TELEMOTIVE SERIES 8000

RADIO

CONTROL

SYSTEM

telemotive®
Industrial Controls

TELEMOTIVE PART NUMBER - TC8000-10.B

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RADIO CONTROLLED CRANE SAFETY

The safety rules in this section of the manual are not intended to replace rules or regulations of our customers or any applicable local, state, or federal governing organizations. The safety information that follows is based on data gathered from various users of radio controlled cranes in this country and abroad and is only meant to be used as a general safety procedure in conjunction with any other rules or regulations already in existence. It is important to read all of the safety information contained in this section before operating the Telemotive Series 8000 Radio Control System.

Radio controlled overhead travelling cranes operate in three directions. They are large, bulky pieces of equipment that handle heavy loads efficiently at comparatively high speeds. Quite frequently they are operated in restricted areas where workers are engaged in various tasks on the floor below. Under these conditions, extreme care must be taken by the crane operator and workers must be constantly on the alert to avoid accidents. The following rules have been assembled and included in this manual to indicate how your careful and thoughtful actions may prevent injuries, prevent damage to equipment, or even save a life. If a radio controlled crane is operated from the cab, special care must be taken to secure the radio control box (transmitter) (see the section titled **"BOARDING THE CRANE"** for specific safety rules).

PERSONS AUTHORIZED TO OPERATE RADIO CONTROLLED CRANES

1. Only properly trained employees that have been designated by management should be permitted to operate radio controlled cranes.
2. Radio controlled cranes should not be operated by any person who cannot read and understand the signs, notices, and operating instructions that pertain to the crane.
3. Radio controlled cranes should not be operated by any person with insufficient eyesight or hearing or by anyone who may be suffering from a disease or illness that may cause them to lose control of the crane.

TRAINING CHECKLIST FOR OPERATORS OF RADIO CONTROLLED CRANES

Anyone being trained to operate a radio controlled crane should possess the following knowledge and skills before actually operating the crane.

1. Knowledge of hazards inherent to crane operation.
2. Knowledge of safety rules for radio controlled cranes.
3. Ability to judge distance to stationary objects.
4. Knowledge of the radio control box (transmitter).
5. Limit switch test procedure.
6. Instructions as to plugging of crane motions, where authorized.
7. Observance of signal lights on crane.
8. Avoidance of striking any obstructions.
9. Proper clearance of lifts or hooks before moving bridge or trolley.
10. Proper storage space for radio control box when not in use.
11. Transferring radio control box to another person.
12. Reporting unsafe or unusual operating conditions.
13. Caution in approaching bridge or trolley bumpers.

14. Capacity of the equipment.

15. Making lifts below floor level.

16. Making side pulls.

17. Keeping body clear of lifts and avoiding "pinch" points.

18. Inspection of cables and hooks.

19. Procedures for testing hoist, trolley, and bridge brakes.

THE OPERATING AREA

1. Aisleways between equipment, stock, etc., should be unobstructed so that the radio controlled crane operator can move freely. These aisleways should be a minimum of 3 feet wide, or per local regulations.

2. Radio controlled crane operators should always position themselves for the best view of the crane they are controlling. The crane should never be operated blindly; the crane and load should always be in sight and the operator should stay as close to the crane load as possible. Operators should never position themselves in a "pinch" point.

THE TRANSMITTER

1. When "dead man" type motion lever switches (spring return to off) are used, the switches should never be mechanically blocked in the on position.

2. The key lock on the radio control box should always be turned off when the box is not is use or when the operator is putting on or taking off the control box and belt assembly.

3. A prescribed secure storage space should be provided for the radio control box and the radio control box should always be placed there when not in use. This precaution will prevent unauthorized people from operating the radio controlled crane.

OPERATING THE CRANE

1. The crane limit switches should be checked at the beginning of each turn or when a new operator takes control of the crane. While checking the limit switches, the hoist should be centered over an area free of personnel and equipment.

2. The limit switches should never be used as a regular stopping device. They are only intended to be protective devices.

3. The bridge and trolley brakes should be tested at the beginning of each turn or when a new operator takes control of the crane. They should only be tested with the bridge and trolley at low speed.

4. When lifting maximum loads, the operator should test the hoist brakes by raising the load a few inches from the floor. If the brakes do not hold, the load should be immediately lowered to the floor and a report made to the supervisor.

5. Do not make lifts in excess of the rated capacity of the equipment. Consult your supervisor for exceptions, if any.

6. To prevent swinging when making lifts, the bridge and trolley should be centered directly over the load when the load is raised.

7. Side pulls should be made only with permission of the supervisor. When such a lift is being made, the operator should not be positioned in the line of travel of the load. The crane should be operated from a position either to the side or opposite from the direction of travel.

8. When raising or lowering a load, proceed slowly and make certain the load is under control. Tag lines should be used for handling unusual lengths or bulky loads. Take slack out of the chains or slings gradually and make sure all personnel are clear before making a lift.

9. The crane operator should keep all parts of their body away from the lift and should never be positioned under the lift.

10. Do not make a lift or move a load if anyone is in a location where they could be struck by the crane or the load.

11. If the operator of the radio controlled crane is being helped, the crane should not be moved until a signal is received from the helper indicating that they are in the clear.

12. When a load is hanging from the hook of the radio controlled crane and the crane is being moved, the operator should sound the warning device frequently.

13. Loads should not be carried over worker's heads. If anyone is in the path of travel, the radio controlled crane operator should stop and clear the area before proceeding.

14. Runway stops or other cranes should never be bumped into.

15. When moving the crane, the operator of the radio controlled crane should be sure that the hook block, attachments, or cables will not catch on nearby equipment. Slings, chains, or cables should never be dragged along the floor. They could catch on something which might cause them to break and strike the operator or a fellow worker, inflicting a serious injury.

16. Unless required for operator safety, gloves should not be worn when operating a radio controlled crane.

17. All loose materials or parts should be removed from the load before starting the lift so that they cannot fall and strike someone below.

18. The operator of the radio controlled crane should always hoist lifts high enough to clear all apparatus and workmen below the crane.

19. The operator of the radio controlled crane should never permit anyone to ride on the load or hook except when authorized by the supervisor.

20. When another crane on the same runway is stationary with a load hanging from it, the crane operator should maintain a safe distance between the stationary crane and the one under operation.

21. If power is cut off, the crane operator should turn the transmitter off and keep it off until power is restored.

22. If the crane fails to respond properly, the operator should stop operation, turn off the transmitter and report the condition to the supervisor immediately.

23. Outside cranes, subject to movement by wind should be securely anchored when left unattended. If the crane is equipped with bridge brakes, the parking brake should be set immediately.

BOARDING THE CRANE

1. The radio controlled crane should not be boarded without permission of the supervisor.

2. The operator of the radio controlled crane should turn off the transmitter and take it with them when boarding the crane.

3. If more than one person is boarding the radio controlled crane, one person should be made responsible for seeing that all personnel are off the crane before the radio control box is returned to operation.

CRANE REPAIR

Minor repairs include routine maintenance and repairs such as greasing, cleaning, and control troubleshooting; all other repairs should be considered major. If the repair crew consists of more than one person, one person should be designated as the leader of the repair crew with the following responsibilities (if the repair crew consists of only one person, that one person has these responsibilities):

1. Warning signs should be placed on the floor beneath the crane or suspended from the crane. For major repairs, the floor area below the crane should be roped off.

2. When major repairs are to take place, all persons operating other cranes on the same or adjacent runways, if any, must be notified prior to starting of repairs. Such notification should include the nature of the job, safeguards provided, and limitations of their movements while repairs are in progress.

3. Wherever practical, radio controlled cranes which cannot be moved during repairs must be protected against being bumped by other cranes on the runway. Bumpers should be installed on the exposed side or sides of the crane under repair. They should be placed as far away as possible, with a minimum distance of 20 feet. The location of these bumpers should be indicated by red lights placed so that they are clearly visible to other persons operating cranes travelling on the same runway. When it is impossible to use bumpers for protection, red lights must be placed in clear view of other persons operating cranes on the same runway to indicate the repair or restricted travel zone. As with the bumpers, the red lights should be placed at a minimum distance of 20 feet from the crane under repair. All operators of cranes on the same runway must be informed of the repair work contemplated, thoroughly instructed as to what their operations are limited to, and told that they will be notified when repairs are completed.

4. If any hazard involving the repairmen exists when there is a runway adjacent to that of the crane under repair, the adjacent runway should be blocked off as described in the previous paragraph. When it is necessary to continue operation of the cranes on the adjacent runways, warning lights must be installed and be visible to personnel operating cranes on those runways. All cranes should come to a complete stop prior to entering the restricted area and should only proceed through this area after receiving permission from a signal man posted for this purpose. Access of persons to and from the crane being repaired should be under control of the leader of the repair crew.

5. The key switch on the radio control box (transmitter) should be turned off and the radio control box should remain with the repair crew leader when boarding the crane. The leader should board the crane first, open and lock out the main switch, and then signal the other members of the crew that it is safe to board the crane.

6. If work on the crane is to be done in areas that are not protected by standard handrails, approved safety belts should be worn by the repair crew.

7. All tools and equipment should be moved onto the crane by the use of hand lines. The tools and equipment should be adequately secured to the hand lines.

8. If it is necessary to have the crane's control circuits energized, all power circuits for crane movement must be opened before closing the main switch.

9. If during the course of repairs it becomes necessary to move the crane, all personnel and tools should be moved to a safe spot before doing so.

10. Head room is at a minimum in some crane cabs and on some crane walkways. Caution should be exercised by people when boarding cranes and hard hats should be worn whenever possible.

11. When repairs are finished, all personnel, tools, and repair equipment should be removed from the crane before the main switch is turned on.

USING THE CRANE AS A WORK PLATFORM

1. When the radio controlled crane is to be used as a stationary working platform for work to be performed on the building, all the rules in the "CRANE REPAIRS" section should be followed.

2. When it is necessary to perform work on the building that requires the crane to be moved from time to time, the crane operator should board the crane with the radio control box. The operator should make sure that all personnel working on the crane are in a safe position before moving the crane to the next working

station. It should also be the operator's responsibility to see that the main switch is open and locked down before work is resumed.

THE CONDITION OF THE RADIO CONTROLLED CRANE

If the crane fails to respond properly, the operator of the radio controlled crane should notify the supervisor. When serious faults are noticed (that make the crane unsafe to operate), the crane should be shut down immediately and the supervisor should be notified. The following is list of what should be included in the report:

1. Condition of hoisting cable and hook block (broken strands, clipped sheave wheels, etc.).
2. Condition of brakes (hoist, trolley, and bridge).
3. Alignment of bridge (screeching or squealing wheels indicate bridge is out of line).
4. Broken, cracked, or chipped rails on trolley or runway.
5. Condition of all limit switches.
6. Condition of electrical and mechanical control (electrical or mechanical defects which cause faulty operation such as uncommanded stopping or starting of any crane motion, warning devices, lights, or auxiliary functions).
7. Condition of gears (grinding or squealing may indicate foreign materials in gear teeth or a lack of lubrication).
8. Frequent overload relay tripping of power circuits.
9. Mechanical parts loosened by vibration (loose rivets, covers, bolts, etc.).
10. Bumpy riding (worn wheels).
11. Condition of collector shoes or bars.
12. Condition of warning or signal lights (burned out or broken).

WARNING

The crane operator should not attempt to make these repairs. The condition should be reported to the supervisor so that a properly qualified repair person can execute the repairs.

MICROCOMPUTER BOARD CONTROLS AND INDICATORS

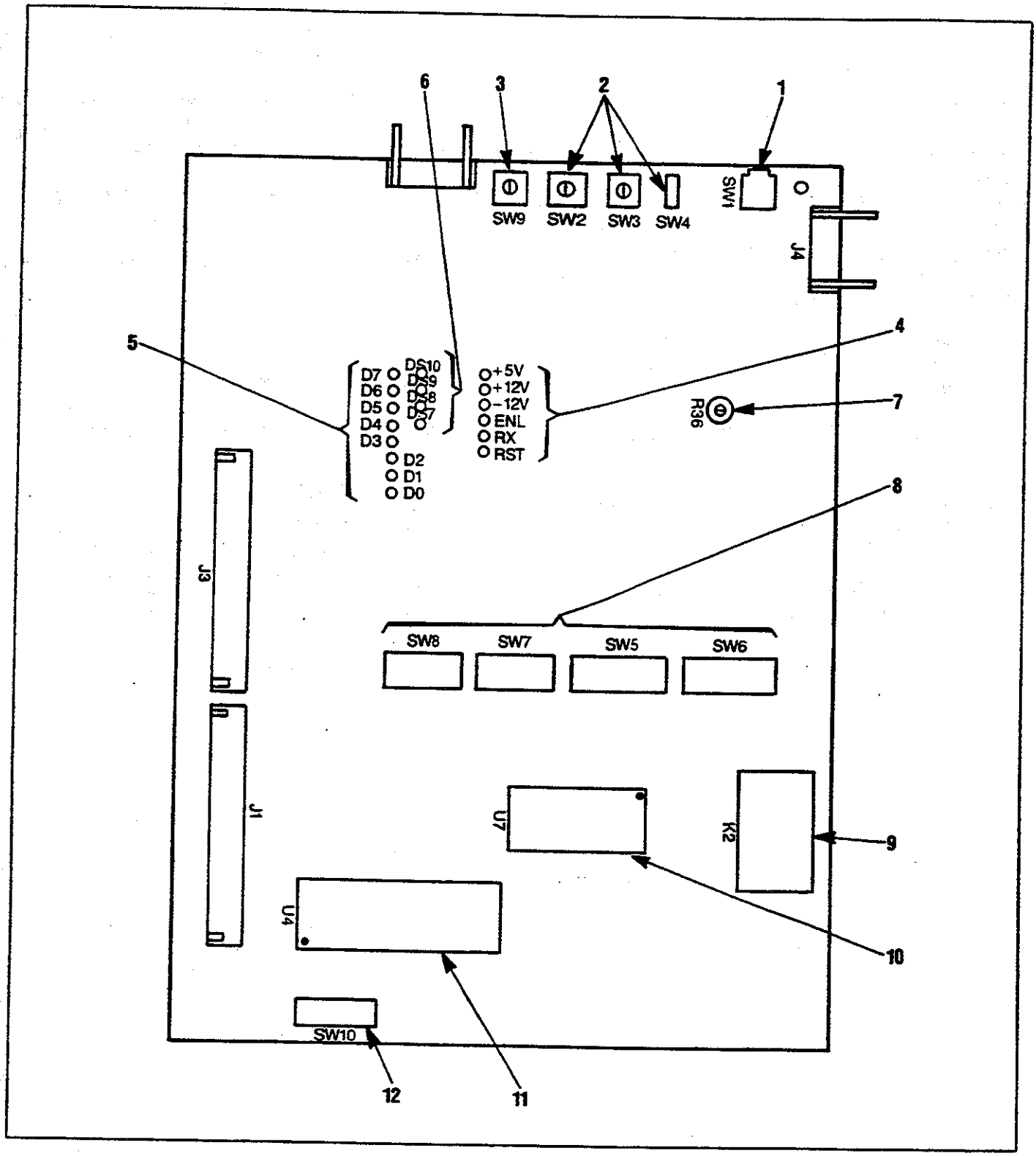


Fig. 1. Microcomputer Board Controls And Indicators.

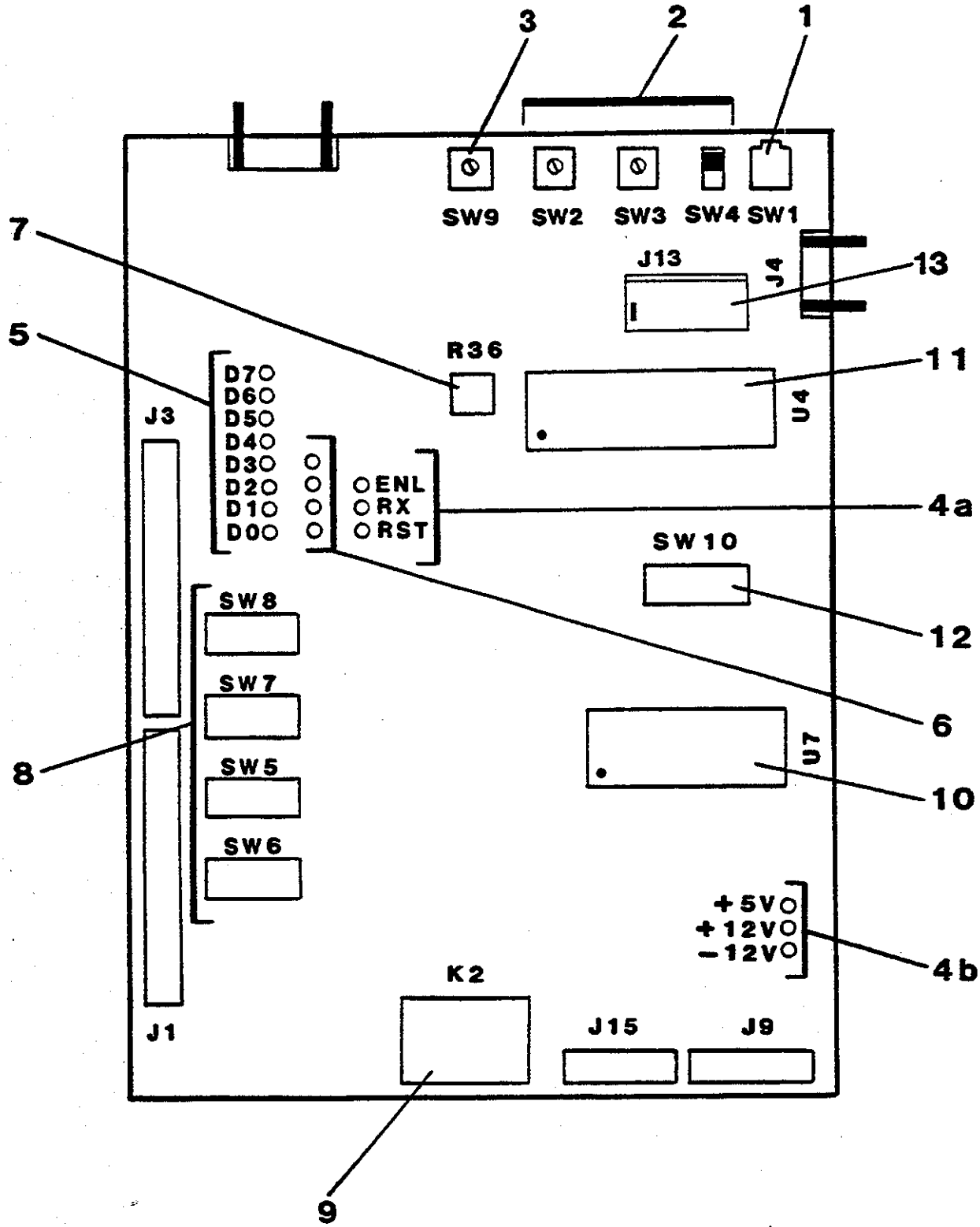


Fig. 1b. Microcomputer Board Controls & Indicators (E8001; revised model).

1. **SW 1.** Reset switch. When a permanent error occurs and shuts down the system, pressing this button will reset the microcomputer and restart the system.

2. SW 2. Least significant digit frequency code switch. This 16-position (hexidecimal) switch (positions 0 through F) is used to set the least significant (hexidecimal) digit of the receiver frequency code.

   SW 3. Middle digit frequency code switch. This 16-position (hexidecimal) switch (positions 0 through F) is used to set the middle (hexidecimal) digit of the receiver frequency code.

   SW 4. Most significant digit frequency code switch. This two-position (binary) switch is used to set the most significant (binary) digit of the receiver frequency code.

3. **SW 9.** Diagnostic mode switch. This 16-position (hexidecimal) switch selects the different diagnostic modes (refer to the **SYSTEM TROUBLESHOOTING** section of this manual for explanation of the diagnostic modes).

4. **System Enable Indicators.** All of these green indicators should be lit once the system has been started.

   +5 V Indicator (Green). When this indicator is lit, the +5 V power supply and its connections to the Microcomputer Board are good.

   +12 V Indicator (Green). When this indicator is lit, the +12 V power supply and its connections to the Microcomputer Board are good.

   -12 V Indicator (Green). When this indicator is lit, the -12 V power supply and its connections to the Microcomputer Board are good.

   ENL (Dynamic Enable) Indicator (Green). When this indicator is lit, the system is enabled.

   RX (Received Signal) Indicator (Green). When this indicator is lit, the system is receiving and demodulating the radio control signal.

   RST (Reset) Indicator (Green). When this indicator is lit, the system has been started and reset and is in operation.

5. **Diagnostic Error Indicators (Red).** When the built-in system diagnostics are performed and an error is discovered, one or more of these eight indicators (D0 through D7) will light (refer to the **SYSTEM TROUBLESHOOTING** section of this manual for information on what each indicator signifies). None of these indicators should be lit once the system has been started.

6. **Channel Indicators (Yellow).** These indicators show which channel is currently in use for multi-box or pitch and catch systems (these circuit board positions are not populated for systems other than multi-box or pitch and catch).

7. **R36.** Adjustment control for use with antenna diversity option. Counterclockwise rotation increase switching threshold and clockwise rotation decrease switching threshold.

8. **SW 5, SW 6, SW 7, and SW 8.** These circuit board positions are not normally populated. When feedback circuits from the users equipment contactors are not possible or not wanted, these switches are used to control feedback signals from the Series 8000 System.

9. **K2 Relay.** This is the location of the K2 (sensitive) relay.

10. **U7, EPROM.** This is the location of the system EPROM (Erasable Programmable Read Only Memory).

11. **U4, Microprocessor.** This is the location of the system's Intel 8031 Microprocessor.

12. **SW 10.** Access code switches. This eight bit DIP (Dual In-Line Package) switch is used to set the receiver access code.

13. J13. This connector provides test points for several important signals. Starting from pin 1 (leftmost pin), the connector has the signals of SYNC, dynamic enable, AGC level, receiver data, and squelch.

INTRODUCTION

The Telemotive Series 8000 is a radio control system for stepped and stepless cranes, locomotives, rail car movers, and other heavy industrial equipment. Radio control systems aid in conserving manpower, protecting plant personnel, and increasing production efficiencies. By moving the operator out of the cab and down on the ground or floor, a better viewpoint is obtained, allowing the operator to better judge crane load or rail car clearances.

The Telemotive Series 8000 system consists of a computer controlled transmitter and a Receiver/Control Unit. Part count is kept low, and thus reliability is improved, because all core circuitry for the Receiver/Control Unit such as the cpu, receiver support, decoder, security, diagnostic, and housekeeping are located on a single board.

THE TRANSMITTER

Transmitter Description (Refer To Fig. 2)

Two types of self-contained computer controlled series 8000 transmitters are available. Both transmitters provide long battery

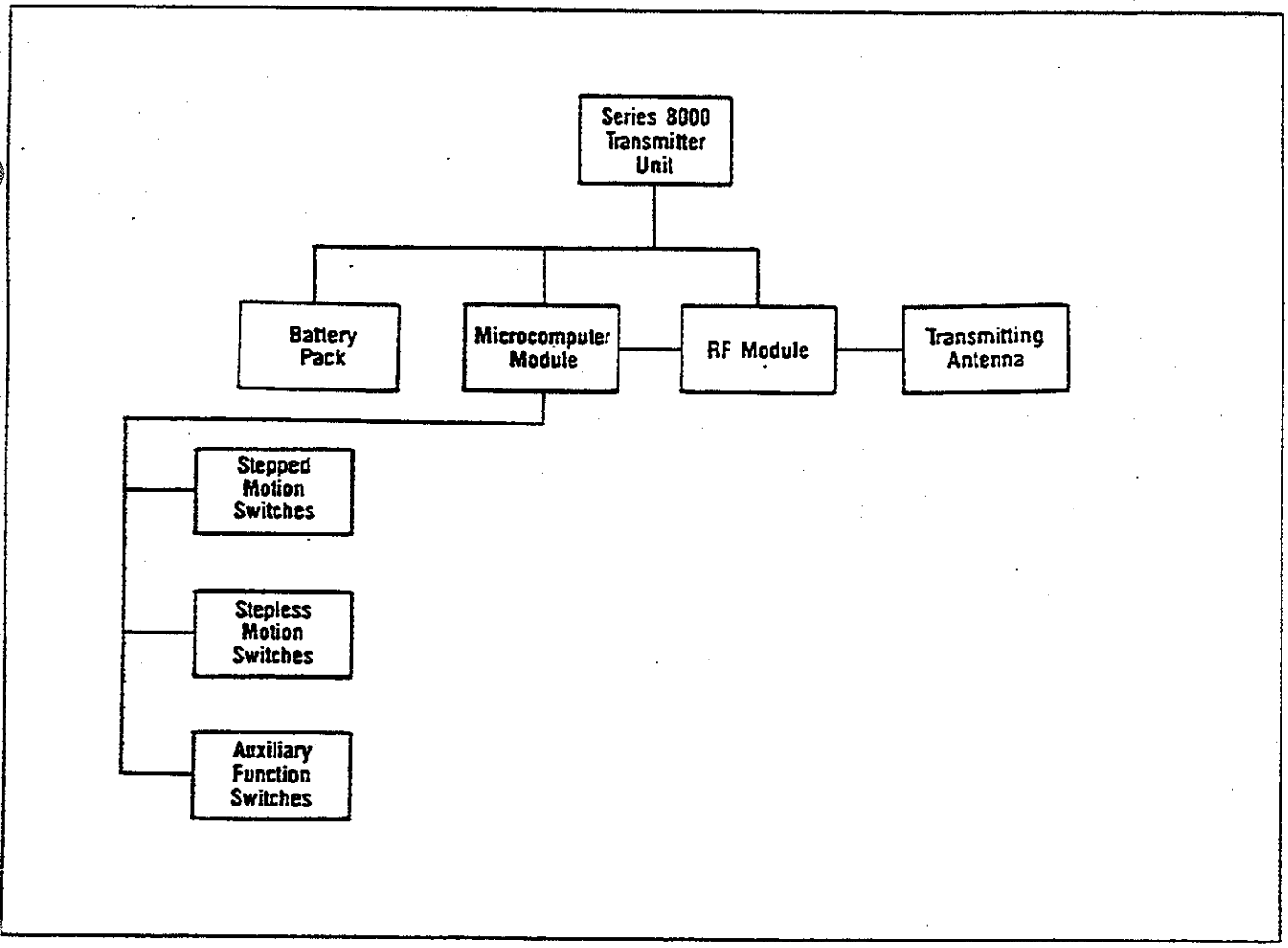


Fig. 2. Series 8000 Transmitter Block Diagram.

life because the Intel 8031 microcomputer turns off the transmitter after the controls have been idle for a set time period and low current CMOS devices are used extensively. Fig. 2 is a block diagram of the system 8000 transmitter.

Lever Switch Transmitter

The standard lever switch type transmitter (LTx) is housed in an extruded aluminum case with high impact plastic protective end caps allowing easy access to the electronics (located on two circuit boards). Different shaped knobs enable the operator to identify, by feel, the motion that is being activated. Up to 7 motion controls can be incorporated into the standard lever switch transmitter. The stepped motion switches have been cycled up to 10 million times without failure. The standard lever switch transmitter can use a variety of battery options which include rechargeable Ni-Cad (nickel cadmium), rechargeable Lead-Acid, disposable Lithium, or disposable 14 amp/hour Mercury batteries.

Membrane Switch Transmitter

The membrane switch transmitter (MTx) features a rugged hand-held aluminum case with an internal battery compartment. Motor functions are controlled with finger-tip slide speed controls. Up to 4 motion controls can be incorporated into the membrane switch transmitter. For safety, the locomotive control version of the membrane transmitter contains a tilt switch. The membrane transmitter uses either a disposable lithium battery or a rechargeable lead acid battery.

Transmitter Operation

To start the radio control system, the transmitter sends a special access code which allows the system outputs to be enabled. The signals from the stepped/stepless motion switches and auxiliary function switches on the transmitter are digitally encoded before transmission. The transmitted frequency is dependent on the binary states because the transmitter directly modulates a carrier signal with a time ordered sequence of binary states. This type of transmission is called direct frequency shift keying (DFSK) modulation. This means that the actual transmitted RF signal is a serial time ordered sequence of two possible transmitter RF frequency states. Only one of these two possible frequency states is present during any bit period. The transmitter is designed to operate in the VHF and UHF bands with an rf power output (into a tuned 50 Ω antenna) of 50 to 400 mW.

