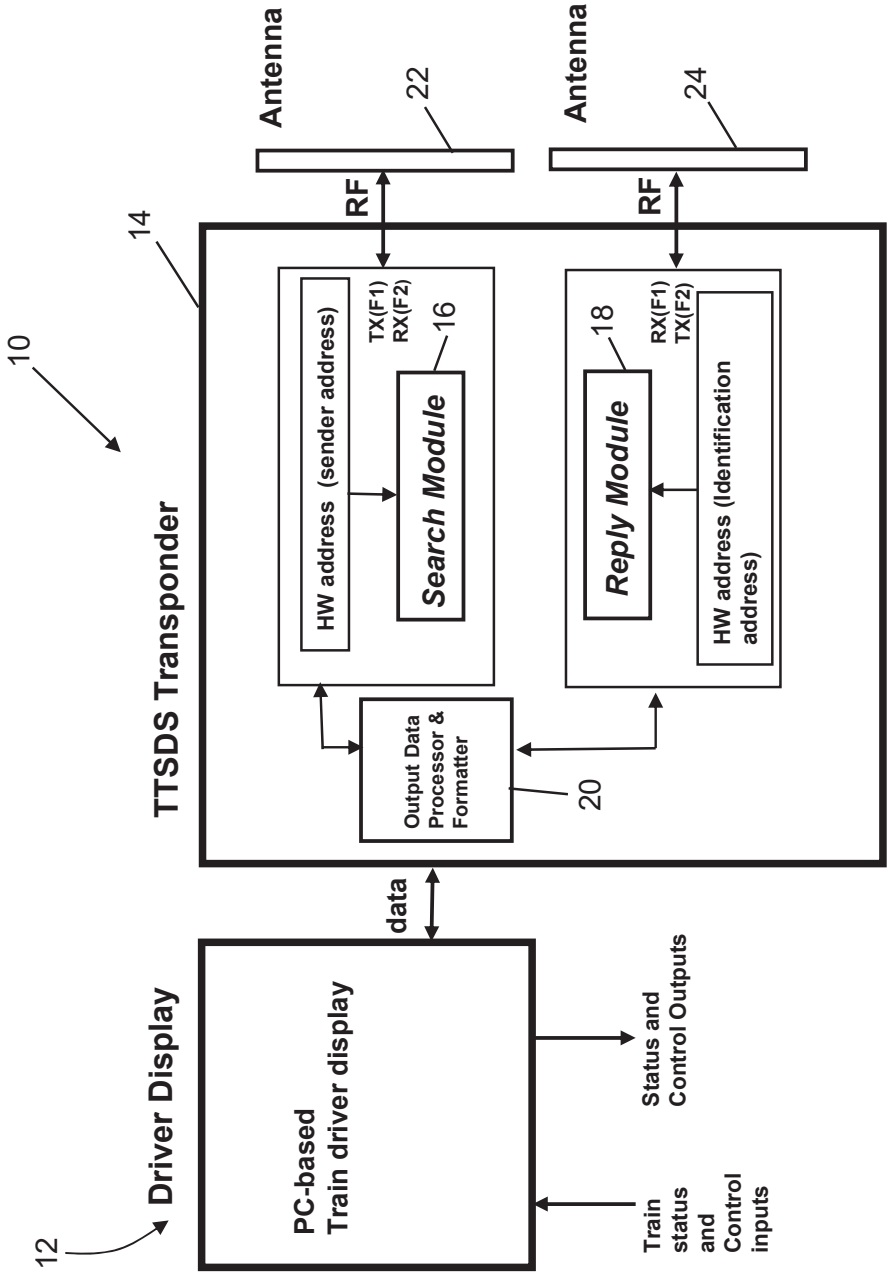

10
12
Driver Display
PC-based
Train driver display
Train
status
and
Control
inputs
Status and
Control Outputs
data
14
TTSDS Transponder
Output Data
Processor &
Formatter
20
HW address (sender address)
TX(F1)
RX(F2)
16
Search Module
18
Reply Module
RX(F1)
TX(F2)
HW address (Identification
address)
RF
RF
Antenna
22
Antenna
24

