Supporting IP-Multicast based on OSPF and PIM SM

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1 Introduction

1.1 Intention

In modern networks IP multicast becomes more and more important. Especially when it comes to video applications like CCTV, IP multicast is used to decrease the load on the cameras and the networks. This paper describes a basic configuration of an IP network, supporting IP multicast based on OSPF and PIM Sparse Mode (short: PIM-SM).

The intention is to give the network designer an example configuration as introduction and as a starting point for application specific configuration. It’s assumed, that the audience is aware of IP networking, OSPF and IP Multicast concepts including PIM.

1.2 Example Network

The example network consists of SCALANCE Layer 3 switches interconnected using single port VLANs. As end systems, three cameras are connected as multicast sources and four PCs as multicast receivers.
2 Configuration

2.1 Basic Layer 3 configuration

Transfer Networks

PIM is only supported on VLAN interfaces but not on router ports. Therefore the transfer networks between the routers are realized with single port VLANs using /30 subnets of the private network 10.0.0.0/8.

It's important, that this VLAN is configured only at one port in order to avoid black holing in case of a link failure.

In the following you see an example configuration for transfer network 10.192.13.0/30 (VLAN 10) at router PIMR1:

```
vlan 10
  ports gigabitethernet 1/1 untagged gigabitethernet 1/1
  interface gigabitethernet 1/1
    switchport pvid 10
  interface vlan 10
    ip address 10.192.13.1 255.255.255.252

```

Loopback interfaces

In order to provide an always reachable IP interface, a loopback interface is configured at all routers. With SCALANCE X, the loopback interface is configured based on VLAN interfaces.

In the following you see an example configuration for loopback interface of router PIMR1:

```
vlan 110
  interface vlan 110 loopback
    ip address 1.1.1.1 255.255.255.255

```

User Networks

The cameras and PCs are connected to the user networks. In this example all user networks are realized in VLAN1 using a /24 IP subnet of the private network 192.168.0.0/16. In order to keep the example simple, there are no redundancies implemented here.

In the following you see an example configuration for user network 192.168.73.0/24 (VLAN 1) at router PIMR1:

```
vlan 1
  ports gigabitethernet 1/2-8,2/1-8,3/1-8 untagged gigabitethernet 1/2-8,2/1-8,3/1-8
  interface vlan 1
    no ip address
    ip address 192.168.73.1 255.255.255.0
```
2.2 Unicast Routing

For unicast IP routing, a single area OSPF concept has been chosen. This is also a valid option for most of real networks. All transfer networks are configured as member of the OSPF area 0.0.0.0. The user networks are configured as passive members of area 0.0.0.0 which avoids the need for ASBR and external routes in area 0.0.0.0.

According to best practice, the loopback IP address is used as router ID. This simplifies the diagnostics of OSPF.

In the following you see an example OSPF configuration at router PIMR1:

```plaintext
ip routing
!
router ospf
  router-id 1.1.1.1
  network 1.1.1.1 area 0.0.0.0
  network 10.192.13.1 area 0.0.0.0
  network 192.168.73.1 area 0.0.0.0
  passive-interface vlan 1
```

2.3 IP Multicast Routing

2.3.1 IGMP

In this example, IGMP is needed for the end systems in order to join a specific multicast group. Therefore IGMP has to be enabled globally and at all user network interfaces. It’s not necessary or recommended, to enable IGMP at the transfer networks between the routers.

In the following you see an example IGMP configuration at router PIMR1:

```plaintext
ip igmp
!
interface vlan 1
  ip igmp
!```
2.3.2 PIM configuration

Basic PIM configuration

PIM has to be enabled at all routers globally and all IP interfaces. At user networks, where multiple PIM routers could be connected, it’s recommended to define, which router becomes the PIM Designated Router (short: DR) for that segment. Therefore the PIM DR-priority is set to 255 in user networks.

In the following you see an example basic PIM configuration at router PIMR1:

```ourg organic
t unwind
```

PIM Bootstrap Router

In the example network, PIMR4 is defined as PIM Bootstrap Router (short: BSR). All Rendezvous Points (short: RP) register their multicast ranges and their IP address at the BSR. The BSR informs all PIM routers about the RPs and their multicast ranges. In order to improve the availability of the BSR IP address, the loopback interface of PIMR4 is used as PIM source.

In the following you see a PIM BSR configuration at router PIMR4