THE RECEIVER/CONTROL UNIT (Refer to Fig. 3)

The Series 8000 system Receiver/Control Unit is comprised of three parts; the RF Receiver Module, the Microcomputer Board, and the Driver Rack. The Receiver Module demodulates the rf signal from the transmitter and feeds it to the Microcomputer Board. The Microcomputer Board decodes the data and feeds the appropriate signals to the Driver Rack. The maintain access code (transmitted as part of the rf signal) enables the equipment's main contactor (MC). Once the main contactor is enabled, the Driver Rack sends stepped or stepless (for motion) outputs and auxiliary outputs (for warning devices) to the equipment.

The Series 8000 Receiver/Control Unit contains built-in diagnostic circuitry to aid in troubleshooting the system. After the system has been reset, the microcomputer performs a ROM (Read Only Memory) check, internal RAM (Random Access Memory) check, a watchdog timer, and a **K2 relay** check (the sensitive relay on the Microcomputer Board). In addition, the diagnostics include a 32 step AGC (automatic gain control) indicator, a received access code indicator, an operation error indicator, a contact monitoring input indicator, and a bad transmitter switch indicator.

The circuitry for six available options is also contained on the Microcomputer Board. These options are controlled range, antenna diversity, multi-box operation, pitch and catch operation, tandem operation, and two-box tandem operation.

The controlled range option allows the user to set the maximum operating range of the

system. This option requires the use of the antenna diversity option (the antenna diversity option can be used without the controlled range option however). Antenna diversity is an option which monitors two antennas (located apart from each other) and selects the antenna with the best signal.

Multibox operation allows up to 16 transmitters to be used on a first come/first served basis. If control of the crane is to be passed from one transmitter to another, the first transmitter must be shut down before the second one can take over.

Pitch and catch operation allows the crane operators to "hand" the control of the crane from one transmitter to another without system shutdown (continuous operation).

Tandem operation allows one transmitter to be used with a split crane. Both crane sections can be used together or individually (one at a time). Two-box tandem operation utilizes two transmitters and two receivers to operate a split crane either together (both cranes being operated simultaneously from one transmitter) or separately (one crane being operated by one transmitter and the other crane being operated by the other transmitter).

RADIO SYSTEM OPERATING PRINCIPLES

The output of the Receiver/Control Unit cannot be enabled until the following conditions have been met:

1. The received rf signal must be within the proper frequency passband.
2. The access code must be received and it must meet the prescribed format.
3. The received data must meet a prescribed format.

These stringent requirements are unique to each receiving system and its companion transmitter.

Frequency Setting

The transmitter is set to transmit a specific rf carrier frequency that is based on the frequency generated by the crystal oscillator. With single-box systems, the RF receiver (located in the Receiver/Control Unit) is set to respond to a specific rf frequency based upon the settings of the frequency programming switches (**SW2, SW3,** and **SW4** on the Microcomputer Board). Table 1 shows the frequency code settings for the receiver. With multi-box and pitch and catch systems, frequency programming switches are not used. The received frequency is controlled by the program in the applications EPROM (located on the Microcomputer Board) and the frequency currently being used is indicated by four yellow LED's located on the Microcomputer Board.

Access Code Setting

The transmitter sends two types of access codes; first the start access code, then the maintain access code. The start access code is momentary and is only required to initiate the system. It is only sent while the transmitter **START** button is depressed. The maintain access code is continuously sent immediately after the transmitter **START** button is released. The maintain access code must be present for the system to operate.

The maintain access code is simply the complement of the start access code. This allows a single set of switches to be used to set both access codes. The transmitted access code is set with the switches on the Transmitter Interface Module (**SW1**) and the received access code is set with the switches located on the Microcomputer Board in the Receiver/Control Unit (**SW10**).

The microcomputer decodes the access code data word (data word #0) and the remaining data words contained in the received signal. When the microcomputer decodes the start access code, it enables the **K2** (sensitive) **relay.** The **K2 relay** enables the system MR (machine tool relay) located on the back panel of the receiver cabinet. The output interfaces are not enabled until the transmitter **START** button is released and the maintain access code is sent. Releasing the **START** button enables the output buffer latch and allows the system to be operated. A listing of the access code settings is given in Table 2.

ASSOCIATED TELEMOTIVE RF FREQ		MICROCOMPUTER BOARD FREQ SETTING		
FREQ (IN MHz)	T#	S4	S3	S2
40.01		1	3	0
40.03		1	2	E
40.05		1	2	C
40.07		1	2	A
40.09		1	2	8
40.11		1	2	6
40.13		1	2	4
40.15		1	2	2
40.17		1	2	0
40.19		1	1	E
40.21		1	1	C
40.23		1	1	A
40.25		1	1	8
40.27		1	1	6
40.29		1	1	4
40.31		1	1	2
40.33		1	1	0
40.35		1	0	E
40.37		1	0	C
40.39		1	0	A
40.41		1	0	8
40.43		1	0	6
40.45		1	0	4
40.47		1	0	2
40.49		1	0	0
40.51		0	F	E
40.53		0	F	C
40.55		0	F	A
40.57		0	F	8
40.59		0	F	6
40.61		0	F	4

Table 1. System Frequency Code Setting.

ASSOCIATED TELEMOTIVE RF FREQ		MICROCOMPUTER BOARD FREQ SETTING		
FREQ (IN MHz)	T#	S4	S3	S2
40.63		0	F	2
40.65		0	F	0
40.67		0	E	E
40.69		0	E	C
40.71		0	E	A
40.73		0	E	8
40.75		0	E	6
40.77		0	E	4
40.79		0	E	2
40.81		0	E	0
40.83		0	D	E
40.85		0	D	C
40.87		0	D	A
40.89		0	D	8
40.91		0	D	6
40.93		0	D	4
40.95		0	D	2
40.97		0	D	0
40.99		0	C	E
41.01		0	C	C
41.03		0	C	A
41.05		0	C	8
41.07		0	C	6
41.09		0	C	4
41.11		0	C	2
41.13		0	C	0
41.15		0	B	E
41.17		0	B	C
41.19		0	B	A
41.21		0	B	8

Table 1. System Frequency Code Settings (Continued).

ASSOCIATED TELEMOTIVE RF FREQ		MICROCOMPUTER BOARD FREQ SETTING		
FREQ (IN MHz)	T#	S4	S3	S2
41.23		0	B	6
41.25		0	B	4
41.27		0	B	2
41.29		0	B	0
41.31		0	A	E
41.33		0	A	C
41.35		0	A	A
41.37		0	A	8
41.39		0	A	6
41.41		0	A	4
41.43		0	A	2
41.45		0	A	0
41.47		0	9	E
41.49		0	9	C
41.51		0	9	A
41.53		0	9	8
41.55		0	9	6
41.57		0	9	4
41.59		0	9	2
41.61		0	9	0
41.63		0	8	E
41.65		0	8	C
41.67		0	8	A
41.69		0	8	8
41.71		0	8	6
41.73		0	8	4
41.75		0	8	2
41.77		0	8	0
41.79		0	7	E
41.81		0	7	C
41.83		0	7	A
41.85		0	7	8
41.87		0	7	6

Table 1. System Frequency Code Settings (Continued).

ASSOCIATED TELEMOTIVE RF FREQ		MICROCOMPUTER BOARD FREQ SETTING		
FREQ (IN MHz)	T#	S4	S3	S2
41.89		0	7	4
41.91		0	7	2
41.93		0	7	0
41.95		0	6	E
41.97		0	6	C
41.99		0	6	A
49.61		0	7	0
49.63		0	6	E
49.65		0	6	C
49.67		0	6	A
49.69		0	6	8
49.71		0	6	6
49.73		0	6	4
49.75		0	6	2
49.77		0	6	0
49.79		0	5	E
49.81		0	5	C
49.83		0	5	A
49.85		0	5	8
49.87		0	5	6
49.89		0	5	4
49.91		0	5	2
49.93		0	5	0
49.95		0	4	E
49.97		0	4	C
49.99		0	4	A
72.02	LR11	1	0	5
72.04	LR21	1	0	4
72.06	LR12	1	0	3
72.08	LR22	1	0	2
72.10	LR13	1	0	1
72.12	LR23	1	0	0
72.14	LR14	0	F	F

Table 1. System Frequency Code Settings (Continued).

ASSOCIATED TELEMOTIVE RF FREQ		MICROCOMPUTER BOARD FREQ SETTING		
FREQ (IN MHz)	T#	S4	S3	S2
72.16	LR24	0	F	E
72.18	LR15	0	F	D
72.20	LR25	0	F	C
72.22	LR16	0	F	B
72.24	LR26	0	F	A
72.26	LR17	0	F	9
72.28	LR27	0	F	8
72.30	LR18	0	F	7
72.32	LR28	0	F	6
72.34	LR19	0	F	5
72.36	LR29	0	F	4
72.38	LR20	0	F	3
72.40	LR30	0	F	2
72.42		0	F	1
72.44	LR1	0	F	0
72.46		0	E	F
72.48	LR2	0	E	E
72.50		0	E	D
72.52	LR3	0	E	C
72.54		0	E	B
72.56	LR4	0	E	A
72.58		0	E	9
72.60	LR5	0	E	8
72.62		0	E	7
72.64		0	E	6
72.66		0	E	5
72.68		0	E	4
72.70		0	E	3
72.72		0	E	2
72.80		0	D	E
72.90		0	D	9
75.34		0	5	F
75.42		0	5	B

Table 1. System Frequency Code Settings (Continued).

ASSOCIATED TELEMOTIVE RF FREQ		MICROCOMPUTER BOARD FREQ SETTING		
FREQ (IN MHz)	T#	S4	S3	S2
75.44	LR6	0	5	A
75.48	LR7	0	5	8
75.52	LR8	0	5	6
75.54		0	5	5
75.56	LR9	0	5	4
75.58		0	5	3
75.60	LR10	0	5	2
75.62		0	5	1
75.64		0	5	0
75.66		0	4	F
75.70		0	4	D
75.72		0	4	C
75.82		0	4	7
75.84		0	4	6
75.86		0	4	5
75.90		0	4	3
467.750		0	2	1
467.7625		0	4	2
467.775		0	2	0
467.7875		0	4	0
467.800		1	1	F
467.8125		1	3	E
467.825		1	1	E
467.8375		1	3	C
467.850		1	1	D
467.8625		1	3	A
467.875		1	1	C
467.8875		1	3	8
467.900		1	1	B
467.9125		1	3	6
467.925		1	1	A
467.9375		1	3	4
467.9625		1	3	2
467.9875		1	3	0
468.0125		1	2	E

Table 1. System Frequency Code Settings (Continued).

START ACCESS CODE (IN DECIMAL)	ACCESS CODE BOARD SETTING (IN BINARY) FOR E8001 RECEIVER MICROCOMPUTER MODULE (SW10) AND E7630 TRANSMITTER COMPUTER MODULE (SW4)	ASSOCIATED TELEMOTIVE RF FREQ (IN MHz)		ASSOCIATED TELEMOTIVE RF FREQ (IN MHz)	
	12345678	T#	FREQ	T#	FREQ
0	00000000	NOT AVAILABLE			
1	00000001	NOT AVAILABLE			
2	00000010	NOT AVAILABLE			
3	00000011	NOT AVAILABLE			
4	00000100	NOT AVAILABLE			
5	00000101	LR75	72.42		
6	00000110	LR76	72.80		
7	00000111	LR77	72.90		
8	00001000	NOT AVAILABLE			
9	00001001	LR78	75.34		
10	00001010	LR80	75.58		
11	00001011	LR81	75.54		
12	00001100	LR82	75.84		
13	00001101	LR86	72.46		
14	00001110	LR84	75.82		
15	00001111	LR85	75.90		
16	00010000	NOT AVAILABLE			
17	00010001	LR127	72.28		
18	00010010	LR128	72.32		
19	00010011	LR129	72.36		
20	00010100	LR130	72.40		
21	00010101	LR175	72.42		
22	00010110	LR176	72.80		
23	00010111	LR178	75.34		
24	00011000	LR179	75.42		
25	00011001	COMPLEMENT			
26	00011010	COMPLEMENT			
27	00011011	COMPLEMENT			
28	00011100	COMPLEMENT			
29	00011101	COMPLEMENT			
30	00011110	COMPLEMENT			
31	00011111	COMPLEMENT			
32	00100000	NOT AVAILABLE			
33	00100001	COMPLEMENT			
34	00100010	COMPLEMENT			
35	00100011	COMPLEMENT			
36	00100100	COMPLEMENT			
37	00100101	COMPLEMENT			
38	00100110	COMPLEMENT			
39	00100111	COMPLEMENT			
40	00101000	COMPLEMENT			
41	00101001	COMPLEMENT			

Table 2. Access Code Settings.

START ACCESS CODE (IN DECIMAL)	ACCESS CODE BOARD SETTING (IN BINARY) FOR E8001 RECEIVER MICROCOMPUTER MODULE (SW10) AND E7630 TRANSMITTER COMPUTER MODULE (SW4)	ASSOCIATED TELEMOTIVE RF FREQ (IN MHz)		ASSOCIATED TELEMOTIVE RF FREQ (IN MHz)	
	12345678	T#	FREQ	T#	FREQ
42	00101010	COMPLEMENT			
43	00101011	COMPLEMENT			
44	00101100	COMPLEMENT			
45	00101101	COMPLEMENT			
46	00101110	COMPLEMENT			
47	00101111	COMPLEMENT			
48	00110000	COMPLEMENT			
49	00110001	COMPLEMENT			
50	00110010	COMPLEMENT			
51	00110011	COMPLEMENT			
52	00110100	COMPLEMENT			
53	00110101	COMPLEMENT			
54	00110110	COMPLEMENT			
55	00110111	COMPLEMENT			
56	00111000	COMPLEMENT			
57	00111001	SPECIAL USE			
58	00111010	COMPLEMENT			
59	00111011	COMPLEMENT			
60	00111100	COMPLEMENT			
61	00111101	COMPLEMENT			
62	00111110	COMPLEMENT			
63	00111111	COMPLEMENT			
64	01000000	NOT AVAILABLE			
65	01000001	COMPLEMENT			
66	01000010	COMPLEMENT			
67	01000011	COMPLEMENT			
68	01000100	COMPLEMENT			
69	01000101	COMPLEMENT			
70	01000110	COMPLEMENT			
71	01000111	COMPLEMENT			
72	01001000	COMPLEMENT			
73	01001001	COMPLEMENT			
74	01001010	COMPLEMENT			
75	01001011	COMPLEMENT			
76	01001100	COMPLEMENT			
77	01001101	COMPLEMENT			
78	01001110	COMPLEMENT			
79	01001111	COMPLEMENT			
80	01010000	COMPLEMENT			
81	01010001	COMPLEMENT			
82	01010010	COMPLEMENT			
83	01010011	COMPLEMENT			
84	01010100	COMPLEMENT			

Table 2. Access Code Settings (Continued).

START ACCESS CODE (IN DECIMAL)	ACCESS CODE BOARD SETTING (IN BINARY) FOR E8001 RECEIVER MICROCOMPUTER MODULE (SW10) AND E7630 TRANSMITTER COMPUTER MODULE (SW4)	ASSOCIATED TELEMOTIVE RF FREQ (IN MHz)		ASSOCIATED TELEMOTIVE RF FREQ (IN MHz)	
	12345678	T#	FREQ	T#	FREQ
85	01010101	COMPLEMENT			
86	01010110	COMPLEMENT			
87	01010111	COMPLEMENT			
88	01011000	COMPLEMENT			
89	01011001	COMPLEMENT			
90	01011010	COMPLEMENT			
91	01011011	U99	410.350		
92	01011100	U85	411.200		
93	01011101	U87	412.750		
94	01011110	U88	413.800		
95	01011111	LR74	75.80	U89	413.950
96	01100000	COMPLEMENT			
97	01100001	COMPLEMENT			
98	01100010	COMPLEMENT			
99	01100011	COMPLEMENT			
100	01100100	U95	467.850	U46	413.850
101	01100101	U01	467.750		
102	01100110	U02	467.775		
103	01100111	U03	467.800		
104	01101000	U04	467.825		
105	01101001	U05	467.850		
106	01101010	U06	467.875		
107	01101011	U07	467.900		
108	01101100	U08	467.925		
109	01101101	U09	467.7625		
110	01101110	U10	467.7875		
111	01101111	U11	467.8125		
112	01110000	U12	467.8375		
113	01110001	U13	467.8625		
114	01110010	U14	467.8875		
115	01110011	U15	467.9125		
116	01110100	U16	467.9375		
117	01110101	U17	467.9625		
118	01110110	U18	467.9875		
119	01110111	U19	468.0125		
120	01111000	U20	468.0375		
121	01111001				
122	01111010				
123	01111011				
124	01111100				
125	01111101				
126	01111110				
127	01111111	NOT AVAILABLE			

Table 2. Access Code Settings (Continued).

START ACCESS CODE (IN DECIMAL)	ACCESS CODE BOARD SETTING (IN BINARY) FOR E8001 RECEIVER MICROCOMPUTER MODULE (SW10) AND E7630 TRANSMITTER COMPUTER MODULE (SW4)	ASSOCIATED TELEMOTIVE RF FREQ (IN MHz)		ASSOCIATED TELEMOTIVE RF FREQ (IN MHz)	
	12345678	T#	FREQ	T#	FREQ
128	10000000	NOT AVAILABLE			
129	10000001	COMPLEMENT			
130	10000010	COMPLEMENT			
131	10000011	COMPLEMENT			
132	10000100	COMPLEMENT			
133	10000101	COMPLEMENT			
134	10000110	COMPLEMENT			
135	10000111	COMPLEMENT			
136	10001000	COMPLEMENT			
137	10001001	COMPLEMENT			
138	10001010	COMPLEMENT			
139	10001011	COMPLEMENT			
140	10001100	COMPLEMENT			
141	10001101	COMPLEMENT			
142	10001110	COMPLEMENT			
143	10001111	COMPLEMENT			
144	10010000	COMPLEMENT			
145	10010001	COMPLEMENT			
146	10010010	COMPLEMENT			
147	10010011	COMPLEMENT			
148	10010100	COMPLEMENT			
149	10010101	COMPLEMENT			
150	10010110	COMPLEMENT			
151	10010111	COMPLEMENT			
152	10011000	COMPLEMENT			
153	10011001	COMPLEMENT			
154	10011010	COMPLEMENT			
155	10011011	COMPLEMENT			
156	10011100	LR87	72.50		
157	10011101	LR88	72.54		
158	10011110	LR89	72.58		
159	10011111	LR90	72.62		
160	10100000	SPECIAL USE			
161	10100001	COMPLEMENT			
162	10100010	COMPLEMENT			
163	10100011	COMPLEMENT			
164	10100100	COMPLEMENT			
165	10100101	SPECIAL USE			
166	10100110	LR91	72.64		
167	10100111	LR92	72.66		
168	10101000	LR93	72.68		
169	10101001	LR94	72.70		
170	10101010	LR95	72.72		

Table 2. Access Code Settings (Continued).

START ACCESS CODE (IN DECIMAL)	ACCESS CODE BOARD SETTING (IN BINARY) FOR E8001 RECEIVER MICROCOMPUTER MODULE (SW10) AND E7630 TRANSMITTER COMPUTER MODULE (SW4)	ASSOCIATED TELEMOTIVE RF FREQ (IN MHz)		ASSOCIATED TELEMOTIVE RF FREQ (IN MHz)	
	12345678	T#	FREQ	T#	FREQ
171	10101011	LR96	75.62		
172	10101100	LR83	75.86		
173	10101101	LR79	75.42		
174	10101110	LR97	75.64		
175	10101111	LR98	75.66		
176	10110000	LR99	75.70		
177	10110001	LR100	75.72		
178	10110010	LR101	72.44		
179	10110011	LR102	72.48		
180	10110100	LR103	72.52		
181	10110101	LR104	72.56		
182	10110110	LR105	72.60		
183	10110111	LR106	75.44		
184	10111000	LR107	75.48		
185	10111001	LR108	75.52		
186	10111010	LR109	75.56		
187	10111011	LR110	75.60		
188	10111100	LR111	72.02		
189	10111101	LR112	72.06		
190	10111110	LR113	72.10		
191	10111111	NOT AVAILABLE			
192	11000000	LR114	72.14		
193	11000001	LR115	72.18		
194	11000010	LR116	72.22		
195	11000011	LR117	72.26		
196	11000100	LR118	72.30		
197	11000101	LR119	72.34		
198	11000110	SPECIAL USE			
199	11000111	LR120	72.38		
200	11001000	LR23	72.12	LR31	49.61
201	11001001	LR1	72.44	LR32	49.63
202	11001010	LR2	72.48	LR33	49.65
203	11001011	LR3	72.52	LR34	49.67
204	11001100	LR4	72.56	LR35	49.69
205	11001101	LR5	72.60	LR36	49.71
206	11001110	LR6	75.44	LR37	49.73
207	11001111	LR7	75.48	LR38	49.75
208	11010000	LR8	75.52	LR39	49.77
209	11010001	LR9	75.56	LR40	49.79
210	11010010	LR10	75.60	LR41	49.81
211	11010011	LR11	72.02	LR42	49.83
212	11010100	LR12	72.06	LR43	49.85
213	11010101	LR13	72.10	LR44	49.87

Table 2. Access Code Settings (Continued).

START ACCESS CODE (IN DECIMAL)	ACCESS CODE BOARD SETTING (IN BINARY) FOR E8001 RECEIVER MICROCOMPUTER MODULE (SW10) AND E7630 TRANSMITTER COMPUTER MODULE (SW4)	ASSOCIATED TELEMOTIVE RF FREQ (IN MHz)		ASSOCIATED TELEMOTIVE RF FREQ (IN MHz)	
	12345678	T#	FREQ	T#	FREQ
214	11010110	LR14	72.14	LR45	49.89
215	11010111	LR15	72.18	LR46	49.91
216	11011000	LR16	72.22	LR47	49.93
217	11011001	LR17	72.26	LR48	49.95
218	11011010	LR18	72.30	LR49	49.97
219	11011011	LR19	72.34	LR50	49.99
220	11011100	LR20	72.38		
221	11011101	LR21	72.04		
222	11011110	LR22	72.08		
223	11011111	NOT AVAILABLE			
224	11100000	LR24	72.16		
225	11100001	LR25	72.20		
226	11100010	LR26	72.24		
227	11100011	LR27	72.28		
228	11100100	LR28	72.32		
229	11100101	LR29	72.36		
230	11100110	LR30	72.40		
231	11100111	COMPLEMENT			
232	11101000	COMPLEMENT			
233	11101001	COMPLEMENT			
234	11101010	COMPLEMENT			
235	11101011	COMPLEMENT			
236	11101100	COMPLEMENT			
237	11101101	COMPLEMENT			
238	11101110	COMPLEMENT			
239	11101111	NOT AVAILABLE			
240	11110000	COMPLEMENT			
241	11110001	COMPLEMENT			
242	11110010	COMPLEMENT			
243	11110011	COMPLEMENT			
244	11110100	COMPLEMENT			
245	11110101	COMPLEMENT			
246	11110110	COMPLEMENT			
247	11110111	NOT AVAILABLE			
248	11111000	COMPLEMENT			
249	11111001	COMPLEMENT			
250	11111010	COMPLEMENT			
251	11111011	NOT AVAILABLE			
252	11111100	NOT AVAILABLE			
253	11111101	NOT AVAILABLE			
254	11111110	NOT AVAILABLE			
255	11111111	NOT AVAILABLE			

Table 2. Access Code Settings (Continued).

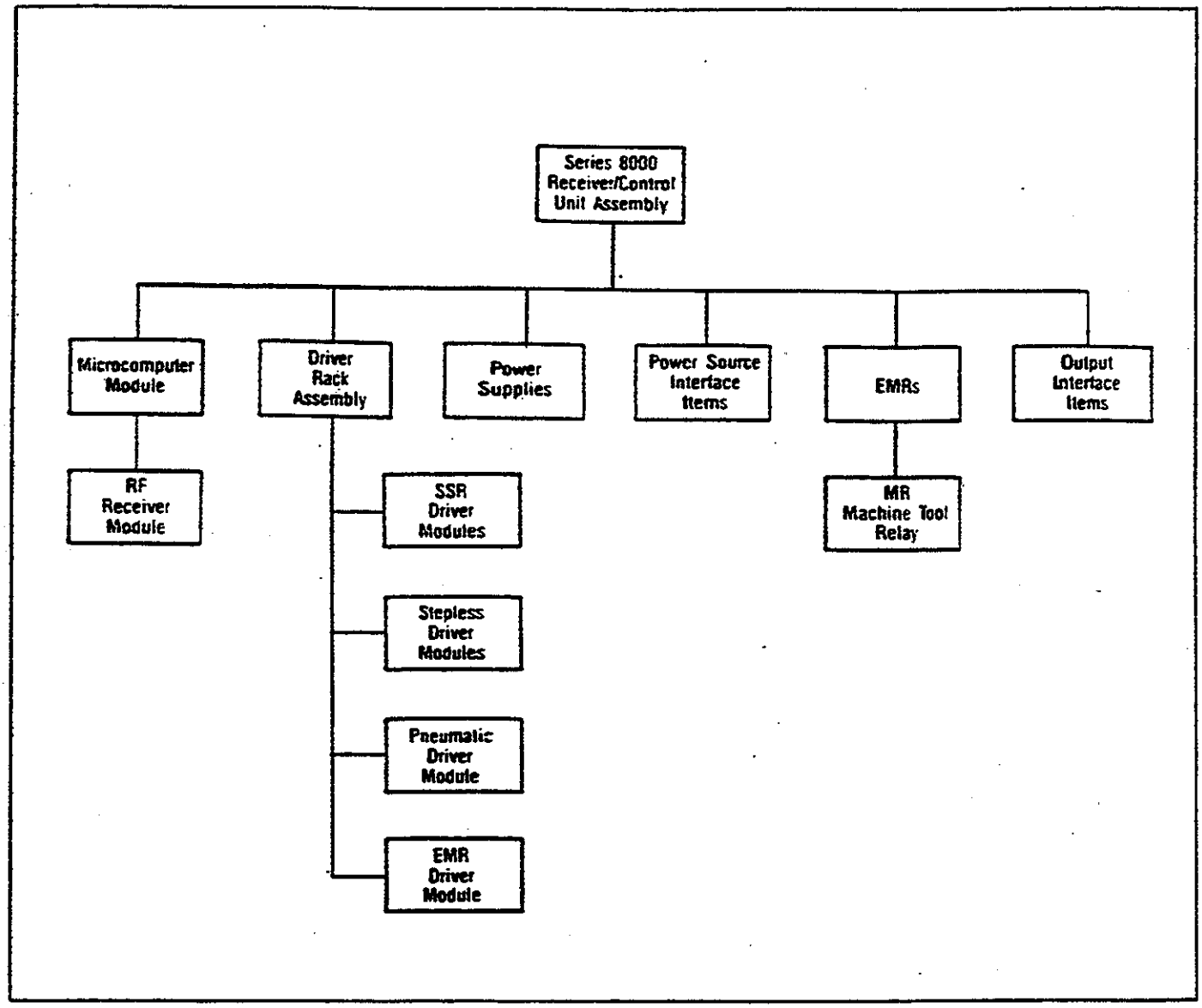


Fig. 3. System 8000 Receiver/Control Unit Block Diagram.

Alarm Auxiliary Function

The alarm auxiliary function is activated when the **START** or **WARNING DEVICE** buttons are pressed. The alarm function typically occupies a bit position in the auxiliary function data word (data word #1). When the transmitter **START** button is pressed, the Receiver/Control Unit **K2 relay** (the sensitive relay on the Microcomputer Board) is activated. This enables the output interface and activates the alarm function. Once the Receiver/Control Unit is started up, the alarm function can be activated anytime simply by pressing the **WARNING DEVICE** button on the transmitter.

MR Relay Function

The purpose of the MR Relay output function is to act as a master power signal to the equipment's master control (MC) relay. The MR intermediate relays are present to boost the power level of the MR enable signal to the point where it can drive the main contactor (MC) coil in the user's equipment.

At the MR enable circuit, an output is derived directly from the signal received by the radio control system. This approach is taken to guarantee the "no signal no operation" feature for the MR relay function. Thus, power will not be applied to the equipment if the rf signal is lost or degraded significantly.

RADIO SYSTEM OPERATING PROCEDURE

The overall starting and shutdown procedures provided by the original equipment system manufacturer should be followed for starting up and shutting down the equipment which is radio controlled by the Series 8000 system.

Manual-Radio Switching Procedure

1. To switch from manual control to radio control, perform the following steps:
   a. Make sure that the power to the equipment (crane, locomotive, etc.) is off.
   b. Set the transfer switch to the **RADIO** position. Check for push to operate type switches.
   c. Turn the equipment power on. The system is now ready for remote control operation (after the radio control system is powered up).
2. To switch from radio control to manual control operation perform the following steps:
   a. Turn the transmitter off by setting the **ON/OFF** switch and key lock switches to the off position.
   b. Set the equipment's transfer switch to the **MANUAL** position. The system is now ready for manual operation.

