

Agilent Technologies Emulating GSM GPRS Network Elements Across the Gb Interface

Product Note



Agilent Technologies

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Introduction

This document looks at the complexity of the Gb protocol stack and shows how the powerful features of the Agilent Technologies Signaling Advisor can be used to dramatically reduce the time and effort taken to find problems in this portion of a GPRS network. This document attempts to fill any gaps in the users knowledge of the Gb link and highlight some of the features of the Signaling Advisor emulation software (EmuLite). Real examples will be included and some common questions will be answered. It is intended for people using the Signaling Advisor to emulate the BSS or SGSN on a GPRS Gb link. It is not intended to be an in depth guide to the EmuLite application or the GPRS protocols but rather a guide on how the Signaling Advisor can make emulating on this link a simpler task. The content is aimed at people familiar with the Signaling Advisor software and its monitoring capabilities.

For a more in depth overview of GPRS please refer to the Agilent Technologies Product Note “Testing GPRS Signaling”. The protocols are complex at first glance and users should refer to the protocol standards for details (*See related literature*).



Figure 1. Agilent Signaling Advisor

The introduction of GPRS (General Packet Radio Service) requires significant changes to the existing GSM network architecture to enable it to deal with packet and circuit switched data. The main difference is the addition of three new network entities:

- Gateway GPRS Support Node (GGSN)
- Serving GPRS Support Node (SGSN)
- Packet Control Unit (PCU)

These will be interconnected with each other and the existing GSM network elements via a series of new interfaces which all have the prefix G.

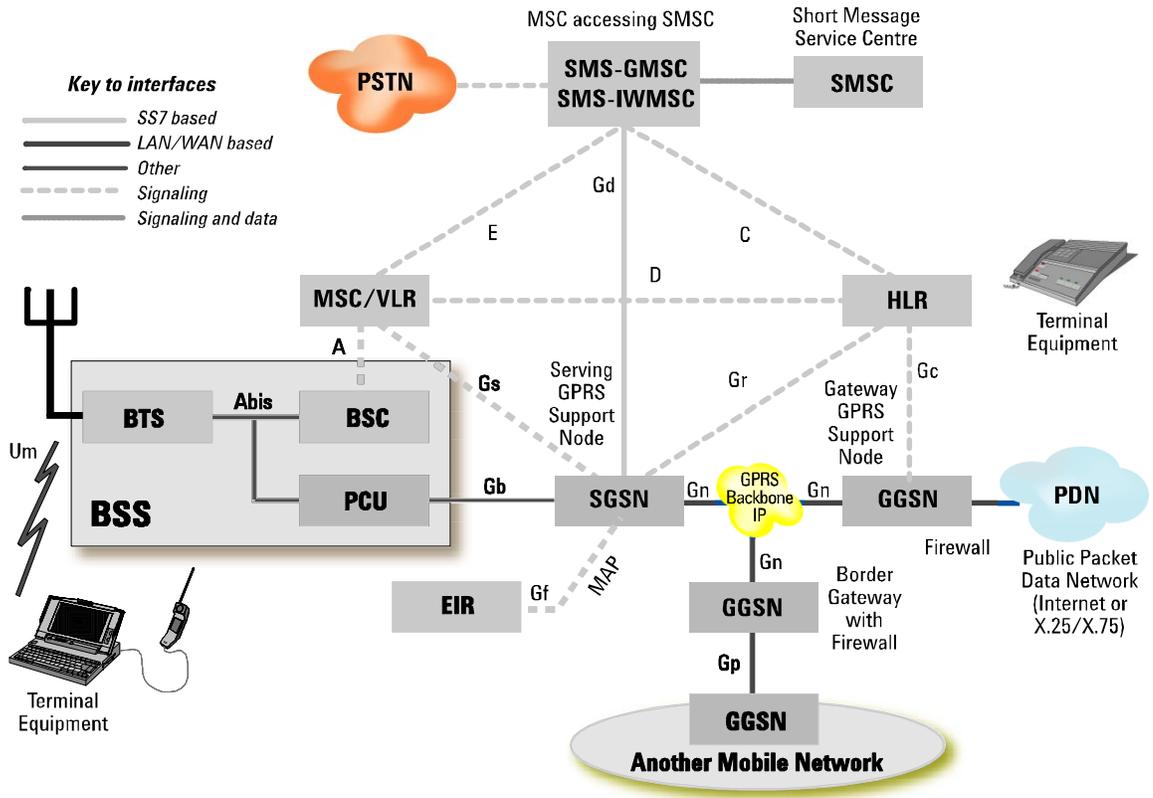


Figure 2. GPRS network.

The Gb link connects the BSS to the SGSN and is probably the most involved in terms of emulation. It does not conform to the usual SS7/ISDN structure with which you may already be familiar. To emulate on this link you will have to have a good understanding of the structure of the Gb stack and what the Signaling Advisor is capable of to make any emulation projects as simple as possible.

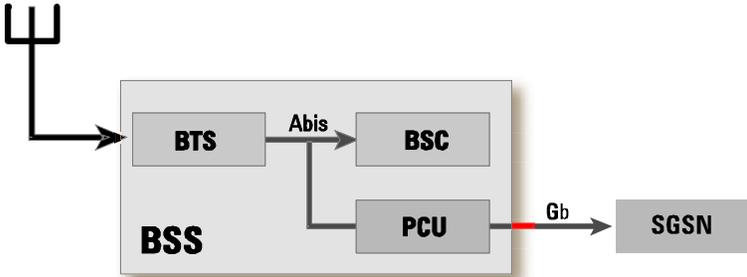


Figure 3. Gb link between the BSS and SGSN

The Gb Stack is Upside Down

To emulate on a Gb link it is first necessary to have an understanding of how the Gb stack works.

