Retlif Testing Laboratories

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27777 Franklin Road
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FCC PART 15 TEST REPORT
ON

UNION SWITCH & SIGNAL, INC.'S
DIGITRAC
FCC ID: J8C6MXDUALANTENNA

CUSTOMER NAME: Union Switch & Signal, Inc.

CUSTOMER P.O.: C96M06E21

DATE OF REPORT: April 9, 1999

TEST REPORT NO.: R-7999

TEST START DATE: March 16, 1999

TEST FINISH DATE: March 25, 1999

TEST TECHNICIAN: Dennis Cortes

TEST ENGINEER: T. Schneider

SUPERVISOR: R. Reitz

REPORT PREPARED BY: T. Schneider

GOVERNMENT SOURCE INSPECTION: Not Applicable

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CERTIFICATION AND SIGNATURES

We certify that this report is a true representation of the results obtained from the tests of the equipment stated. We further certify that the measurements shown in this report were made in accordance with the procedures indicated and vouch for the qualifications of all Retlif Testing Laboratories personnel taking them.

Thomas J. Schneider
EMC Test Engineer

Richard J. Reitz
Laboratory Manager

NON-WARRANTY PROVISION
The testing services have been performed, findings obtained and reports prepared in accordance with generally accepted laboratory principles and practices. This warranty is in lieu of all others, either expressed or implied.

NON-ENDORSEMENT
This test report contains only findings and results arrived at after employing the specific test procedures and standards listed herein. It is not intended to constitute a recommendation, endorsement or certification of the product or material tested. This test report must not be used by the client to claim product endorsement by NVLAP or any agency of the U.S. Government.

REVISION HISTORY

Revision	Date	Pages Affected

ADMINISTRATIVE DATA

RETLIF TESTING LABORATORIES TEST REPORT NUMBER: R-7999

CUSTOMER: Union Switch & Signal, Inc.
1000 Technology Drive
Pittsburgh, PA. 15219-3120

TEST SITES: Testing was performed on Retlif's Open Air Test Site located in Ronkonkoma, NY.

APPLICABLE DOCUMENTS: See Applicable Documents Paragraph 2.0

1.0 SCOPE

The purpose of this FCC Part 15 Test Report is to define the procedures and test methods which were used in conducting radiated emissions measurements on the DIGITRAC. The intention of this testing was to determine compliance with Part 15 of the FCC rules in a configuration which represents emission levels which will be encountered when the system is installed on a train.

2.0 APPLICABLE DOCUMENTS

The following documents form a part of this test report to the extent specified herein:

RCM-001, Retlif Testing Laboratories, Calibration Manual.

RQM-001, Retlif Testing Laboratories, Quality Assurance Manual.

MIL-STD-45662A, Calibration System Requirements.

Part 15, Federal Communications Commisssion, Rules and Regulations, Part 15-Radio Frequency Devices.

ANSI C63.4-1992, Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 Ghz.

3.0 GENERAL REQUIREMENTS

3.1 TEST ENVIRONMENT

Testing was performed at Retlif's Open Air Test Site(OATS), located in Ronkonkoma, NY. The test area was kept free of all unnecessary personnel and equipment within the constraints of the location.

3.2 TEST INSTRUMENTATION

A listing of all test instrumentation which was utilized for testing is contained within each applicable test method. These listings indicate the model, manufacturer, frequency range, last calibration date and calibration due date of all instrumentation which was utilized. All instrumentation utilized was calibrated prior to use in accordance with the procedures set forth in Retlif Testing Laboratories standard manuals RCM-001 and RQM-001 which are in accordance with the requirements of MIL-STD-45662A.

3.2.1 Measurement Accuracy

The accuracy of all formal field measurements is as follows:

Frequency Accuracy: ± 2%

Amplitude Accuracy: ±2 dB

3.2.2 Detector Function

The peak detector and quasi-peak detector functions of the EMI analyzer or measuring system were used for all applicable measurements during the course of formal testing. Detector function used was dependent on frequency range of measurement. A listing of detector function used is listed in Table 1 in paragraph 3.2.3 herein. Where average limits were specified, peak measurements were taken and either measured or calculated duty cycle factors were applied to determine compliance with the applicable limits. The provisions of 15.35(b) for limiting peak emissions was also verified.

3.2.3 Measurement Bandwidths and Measurement Detectors

All measurements were taken utilizing the frequency ranges, resolution bandwidths, and detectors as specified in Table 1, below. These parameters were derived from the requirements set forth in FCC Part 15 and ANSI C63.4. For each resolution bandwidth specified below, the video bandwidth was set to at least 3 times the resolution bandwidth. The entire frequency range was scanned, and data recorded, for each applicable method.

3.2.3 Measurement Bandwidths and Measurement Detectors (continued)

3.2.3 Measurement Bandwidths and Measurement Detectors (continued)

TABLE 1 - Emission BANDWIDTH AND DETECTOR FUNCTIONS

Frequency Range	Resolution Bandwidth	Detector function
9 kHz to 90 kHz	200 Hz	Peak
90 kHz to 110 kHz	200 Hz	Quasi-Peak
110 kHz to 150 kHz	200 Hz	Peak
150 kHz to 490 kHz	10 kHz	Peak
490 kHz to 1.705 MHz	10 kHz	Quasi-Peak
1.705 MHz to 30 MHz	10 kHz	Quasi-Peak
30 MHz to 1000 MHz	100 kHz	Quasi-Peak

3.2.4 Measurement Antennas and Antenna Height

Electric field strength measurements were measured using the types of antennas and antenna heights specified in TABLE 2 below.

TABLE 2- MEASUREMENT ANTENNAS AND ANTENNA HEIGHTS

Frequency Range	Antenna Type	Antenna Height
9 kHz to 30 MHz	Loop	1 meter
30 MHz to 200 MHz	Biconical	varied; 1 to 4 meters
200 MHz to 1000 MHz	Log Periodic	varied; 1 to 4 meters

3.2.5 Measurement Distances

All measurements were recorded at a distance of three meters. The measurement distance was taken from the envelope of the test sample. At frequencies below 30 MHz measurement results were extrapolated to the specified distance using the square of an inverse linear distance extrapolation factor (40 dB/decade) as specified in paragraph 15.31(f)(2) of the FCC rules, except for the fundamental transmit frequency which was measured by taking measurements at two test distances and then calculating the extrapolation factor as specified in 15.31(f)(2) of the FCC rules.

4.0 TEST SAMPLE DESCRIPTION

4.1 GENERAL

The DIGITRAC is part of a train wayside signaling system. The system is comprised of a 200 kHz transmitter/27 MHz receiver which is train mounted and a 200 kHz receiver /27 MHz transmitter (transponder) which is mounted wayside(this device is not covered in this test report). The 200 kHz transmitter is mounted on the underside of a locomotive approximately 15 inches above the ground with it's antenna pointed toward the ground and is powered by 72 VDC supplied by the train. The 200 kHz transmitter inductively couples power to the wayside transponder as the train passes over it at a given location. The wayside transponder transmits a unique message back to the train at 27 MHz.

