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SAI and NAI Experimental Interoperability Test

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Abstract

The connection with neighboring networks is fully automatic with some other military networks is manual with conventional manually operated networks. Interoperability of command, control and communication systems, and electronic interface of military communication systems are all critical issues in the modern battlefield. The ROK digital common user system, SPIDER, have been designed without joint operation concept at first. The ROK has developed a prototype SPIDER Analog Interface (SAI) device to provide U.S forces in Korea with the interoperability. The ROK SAI electrical characteristics were measured in the preliminary interoperability test in Korea, and the SAI and the U.S. NAI (NATO Analog Interface) device experimental interoperability test results are presented in this paper. From the preliminary interoperability test, the compatibility between the SAI and the NAI was verified.

Keywords: Component, Interoperability, STANAG, Tactical Communications, TRI-TAC/MSE

1. Introduction

A modern communication system must be able to handle a large amount of traffic and to achieve this channel dedication must be avoided. And the modern combat requires more flexible and adaptable capabilities on communications systems. Success on the battlefield relies on the ability of a commander and staff to process rapidly a large amount of information that has been presented to them by the vast array of sensors that may be deployed on the battlefield in near rear time. This battlefield information must be accurate and received in near rear time to allow the preparation of appropriate plans that can then be communicated in a timely manner to those forces that will implement them. Command and control must therefore be connected to their sensors deployed and to subordinates by reliable, survivable communications systems with sufficient capacity[1]. A military communication network must be adapted to match forces organization and the predictable type of combat. The tactical networks and strategic networks can change very frequently and experience dynamic traffics and link failures in the networks and sometimes they can be jammed by a strong radio signal in the same frequency. The characteristics of military networks are dynamic topologies, bandwidth limitations, variable capacity links, high survivability, and high-level communication security[2]. The doctrine of modern armies is based on several principles to provide tactical communications supporting the command and control. Tactical communications should be reliable, simple to use, flexible, highly mobile, secure, interoperable with other tactical networks, strategic networks, and allied networks. This interoperability is the most important issue in order to send information seamlessly in the battlespace network. In addition, new equipment should be interoperable with current in-service equipment[1]. The connection with neighboring networks is fully automatic with some other military networks and is manual with conventional manually operated networks.

While the Cold War deployments are less likely, multinational alliances are essential in almost all modern deployments and it is perhaps even more important for modern networks to be able to interface to those of other nations. The connection with civilian post office networks

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may be automatic, but owing to communications security, communications should be assumed by an operator. There are therefore a large number of standards and agreements that cover automatic interface of trunk networks. Within NATO, the internetwork interface for analog signals, voice, and telegraph is arranged through the standard agreement STANAG 5040[3], and interoperability between digital EUROCOM[4] systems using 16-Kbps modulation is provided by STANAG 4208. The U.S. TRI-TAC and MSE system allows the automatic establishment of voice communications between NATO subscribers in concordance with STANAG 5040 specifications. The Republic of Korea Army (ROKA) had developed a tactical digital common user communications system, SPIDER. In order to realize the interoperability between SPIDER and the U.S. TRI-TAC/MSE, the U.S. requested that the ROKA develop a digital trunk interface complying with the STANAG 4206 through 4214 protocols. The ROK Joint Chief of Staff (JCS) decided to develop an analog trunk interface complying with the NATO Analog Interface (NAI) specification, STANAG 5040, as a first step. As the result the ROKA had developed a prototype SPIDER SAI device based on the STANAG 5040. Full scale interoperability test between the TRI-TAC/MSE and the SPIDER was conducted to ensure that the SAI is compatible with NAI in the physical level and to verify the network level interoperability of switching systems of two countries.

In this paper, we described the architecture of ROK and U.S battlefield communications systems. The ROK SAI electrical characteristics were measured in the preliminary interoperability test in Korea, and the SAI and the NAI experimental interoperability test results are also presented in this paper. From the preliminary interoperability test, the compatibility between the SAI and the NAI based on the STANAG 5040 was confirmed.