Radio System Starting Procedure

1. Turn the transmitter key lock switch to the **ON** position. This connects the battery to the transmitter **ON/OFF** switch (but the transmitter is still not powered up).
2. Set the transmitter **ON/OFF** switch to the **ON** position. This connects the battery to the transmitter circuitry and allows the transmitter to transmit a properly formatted signal (except data word #0 doesn't contain an access code yet).
3. Press the **START** button on the transmitter. A properly formatted signal that includes the start access code is transmitted. The override auxiliary start function (horn or start light) is also activated.
4. Release the **START** button. The transmitter will now transmit a properly formatted signal that includes the maintain access code.

Radio System Operating Conditions

In order for the Receiver/Control Unit master relay (MR) to remain in the on state, the rf signal from the transmitter must have the proper carrier frequency, contain the proper code, and be above a minimum level. Also, the properly coded signal must be continuously received and decoded by the receiver rack assembly.

Maximum Range Control Setting

The RF Receiver Module has an adjustment that allows the maximum range of the system to be set.

WARNING

Do not change this setting. It can only be adjusted by the factory.

Antenna Diveristy Option

This option will only be used in special applications. Consult factory for technical information.

Radio System Shut Down Procedure

To shut down the system for any reason, just set the **ON/OFF** switch (on the transmitter) to the **OFF** position. For safety reasons it is best to also turn the key lock **ON/OFF** switch to the **OFF** position.

Radio System Restarting Procedure

If the system is shut down for any reason (intentional or automatic shut down), restarting should be attempted by momentarily pressing the **START** button. If this fails to restart the system, set the transmitter **ON/OFF** switch to the **OFF** postion. After the switch has been off for at least two seconds, set it back to the **ON** position and then momentarily press the **START** button again. This should restart the system.

BATTERY CHARGER OPERATION

When transmitters are equipped with a rechargeable battery, the transmitter should be plugged into the supplied battery charger whenever it is not in use. Different battery options use different battery chargers and only the specified charger should be used.

PREVENTIVE MAINTENANCE

The Series 8000 radio control system requires a limited amount of routine maintenance to achieve optimum system performance. The system is physically arranged for quick and easy service through part swapping. For convenience in servicing the system, a complete set of electronic, electrical, and pneumatic spare parts should be available at the job site. This allows the user to take advantage of the physical construction of the system and simply replace a malfunctioning part with a new part.

ROUTINE INSPECTION

On a periodic basis, the entire system should be routinely checked for proper physical and electrical conditions. The condition under which the system is operated should be taken into consideration (i.e., systems operated in a harsh environment should be inspected more frequently than systems that are operated in a clean environment with relatively constant temperature and humidity). Any parts that are found to be defective should be replaced immediately.

RECEIVER/CONTROL UNIT MAINTENANCE

The receiver assembly should fit snugly and tightly on the shock mounts. If it is loose, the shock mounts should be inspected carefully and replaced if damaged.

TRANSMITTER MAINTENANCE

1. Keep the transmitter clean and free of all coatings, especially those that are electrically conductive.
2. Inspect the case hardware and make sure that everything is tightened adequately. Replace broken or missing hardware immediately.
3. For lever switch transmitters (not the 8000 MTx membrane switch transmitter), check the motion lever switches and make sure that they move smoothly in both directions and return to their neutral (center) position.
4. Make sure that the battery voltage indicator flashes whenever the transmitter is on.

SYSTEM TROUBLESHOOTING

The following troubleshooting guide is only intended as a general troubleshooting procedure. It is recommended that only qualified electronics technicians attempt to repair the system and the person performing the repairs should refer to the Telemotive Technical Manual for the Series 8000 System before attempting to make any repairs. While each system is supplied with system drawings, transmitter engraving drawings, and a user's manual, the Technical Manual supplies important information not found in any of these other documents. The Technical Manual contains the information necessary for troubleshooting and repairing individual circuit boards.

In addition to the supplied documents and the Technical Manual, several pieces of electronic test equipment are necessary to fully diagnose circuit problems. These are a Volt/Ohm meter or DMM (Digital Multimeter), a transmitter test receiver, and a dual-trace oscilloscope with at least 10 MHz bandwidth. A complete set of electronic, electrical, and pneumatic spare parts should also be available so that when problems arise, parts can be swapped and the system can be put back into working order quickly.

The Receiver/Control Unit has indicators, test points, and built in diagnostic software to aid in troubleshooting. These functions are described in the following troubleshooting procedures.

In the event of a malfunction in the radio control system, the logical approach is to determine the nature of the trouble and replace the malfunctioning part. This can usually be accomplished by operating the system and observing the diagnostic indicators and the output indicators located on the Microcomputer Board and the Output Driver Modules. Most failures can be classified as either a completely inoperative system, a system that is operating erratically, or a system that is only partially inoperative. For this reason, the troubleshooting section of this manual is broken up into these catagories. Once the nature of the problem has been classified into one of these catagories, refer to the troubleshooting procedure covering that type of problem. Once the malfunctioning part is identified, it can be replaced with a new part and the system can be brought back into operation quickly. To maintain warranty coverage, the defective modules or circuit boards should be returned to Telemotive for repair or replacement. Refer to the **SERVICE INFORMATION** section of this manual for the correct address.

NOTE

Perform each troubleshooting routine only in the specified order. It is important that a "known good" transmitter be used for all checks other than transmitter checks.

COMPLETELY INOPERATIVE SYSTEM (Refer To Flowchart 1)

The fact that the system is not sending any commands implies that a proper signal is not being sent by the transmitter, the Receiver/Control Unit is not properly receiving and decoding the transmitted signal, or a problem exists with the MR circuit in the Receiver/Control Unit.

Transmitter Checks

1. Turn on the transmitter key lock and **ON/OFF** switches.
2. Momentarily press the transmitter **START** switch.
3. Check that the battery monitor on the transmitter indicates the proper battery voltage (the indicator will flash when battery voltage is correct). If the voltage is not sufficient, refer to the Technical Manual or contact Telemotive's service department.

4. Using a VOM, measure the transmitter current drain. The measured value should be within ±10% of the value shown in Table 3.

5. If the transmitter appears to be working properly, go on to the **Power Supply Checks.**

6. If the proper DC voltage and current are present on the transmitter microcomputer, but the proper tones are not heard from the test receiver, replace the E7123 Module. (This module should be matched in frequency). After replacing the module, check to see if the high pitched tones are heard at the transmitter test receiver.

7. If the transmitter is still not operating properly, replace the transmitter Microcomputer Module.

Power Supply Checks

1. Turn on the transmitter key lock and **ON/OFF** switches.

2. Check the Microcomputer Board to see if the **+5 V, +12 V,** and **-12 V** output voltage indicators are lit. Also check to see if all three (also **+5 V, +12 V,** and **-12 V**) indicators are lit on the Driver Rack backplane.

3. If all of the indicators are lit, go on to the **"Receiver Module"** checks.

4. If at least one of the power supply indicators is lit (e.g., the **+5 V** indicator is lit on the Microcomputer Board), replace the power supply assembly.

5. If none of the DC output voltage indicators are lit, check the AC (DC) input power line to the system. The input voltage should be within ±10% of the specified voltage that the system is designed to operate from. See the system wiring diagram for the AC (DC) input power terminal locations and required voltage.

6. If the AC (DC) voltage is not present at the power line input terminals of the power supply, check the wiring between the input terminals and the power source and the wiring between the power source and the Receiver/Control Unit power line input for loose connections.

7. If the AC (DC) power line voltage is present at the power supply assembly's connector and the DC output indicators are not lit, check the power supply input fuse. If the fuse is blown, replace with a new fuse of the correct value. If the fuse is good, replace the power supply assembly.

Receiver Module Checks

1. Turn on the transmitter key lock and **ON/OFF** switches.

2. Momentarily press the transmitter **START** switch.

3. Check to see if the **RX** (received signal) and the **ENL** (dynamic enable) indicators on the Microcomputer Board are lit.

4. If the indicators are lit, go on to the **Microcomputer Board Checks.**

5. If the **ENL** and **RX** indicator still will not light, perform the following checks:

   a. Reposition either the transmitting or receiving antenna in order to obtain an unobstructed signal path. If necessary, bring the transmitter closer to the receiver to check operation.

   b. Check to see if the Receiver Module case is properly grounded.

   c. Check the antenna and associated coaxial cable going to the Receiver Module for damage or broken connectors.

   d. Check the Range Control settings on the Receiver Module and Microcomputer Board to see if they are still set properly.

NOTE

Do not attempt to adjust anything on the Receiver Module

other than the Range Control. The Receiver Module was adjusted at the factory and should require no further adjustment.

6. If the **ENL** and **RX** indicators are not lit, replace the Receiver Module. Be sure that the VCO (voltage controlled oscillator) on the Receiver Module is programmed for the proper frequency. Check the Microcomputer Board for the proper frequency programming. See Table 1 in the **SYSTEM DESCRIPTION** section of this manual.

7. If the **ENL** and **RX** indicators are still not lit, replace the Microcomputer Board.

Microcomputer Board Checks

1. Set **SW 9** (located on the Microcomputer Board) to the **0** position.

2. Turn on the transmitter key lock and **ON/OFF** switches.

3. Momentarily press the transmitter **START** switch.

4. Check to see if the green **+5 V, +12 V, -12 V, ENL, RX,** and **RST** indicators on the Microcomputer Board and the **+12 V, -12 V,** and **+5 V** indicators on the Driver Rack backplane are lit. The whole system is operating correctly when all the red LED's go out, all the green LED's light, and operation of the transmitter controls causes the associated indicators on the Output Driver Modules to light. Consult the system drawings to determine the relationship between the output indicators and the proper associated function.

5. If any of the red indicators do not turn off and/or any of the green indicators do not light, go through the following dignostics check (refer to Fig. 4):

   a. **SW9** on the Microcomputer Board should be in the **0** position. In this position, each of the 8 red LED's indicates the following (if it is lit):

      D7 - Reserved For Future Use.

      D6 - Contact Monitoring Error. If system dropout occurs when this LED is lit, step d (switch positions 6 through **9**) of this diagnostic procedure will give more information.

      D5 - Bad Switch Error. This indicator lights when bad switch data is received. Setting **SW9** to position A will indicate which transmitted word is bad. Usually this will indicate which transmitter motion switch is bad. However, this indicator will also light if the transmitter **START** switch is pressed after the system is enabled (started). When this occurs, the warning device will also turn on.

      Corrective Action: Replace any switches that are indicated as defective.

      D4 - Bad Received Data Error. This indicator will light if the system has received bad data that either does not conform to the Telemotive data format, has parity error, or contains too much noise.

      Corrective Action: Make sure that the system is operated in an electrical noise free area and, if necessary, repair the transmitter.

      D3 - **K2 Relay** Error. This indicator will light if the **K2** (Sensitive) **relay** or the MC circuit on Microcomputer Board are defective. If the relay is stuck in the on position, the warning device will turn on.

      Corrective Action: Replace the **K2 relay.** If this does not correct the situation, replace the Microcomputer Board.

NOTE

If D0, D1, or D2 light, the system will enter lock up mode. This will not allow further operation of the system. If the error is temporary, depressing the **RESET** (**SW1**) switch on the Microcomputer Board will restart the system. If any LED remains lit, an error condition

exists and the corrective action should be initiated.

D2 - Checksum Error. This indicator will light if the EPROM on the Microcomputer Board is defective.

Corrective Action: Replace the EPROM.

D1 - Internal Memory Error. This indicator will light if the Microprocessor on the Microcomputer Board is defective.

Corrective Action: Replace the Microprocessor.

D0 - Watchdog Timer Error. This indicator will light if the watchdog timer circuit is defective.

Corrective Action: Replace the Microcomputer Board.

b. Set **SW9** on the Microcomputer Board to the 1 position. **D0** through **D7** indicate the access/maintain code received by the system. In order for the system to operate, the code indicated by **D0** through **D7** has to match the code set on the access code switch (**SW2**) on the Microcomputer Board.

Corrective Action: Set the transmitter and receiver access code switches to the same code.

c. **D0** through **D7** indicate the AGC (automatic gain control) level when **SW9** is in position **2, 3, 4, or 5.** The 32 step bar graph is divide into 4 sections, with the lowest value being shown when **SW9** is set to position 2 and the highest value being shown when **SW9** is set to position **5.**

d. When **SW9** is set to positions **6** through **9, D0** through **D7** will indicate the status of the input lines. However, if system dropout occurs due to a contact monitoring error, the indicators will show the faulty lines that are causing the dropout (dropout is caused by a contact that is stuck in the on position). The indicators will match the physical position of the contact in the system.

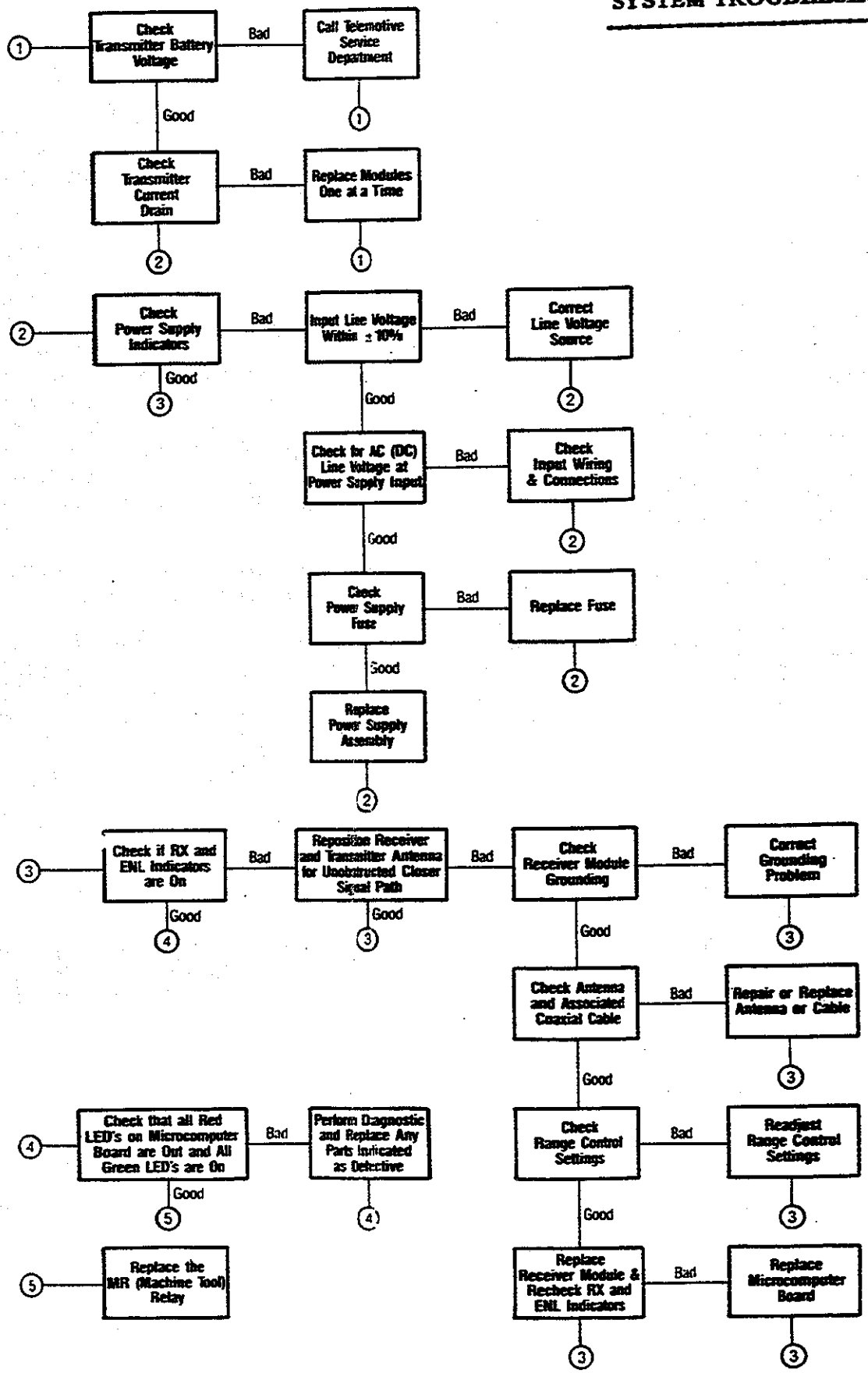
Corrective Action: Replace the defective relay board(s).

e. Set **SW9** to position **A. D0** through **D7** will indicate any word that contains bad switch data. **D0** corresponds to word 0, **D1** corresponds to word 1, etc.

Corrective Action: Replace any transmitter motion switches that are shown to be bad.

MR Relay Circuit Checks

If the system is still not operating properly, replace the MR (Machine Tool) relay mounted on the Receiver/Control Unit Cabinet.



Flowchart 1. Troubleshooting a Completely Inoperative System.

ERRATICALLY OPERATING SYSTEM (Refer To Flowchart 2)

The fact that the radio control system starts up but some or all outputs operate erratically implies that there is an intermittent problem with the transmitted signal, the power supplies in the Receiver/Control Unit, the received signal, the decoding of the received frame of data, the output interfacing of a specific system output signal, or a problem in the Receiver/Control Unit wiring.

Transmitter Checks

While operating the system, observe whether the problem occurs only when a certain switch is activated. Replace any controls that cause erratic operation.

NOTE

It is possible to interchange similar transmitter controls when troubleshooting the transmitter but stepless switches, stepped switches, and auxiliary switches should never be interchanged.

Receiver Signal Strength Checks

1. Set **SW 9** to position **2** and set the range adjustment controls on the RF Receiver Module and the Microcomputer Board (R36) fully counterclockwise. At least four of the red LED's (**D0** through **D4**) should light.
2. If at least four of the red LED's do not light and the **RX** indicator does not light, the problem is most likely in the RF Receiver Module or the Microcomputer Board. Replace the RF Receiver Module and the Microcomputer Board one at a time.
3. Return **SW9** to position **0**.

Power Supply Checks

1. Turn on the transmitter key lock and **ON/OFF** switches.
2. Check the Microcomputer Module and the Driver Module backplane to see if the **+5 V, +12 V,** and **-12 V** indicators are intermittent or dim. If the indicators show a normal voltage, go on to the **Receiver Module Checks.**
3. If the indicators are intermittent or dim, check the AC (DC) input power line to the system. The input voltage should be steady and be within ±10 % of the specified voltage. See the system wiring diagram for the AC (DC) input power terminal location and the specified voltage.
4. If the AC (DC) voltage is intermittent at the power line input pins of the power supply assembly, check the wiring between the input terminals and the power source and the wiring between the power source and the Receiver/Control Unit power line input for loose connections or broken wires.
5. If the power supply input line voltage is correct but the output voltages remain intermittent, replace the power supply assembly.

Receiver Module Checks

NOTE

Do not attempt to make any adjustments on the Receiver Module other than range control adjustment. The Receiver Module was adjusted at the factory and should not need any further adjustments other than range control.

1. Turn on the transmitter key lock and **ON/OFF** switches.
2. Momentarily press the **START** switch.
3. Check to see if the **ENL** and the **RX** indicators on the Microcomputer Board are lit. If they are lit, go on to the **Microcomputer Checks.** If not, continue with this procedure.
4. To try to get the system to work properly, reposition the transmitter or receiver antenna and bring the transmitter and receiver closer together to obtain an unobstructed path.

5. Check the Receiver Module grounding.

6. Check the antenna and associated coaxial cable for damage or faulty connections.

7. If grounding, the antenna, and the coaxial cable are good but the indicators will not light, replace the Receiver Module.

Microcomputer Checks

1. Set **SW 9** (located on the Microcomputer Board) to the **0** position.

2. Turn on the transmitter key lock and **ON/OFF** switches.

3. Momentarily press the transmitter **START** switch.

4. On the Microcomputer Board, all the red LED's (**D0** through **D7**) should go out and all the green LED's (**+5 V, +12 V, -12 V, ENL, RX,** and **RST**) should light.

5. In a properly functioning system, operating the transmitter controls should cause the associated output indicators to light. Refer to the system drawings to determine the relationship between the output indicators and there associated functions.

6. If any of the red LED's do not go out and any of the green LED's will not light, perform the following diagnostic checks (refer to Fig. 4):

   a. **SW9** on the Microcomputer Board should be in the **0** position. In this position, each of the 8 red LED's indicates the following (if it is lit):

      D7 - Reserved For Future Use.

      D6 - Contact Monitoring Error. If system dropout occurs when this LED is lit, step d (switch positions **6** through **9**) of this diagnostic procedure will give more information.

      D5 - Bad Switch Error. This indicator lights when bad switch data is received. Setting **SW9** to position A will indicate which transmitted word is bad. Usually this will indicate which transmitter motion switch is bad. However, this indicator will also light if the transmitter **START** switch is pressed after the system is enabled (started). When this occurs, the warning device will also turn on.

      Corrective Action: Replace any switches that are indicated as defective.

      D4 - Bad Received Data Error. This indicator will light if the system has received bad data that either does not conform with the Telemotive data format, has parity error, or contains too much noise.

      Corrective Action: Make sure that the system is operated in an electrical noise free area and if necessary, repair the transmitter.

      D3 - **K2 Relay** Error. This indicator will light if the **K2** (Sensitive) **relay** or the MC circuit on Microcomputer Board are defective. If the relay is stuck in the on position, the warning device will turn on.

      Corrective Action: Replace the **K2 relay. If this does not correct the situation, replace the Microcomputer Board.**

NOTE

If D0, D1, or D2 light, the system will enter lock up mode. This will not allow further operation of the system. If the error is temporary, depressing the **RESET (SW1)** switch on the Microcomputer Board will restart the system. If any LED remains lit, an error condition exists and the corrective action should be initiated.

      D2 - Checksum Error. This indicator will light if the EPROM on the Microcomputer Board is defective.

Corrective Action: Replace the EPROM.

D1 - Internal Memory Error. This indicator will light if the Microprocessor on the Microcomputer Board is defective.

Corrective Action: Replace the Microprocessor.

D0 - Watchdog Timer Error. This indicator will light if the watchdog timer circuit is defective.

Corrective Action: Replace the Microcomputer Board.

b. Set **SW9** on the Microcomputer Board to the **1** position. **D0** through **D7** indicate the access/maintain code received by the system. In order for the system to operate, the code indicated by **D0** through **D7** has to match the code set on the access code switch (**SW2**) on the Microcomputer Board.

Corrective Action: Set the transmitter and receiver access code switches to the same code.

c. **D0** through **D7** indicate the AGC (automatic gain control) level when **SW9** is in position **2, 3, 4,** or **5.** The 32 step bar graph is divide into 4 sections, with the lowest value being shown when **SW9** is set to position **2** and the highest value being shown when **SW9** is set to position **5.**

d. When **SW9** is set to positions **6** through **9, D0** through **D7** will indicate the status of the input lines. However, if system dropout occurs due to a contact monitoring error, the indicators will show the faulty lines that are causing the dropout (dropout is caused by a contact that is stuck in the on position). The indicators will match the physical position of the contact in the system.

Corrective Action: Replace the defective relay board(s).

e. Set **SW9** to position **A. D0** through **D7** will indicate any word that contains bad switch data. **D0** corresponds to word 0, **D1** corresponds to word 1, etc.

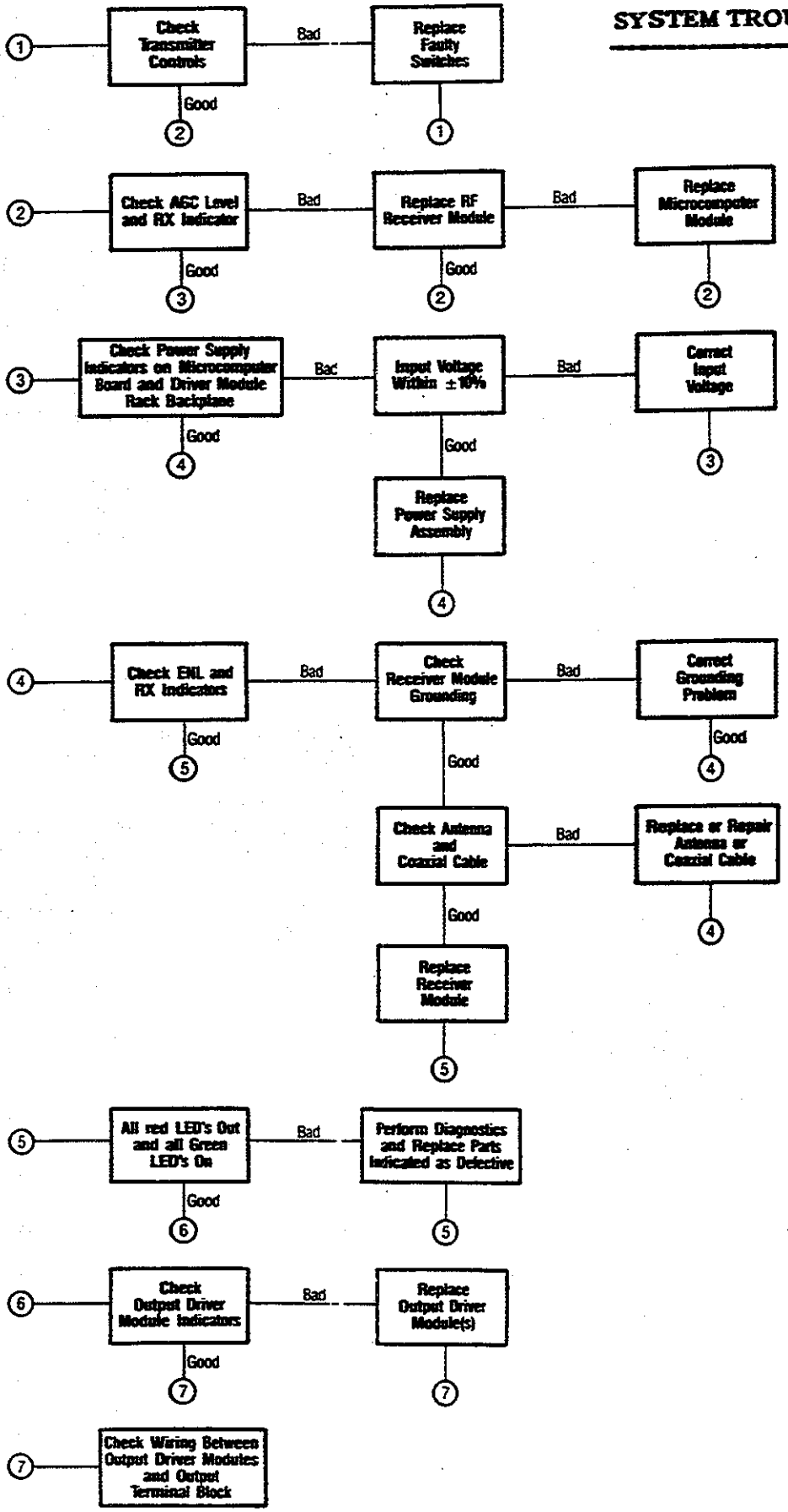
Corrective Action: Replace any transmitter motion switches that are shown to be bad.

Output Driver Module Checks

1. Turn on the transmitter key lock and **ON/OFF** switches.
2. Momentarily press the transmitter **START** switch.
3. If the indicator lights on each of the Output Driver Modules does not light when the corresponding control is operated or any of the indicators are stuck on, replace that Output Driver Module.

Receiver/Control Unit Wiring Checks

1. Turn on the transmitter key lock and **ON/OFF** switches.
2. Momentarily press the transmitter **START** switch.
3. If the Output Driver Modules are operating properly but the system will not operate properly, use a meter to check the voltage on the wiring between the Output Driver Modules and the output terminal block.



Flowchart 2. Troubleshooting an Erratically Operating System.

PARTIALLY OPERATIVE SYSTEM (Refer To Flowchart 3)

If the system starts up, transmits, and receives and outputs some commands properly, it implies that: the transmitter is encoding and transmitting the signal properly but some of its controls are not operating properly; the Receiver/Control Unit is starting-up, receiving, and decoding the signal properly but some of its output driver circuits are not operating properly; or there is a Receiver/Control Unit wiring problem.

Transmitter Control Check

With the suspected transmitter, start the system and work each switch to determine which functions are not functioning properly. For functions that do not operate properly, replace the switches.

NOTE

It is possible to interchange similar transmitter controls when troubleshooting the transmitter but stepless switches, stepped switches, and auxiliary switches should never be interchanged.