Fig. 1

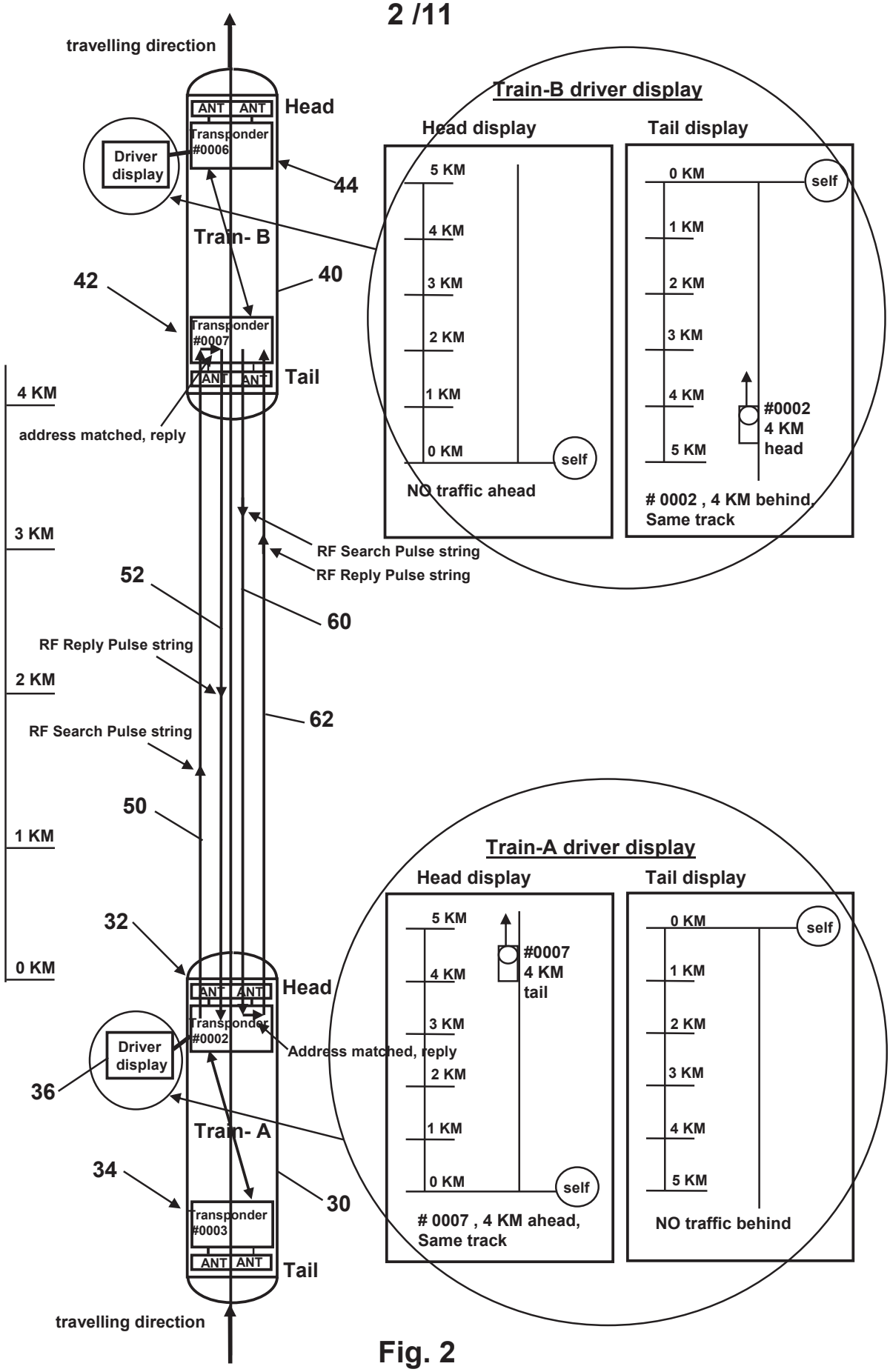

travelling direction
Head
ANT ANT
Transponder #0006
Driver display
44
Train- B
40
42
Transponder #0007
Tail
ANT ANT
4 KM
address matched, reply
3 KM
RF Search Pulse string
RF Reply Pulse string
52
60
RF Reply Pulse string
2 KM
62
RF Search Pulse string
50
1 KM
0 KM
32
Head
ANT ANT
Transponder #0002
Driver display
Address matched, reply
36
Train- A
34
30
Transponder #0003
ANT ANT
Tail
travelling direction
Train-B driver display
Head display
Tail display
5 KM
4 KM
3 KM
2 KM
1 KM
0 KM
self
NO traffic ahead
0 KM
self
1 KM
2 KM
3 KM
4 KM
5 KM
#0002
4 KM
head
0002 , 4 KM behind,
Same track
Train-A driver display
Head display
Tail display
5 KM
4 KM
3 KM
2 KM
1 KM
0 KM
#0007
4 KM
tail
self
0007 , 4 KM ahead,
Same track
0 KM
self
1 KM
2 KM
3 KM
4 KM
5 KM
NO traffic behind

Fig. 2

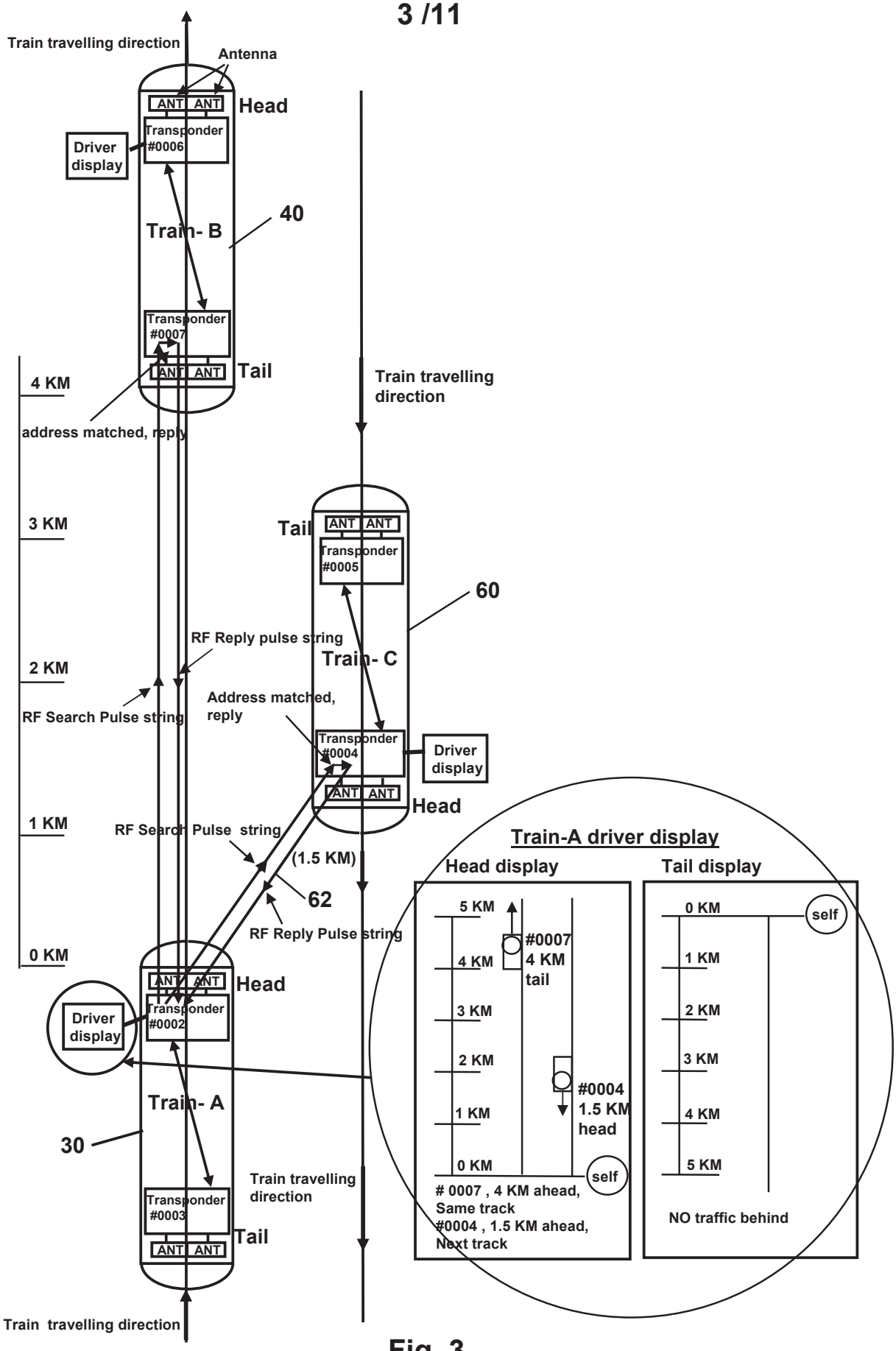

Train travelling direction
Antenna
ANT ANT
Head
Transponder #0006
Driver display
Train- B
40
Transponder #0007
ANT ANT
Tail
4 KM
address matched, reply
3 KM
2 KM
RF Search Pulse string
RF Reply pulse string
1 KM
0 KM
Train travelling direction
Tail
ANT ANT
Transponder #0005
60
Train- C
Address matched, reply
Transponder #0004
Driver display
ANT ANT
Head
RF Search Pulse string
(1.5 KM)
62
RF Reply Pulse string
ANT ANT
Head
Driver display
Transponder #0002
Train- A
30
Transponder #0003
ANT ANT
Tail
Train travelling direction
Train travelling direction
Train-A driver display
Head display
Tail display
5 KM
4 KM
3 KM
2 KM
1 KM
0 KM
#0007
4 KM
tail
#0004
1.5 KM
head
self
0007 , 4 KM ahead,
Same track
#0004 , 1.5 KM ahead,
Next track
0 KM
1 KM
2 KM
3 KM
4 KM
5 KM
self
NO traffic behind