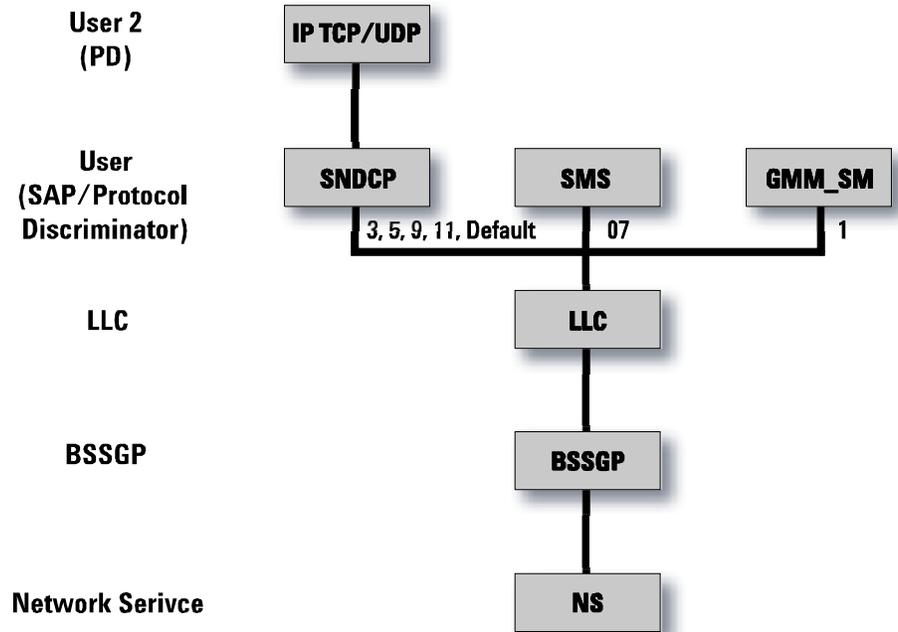


Figure 4. GPRS Gb protocol stack

When first confronted with the Gb stack most engineers who are familiar with SS7/ISDN protocols are confused. It seems to be slightly back to front. There is no error detection/correction at the lowest layers. There are multiple frame check sequences and sequence numbers embedded within the messages. It may even seem messy and unstructured to some. After having a closer look at the stack layers and how they interact it will hopefully be clearer why it has been designed this way and what problems this brings to emulation.

The Network Service Layer

Many documents will describe this layer as frame relay. This is not really the case. The layer is actually a hybrid of three protocols and frame relay plays a very small part in the overall operation of the layer. The NS layer is broken into three parts as follows:

Q.933 Annex A (Management for PVCs)	Network Service (GSM 08.16)
Q.922 Annex A (LAP-F Core Procedures)	

The first part is the LAP-F core procedures. This only accounts for the first two octets of each message. These octets contain the DLCI the FECN and the BECN. The DLCI is fixed per link and the FECN and BECN are not used and set to zero.

Messages with a DLCI of zero are from the Q.933 part of the layer. This is mainly concerned with managing the Permanent Virtual Circuits (PVC) i.e. which DLCI values exist, which are new or deleted. The BSS (or in some cases the SGSN) will send status request messages which will either ask for full status reports or link integrity verification. If these messages are not answered then the link will not be operational.

Octet	MSB	Bin	LSB	Hex	Type	Description
Message 117 of 2884 on Link2 (Gb RxA) at 19 May 2000 12:21:46.849502; Size 13 Octets						
1	0	00000000	00	MF	DLCI=0; EA=Extension; C/R=Command Frame	
2	0	00000001	01	MF	EA=No Extension; DE=Frame should not be discarded; BECN=Shouldn't encounter congested resources; FECN=Congested resources not encountered	
3	0	00000011	03	MF	Q922.MT=UI_P=0	
4	0	00001000	08	MF	Protocol Discriminator=Q933 Message	
5	0	00000000	00	MF	Call Reference=0(dec)	
6	0	1110101	75	MF	Q933 Message Type=Status Enquiry	
7	0	10100001	51	MF	Report Type ID=51(hex)	
8	0	00000001	01	MF	Length=1 octet	
9	0	00000001	01	MF	Report Type=Link integrity verification only	
10	0	10100011	53	MF	Link Integrity Verification ID=53(hex)	
11	0	00000010	02	MF	Length=2 octets	
12	0	00000101	05	MF	Send Sequence Number=5(dec)	
13	0	00000100	04	MF	Receive Sequence Number=4(dec)	

Figure 5. Decoded message from a Gb link

The decoded message above is an ITU-T Q.933 status enquiry message. It has a DLCI of zero and is requesting a link integrity verification.

The main part of the layer is GSM 08.16 which is the network service operations. Its main role is to provide management procedures for maintaining the virtual connections between remote entities i.e. blocking/ unblocking virtual connections due to some external event such as equipment failure.

When a new NS-VC is set up, after processor restart, after failure recovery or when restoring a VC the layer will reset that VC by sending NS-RESET messages. The Signaling Advisor uses this procedure when aligning the NS layer and will be explained in more detail later.

Like the Q.933 part of the layer it also has messages which check the integrity of the link. These are NS-ALIVE messages that must be acknowledged with NS-ALIVE-ACK messages or the link will come out of alignment with an error.

Unlike most SS7 protocols there is no error correction or retransmission procedures at this level. This is because the Gb link is supposed to be very reliable. Retransmission and error correction are done at the LLC layer and higher.

The BSSGP Layer

Several MS's may wish to use the same link. This is possible due to the Frame Relay protocol architecture. This utilizes virtual circuits allowing data to be multiplexed from different sources. Multiple BVCI (BSSGP Virtual Connection Identifier) values can be set up to use the same DLCI between the two BSSGP entities.

A simple script will have to be written to provision your BVCI's after the NS layer has been aligned. Examples of BSSGP operations will be shown in section 0 (A Simple Guide to the BSSGP Layer).