4.2 TEST CONFIGURATION

In order to represent the actual installation on a train as closely as possible, the 200 kHz transmitter was placed on top of the non-metallic 80cm high table with the antenna facing downward as it would be mounted on a train. The non-metallic table was mounted to a turntable which is remotely rotated a full three-hundred and sixty degrees during measurements.

5.0 TEST METHODS PERFORMED

5.1 TEST METHOD SUMMARY

The following test methods were performed as described in the referenced paragraphs herein:

PARAGRAPH	DESCRIPTION	RESULTS
5.2	RADIATED EMISSIONS, 200 KHZ TRANSMITTER	Complied

5.2 RADIATED EMISSIONS, 200 KHZ TRANSMITTER

PURPOSE

The DIGITRAC train mounted transmitter's fundamental field strength and spurious case emissions were measured from 9 kHz to 500 MHz in order to determine compliance with the limits specified in FCC Part 15, Subpart C.

LIMITS

The limits listed in the table below were used to determine if the equipment complies with the requirements of FCC Part 15. These limits were derived from section 15.209 :

FREQUENCY (MHz)	FIELD STRENGTH (MICROVOLTS per METER)	EXTRAPOLATION FACTOR (dB/DECADE)
0.200	12	63.4*
0.009-0.490	2400/F (kHz)	40
0.490-1.705	24,000/F (kHz)	40
1.705-30.0	3000	40
30-88	100	N/A
88-216	150	N/A
216-500	200	N/A

*-At the fundamental transmit frequency the measurements were performed at two test distances; 3 & 10 meters. The extrapolation factor was then calculated from the measurements obtained at these two distances as follows:

Field Strength at 3 meters= 124.3 dBuV/M

Field Strength at 10 meters= 91.2 dBuV/M

Difference in Field Strength from 3 to 10 meters= 124.3 - 91.2= 33.1 dB

Difference in test distance in Decades= log(10/3)= 0.522 Decades

Extrapolation Factor = (33.1 dB/ 0.522 Decades)= 63.4 dB/Decade

TEST SETUP

In order to represent the actual installation on a train as closely as possible, the 200 kHz transmitter was placed on top of the non-metallic 80cm high table with the antenna facing downward as it would be mounted on a train. The non-metallic table was mounted to a turntable which is remotely rotated a full three-hundred and sixty degrees during measurements. The measurement antenna was placed a distance of 3 meters from the envelope occupied by the DIGITRAC transmitter and additionally at 10 meters when measuring the fundamental. A pre-amplifier and spectrum analyzer were connected to the measurement antenna via a fifty ohm coaxial cable.

TEST PROCEDURE

With the test setup as specified above the following procedure was performed:

1. The loop antenna was mounted on a tripod at a 1 meter vertical height.
2. The spectrum analyzer was configured to measure the fundamental transmit frequency using a peak detector.
3. The loop antenna and turntable were rotated 360 degrees until the maximum reading was obtained on the spectrum analyzer.
4. The antenna position, orientation, meter reading, and antenna factor was recorded.
5. Steps 2 thru 4 were repeated with the loop antenna horizontally polarized.
6. The spectrum analyzer was configured to measure emissions in the 9 kHz to 150 kHz range.
7. Steps 3 thru 5 were repeated for each emission found in the 9 kHz to 150 kHz range.
8. The spectrum analyzer was configured to measure the 150 kHz to 30 MHz range.
9. Steps 3 thru 5 were repeated for each emission found within the 150 kHz to 30 MHz range excluding the fundamental transmit frequency.
10. The loop antenna and tripod were replaced with the biconical antenna and a mast which varied the antenna height from 1 to 4 meters.
11. The biconical antenna, vertically polarized, was placed 3 meters from the test sample and the analyzer was configured to measure emissions in the 30 MHz to 200 MHz range.

TEST PROCEDURE (continued)

12. At each frequency that an emission was found, the following steps were performed:
    a. The antenna height was varied from 1 to 4 meters.
    b. The antenna was horizontally polarized, and height varied from 1 to 4 meters.
    c. The test sample was rotated 360 degrees.

13. When the maximum meter reading was achieved, the meter reading, antenna factor, antenna polarization, test sample orientation and antenna height was recorded.

14. The biconical antenna was replaced by the log periodic antenna, and the spectrum analyzer was configured to measure the 200 MHz to 500 MHz range. Steps 11 thru 13 were repeated.

TEST RESULTS

The 200 kHz transmitter complied with all the emissions requirements specified in Paragraph 15.209 of the FCC Rules when tested as stated above. See the two data sheets following for a complete presentation of the test results.

200 kHz Transmitter

Fundamental Emission Measurements

Test Method:	FCC Part 15 Radiated Emissions, Fundamental Field Strength		
Customer:	Union Switch and Signal	**Job No.**	R-7999
Test Sample:	200Khz Carborne Transmitter		
Model No.:	6219	**Serial No.**	1397002
Operating Mode:	Continuously transmitting 200 Khz signal. EUT located .8 meters above groundplane.		
Technician:	Dennis Cortes	**Date:**	March 25,1999

Notes: Test Distance: 3 Meters or 10 Meters as specified below Temp:10C Humidity:40%
Detector: Peak

Test Freq.	Antenna Position	EUT Orientation	Meter Reading	Correction Factor	Corrected Reading	Extrapolated Reading	Converted Reading	Limit (300M)
Mhz	(V/H)	Degrees	dBuv	dB	dBuv/m	dBuv	uv/m	uV/m
3 meters:								
0.199	H-180	180	65.3	59.0	124.3	-2.5	0.75	12.0
10meters								
0.199	V-180	180	32.2	59.0	91.2	-2.5	0.75	12.0

Extrapolation Factor = 63.4 dB/decade

Retlif Testing Laboratories

Retlif Job Number R-7999

200 kHz Transmitter

Spurious Case Emission Measurements

Test Method:	FCC Part 15 Radiated Emissions, Spurious Case, 9 khz to 500 Mhz		
Customer:	Union Switch and Signal	**Job No.**	R-7999
Test Sample:	200Khz Carborne Transmitter		
Model No.:	6219	**Serial No.**	1397002
Operating Mode:	Continuously transmitting 200 Khz signal. EUT located .8 meters above groundplane.		
Technician:	Dennis Cortes	**Date:**	March 25,1999

Notes: Test Distance: 3 meters Temp:10C Humidity:40%
Detector: Quasi-Peak except for readings between 110-490Khz (Peak)