Fig. 3

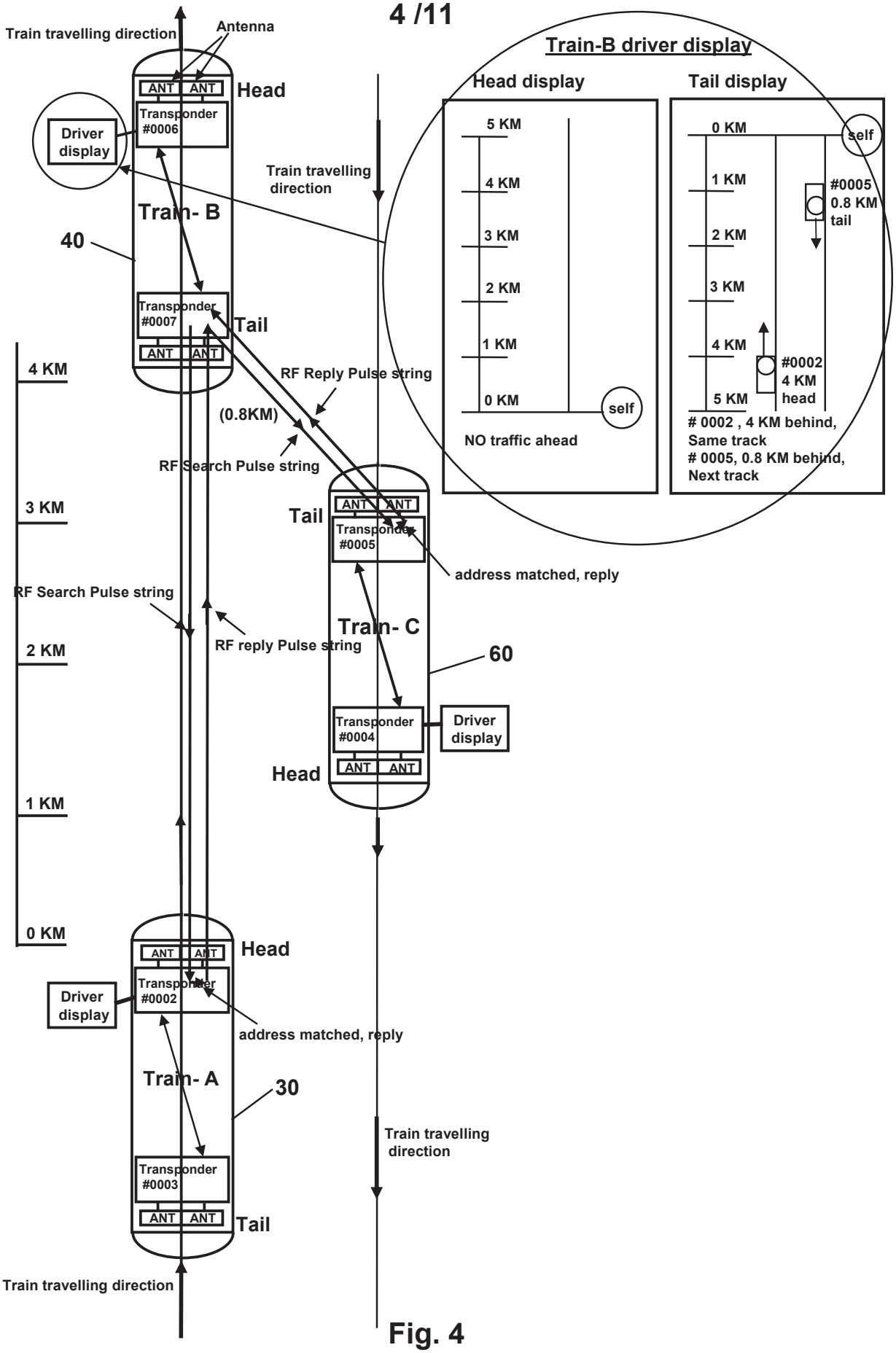

Train travelling direction
Antenna
ANT ANT
Head
Transponder #0006
Driver display
Train- B
40
Transponder #0007
Tail
ANT ANT
4 KM
3 KM
2 KM
1 KM
0 KM
RF Reply Pulse string
(0.8KM)
RF Search Pulse string
Tail
Transponder #0005
address matched, reply
RF Search Pulse string
RF reply Pulse string
Train- C
60
Transponder #0004
Driver display
Head
Train travelling direction
Train-B driver display
Head display
5 KM
4 KM
3 KM
2 KM
1 KM
0 KM
self
NO traffic ahead
Tail display
0 KM
self
1 KM
#0005
0.8 KM
tail
2 KM
3 KM
4 KM
#0002
4 KM
head
5 KM
0002 , 4 KM behind,
Same track
0005, 0.8 KM behind,
Next track
Head
Transponder #0002
Driver display
address matched, reply
Train- A
30
Transponder #0003
Tail
Train travelling direction
Train travelling direction

