(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
16 November 2017 (16.11.2017)

WIPO | PCT

(10) International Publication Number
WO 2017/195213 A1

(51) International Patent Classification:
H02J 3/38 (2006.01)

(21) International Application Number: PCT/IN2017/000102

(22) International Filing Date: 12 May 2017 (12.05.2017)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
201621016652 12 May 2016 (12.05.2016) IN

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC,

(54) Title: INTEGRATION OF MULTIPLE POWER SOURCE WITH OPTIMIZATION OF POWER SOURCE AND LOAD CONDITIONS

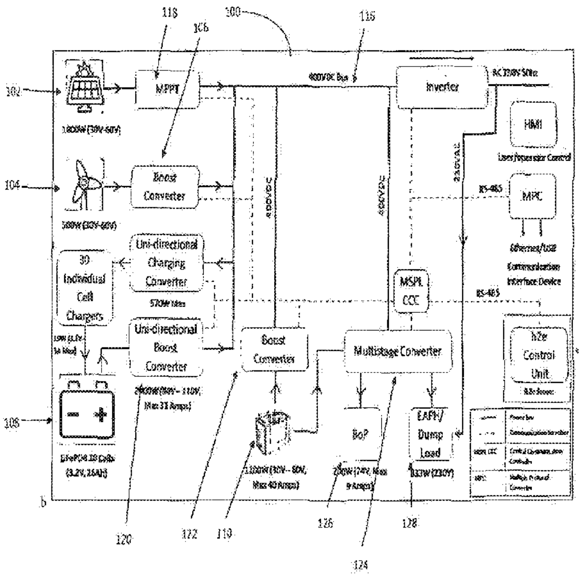

Figure-1

(57) Abstract: The present disclosure discloses a system for integrating multiple power sources and to optimize power source and load conditions. The system may comprise a plurality of power source. The system may further comprise a D C bus electrically coupled with the plurality of power source. Further the system may comprise a control unit electrically coupled with the D C bus, wherein the control unit as at least two side, a first side and a second side, wherein the first side is connected to the source side and the second side connected to a load side.

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[Continued on next page]

SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *as to the identity of the inventor (Rule 4.17(i))*
— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
— *of inventorship (Rule 4.17(iv))*

Published:

— *with international search report (Art. 21(3))*
— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

INTEGRATION OF MULTIPLE POWER SOURCE WITH OPTIMIZATION OF POWER SOURCE AND LOAD CONDITIONS

TECHNICAL FIELD

[0001] The present disclosure relates to multiple power sources more particularly relates to a platform for integrating the multiple power source and optimizing the power source and load conditions.

BACKGROUND

[0002] At present multi-input power system use a grid power supply and at least one other renewable source of energy to provide a hybrid/multi-input power system. Further, few multi-input systems integrate different renewable power/energy sources along with the grid power source to fulfill the power requirement at load. These systems may comprise multi-input power converter, a battery bank and a dynamic voltage restorer.

[0003] The multi-input power system at present may generate DC power from the power source for a DC load by using a DC bus. Moreover, these systems can store surplus power in a battery bank and also provide AC power to an AC load by way of an AC bus or to an AC grid. However, these systems do not control the multi-input power source nor do they control the load.

SUMMARY

[0004] In an implementation of the present disclosure a system for integrating multiple power sources and to optimize power source and load conditions is disclosed. The system may comprise a plurality of power source. The system may further comprise a D C bus electrically coupled with the plurality of power source. Further the system may comprise a control unit electrically coupled with the D C bus, wherein the control unit as at least two side, a first side and a second side, wherein the first side is connected to the source side and the second side connected to a load side.

[0005] In another implementation system for optimization of power at source and load is disclosed. The system may comprise a D C bus. Further the D

C bus may be coupled to a plurality of power sources, wherein the plurality of power sources may comprise solar power source, wind power source, battery inverter source, a fuel cell, and a power grid source. The system may further comprise a control unit electrically coupled with the D C bus at source side, and connected with the load on a load side, wherein the control unit is configured to control the source and the load.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] The detailed description is described with reference to the accompanying figures.