Output Driver Module Checks

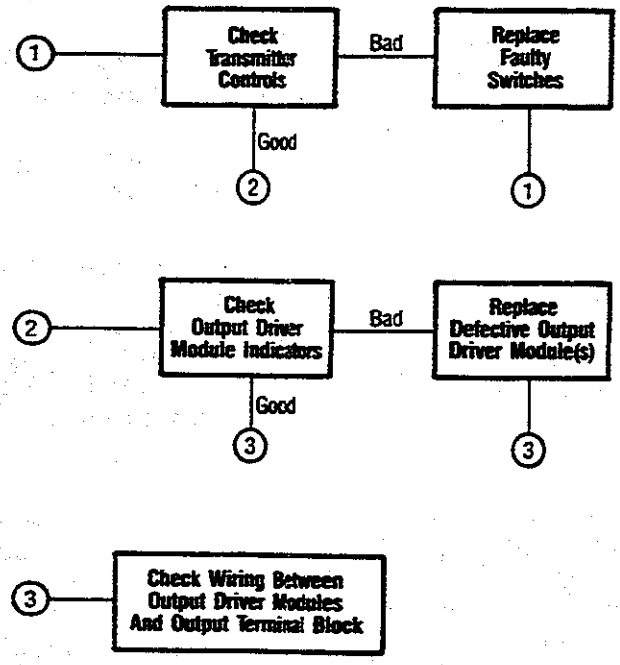
1. Turn on the transmitter key lock and **ON/OFF** switches.
2. Momentarily press the transmitter **START** switch.
3. If the indicator lights on each of the Output Driver Modules does not light when the corresponding control is operated or any of the indicators are stuck on, replace that Output Driver Module.

Receiver/Control Cabinet Wiring Checks

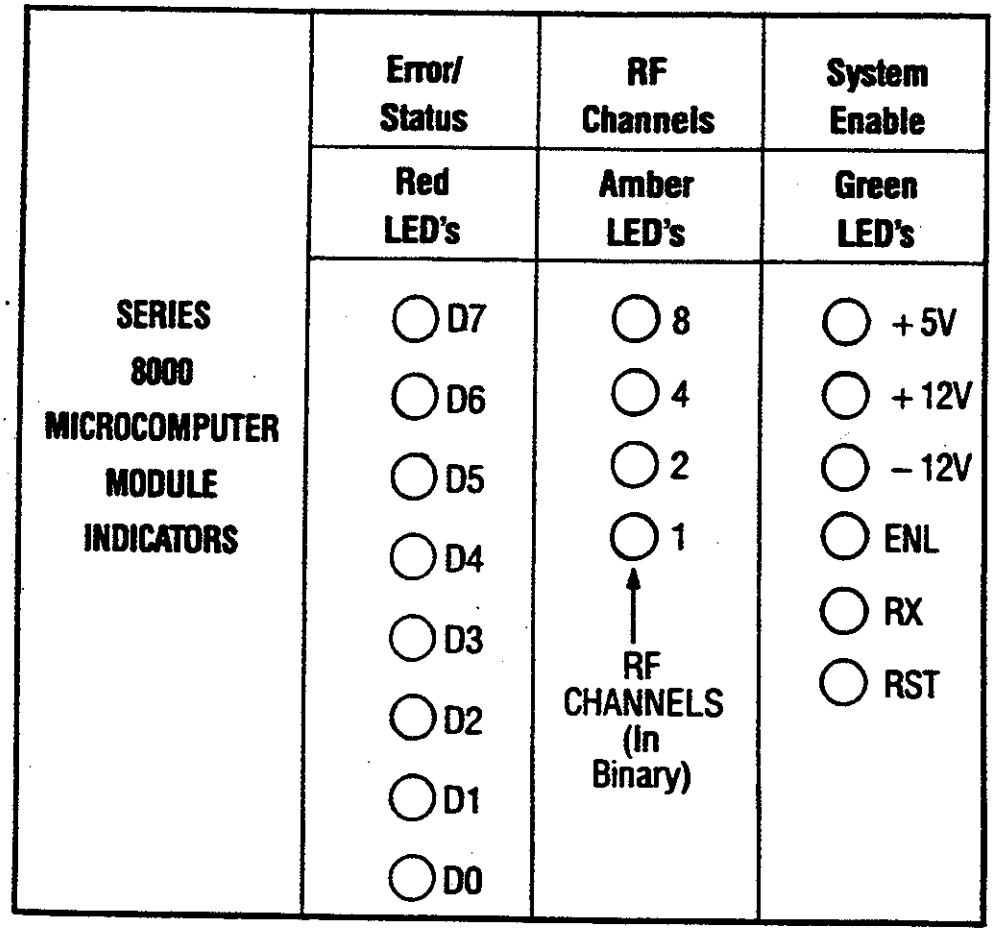
1. Turn on the transmitter key lock and **ON/OFF** switches.
2. Momentarily press the transmitter **START** switch.
3. If the Output Driver Modules are operating properly but the system will not operate properly, use a meter to check the voltage on the wiring between the Output Driver Modules and the output terminal block.

TPN	RF POWER OUT	NOM BATTERY VOLTAGE	NOM CURRENT DRAIN
E8600-1	50 mW	5.3 V	50 mA
E8600-2	100 mW	5.3 V	70 mA
E8600-3	400 mW	10.0 V	140 mA

Table 3. Series 8000 Transmitter Nominal Current Drain.



Flowchart 3. Troubleshooting a Partially Operative System.



SW 9 SETTING	0	1	2-5	6-9	A
RED LED'S INDICATE	ERROR	STATUS	STATUS	STATUS/ ERROR	ERROR
D7	Not Used	↑ Access Code ↓	↑ 32 Step AGC Level ↓	↑ Input Line Level/ Contact Dropout ↓	↑ Bad TX Switch ↓
D6	Contact Monitor				
D5	TX Switch				
D4	RX Data				
D3	K2 Relay				
D2	Checksum				
D1	Memory				
D0	Watchdog Timer				

Fig. 4. Diagnostic/Status Indicators.

SERVICE INFORMATION

For questions about servicing, technical information, or parts information contact Telemotive's Field Service Department at the following address:

Telemotive Industrial Controls
Field Service Department
175 Wall Street
Glendale Heights, Illinois 60139-1985
Phone: 630-582-1111
Toll Free: 888-687-4400
Website: www.telemotive.com

MEMBRANE SWITCH TRANSMITTER OPERATING INSTRUCTIONS

WARNING

Follow ALL Radio Control Crane Safety instructions given in the User's Manual before using Transmitter Unit.

SERIES 8021/51 CONTROL PANEL

(Refer to Fig. 5)

The Series 8021/51 Transmitter Unit uses finger-touch membrane slide-strip controls in place of lever-type controls found on earlier transmitters; sliding a finger along the membrane strip varies the equipment speed. In place of the booted AUX, WARNING, START, and OFF switches found on earlier transmitters, the 8021/51 uses momentary-contact membrane switches.

1. **START Pushbutton.** Momentary-contact switch. Pressing this switch turns Transmitter ON and sends "start" code to Receiving/Control Unit.

2. **AUXiliary Pushbuttons.** Momentary-contact switches. Pressing switch turns auxiliary function ON. Function remains ON as long as AUX switch is pressed; function ceases when finger is lifted from switch.

3. **Motor Controls.** Slide-strip momentary-contact control. Pressing a given slide control at either the top or bottom of the strip turns on the selected equipment.

   a. **Direction** is selected depending on which end of the strip is pressed. For example, pressing the "**UP**" end of a strip selects motion in the "up" direction, pressing the "**DN**" end of a strip selects motion in the "down" direction.

   b. **Speed** is selected by sliding finger away from direction point that was first pressed. In other words, the farther you slide your finger away from selected direction, the faster the load will move.

   c. **Halt** motion by simply removing finger from the slide strip. When this is done, switch will immediately resume neutral position.

4. **HORN Pushbutton.** Momentary-contact switch. Pressing switch sounds horn. Horn remains on as long as switch is pressed; horn ceases when finger is lifted from switch.

5. **OFF Pushbutton.** Momentary-contact switch. Pressing this switch shuts Transmitter OFF. To restart, press START pushbutton.

6. **Keyswitch (not shown).** Turns Transmitter Unit battery power ON and OFF. ON position is indicated by flashing Battery Monitor LED. Keyswitch is located adjacent to antenna.

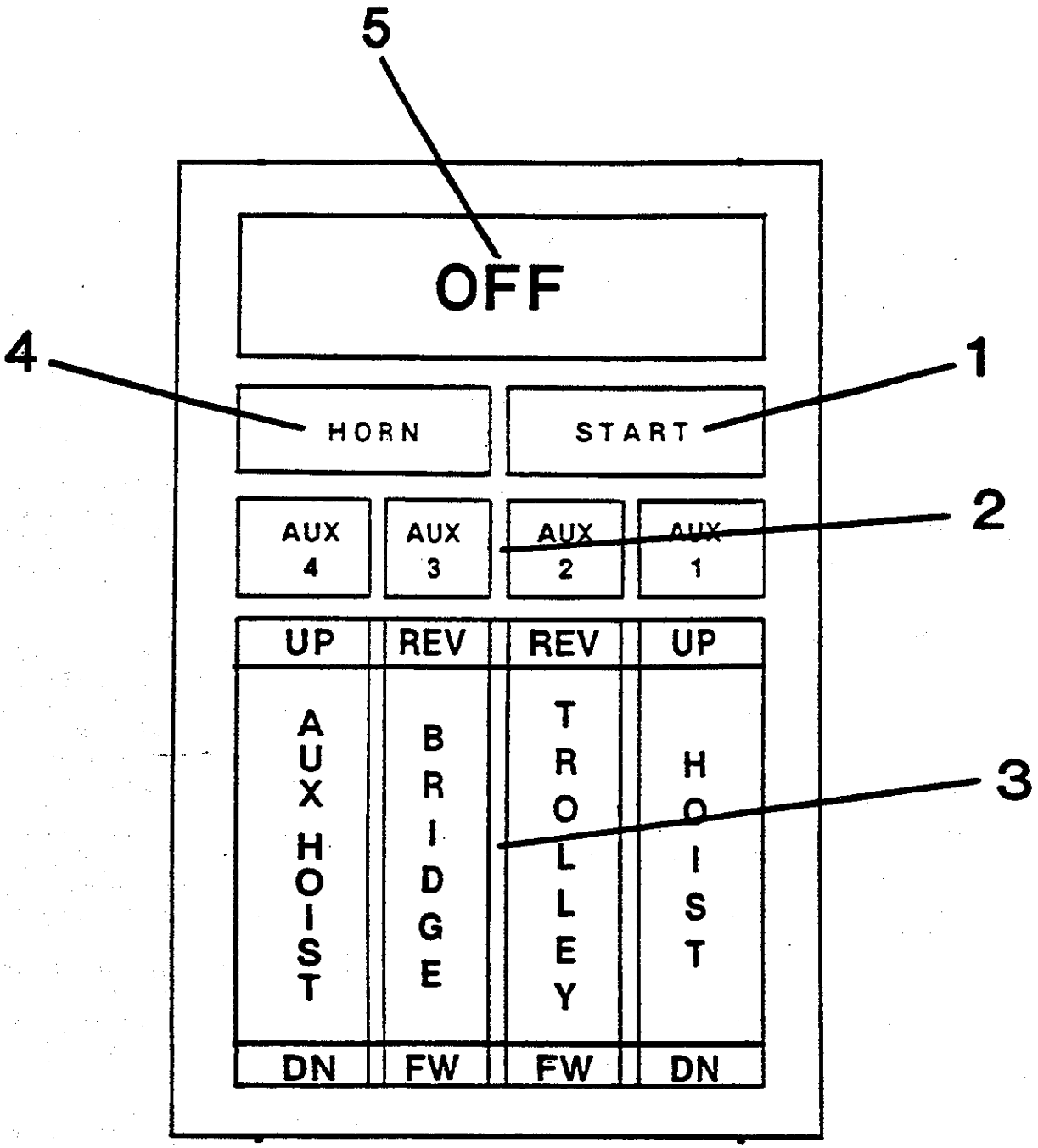


Fig. 5. Series 8021/51 Control Panel.

USING SLIDE-STRIP MOTOR CONTROLS
(Refer to Fig. 6)

NOTE

The Series 8021/51 Transmitter Unit uses low-tension mechanical membrane switches. Merely placing your finger over a control will not cause the switch to operate: You must press the control a small amount in order to ensure operation.

1. Locate desired Motor Control(s) on Transmitter Control Panel. Control functions are labeled on Transmitter Control Panel and top cover.

2. Select desired **DIRECTION** by placing finger over corresponding direction label.

Example

HOIST UP is selected. Finger is placed over "UP" label on "HOIST" slide-strip.

3. Select equipment **SPEED** by sliding finger away from end of slide-strip that was pressed in step 2. The farther you slide your finger away, the faster the equipment will move.

Example

HOIST UP is selected. Noting that more speed is required, the operator slides his finger away from the "UP" label.

4. **To HALT equipment motion,** simply remove finger from control.

NOTE

Removing your finger from a control at any time halts equipment motion. Therefore, when sliding finger up or down slide-strip, do not release finger until desired movement is completed.

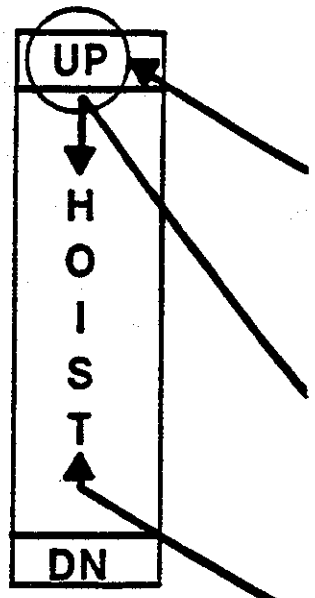
RADIO SYSTEM STARTING PROCEDURE

1. Follow all Safety Instructions listed in the User's Manual.
2. Make sure that the power to the material handling equipment is OFF.
3. Turn the Transmitter keyswitch to the ON position ("ON" is indicated when Battery Monitor LED repeatedly flashes on and off).
4. Set the equipment transfer switch to the RADIO position. Check for "push-to-operate" switches.
5. Turn the material handling equipment power ON.
6. Hold the Transmitter Unit with the antenna facing forward; or clip Transmitter to your belt.
7. Press the **START** Pushbutton. System is now under radio control.

BATTERY REPLACEMENT

Battery condition is indicated by the Battery Monitor LED located on the Transmitter Control Panel. When battery is near discharge, Battery Monitor LED remains constantly lit.

1. Turn keyswitch to the OFF position and remove key.
2. Battery is contained in compartment located in the transmitter end opposite from the antenna end-panel.
3. Transmitter end-panel hinges open, allowing access to battery. Open compartment door by unscrewing the two thumbscrews located on the end-panel (when screws are fully unscrewed, screws still remain in door).
4. Tilt door open and remove battery.
5. Follow this procedure in reverse to reinstall battery.



Pressing "HOIST UP" label selects "UP" direction of hoist.

Sliding finger **away** from starting point (in this case, "HOIST UP") **increases** speed.

Sliding finger **back towards** starting point **decreases** speed.

Releasing finger from slide-strip at any time **halts** equipment movement.

Fig. 6. Slide-Strip Motor Control.

TELEMOTIVE BATTERIES

PERSONNEL SAFETY PRECAUTIONS

WARNING

The following precautions must be observed to help prevent conditions which are dangerous to persons servicing the equipment and persons in the area of the equipment.

1. Never incinerate batteries. Incinerating most batteries causes an explosion hazard.

2. Only Lead-Acid and Nickel-Cadmium ("Ni-Cad") batteries can be recharged. Never attempt to recharge non-rechargeable batteries; recharging such batteries presents an explosion hazard.

3. If battery electrolyte is leaked on skin, rinse skin with clean cool water for at least fifteen minutes. Get medical attention immediately.

4. Store batteries in a cool, dry, well-ventilated area.

5. Only use approved Telemotive Battery Chargers when recharging rechargeable batteries.

EQUIPMENT PROTECTION PRECAUTIONS

CAUTION

The following precautions will help avoid damage to the battery and Transmitter Unit.

1. Immediately discard any battery leaking electrolyte. Discard battery safely.

2. If battery electrolyte leaks in transmitter battery compartment, Transmitter Unit must be removed from case for cleaning. Thoroughly clean any trace of electrolyte from case or circuitry. Wear proper safety garments such as rubber gloves and safety glasses when cleaning electrolyte.

3. Only use a battery having the same voltage rating as the battery being replaced.

4. Do not allow battery terminals to short. Many Telemotive batteries are internally fused for safety. Shorting will necessitate replacement of the battery.

OBTAINING MAXIMUM BATTERY LIFE

Following the steps listed below will help maximize the life of both rechargeable and disposable batteries:

1. Turn Transmitter Unit OFF if use in the next few minutes is not anticipated.

2. Recharge lead/acid battery as soon as possible following a low-battery indication. Continual deep discharging and recharging of lead/acid batteries reduces the maximum charge a battery can hold.

3. Whenever possible, recharge NiCad batteries using the "Trickle" setting on the battery charger: A slow, low-current charge more thoroughly recharges a battery than a quick, high-current charge.

4. If a battery is not in normal use for an extended period, trickle-charge the battery periodically.

Telemotive Batteries are identified by a label listing Telemotive Part Number, Voltage, and Amp-Hour ratings. Safe operation and satisfactory performance is obtained using batteries of identical voltage and current ratings as the battery being replaced.

TELEMOTIVE BATTERIES

Telemotive Part Number	Type	Nominal Volts	Nominal A-H	Comments
BT622-0	Lithium	5.4	14	Non-Rechargeable. Suited for outdoor use in extreme cold.
BT624-0	Lithium	10.8	14	Non-Rechargeable. Suited for outdoor use in extreme cold.
BT625-0	Mercury	5.3	14	Non-Rechargeable.
BT627-0	Lead-Acid	12.0	2.5	Rechargeable.
BT644-6	Lead-Acid	6.0	2.5	Rechargeable.
BT626-0	Lead-Acid	10.0	2.5	Rechargeable.

E12102-X MICROCOMPUTER MODULE

AND

E12103-X OUTPUT MODULE

E12102-X Description

The E12102 Microcomputer Module (uC) processes, decodes, and performs checks on the serially oriented frames of incoming (received and demodulated) RF binary digital data. The uC Module also decodes the information contained in each data word and routes the data to the appropriate Output Module (OM).

The Intel 8032 microcomputer IC serves as the System CPU and performs the following functions:

1. Provides the System intelligence.
2. Performs error checks regarding frame format of the RF signal.
3. Transforms the frame of data into the appropriate format, based on the user's material handling equipment and discrete control function requirements; this information is then forwarded via flat-lead cables to the Output Module.

The uC Module mounts on the Receiving/Control Unit door and interconnects to other modules via flat lead cables.

- Microcomputer

The E12102 Microcomputer Module uses an Intel 8032 uC IC for uC functions. The uC includes 128 bytes of internal RAM and two 16 bit timers. The uC clock frequency is crystal controlled.

A reset circuit produces a reset signal at power-up that causes the uC to initialize.

Other reset circuits are used to reset the uC in the event of a received signal error. Manual reset is performed by pressing SW1.

The uC interfaces with the EPROM and I/0 devices contained on the board using address latches, a shared LO-order data/address bus, two HI order address busses (P1 and P2), several individual control bits (typically P3), and various decoders.

- Memory Addressing & Device Selection

The uC uses a multiplexed eight-bit data/address bus via a shared port (P0.0 - 0.7). When address memory of peripherals is required, the 8032 provides eight address bits (LO-order address); when data read (RD) or write (WR) is required, the 8032 transfers data on port P0. LO-order memory address latching is provided via the standard method of using the 8032 ALE (Address Latch Enable) signal and an address latch (U5). The 8031 memory address bits (A8 - A14) use a dedicated port (P2.0 - P2.7). Using the typically supplied 2764 8k x 8 EPROM, A13 - A15 (P2.5 - 2.7) are not used for memory addressing. I/0 functions contained on the board are memory-map selected using dedicated address lines Port P1 and Port P2.

- EPROM

EPROM U7 (2764) provides both material handling equipment control, as well as system (uC) control program instructions; total storage capacity is 64k.

E12102-X uC Board Controls and Indicators

1. **SW 1.** Reset switch. When a permanent error occurs and shuts down the system, pressing this button will reset the micro-computer and restart the system.

2. **SW 2.** Least significant digit frequency code switch. This 16-position (hexadecimal) switch (positions 0 through F) is used to set the least significant (hexadecimal) digit of the receiver frequency code.

SW 3 Middle digit frequency code switch. This 16-position (hexadecimal) switch (positions 0 through F) is used to set the middle (hexadecimal) digit of the receiver frequency code.

SW 4 Most significant digit frequency code switch. This two-position (binary) switch is used to set the most significant (binary) digit of the receiver frequency code.

SW2, SW3, and SW4 on the El2102 board must be set to the proper codes in order to receive the correct frequency.

3. **SW 9.** Diagnostic mode switch. This 16-position (hexadecimal) switch selects the different diagnostic modes.

4. **System Enable Indicators.** All of these green indicators should be lit once the system has been started.

+5V Indicator (Green). When this indicator is lit, the +5V power supply and its connections to the Microcomputer Board are good.

+12V Indicator (Green). When this indicator is lit, the +12V power supply and its connections to the Microcomputer Board are good

ENL (Dynamic Enable) Indicator (Green). When this indicator is lit, the system is enabled.

RST (Reset) Indicator (Green). When this indicator is lit, the system has been started and reset and is in operation.

5. **Diagnostic Error Indicators** (Red). When the built-in system diagnostics are performed and an error is discovered, one or more of these eight indicators (DO through D7) will light (refer to the DIAGNOSTICS section of this manual for information on what each indicator signifies). None of these indicators should be lit once the system has been started, with SW9 in position 0.

6. **K1 Relay.** This is the location of the Kl (sensitive) relay, that switches power to the output board once the system is enabled.

7. **U5, EPROM.** This is the location of the system EPROM (Erasable Programmable Read Only Memory).

8. **U3, Microprocessor.** This is the location of the system's Intel 8032 Microprocessor.

9. **SW 10.** Access code switches. This eight bit DIP (Dual In-Line Package) switch is used to set the receiver low order access code.

SW12. This 4 bit dip sets the high order access code. The receiver access code must be set to match the code for the correct transmitter.

10. **TP1-4.** These are test points for several important signals. TP1 is the Rx DATA, TP2 is the Rx AGC, TP3 is SYNC DETECT and TP4 is GROUND.

E12102-X Troubleshooting Information

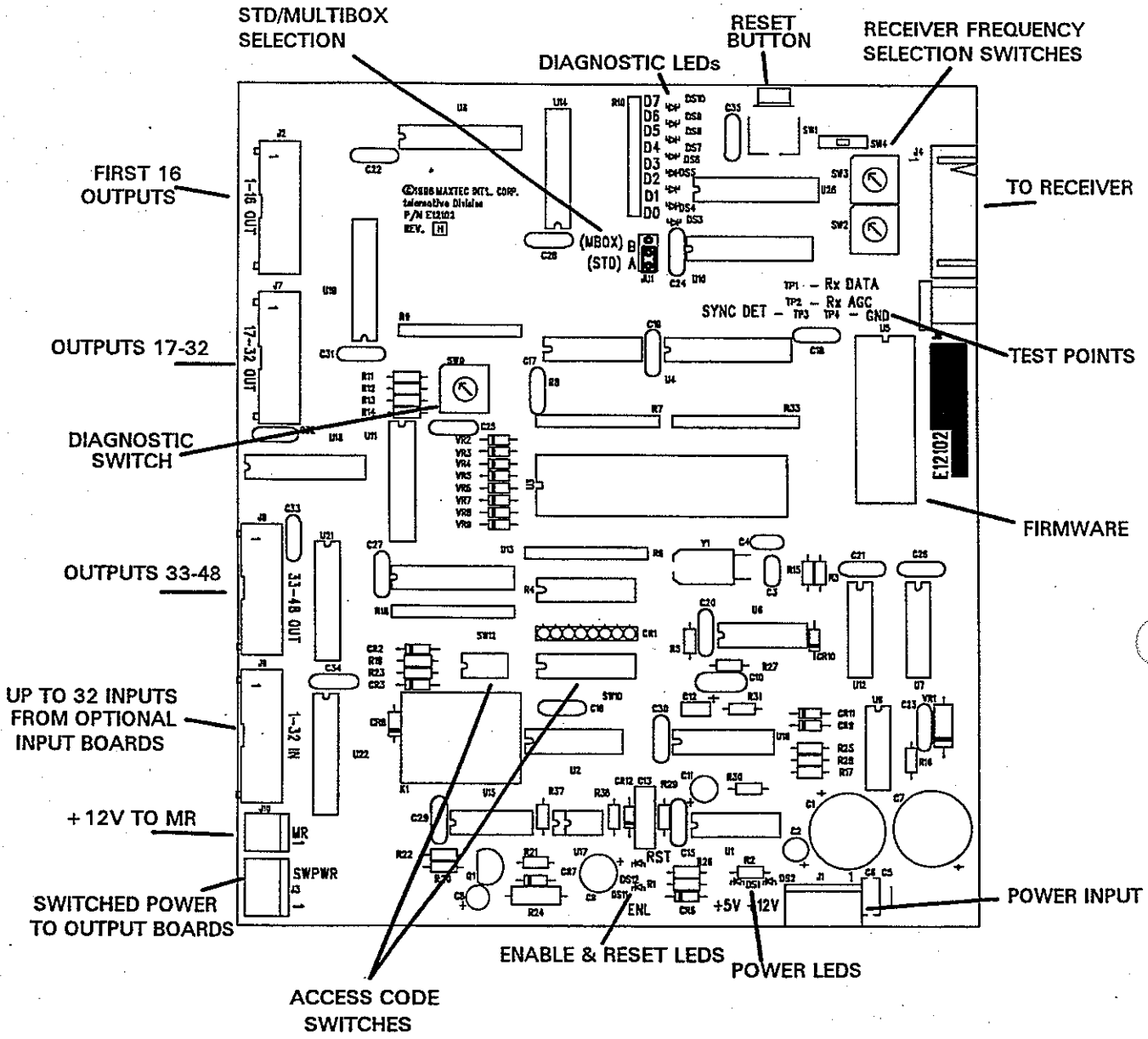
First check that the +5V and +12V LED's are on and that power is getting to the board. The RST LED should always be on, if not, try pushing the reset switch SW1. The ENL LED will be on only when data with the correct format and access code has been received within the last 2.8 seconds.

Check that the FREQUENCY CODE SWITCHES and the ACCESS CODE SWITCHES are set to the proper codes, matching the control transmitter.

A digital storage oscilloscope is required to look at the test points to check the inputs coming from the receiver.

Go to the diagnostic section of the manual for the functions of the DIAGNOSTIC SWITCH SW9.

E12102-X RECEIVER uC MODULE



NOTE: If STD/MULTIBOX JUMPER (MBOX) B / (STD) A JU1 is placed in MBOX position, then all three RECEIVER FREQUENCY SELECTION SWITCHES must be set to 0 for proper operation.

E12103-2 Description

The OUTPUT MODULE provides an interface between the COMPUTER MODULE digital control outputs and the end-user's equipment.

The OUTPUT MODULE is the least complicated of all modules residing in the RECEIVER ASSEMBLY, and, as a result is the most straight forward to analyze. This module contains all of the necessary circuitry to transform the COMPUTER MODULE's digital control outputs to the appropriate switching levels required by the customer's equipment.

INPUTS: The OUTPUT MODULE can accept up to sixteen (16) control inputs from the COMPUTER MODULE. All inputs are TTL compatible. The decoded COMPUTER MODULE digital control signals turn "on" or "off" the electronic bi-lateral FET switches residing in the solid state optoisolator packages that ultimately switch the electronic outputs. This circuitry derives its power from +5 VDC. Light emitting diodes (LED's) for each line provide visual indication when a line is activated.

OUTPUTS: The OUTPUT MODULE provides up to sixteen (16) outputs. Each output is optically isolated from its corresponding input via a solid state opto-isolator. All outputs are suplied as "normally open" electromagnetic relay (dry contacts). The eight odd numbered outputs can be changed to "normally closed" contacts simply by removing the corresponding fuse from its standard position and inserting it in the NC fuse clips for that function. Each output can switch up to 10A of current. Metal oxide varistors (MOVs) and RC circuits provide transient protection for each output. Additional protection of each output line is provided by a 10 amp fuse. Terminal blocks are provided on the printed circuit board allowing for convenient interface to customer equipment. Customer loads can be connected on either side of the terminal block outputs.