Fig. 4

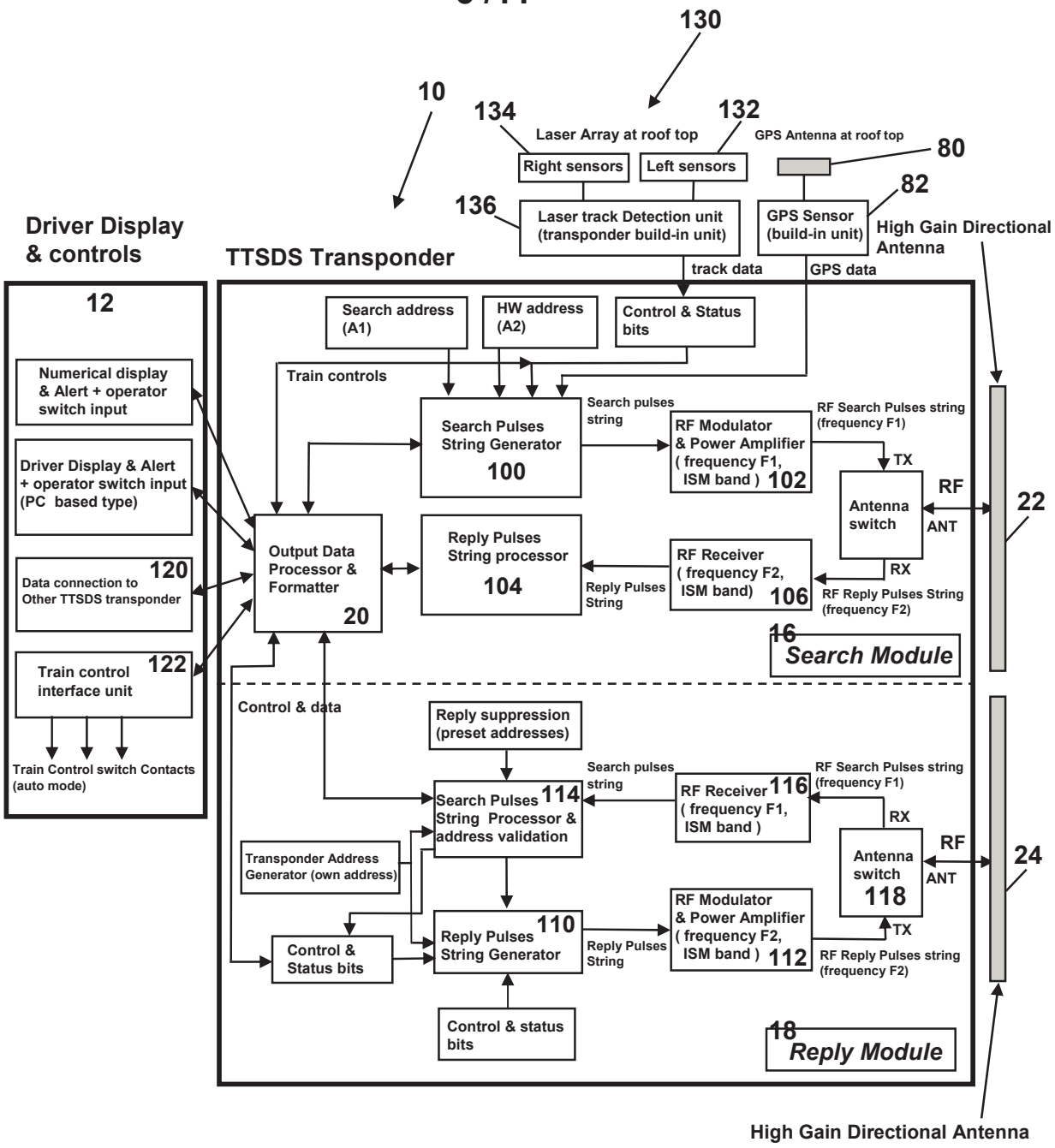
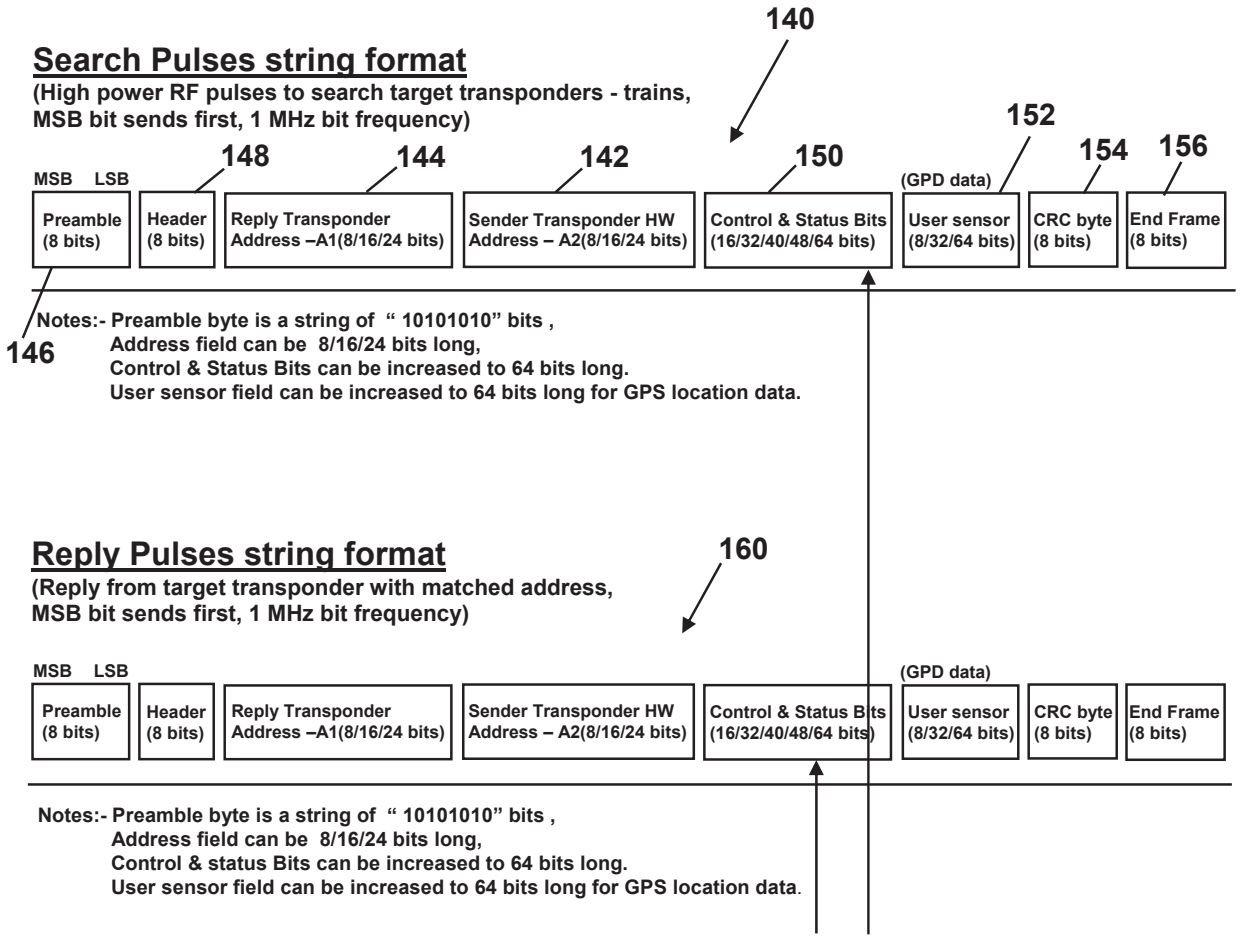

