

# Digital Radio Linking Using T1/E1

## White Paper

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## Introduction

This white paper discusses the use of linking digital radio sites using T1/E1 links rather than the more common IP based links. The connection of various digital repeater systems discussed with test setups and results are provided.

T1 or E1 links provide a cost effective alternative and can be used to link multiple repeaters on an individual site.

Most digital radio repeaters have an Ethernet port to allow direct connection to other network elements (other repeaters, repeater sites, network management and dispatch).



Where an IP connection is available, setting up and connecting to a radio network is quick and easy. In this case the term “digital repeater” is used as a generic term for any digital format such as P25, DMR or dPMR (NexEdge).

The IP Connection is often provided via an ISP, fiber, or microwave link but one that can sometimes fly under the radar is the use of T1 links to connect radio systems.

## Why use T1?

T1 lines are generally available in much of the US and are a cost-effective solution for linking radio sites. As a typical digital radio system uses less than 40kb/s per channel, you can connect multiple repeaters at a site to a single T1. However in order to achieve this, you will need to use a converter such as the TC Communications TC8619 Ethernet to T1 Multiplexer, as the T1 lines do not connect directly to the Ethernet port of the repeater as T1 is not natively IP compatible.

## What is a T1/E1?

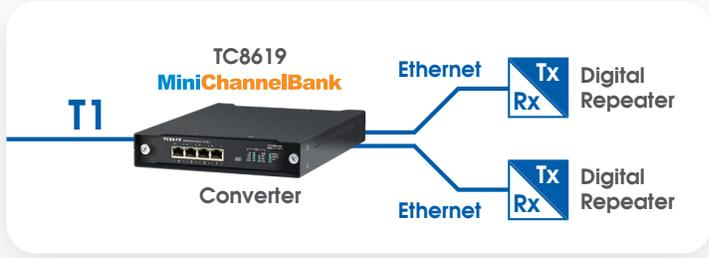
Originally defined as a specification for carrying multiple time division multiplexed (TDM) telecommunications channels over a 4 wire transmission circuit.

The T1 is used in the US and can transmit 24 telephone calls simultaneously. As the calls are transmitted digitally with each call using 64kb/s the T1 is a link that carries a data throughput of 1.544MB/s.

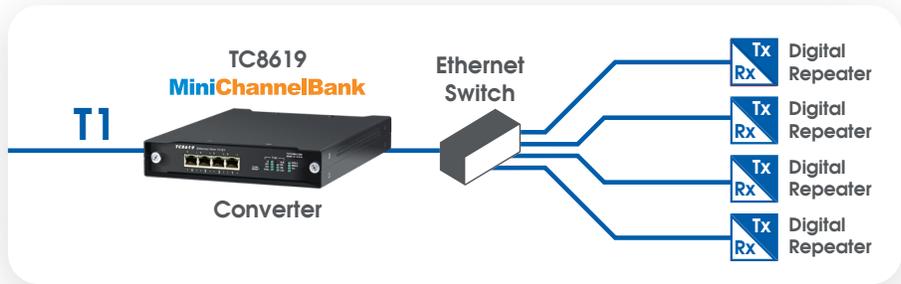
Outside of the US the standard used is E1, which carries 32 calls and therefore has an overall data throughput of 2.048Mb/s.

T1 and E1 are not compatible, but many devices such as the ones from TC Communications are compatible with both standards.

A typical setup is shown below:



Most Ethernet to T1 Conversion devices have more than one Ethernet port which allows the connection to multiple repeaters without the use of a switch. In the above example 4 digital radio channels can be connected without the use of a switch, however if there is a need for more repeaters, the addition of an Ethernet switch allows for easy connection of more repeaters. Based on typical specifications, 20+ digital channels can easily be supported using a single T1 link, making this a very reliable and cost effective solution.



The T1 signaling is synchronous, very reliable, and exceeds the latency and jitter requirements of various digital systems. A comparison of link options is provided in the following table.

	Capital Cost	Operating Cost	Link Specs
T1	0	\$\$	✓
Fiber IP	0	\$\$	✓
Microwave	\$\$\$	\$	✓
LTE		\$	X

\*LTE links such as Verizon cradlepoint do not meet the link standards for most digital radio systems