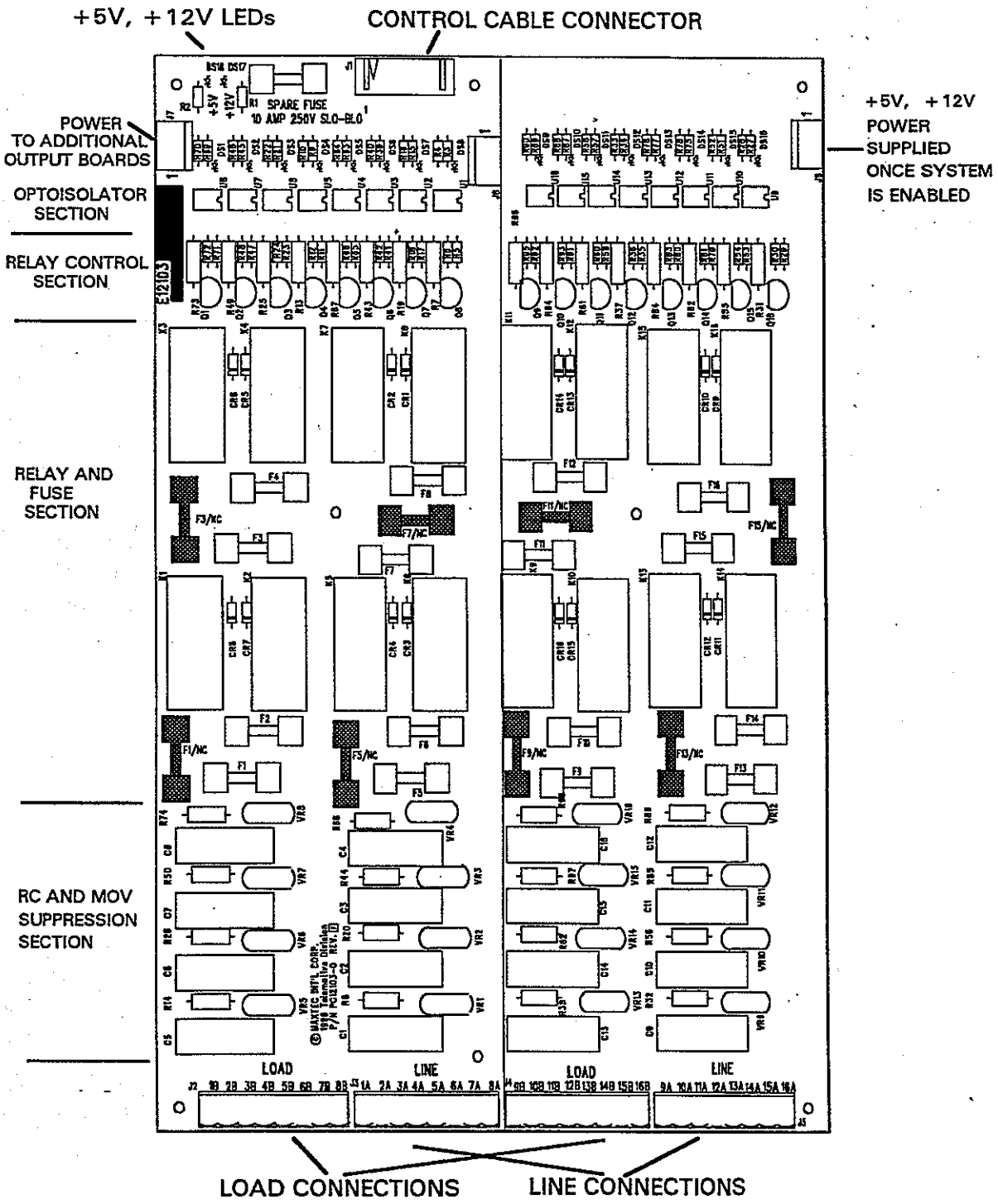
E12103-2 Alignment

No alignment of the OUTPUT MODULE is required.

E12103-2 Troubleshooting Information

Should a failure occur in the field, disconnect all wires from the OUTPUT MODULE terminal block first. Check for blown fuses with an ohmmeter in the output lines. If no open fuses are found, then each input to output line can be checked by tracing the digital input signals through the opto-isolation circuitry for each input/output pair. The switched power LED's should be on when the system is started and the ENL LED on the uC board is on.

E12103-2 SIXTEEN OUTPUT MODULE



Shaded fuses are not normally populated, these are used when normally closed outputs are desired. The eight odd numbered ouputs can be converted from normally open to normally closed by removing the corresponding fuse from its standard location and placing it in its NC location.

E12103-3 EIGHT OUTPUT MODULE

E12103-3 Description

The OUTPUT MODULE provides an interface between the COMPUTER MODULE digital control outputs and the end-user's equipment.

The OUTPUT MODULE is the least complicated of all modules residing in the RECEIVER ASSEMBLY, and, as a result is the most straight forward to analyze. This module contains all of the necessary circuitry to transform the COMPUTER MODULE's digital control outputs to the appropriate switching levels required by the customer's equipment.

INPUTS: The OUTPUT MODULE can accept up to eight (8) control inputs from the COMPUTER MODULE. All inputs are TTL compatible. The decoded COMPUTER MODULE digital control signals turn "on" or "off" the electronic bi-lateral FET switches residing in the solid state optoisolator packages that ultimately switch the electronic outputs. This circuitry derives its power from +5 VDC. Light emitting diodes (LED's) for each line provide visual indication when a line is activated.

OUTPUTS: The OUTPUT MODULE provides up to eight (8) outputs. Each output is optically isolated from its corresponding input via a solid state opto-isolator. All outputs are suplied as "normally open" electromagnetic relay (dry contacts). The four odd numbered outputs can be changed to "normally closed" contacts simply by removing the corresponding fuse from its standard position and inserting it in the NC fuse clips for that function. Each output can switch up to 10A of current. Metal oxide varistors (MOVs) and RC circuits provide transient protection for each output. Additional protection of each output line is provided by a 10 amp fuse. Terminal blocks are provided on the printed circuit board allowing for convenient interface to customer equipment. Customer loads can be connected on either side of the terminal block outputs.

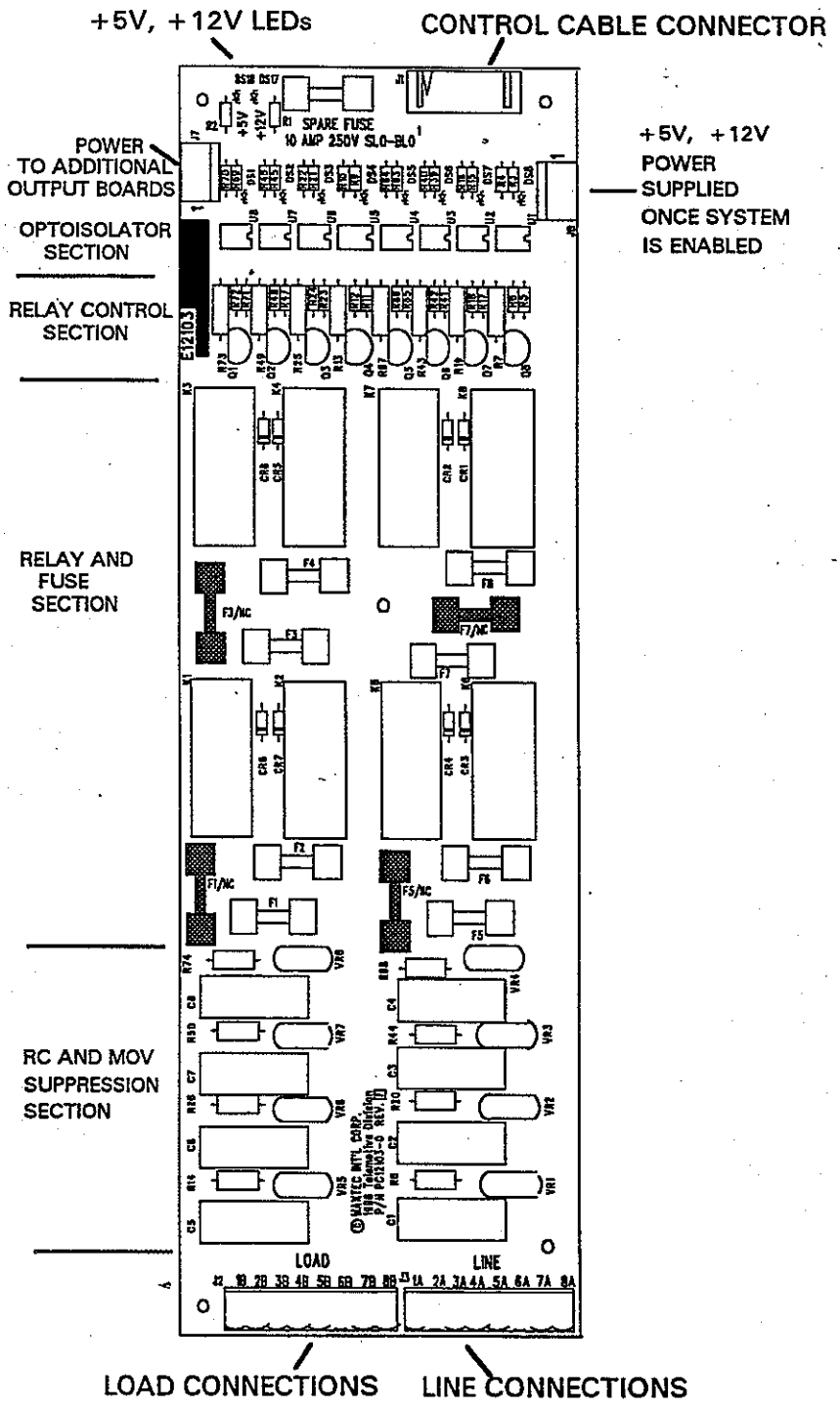
E12103-3 Alignment

No alignment of the OUTPUT MODULE is required.

E12103-3 Troubleshooting Information

Should a failure occur in the field, disconnect all wires from the OUTPUT MODULE terminal block first. Check for blown fuses with an ohmmeter in the output lines. If no open fuses are found, then each input to output line can be checked by tracing the digital input signals through the opto-isolation circuitry for each input/output pair. The switched power LED's should be on when the system is started and the ENL LED on the uC board is on.

E12103-3 EIGHT OUTPUT MODULE



Shaded fuses are not normally populated, these are used when normally closed outputs are desired. The four odd numbered ouputs can be converted from normally open to normally closed by removing the corresponding fuse from its standard location and placing it in its NC location.

SERIES 8000 VHF TMS USER/INSTALLATION MANUAL SUPPLEMENT

TC8000-5-0.0A

SERIES 8000 VHF TMS USER/INSTALLATION MANUAL SUPPLEMENT

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GENERAL

The **Series 8000 VHF TMS User/Installation Manual Supplement** covers the unique features of the Series 8000 VHF TMS System. The transmitter and receiver/control unit portions of the **System Description** in the **User/Installation Manual** are superseded by the information in this Supplement. This Supplement also contains a new section covering the **SLTX Transmitter Model, the E7632 Transmitter Microcomputer (uC) and E7650 RF Modules.** The Membrane Transmitter (MTx) is not available with Series 8000 VHF TMS systems.

TMS System Description

The **TMS** (**T**ime **M**ultiple **S**hared) system allows for the use of several systems on the same frequency in the same area. This is accomplished by a proprietary (patent pending) system which compresses data and transmits it in a predetermined burst pattern. Each transmitter operates independently; there is no need for complex frequency coordination of equipment. The independent operation allows for overlap of data from different transmitters; because of the burst pattern there is no chance of several data packets in a row overlapping, and with a transmission every 100 ms on average (50 ms when a switch is moved), these infrequent overlaps have no noticeable effect on system performance. The packet data is protected against corruption by several layers of error checking and redundancy. This makes data corruption virtually impossible.

TMS Theory of Operation

TMS operation involves intermittent, "packet" transmissions. A TMS transmitter transmits on average, only 10% of the time, versus 100% for a standard "continuous carrier" Series 8000 transmitter model. This allows other systems to use the open time that the packet system frees up to operate on the same channel, something that is impossible on a conventional system.

A TMS transmitter is similar to the standard Series 8000 transmitters except for the software. The software protocol has been significantly advanced to a) compress the control information, b) increase the data rate, c) add more data protection, and d) transmit data in intermittent packets. The SLTX also has a new "turn-off" feature added whereby the transmitter sends a positive "shut-down" signal upon "turn-off". Should an operator "turn-off" the transmitter in an emergency, the system will immediately "shut-down" and all motion will cease instead of waiting for the "time-out" feature. An emergency stop button can also be accommodated. This feature will also become standard on LTX transmitters after December 1992.

It should also be noted that since the power amplifier stage in the transmitter RF module consumes over half of the battery power, changing to intermittent TMS operation adds almost 40% to the battery life.

The receiver/control sub-system uses the E7150-X Receiver Module. This hardware has been optimized for packet data transmission and can recover the first data bit from an intermittent packet eliminating the need for the long preamble needed to settle other receivers. In addition, the software has been significantly updated allowing the E8001-X uC module to handle the new packet data format and still retain the usual Series 8000 operating characteristics. The back plane and output relay systems are unchanged, although a new E8003 output board has been developed for interface to programmable logic controllers and other electronic interfaces.

TMS Specifications

PARAMETER	SPECIFICATION
FCC REQUIREMENTS:	Part 90/ End-User License Required
AUTHORIZED FREQUENCIES:	VHF: 72-76 MHz
NUMBER OF CHANNELS:	200
CHANNEL SPACING:	20 KHz
FREQUENCY GENERATION:	Rx: Synthesized Tx: Crystal Controlled
FREQUENCY STABILITY:	10 PPM
MODULATION:	FSK: +/- 3 KHz Deviation
DATA RATE:	4800 Baud
OPERATING TEMPERATURE:	$-30^{O}C$ to $+70^{O}C$
STORAGE TEMPERATURE:	$-40^{O}C$ to $+100^{O}C$
HUMIDITY:	0-95% Non-Condensing
OPERATING VOLTAGES:	Rx: 120/240 VAC, 60 Hz, 0.25 A Tx: Battery Powered

RECEIVER

Description

The Series 8000 VHF TMS Receiver Model is an "Engineered System", customized for your particular application. However, there are several common modules. The E8001-X Microcomputer (uC) Module is common to all Series 8000 systems, although it has several variants. The variants that are usually deployed in Series 8000 VHF TMS systems either have the typical manual frequency control as shown in the **Radio System Operating Principles** of this manual, or cause the receiver to scan several RF channels under computer control for the multibox option. Note that the software employed in a Series 8000 VHF TMS system is quite different from the standard Series 8000 software. Also note that the output board module configurations are virtually identical to standard Series 8000 product.

The E7150-X Receiver Module RF, however, is significantly different. It is optimized for high efficiency packet data reception. While it receives direct FSK like other Series 8000 products, it uses a 4800 baud data rate instead of the 2400 baud rate employed in standard Series 8000 systems.

Theory of Operation

The Receiver Model is comprised of several sub-assemblies. Operation of the E7150-X Receiver and E8001-X Microcomputer (uC) Modules follows:

E7150-X Receiver Module

The E7150-X Receiver Module is a dual conversion "superhet", with a synthesized first local oscillator. The final conversion and quadrature detection are built around the Motorola MC3362 multi-function IC. The uniqueness of this module lies in the data processing which preserves the level of the audio from the beginning to the end of a data packet regardless of length. This insures that the data conversion is valid throughout the duration of the packet. Data conversion simply becomes a straightforward level detection.

The synthesized first local oscillator allows for computer control of the radio control carrier frequency. The TMS data format and software is set-up so that several channels can be scanned without missing a "turn-on" signal on any of the scanned channels. This function is identical to the multibox function of standard Series 8000 systems and is similarly transparent to the user.

E8001-X Microcomputer (uC) Module

The standard E8001-X Microcomputer (uC) Module used in the Series 8000 VHF TMS system is the version with manual frequency selection described elsewhere (**Radio System Operating Principles**) in this manual. If the multibox option is selected, an electronically scanning version of the E8001-X is provided. Note that with this option, the channels are programmed in an EPROM and cannot be manually set to any channel in the band. The uC module controls all relay actions, as well as processing incoming data from the receiver and controlling channel operation. The software, along with the wiring and output board selections made for your system, determines how your system will respond to commands from the transmitter.

Software

The software version used for TMS operation is unique and interprets the TMS protocol and adapts the intermittent TMS system so that it operates like a standard Series 8000 system. Relay operation is very similar to normal Series 8000 system.

Much effort goes into insuring the integrity of the data. The data has a unique format. First, there is an access code that is unique to each system. On standard Series 8000 TMS systems, only a transmitter with that access code can start the system. With the multibox option or the Access Code Plug option, several transmitters are capable of starting a receiver, but only the transmitter that starts the receiver can operate it. This allows the use of "universal spare transmitters" while insuring that normal operation is not disrupted. There also is an error checking system (Cyclic Redundancy Count, or CRC) which protects against corrupted data. Corruption is further protected against by a four bit double redundant direction command for each direction; only half of the possible combinations are valid. It is virtually impossible to get a sequence of proper commands, proper access code, and correct CRC word from noise or other undesired transmissions.

Installation

A Series 8000 VHF TMS system is installed in a similar manner to standard Series 8000 systems. However, there are certain issues that should be addressed for best performance:

1) Never mount the antenna on the receiver cabinet.

2) If there is a problem with receive noise, remove or re-route the excess coaxial cable out of the receiver cabinet.

3) The antenna should be able to be seen from most operating positions on the ground. The antenna should not be obstructed by the crane.

4) Do not attach the receiver to a case for a variable frequency drive. Do not use the same power line for the receiver as for a variable frequency drive. Make sure that the receiver power feed is separate from the variable frequency drive feed, at least to the pickup shoe. If a separate line is not available, install a line conditioner before the receiver.

Diagnostics and Troubleshooting

NOTE: If you should change the E8001 uC module, MAKE SURE THAT THE SWITCHES ARE SET TO THE FACTORY SETTINGS AND THAT THE CORRECT SOFTWARE FOR YOUR SYSTEM IS INSTALLED.

The receiver RF has an LED to indicate synthesizer lock similar to other radios. It works identically to the LED on standard Series 8000 receivers. It also has a signal output, again similar to standard Series 8000 receivers.

The various output modules are common to all Series 8000 systems.

The Microcomputer Module has two (2) rows of LEDs, similar to most E8001-X uC modules. However, the operation of some of the diagnostics are different. The following lists the differences in operation of the LED diagnostics of a Series 8000 VHF TMS system versus the standard Series 8000 diagnostics:

Table 1: System Frequency Code Settings - The frequency selection of Series 8000 TMS multibox systems is under computer control; SW2, SW3, and SW4 do not exist on the E8001 version used in multibox TMS. Single frequency TMS systems have manual selection identical to standard Series 8000, and Table 1 applies.

Table 2: Access Code Settings - The main transmitter access code is set in SW10. If the access code plug option is ordered, the transmitter access code is set by the code plug.

The decimal to binary access code translation contained in Table 2 is applicable. However, the access codes are assigned differently; refer to your rack chart (at the end of this supplement, or supplied with the receiver) for the correct access code(s) for your system. Access codes <u>should not</u> be changed from the factory setting. Any spare or substitute uC modules should be set to the factory setting.

Maximum Range Control Setting - This is preset at the factory. Incorrect setting can disable your Series 8000 VHF TMS system.

System Troubleshooting Changes:

AGC Level - AGC does not operate normally in TMS due to the intermittent nature of the radio signal. This reading (SW9 in positions 2, 3, 4, and 5) described in the **Microcomputer Board Checks** 5c should be ignored. This check appears in two places, **Completely Inoperative System**, and **Partially Operative System.** The same applies to the **Receiver Signal Strength Checks** in the **Erratically Operating System** section, and this check should also be ignored.

Squelch - The squelch is "high" at all times in a TMS system; therefore, the squelch light should always be "on".

The following functions and procedures remain unchanged from the **Series 8000 User/Installation Manual:**

- Alarm Auxiliary Function
- Main Relay (MR) Function
- Manual-Radio Switching Procedure (if applicable)
- Radio System Starting Procedure
- Radio System Shut Down Procedure
- Radio System Restarting Procedure

TRANSMITTER(S)

Description

There are two transmitter models currently available for the Series 8000 VHF TMS system. They are; 1) the Lever Transmitter (**LTX**), and 2) the Small Lever Transmitter (**SLTX**). Both transmitter models contain an RF, a Microcomputer and an Antenna module. They also contain a battery and lever switches. However, only the lever switches are common between them, so each transmitter will be described separately.

Theory of Operation

The Series 8000 VHF TMS system is available with either the LTX or SLTX transmitter models. A Series 8000 VHF TMS transmitter is electrically very similar to a standard Series 8000 transmitter. The SLTX has a new electronic "shut-off" switch that will be described in detail in the SLTX section. As with the receiver, the transmitter software is significantly different. The software generates the unique data packets and keys the transmitter for intermittent RF carrier operation. As with standard Series 8000 and other Telemotive equipment, the software reads the switches and interprets their positions to the desired signals to be sent to the receiver.

LTX Transmitter Model

The LTX transmitter is the standard Series 8000 transmitter. It has been adapted to TMS operation by the inclusion of special TMS software. The E7630 Microcomputer (uC) and E7123 RF Modules are quite similar to their standard Series 8000 counterparts. Some small changes have been made to the E7123 RF Module that improve its performance with TMS; these improvements are reflected in current standard Series 8000 product. The electronic "shut-off" switch will become standard on LTX transmitters after December 1992.

SLTX Transmitter Model

The SLTX transmitter model contains a different uC module, the E7632 which does the same job as the E7630 except for different dimensions and the new electronic "shut-off" switch. The SLTX also has a different RF Module, namely the E7650 which performs the same function as the LTX RF Module.

The SLTX has an electronic "shut-off" switch that replaces the usual physical switch on standard Series 8000 and most other Telemotive equipment. This change was made so that turning off the transmitter would cause a shut-down command to be sent, resulting in an immediate system shut-down.

Access Code Plugs (Optional)

Some customers desire positive activation of one of several receivers by the same transmitter. For these situations Telemotive has developed access code plugs. By changing the access code plug, an operator can determine which receiver is controlled, even though several receivers are within range of the transmitter.

The access code plug is a military style connector (for ruggedness) which is hard wired for a particular code. access code plug transmitters get their actual access code from the access code plug. The receiver only responds to one access code, just like standard Series 8000 systems.

To operate a different receiver, the access code plug should be changed, and the new receiver started. **NOTE:** If you remove the access code plug while operating a system, the system will "shut-down" and will need to be restarted. This prevents any possibility of two transmitters trying to operate the receiver with the same access code plug.

Batteries

The TMS system improves battery life due to the intermittent nature of the transmissions. A standard Series 8000 transmitter transmits continuously when turned on, except for the 16 minute time-out. A Series 8000 VHF TMS transmitter transmits intermittently for between 10 and 20 percent of the time. This causes the transmitter to use about 60% of the power that it otherwise would, leading to a 40% increase in battery life.

It should also be noted that the SLTX case has a different battery arrangement. Access is through the side plate that has the thumbscrews and the battery compartment is smaller than the LTX battery compartment. Therefore, many of the batteries used with the LTX cannot be used with the SLTX.

SYSTEM

TMS System Components

A single Series 8000 VHF TMS system consists of one or more receivers and one or more transmitters. While several Series 8000 VHF TMS systems can operate on the same frequency, each system is completely independent. Generally, there is one receiver per system unless the Access Code Plug option is ordered.

Unique TMS Features

The Series 8000 VHF TMS system offers as its primary unique feature the ability to operate several systems independently on one channel without the systems interfering with each other. This is inherent in the TMS system.

Unique TMS Options

The Series 8000 VHF TMS system is available with most of the options available on standard Series 8000 systems. In addition, the following TMS options are available:

- Access Code Plug receiver selection
- Electronic "Turn-Off" with "Positive Stop" (standard on SLTX transmitter models)

For control of multiple selectable trolleys or bridges from a single transmitter, please inquire about the Telemotive Series 8000 VHF TDMA (Time Division Multiple Access) system.

Access Code Plug Operation

Use of optional access code plugs is very simple. Each receiver will have a corresponding access code plug. If the correct plug for a given receiver is not in place already, remove any plug that is in place by twisting and pulling it out, then insert the correct plug by pushing it into the socket and twist it in. The operating socket will be on top of the transmitter; any storage sockets will be on back. Once the correct plug is inserted, make sure that you are in range, and start the system. Operate the system as usual. Remember not to remove the plug while you are operating a system, or the system will shut-down.

Operating Characteristics

Operating characteristics are the same as with standard Series 8000 systems, except for some time-outs that slightly differ. Refer to the **Series 8000 VHF TMS/TDMA Technical Manual Supplement** (optional), for details.

Rack Charts

Rack charts for your system are inserted after this page.

SERIES 8000 VHF TDMA USER/INSTALLATION MANUAL SUPPLEMENT

TC8000-4-0.0A

SERIES 8000 VHF TDMA USER/INSTALLATION MANUAL SUPPLEMENT

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GENERAL

The **Series 8000 VHF TDMA User/Installation Manual Supplement** covers the unique features of the Series 8000 VHF TDMA System. The transmitter and receiver/control unit portions of the **System Description** in the **User/Installation Manual** are superseded by the information in this Supplement. This Supplement also contains a new section covering the **SLTX Transmitter Model**, and the **E7632 Transmitter Microcomputer (uC)** and the **E7650 RF Modules**. The Membrane Transmitter (MTx) is not available with Series 8000 VHF TDMA systems.

TDMA System Description

The **TDMA** (Time Division Multiple Access) system allows for the use of several systems on the same frequency in the same area. This is accomplished by a proprietary (patent pending) system which compresses data and transmits it in a predetermined burst pattern. Each transmitter operates independently; there is no need for complex frequency coordination of equipment. The independent operation allows for overlap of data from different transmitters; because of the burst pattern there is no chance of several data packets in a row overlapping, and with a transmission every 100 ms on average (50 ms when a switch is moved), these infrequent overlaps have no noticeable effect on system performance. The packet data is protected against corruption by several layers of error checking and redundancy. This makes data corruption virtually impossible.

TDMA Theory of Operation

TDMA operation involves intermittent, "packet" transmissions. A TDMA transmitter transmits on average, only 10% of the time, versus 100% for a standard "continuous carrier" Series 8000 transmitter model. This allows other systems to use the open time that the packet system frees up to operate on the same channel, something that is impossible on a conventional system.

A TDMA transmitter is similar to the standard Series 8000 transmitters except for the software. The software protocol has been significantly advanced to a) compress the control information, b) increase the data rate, c) add more data protection, d) transmit data in intermittent packets, and e) store and use the transmitter access code of the transmitter that starts the receiver. The SLTX also has a new "turn-off" feature added whereby the transmitter sends a positive "shut-down" signal upon "turn-off". Should an operator "turn-off" the transmitter in an emergency, the system will immediately "shut-down" instead of waiting for the "time-out" feature. An emergency stop button can also be accommodated. This feature will also become standard on LTX transmitters after December 1992.

It should be noted that since the power amplifier stage in the transmitter RF module consumes over half of the battery power, changing to intermittent TDMA operation adds almost 40% to the battery life.

The receiver/control subsystem, uses the E7150-X Receiver Module. This hardware has been optimized for packet data transmission and can recover the first data bit from an intermittent packet eliminating the need for the long preamble needed to settle other receivers. In addition, the software has been significantly updated allowing the E8001-X uC module to handle the new packet data format and still retain the usual Series 8000 operating characteristics. The back plane and output relay systems are unchanged, although a new E8003 output board has been developed for interface to programmable logic controllers and other electronic interfaces.

TDMA Specifications

PARAMETER	SPECIFICATION
FCC REQUIREMENTS:	Part 90/ End-User License Required
AUTHORIZED FREQUENCIES:	VHF: 72-76 MHz
NUMBER OF CHANNELS:	200
CHANNEL SPACING:	20 KHz
FREQUENCY GENERATION:	Rx: Synthesized Tx: Crystal Controlled
FREQUENCY STABILITY:	10 PPM
MODULATION:	FSK: +/- 3 KHz Deviation
DATA RATE:	4800 Baud
OPERATING TEMPERATURE:	$-30^{O}C$ to $+70^{O}C$
STORAGE TEMPERATURE:	$-40^{O}C$ to $+100^{O}C$
HUMIDITY:	0-95% Non-Condensing
OPERATING VOLTAGES:	Rx: 120/240 VAC, 60 Hz, 0.25 A Tx: Battery Powered

RECEIVER

Description

The Series 8000 VHF TDMA Receiver Model is an "Engineered System", customized for your particular application. However, there are several common modules. The E8001-X Microcomputer (uC) Module is common to all Series 8000 systems, although it has several variants. The variants that are usually used in Series 8000 VHF TDMA systems either have the typical manual frequency control as shown in the **Radio System Operating Principles** of this manual, or cause the receiver to scan several RF channels under computer control for the multibox option. Note that the software used for a Series 8000 VHF TDMA system is quite different from standard Series 8000 software. Also note that the output board module configurations are virtually identical to standard 8000 product.