130
10
134
132
Laser Array at roof top
GPS Antenna at roof top
80
Right sensors
Left sensors
82
136
Laser track Detection unit (transponder build-in unit)
GPS Sensor (build-in unit)
High Gain Directional Antenna
Driver Display & controls
TTSDS Transponder
track data
GPS data
12
Search address (A1)
HW address (A2)
Control & Status bits
Numerical display & Alert + operator switch input
Train controls
Search Pulses String Generator 100
Search pulses string
RF Modulator & Power Amplifier (frequency F1, ISM band) 102
RF Search Pulses string (frequency F1)
TX
Driver Display & Alert + operator switch input (PC based type)
Antenna switch
RF
ANT
22
120
Data connection to Other TTSDS transponder
Output Data Processor & Formatter 20
Reply Pulses String processor 104
RF Receiver (frequency F2, ISM band) 106
RX
Reply Pulses String
RF Reply Pulses String (frequency F2)
122
Train control interface unit
16
Search Module
Control & data
Reply suppression (preset addresses)
Train Control switch Contacts (auto mode)
Search pulses string
RF Search Pulses string (frequency F1)
Search Pulses String Processor & address validation 114
RF Receiver (frequency F1, ISM band) 116
RX
Transponder Address Generator (own address)
Antenna switch 118
RF
ANT
24
Control & Status bits
Reply Pulses String Generator 110
RF Modulator & Power Amplifier (frequency F2, ISM band) 112
TX
Reply Pulses String
RF Reply Pulses string (frequency F2)
Control & status bits
18
Reply Module
High Gain Directional Antenna

Fig. 5



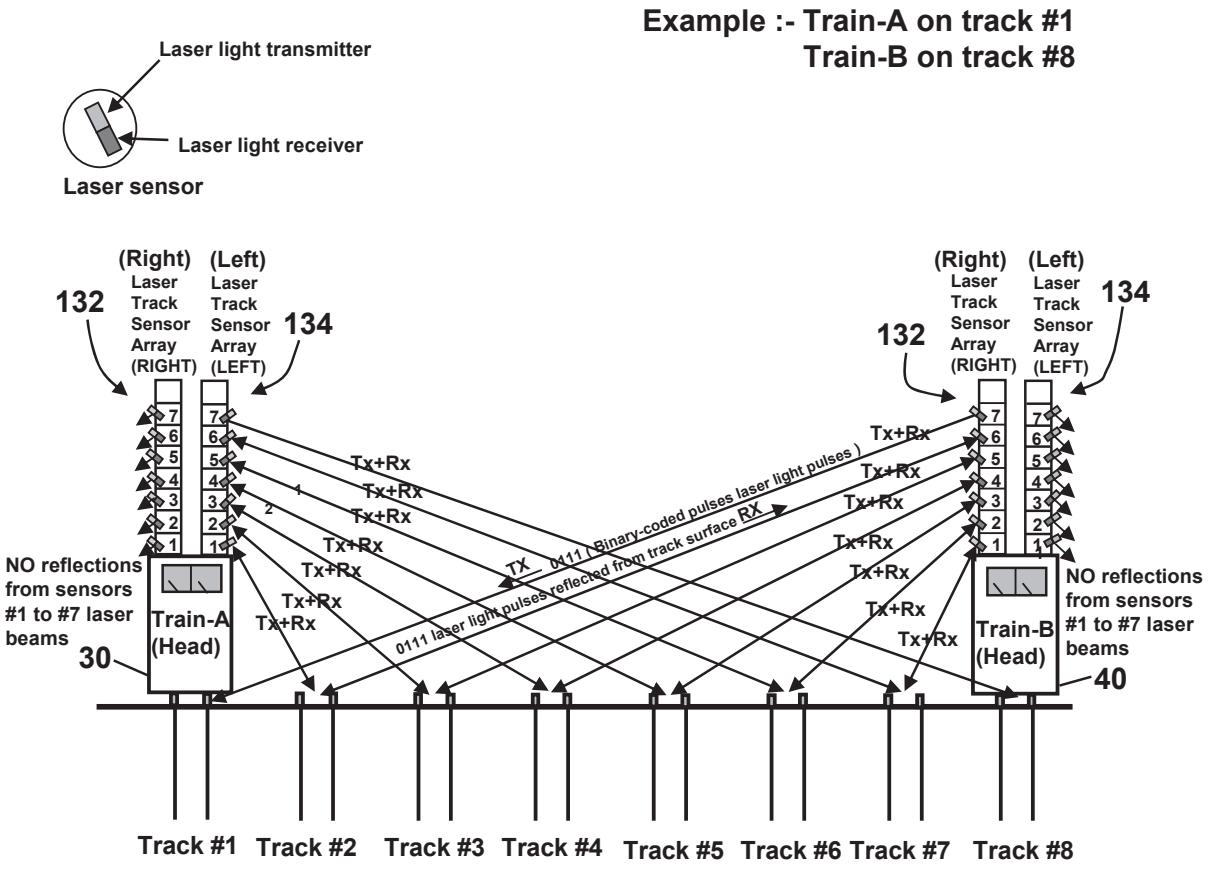
Control & Status bits format (16/32/40/48/64 bits , programmable by user)

Example (40-bit control and status format) :-

Bit No.	size	Function / usage
Bit-1	1 bit	Reserved
Bit-2	1 bit	communication failure
Bit-3	1 bit	Electrical system failure
Bit-4	1 bit	Train stopped
Bit-5	3 bits	Train type
		0= passenger train
		1= cargo train
		2= maintenance train
		3= cross-country, none stop
		4= ????
		5= ????
Bit-8	6 bits	Length ,number of carriages (1 – 63 carriages)
Bit-14	1 bit	0= Front (train head) sensor, 1= Rear (train tail) sensor
Bit-15	1 bit	Emergency Stopped
Bit-16	4 bits	number of tracks at right (0 to 15 tracks)
Bit-20	4 bits	number of tracks at left (0 to 15 tracks)
Bit-24	4 bits	number of tracks detected (1 to 15 tracks)
Bit-28	1 bit	track data available (1=valid track data , 0= no track data)
Bit-29	1 bit	reserved
Bit-30	4 bits	Platform Number (0 to 15)
Bit-34	7 bits	reserved for train controls

Track information output from Laser Track Detection Unit

Fig. 6


Example :- Train-A on track #1
Train-B on track #8
Laser light transmitter
Laser light receiver
Laser sensor
(Right) Laser Track Sensor Array (RIGHT)
(Left) Laser Track Sensor Array (LEFT)
132
134
Tx+Rx
TX
RX
0111 (Binary-coded pulses laser light pulses)
0111 laser light pulses reflected from track surface
NO reflections from sensors #1 to #7 laser beams
Train-A (Head)
Train-B (Head)
30
40
Track #1
Track #2
Track #3
Track #4
Track #5
Track #6
Track #7
Track #8