[0007] Figure 1, illustrates a schematic representation in accordance with exemplary embodiment of the present disclosure.

[0008] Figure 2a, illustrates a schematic representation for multistage convertor during startup in accordance with exemplary embodiment of the present disclosure.

[0009] Figure 2b, illustrates a schematic representation for multistage convertor during normal operation in accordance with exemplary embodiment of the present disclosure.

DETAILED DESCRIPTION OF THE INVENTION

[0010] A system for integrating multiple power sources is disclosed. The system further enables optimization of the power source and the load conditions.

[0011] According to the present disclosure the system enables integration of plurality of power sources like wind, solar, Fuel cell and battery banks to be integrated on a platform. Further the platform can be configured to extract power from one or more of the power source from the plurality of power sources, based on pre-defined parameters. The parameters may be based on reliability of the power source at the time, or the availability of the power source, or the cost of power source. For e.g. if the load on the system requires power during the day, then the system will seek power from solar and wind in order to reduce the cost of power generation and there availability during the day; similarly if the load increase during the night, the system may use power from Wind, and either battery bank or fuel cell or both.

[0012] Further according to the present disclosure the system may be able to control the load acting on the system. The system might segregate the loads into critical load and non-critical load. The segregation of load into critical or non-critical maybe based on factors defined by an user or based on historical data. The ability of the system to integrate plurality of power sources on the single platform and control the power generation and extract from each of the power source and further control the power distribution to the critical and non-critical load enables the system to provide holistic system for optimizing power generation, power supply, and power distribution in hybrid power system.

[0013] Referring to Figure 1 illustrates a system in accordance with the present disclosure. The system **100** may comprise a plurality of power sources. The plurality of power sources may comprise a solar power source **102**, a wind power source **104**, a battery inverter source **108**, a fuel cell source **110**, and a grid source **112**. The battery inverter source **108** may further comprise a battery bank **114** having a plurality of battery units. The plurality of power sources generate and provide power to the system **100**.

[0014] In an exemplary embodiment of the present disclosure each power source from the plurality of power sources may be electrically coupled/connected to a D C bus **116**, the D C bus **116** may be of 400 V DC power capacity. The solar power source **102** may be connected to the D C bus **116** via maximum power point tracking module (MPPT) **118**. Further the MPPT **118** may boost the low voltage DC power to high voltage DC for efficient DC to AC conversion.

[0015] The wind power source **104** may be connected to the DC bus **116**, via a first boost convertor **106**. Further, the battery power source **108** may be connected to the DC bus **116** and be configured to store excess of power generated or as a dump load. The battery bank **114** of the battery power source may be charged when the excess power from the plurality of power sources is routed to the battery power source **108**, or when it is acting as a dump load. The battery bank **114**, may be charged using a charge equalization to achieve balancing of battery bank **114** in terms of voltage and charge, wherein each battery unit from the battery bank has an Individual Cell Charger (ICC). Further the battery bank **114** discharges back to the D C bus **116** via a DC –DC boost convertor **120**, wherein the DC-DC boost convertor is unidirectional and boost voltage from 96 Volts to 400 Volts.

[0016] In the exemplary embodiment the fuel cell **110** may be connected to the D C bus **116** via a second boost convertor **122**. The second boost converter **122** may use DC-DC boost converter topology to boost fuel cell **110** output voltage from 0-60 VDC to 400VDC. The boosted power can be used to maintain stable bus voltage. Further fuel cell **110** may be connected to multistage convertor **124**. The multistage convertor **124** may further be connected to balance of plant components (BoP) **126** and an electric air pre-heater (EAPH) **128**.