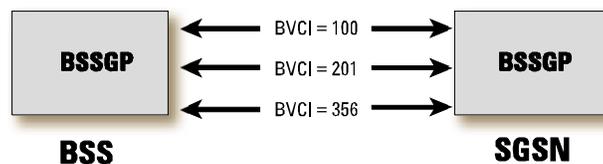


Figure 6. Multiple connections between BSSGP layers

The LLC Layer

The LLC (Link Layer Control) layer securely transfers messages between two points. It has a 24-bit frame check sequence, supports encryption and protection. It has been designed to be independent of the underlying radio interface protocol to allow for the introduction of alternative GPRS radio solutions at a later date.

The SNDCP Layer

The SNDCP (Subnetwork Dependent Convergence Protocol) layer is used for transferring IP Data (TCP/UDP). It supports compression and segmentation.

The set of protocol entities sitting above SNDCP consists of commonly used network protocols. These all use the same SNDCP entity, which then performs multiplexing of data coming from different sources before being sent via the services provided by the LLC layer. The NSAPI (Network Service Access Point Identifier) acts as an index for the appropriate PDP (Packet Data Protocol) which is using the services of SNDCP. Each active NSAPI uses the services provided by the SAPI in the LLC layer and as such several NSAPIs may be associated with the same SAPI.

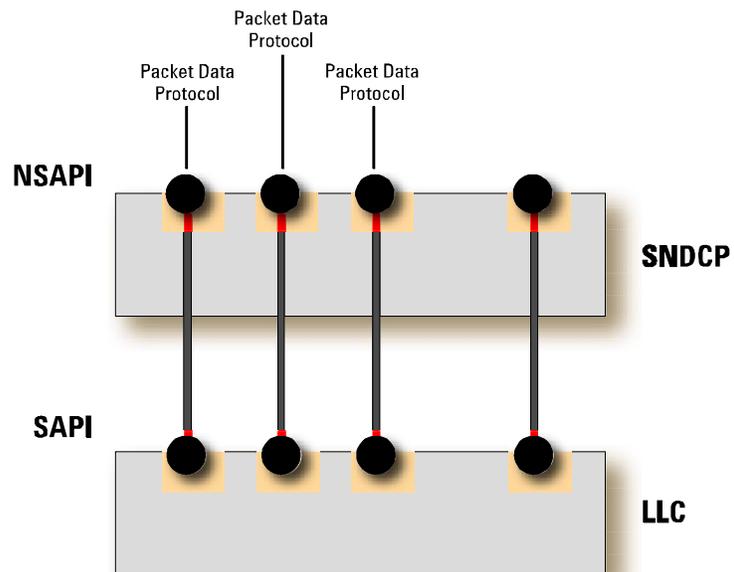


Figure 7. Interactions between the SNDCP layer and the LLC layer

The SMS Layer

The SMS (Short Message Service) layer is used for text messages between mobiles.

The GMM_SM Layer

The GMM_SM (GPRS Mobility Management and Session Management) layer has two functions. The GMM part is used to attach/detach/page mobiles. The SM part is used to control data transfer.

Emulation Made Easy

This section will highlight some of the powerful features of the Signaling Advisor that will allow you to create emulate sequences in minutes.

Using Captured Traffic

All networks are configured differently and to emulate effectively it is often necessary to understand even the most trivial of message parameters. Creating messages from scratch would be time consuming and require a great deal of knowledge of network and message structure to get right.

A faster and more accurate method of obtaining these messages is to use the monitor capabilities of the Signaling Advisor. Capture data from the link that you wish to emulate on and then highlight the messages you wish to use. These messages can then be copied into the Emulite sequence editor. This means that only the parameters required need to be modified and the remaining message should meet the networks expectations.

Frame check sequences, pointers and length fields

Alongside the parameters of the GPRS protocol are pointers, lengths and frame check sequences. These fields carry no data of interest to the user but are required to be correct so that the message frame is validated at the other side. The overhead of maintaining these fields would be huge if, like some of the competitors to the Signaling Advisor, the user had to manually calculate these values. For example each time a value is changed in the message the frame check sequence, pointer or length field would require recalculation.

GPRS is unusual in that there exist frame check sequences within the message and not only at the end of the frame as in SS7. There are five possible frame check sequences embedded within the Gb stack messages. These are:

- LLC layer
- IP header
- TCP data
- UDP data
- ICMP data

To make creation and maintenance of emulation scripts as simple as possible the Signaling Advisor will calculate these fields automatically. This means that the user will be able to concentrate on the information in each message and not its structure.

Session trace

Session trace is a powerful application on the Signaling Advisor. It allows to view vast amounts of data at a graphical level and shows each phase of the call as colored blocks. When this application is used in conjunction with Emulite then complex sequences can be created in minutes.

The figure below shows how to create a sequence from the session trace view. Just right click on the call of interest and the sequence is generated automatically. In this example below a session trace has been carried out on some data from a live Gb link. The selected call is a PDP context request and all the relevant messages required to carry out this operation will be copied in the sequence editor, given a relevant name and placed within a sequence that mimics the call.

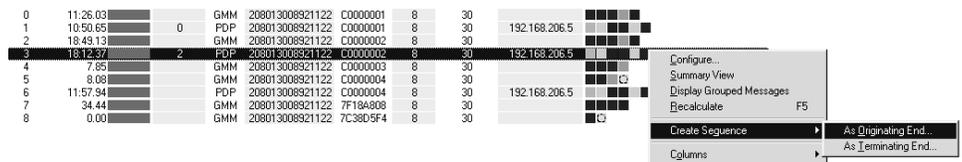


Figure 8. Session trace interface

Automatic network service layer

If every emulate script had to be written to handle the NS layer then the complexity of even the simplest sequence would be astronomical. This is why the Signaling Advisor will manage this layer automatically. This will entail:

- Checking for invalid DLCI, NS-VCI and NS-EI values.
- Responding to and generating NS_ALIVE and NS_ALIVE_ACK PDU's
- Responding to and generating ITU-T Q.933 status enquiry (full status and link integrity checks)
- Maintaining sequence numbers in ITU-T Q.933 messages.
- Maintaining error rate monitors and other error condition checks.
- Maintaining the many timers and counters used in the layer.

The only messages that are valid within a sequence are from the BSSGP layer upwards i.e. you cannot use NS-ALIVE messages within your sequence.