2. Architecture of Spider System

The tactical commander in the battlefield requires two types of battlefield communications systems:

1. Trunk communications system which is above battalion provide high capacity infrastructure links and bidirectional links from one unit to another.
2. Combat Net Radio (CNR) using single channel frequency supports units at battalion and below to perform tactical mission. The CNR requires flexibility and rapid response, under the chain of command and links use half-duplex channel and single-frequency or a discrete set of radio frequencies when in a frequency hopping mode. In an Army with a high forces density on the battlefield, a tight meshing will give excellent redundancy and a high survivability rare. Overlying both of these services was still the requirement to send and receive bulky information. Within a major headquarters or logistics installation, commanders and staff officers are connected by means of local links to a central headquarters communication center. The links may consist of a LAN(Local Area Network) for data, local loops for telephony or a single converged system. The hub center provide subscribers in the network with connections to other subscribers within the headquarters using the local networks, as well as with remote access to the combat radio network and access to the trunk network. To transmit tactical data, the ROKA had developed transportable *radio* set providing facilities for multichannel *radio* transmissions and area communication system, SPIDER, which is normally carried on 5/4 ton military vehicles. SPIDER is designed in order to build up a combat area network and SPIDER equipment are thus carried on vehicles and usually placed in sheltered installations. Each switch in the node can manage communications up to four radio sets, and it is possible to cover with mobile radio integration from 1900 to 7000 square km. The network is moved by placing on the front side reserve nodal centers. Starting from the time when all the vehicles arrive on the chosen site, the switch and the first meshing trunk link are activated in between half and one hour. The full activation of a nodal center with four meshing links and two connecting links requires approximately two hours. According to the needs, the number of available link terminal equipment such as telephone, telegraph, facsimile, and computer, and the command and control link type with the network commander may vary. The SPIDER system also provides circuit-switched secure digital voice and packet-switched data overlay. The ROK SPIDER architecture for division level is shown in Figure 1[5]. SIIDER equipment grouping is tailored to meet the network design and operation requirements and typical division level grouping in Figure 1 consist of Node Controller (NC) shelters, System Controller (SC) shelter, Extension Node (EN) shelter, Radio Access Points (RAPs) shelter, Combat Net Radio (CNR), Remote

Switching Unit (RSU), Combat Net Radio Interface (CNRI), Digital Multi Role Terminal (DMT), and Mobile Radio Terminals (MRTs). The NC is the hub of the SPIDER node and provides network interface for subscriber access elements.The NC Shelter consists of four S-250 shelters: Switching Shelter, Large Extension Node (LEN) Shelter, Radio Access Point (RAP) Shelter and Unit Level Switch (ULS) Shelter. Power supply is provided by 10kW gasoline generators which is carried by trailer. The SC Shelter consists of three shelters: Planning Shelter, Management Shelter and Maintenance Shelter. And the RAP and the ULS Shelters can be added if necessary. Subscribers have access to NCs and to the rest of SPIDER via VHF LOS (Line of Sight) radios that connect to the Extension Node (EN). The LEN provides wired communications for personnel at large Command Posts (CPs). The automatic switch in the NC is the main basic component and it provides key switching, traffic control and access points for SPIDER. The switch is designed to use digital form information which provides a constant communication quality, independent from the number of switches crossed by the signal. The automatic communication routing is obtained by the flood search routing algorithm. Flood search ensures network survivability in spite of node damage, congestion, and frequent changes in subscriber locations[6]. In terms of wasted bandwidth flooding algorithm is inefficient but it can provide the best solution when a network topology changes rapidly and dynamically reconfigured[7]. The SC communicates with NCs and provides an automatic function for planning and managing the SPIDER. The mobile radio interface is achieved by the RAP with Combat Net Radio Interface (CNRI) unit which provides automatic radio interface for MRT subscribers, PRC-999K, and connects directly to the NC by cable or remotely via LOS radio. It is designed to allow the establishment of secure and bilateral automatic duplex communications between mobile and wire connected subscribers. The Remote Switching Unit (RSU) can support 30 wired subscribers and provide automatic subscriber finding features when connected to an NC or a LEN. A Unit Level Switch (ULS) can be used as local call switching centers and it can provide small group access to the network by connecting to the NC (Figure 2). The computers are configured for digital connection through Digital Multi Terminal (DMT). The Tactical Microwave Radio (TMR) radio set operated in UHF band can be used for the short range Down the Hill (DTH) application as shown in Figure 2. Nominal range of TMR is about 15 km depending on terrain.