## Product tested:

# The TC Communications TC8619 Ethernet to T1 Multiplexer



## IP-over-T1/E1 Multiplexer

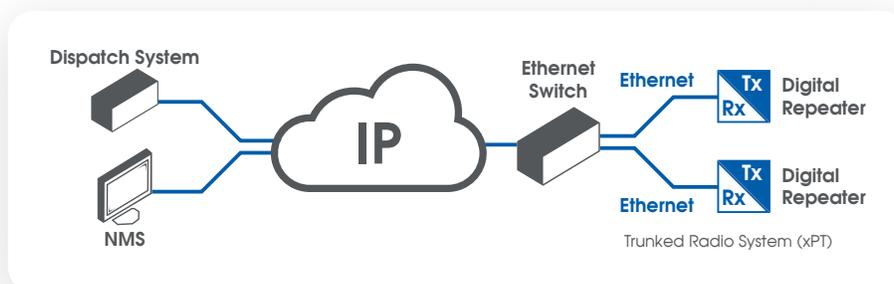
### TC8619

- Fast Ethernet Transport over Framed T1 or E1
- IEEE 802.1p QoS with Four Queues
- Strict or Weighted Round Robin Priority Scheduling
- Extreme Temp (-40°C to +80°C) Optional
- Built-in Power Redundancy
- Meets or Exceeds IEC 61850-3, IEEE 1613 & NEMA TS-2 Standards
- Member of the Mini Channel Bank Product Family

## Testing

To test the TC8619 we used two modern trunking systems and the associated dispatch solution. The trunked systems used was XPT, transmission trunked and DMR Tier 3, which is message trunked. This combination is typical of digital radio technology, including competing technologies to DMR such as P25 and dPMR.

### XPT (Transmission trunked)



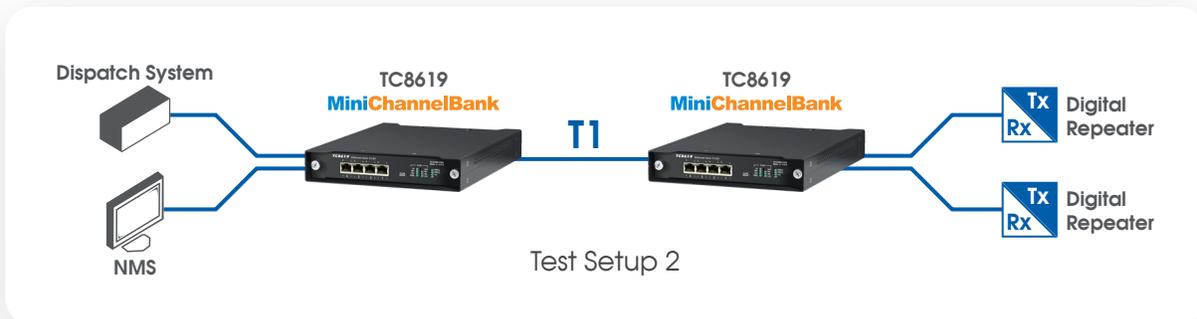
In this case the 'IP link' was simply an Ethernet cable providing minimal delay, so part of the testing was to see if there was an increase in digital delay by using the T1.

Initially we simply replaced the IP connection with the T1 based Ethernet connection:



This worked immediately. As soon as we replaced the link with the T1 based solution, the system instantly became operational and the Network Management System reported all the linking to be within the expected limits.

We then eliminated the switch as we had two repeaters and the TC8619 has four Ethernet ports. The test setup looked as follows and worked exactly as before.

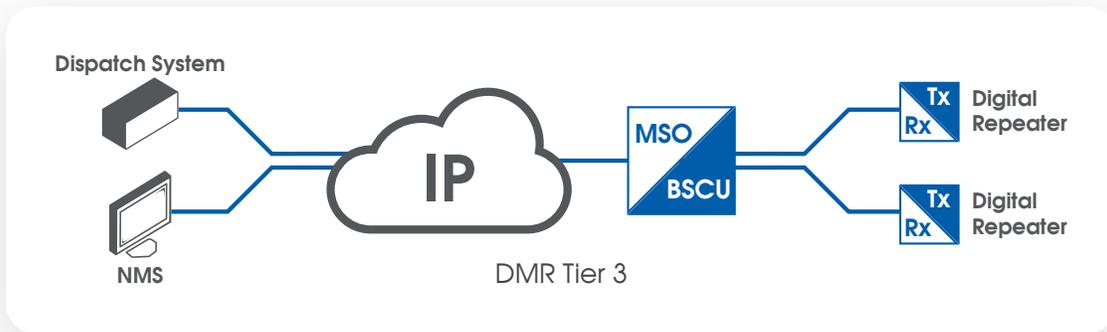


We placed multiple simultaneous voice calls through the dispatcher and the audio was crisp, clear and there was no increase in delay by using the T1 link.

We did not have 20 repeaters on hand so we did not test the limitations of the number of repeaters that could be linked using the T1, but as the XPT system does not have a central audio switch, it is quite data heavy between the sites and so a T1 link is a good solution with the capability to link over 20 repeaters in the system.