The BSS State Machine

A simplified version of the state machine for emulating the BSS side of the Gb link is shown below. It does not include timers, counters or any of the error condition monitors. It shows the start-up sequence and how the layer is separated into three simultaneous state machines.

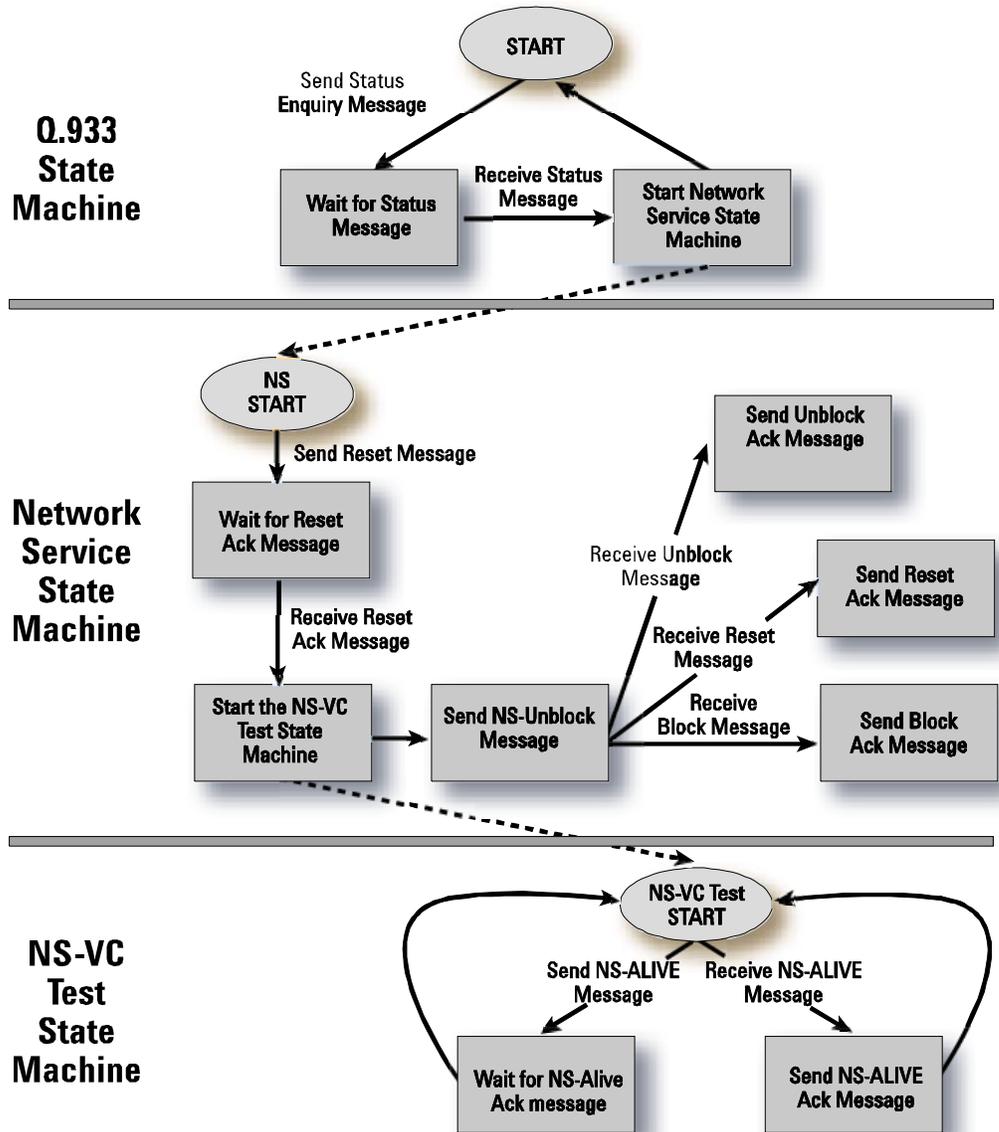


Figure 9. BSS side of the Gb link (simplified state)

SGSN State Machine

A simplified version of the state machine for emulating the SGSN side of the Gb link with the Signaling Advisor is shown below. Again no timers, counters or error monitors are shown. The same three simultaneous state machines are used.