```ourg organic
t unwind
```

PIM Rendezvous Point configuration

For PIM SM, a rendezvous point is required to register multicast sources in the network. Each PIM router registers it multicast sources to the RP.

In the example, PIMR5 and PIMR6 are configured as RP candidates. At both routers, the same multicast ranges are configured in order to provide a basic redundancy. At PIMR5 a lower priority has been set. Since PIM routers select the RP with the lower priority, the router PIMR5 will be used as RP for both ranges. In case of a failure of PIMR5, all PIM routers will select PIMR6 as RP.

In the following you see a PIM RP configuration at router PIMR5

```ourg organic
t unwind
```

In the following you see a PIM RP configuration at router PIMR6

```ourg organic
t unwind
```

NOTE

The router PIMR6 receives, during the redundancy switchover phase, “PIM Register Messages” this may increase the load of the CPU. These “PIM Register Messages” are sent from the multicast sources to be registered at the new rendezvous point.
3.1 Diagnostics

In this chapter you see the CLI commands for diagnostics.

**show ip pim**

PIMR8# show ip pim

PIM Routing Information

-------------
PIM Mode: sparse, PIM Version: 2
Elected BSR: 4.4.4.4
Candidate RP Holdtime: 0

**show ip pim interface**

PIMR8# show ip pim interface

PIM is globally enabled

<table>
<thead>
<tr>
<th>Address</th>
<th>IfName/IfId</th>
<th>Ver/Mode</th>
<th>Nbr Qry</th>
<th>DR Address</th>
<th>DR-Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>192.168.11.1</td>
<td>vlan1/62</td>
<td>2/Sparse</td>
<td>0 30</td>
<td>192.168.11.1</td>
<td>255</td>
</tr>
<tr>
<td>10.192.13.22</td>
<td>vlan16/63</td>
<td>2/Sparse</td>
<td>1 30</td>
<td>10.192.13.22</td>
<td>1</td>
</tr>
<tr>
<td>10.192.13.26</td>
<td>vlan17/64</td>
<td>2/Sparse</td>
<td>1 30</td>
<td>10.192.13.26</td>
<td>1</td>
</tr>
<tr>
<td>10.192.13.29</td>
<td>vlan18/65</td>
<td>2/Sparse</td>
<td>1 30</td>
<td>10.192.13.30</td>
<td>1</td>
</tr>
<tr>
<td>8.8.8.8</td>
<td>vlan100/66</td>
<td>2/Sparse</td>
<td>0 30</td>
<td>8.8.8.8</td>
<td>1</td>
</tr>
</tbody>
</table>

**show ip pim neighbor**

PIMR8# show ip pim neighbor

<table>
<thead>
<tr>
<th>Neighbour Address</th>
<th>IfName/IfId</th>
<th>Uptime/Expiry</th>
<th>Ver/Mode</th>
<th>DR-Priority</th>
<th>OverRide</th>
<th>Lan</th>
<th>CompId</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.192.13.21</td>
<td>vlan16/63</td>
<td>00:50:55/55</td>
<td>2/Sparse</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>10.192.13.25</td>
<td>vlan17/64</td>
<td>00:50:55/55</td>
<td>2/Sparse</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>10.192.13.30</td>
<td>vlan18/65</td>
<td>00:50:55/55</td>
<td>2/Sparse</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

**show ip pim bsr**

PIMR8# show ip pim bsr

PIMv2 Bootstrap Configuration

-------------
Elected BSR

BSR Address : 4.4.4.4
BSR Priority : 100, Hash Mask Length : 30
BSR UpTime: 00:49:56
3 Additional Information

**show ip pim rp-hash**

```
PIMR8# show ip pim rp-hash

Component 1
----------
Group Address/Network Mask: 239.193.128.0/255.255.255.0
RP Address: 5.5.5.5
Priority: 120, Hold Time: 150

Group Address/Network Mask: 239.194.128.0/255.255.255.0
RP Address: 5.5.5.5
Priority: 120, Hold Time: 150
```

**show ip pim rp-set**

```
PIMR8# show ip pim rp-set

PIM Group-to-RP mappings
------------------------
Group Address : 239.193.128.0 Group Mask : 255.255.255.0
RP: 5.5.5.5
Hold Time : 150, Expiry Time : 00:01:39

Group Address : 239.193.128.0 Group Mask : 255.255.255.0
RP: 6.6.6.6
Hold Time : 150, Expiry Time : 00:01:39