Test Freq.	Antenna Position	EUT Orientation	Meter Reading	Correction Factor	Corrected Reading	Extrapolated Reading	Converted Reading	Peak Limit
Mhz	(V/H)	Degrees	dBuv	dB	dBuv/m	dBuv	uv/m	uV/m
.009								266.7
.399	H-180	180	32.6	36.0	68.6	-11.4	0.3	6.0
.490								4.89
.490								48.9
.598	H-180	180	27.2	35.0	62.2	22.2	12.9	40.0
.796	V-180	180	20.5	33.0	53.5	13.5	4.7	30.1
1.705								14.0
1.705								30.0
1.989	V-180	180	18.9	29.0	47.9	7.9	2.5	
2.379	V-180	180	20.6	27.5	48.1	8.1	2.5	
V								V
30.0								30.0
30.0								100
40.0	V-1.0	180	31.8	-5.4	26.4	26.4	20.9	
64.6	V-1.0	180	33.1	-10.9	22.2	22.2	12.9	
70.7	V-1.0	338	32.0	-11.2	20.8	20.8	11.0	
74.0	V-1.0	158	24.0	-11.2	12.8	12.8	4.4	
								V
88.0								100
88.0								150
110.6	V-1.0	045	34.0	-10.5	23.5	23.5	15.0	
								V
216.0								150
216.0	The EUT was scanned from hz to 500 Mhz							200
	All readings below 30 Mhz were extrapolated via $1/D^2$							
								V
500.0								200

Retlif Testing Laboratories

Retlif Job Number R-7999

TEST EQUIPMENT LIST

EQUIPMENT LIST

FCC Part 15 Radiated Emissions, 9 kHz to 500 MHz

EN	Type	Manufacturer	Frequency Range	Model No.	Cal Date	Due Date
012	Loop Antenna, Active	EMCO	9 kHz - 30 MHz	6502	10/12/98	10/12/99
067	Open Area Test Site	Retlif	3 Meter	RNY	8/30/97	8/30/99
092H	Loop Antenna	Empire Devices	150 kHz - 30 MHz	LP-105	6/4/98	6/4/99
133	Broadband Pre-Amplifier	Electro-Metrics	10 kHz - 1 GHz, 26dB	BPA-1000	6/22/98	6/22/99
141	Spectrum Analyzer	Hewlett Packard	100 Hz - 40 GHz	8566B	3/16/99	9/16/99
141A	Graphics Plotter	Hewlett Packard	N/A	7470A	3/5/99	3/5/00
141B	Quasi-Peak Adaptor	Hewlett Packard	100 Hz - 1 GHz	85650A	3/16/99	9/16/99
206B	6.0 dB Attenuator	Texscan	0 - 1.0 GHz	FP-50 - 6 dB	6/22/98	6/22/99
544	EMC Analyzer	Hewlett Packard	9.0 kHz - 1.8 GHz	8591EM	8/6/98	8/6/99

EXHIBIT 1

FCC ID LABEL

Item 7: Draft of FCC ID Label (located on the top surface of the antenna)

FCC ID: J8C6MXDUALANTENNA
DIGITRAC

This device complies with Part 15 of the FCC Rules. Operation is subject to the following conditions: (1) This device may not cause harmful interference and (2) This device must accept any interference received, including interference that may cause undesired operation.

Item 8: The antenna is one component in the US&S Digitrac System. It is typically mounted on board a train and powered by 72VDC. The antenna inductively transmits power at 200 kHz to a wayside transponder as a train passes over the given location. The wayside transponder transmits a unique message back to the train at 27 MHz.

The carborne antenna receives 72VDC power from the Interrogator, mounted in a separate enclosure on board the train. The 200 kHz is generated by a transistorized push-pull inverter, the operating frequency controlled by LC elements in the inverter feedback path. The inverter drives a 200 kHz transmitting loop, which is etched onto the Antenna PCB. Inside the 200 kHz transmitting loop is a smaller pickup loop tuned to 27 MHz. This antenna picks up the signal returned by the wayside transponder. This received signal is carried back to the Interrogator via interconnecting cable for further processing.

EXHIBIT 2

EQUIPMENT PHOTOGRAPHS

EXHIBIT 3

SERVICE MANUAL

UNION SWITCH & SIGNAL
A member of the ANSALDO Group
5800 Corporate Drive, Pittsburgh, PA 15237

SERVICE MANUAL 7020

User's Manual

DIGITRAC®

Train Location System

Asynchronous Serial Output
Issue 2

Formerly Dynamic Sciences Limited Document
Reference 176-0003-00

July, 1990
A-2/93-2992-1

ANSALDO
Trasporti

NOTICE

Effective July, 1992, this document became the property of Union Switch & Signal Inc. All references to "Dynamic Sciences Limited" and "DSL" apply to Union Switch & Signal Inc.

For service on this Union Switch & Signal product, please contact:

Union Switch & Signal Inc.
The Service Shop
645 Russell St.
Batesburg, SC
29006

Toll-Free Phone: 1-800-652-7276
Fax: 803-532-2940

INTRODUCTION

This manual gives an overview description of DIGITRAC®, the Transponder/ Interrogator train location technology chosed for the Advanced Train Control System (ATCS).

DIGITRAC technology has been used in train service for many years. Its design objective was to utilize the most appropriate technology for the best possible accuracy and reliability in determining train location. No secondar applications were considered or included which might detract from the objective. It has been thoroughly tested and evaluated in many diverse applications and has an outstanding record of service.

During the process of selecting train location technology for the ATCS, several candidate systems were tested by the AAR at the Pueblo test track. DIGITRAC gave the best performance of all the equipment tested and this resulted in its selection and approval as the ATCS standard.

The equipment described in this manual is fully compliant with ATCS spec 335, except: i) data output to the user is asynchronous serial rather than HDLC; ii) data format is greatly simplified; and, iii) some connectors are different. For details on the fully compliant system, see manual 176-0000-00.

PROPRIETARY CONFIDENTIAL INFORMATION

This document contains commercial and technical and data designs which are the exclusive property of DSL Dynamic Sciences Limited (DSL) and may contain proprietary information of others, which shall not be used, copied or disclosed in any way to any third party, without the prior written consent of the Manager of Contracts of DSL. The recipient of this ducoment, bu its retention and use, agrees to maintain it in confidence using the same safeguards as it uses to protect its own confidential information.

PATENT INFORMATION

Patents are issued on the equipment described in this manual.

In the USA, the following patent is issued:

Object Location/Identification System, Patent 3,898,619

REGISTERED TRADEMARK

DIGITRAC® is a Registered Trademark of DSL Dynamic Sciences Limited (United States Trademark Registration No. 1,158,953; Canadian Trademark Registration No. 252,080).

FCC ID: J8C6MXDUALANTENNA
DIGITRAC

This device complies with Part 15 of the FCC Rules. Operation is subject to the following conditions: (1) This device may not cause harmful interference and (2) This device must accept any interference received, including interference that may cause undesired operation.