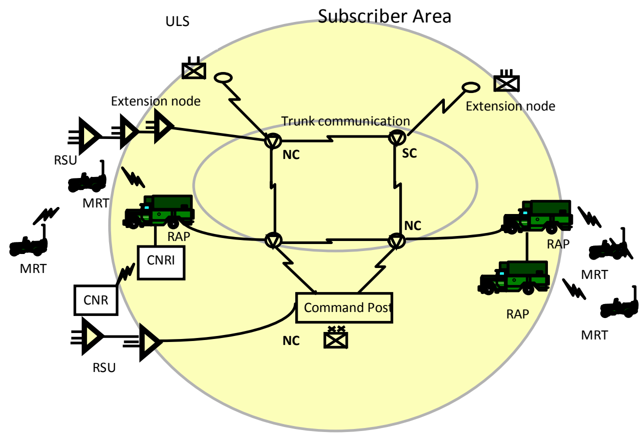

Figure 1. ROK SPIDER Architecture.

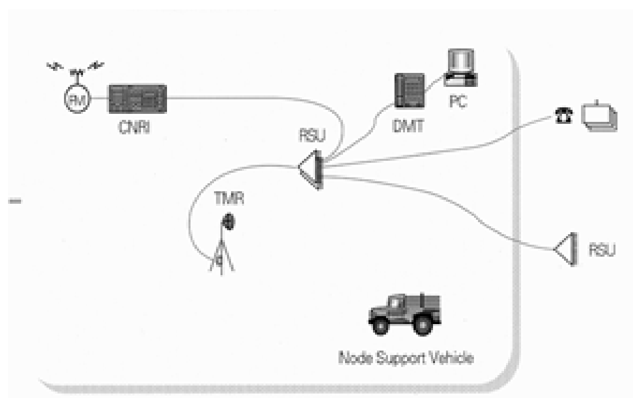

Figure 2. Unit Level Switch (ULS).