Group Address : 239.194.128.0 Group Mask : 255.255.255.0
RP: 5.5.5.5
Hold Time : 150, Expiry Time : 00:01:39

Group Address : 239.194.128.0 Group Mask : 255.255.255.0
RP: 6.6.6.6
Hold Time : 150, Expiry Time : 00:01:39
```
**show ip pim mroute**

```
PIMR8# show ip pim mroute

IP Multicast Routing Table
--------------------------
Route Flags S: SPT Bit W: Wild Card Bit R: RPT Bit
IIF State P: Pruned F: Forwarding A: Graft Ack Pending
Timers: Uptime/Expires
Interface State: Interface, State/Mode

PIM Multicast Routing Table

Total number of Multicast Routes is 6

(*, 239.193.128.27) ,00:22:27/--- ,RP : 5.5.5.5
  Incoming Interface : vlan16 ,RPF nbr : 10.192.13.21 ,Route Flags : WR
  Outgoing InterfaceList :
    vlan1, Forwarding/Sparse ,00:22:27/---

(192.168.73.25,239.193.128.27) ,00:22:27/00:33:47
  Incoming Interface : vlan16 ,RPF nbr : 10.192.13.21 ,Route Flags : S
  Outgoing InterfaceList :
    vlan1, Forwarding/Sparse ,00:22:27/---

(*, 239.193.128.32) ,00:22:06/--- ,RP : 5.5.5.5
  Incoming Interface : vlan16 ,RPF nbr : 10.192.13.21 ,Route Flags : WR
  Outgoing InterfaceList :
    vlan1, Forwarding/Sparse ,00:22:06/---

(192.168.75.25,239.193.128.32) ,00:22:06/01:09:17
  Incoming Interface : vlan16 ,RPF nbr : 10.192.13.21 ,Route Flags : S
  Outgoing InterfaceList :
    vlan1, Forwarding/Sparse ,00:22:06/---

(*, 239.194.128.32) ,00:21:43/--- ,RP : 5.5.5.5
  Incoming Interface : vlan16 ,RPF nbr : 10.192.13.21 ,Route Flags : WR
  Outgoing InterfaceList :
    vlan1, Forwarding/Sparse ,00:21:43/---

(192.168.77.25,239.194.128.32) ,00:21:43/01:45:50
  Incoming Interface : vlan16 ,RPF nbr : 10.192.13.21 ,Route Flags : S
  Outgoing InterfaceList :
    vlan1, Forwarding/Sparse ,00:21:43/---
3.2 Configuration Scripts

In this chapter you can see the complete configuration script.

```
! system name "PIMR1"
! ip routing
ip pim routing
ip igmp
!
no spanning-tree
!
vlan 1
  ports gigabitethernet 1/2-8,2/1-8,3/1-8 untagged
gigabitethernet 1/2-8,2/1-8,3/1-8
!
vlan 10
  ports gigabitethernet 1/1 untagged gigabitethernet 1/1
!
vlan 100
!
interface gigabitethernet 1/1
  switchport pvid 10
!
interface vlan 1
  no ip address
  ip address 192.168.73.1 255.255.255.0
  ip igmp
  ip pim
  ip pim dr-priority 255
!
interface vlan 10
  ip address 10.192.13.1 255.255.255.252
  ip pim
!
interface vlan 100 loopback
  ip address 1.1.1.1 255.255.255.255
  ip pim
!
router ospf
  router-id 1.1.1.1
  network 1.1.1.1 area 0.0.0.0
  network 10.192.13.1 area 0.0.0.0
  network 192.168.73.1 area 0.0.0.0
  passive-interface vlan 1
!
end
```
system name "PIMR2"
!
ip routing
ip pim routing
ip igmp
!
no spanning-tree
!
vlan 1
 ports gigabitethernet 1/2-16,2/1-8 untagged gigabitethernet 1/2,1-8
!
vlan 11
 ports gigabitethernet 1/1 untagged gigabitethernet 1/1
!
vlan 110
!
interface gigabitethernet 1/1
 switchport pvid 11
!
interface vlan 1
 no ip address
 ip address  192.168.75.1 255.255.255.0
 ip igmp
!
interface vlan 1
 ip pim
 ip pim dr-priority 255
!
interface vlan 11
 ip address  10.192.13.5 255.255.255.252
 ip pim
!
interface vlan 110 loopback
 ip address  2.2.2.2 255.255.255.255
 ip pim
!
router ospf
 router-id 2.2.2.2
 network 2.2.2.2 area 0.0.0.0
 network 10.192.13.5 area 0.0.0.0
 network 192.168.75.1 area 0.0.0.0
 passive-interface vlan 1
!
end
system name "PIMR3"
!
ip routing
ip pim routing
ip igmp
!
vlan 1
  ports gigabitethernet 1/1-3,1/5-8,2/1-8,3/1-8 untagged
gigabitethernet 1/1-3,2/1-8,3/1-8