Caution: Any modification to this device not expressly approved by Union Switch & Signal Inc. could void the user's authority to operate this device under Part 15 of the FCC Rules.

PREFACE

This manual is intended for reference by users and potential users of DIGITRAC. It contains all the information necessary to procure, install, and operate the equipment. Any changes which occur after the printing date will be issued on pink addendum sheets bearing the same document number. Questions regarding the manual should be directed to:

DSL Dynamic Sciences Limited
4279 Canada Way
Burnaby, B.C.
Canada V5G 4P1

Telephone: (604)437-1600
In U.S.: (800)663-8667
Fax: (604)439-1472
Telex: 04-352848 Vcr

This manual covers the following units:

Transponder	Model 6130	Order number 031-0012-00
Antenna	Model 6219	Order number 031-0110-00
Reader	Model 6507/8	Order number ~~031-0104-00~~ 031-0043-00

WARRANTY

(a) Seller's liability in respect of any defect in or failure of the Products supplied hereunder, or for any loss, damage or injury attributable thereto, is limited to making good by repair or replacement, at Seller's discretion, defects which under proper use, care and maintenance, appear therein and arise solely from defective design, materials or workmanship, within a period of twelve (12) months from delivery, PROVIDED ALWAYS THAT:

(i) Buyer advises Seller of any such defect or failure within thirty (30) days of its occurrence; and

(ii) Buyer obtains Seller's authorization to return, at Buyer's expense, the defective Product or part, in the following way; upon receipt by Seller of the serial number and proper identification of the defective Product, Seller shall issue to Buyer a return authorization number which must appear on labels and documents accompanying the returned Product. A full description of the fault must also accompany each return.

(b) Seller shall return the repaired unit or a replacement thereof prepaid to Buyer.

(c) Repair, attempted repair or alteration, by other than Seller or its authorized representative, without prior authorization, in writing by Seller, or alteration or effacement of any part of Seller's nameplate or marking affixed to a Product supplied by Seller, shall void this Warranty.

(d) Products not identified by Seller's nameplate are expressly excluded from this Warranty. However, Seller will pass on to Buyer the warranties, received from it ssuppliers, if any and to the extent it is permitted to do so, but only so far as to not impose on Seller a liability greater than that imposed on Seller by this Warranty.

(e) No warranty is given in respect of any consumable items.

(f) NO WARRANTIES, WHETHER STATUTORY, EXPRESSED OR IMPLIED, INCLUDING BUT NOT LIMITED TO THOSE OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE, OTHER THAN THOSE EXPRESSED IN THIS ARTICLE SHALL APPLY TO THE PRODUCT OR SERVICE AND, IN ANY EVENT, SELLER SHALL NOT BE LIABLE TO BUYER OR ANY OTHER PERSON FOR ANY DAMAGE, INJURY OR LOSS, INCLUDING WITHOUT BEING LIMITATIVE LOSS OF USE, REVENUE OR PROFIT, OR ANY OTHER ECONOMIC LOSSES, OR FOR ANY DIRECT OR INDIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGES.

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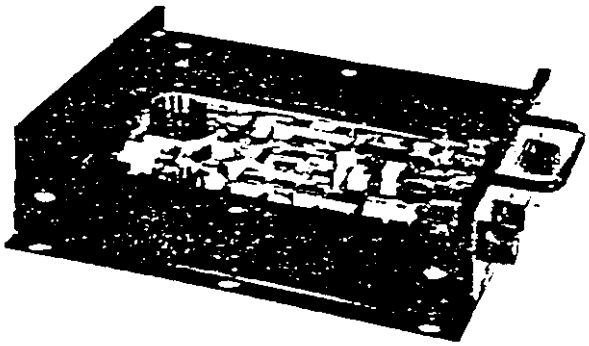
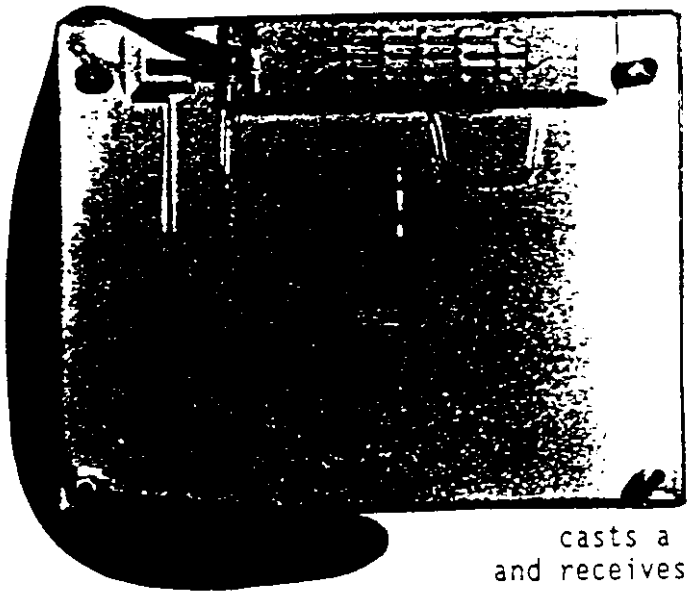
DIGITRAC SYSTEM

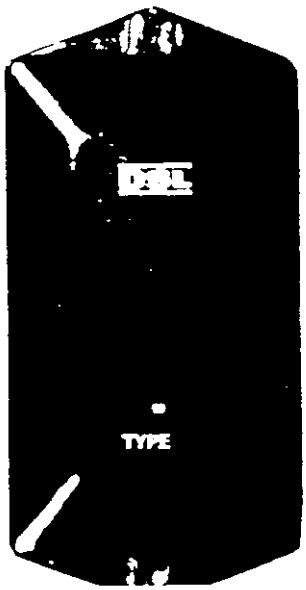
DIGITRAC READER
The DIGITRAC Reader is a micro-computer-based data acquisition unit. It interfaces to vehicle power directly and supplies power to the antenna unit. Transponder data signals received by the antenna are demodulated in the reader and checked for integrity. After verification, the validated transponder number is available at the reader output interface.





ANTENNA
The DIGITRAC antenna is a hermetically sealed unit which is normally mounted on the underside of the vehicle. It continuously generates and broadcasts a low power electromagnetic field, and receives transponder data transmissions.

TRANSPONDER
The DIGITRAC transponder is a small hermetically sealed unit which is normally mounted on the track roadbed at points where train location is required. When inductively energized the transponder continuously transmits binary data frames. BCH error check security techniques protect all transmitted data to ensure accuracy.