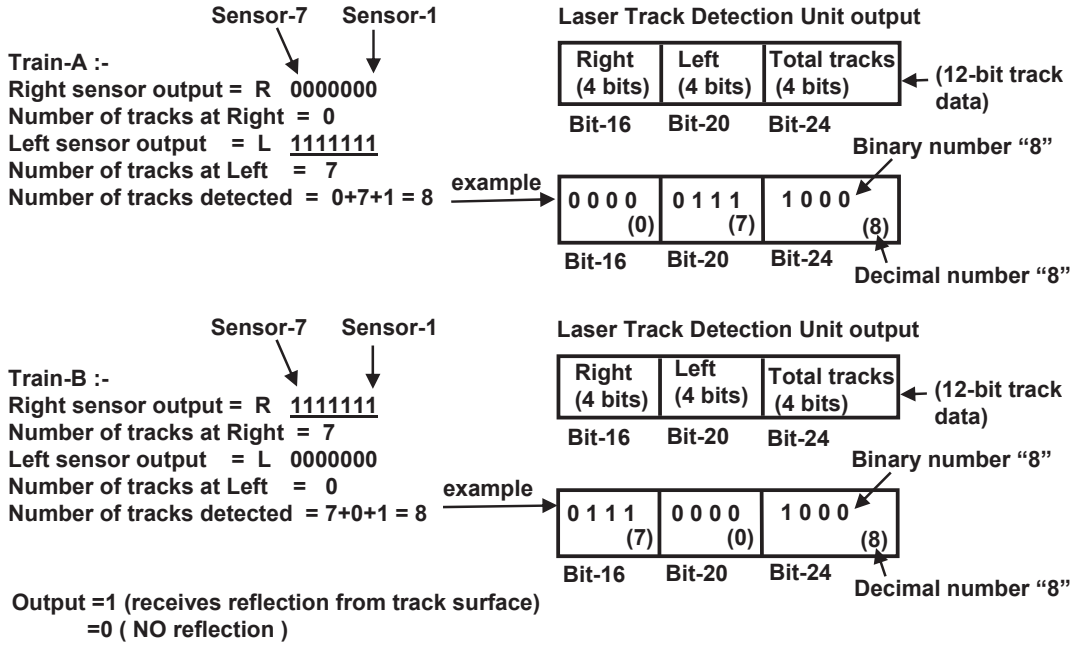

Sensor-7
Sensor-1
Train-A :-
Right sensor output = R 0000000
Number of tracks at Right = 0
Left sensor output = L 1111111
Number of tracks at Left = 7
Number of tracks detected = 0+7+1 = 8
Laser Track Detection Unit output
Right (4 bits)
Left (4 bits)
Total tracks (4 bits)
(12-bit track data)
Bit-16
Bit-20
Bit-24
example
0 0 0 0 (0)
0 1 1 1 (7)
1 0 0 0 (8)
Binary number "8"
Decimal number "8"
Train-B :-
Right sensor output = R 1111111
Number of tracks at Right = 7
Left sensor output = L 0000000
Number of tracks at Left = 0
Number of tracks detected = 7+0+1 = 8
0 1 1 1 (7)
0 0 0 0 (0)
1 0 0 0 (8)
Output =1 (receives reflection from track surface)
=0 (NO reflection)

Fig. 7

Example :- Train-A located on Track #3

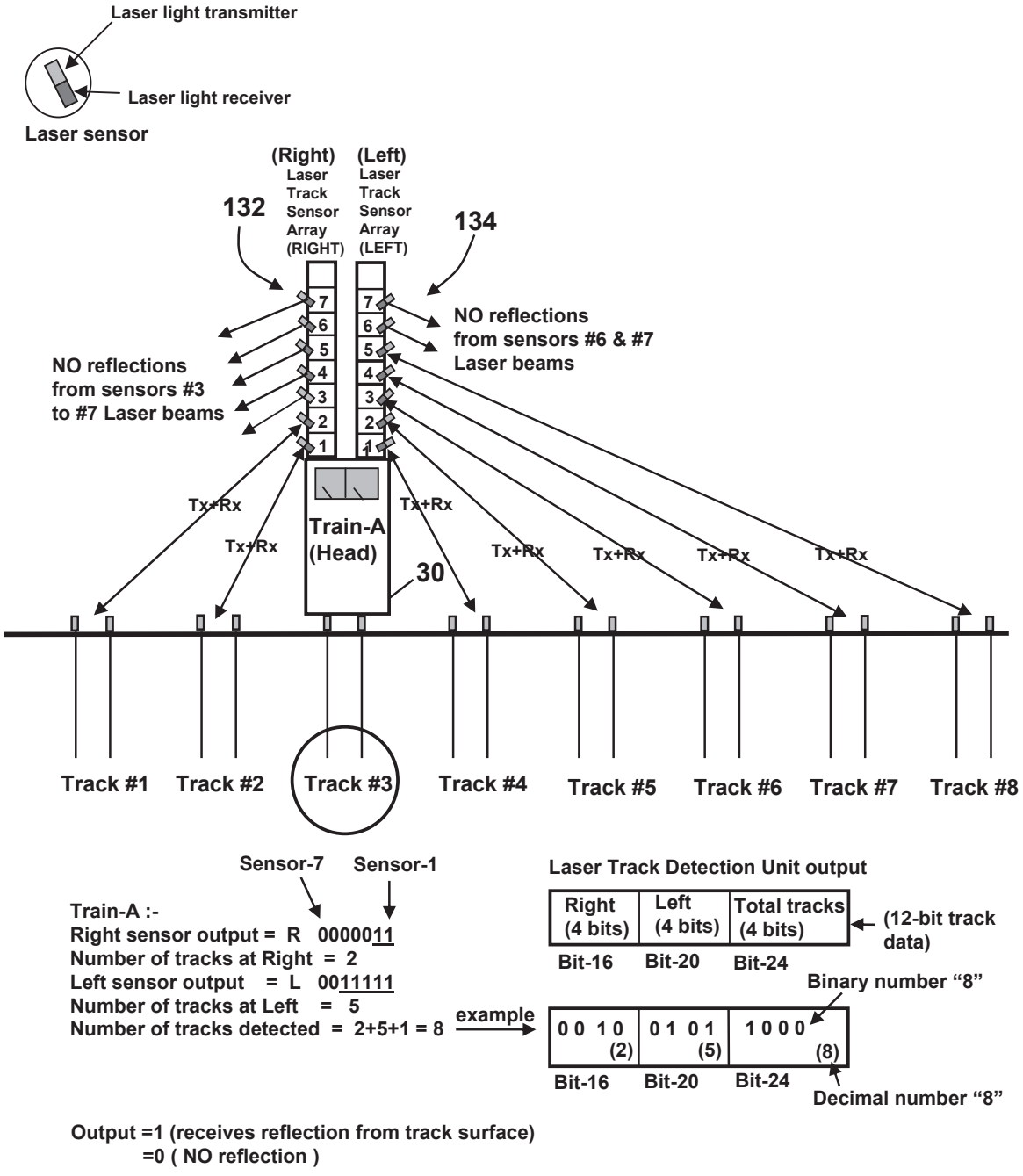
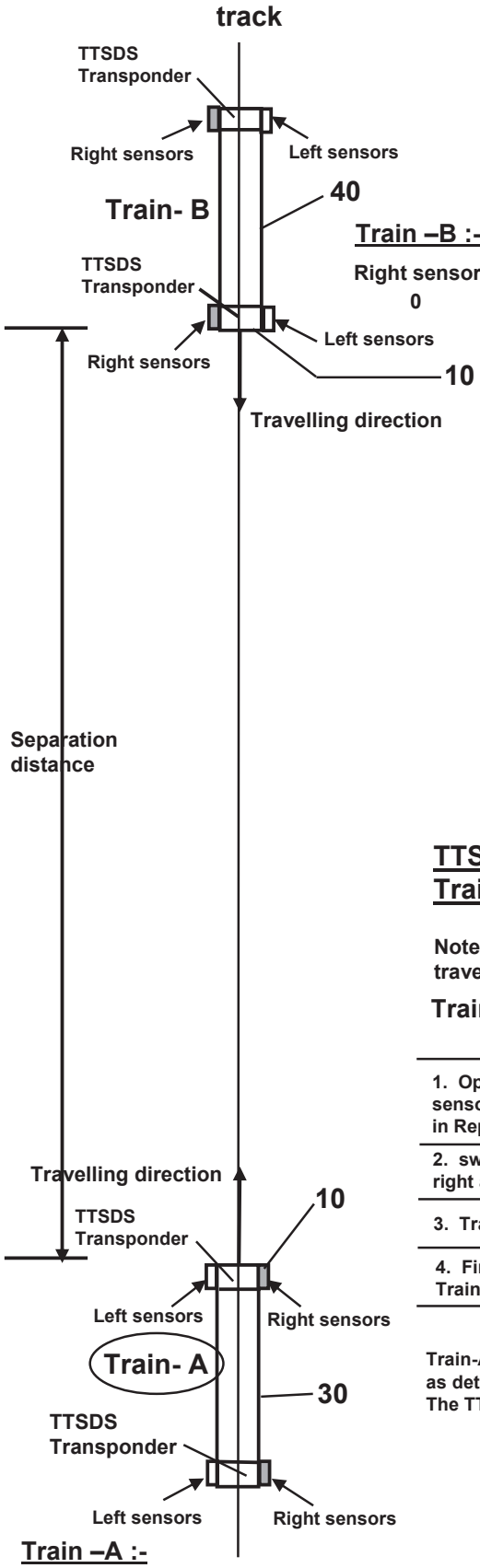