The E7150-X Receiver Module RF, however, is significantly different. It is optimized for high efficiency packet data reception. While it receives direct FSK like other Series 8000 products, it uses a 4800 baud data rate instead of the 2400 baud rate employed in standard Series 8000 systems.

Theory of Operation

The Receiver Model is comprised of several sub-assemblies. Operation of the E7150-X Receiver and E8001-X Microcomputer (uC) Modules follows:

E7150-X Receiver Module

The E7150-X Receiver Module is a dual conversion "superhet", with a synthesized first local oscillator. The final conversion and quadrature detection are built around the Motorola MC3362 multi-function IC. The uniqueness of this module lies in the data processing which preserves the level of the audio from the beginning to the end of a data packet regardless of length. This insures that the data conversion is valid throughout the duration of the packet. Data conversion simply becomes a straightforward level detection.

The synthesized first local oscillator allows for computer control of the radio control carrier frequency. The TDMA data format and software is set-up so that several channels can be scanned without missing a "turn-on" signal on any of the scanned channels. This function is identical to the multibox function of standard Series 8000 systems and is similarly transparent to the user.

E8001-X Microcomputer (uC) Module

The standard E8001-X Microcomputer (uC) module used in Series 8000 VHF TDMA systems is the version with manual frequency selection described elsewhere (**Radio System Operating Principles**) in this manual. If the multibox option is selected, an electronically scanning version of the E8001-X is provided. Note that with this option, the channels are programmed in an EPROM and cannot be manually set to any channel in the band. The uC module controls all relay actions, as well as processing incoming data from the receiver and controlling channel operation. The software, along with the wiring and output board selections made for your system, determines how your system will respond to commands from the transmitter.

Software

The software version used for TDMA operation is unique and interprets the TDMA protocol and adapts the intermittent TDMA system so that it operates like a standard Series 8000 system. Relay operation is similar to normal Series 8000 system.

In addition, TDMA software is specifically designed to allow control of multiple receivers via access code plugs. The transmitter sends its master code and the receiver access code at start up; the receiver stores the transmitter master code in RAM upon recognizing its code in a good packet.

Much effort goes into insuring the integrity of the data. The data has a unique format. First, there is an access code that is unique to each system. On standard Series 8000 TDMA systems, only a transmitter with that access code plug can start the system. With the multibox option, several transmitters are capable of starting a receiver, but only the transmitter that starts the receiver can operate it. This allows the use of "universal spare transmitters" while insuring that normal operation is not disrupted. There also is an error checking system (Cyclic Redundancy Count, or CRC) which protects against corrupted data. Corruption is further protected against by a four bit double redundant direction command for each direction; only half of the possible combinations are valid. It is virtually impossible to get a sequence of proper commands, proper access code, and correct CRC word from noise or other undesired transmissions.

Installation

A Series 8000 VHF TDMA system is installed in a similar manner to standard Series 8000 systems. However, there are certain issues that should be addressed for best performance:

1) Never mount the antenna on the receiver cabinet.

2) If there is a problem with receive noise, remove or re-route the excess coaxial cable out of the receiver cabinet.

3) The antenna should be able to be seen from most operating positions on the ground. The antenna should not be obstructed by the crane.

4) Do not attach the receiver to a case for a variable frequency drive. Do not use the same power line for the receiver as for a variable frequency drive. Make sure that the receiver power feed is separate from the variable frequency drive feed, at least to the pickup shoe. If a separate line is not available, install a line conditioner before the receiver.

Diagnostics and Troubleshooting

NOTE: If you should change the E8001 uC module, MAKE SURE THAT THE SWITCHES ARE SET TO THE FACTORY SETTINGS AND THAT THE CORRECT SOFTWARE FOR YOUR SYSTEM IS INSTALLED.

The receiver RF has an LED to indicate synthesizer lock similar to other radios. It works identically to the LED on standard Series 8000 receivers. It also has a signal output, again similar to standard Series 8000 receivers.

The various output modules are common to all Series 8000 systems.

The Microcomputer Module has two (2) rows of LEDs, similar to most E8001-X uC modules. However, the operation of some of the diagnostics are different. The following lists the differences in operation of the LED diagnostics of a Series 8000 TDMA system versus the standard Series 8000 diagnostics:

Table 1: System Frequency Code Settings - The frequency selection of Series 8000 TDMA multibox systems is under computer control; SW2, SW3, and SW4 do not exist on the E8001 version used in multibox TDMA. Single frequency TDMA systems have manual selection identical to standard Series 8000, and Table 1 applies.

Table 2: Access Code Settings - The main receiver access code is set in SW10. The transmitter master code that started the system is stored in RAM as described in the Software portion of the Receiver section, earlier in this Supplement.

The decimal to binary access code translation contained in Table 2 is applicable. However, the access codes are assigned differently; refer to your rack chart (at the end of this supplement, or supplied with the receiver) for the correct access code(s) for your system. Access codes should not be changed from the factory setting. Any spare or substitute uC modules should be set to the factory setting.

Maximum Range Control Setting - This is preset at the factory. Incorrect setting can disable your Series 8000 VHF TDMA system.

System Troubleshooting Changes:

AGC Level - AGC does not operate normally in TDMA due to the intermittent nature of the radio signal. This reading (SW9 in positions 2, 3, 4, and 5) described in the **Microcomputer Board Checks** 5c should be ignored. This check appears in two places, **Completely Inoperative System**, and **Partially Operative System**. The same applies to the **Receiver Signal Strength Checks** in the **Erratically Operating System** section, and this check should also be ignored.

Squelch - The squelch is held open all the time in a TDMA system; therefore this light should always be on.

The following functions and procedures remain unchanged from the **Series 8000 User/Installation Manual:**

- Alarm Auxiliary Function
- Main Relay (MR) Function
- Manual-Radio Switching Procedure (if applicable)
- Radio System Starting Procedure
- Radio System Shut Down Procedure
- Radio System Restarting Procedure

TRANSMITTER(S)

Description

There are two transmitter models currently available for the Series 8000 VHF TDMA system. They are; 1) the Lever Transmitter (**LTX**), and 2) the Small Lever Transmitter (**SLTX**). Both transmitter models contain an RF, a Microcomputer and an Antenna Module. They also contain a battery and lever switches. However, only the lever switches are common between them, so each transmitter will be described separately.

Theory of Operation

The Series 8000 VHF TDMA system is available with either the LTX or SLTX transmitter models. A Series 8000 VHF TDMA transmitter is electrically very similar to a standard Series 8000 transmitter. The SLTX has a new electronic "shut-off" switch that will be described in detail in the SLTX section. As with the receiver, the transmitter software is significantly different. The software generates the unique data packets and keys the transmitter for intermittent RF carrier operation. As with standard Series 8000 and other Telemotive equipment, the software reads the switches and interprets their positions to the desired signals to be sent to the receiver.

LTX Transmitter Model

The LTX transmitter is the standard Series 8000 transmitter. It has been adapted to TDMA operation by the inclusion of special TDMA software. The E7630 Microcomputer (uC) and E7123 RF Modules are quite similar to their standard Series 8000 counterparts. Some small changes have been made to the E7123 RF Module that improve its performance with TDMA; these improvements are reflected in current standard Series 8000 product. The electronic "shut-off" switch will become standard on LTX transmitters after December 1992.

SLTX Transmitter Model

The SLTX transmitter model contains a different uC module, the E7632 which does the same job as the E7630 except for different dimensions and the new electronic "shut-off" switch. The SLTX also has a different RF Module, namely the E7650 which performs the same function as the LTX RF Module. The SLTX has an electronic "shut-off" switch that replaces the usual physical switch on standard Series 8000 and most other Telemotive equipment. This change was made so that

turning off the transmitter would cause a shut-down command to be sent, resulting in an immediate system shutdown.

Access Code Plugs

The Series 8000 VHF TDMA System was developed specifically to allow the ultimate flexibility in controlling different combinations of hoists/trolleys and/or bridges. The selection of a particular combination of hoists/trolleys and bridge is accomplished by the use of the correct combination of access code plugs. By changing access code plugs, an operator can determine which receivers are controlled, even though several receivers are within range of the transmitter.

The access code plug is a military style connector (for ruggedness) which is hard wired for a particular code. When an access code plug is inserted into an appropriate transmitter, the transmitter sends that code along with its master code when the start button is depressed. The receiver writes the transmitter master code into memory and only responds to that transmitter until it shuts-down.

To operate a different receiver, the access code plug should be changed and the new receiver started. **NOTE:** If you remove the access code plug while operating a system, the system will "shut-down" and will need to be restarted. This prevents any possibility of two transmitters trying to operate the receiver with the same access code plug.

TDMA systems are usually configured to operate one selectable bridge and several selectable trolleys. The number of selectable trolleys is a function of the engineering of your particular system. If a need arises for a configuration different from what is possible with your system, please contact the factory.

Batteries

Battery life is increased for a TDMA system due to the intermittent transmission of data. A standard Series 8000 transmitter continuously sends data when turned on (except for the 16 minute time-out). However, a TDMA transmitter intermittently sends data and is "on-the-air" only 10 - 20 percent of the time. This provides a 40% increase in battery life.

It should also be noted that the SLTX case has a different battery arrangement. Access is through the side plate that has the thumbscrews and the battery compartment is smaller than the LTX battery compartment. Thus, many of the batteries used with the LTX cannot be used with the SLTX.

SYSTEM

TDMA System Components

A single Series 8000 TDMA system consists of several receivers and one or more transmitters. Because of the combinations possible and the unique engineering required to allow all of the desired modes of operation, Series 8000 VHF TDMA receiver/transmitter systems must be configured in a coordinated fashion across the entire building in which they are installed. Please consult the factory for any additions to your systems.

Unique TDMA Features

The Series 8000 VHF TDMA system offers as one unique feature the ability to operate several systems independently on one channel without the systems interfering with each other. The other unique feature is the ability to control different combinations of bridges and trolleys with one transmitter using access code plugs. Both are inherent in TDMA.

Unique TDMA Options

The Series 8000 VHF TDMA system is available with most of the options available on standard Series 8000 systems. In addition, the following TDMA options are available:

- Electronic Turn-Off with Positive Stop (standard on SLTX)

For control of multiple single trolleys or bridges from different transmitters on the same frequency, please inquire about the Telemotive Series 8000 VHF TMS (Time Multiple Shared) system.

Access Code Plug Operation

Use of the access code plug is very simple. Each receiver will have an associated access code plug. If the correct plug for a given receiver is not in place already, remove any plug that is in place by twisting and pulling it out, then insert the correct plug by pushing it into the desired socket and twist it in. The operating sockets will be on top of the transmitter; any storage sockets will be on back. Once the correct plug(s) is inserted, make sure that you are in range, and start the system. Operate the system as usual. Remember not to remove any plugs while you are operating a system, or the system will shut-down.

NOTE: - Since Series 8000 VHF TDMA systems can control multiple combinations of trolleys, relationships between the transmitter levers and the trolleys ARE NOT fixed. A lever controls whatever trolley that has its access code plug plugged in. Be sure that you have the desired trolley order reflected in the order of inserted access code plugs.

Operating Characteristics

Operating characteristics are the same as the standard Series 8000 systems, except for some time-outs that slightly differ. Refer to the **Series 8000 VHF TMS/TDMA Technical Manual Supplement** (optional) for details.

Rack Charts

Rack charts for your system are inserted after this page.

TELEMOTIVE

LTX TRANSMITTER

SUPPLEMENT TO
TELEMOTIVE
RADIO CONTROL SYSTEM
USER'S MANUAL

TC7000-13-0.0A-Z

MAINTENANCE & GENERAL SERVICE INSTRUCTIONS: LTX

PERSONNEL SAFETY PRECAUTIONS

WARNING

The following precautions must be observed to help prevent conditions which are dangerous to persons servicing the equipment and persons in the area of the material handling equipment.

1. In *all* cases, turn the Transmitter Unit keyswitch to OFF position and remove the key *before* starting any maintenance or repairs on the Transmitter Unit.

2. Before servicing transmitter, make sure you do not inadvertently activate material handling equipment. Either turn material handling equipment off, or service transmitter in a shielded enclosure or at a far enough distance (beyond signal control of equipment).

3. When operating or testing the system, follow all SAFETY PRECAUTIONS listed in this Manual.

4. When attempting repair of physically-damaged switches, controls, or cases. While not always apparent, damaged controls can lock unexpectedly in active positions, thereby preventing normal equipment braking. Replace damaged components only with Telemotive factory authorized components.

EQUIPMENT PROTECTION PRECAUTIONS

CAUTION

The following precautions will help avoid damage to the Transmitter Unit

1. Any work performed on the RF section of the Transmitter Unit must be performed by an FCC licensed technician (or equivalent in other countries). Additionally, you may be responsible for compliance with other local regulations.

2. Certain Transmitter Unit modules contain several adjustments: Do not attempt to perform adjustments without the Technical Manual, and procedures for adjustments.

MAINTENANCE & GENERAL SERVICE INSTRUCTIONS: LTX

BATTERY REPLACEMENT

Battery Monitor Indicator (models equipped with battery monitor only)

Battery condition is indicated by the red BATTERY MONITOR LED located on the Transmitter Control Panel. When the transmitter is turned ON and the battery is sufficiently charged, the LED flashes at a 3 Hz rate. When the charge is below acceptable limits, the LED turns off.

BATTERY REMOVAL/REINSTALLATION

1. Turn keyswitch to the OFF position and remove key.
2. Battery compartment is located on right-hand side ot Transmitter Unit (as viewed from normal operating position; see Fig. 1.
3. Open compartment door by rotating latch to horizontal position, as shown in Fig. 1.
4. Pull velcro-type tape strips from each other and slide battery out of compartment.
5. Disconnect battery from transmitter by grasping and unplugging battery/transmitter connector *as close to the connector as possible. Do not* disconnect connector without supporting connector leads.
6. Slide charged battery into compartment while holding tape strips away from battery.
7. Firmly reconnect battery connector (connector is polarized).
8. Push excess battery leads into compartment. Reattach velcro-type tape strips.
9. Close compartment door and rotate latch to vertical position.

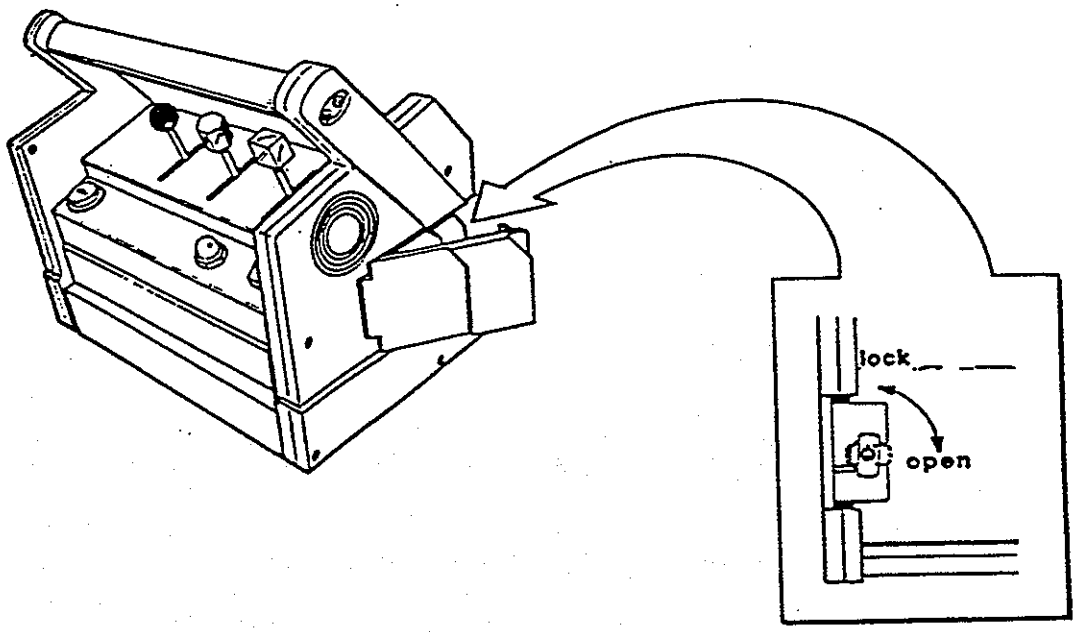


Fig 1 LTX Battery Compartment

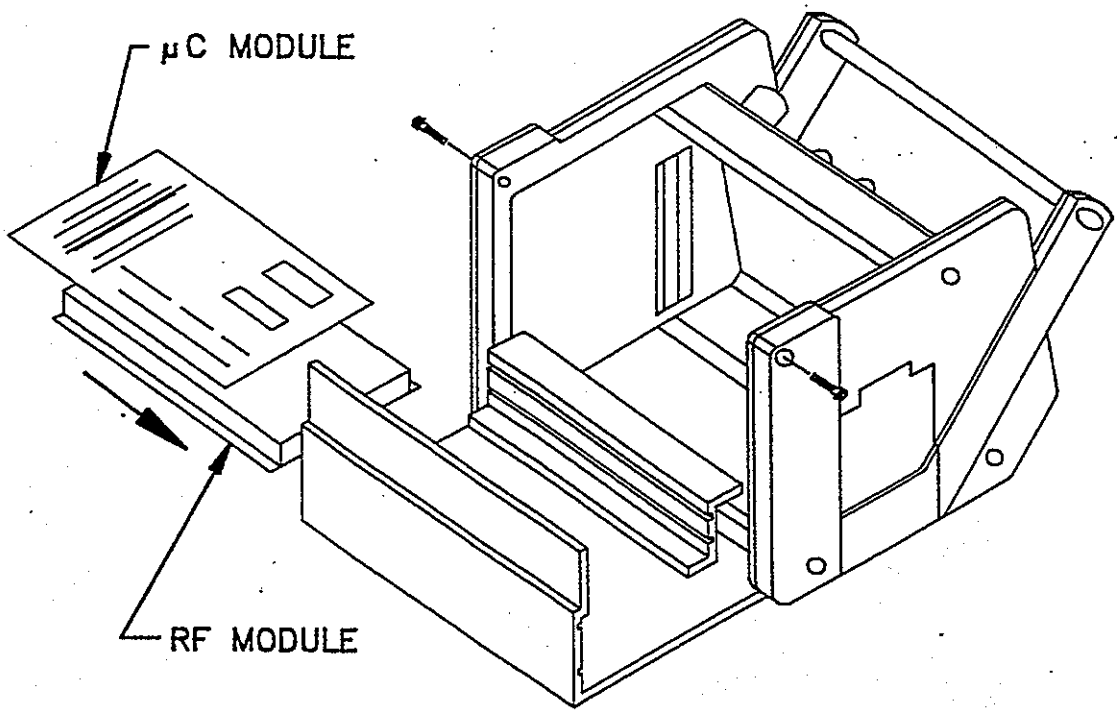


Fig 2 LTX with Access Door in Open Position

OPENING CASE FOR SERVICE

(refer to Fig 2.)

The LTX Transmitter Unit is equipped with a hinged panel which allows access to all internal components and modules without case disassembly. Follow the instructions given below for internal access:

1. Make certain keyswitch and POWER switch are in OFF position.

2. Open housing by removing the two Phillips-head screws located on the transmitter panel (black plastic) ends. These screws are located near the bottom of the transmitter near the bottom front panel.

3. Tilt front panel/card guide; away from control panel.

4. μC Module slides into top guide; RF Module slides into lower guide. Remove both Modules.

TRANSMITTER GENERAL DESCRIPTION: LTX

The Telemotive VHF and UHF Lever-Switch Transmitter (LTX) Units are completely self-contained with controls, circuit modules, antenna, and battery housed in one hand-held case. Units are available for VHF and UHF ranges in power outputs from 50mW to 700mW.

The LTX Transmitter Unit is comprised of the following major items:

CONTROL (FRONT) PANEL EXTRUSION

In addition to serving as the top portion of the case, the Control Panel Extrusion supports all motor controls, auxiliary function and warning device switches, an ON-OFF switch, and a battery monitor indicator. The switches and motor controls are connected to the the μC Module via multiconductor ribbon ("flat-lead") cables fitted with locking connectors, thereby allowing easy separation of individual controls from the μC Module without desoldering.

LTX Control Panel and Case (housing) Assemblies are covered on page 12.

TRANSMITTING ANTENNA

VHF Transmitters typically use an antenna which is integrated into the left hand end cap (as viewed from normal operating position).

All UHF Transmitter Units use a helical ("rubber-duckie") antenna which mounts to the Transmitter Control Panel using a BNC connector.

LTX antennas are covered on page 10.

BOTTOM EXTRUSION: END CAPS

In addition to serving as the bottom portion of the case, the bottom extrusion serves as a card guide chassis for the two transmitter electronic modules. The bottom extrusion swings away from the case with the removal of two screws, allowing access to internal components without case disassembly (refer to Transmitter MAINTENANCE & GENERAL SERVICE INSTRUCTIONS page 5)

BATTERY PACK

Several Batteries are available and are applications-matched to the transmitter electrical and environmental requirements. On Transmitters not equipped with optional charging jack, remove battery from Transmitter as described in Transmitter MAINTENANCE & GENERAL SERVICE INSTRUCTIONS page 3.

See user's Manual for battery options.

μC (DIGITAL) MODULE

The μC Module encodes motor control data and switch closures into serial digital data . Additionally, the serial data is encoded with system control data. The μC Module consists of an Intel 8031 microcomputer IC and 8K x 8 EPROM memory which controls input/output functions. Briefly, the μC Module performs the following functions:

1. Multiplexes the various motor and on-off functions onto a serial data signal.

2. Encodes the serial data with system control data such as sync, baud rate selection, selectable defeat time-out (dead-man's throttle" feature), and access code programming.

RF MODULE

The RF Module accepts serial data from the μC and modulates the data onto an RF carrier via FSK (Frequency-Shift-Keying) modulation.

TRANSMITTER GENERAL DESCRIPTION LTX

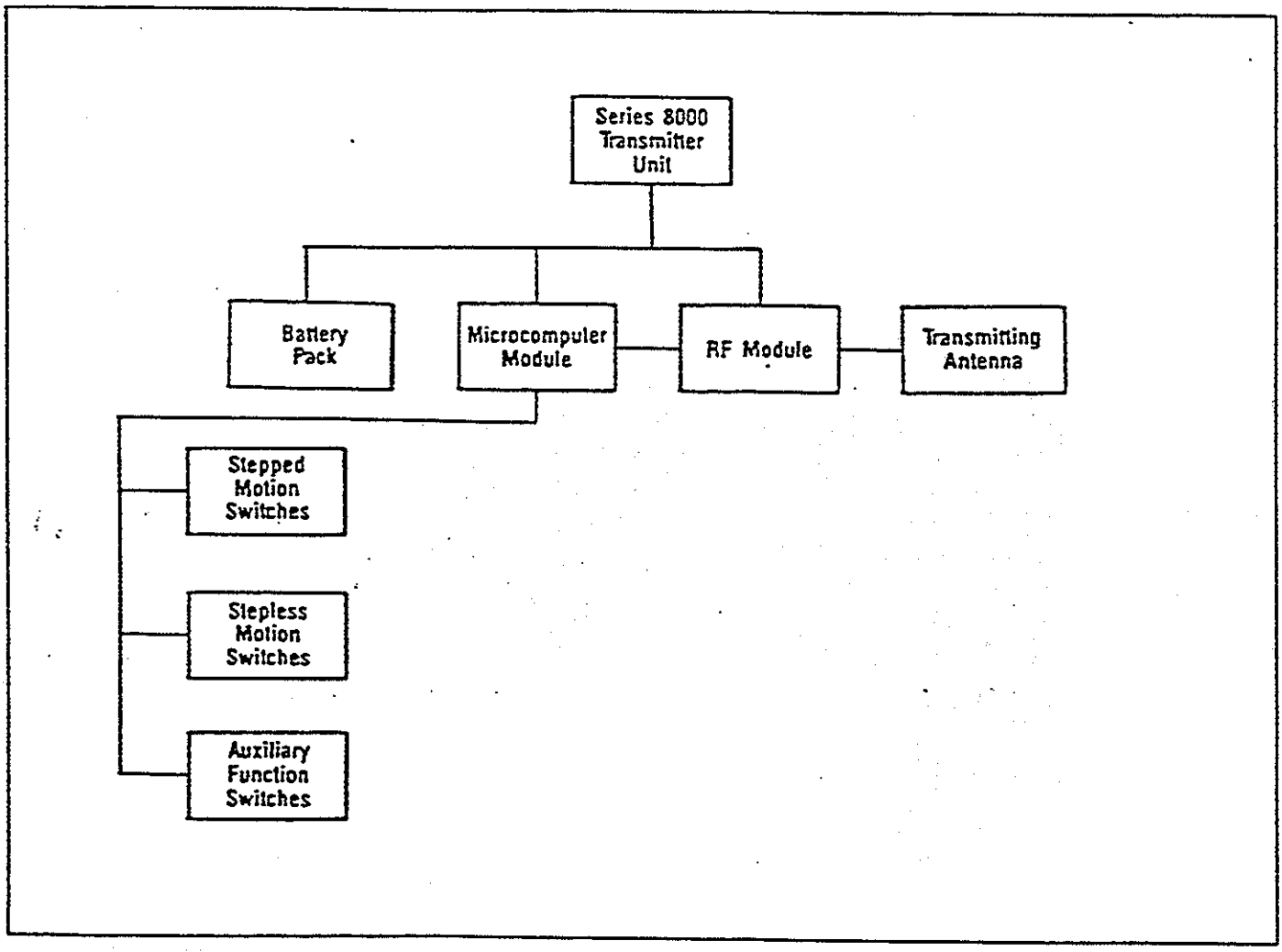


FIGURE 3 LTX TRANSMITTER BLOCK DIAGRAM

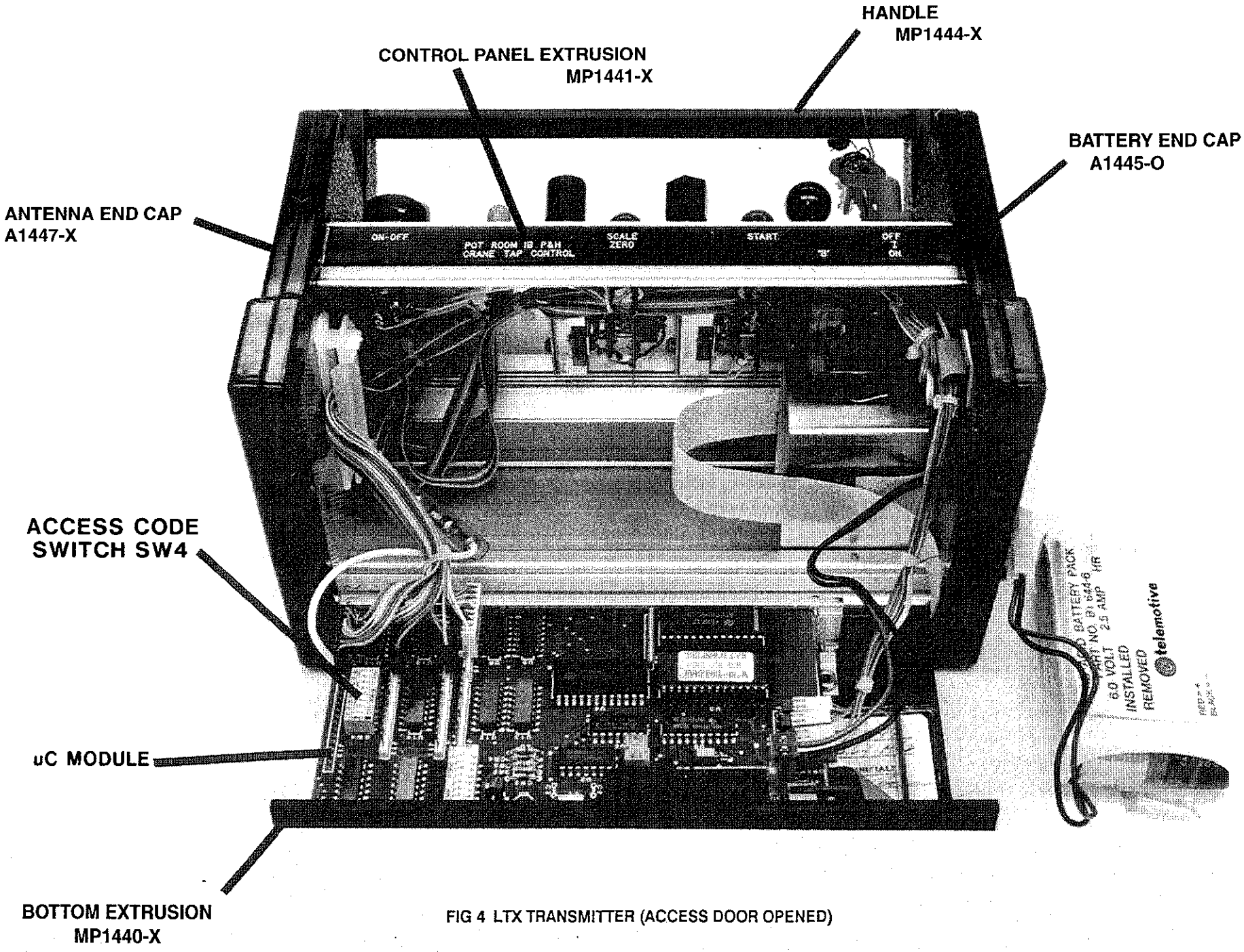


FIG 4 LTX TRANSMITTER (ACCESS DOOR OPENED)

TRANSMITTER ANTENNA: LTX

CAUTION

Replace antenna only with the Telemotive part that corresponds to the frequency and model number of the Transmitter Unit. An improper antenna will rapidly damage the Transmitter Unit.