[0017] Referring to Figure 2a and 2b the multistage convertor **124** may works in two modes, a high voltage DC mode, and a stack power mode. Further the multistage convertor **124** may work in at least four mode, a start-up mode, a high voltage mode, a stack power mode, and a dump load mode. Further during start up, the multistage convertor **124** powers up balance of plant of fuel cell via DC bus and electric air pre-heater via mains as shown in Figure 2(a). During normal operation multistage convertor **124** has the capability of extracting power directly from fuel cell and hence feeds power to BoP **126** as well as EAPH **128** as dump load thus eliminating the need of two conversion stages.

Working Example

[0018] The following write-up illustrates an exemplary embodiment in accordance with the present disclosure. The system according to the disclosure may comprise a D C bus. The D C bus may be coupled with a plurality of power sources. The power sources may be solar power source, wind power source, a battery inverter source, and a fuel cell. The D C bus may further be connected to a power grid and load side/power requirement side.

[0019] Further each power source may be given a priority based on the cost associated for power generation from the respective power source and the availability. For e.g. the cost associated with the solar power may be Rs. 1/Watt, similarly for the wind power source it may be Rs. 2/watt, for battery inverter it may be Rs. 3/watt, and for the Fuel cell it may be Rs. 4/watt.

[0020] Further each power source may have a defined power generation capacity like the solar power source may have 1000 watt, the wind source may have 500 watt, the battery invertor may have 2400 watt and the Fuel cell may have 1200 watt.

[0021] In an exemplary scenario if the power required at load side is 1500 watt during day, then as per the present disclosure the first priority would be given to solar power source followed by the wind power source, and then by the battery power source.

[0022] However, during evening time when neither solar power or the wind power source are not available, the priority would be given to the battery invertor power source and fuel cell power source, then followed by the solar and the wind power source.

[0023] In yet another scenario if the combined power of the plurality of power sources at a given moment is not sufficient to meet the load requirement, the system then might segregate the load into critical load and non-critical load, thereby managing the load side.

We Claim:

1. A system comprising:

a plurality of power source, wherein the plurality of power are distinct from each other;

a D C bus electrically coupled with the plurality of power source, wherein the D C bus is further connected to a source side; and

a control unit electrically coupled with the D C bus, wherein the control unit as at least two side, a first side and a second side, wherein the first side is connected to the source side and the second side connected to a load side.

2. The system as claimed in claim 1, wherein the control unit is configured to control the source side and the load side.
3. The system as claimed in claim 1, wherein the load side further comprises a plurality of critical loads and a plurality of non-critical loads.
4. The system as claimed in claim 1, wherein the plurality of power source further comprises at least one of solar power source, wind'power source, battery inverter source, or a fuel cell.
5. The system as claimed in claim 4, wherein the solar power source is electrically coupled with the D C bus via maximum power point tracking module (MPPT).
6. The system as claimed in claim 4, wherein the wind power source is electrically coupled with the D C bus via first boost convertor to convert low D C voltage to high D C voltage.
7. The system as claimed in claim 4, wherein the battery inverter source is charged via the D C bus using a charge equalization to achieve balancing of battery bank, in the battery inverter source, in terms of voltage and charge, wherein each battery cell from the battery bank has an Individual Cell Charger (ICC).
8. The system as claimed in claim 7, wherein the battery inverter discharges back to the D C bus via a DC –DC boost convertor, wherein the DC-DC boost convertor is unidirectional and boost voltage from 96 Volts to 400 Volts.

9. The system as claimed in claim 4, wherein the fuel cell is connected to the D C bus via at least one of second boost convertor, BoP multistage convertor, or electric air pre-heater (EAPH) multistage convertor.
10. The system as claimed in claim 9, wherein the BoP multistage convertor works in at least two modes, a high voltage DC mode, and a stack power mode.
11. The system as claimed in claim 9, wherein the EAPH multistage convertor works in at least four mode, a start-up mode, a high voltage mode, a stack power mode, and a dump load mode.