3. SAI and NAI Experimental Interoperability Test

The combined forces of the ROK and the U.S. were studying the communication interoperability for joint operation. In early 1990s, ROK had developed tactical data system and communication system for ROKA but they were not designed to operate without joint interoperability concept and the network topology was tree topology in which fewer links can cause major network failures. Therefore they developed mesh type network which provides a high degree of survivability and secure telephone and data encryption devices[8]. Also, for the joint interoperability, the ROK has developed a prototype SAI device based on NATO STANAG, which has not yet been fully tested. The major equipment for the ROK U.S. interoperability test included the following switches and trunk interface devices; one MSE Node Center Switch, TTC-47, one TRI-TAC Switch, TTC-39D, one digital NAI for MSE, CV-4002, one analog NAI TRI-TAC, CV-3478, two SAI equipment, two SPIDER switches, SB-92K, U.S. communications terminals, TA-1035/U Digital Non-secure Voice Terminal (DNVT) and Tactical Terminal Adapter (TTA), 2936C, ROK communications terminals, DMT, commercial telephone sets, commercial facsimile, commercial modems and personal computers. The U.S. army had developed MSE (mobile subscriber equipment) system to meet battlefield commanders' requirements for maneuverability and for secure voice, data, and facsimile communications. In a NATO environment, it must be able to interface with tactical European and allied networks. In order to define uniform communications standard, a joint European committee was established that developed the EUROCOM standard for digital communications systems. The standard defines not only the configuration and the communication protocols but also equipment interfaces. The U.S. had designed the MSE system to this standard. A typical corps-level MSE deployment will involve some 8,100 subscribers over a five division area of 37,500 km^2, about 150 x 250 km. The U.S TTC-47 is the heart of the node based communications network. Its purpose is to receive all of the input communications lines into the node and to route them to their required destinations. As a node switch, it provides large subscriber capacity, subscriber groups handling, non-blocking capability and automatic links search in the network. The switch must support a numbering program that is flexible in its ability to define subscriber numbers, and that is of fixed form and length, and that is independent of the number of nodes along the route, and that is located with the subscriber, even if the subscriber moves from one node to another. The TRI-TAC system which is a tactical command, control, and communications provides interoperability between tactical and strategic communications systems in the U.S. The major component of the TRI-TAC is a circuit switch AN/TTC-39D designed to provide secure and non-secure automatic switching capability to terminate 712 lines. And it can interface with NATO telephone systems for EAC (Echelon Above Corps) units[9].

3.1 Measurement of Traffic Line Return Loss

Based on the EUROCOM STANAG 5040, the return loss from the connection point of the SAI output port and NATO interface cable was measured 32.3 dB by HP TIMS (Transmission Impairment Measurement Set) 4936A and input signal was -20 dBm at 820 Hz and out signal was -30.5 dBm. It satisfied the STANAG 5040 specification of 18 dB. The return loss in the other direction from the SAI and SB-Y interconnection port was only 10.5 dB which was not enough loss for the STANAG 5040 requirement of 18 dB. This issue was fixed and confirmed after the test by the ADD.

3.2 Measurement of Crosstalk

Measurement of crosstalk between traffic lines and receive lines, and measurement of crosstalk between traffic lines and signal lines were carried out in this test. Figure 3 shows crosstalk measurement of SAI and NAI using HP 4936A TIMS from channel 1 to channel 2[10]. To measure crosstalk, we established call connections for both channels and terminate the traffic lines with 600 ohm resistor. The maximum crosstalk of traffic signal line was -61 dB which satisfied the STANAG 5040 requirement of less than -65 dB.

3.3 Measurement of Insertion Loss and Linear Dynamic Operating Range

In order to obtain good performance, it is required to measure low insertion loss of the system. Base on the bench test measurements, U.S recommended that the ADD reduce the dynamic range of the SAI traffic signal. ADD implemented the recommendation and Figure 4 shows the measurement of insertion loss for channel 1 traffic line. With input signal frequency of 820 Hz, measured data are shown in Table 1. The STANAG 5040 specification

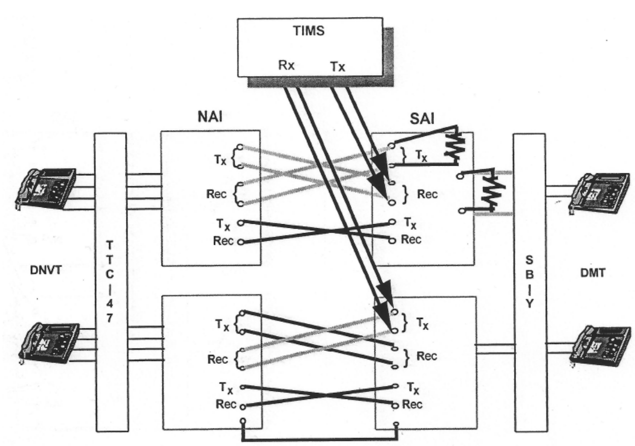

Figure 3. Crosstalk Measurement of the SAI and the NAI.

requires ±0.5 dB within -2 dBm dynamic range and the insertion loss of SAI satisfied this requirement.