The VHF LTX Transmitter Unit is available with the antenna types, discussed on the following two pages.

VHF END CAP ANTENNA

Typically, VHF Lever-Switch Transmitter Units use an integral end cap antenna which is built in to the left-hand case end cap (plastic side cover, as viewed from normal operating position).

The antenna portion of the end cap is not separable from the end cap. Therefore, if either the end cap or the antenna requires replacement, both are replaced as a single integrated part using one part number.

REMOVAL/REINSTALLATION
(REFER TO FIG. 5)

1. Turn keyswitch to OFF position and remove key.
2. Remove the two Phillips-head screws that attach the end cap to the handle.
3. Remove the remaining four Phillips-head screws on the end cap panel.
4. Pull end cap away from Transmitter case. *Do not attempt to completely remove at this point.*
5. Disconnect antenna end cap from transmitter module by grasping and unplugging in-line coaxial connector as close to *the connector as possible. Do not* disconnect connector without supporting connector cable ends.
6. Perform the steps listed above in reverse order when reinstalling antenna end cap.

NOTE:

Factory-replacement end cap antennas are frequency-tuned at the factory and require no field tuning or matching in most situations. If performance is degraded (i.e. significantly reduced range) following an antenna replacement, this indicates that SWR requires further fine adjustment due to uncontrollable factors: Call Telemotive Service for further instruction.

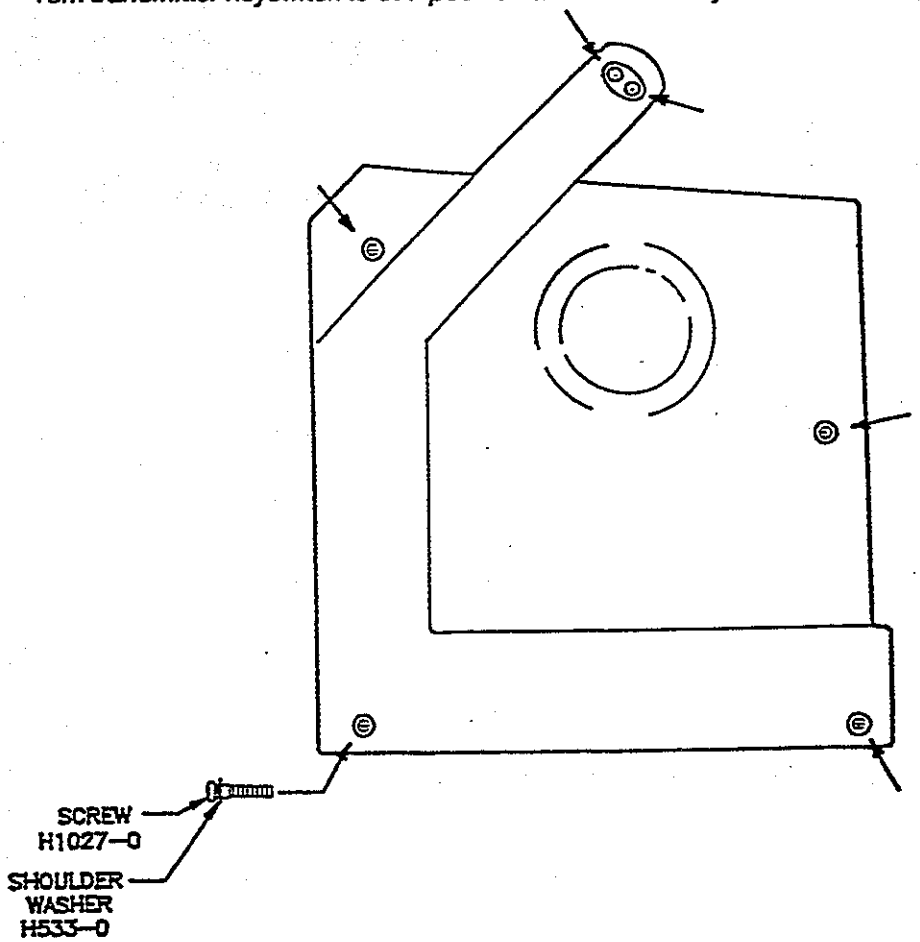
TRANSMITTER ANTENNA LTX:

VHF & UHF HELICAL ANTENNA

Certain VHF and all UHF Lever-Switch Transmitters use a helical ("rubber-duckie") antenna. The antenna is mounted to the Transmitter Control Panel using a standard BNC connector bayonet-mount. Replacement helical antennas are frequency-tuned at the factory.

CAUTION

Turn transmitter keyswitch to OFF position and remove key before removing antenna.



ANTENNA TYPE	FREQUENCY RANGE	ANTENNA PART NUMBER*
INTEGRAL END CAP	75-76 MHz	A1447-0
INTEGRAL END CAP	72-72.86 MHz	A1447-1
INTEGRAL END CAP	49-50 MHz	A1447-2
INTEGRAL END CAP	40-42 MHz	A1447-3
HELICAL	72-72.86 MHz	E8010-0
HELICAL	75-76 MHz	E8010-1
HELICAL	406-430 MHz	E8010-2
HELICAL	450-470 MHz	E8010-3

*When ordering, please include transmitter frequency and/or job number to insure antenna is tuned to the proper frequency.

TABLE 1 LTX TRANSMITTER-TO-ANTENNA CORRELATION

CONTROL PANEL/HOUSING: LTX

The LTX Control Panel/Housing consists of the following major items:

1. *Control Panel/Chassis*. The Control Panel/Chassis ("front extrusion") consists of an angle-shaped extrusion which serves both as the control panel and as the major chassis.

2. *Access Door/Card Guide*. The Access Door ("door extrusion") consists of a black anodized extrusion which hinges away from the control panel, thereby providing access to the transmitter circuitry without case disassembly. The access door is equipped with card guides that hold the two transmitter electronic modules.

3. *End Caps* As viewed from the operator's position, the left End Cap typically contains the antenna on VHF units. The right End Cap includes the battery compartment door. Both end caps fasten to the Control Panel/Chassis.

4. *Handle* The Handle fastens to the End Caps and is mounted using four Phillips-head screws.

REMOVING CONTROLS AND SWITCHES

WARNING

Do not attempt the repair of mechanically or eletrically faulty controls. Faulty controls must only be replaced with factory authorized replacement parts.

1. Turn keyswitch to the OFF position and remove key.

2. Open access door. See "Opening Case for Service" instructions in MAINTENANCE & GENERAL SERVICE INSTRUCTIONS. Page 5.

3. Noting which flat-lead cable corresponds to the control being removed, disconnect the corresponding cable from the Transmitter μC Module. Note the relative location of the connector(s) using a sketch or note; this helps avoid confusion when reinstalling a replacement part (connectors are polarized).

4. Remove lever switch knobs by unscrewing knobs counter-clockwise.

5. Remove lever control from control panel by removing the two screws from the top of the control next to the switch.

6. ON-OFF and AUX rubber-booted switches have a hex nut molded into the boot base just above the switch mounting hex nut. Remove switch boot first by supporting switch hex nut with a low-profile open-end wrench while unscrewing switch boot, then remove switch hex nut.

7. Keyswitch is fastened by a hex nut located underneath control panel.

MOTION CONTROLS & SWITCHES

The type and number of controls found on a given Transmitter depend upon the configuration of the radio remote control system. However, various combinations of the following controls and/or switches are found on all LTX Transmitters:

1. *MOTION CONTROL* These are the larger, lever-type controls; two types are available.

   a. *STEPPED MOTION CONTROL:* This control uses a lever to operate a drum-type cam which progressively opens and closes several switches. Combined closures of the motor control's individual switch elements develop the digital code that constitutes the stepped motor-control signal.

   b. *STEPLESS MOTION CONTROL:* This control uses a lever to operate a potentiometer which, in conjunction with Transmitter μC A/D circuitry, develops the digitally-coded stepless motor-control signal.

2. *MOMENTARY-CONTACT PUSHBUTTON SWITCH* This switch is used as the "START" button, as well as for warning functions such as a horn.

3. *SINGLE-THROW TOGGLE SWITCH:* This switch is used as the transmitter power ON/OFF switch, as well as for AUXiliary functions such as lights, grab, etc.

All controls which conect to the Transmitter μC Module are connected to the module via flat-lead multiconductor ("ribbon") cables fitted with Molex-type connectors. Each such control uses its own cable, thereby permitting easy removal of a control without disturbing the wiring of other controls.

TC4023-0-0.0A-Z

AC INPUT

LEAD-ACID

BATTERY CHARGER

OPTION

5.0 VOLT

NI-CD

BATTERY CHARGER

OPTION

GENERAL INFORMATION

The material covering the Telemotive AC input lead-acid battery charger option is divided into the following five parts:

1. General Information
2. Specifications
3. Battery Charging Principals
4. Battery Charger Circuit Description
5. Battery Charger Checkout Procedure
6. Battery Charger Operating Procedure

The Telemotive AC input lead-acid battery charger option is made up of the following items:

1. E1012-1 or E1012-3 or E1012-6 or E1012-8

2. A101 Battery Charger Cable and WA272-0 Battery Charger Cable

3. BT626-0 or BT627-0, or BT644-6 or BT652-0, or BT653-12, or BT657-0 or BT658-0 lead-acid battery pack.

The Telemotive E1012 AC input Battery Charger is a constant voltage type with provisions for simultaneous float charging of up to two lead-acid battery packs and two lead-acid battery powered transmitters. A battery pack discharged to 100% of capacity will take 50 hours to recharge to 100% of capacity. Only one discharged battery pack should be connected to the charger, any more will only increase the time needed to charge. Most of the capacity is returned to the cells in 16 hours, thus an application where the battery pack is used three times a week and left on charge the rest of the time, will maintain capacity and optimize total cycle life. The battery charger unit is designed to be used only with the Telemotive lead-acid battery pack. DO NOT ATTEMPT TO CHARGE MERCURY, LITHIUM, OR NICKEL-CADMIUM CELLS.

The lead-acid battery pack is connected directly to the charger. Telemotive A101-0 or WA272-0 battery charger cable is used to charge a battery pack in the transmitter. The Telemotive lead-acid battery pack is capable of providing up to 25 hours of operation at the 100mA level before recharging.

2. SPECIFICATIONS

A. E1012 AC Input Battery Charger Unit

1. AC input voltage: 103 VAC to 127 VAC @ 60 Hz
2. Maximum charging output current: 1.5A nominal
3. Float charging output current: 3mA nominal
4. Battery: For use only with Telemotive battery pack

B. Lead-Acid Battery

1.	Number of cells:	3,5,6 or 12 cells
2.	Min. charge voltage:	2.35 Volts/cell
3.	Nominal voltage:	2.00 Volts/cell
4.	Voltage at discharge:	1.81 Volts/cell
5.	Charge Capacity:	2.5 Amp-Hour Min.

3. BATTERY CHARGING PRINCIPLES

A. General Principles

The following is a list of some general principles relating to the charging of a lead-acid battery:

1. The electrical charge holding capacity of a battery is usually given as an Amp x Hour (A-Hr) rating.

2. The battery A-Hr rating is directly proportional to the charge in coulombs stored by the battery. The electrical charge taken from a battery in a given time is approximated by multiplying its average current drain (in amps) by the length of time the current is taken (in hours).

3. Electrical charge is added to a battery by injecting current into it. The amount of electrical charge added in a given time is approximated by multiplying the average current injected by the length of time the current is applied.

4. When a battery is being charged, we are witnessing a case of the conversion of electrical energy into chemical energy. With the charging process, a current is made to flow into a battery that presents a given voltage drop. In a resistor these conditions would result in the generation of heat energy in an amount proportional to Volts x Currents x Time. In a battery the electrical energy is not converted into heat, instead, it is converted into chemically stored energy in an amount proportional to Volts x Current x Time.

5. After a battery is fully charged, further conversion of electrical energy to chemical energy stops. With continued charging the battery starts to act as a load resistor, thus a fully charged battery will start to heat up significantly if it left at a high rate of charge after it has already accepted a full charge. Furthermore, this excessive heating of the battery can cause harmful effects on the battery chemicals that reduces battery life.

6. A "float charge" is a level of charging voltage that can be maintained over a long period of time to keep a battery fully charged. This rate of charging will cause minimum detrimental effects to the battery and is sufficient to overcome the normal "self-discharge" effects of the battery.

7. The total charge required to charge a battery is usually a little more than the charge stored. This takes into account the internal resistive losses and "self-discharge" effects in the battery.

8. The total charge removed from a battery is usually a little more than the charge taken by the load. This takes into account the internal resistive losses and "self-discharge" effects in the battery.

9. A partially charge battery will obtain full charge in a period of time proportional to its state of discharge. For example, a battery that is 80% discharged will obtain full charge in less time than required to charge a fully discharged battery with the same level of current.

B. Lead-Acid Principles

The following material applies more specifically to lead-acid batteries:

1. Lead-acid batteries do not have many of the problems associated with other systems, such as cell reversal, memory and thermal runaway.

2. The lead-acid battery packs should not be allowed to self-discharge below 1.81V per cell because this would appreciably change the recharge characteristics and adversely affect the cycle life.

3. Under load 100% of the available capacity has been removed at about 1.75V per cell. Discharging the battery pack below 1.4V per cell will impair the ability of the cell to accept a charge.

4. Avoid recharging lead-acid batteries at temperatures below $-40^{o}C$ or above $65^{o}C$.

5. Do not dispose of lead-acid batteries in a fire .... they may explode!

C. State of Charge

Table 1 shows the state of charge versus the open circuit voltage for the Telemotive lead-acid battery packs. These figures are representative of an ideal battery. They are useful for getting "ball park" estimates for the state of charge for the actual battery pack.

STATE OF CHARGE

Table 1

% OF RATED CAPACITY	V/CELL	OC VOLTS PER BATTERY PACK			
		BT644-6 BT652-0	BT626-0	BT627-0 BT658-0 BT653-12	BT657-0
0	1.98	5.94	9.90	11.88	23.76
10	2.00	6.00	10.00	12.00	24.00
20	2.02	6.06	10.10	12.12	24.24
30	2.04	6.12	10.20	12.24	24.48
40	2.06	6.18	10.30	12.36	24.72
50	2.08	6.24	10.40	12.48	24.96
60	2.10	6.30	10.50	12.60	25.20
70	2.12	6.36	10.60	12.72	25.44
80	2.14	6.42	10.70	12.84	25.68
90	2.16	6.48	10.80	12.96	25.92
100	2.18	6.54	10.90	13.08	26.16
MIN	1.81	5.43	9.05	10.86	21.72
MAX	2.35	7.05	11.75	14.10	28.20

The % of rated capacity remaining is accurate to within 20% if the cells have not been charged or discharged within 24 hours and is accurate to within 5% if the cells have not been charged or discharged within the past 5 days.

The cells should not be allowed to self-discharge below the minimum open circuit voltage.

The maximum voltage would be obtained with the cells right off the battery charger.

BATTERY CHARGER CIRCUIT DESCRIPTION

In the Telemotive AC input lead-acid battery charger unit, the AC line voltage is stepped down by transformer T-1 and rectified by a full wave center tapped rectifier circuit. The rectified DC voltage is fed to a voltage regulator which is set to provide the correct charging voltage to the four output jacks.

The two jacks that connect to the battery packs directly are set to charge the packs at a nominal 2.35V/cell. The two jacks that connect to the charging terminal on the transmitters are set higher because of the voltage drop across two diodes inside the transmitter which prevent accidental discharge of the battery pack.

5. BATTERY CHARGER CHECKOUT PROCEDURE

a. With 115V AC +/-5% input to the charger, measure the voltage at each receptacle with a volt OHM meter.

b. Connect a 1K ohm 2 watt resistor across each receptacle, one at a time, and measure the voltage across the resistor.

c. Listed below are the normal readings for those tests listed above:

BATTERY CHARGER	LOAD	TX JACK J1 & J2	BATTERY JACK J3 & J4	TOLERANCE
E1012-1 (10V)	None	13.7	12.9	+/-0.3
	1K	13.4	11.9	+/-0.3
E1012-3 (6V)	None	8.8	8.1	+/-0.2
	1K	8.5	7.1	+/-0.2
E1012-6 (12V)	None	16.0	15.3	+/-0.4
	1K	15.7	14.3	+/-0.4
E1012-8 (24V)	None	30.4	29.7	+/-0.7
	1K	30.1	28.7	+/-0.7

6. BATTERY CHARGER OPERATING PROCEDURE

a. Connect a charging cable between the receptacle on the charger and the transmitter or connect a battery pack directly to the charger.

b. The transmitter ON/OFF switch must be set to the OFF position when charging through the panel jack on the transmitter.

c. Move the toggle switch below the indicator lamp to the ON position. The lamp should light, indicating that the unit is on.

d. All four jacks can be used for float operation to keep batteries at full charge for over 8 years at room temperature.

e. Only one discharged battery should be connected at any time.

f. When a new battery is received, always charge it for at least 16 hours before attempting to use it.

g. Cycle life depends on depth of discharge, temperature and charging rate. Under normal operation with occasional long charge periods, in excess of 200 charge-discharge cycles can be expected.

+ −

NICKEL CADMIUM RECHARAGEABLE BATTERY PACK

PART NO. RC-BT104A

5.0VOLTS 4.0A.H.

INSTALLED ☐

REMOVED ☐

telemotive®

TELEMOTIVE INDUSTRIAL CONTROLS
175 WALL STREET
GLENDALE HEIGHTS, ILLINOIS 60139-1985
630-582-1111

5.0VOLT NI-CD BATTERY CHARGER RC-E 3607

1. GENERAL INFORMATION:

The material covering the Telemotive 5.0 volt nickle-cadmium battery charger option is divided into the following five parts:

1. General Information
2. Specifications
3. Battery Charging Principals
4. Battery Charger Circuit Description
5. Battery Charger Checkout Procedure
6. Battery Charger Operating Procedure

The Telemotive 5.0 volt NI-CD battery charger option is made up of the following items:

1. RC-E3607 5.0 V Battery Charger
2. RC-A101 Battery Charger Cable
3. RC-BT104 5.0 V 4A-H NI-CD Battery

The Telemotive RC-E3607 Battery Charger is a constant current type with provisions for simultaneous charging of up to four RC-BT104 Nickel-Cadmium battery packs. Along with the "normal quick charge" circuit the unit includes a switch selected "trickle" charge circuit. The "trickle" charge circuit prevents overcharging if the battery is to be left on charge for an extended period of time.

The battery charger unit is designed for use only with the Telemotive RC-BT104 Nickel-Cadmium battery pack. DO NOT ATTEMPT TO CHARGE MERCURY CELLS.

The Nickel-Cadmium battery pack is connected to the charger with a Telemotive RC-A101 battery charger cable.

The Telemotive RC-BT104 Nickel-Cadmium battery pack is 5.0 volt, 4.0 A.H., 4 cell unit. It is capable of providing up to 80 hours of operation at the 50 mA level before recharging.

In standard operations, two battery packs are provided with each transmitter and the recommended mode for continuous operation is a fixed number of hours of discharge use followed by a fixed amount of hours of charging at the "NORMAL" charging rate.

The proper amount of "NORMAL" charging time can be estimated by knowing the transmitter current drain, the active transmitter hours, and the "NORMAL" charging current level.

2. SPECIFICATIONS:

A. RC-E3607 Battery Charger Unit

1. AC input voltage: 103 VAC to 127 VAC @ 60 Hz
2. Normal charging output current: 400 mA
3. Trickle charging output current: 90 mA
4. Battery: For use only with Telemotive RC-BT104 5.0 V 4.0 A-H Nickel-Cadmium battery pack

B. RC-BT104 Nickel-Cadmium Battery

1. Number of cells: 4 cells
2. Min charge voltage: 1.35 Volts/cell
3. Nominal voltage: 1.20 Volts/cell
4. Voltage at discharge: 1.00 volts/cell
5. Charge Capacity: 4.0 Amp-Hour Min

3. BATTERY CHARGING PRINCIPLES:

A. General Principles:

The following is a list of some general principles relating to the charging of a NI-CD battery:

1. The electrical charge holding capacity of a battery is usually given as an Amp x Hour (A-Hr) rating.
2. The battery A-Hr rating is directly proportional to the charge in coulombs stored by the battery. The electrical charge taken from a battery in a given time is approximated by multiplying its average current drain (in amps) by the length of time the current is taken (in hours).
3. Electrical charge is added to a battery by injecting current into it. The amount of electrical charge added in a given time is approximated by multiplying the average current injected by the length of time the current is applied.
4. When a battery is being charged we are witnessing a case of the conversion of electrical energy into chemical energy. With the charging process, a current is made to flow into a battery that presents a given voltage drop. In a resistor these conditions would result in the generation of heat energy in an amount proportional to Volts x Currents x Time. In a battery the electrical energy is not converted into heat, instead, it is converted into chemically stored energy in an amount proportional to Volts x Current x Time.

5. After a battery is fully charged further conversion of electrical energy to chemical energy stops. With continued charging the battery starts to act as a load resistor, thus a fully charged battery will start to heat up significantly if it left at a high rate of charge after it has already accepted a full charge. Furthermore, this excessive heating of the battery can cause harmful effects on the battery chemicals that reduces battery life.
6. A "trickle charge" current is a level of charging current that can be maintained over a long period of time to keep a battery fully charged. This rate of charging will cause minimum detrimental effects to the battery and is sufficient to overcome the normal "self-discharge" effects of the battery.
7. The total charge required to charge a battery is usually a little more than the charge stored. This takes into account the internal resistive losses and "self-discharge" effects in the battery.
8. The total charge removed from a battery is usually a little more than the charge taken by the load. This takes into account the internal resistive losses and "self-discharge" effects in the battery.
9. A partially charged battery will obtain full charge in a period of time directly proportional to its state of discharge. For example, a battery that is 1/4 discharged will obtain full charge in about 1/4 the time required to charge up a full discharged battery with the same level of current.

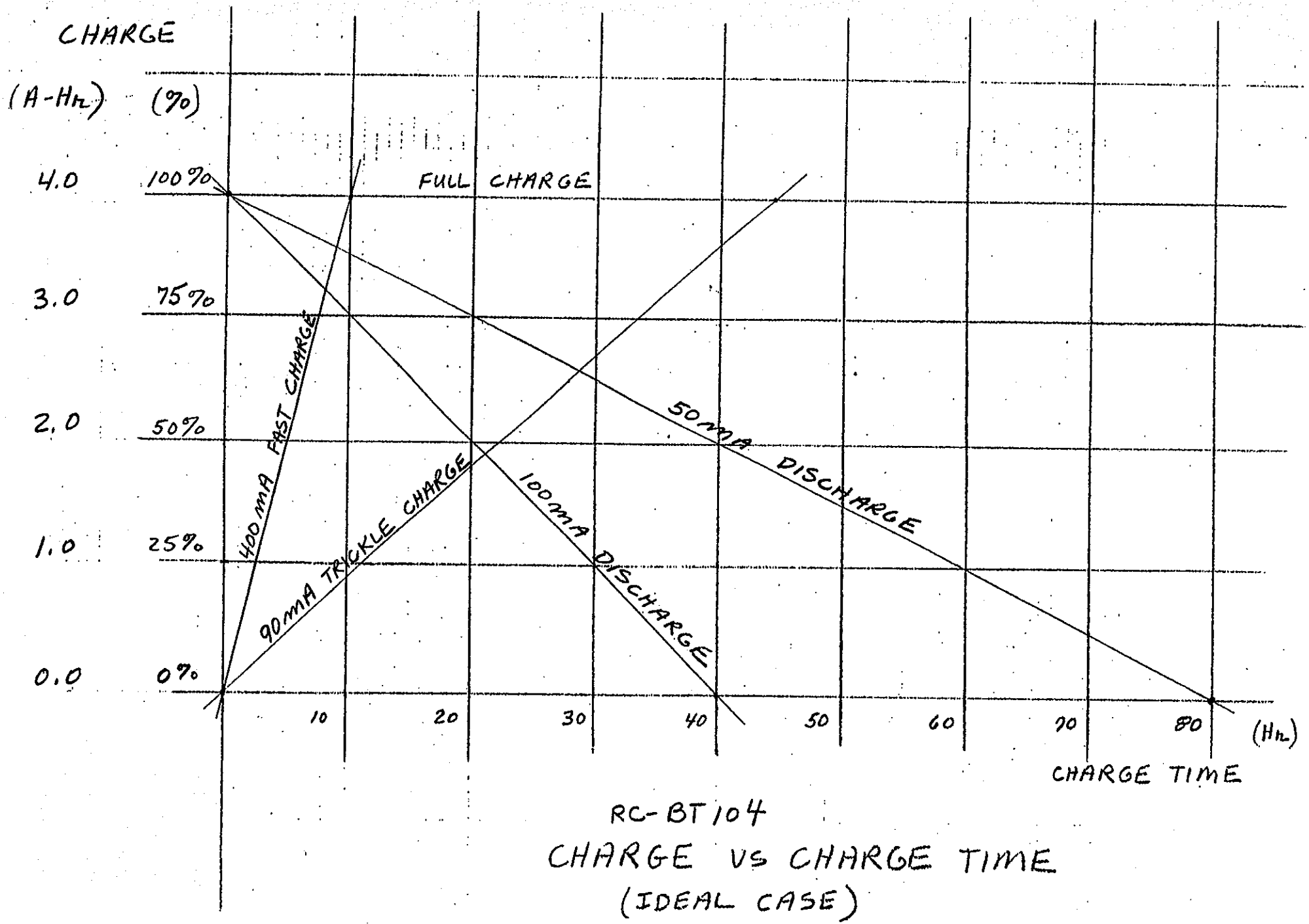
B. NI-CD Principles:

The following material applies more specifically to NI-CD batteries:

1. Nickel-cadmium batteries operate best and avoid the cell "memory effect" under the following conditions:
   a. When they are "deep discharged" regularly
   b. When long periods of uninterrupted charging are avoided.
2. Do not run a multi-cell NI-CD battery pack to a point of total discharge. The reason for this is the following: NI-CD battery cells when employed in a series multi-cell battery pack employ cells that have been matched for charge holding capacity. But the match isn't perfect. Thus, when the battery pack nears total discharge, one of the cells may loose its charge before the others. Further discharging of the NI-CD battery pack will actually cause the depleted cell to start to charge in the opposite direction. This phenomena called "call reversal" has a damaging effect on the cell involved.
3. Avoid recharging NI-CD batteries at temperatures below $-20^{o}F$ or above $110^{o}F$.
4. Do not dispose of NI-CD batteries in a fire--they may explode.