12. A system for optimization of power at source and load, the system comprising:

a D C bus;

a plurality of power sources electrically coupled with the D C bus, wherein the plurality of power sources comprises solar power source, wind power source, battery inverter source, a fuel cell, and a power grid source; and

a control unit electrically coupled with the D C bus at source side, and connected with the load on a load side, wherein the control unit is configured to control the source and the load.

13. The system of claim 12, wherein the load is segregated into critical load and non-critical load.
14. The system of claim 13, wherein the control unit is configured to distribute the power to the critical load and the non-critical load based on availability of the source.
15. The system of claim 12, wherein the control unit is further configured to prioritize generation of power from the plurality of power source based on pre-defined parameters.
16. The system of claim 15, wherein the pre-defined parameter comprises of reliability, cost and availability.

17. The system as claimed in claim 12, wherein the solar power source is electrically coupled with the D C bus via maximum power point tracking module (MPPT).
18. The system as claimed in claim 12, wherein the wind power source is electrically coupled with the D C bus via first boost convertor to convert low D C voltage to high D C voltage.
19. The system as claimed in claim 12, wherein the battery inverter source is charged via the D C bus using a charge equalization to achieve balancing of battery bank, in the battery inverter source, in terms of voltage and charge, wherein each battery cell from the battery bank has an Individual Cell Charger (ICC).
20. The system as claimed in claim 19, wherein the battery inverter discharges back to the D C bus via a DC -DC boost convertor, wherein the DC-DC boost convertor is unidirectional and boost voltage from 96 Volts to 400 Volts.
21. The system as claimed in claim 12, wherein the fuel cell is connected to the D C bus via at least one of second boost convertor, BoP multistage convertor, or electric air pre-heater (EAPH) multistage convertor.
22. The system as claimed in claim 21, wherein the BoP multistage convertor works in at least two modes, a high voltage DC mode, and a stack power mode.
23. The system as claimed in claim 21, wherein the EAPH multistage convertor works in at least four mode, a start-up mode, a high voltage mode, a stack power mode, and a dump load mode.

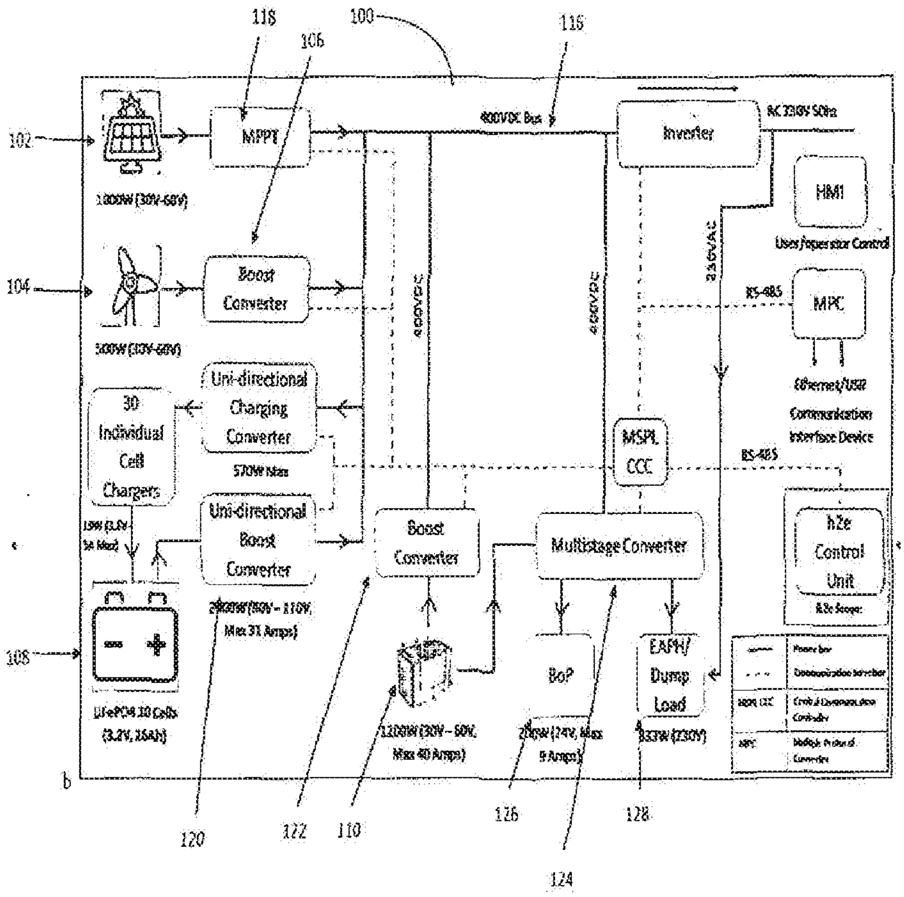
100
118
106
116
102
104
108
MPPT
400VDC Bus
Inverter
AC 230V 50Hz
HMI
User/operator Control
1800W (30V-60V)
Boost
Converter
500W (30V-60V)
400VDC
400VDC
230VAC
RS-485
MPC
Ethernet/USB
Communication
Interface Device
Uni-directional
Charging
Converter
570W Max
30
Individual
Cell
Chargers
MSPL
CCC
RS-485
Uni-directional
Boost
Converter
Boost
Converter
Multistage Converter
hZe
Control
Unit
LiFePO4 30 Cells
(3.2V, 16Ah)
1200W (30V - 60V,
Max 40 Amps)
BoP
EAPH/
Dump
Load
833W (230V)
120
122
110
126
128
124