vlan 12
  ports gigabitethernet 1/4 untagged
gigabitethernet 1/4
!
vlan 100
!
interface gigabitethernet 1/4
  switchport pvid 12
!
interface vlan 1
  no ip address
  ip address 192.168.77.1 255.255.255.0
  ip igmp
  ip pim
  ip pim dr-priority 255
!
interface vlan 12
  ip address 10.192.13.9 255.255.255.252
  ip pim
!
interface vlan 100 loopback
  ip address 3.3.3.3 255.255.255.255
  ip pim
!
router ospf
  router-id 3.3.3.3
  network 3.3.3.3 area 0.0.0.0
  network 10.192.13.9 area 0.0.0.0
  network 192.168.77.1 area 0.0.0.0
!
exit
system name "PIMR4"
!
ip routing
ip pim routing
ip igmp
!
no spanning-tree
!
vlan 1
  ports gigabitethernet 1/6-8,2/1-8,3/1-8 untagged
gigabitethernet 1/6-8,2/1-8,3/1-8
!
vlan 10
  ports gigabitethernet 1/1 untagged gigabitethernet 1/1
!
vlan 11
  ports gigabitethernet 1/2 untagged gigabitethernet 1/2
!
vlan 12
  ports gigabitethernet 1/3 untagged gigabitethernet 1/3
!
vlan 13
  ports gigabitethernet 1/4 untagged gigabitethernet 1/4
!
vlan 14
  ports gigabitethernet 1/5 untagged gigabitethernet 1/5
!
vlan 100
!
interface gigabitethernet 1/1
  switchport pvid 10
!
interface gigabitethernet 1/2
  switchport pvid 11
!
interface gigabitethernet 1/3
  switchport pvid 12
!
interface gigabitethernet 1/4
  switchport pvid 13
!
interface gigabitethernet 1/5
  switchport pvid 14
!
interface vlan 1
  no ip address
  ip address 192.168.4.1 255.255.255.0
  ip igmp
  ip pim
  ip pim dr-priority 255
!
interface vlan 10
  ip address 10.192.13.2 255.255.255.252
  ip pim
!
interface vlan 11
  ip address 10.192.13.6 255.255.255.252
  ip pim
!
interface vlan 12
  ip address 10.192.13.10 255.255.255.252
  ip pim
!
interface vlan 13
  ip address 10.192.13.14 255.255.255.252
  ip ospf cost 3
  ip pim
!
interface vlan 14
  ip address 10.192.13.18 255.255.255.252
  ip pim
!
interface vlan 100 loopback
  ip address 4.4.4.4 255.255.255.255
ip pim bsr-candidate 100
ip pim
!
router ospfouter-id 4.4.4.4
network 4.4.4.4 area 0.0.0.0
network 10.192.13.2 area 0.0.0.0
network 10.192.13.6 area 0.0.0.0
network 10.192.13.10 area 0.0.0.0
network 10.192.13.14 area 0.0.0.0
network 10.192.13.18 area 0.0.0.0
network 192.168.4.1 area 0.0.0.0
passive-interface vlan 1
!
end
```
system name "PIMR5"
!
ip routing
ip pim routing
ip igmp
!
no spanning-tree
!
vlan 1
  ports gigabitethernet 0/2-10,0/13-24 extreme-ethernet 0/25-26 untagged gigabitethernet 0/2-10,0/13-24 extreme-ethernet 0/25-26
!
vlan 13
  ports gigabitethernet 0/12 untagged gigabitethernet 0/12
!
vlan 15
  ports gigabitethernet 0/1 untagged gigabitethernet 0/1
!
vlan 16
  ports gigabitethernet 0/11 untagged gigabitethernet 0/11
!
vlan 100
!
vlan 111
!
interface gigabitethernet 0/1
  switchport pvid 15
!
interface gigabitethernet 0/11
  switchport pvid 16
!
interface gigabitethernet 0/12
  switchport pvid 13
!
interface vlan 1
  no ip address
  ip address 192.168.5.1 255.255.255.0
!
interface vlan 13
  ip address 10.192.13.13 255.255.255.252
  ip pim
!
interface vlan 15
  ip address 10.192.13.33 255.255.255.252
  ip pim
!
interface vlan 16
  ip address 10.192.13.21 255.255.255.252
  ip pim
!
interface vlan 100 loopback
  ip address 5.5.5.5 255.255.255.255
  ip pim
!
router ospf
  router-id 5.5.5.5
  network 5.5.5.5 area 0.0.0.0
  network 10.192.13.13 area 0.0.0.0
  network 10.192.13.21 area 0.0.0.0
  network 10.192.13.33 area 0.0.0.0
  network 192.168.5.1 area 0.0.0.0
  passive-interface vlan 1
!
router pim
  rp-candidate rp-address 239.193.128.0 255.255.255.0
  5.5.5.5 120
  rp-candidate rp-address 239.194.128.0 255.255.255.0
  5.5.5.5 120
!
end
```
system name "PIMR6"
!
ip routing
ip pim routing
ip igmp
!
no spanning-tree
!
vlan 1
  ports gigabitethernet 0/1,0/3-10,0/13-24 untagged
gigabitethernet 0/1,0/3-10,0/13-24
!
vlan 14
  ports gigabitethernet 0/12 untagged gigabitethernet 0/12
!
vlan 17
  ports gigabitethernet 0/11 untagged gigabitethernet 0/11
!
vlan 19
  ports gigabitethernet 0/2 untagged gigabitethernet 0/2
!
vlan 100