Section 1

General Information

Contents

1.0 GENERAL INFORMATION

1.1 Introduction

The Digitrac System provides a means of data transfer between moving vehicles and the wayside. The data transfer occurs at fixed point locations precisely defined by the position of the equipment. DIGITRAC is designed primarily to provide location information from the roadbed to a locomotive, but can be inverted to pass information from vehicle to wayside. The flow of information is in one direction. The System can be used on any vehicle provided the path of travel of the vehicle can be closely controlled. This manual describes the system configuration for which the direction of information flow is from the wayside to the vehicle.

The mechanical design of the equipment is suitably rugged for the rigors of the transportation industry environment with its extremes of temperature, weather, and vibration. It has been used over a wide range of operating conditions in railroad and rapid transit applications. Powerful data acquisition techniques assure reliable and secure data transfer at vehicle speeds from zero to over 200 kph.

The system has been designed for flexibility of use and its output can readily be interfaced to other display, recording, or processing equipment. Applications include vehicle location, speed control, electronic sentry, route control, and trip recording.

1.2 System Description

The system comprises three elements:

- Transponder
- Antenna
- Reader

The block diagram in Figure 1 shows the system configuration of these elements.

The Transponder is a small hermetically sealed unit which transmits digital data only when inductively energized. It is normally mounted on the crossties between the rails at points where location is required. The transponder has a data capacity of either four or ten fixed decimal digits.

The Antenna is a rugged hermetically sealed unit which is normally mounted on the underside of the vehicle. It continuously generates and broadcasts a low power electromagnetic field at 200 kHz. When a transponder enters this field, its circuitry is energized and it transmits a modulated signal in the HF radio band. This signal is picked up by a receiving antenna located in the Antenna and is passed to the Reader.

The Reader is a rugged microprocessor-based data acquisition unit. It interfaces to the vehicle power directly, provides complete protection against input transients, and powers the Antenna. The received transponder data signal is demodulated in the Reader and checked for integrity. Data protection is provided by powerful BCH error check coding which virtually eliminates erroneous number acceptance. After data verification, the validated transponder number is available at the output interface in ASCII form. The interface may be either RS232 or RS422 compatible. Data format is serial asynchronous ASCII.

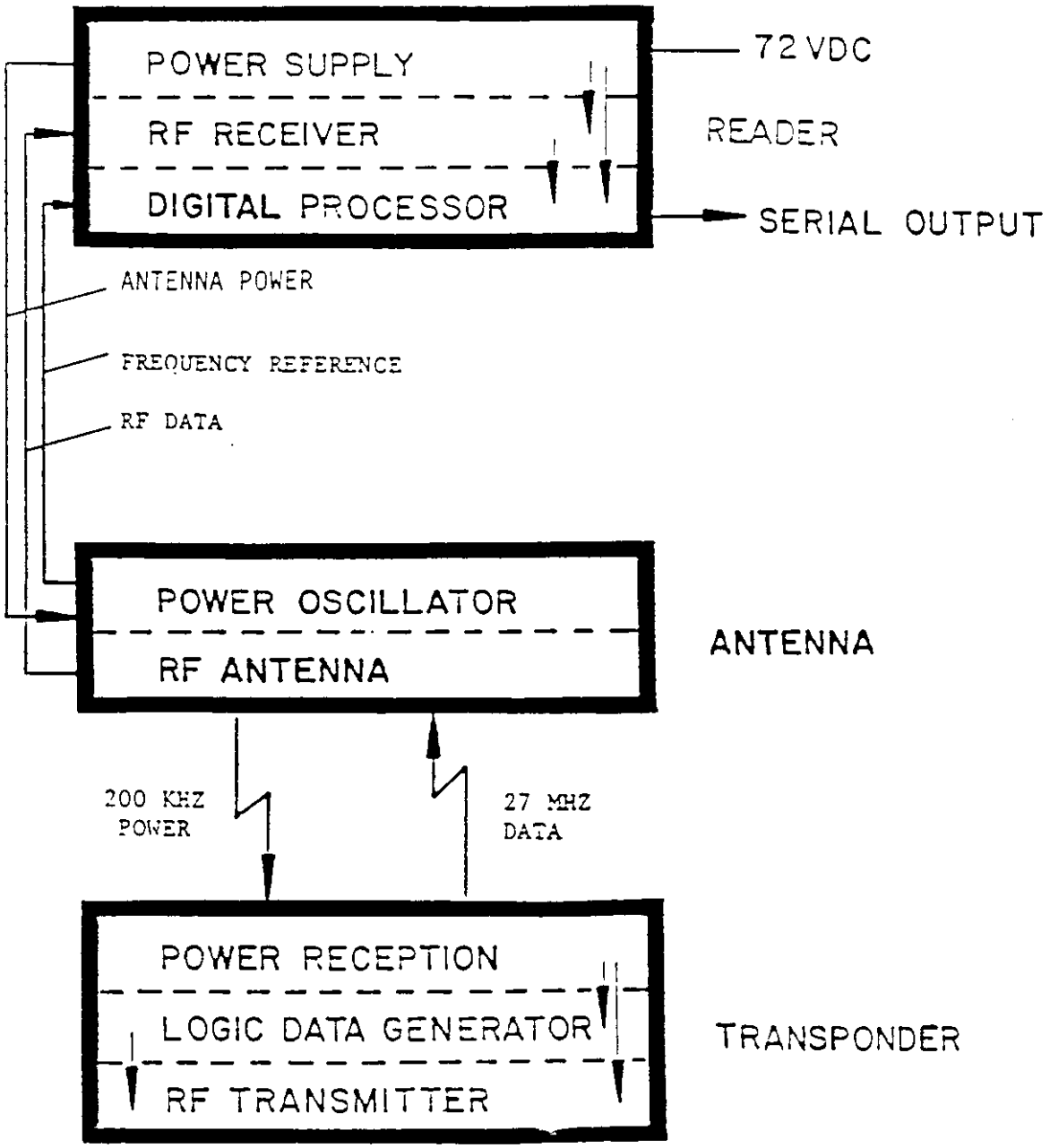


FIGURE 1 - DIGITRAC System Block Diagram

Section 2

Installation

Contents

2.0 INSTALLATION

2.1 Transponder

The transponder may be mounted in any of the three configurations shown in Figures 2, 3 and 4. Figure 2 shows the preferred mounting with the transponder under a protective coverboard. This provides protection to the unit yet leaves it visible to avoid damage when track work is in progress. Ballast must be cleared from under the transponder during installation to avoid damage during track pumping.

The method of Figure 3 gives maximum protection from dragging equipment damage. The transponder must be securely anchored to the tie to prevent its moving and rotating as the ballast moves. It is vulnerable to inadvertent damage from aligning spikes, etc, as it is not readily visible to track workers.

Figure 4 shows the simplest method of mounting. The transponder is however exposed to damage from dragging equipment as well as loss or other damage. If the transponder is installed this way, a relatively flat tie must be selected to avoid stressing the transponder case when its mounting bolts are secured.

