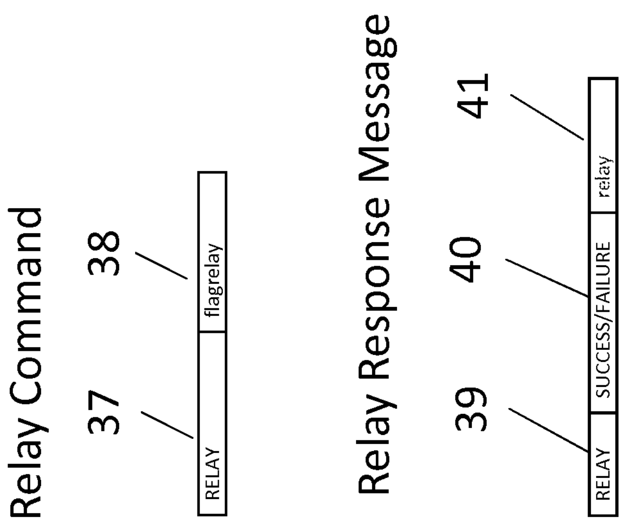

Relay Command
37
38
RELAY
flagrelay
Relay Response Message
39
40
41
RELAY
SUCCESS/FAILURE
relay

*Figure 8*

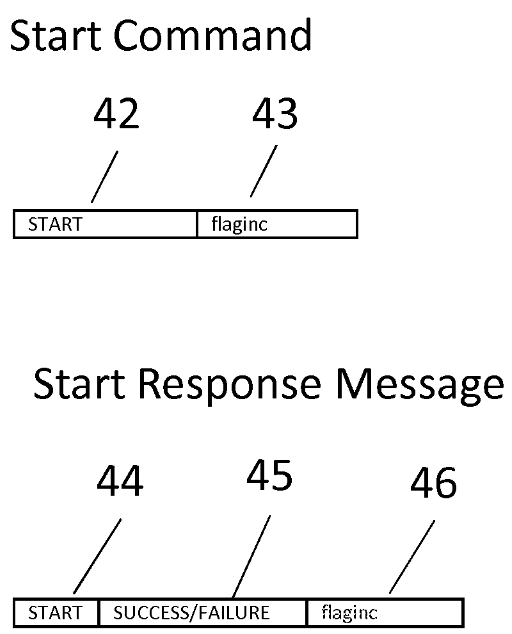
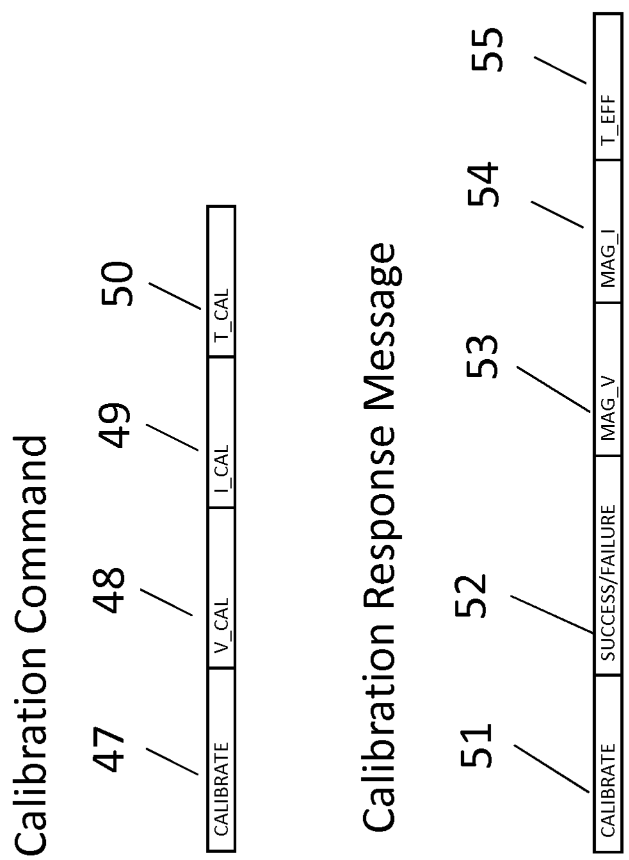

Start Command
42
43
START
flaginc
Start Response Message
44
45
46
START
SUCCESS/FAILURE
flaginc

*Figure 9*


Calibration Command
47
48
49
50
CALIBRATE
V_CAL
I_CAL
T_CAL
Calibration Response Message
51
52
53
54
55
CALIBRATE
SUCCESS/FAILURE
MAG_V
MAG_I
T_EFF

# INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 15/40213

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - G06Q 50/06 (2015.01)
CPC - G06Q 50/06
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8): G06Q 50/06 (2015.01)
CPC: G06Q 50/06

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
CPC: G09G 5/00, G06Q 50/00, G06F 13/00, G06Q 50/06 (Keyword based search below)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PatBase, Google Scholar, Google Patents; Search Terms: smart meter, server, coordinator, communicat*, identification field, ID field, identi* field, broadcast, multicast, network discover*, command identification, command value, parameter, communication type identification, operation status, get parameter, set parameter, get data, respon*, reset

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| Y | US 2014/0039699 A1 (Forbes) 06 February 2014 (06.02.2014) entire document especially Abstract, para [0090], para [0098]-[0100], para [0113], para [0118], para [0126], para [0188]-[0191] | 1-16 |
| Y | US 2012/0231828 A1 (Wang et al.) 13 September 2012 (13.09.2012) entire document especially Abstract, para [0063]-[0069], para [0081], para [0169]-[0181] | 1-16 |
| A | US 2008/0048883 A1 (Boaz) 28 February 2008 (28.02.2008) entire document | 1-16 |

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| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 16 September 2015 (16.09.2015) | 30 OCT 2015 |

| Name and mailing address of the ISA/US | Authorized officer: |
|---|---|
| Mail Stop PCT, Attn: ISA/US, Commissioner for Patents<br>P.O. Box 1450, Alexandria, Virginia 22313-1450<br>Facsimile No. 571-273-8300 | Lee W. Young<br>PCT Helpdesk: 571-272-4300<br>PCT OSP: 571-272-7774 |