!
interface gigabitethernet 0/2
  switchport pvid 19
!
interface gigabitethernet 0/11
  switchport pvid 17
!
interface gigabitethernet 0/12
  switchport pvid 14
!
interface vlan 1
  no ip address
  ip address 192.168.6.1 255.255.255.0
!
interface vlan 14
  ip address 10.192.13.17 255.255.255.252
  ip pim
!
interface vlan 17
  ip address 10.192.13.25 255.255.255.252
  ip pim
!
interface vlan 17
  ip address 10.192.13.25 255.255.255.252
  ip pim
!
interface vlan 100 loopback
  ip address 6.6.6.6 255.255.255.255
  ip pim
!
interface vlan 19
  ip address 10.192.13.38 255.255.255.252
  ip pim
!
router ospf
  router-id 6.6.6.6
  network 6.6.6.6 area 0.0.0.0
  network 10.192.13.17 area 0.0.0.0
  network 10.192.13.25 area 0.0.0.0
  network 10.192.13.38 area 0.0.0.0
  network 192.168.6.1 area 0.0.0.0
  passive-interface vlan 1
!
router pim
  rp-candidate rp-address 239.193.128.0 255.255.255.0
  6.6.6.6 200
  rp-candidate rp-address 239.194.128.0 255.255.255.0
  6.6.6.6 200
!
end
```
system name "PIMR7"
!
ip routing
ip pim routing
ip igmp
!
no spanning-tree
!
  vlan 1
  ports gigabitethernet 1/3-16,2/1-8 untagged
gigabitethernet 1/3-16,2/1-8
!
  vlan 15
  ports gigabitethernet 1/1 untagged gigabitethernet
  1/1
!
  vlan 19
  ports gigabitethernet 1/2 untagged gigabitethernet
  1/2
!
  vlan 100
!
  interface gigabitethernet 1/1
  switchport pvid 15
!
  interface gigabitethernet 1/2
  switchport pvid 19
!
  interface vlan 1
  no ip address
  ip address 192.168.27.1 255.255.255.0
  ip igmp
  ip pim
  ip pim dr-priority 255
!
  interface vlan 15
  ip address 10.192.13.34 255.255.255.252
  ip pim
!
  interface vlan 100 loopback
  ip address 7.7.7.7 255.255.255.255
  ip pim
!
  interface vlan 19
  ip address 10.192.13.37 255.255.255.252
  ip pim
!
router ospf
  router-id 7.7.7.7
  network 7.7.7.7 area 0.0.0.0
  network 10.192.13.34 area 0.0.0.0
  network 10.192.13.37 area 0.0.0.0
  network 192.168.27.1 area 0.0.0.0
  passive-interface vlan 1
!
end
```
system name "PIMR8"
!
no spanning-tree
!
ip routing
ip pim routing
ip igmp
!
vlan 1
  ports gigabitethernet 1/3-4,1/6-8,2/1-8,3/1-8 untagged
gigabitethernet 1/3-4,1/6-8,2/1-8,3/1-8
!
vlan 16
  ports gigabitethernet 1/1 untagged gigabitethernet 1/1
!
vlan 17
  ports gigabitethernet 1/2 untagged gigabitethernet 1/2
!
vlan 18
  ports gigabitethernet 1/5 untagged gigabitethernet 1/5
!
vlan 100
!
  interface gigabitethernet 1/1
    switchport pvid 16
  !
  interface gigabitethernet 1/2
    switchport pvid 17
  !
  interface gigabitethernet 1/5
    switchport pvid 18
!
router ospf
  router-id 8.8.8.8
  network 8.8.8.8 area 0.0.0.0
  network 10.192.13.22 area 0.0.0.0
  network 10.192.13.26 area 0.0.0.0
  network 10.192.13.29 area 0.0.0.0
  network 192.168.11.1 area 0.0.0.0
  passive-interface vlan 1
!
interface vlan 1
  no ip address
  ip address 192.168.11.1 255.255.255.0
  ip igmp
  ip pim
  ip pim dr-priority 255
!
interface vlan 16
  ip address 10.192.13.22 255.255.255.252
  ip pim
!
interface vlan 17
  ip address 10.192.13.26 255.255.255.252
  ip pim
!
interface vlan 18
  ip address 10.192.13.29 255.255.255.252
  ip pim
!
interface vlan 100 loopback
  ip address 8.8.8.8 255.255.255.255
  ip pim
!
end
system name "PIMR9"
!
ip routing
ip pim routing
ip igmp
!
no spanning-tree
!
_vlan 1
  ports gigabitethernet 1/2-8,2/1-8,3/1-8 untagged
gigabitethernet 1/2-8,2/1-8,3/1-8
!
_vlan 18
  ports gigabitethernet 1/1 untagged gigabitethernet
  1/1
 !
_vlan 100
!
_interface gigabitethernet 1/1
  switchport pvid 18
!
_interface vlan 1
  no ip address
  ip address  192.168.21.1 255.255.255.0
  ip igmp
  ip pim
  ip pim dr-priority 255
!
_interface vlan 18
  ip address  10.192.13.30 255.255.255.252
  ip pim
!
_interface vlan 100 loopback
  ip address  9.9.9.9 255.255.255.255
  ip pim
!
router ospf
  router-id 9.9.9.9
  network 9.9.9.9 area 0.0.0.0
  network 10.192.13.30 area 0.0.0.0
  network 192.168.21.1 area 0.0.0.0
  passive-interface vlan 1
!
exit