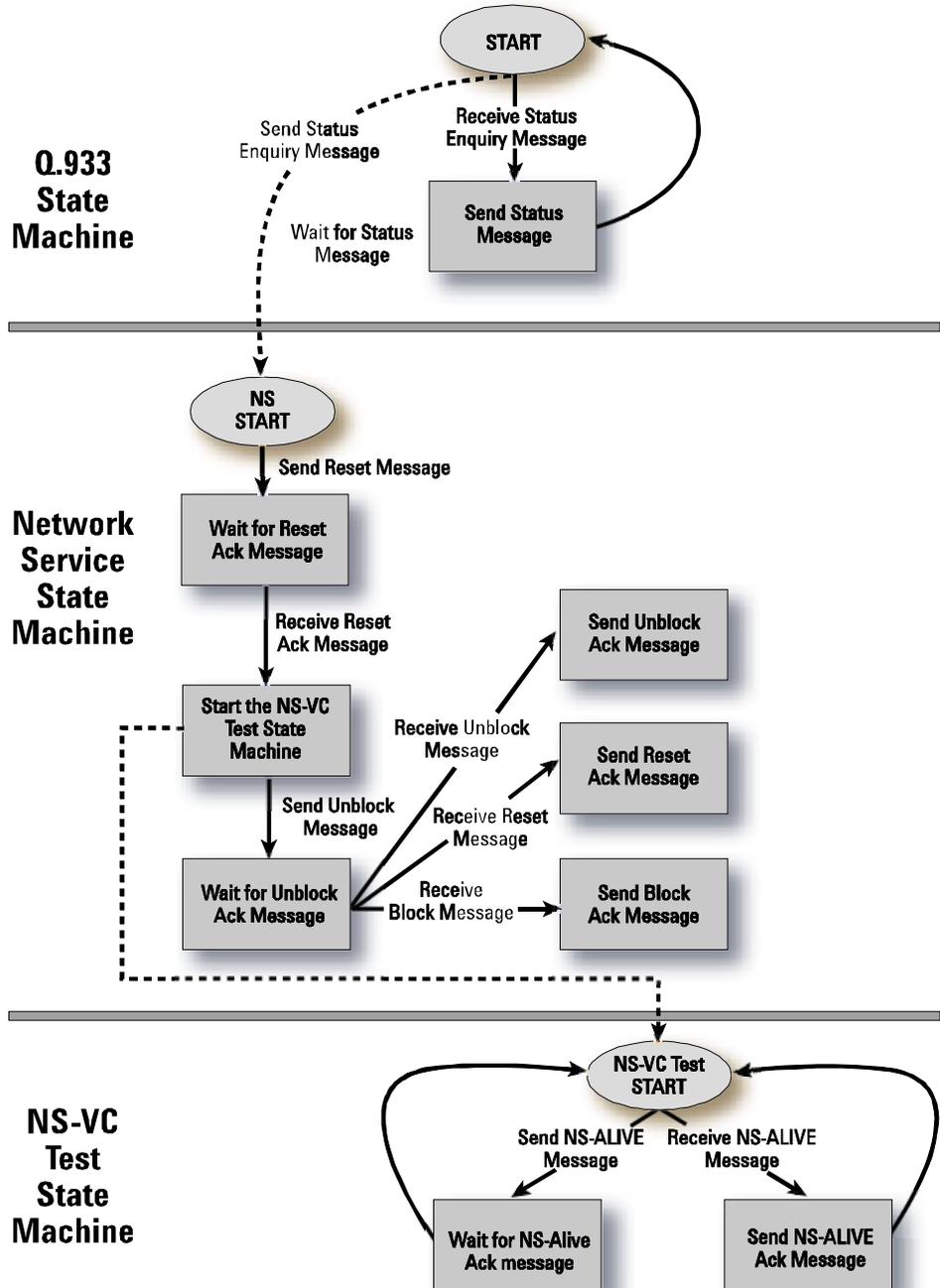


Figure 10. SGSN side of the Gb link (simplified state)

What You Need to Know Before You Connect and Why

This section details the procedures to be carried out before an emulation script can be run.

Configuring a Link

How to configure a Gb link to emulate either the BSS or SGSN.

1. Select the bearer on the Signaling Advisor that you wish to emulate on. Set that bearer into emulate mode.
2. Make sure the alarms for that bearer are green. (Note the alarms for the side of the bearer that will be transmitting will be grayed out).
3. Select the timeslots you wish to use for the Gb link. If the link uses more than one timeslot then select the first timeslot, hold down <shift> and select the last timeslot.
4. Set the protocol stack type to be GPRS NS. Then select the protocol as GPRS Gb (SMG31).
5. If you want to emulate the BSS then select “user” from the options. If you want to emulate the SGSN then select “network”.
6. Enter the DLCI, NS-VCI and NS-EI assigned to that link. See section (0 What to do if the parameters are not know).

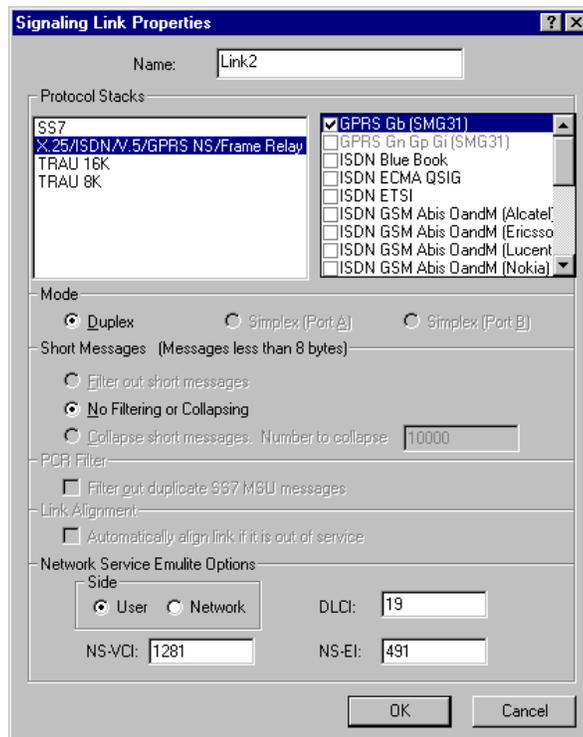


Figure 11. Signaling link properties interface

Aligning the Link

When a link is created on the Signaling Advisor it will by default automatically try and align itself with the equipment at the other end. If the link is required to be stopped i.e. no transmission of any messages, then this is still possible through the link status view. To do this go to link status view and right click on the link that you want to start. Select “Take out of Alignment”.

If at any time the link needs reset then this can be done by stopping the link via link status view and then starting it again.

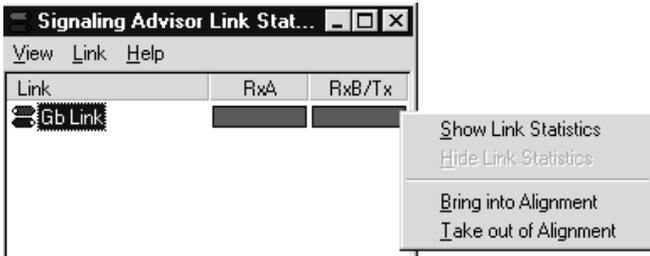


Figure 12. Link status view

The layer is aligned by resetting the virtual connection at the NS layer. This is necessary because the NS layer on the Signaling Advisor needs to have a start point from which to begin the alignment process.