As in Figure 2, an optional protective coverboard may be installed if the tie is notched out as shown.

For all installations, the transponder fastening must not be rigid. The fasteners must have approximately +/- .05 inches of clearance from the sides of the mounting holes to accommodate the expansion and contraction of transponder length which occurs over the full operating temperature range.

It may be noticed during the installation that the transponder circuitry has some freedom of movement inside the case. This is as designed and is no cause for alarm.

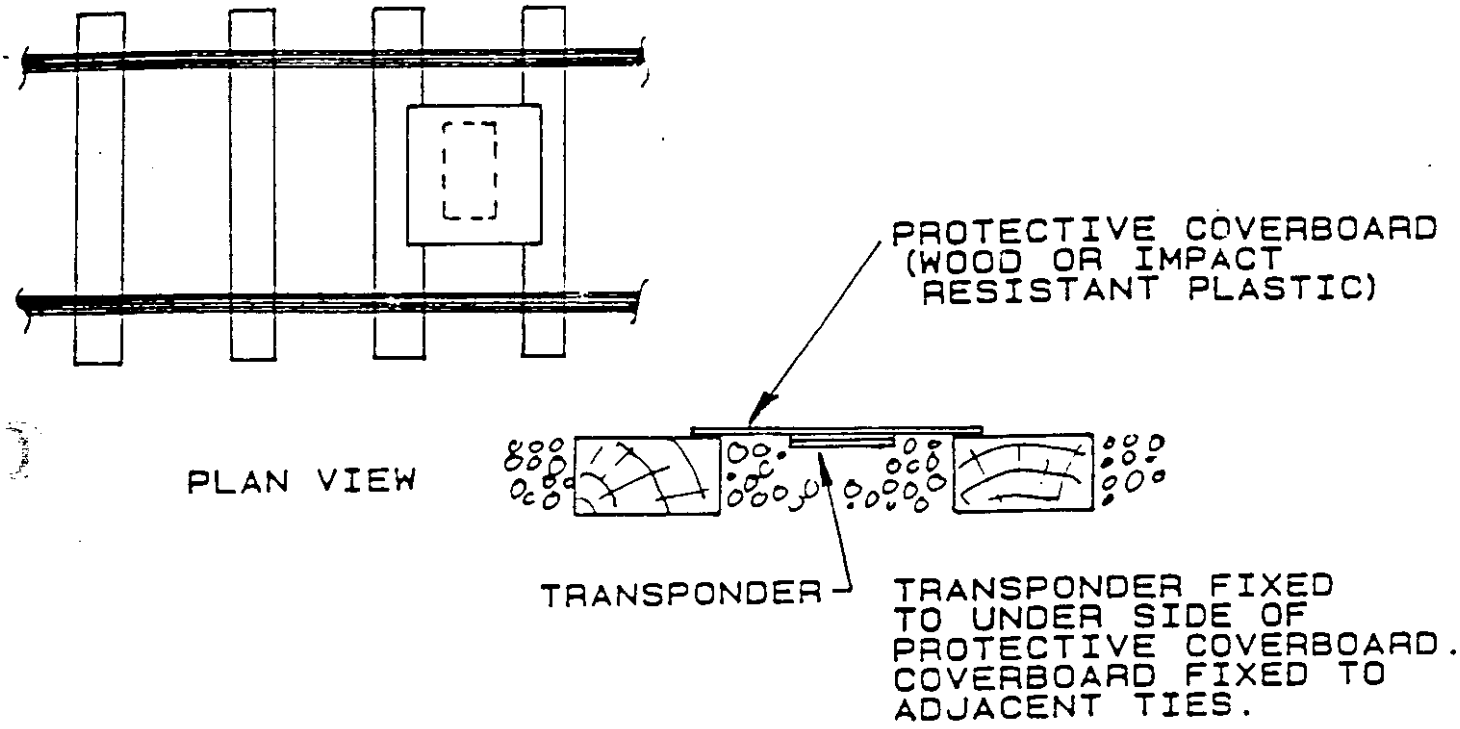
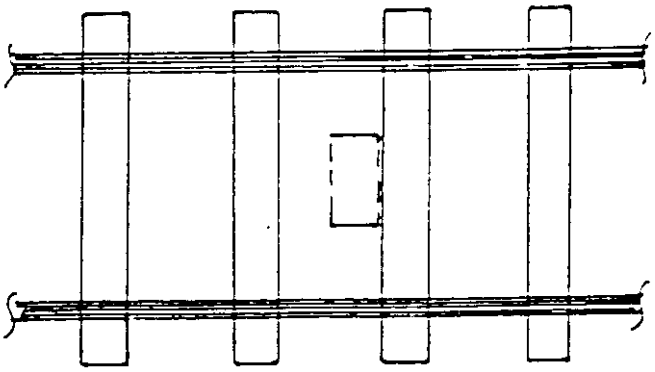


FIGURE 2 - Transponder Mounting Technique



TRANSPONDER BURIED IN BALLAST WITH FIXING BRACKET ON CROSS-TIE.