Fig. 8



Case – 1 track zone,
Track as viewed by Train-A

(The TTSDS Transponder-A will issue a Head-to-Head Collision Warning in this case.)

Train –B :-

Right sensor	Left sensor	Number of tracks detected
0	0	0 + 0 + (1) = 1

Train –A :-

Right sensor	Left sensor	Number of tracks detected
0	0	0 + 0 + (1) = 1

TTSDS collision pre-warning logic (for Train-A) :-
Train-A issued the search

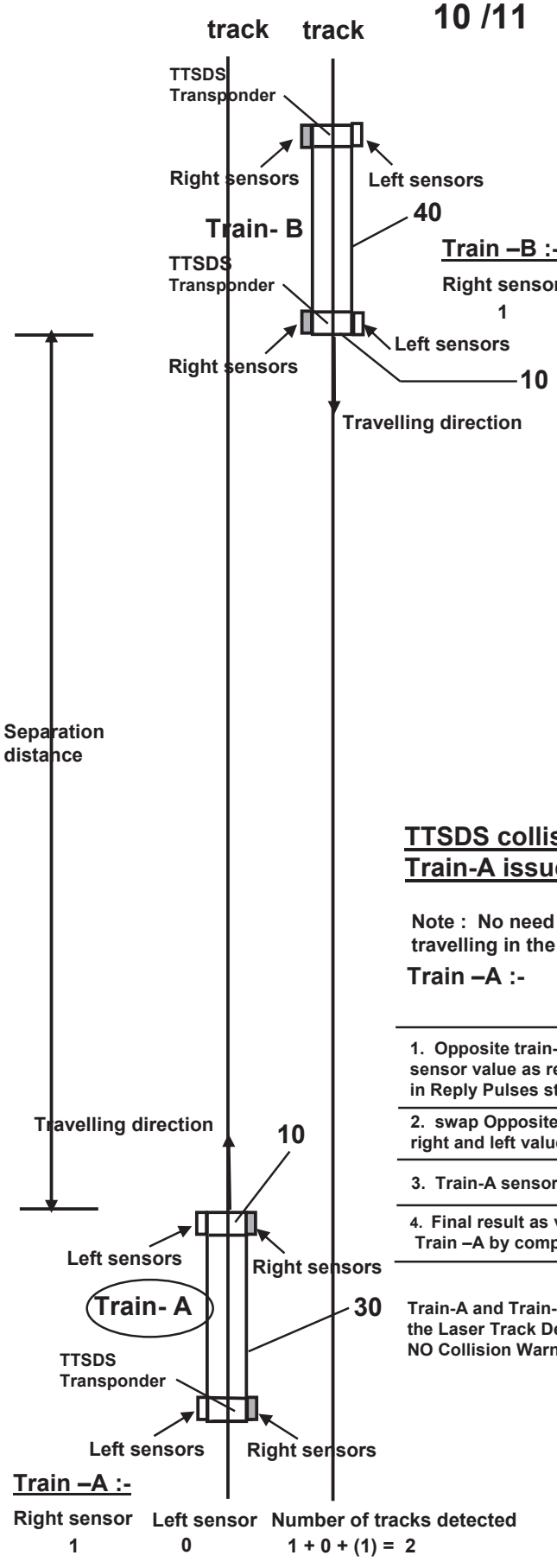
Note : No need to swap opposite train sensor values for trains travelling in the same direction.

Train –A :-

	Right sensor	Left sensor	Number of tracks detected
1. Opposite train-B sensor value as reported in Reply Pulses string	0 swap	0	0 + 0 + (1) = 1
2. swap Opposite sensor right and left values (see note)	0	0	0 + 0 + (1) = 1
3. Train-A sensor values	0 Same value	0 Same value	0 + 0 + (1) = 1
4. Final result as viewed by Train –A by comparison	same	Same value	1 track

Train-A and Train-B are travelling in Opposite Direction on the Same Track as detected by the Laser Track Detection Unit .
The TTSDS Transponder will issue a Head-to-Head Collision Warning.