If there is a problem with the network service layer of the link then this will be displayed in the status window of the link status view. The possible problems and the reasons are as follows:

Failure	Reason
Invalid DLCI	The automatic network service layer has detected messages with an unspecified DLCI value. This is illegal as multiple DLCI values on the same link are not allowed. <i>Check that the correct value for the DLCI has been entered in the link properties.</i>
Invalid NS-VCI	The automatic network service layer has detected an unspecified NS-VCI value on the link. <i>Check that the correct value for the NS-VCI has been entered in the link properties.</i>
Invalid NS-EI	The automatic network service layer has detected an unspecified NS-EI value on the link. <i>Check that the correct value for the NS-EI has been entered in the link properties.</i>
Reset Failure	The automatic network service layer has failed to reset the link. This means that the reset messages sent by the layer have not been acknowledged or have not been acknowledged in time. <i>Check your wiring to the Signaling Advisor and check that the timer RESET in the L2 parameters is set high enough.</i>
VC Test Failure	The virtual connection test procedures in the automatic network service layer have failed. This means that the NS-ALIVE messages sent from the layer have not been acknowledged or have not been acknowledged in time. <i>Check your wiring to the Signaling Advisor and check that the timer ALIVE in the L2 Parameters is set high enough.</i>
Q.933 Error High	The error threshold of the Q.933 part of the automatic network service layer has been reached. This could mean that the Q.933 sequence numbers have gone out of synchronization or STATUS ENQUIRY messages are not being acknowledged by STATUS messages. Check your wiring to the Signaling Advisor.

What To Do If The Parameters Are Not Known

If the DLCI, NS-VCI and NS-EI are not known then a simple way to determine these parameters is to monitor the Gb link. If the BSS or SGSN are reset then this will generate NS-RESET messages. These are network service messages and can be found by applying a view filter.

Octet	MSB	Bin	LSB	Hex	Type	Description
Message 33 of 2884 on Link2 (Gb Rx8) at 19 May 2000 12:14:01.695537; Size 14 Octets						
1	00001000			08	MF	DLCI=40; EA=Extension; C/R=Command Frame
2	10000011			83	MF	EA=No Extension; DE=Frame should be discarded; BECN=Shouldn't encounter congested resources; FECN=Congested resources not encountered
3	00000010			02	MF	Network Service MT=Reset PDU
4	00000000			00	MF	Cause ID=0(hex)
5	10000001			81	MF	Ext=No Extension; Length Octet=1(dec)
6	00000001			01	MF	Cause value=D&M intervention
7	00000001			01	MF	NSVCI ID=1(hex)
8	10000010			82	MF	Ext=No Extension; Length Octet=2(dec)
9	00000000			00	MF	NSVCI=16(dec)
10	00010000			10	MF	
11	00000100			04	MF	NSEI ID=4(hex)
12	10000010			82	MF	Ext=No Extension; Length Octet=2(dec)
13	00000000			00	MF	NSEI=4(dec)
14	00000100			04	MF	

Figure 13. Decoded message from a Gb link

As you can see from this decoded example the message contains the parameters:

DLCI = 40
NS-VCI = 16
NS-EI = 4

These values should be constant for the link. They can be entered when creating the emulate link.

Ciphering Procedures

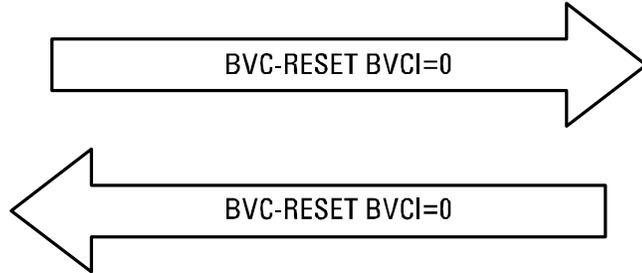
All ciphering procedures must be switched off when emulating with the Signaling Advisor as these are not supported at the present time.

A Simple Guide To The BSSGP Layer

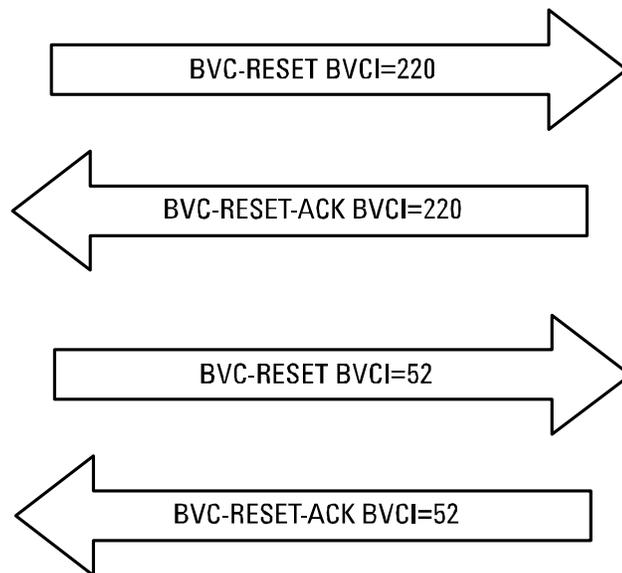
Before any GMM or PDP transfers can take place the BSSGP layer will need to be configured. This section will give you enough information to provision multiple BVCI's to a single DLCI. The BSSGP layer should be simple and a script needs to be run only once after the NS layer has aligned.

The following set of diagrams show how to reset the BVCI, block the BVCI and start the flow control procedures on that BVCI:

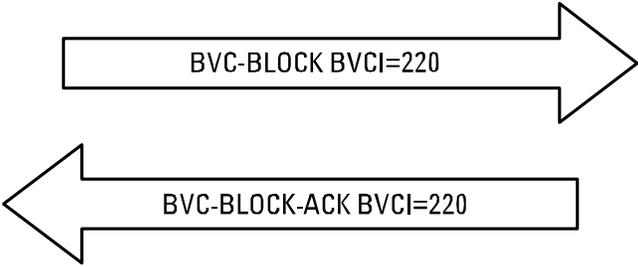
Firstly the initial handshake with the BSSGP layer must be done. This consists of exchanging a BVC-RESET message with BVCI equal to zero. These messages may or may not be acknowledged. In this example these messages are exchanged without an acknowledgment message but it is a simple change to add acknowledgments to this script. The BSS initiates this handshake.