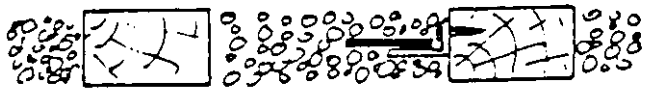


FIGURE 3 - Transponder Mounting Technique

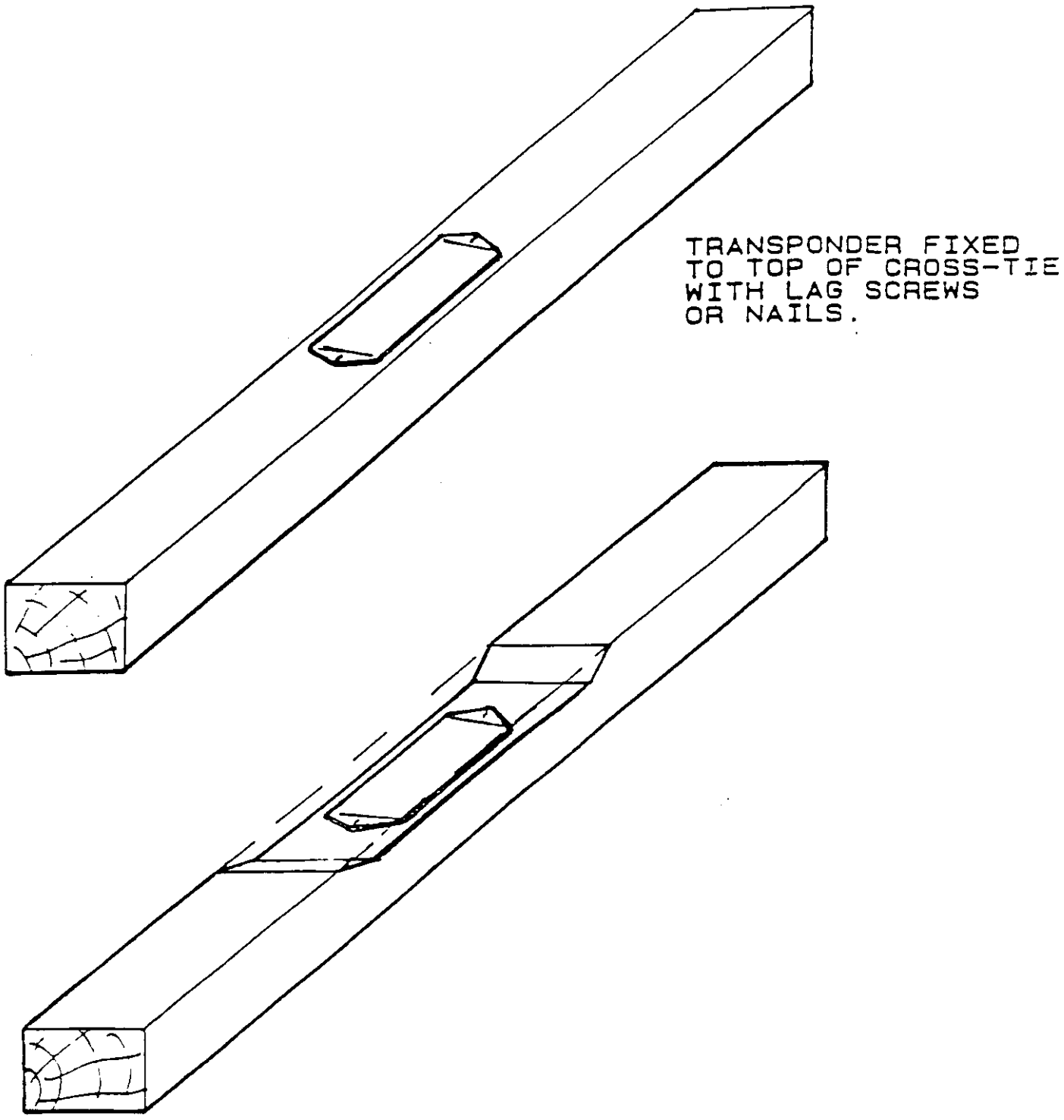


FIGURE 4 - Transponder Mounting Technique

2.2 Antenna

The Antenna is normally mounted ahead of the front wheel truck of the locomotive, under the short hood. It is protected in the direction of motion by the pilot. If no pilot is present then it is recommended that a baffle be welded onto the locomotive structure to provide the necessary protection.

Its principal plane is parallel to the transponders and therefore is parallel to the ground. Unless marked otherwise on the top surface, the longest dimension of the antenna should be in the direction of travel and the antenna centreline should be positioned above the centreline between the rails.

The Antenna is mounted through the four corner mounting holes. It must be ensured that the mounting frame and supports do not form a "shorted turn" which will electrically load the unit and cause a loss of performance.

The Antenna mountings should ideally be flexible or capable of pivoting, such that should the unit strike a very solid obstacle it can move out of the way rather than be destroyed. The unit should not be free to oscillate or sway under normal train motion.

A 20 foot cable is normally more than adequate to run from the Antenna to the radio locker in the locomotive. The cable should be tied down and anchored as securely as possible to avoid damage, especially where ice and compressed snow builds up under the locomotive. The top of the Antenna is especially designed to protect the cable connector. The cable should be tied down close to the antenna and then anchored to the corner support where it turns upward to the chassis.

2.3 Reader

The Reader is normally mounted in the radio locker. The Unit is water and corrosion resistant by virtue of epoxy paint, stainless steel hardware and a conformally-coated PCB. However, liquid sprays, chemical toilet compound or any corrosive agent should not be directed at or near the Unit.

The Reader is supplied with bulkhead mounting flanges. It may be mounted in any plane.

The Reader has LED indicators on the front panel showing power on, 200 kHz lock and data received.

Section 3

Operation

Contents

3.0 OPERATION

3.1 Specifications

Specifications are included for the three system elements:

Transponder	-	Table 3-1
Antenna	-	Table 3-2
Reader	-	Table 3-3

SPECIFICATION

Item	Minimum	Typical	Maximum	Units
Environmental				
Operating Temperature Range	-40	-	+70	deg C
Storage Temperature Range	-55	-	+85	deg C
Vibration, 5-10 Hz	-	7.6	-	mm P-P
Vibration, 10-500 Hz	-	+/- 1.5	-	g P
Shock	-	20	-	g P,11mS
Unaffected by snow, ice, dirt, water, at nominal separation between transponder and antenna of 12 to 14 inches. May be fully immersed.				
Physical				
Width	-	6.2(15.7)	-	In(cm)
Height	-	0.7 (1.8)	-	In(cm)
Length	-	12.8(32.5)	-	In(cm)
Weight	-	1 (0.5)	-	lbs(kg)
Power Requirements				
Nil - Powered by Inductive Coupling with Antenna.				
Operating Range				
Distance from Antenna Face	10(25)	13(33)	24(61)	In(cm)
Data Transmission				
Low power HF near-field propagation				
Complies with FCC Rules Part 15				
RF Carrier Frequency	27.247	27.255	27.263	MHz
RF Amplitude Modulation	50	60	70	Percent
DPSK Sub-Carrier		50		kHz
Data Rate		50		k Baud
Data Capacity				
Decimal Digits	-	10	-	
Data Format				
Per ATCS spec 335				
Data Selection				
Fixed at time of manufacture.				

TABLE 3-1 - Transponder Specifications (Model 6130)

SPECIFICATION

Item	Minimum	Typical	Maximum	Units
Environmental				
Operating Temperature Range	-40	-	+70	deg C
Storage Temperature Range	-55	-	+85	deg C
Vibration, 5-10 Hz	-	5	-	mm P-P
Vibration, 10-500 Hz	-	+/- 2.5	-	g P
Shock	-	20	-	g P,11mS
Unaffected by snow, ice, dirt, water, at nominal separation between antenna and transponder of 12 to 14 inches.				
Physical				
Width	-	19.5(49.5)	-	In(cm)
Height	-	2.5 (6.4)	-	In(cm)
Length	-	24.5(62.2)	-	In(cm)
Weight	-	20 (9.1)	-	lbs(kg)
Power Requirements				
Supplied by Reader	55	-	85	Volts DC
		-	0.25	Amps
Operating Range				
Distance from Transponder	10(25)	13(33)	24(60)	In(cm)

Notes: 1) No conductive materials may be placed between the Antenna and Transponder, or within 6 inches (15 cm) of the Antenna.
2) Two Antennae may not be placed closer than 10 feet (3 meters), if one or both are operating.

Power Transmission
Near Field Induction Coupling with Transponder. Complies with FCC Rules, Part 15.