3.4 Measurement of Signal Line Impedance of SAI

Using a HP multi-meter HP 3468A, we measured the open circuit resistance and the closed circuit resistance as shown in Figure 5. R_D in Figure 5 denotes control signal detector. Two surge protectors were used to limit the voltage supplied to SAI by either blocking or by shorting to ground any unwanted voltages above a safe threshold[11]. STANAG 5040 Specification requires the open circuit resistance of more than 100 KΩ and the closed circuit resistance of less than 100 Ω. We got the open circuit resistance of 105 MΩ and the closed circuit resistance of 1.9 Ω for channel and the closed circuit resistance of 1.8 Ω for channel 2, respectively. The measured resistance values satisfy the STANAG 5040 specifications. These interoperability tests demonstrated that the ROK SPIDER and the U.S TRI-TAC/MSE systems interoperable.

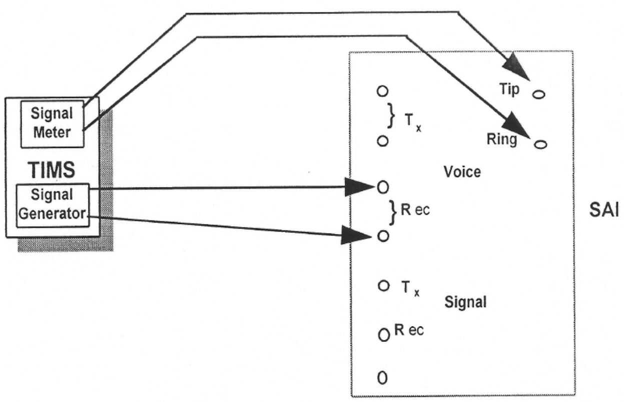

Figure 4. Measurement of Insertion loss of the SAI.

Table 1. Measurement data of insertion loss of the SAI

Input level (dBm)	Output level for Rec to Tip & Ring (dBm)	Loss (dB)	Output level for Tip & Ring to Tx (dBm)	Loss (dB)
-30	-29.5	0.5	-30.1	-0.1
-25	-24.6	0.4	-25.1	-0.1
-20	-19.5	0.5	-20.1	-0.1
-15	-14.6	0.4	-15.1	-0.1
-10	-9.5	0.5	-10.1	-0.1
-5	-4.5	0.5	-5.1	-0.1
-2	-1.5	0.5	-2.1	-0.1

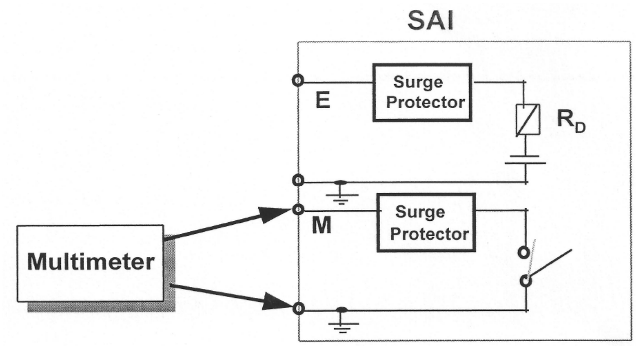

Figure 5. Measurement of signal line impedance of the SAI.

4. Conclusions

The complexity of modern weaponry, the sophistication acquisition means have resulted in a tremendous increase in the volume of the traffic flow, information data carried through in various forms. A military communication network must be adapted to match forces organization and the predictable type of combat. If several Army Corps communication networks are deployed close together, they are connected together by using an automated interface installation. The ROKA developed SPIDER, digital common user system, and has developed a prototype analog interface device (SAI) to provide the interoperability with U.S. TRI-TAC/MSE. In this paper the SAI electrical characteristics were described. From the experimental interoperability test results, the compatibility of the SAI and the NAI was confirmed based on the STANAG 5040 specification.

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