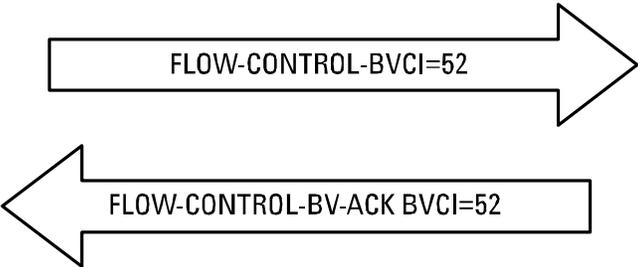
Now we want to provision the BVCI values 220 and 52. These reset messages are acknowledged.



If we now want to block one of these BVCIs then we send a blocking message which is then acknowledged.



Now the flow control procedure must be carried out for the BVC I values that are going to be used.



The following example will show these operations being used. I want to provision the BVC I's 20 and 210. I then want to block BVC I 20.

Remember that a script can be generated in minutes if the messages are copied from a previous monitor session.

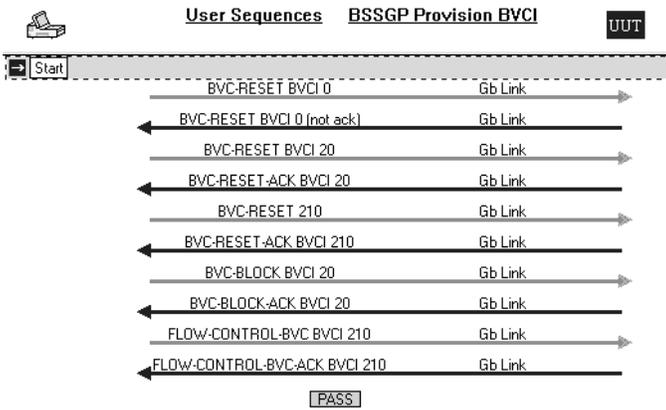


Figure 14. Finished sequence as shown in Signaling Advisor's sequence view

You do not need to run a script after you have finished emulating to take down the BSSGP layer as this layer is reset every time you align the link.

Examples

Now that we have explored the Gb stack and we know how to create links we will now run through a simple example. It will be broken down into three parts and the Signaling Advisor will emulate the BSS. The test we are going to explore is to check if there is end to end routing from the MS to a terminal in the PDN (Packet Data Network).

Before the test is started the NS layer must be aligned and a script must be run to provision a BVCI at the BSSGP.

GMM Attach

When the phone is switched on it must negotiate with the network. We will assume that the phone has a static IP address.

The first message is an 'Attach Request'. It will contain a TLLI (Temporary Logical Link Identifier) which has not been assigned by the network yet so can be any value. It will also contain an IMSI (International Mobile Subscriber Identification) which identifies the mobile phone. Finally there will be the phones IP address.

Note: If the IMSI is not included in the 'Attach Request' message then the SGSN will reply with an 'Identity Request' message.

Fields to set up in this message will be:

- BVCI value at the BSSGP layer (from the script that was run earlier)
- Transmitter unconfirmed sequence number at the LLC layer to zero.



We now expect a 'Attach Accept' message back from the SGSN. This message will contain a TMSI (Temporary Mobile Subscriber Identification). The network has returned the mobile phone an identification that is valid until the mobile is switched off. In the next messages the TLLI will become the TMSI.



Actions to be taken on this message:

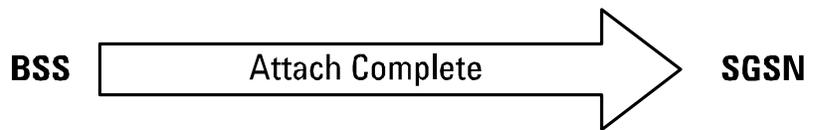
- Save off the TMSI (at the bottom of the message)



Finally the MS will send a 'Attach Complete' message Fields to be set up in this message:

- BVCi value at the BSSGP layer
- Transmitter unconfirmed sequence number at the LLC layer to one.
- Restore the saved off TMSI value to the TLLI value.

The mobile phone is now attached to the network.



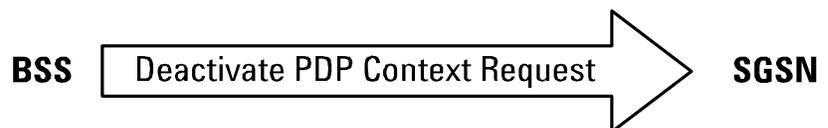
Start the PDP Session

Now that the phone is attached to the network we have to activate the PDP session. If we were using dynamic IP addressing then this would return an IP address for the phone.

Send an 'Activate PDP Context Request Message'.

Fields to be set up in this message:

- BVCi value at the BSSGP layer.
- Transmitter unconfirmed sequence number at the LLC layer to two.
- Restore the saved off TMSI value to the TLLI value.
- The IP Address of the mobile phone in the source address field.



This should result in an 'Activate PDP Context Accept' message being returned.

Using Echo Packets to ping remote terminals

We now want to ping a remote terminal in the PDN. To do this the MS will send 'ICMP Echo' messages . If an 'ICMP Echo Reply' message returns then the ping has been successful.

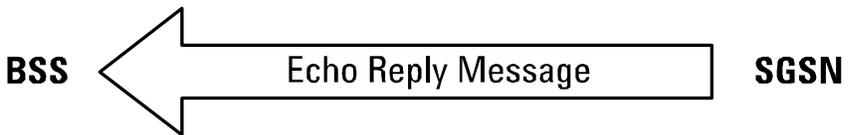
First send the echo message. This is an IP message.

Fields to be set up in this message:

- BVCi value at the BSSGP layer
- Transmitter unconfirmed sequence number at the LLC layer to zero (Not two as this is no longer a GMM message and because GMM and SMDCP use a different SAPI value they have independent sequence numbers).
- Restore the saved off TMSI value to the TLLI value.
- The IP Address of the mobile phone in the source address field.
- The IP address of the remote terminal in the destination address field.