The second system we tested was a DMR Tier 3 system. This is a message trunked system which also utilizes a central switching for the audio in inter-site communications. Based on this, the data requirements are lower, however the link with the control channel is required to have very low latency and jitter, leading to issues with some linking technologies, most typically seen with LTE based Ethernet linking devices.

Setup was as follows:



As we did with the XPT Trunking system, we initially replaced the IP link (again this was a simple Ethernet cable) with the T1 link.



Once again, as soon as the system was connected it operated perfectly. There were no link alarms and the links were well within the required parameters. Multiple calls from the dispatcher were setup and again there was no increase in digital delay across the system.

We would've liked to have tested the T1 as an MSO to BSCU link, but in the setup we were using, these were installed on the same server so this was not possible. Based on the required specifications, we are certain that this will work reliably and well within parameters.

## Conclusion

The T1 is a very good choice for connecting digital radio networks, however this option may be overlooked because the T1 is not directly compatible with the IP/Ethernet connectivity of most digital repeaters. The use of devices such as the TC8619 to interface between the repeaters and the T1 allows a user a cost effective and reliable option for site linking that otherwise may not be considered.

# T1 Extra products

As well as providing Ethernet over T1, TC Communications provides a wide variety of solutions for connecting legacy devices over T1.

The following shows the TC Communications product range with the T1/E1 options Highlighted.

Product Matrix		Click on any product		TC COMMUNICATIONS®		
		Transport				
		Ethernet/IP	T1/E1	Dark Fiber		
Ethernet	TC3841	6-port copper Gb Ethernet	TC3844-1	1-ch. Ethernet over T1/E1	TC3212	Ethernet Media Converter
	TC3842	6-port SFP Gb Ethernet	TC3844-3	1-ch. Ethernet over T3/E3	TC3240	4-port Ethernet Media Converter
	TC3840DR2	Managed Industrial Switch	TC8619	4-ch. Ethernet over T1/E1	TC3340	2+2-ports Fiber Ethernet Switch
	TC3850-1	10G Multi-Service Ethernet				
Analog Leased Line Replacement, 4W/2W E&M	TC3846-6	4-ch. 600 Ω Analog + Dry Contact	TC8614	4-ch. 600 Ω Analog + Dry Contact	TC1901	Fiber Phone/Analog Extender
			TC8624	8-ch. 600 Ω Analog + Dry Contact	TC8000	28-ch. Analog Multiplexer
G.703/64K	TC3846-1	2-ch. G.703/64K				
C37.94	TC3846-2	2-ch. C37.94	TC8616	2-ch. C37.94	TC3025	C37.94 Mode Converter
Serial RS-232 RS-422 RS-485 V.24	TC3847-1	4-ch. Serial Server	TC8610-1	4-ch. Serial	TC1705	Multi-Interface Fiber Modem
	TC3847-3	4-ch. Turbo Serial	TC8631-1	4-ch. Serial	TC1710	Data Fiber Modem
	TC3847-4	2-ch. RS-422 Sync Serial	TC8631-4	2-ch. Serial	TC8108	Serial Data Multiplexer
	TC3847-7	2-ch. RS-422 Sync Turbo Serial			TC8116	16-ch. Data Multiplexer
Analog Phone FXS FXO	TC1910	Phone/Analog over Eth Extender	TC8618	4-ch. Voice	TC1901	Fiber Phone/Analog Extender
	TC1920	1-ch. Phone over Ethernet w/ built-in PBX	TC8638-1	4-ch. FXS	TC1903	Phone/Analog Extender (1-fiber bi-directional option)
	TC3848-1	4+1-ch. VoIP+ w/Virtual PBX	TC8638-2	4-ch. FXO	TC1905	Fiber Optic Phone Dry Contact Extender
	TC3848-2	5-ch. VoIP+ w/Virtual PBX				
	TC3848-3 & TC3848-4	4-ch. Modem over IP (FXS or FXO)			TC8800	28-ch. Phone Multiplexer
T1/E1 T3/E3	TC3845-1	4-ch. T1/E1			TC1631	T1/E1 Modem
	TC3845-3	1-ch. T3/E3			TC1680	T3/E3 Fiber Optic Modem
WDM					TC8518	4-28 ch. T1/E1 w/Ethernet Mux
Dry Contact	TC3847-5	8-ch. Dry Contact	TC8612	8-ch. Dry Contact	TC4001	2-ch. Wave Division Fiber Mux
Alarm Monitoring	TC3847-6	8-ch. Alarm Monitoring Control			TC8116	Multi-Interface Fiber Data Mux
OC-3/STM-1						
Ethernet	TC3844-5 Ethernet over OC-3					

**Legend** JunDoSwitch® MiniChannelBank JunDoBank® Fiber

DIN Rail Option



TC Communications® connecting legacy devices to modern networks.



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Note: Information contained in this document is subject to change without prior notice. LT201214 ver121620