FIG. 9



Case – 2 tracks zone, tracks as viewed by Train-A

NO Collision Warning Issued by TTSDS Transponder-A

Train –B :-

Right sensor	Left sensor	Number of tracks detected
1	0	1 + 0 + (1) = 2

Train –A :-

Right sensor	Left sensor	Number of tracks detected
1	0	1 + 0 + (1) = 2

TTSDS collision pre-warning logic (for Train-A) :- Train-A issued the search

Note : No need to swap opposite train sensor values for trains travelling in the same direction.

Train –A :-

	Right sensor	Left sensor	Number of tracks detected
1. Opposite train-B sensor value as reported in Reply Pulses string	1 (swap)	0	1 + 0 + (1) = 2
2. swap Opposite sensor right and left values (see note)	0	1	0 + 1 + (1) = 2
3. Train-A sensor values	1	0	1 + 0 + (1) = 2
4. Final result as viewed by Train –A by comparison	different	Different value	2 tracks

Train-A and Train-B were travelling on Different tracks as detected by the Laser Track Detection Unit .
NO Collision Warning issued by TTSDS Transponder.

Fig. 10

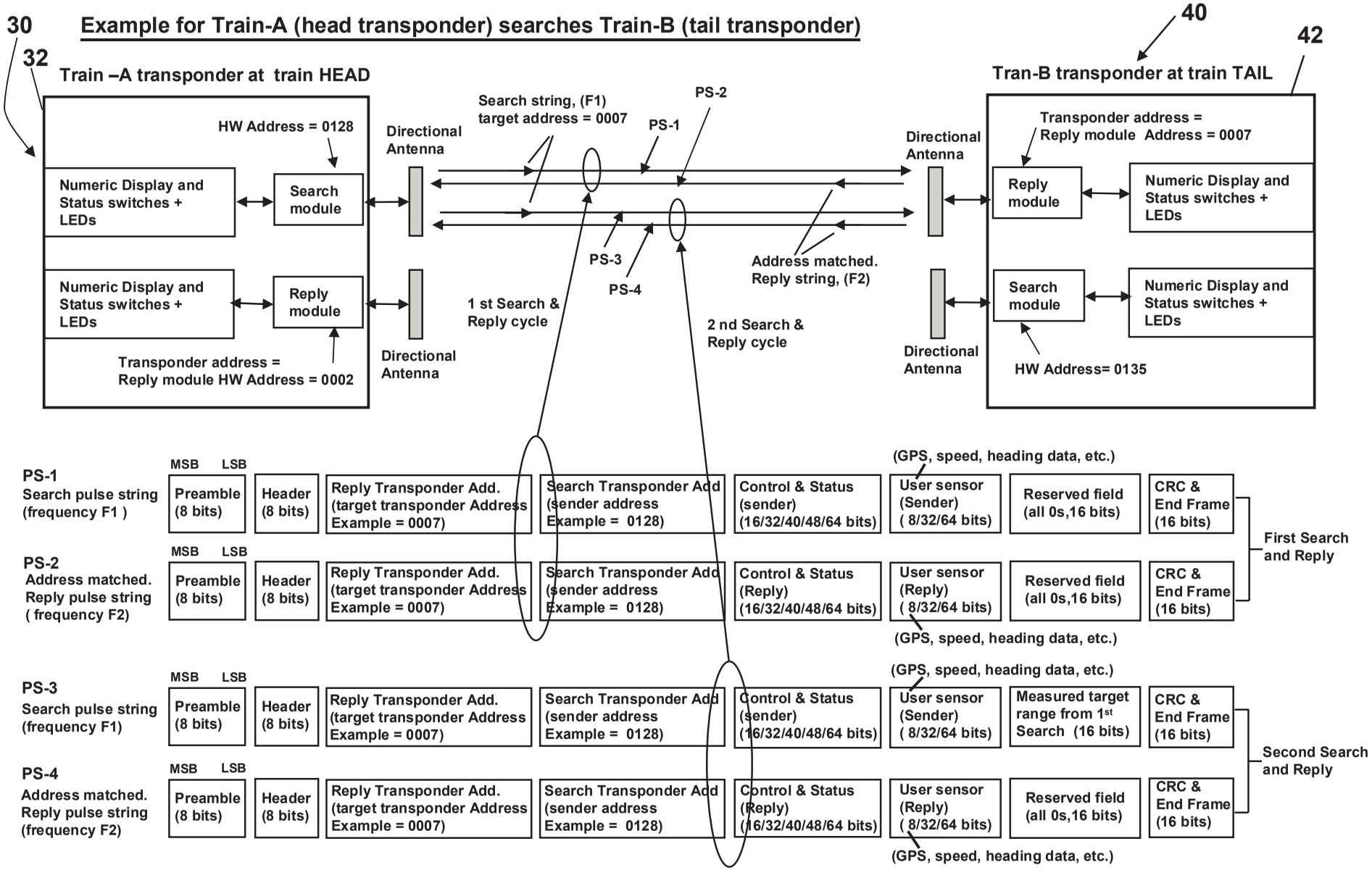

30
32
Example for Train-A (head transponder) searches Train-B (tail transponder)
Train –A transponder at train HEAD
HW Address = 0128
Numeric Display and Status switches + LEDs
Search module
Numeric Display and Status switches + LEDs
Reply module
Transponder address = Reply module HW Address = 0002
Directional Antenna
Directional Antenna
Search string, (F1) target address = 0007
PS-1
PS-2
PS-3
PS-4
1 st Search & Reply cycle
2 nd Search & Reply cycle
Address matched. Reply string, (F2)
40
42
Tran-B transponder at train TAIL
Directional Antenna
Directional Antenna
Transponder address = Reply module Address = 0007
Reply module
Numeric Display and Status switches + LEDs
Search module
Numeric Display and Status switches + LEDs
HW Address= 0135
PS-1
Search pulse string (frequency F1)
PS-2
Address matched. Reply pulse string (frequency F2)
PS-3
Search pulse string (frequency F1)
PS-4
Address matched. Reply pulse string (frequency F2)
MSB LSB
Preamble (8 bits)
Header (8 bits)
Reply Transponder Add. (target transponder Address Example = 0007)
Search Transponder Add (sender address Example = 0128)
Control & Status (sender) (16/32/40/48/64 bits)
Control & Status (Reply) (16/32/40/48/64 bits)
User sensor (Sender) (8/32/64 bits)
User sensor (Reply) (8/32/64 bits)
(GPS, speed, heading data, etc.)
Reserved field (all 0s,16 bits)
Measured target range from 1st Search (16 bits)
CRC & End Frame (16 bits)
First Search and Reply
Second Search and Reply

Fig. 11