4 Appendix

4.1 Service and support

Industry Online Support
Do you have any questions or need assistance?
Siemens Industry Online Support offers round the clock access to our entire service and support know-how and portfolio.
The Industry Online Support is the central address for information about our products, solutions and services.
Product information, manuals, downloads, FAQs, application examples and videos – all information is accessible with just a few mouse clicks:
https://support.industry.siemens.com/

Technical Support
The Technical Support of Siemens Industry provides you fast and competent support regarding all technical queries with numerous tailor-made offers – ranging from basic support to individual support contracts. Please send queries to Technical Support via Web form:
https://www.siemens.com/industry/supportrequest

SITRAIN – Training for Industry
We support you with our globally available training courses for industry with practical experience, innovative learning methods and a concept that’s tailored to the customer’s specific needs.
For more information on our offered trainings and courses, as well as their locations and dates, refer to our web page:
https://www.siemens.com/sitrain

Service offer
Our range of services includes the following:
- Plant data services
- Spare parts services
- Repair services
- On-site and maintenance services
- Retrofitting and modernization services
- Service programs and contracts
You can find detailed information on our range of services in the service catalog web page:
https://support.industry.siemens.com/cs/sc

Industry Online Support app
You will receive optimum support wherever you are with the "Siemens Industry Online Support" app. The app is available for Apple iOS, Android and Windows Phone:
https://support.industry.siemens.com/cs/ww/en/sc/2067
4.2 Links and literature

Table 4-1

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<td>2</td>
<td>Link to this entry page of this application example</td>
<td><a href="https://support.industry.siemens.com/cs/ww/en/view/109758722">https://support.industry.siemens.com/cs/ww/en/view/109758722</a></td>
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4.3 Change documentation

Table 4-2

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<td>First version</td>
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