Figure-1

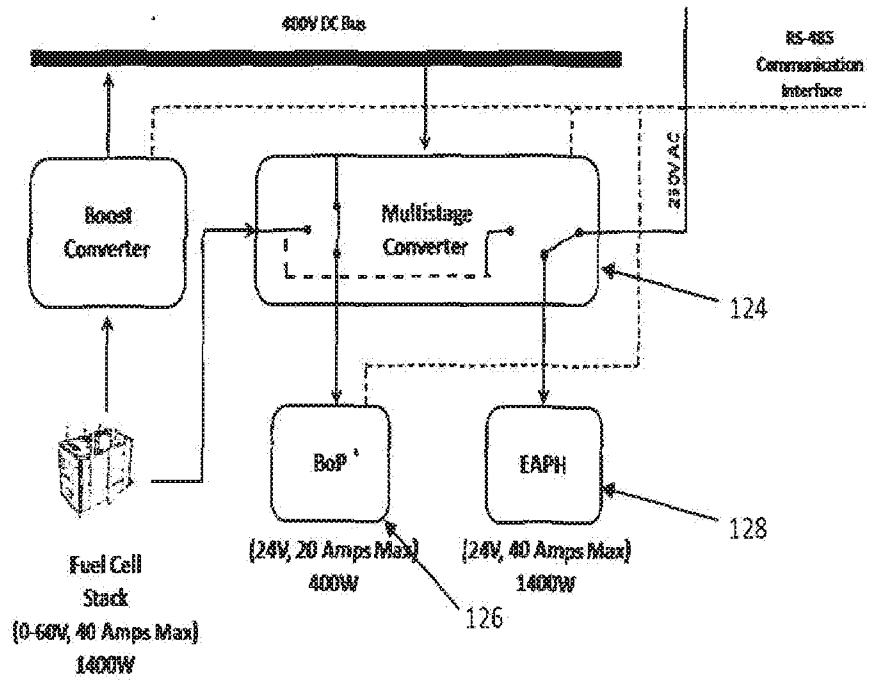
400V DC Bus
RS-485
Communication
Interface
Boost
Converter
Multistage
Converter
124
Fuel Cell
Stack
(0-60V, 40 Amps Max)
1400W
BoP
(24V, 20 Amps Max)
400W
126
EAPH
(24V, 40 Amps Max)
1400W
128

Figure-2(a)