If this has been successful then an 'Echo Reply' message should be received.



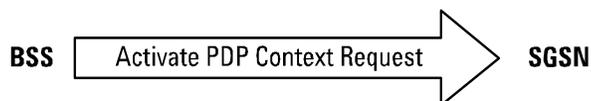
Stop the PDP session

We have finished testing the end to end routing of the network. Stop the session.

Send a 'Deactivate PDP Request' message.

Fields to be set up in this message:

- BVCi value at the BSSGP layer.
- Transmitter unconfirmed sequence number at the LLC layer to three. (this is back to the GMM sequence numbers).
- Restore the saved off TMSI value to the TLLI value.



This should return a "Deactivate PDP Context Accept".



GMM detach

We now want to simulate the mobile phone being switched off. To do this a 'Detach Request' message must be sent.

Fields to be set up in this message:

- BVCi value at the BSSGP layer
- Transmitter unconfirmed sequence number at the LLC layer to four.
- Restore the saved off TMSI value to the TLLI value.



If the detach is successful then a 'Detach Accept' message should be received.



The Final Sequence

The final sequence must put together the five previous sections. At the moment there is no way of saving off variables to have global scope and not just local scope within the sequence. This means for example that we cannot restore a BVCI value saved from a previous sequence.

The finished sequence should look like this.

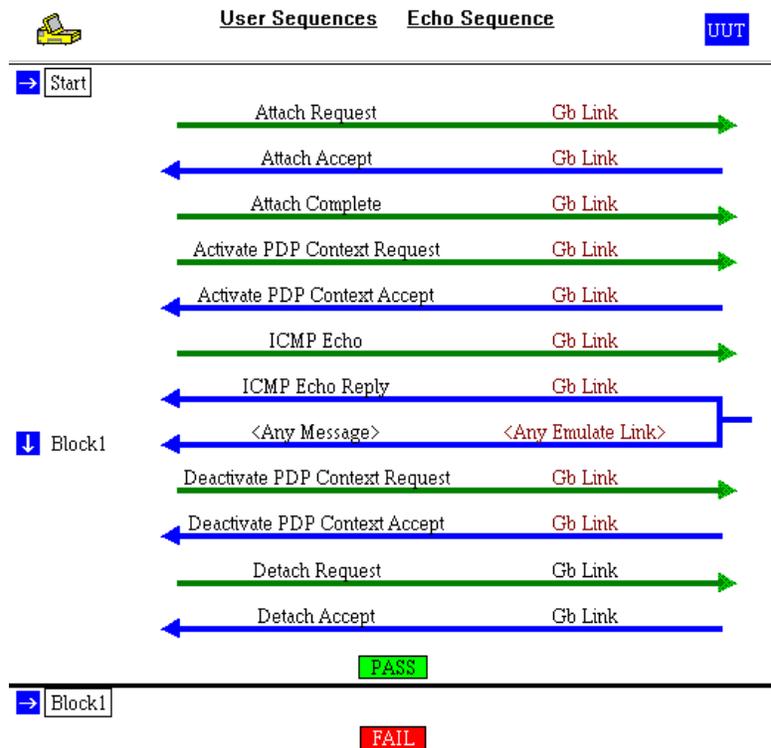


Figure 15. Final sequence as viewed by the Signaling Advisor's sequence view

Glossary

BECN	Backward Explicit Congestion Notification
BSC	Base Station Controller
BSS	Base Station Sub-System
BSSGP	Base Station System GPRS Protocol
BTS	Base Transceiver Station
BVC	BSSGP Virtual Connection
BVCI	BSSGP Virtual Connection Identifier
DLCI	Data Link Connection Identifier
FECN	Forward Explicit Congestion Notification
GPRS	General Packet Radio Service
GSM	Group Special Mobile
IMSI	International Mobile Subscriber Identification
LLC	Logical Link Control
NS	Network Service
NS-EI	Network Service Entity Identifier
NS-VCI	Network Service Virtual Circuits Identifier
PDN	Packet Data Network
PDP	Packet Data Protocol
PDU	Protocol Data Unit
PVC	Permanent Virtual Circuits
SAPI	Service Access Point Identifier
SGSN	Serving GPRS Support Node
SNDCP	Subnetwork Dependent Convergence Protocol
SS7	Signaling System No.7
TLLI	Temporary Logical Link Identifier
TMSI	Temporary Mobile Subscriber Identification
VC	Virtual Connection

Related Literature

“Testing GPRS Signaling” Product Note 5988-0304EN

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Services, and Assistance**

Agilent Technologies aims to maximize the value you receive, while minimizing your risk and problems. We strive to ensure that you get the test and measurement capabilities you paid for and obtain the support you need. Our extensive support resources and services can help you choose the right Agilent products for your applications and apply them successfully. Every instrument and system we sell has a global warranty. Support is available for at least five years beyond the production life of the product. Two concepts underlie Agilent's overall support policy: "Our Promise" and "Your Advantage."

Our Promise

Our Promise means your Agilent test and measurement equipment will meet its advertised performance and functionality. When you are choosing new equipment, we will help you with product information, including realistic performance specifications and practical recommendations from experienced test engineers. When you use Agilent equipment, we can verify that it works properly, help with product operation, and provide basic measurement assistance for the use of specified capabilities, at no extra cost upon request. Many self-help tools are available.

Your Advantage

Your Advantage means that Agilent offers a wide range of additional expert test and measurement services, which you can purchase according to your unique technical and business needs. Solve problems efficiently and gain a competitive edge by contracting with us for calibration, extra-cost upgrades, out-of-warranty repairs, and on-site education and training, as well as design, system integration, project management, and other professional engineering services. Experienced Agilent engineers and technicians worldwide can help you maximize your productivity, optimize the return on investment of your Agilent instruments and systems, and obtain dependable measurement accuracy for the life of those products.

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