Power Frequency	190	200	210	kHz

Connector
Cannon CA3106-E-18-1P-F80 (Model 6219 - flying lead per ATCS spec 335)

TABLE 3-2 - Antenna Specification (Model 6219)

SPECIFICATION

Item	Minimum	Typical	Maximum	Units
Environmental				
Operating Temperature Range	-40	-	+70	deg C
Storage Temperature Range	-55	-	+85	deg C
Vibration, 5-10 Hz	-	7.6	-	mm P-P
Vibration, 10-500 Hz	-	+/- 1.5	-	g P
Shock	-	20	-	g P,11mS
Suitable for physical and electrical environment of a locomotive.				
Physical				
Width	-	11.5(29)	-	In(cm)
Height	-	3.5 (9)	-	In(cm)
Length	-	16 (41)	-	In(cm)
Weight	-	12 (5.5)	-	lbs(kg)
Power Requirements				
Locomotive Power	55	70	85	Volts DC
	-	-	0.5	Amps

Output Interface
EIA RS422 or EIA RS232-C Type Z Serial Asynchronous. Configured as DTE.
Unit is user-configurable RS232 or RS422 by changing jumpers.

Output Data Format
Binary Coded Decimal or 8-bit ASCII no parity, 1 start bit, 2 stop bits.

Baud Rate
Jumper Selectable

300	2400
600	4800
1200	9600 Baud

Connectors
Power: Cannon CA3102E-14S-5P-B-109
Antenna: Cannon CA3102E-18-1S-B-109
Communication: Cannon CA3102E-22-14S-B-109
Pinout (all): See Dwg 031-0043-04 in Appendix A

TABLE 3-3 - Reader Specifications (Model 6508)

3.2 Technical Description

3.2.1 Transponder

This transponder is an inductively powered data source designed to be used with the Antenna. The circuitry on the transponder can be divided into four sections:

1) 200 kHz power reception
2) Logic data generator
3) DPSK synthesizer
4) 27 MHz transmitter

The transponder is a sealed unit designed for long life and high reliability. It is not field servicable. Should a unit fail to function properly it should be replaced or returned to the factory for repair.

3.2.2 Antenna

The Antenna uses DC power to drive the 200 kHz oscillator and thereby generates the 200 kHz electromagnetic field. This electromagnetic field is strong enough in the vicinity of the interrogator to energize the passive Transponder by inductive coupling. The Antenna provides circuitry to receive the high frequency transmission from the Transponder, as well as interface circuitry to the Reader for power, frequency reference, and RF data.

The Antenna is a sealed unit designed for high reliability in the severe environment under a locomotive. It is not field servicable. Should a unit fail to function properly it must be replaced.

3.2.3 Interconnect Cable

The Antenna and Reader are joined by an interconnect cable carrying power, RF data and status. The cable is custom designed for the application and is neoprene jacketed for high resistance to oil and chemical contamination.

3.2.4 Reader

The Reader is a microprocessor-based data acquisition unit. It interfaces to the vehicle electrical system and the Antenna to which it supplies power and from which it receives a reference frequency and RF transponder data. It also passes validated transponder numbers to external equipment.

The circuitry for the unit can be divided into three sections:

1) Power Supply
2) RF Receiver
3) Digital Processor

The Reader is user servicable. Detailed information and the necessary drawings and instructions are supplied in the manual which can be supplied when equipment is shipped.

3.2.4.1 Input Power

The Reader operates by direct connection to the locomotive 74 Vdc electrical system. Presence of power is indicated by the POWER indicator on the Reader's front panel. The Reader's internal power supply provides both reverse polarity protection and spike/surge protection.

3.2.4.2 Communication Interface

The output of the Reader is serial ~~RS42~~ 422 or RS232-C (user configurable) type Z. Type Z means a user-defined interface. In this case, the request to re-transmit (RTR) is a custom feature. It allows for re-transmission of the latest transponder number in the event of transmission or reception error. An LSI universal synchronous or asynchronous receiver/transmitter (USART) U514 is used to generate serial asynchronous character data output under control of the Reader's micro-computer.

Refer to wiring diagram 031-0043-04 in Appendix A for communication connector pinout. Data rate is determined by a user-selectable jumper and may be 300, 600, 1200, 2400, 4800, or 9600 Baud.

Output Protocol

Refer to drawing 031-0043-68 which shows output timing.

When a verified transponder number is available for output, the Request To Send (RTS) line (active high) is activated. The Clear To Send (CTS) line is tied "on" (active low) so RTS results in immediate transmission of the output message at the selected Baud rate. After transmission, the RTS line is

de-activated and the transaction is complete. Receipt of Request-To-Retransmit (RTR), which is active high, activates the RTS line and causes the output transaction to take place as described above.

Output Message Format

The output characters comprise a 10-digit transponder ID number followed by line feed (LF) and carriage return (CR). The order of sending is ID numbers D1 through D10, LF, CR. Unless custom software has been supplied, the output message will conform to the standard software which produces 8-bit ASCII characters. Bit sequence is 1 start bit, 8-bit ASCII data sent LSB first (no parity), 2 stop bits.

3.2.4.3 Antenna

The Reader delivers 74 VDC power to the Antenna for generation of the 200 kHz field to power transponders within range. A sample of this frequency is returned to the Reader for phase reference. When the Reader locks onto this signal, the CARRIER LOCKED indicator is illuminated.

The Reader also receives the 27 MHz signal from the transponder through the Antenna. Whenever the signal from an approaching transponder reaches detection threshold, the DATA indicator flashes briefly and the encountered transponder's ID is output on the communication port.

Section 4

Test Equipment

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4.0 TEST EQUIPMENT

4.1 Introduction

The following test equipment is available to aid in maintenance, trouble-shooting and verifying correct operation of the DIGITRAC equipment.

i) Antenna Load Meter Monitor
ii) Mating Connectors

Instructions for the use of each item is included with the equipment as delivered. The following is a brief description of the functions and features.

4.2 Antenna Load Meter

The Antenna Load Meter is used to verify that the Antenna is properly installed and is not unduly loaded by surrounding metal or coils.

The meter is inserted between the Reader and its connecting cable to the Antenna. It shows the current and voltage supplied to the Antenna and enables verification that the current drain is not excessive.

4.3 Mating Connectors

The connectors that mate with the Digitrac 6508 Reader are available as single items, or complete with cables installed.

Power Cable 10 ft with 1 mating connector
Order number 031-0155-00

Antenna Cable 20 ft with 2 mating connectors
Order number 031-0109-00

Mating connectors to Reader

Power	CA3106E-14S-5S-B-F80	Order number 031-0044-00
Communication	CA3106E-22-14P-B-F80	Order number 031-0013-00
Antenna	CA3106E-18-1P-B-F80	Order number 310-2022-00