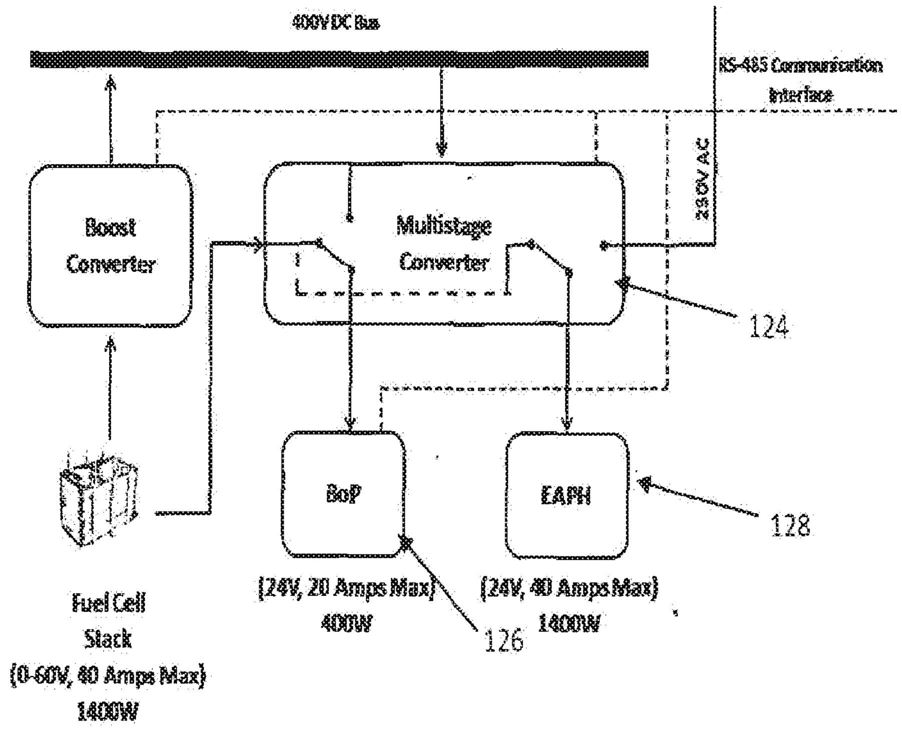
400V DC Bus
RS-485 Communication Interface
230V AC
Boost Converter
Multistage Converter
124
BoP
EAPH
128
Fuel Cell Stack (0-60V, 40 Amps Max) 1400W
(24V, 20 Amps Max) 400W
126
(24V, 40 Amps Max) 1400W

Figure-2(b)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IN2017/000102

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - H02J 3/387 (2017.01)
CPC - H02J 3/383; H02J 3/385; H02J 3/386; H02J 3/387 (2017.08)

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)
See Search History document

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
USPC - 320/101 (keyword delimited)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
See Search History document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US 2013/0041516 A1 (ROCKENFELLER et al) 14 February 2013 (14.02.2013) entire document	1-4, 12-16 --- 5-9, 17-21
Y	US 2009/0160258 A1 (ALLEN et al) 25 June 2009 (25.06.2009) entire document	5, 6, 17-20
Y	US 2015/0229131 A1 (NEXTRONEX INC) 13 August 2015 (13.08.2015) entire document	7, 8
Y	US 2004/0135545 A1 (FOWLER et al) 15 July 2004 (15.07.2004) entire document	8, 20
Y	US 2010/0136379 A1 (KING et al) 03 June 2010 (03.06.2010) entire document	9, 21
A	US 7,728,562 B2 (KAJOUKE et al) 01 June 2010 (01.06.2010) entire document	1-23
A	US 20040155526 A1 (NADEN et al) 12 August 2004 (12.08.2004) entire document	1-23
A	US 20120071044 A1 (REMBACH et al) 22 March 2012 (22.03.2012) entire document	1-23

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 September 2017	06 OCT 2017

Name and mailing address of the ISA/US	Authorized officer
Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, VA 22313-1450 Facsimile No. 571-273-8300	Blaine R. Copenheaver PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774