C. Charge vs. Charge Time Curves:

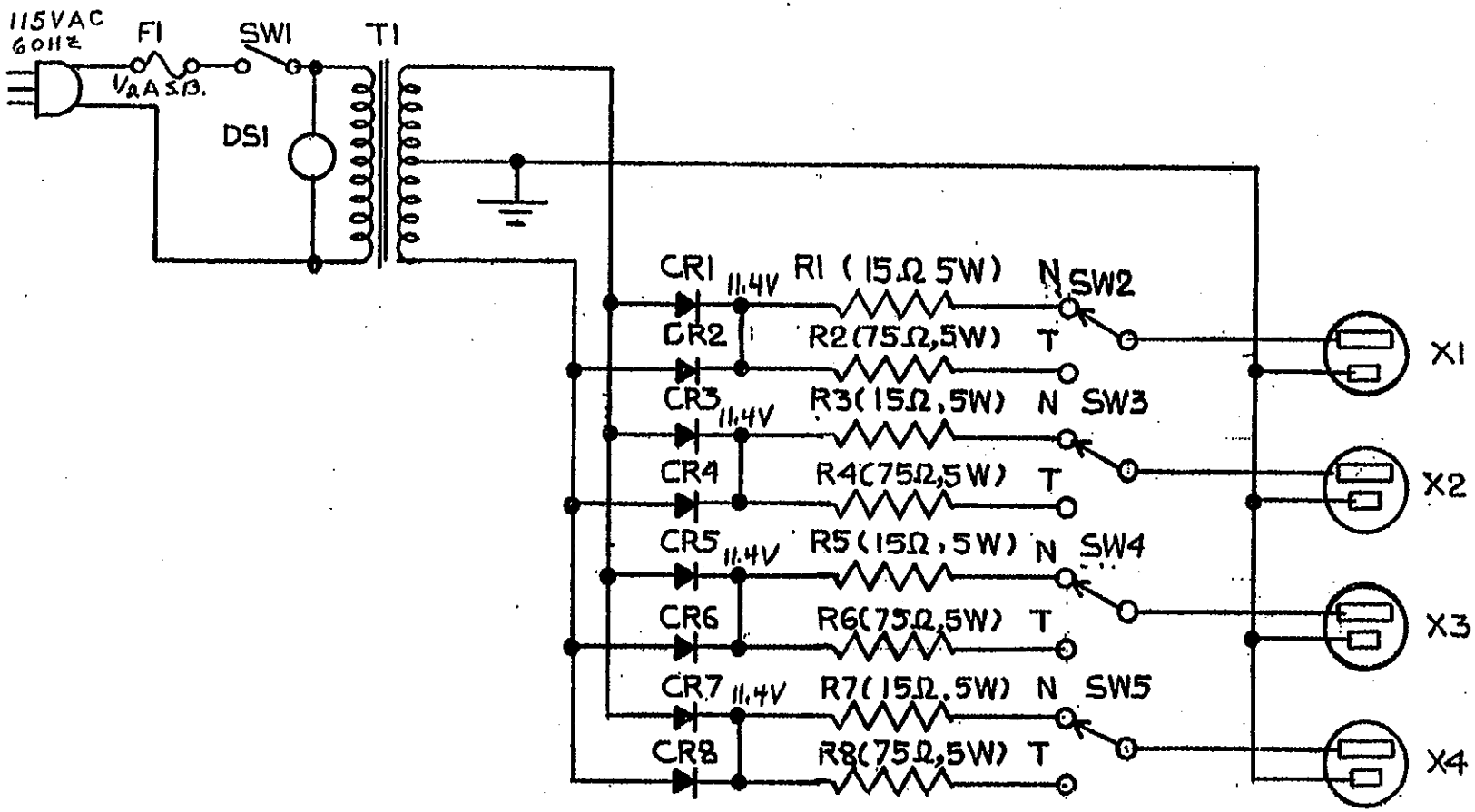
The attached figure shows the state of charge versus various charge rates and discharge rates for the Telemotive NI-CD battery pack. These curves are representative of an ideal battery. They are useful for getting "ball park" estimates for the state of charge, the charge time and the discharge time for the actual NI-CD battery pack.



RC-BT104

CHARGE VS CHARGE TIME

(IDEAL CASE)



NO.	DATE	REMARKS	BY

REVISIONS

TELEMOTIVE
DIVISION OF *DYNASCAN CORPORATION*

1801 BELLE PLAINE AVE.
CHICAGO ILLINOIS 60613
AREA CODE 312 BITTERSWEET 8-9111

5V, 4A, Ni-Cad BATTERY CHARGER

USER

JOB	DRN	CHKD	APPV'D
	K.S. BHOGAL	G.B	
SCALE	DATE	DRAWING NO.	
X	6-22-73	RC-E3607-A	
REF			

POST

4. BATTERY CHARGER CIRCUIT DESCRIPTION:

In the Telemotive RC-E3607 battery charger unit, the AC line voltage is stepped down by transformer T-1 and rectified by a full wave center tapped rectifier circuit. Each charging output has its own separate rectifiers. The rectified DC voltage is fed to the charging receptacles through resistors which are switch selected for either "normal" or "trickle" charge operation.

Under "normal" charging a 15 OHM resistor limits the average battery charging current to 400 mA. This current level is sufficient to completely charge a RC-BT104 battery in 12 hours to 14 hours. Under "trickle" charging a 75 OHM resistor limits the average battery charging current to 90 mA. This current level will charge a RC-BT104 battery in 60 hours and is normally used to maintain the charge of a battery after it has been recharged.

5. BATTERY CHARGER CHECKOUT PROCEDURE:

A. With 115 V AC ± 5% input to the charger and the "Charge Rate" switch in the "NORMAL" position, measure the voltage at each receptacle with a volt OHM meter.

B. Connect a 15 OHM 10 watt resistor across each receptacle one at a time and measure the voltage across the resistor with the "Charge Rate" switch in both the NORMAL and the TRICKLE position.

C. Listed below are the normal readings for those tests listed above:

SWITCH POSITION	LOAD	READING	TOLERANCE
Normal	None	12.8 V	±2.0 V
Normal	100 OHM	5.7 V	±0.6 V
Trickle	100 OHM	2.1 V	±0.4 V

6. BATTERY CHARGER OPERATING PROCEDURE:

A. Connect a charging cable between the receptacle on the charger and the transmitter or battery pack to be charged.

B. The transmitter ON/OFF switch must be set to the OFF position when charging through the panel jack on the transmitter.

C. Set the "Charge Rate" switch, above the receptacle in use, to the NORMAL position. Move the toggle switch below the indicator lamp to the ON position. The lamp should light, indicating that the unit is on and that the battery is being charged.

D. Use the NORMAL position for charging when the battery pack duty cycle is high. A partially charged battery will attain full charge in a period inversely proportional to its state of charge. assuming that a fully charged battery which is used for 8 hours can be completely recharged in 4 hours to 6 hours. Then, if that same battery were only used for 4 hours, it should reach its full charge in only 2 hours to 3 hours.

A completely discharged battery will be restored to full capacity with 14 hours to 16 hours of charging, and to 50% of its capacity in 7 hours.

E. Use the TRICKLE charge position when charging for extended periods or when battery use is very light.

F. When a new battery is received, always charge it at the NORMAL rate for 14 hours before attempting to use it.

Gerald Berger
1-7-87
REV. 8-06-87
6-30-88
10-19-90

DOCUMENT NO. TC2800-0-0.05

PRODUCT DESCRIPTION FOR THE PNEUMATIC THROTTLE LOCOMOTIVE CONTROL SYSTEM

PRODUCT DESCRIPTION FOR THE PNEUMATIC THROTTLE LOCOMOTIVE CONTROL SYSTEM

The Locomotive Control System differs from the Crane Control System in that pressure switches are utilized in various pneumatic lines to monitor the pressure in these circuits. Depending upon the pressure in these monitored lines, the software will modify the transmitted commands in accordance to the specified requirements of the Locomotive System. This essentially produces a closed loop system in which the computer is required to make intelligent decisions on the operation of the machine based on the status of sensing elements on the locomotive itself.

A. DESCRIPTIONS OF CONTROL FUNCTIONS

The following is a description of the various functions available for this type of Control System:

1. HORN

The horn will sound each time the momentary horn pushbutton or start button is depressed and will continue to sound so long as the button is depressed. The horn will also sound for 2 seconds after the pneumatics has passed its self-check when the system is started.

2. BELL

The bell will respond each time the momentary pushbutton is depressed and will continue to respond so long as the button is depressed. The bell will also respond for a ten-second period each time the conditions are such that a motion takes place. That is, if a directional has been selected, the brakes released and the throttle applied, the bell will sound for ten seconds on an automatic software timer. If the throttle is released before the ten seconds has elapsed, the bell will shut off instantly. Any time the throttle is returned to its neutral position and then again advanced, the timer will reactivate the ten second period for the bell. The bell will also sound even though brake pressure is present if the drag brake command has been transmitted. The bell software time is a selected feature and can be selected by Telemotive and therefore will be present at all times. This feature can also be user selected by setting a dip switch which is located in a personality module plugged into Word 7 of the transmitter. Therefore, the

customer can elect to use or not to use this feature at his own option.

3. BRAKE RELEASE

This is a momentary toggle switch which will release the brakes when activated. The brake release can also be performed automatically by activating the throttle. This feature is also user selectable by means of the personality module. With this optional method of control a directional has to first be selected and then the throttle control activated. The software will then decrease the brake pressure but will not permit the throttle command to come through until brake pressure has dropped, at which time the throttle command will be permitted to go through and motion will take place. If the automatic bell timer option has been selected, the bell will then sound for ten seconds.

4. FORWARD, REVERSE

These commands will only be acknowledged or permitted to be changed if the brakes are fully applied and the throttle is in the idle position. When a direction has been selected, while the brakes are applied, the throttle command will be blocked out and not permitted. However, if the brakes are released or the drag brake applied, the throttle command will be recognized and motion will take place. Once the brakes have been released, the directional condition selected just prior to the release of the brakes will be locked into memory and cannot be changed regardless of the position of the directional switch until the brakes have been reapplied. This feature prevents plugging of the locomotive.

When the directional switch on the transmitter is changed from that which is locked into memory the throttle commands will be blocked. This blocked throttle condition will be released if the directional switch on the transmitter is returned to the position that matches that in memory or the brakes are applied and the throttle control is released long enough to allow the directional memory to change and then release the brakes again. The directional status lights show the direction the locomotive will move and not necessarily the direction setting of the transmitter switch.

5. HEAD LAMPS

When this toggle switch is activated on the transmitter both front and rear lamps of the locomotive will turn on in a dim condition. If a directional had been selected,

then that lamp which faces the direction in which the locomotive has been commanded to go in will be at full brightness. The operator does not select which lamp he desires to be bright, he just selects lamps and the software will determine which, if any, of the lamps will be operated at full brightness.

6. DRAG BRAKE

This is a momentary toggle switch or pushbutton, when depressed will release brake pressure down to its low brake pressure point and will set a software latch so as to maintain this command without the need for continuously transmitting the drag brake function. If a directional had not been chosen prior to the transmission of the drag brake, the throttle command will operate, however, the directionals can not be changed under these conditions. Full brakes will have to be applied and then a directional selected. The drag brake latch will be canceled when the brake release or brake apply command are activated. This prevents a conflict in commands and allows full brake pressure to be applied in an emergency when the brake apply command is sent.

7. SAND

This command is activated from a momentary pushbutton and will activate a sander either on the front or rear of the locomotive, depending upon which directional has been selected. The Sand command gets its directional information from internal memory and does not read the transmitted function which may not correspond to the actual direction of the vehicle. This command will not activate the sander if a directional has not been selected.

8. FIVE SPEED THROTTLE AND BRAKE APPLY

The throttle control will only be acknowledged if the brakes are applied and a directional has not been selected, or if the brakes are released with or without the directional. The throttle command will also be acknowledged when only the low pressure brake switch is activated and the drag brake command latch has been set with a directional selected.

The throttle will also be blocked whenever the transmitted directional does not match the directional locked into memory. See Forward, Reverse.

Each time this control is moved to the brake apply position, the brake pressure will increase under a controlled rate. This increase in pressure will stop if this control is released. When the brake apply causes the brake pressure to activate the high brake pressure switch, the brake apply command will be maintained by the computer until a brake release command lowers the pressure below this preset high pressure setting.

9. UNCOUPLE

This is a momentary pushbutton. When depressed, will uncouple the locomotive from its load.

10. PERSONALITY MODULE

This is a small PC Board with an eight position dip switch which plugs into the transmitter motherboard at word location #7. This board allows the user to select certain features such as brake release with the throttle command lever and bell timer when a motion is selected, to be selected as he sees fit. Other special features can be programmed in so as to be selectable by the user as they are developed in the future.

Since this system has been made as universal as possible and needs minimal application engineering time, all functions that have been listed are available if the transmitter is configured to transmit them and the receiver system is wired to respond to them. No special application engineering time would be required to configure the receiving panel other than to label those functions or features that are to be utilized on a given job and to mark the transmitter print to show the functions that are to be installed and the bit location to be wired.

11. ERROR TEST

Besides the error conditions that are normally detected by the systems software which are considered standard for the 7000 System, the following special error checks are made for the locomotive system. These error checks are primarily aimed at catching discrepancies in transmitted functions that could occur due to a defective switch in the transmitter or, in some cases, by misuse of the controls by the operator.

a. Directional Test

Should both directional commands be transmitted at the same time, both of them will be ignored by the software and no directional outputs will take place. However, if a valid directional signal had been sent and locked into memory and the system is in a condition where new directional information would not be accepted, then this error condition will be ignored until such time that the new directional information would normally be accepted. When this error condition exists, a directional error software flag will be set and will only be cleared if the error condition goes away within a second and a half, at which time the system will shut down.

b. Brake Apply - Brake Release Test

Should both of these commands occur at the same time, and they can since these commands are on separate switches on the transmitter, the software will acknowledge the brake apply command applying full brakes to the locomotive and will ignore the brake release command. A brake error flag will be set and system shut down will occur in one and a half seconds. Under the brake apply command, two bits are sent for this function. If for any reason only one of the bits are received due to a defect in the TX motherboard, an error flag will be set for the brakes; however, the brakes will not be applied for a second and a half interval, at which time, the entire system will shut down and the brakes will be applied.

c. Throttle and Brake Apply

Since both of these commands are on the same motion switch, a defective switch can conceivably ask for both commands at the same time. If this should happen, the throttle command will be ignored and the brake command will be accepted applying full brake pressure to the system and at the same time, a throttle error flag will be set. When the throttle's first step is sent, two bits of data are used and if for some reason only one of the bits is transmitted due to a defect on the transmitter motherboard, then the throttle command will be ignored and a throttle error flag will be set with system shut down occurring in one and a half seconds. A throttle error will also occur if first speed is not transmitted when any of the other four

speed steps are transmitted.

When any one of the three above mentioned error flags are set, an error counter will be started and if all error conditions are not cleared up within a second and a half, the entire system will shut down applying brakes. The error flags will be permanently stored in memory so long as the power to the system is not interrupted or a reset command is applied to the computer. Therefore, if a diagnostic module is plugged into the standard BUS rack even after the error has occurred, you can read out on the diagnostic board which function caused the shut down.

12. Pneumatic Self-Check

The pneumatic self-check is made once each time the start button is pressed to start the system after it has been shut down. This self-check takes about 5 to 7 seconds, however, it can extend to approximately 20 seconds if the condition of the pneumatics are marginal. While the tests are in progress all transmitted commands, except horn, will be blocked. When the pneumatics have passed the test the horn will sound for 2 seconds, if the operator is not himself sounding the horn at this time, indicating that the commands are no longer blocked and the system is ready to go. If the pneumatics fail the test, the receiver system will shut down without the 2 second sounding of the horn.

The pneumatic self-check consists of the following:

a. Block all transmitted signals except horn.

b. Check initial output status of control pressure switches.

c. Release brake pressure.

   (1) Monitor brake pressure switches. If switches do not change from original state within 5 seconds, system will shut down. If switches change within time limit, proceed with next test.

d. Reapply brake pressure.

   (1) Monitor brake pressure switches. If switches do not return to original state within 5 seconds, system will shut down. If switches change within time limit, proceed with next

test.

e. Energize 2nd step throttle.

(1) Monitor throttle pressure switch. If switch does not change from original state within 5 seconds system will shut down. If switch changes within the time limit, proceed with next test.

f. Release 2nd step throttle.

(1) Monitor throttle pressure switch. If switch does not return to original state within 5 seconds, system will shut down in 1-1/2 seconds and no other test or operations will be made. If switch changes, proceed with next step.

g. Energize horn for 2 seconds.

h. Release control to operator.

B. **PNEUMATIC AND MECHANICAL DESCRIPTION**

1. Air Supplied

a. Five micron filter regulator set at 90 PSI with automatic water rejection.

b. Pressure switch monitor which will cut-out radio system at 70 PSI.

c. Three way shut-off valve in cabinet to isolate pneumatics.

2. Control Regulators

a. Set point regulators for brake and pneumatic throttle. These are field adjustable for optimum control.

b. Output gages for brake and pneumatic throttle pressures.

3. Combo Rack

a. Combined 19" receiver and interface control module rack.

b. Power switch for rack isolation.

c. All modules are plug-in boards which plug into a common motherboard.

d. All outputs are from the front of the plug-in card edge for ease of maintenance and troubleshooting.

e. Two part hinged control panel for total access to system.

f. Separate power supplies for receiver and computer boards and output modules, thereby isolating the output modules from the rest of the system.

g. All receiver and control modules have LED indicators which are used the same as they are in the 7000 system crane control. The pneumatic output boards have four LEDs to show when the pneumatic valves have been energized. In addition to this, there are two more LEDs which will indicate that the pressure switches, if so equipped, have been activated by pressure in the lines they are monitoring.

4. Cabinet

The one cabinet houses the total system which includes the radio receiver, the electrical and pneumatic controls with circuit breakers, power supplies, power relays, output terminals, pneumatic filters and control valves. This cabinet is a two-part hinged control cabinet measuring 19" high, 24" wide and 16" deep.

5. Receiver Rack PC Board Accompaniment

a. One Receiver.

b. One Frequency Support Board or Datacom Board. Datacom Board is required if diversity antenna system is used in system to reduce multi-path.

c. One 8/IO Board.

d. One 16/O Board.

e. One Computer Board.

f. Four Pneumatic Output Boards.

g. One EMR Board (two boards are required if head lamps are used).

Locomotive Transmitter Word Assignment

Word 1 - Aux Function

BIT	FUNCTION
7	Horn
6	Bell
5	* Brake Release

4	FWD
3	REV
2	Head Lamps
1	Drag Brake
0	Sand

Word 2 - Stepped Function

BIT	FUNCTION
7-5	* Brake Apply
6-4	* 1st Step Throttle
3	* 2nd Step Throttle
2	* 3rd Step Throttle
1	* 4th Step Throttle
0	* 5th Step Throttle

Word 3 - Aux Function

BIT	FUNCTION
7	Transmission 1st
6	Transmission 2nd
5	Transmission 3rd
4	NU
3	* Gradual Throttle Advance
2	* Gradual Throttle Retard
1	* Uncouple Rear
0	* Uncouple Front (Use this Bit when only one uncouple command is used.)

Word 4 - Stepped Function (Train Brake)

BIT	FUNCTION
6-4	* Brake Release
7-5	* 1st Step Brake Apply
3	* 2nd Step Brake Apply
2	* 3rd Step Brake Apply

Word 5 - Aux Function (Knuckel)

BIT	FUNCTION
7	* KF Up
6	* KF Down
5	* KF Right
4	* KF Left
3	* KR Up

2	* KR Down
1	* KR Right
0	* KR Left

Word 6 - Aux Function

BIT	FUNCTION
7	Front Extended Head Up
6	Front Extended Head Down
5	NU
4	NU
3	NU
2	NU
1	NU
0	NU

Word 7 - Personality Module

BIT	SW	FUNCTION
7	1	Bell Timer (10 Sec.)
6	2	Brake Release
5	3	Loco Brake controlled by Train Brake
4	4	Cont. Bell Timer
3	5	No Horn after self-check
2	6	Throttle with Train Brake
1	7	NU
0	8	NU

*NOTE: The system will not start if these functions are activated when the system is started.

LOCOMOTIVE RECEIVER OUTPUT ASSIGNMENT

PNEUMATIC THROTTLE & DIRECTIONAL

8/IO (Location 7F)

BIT #	FUNCTION	
7	BRAKE RELEASE	PNEUMATIC BOARD (E7208-1)
6	BRAKE APPLY	
5	DRAG BRAKE	
4	EMERGENCY BRAKE	
3	THROTTLE 1ST STEP	PNEUMATIC BOARD (E7208-8)
2	DIR FWD	
1	DIR REV	
0	UNCOUPLE	

16/O (Location 7E)

BIT #	FUNCTION	
15	THROTTLE 2ND STEP	PNEUMATIC BOARD (E7208-13)
14	THROTTLE 3RD STEP	
13	THROTTLE 4TH STEP	
12	THROTTLE 5TH STEP	
11	HORN	PNEUMATIC BOARD (E7208-10)
10	BELL	
9	SAND FWD	
8	SAND REV	
7	STATUS LIGHT FWD	RELAY BOARD (E7207-19)
6	STATUS LIGHT REV	
5	STATUS LIGHT BRAKE APPLY	
4	STATUS LIGHT THROTTLE	
3	HEAD LAMP DIM FWD	RELAY BOARD (E7207-19)
2	HEAD LAMP DIM REV	
1	HEAD LAMP BRIGHT FWD	
0	HEAD LAMP BRIGHT REV	

NOTES

I. SLTX TRANSMITTER

A. TOP EXTRUSION

Series 7000, 8000

1. ALL MOTOR CONTROLS
2. AUXILIARY FUNCTIONS
3. ON/OFF SWITCH
4. BATTERY MONITOR
5. JOB NUMBER & SERIES TYPE
6. ACCESS CODE (Plugs if used)

B. BOTTOM EXTRUSION

1. CARD GUIDE
2. TWO ET. MODULES
   (How to remove and install)

C. END CAPS

1. BATTERY DOOR SIDE
2. ANTENNA SIDE

D. TX ANTENNA

1. INTEGRATED END CAP
2. UHF (Rubber Duckie)

E. BATTERY PACK

1. THROW AWAY
2. RECHARGEABLE
3. BATTERY LIFE
4. BATTERY MONITOR

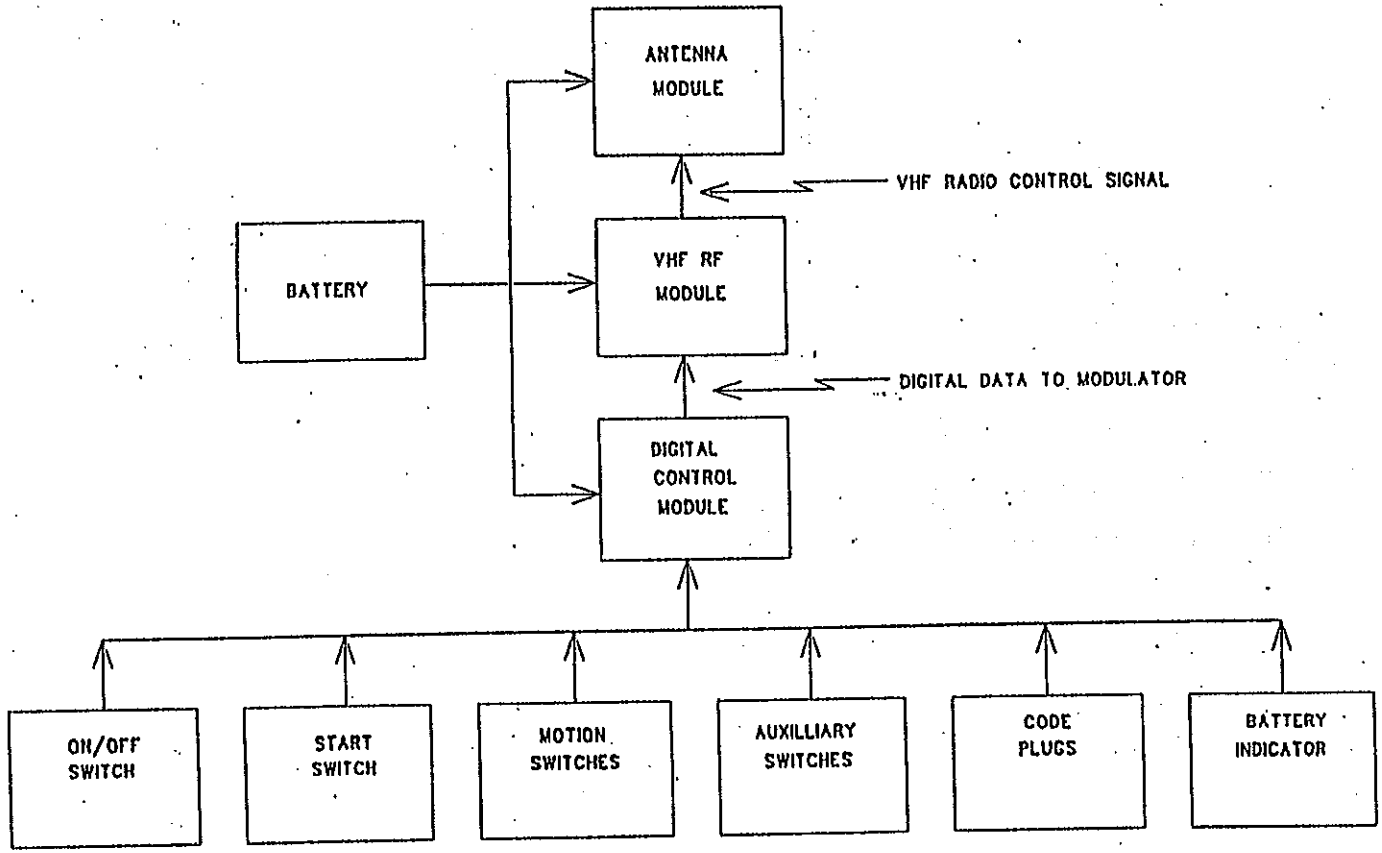
F. M/C MODULE

1. AUXILIARY PLUGS
2. SW. PLUGS
3. ACCESS CODE SW5
4. SW3 SWITCH
5. SW1 SWITCH
6. EPROMS
7. U1/U2 CHIPS
8. DIODE MATRIX
9. BAT. MONITOR POT R3
10. DATA INFORMATION
11. AUTO SHUTDOWN

G. R.F. MODULE

1. ANT. CABLE
2. S1/S2 SWITCH
3. HIGH/LOW FREQ.
4. R9 and R11 POTS
5. OSCILLATOR/MODULATOR
6. MULTIPLIER
7. FINAL AMP.
8. 50 OHM ANTENNA
9. OUTPUT POWER

SLTX-H VHF TRANSMITTER



telemotive	MAXTEC CORPORATION	
8023 SYSTEM BLOCK DIAGRAM		
SLTX-H VHF TRANSMITTER		
	J.P.BATES	
	7/11/91	
SHEET 1 OF 2		DD-E8023-X-0.0A-C

Transmitter General Description

The transmitter is self-contained with controls, circuit, modules, antenna, and battery housed in one hand-held case. Units are available for VHF and UHF ranges in power outputs of 50mw, 100mw, 400mw, and 700mw and is comprised of the following major items:

Control (Front) Panel Extrusion

Serves as the top portion of the case and supports all motor controls, auxiliary functions and warning device switches, an on/off switch along with the battery monitor indicator. The switches are connected to the microcomputer module via ribbon cables. The battery monitor indicator monitors the battery condition and is indicated by the red LED. When the transmitter is turned on and the battery is sufficiently charged the LED flashes. When the charge is below acceptable limits, the LED turns off.

Note: The type and part number of the switches on a given transmitter can be located on the transmitter layout blueprint.

Bottom (Access Door/ Card Guide Extrusion.

Serves as the bottom portion of the case which hinges away from the control panel, thereby providing access to the transmitter modules, switches, wiring and history card.

End Caps

As viewed from the operators position, the right end cap includes the battery compartment access door and is fastened to the control panel. The left end cap typically contains the antenna on VHF units and it too is fastened to the control panel.

Transmitter Antenna

VHF transmitters typically use an antenna which is integrated into the left hand end cap. The antenna is not separable from the end cap. UHF transmitters use a helical (rubber duckie) antenna which mounts to the transmitter control panel using a BNC connector. Either antenna must be replaced with the Telemotive part that corresponds to the frequency and model number of the transmitter.

Battery Packs

Several batteries are available and are applications-matched to the transmitter electrical and environmental requirements. To obtain maximum battery life do the following: 1. Turn the transmitter off when not in use 2. Recharge the battery as soon as possible following a low-battery indication. 3. Ni-cad because of amemory factor, recharging without a low battery indication reduces the maximum charge the battery canhold. Therefore when using a ni-cad battery deep charge only after low battery indication.

Microcomputer Module

Briefly, the microcomputer module; 1. Multiplexes the various motor and on-off functions onto a serial data signal. 2. Encodes the serial data with system control data such as sync, baud rate selection and access code programming.

R.F. Module

Accepts serial data from the microcomputer and modulates the data onto an R.F. carrier via FSK (Frequency-Shift-Keying) modulation.

Note: *Additional information on battery pack, microcomputer module, switches and R.F. module can be located on the transmitter layout blueprint.*

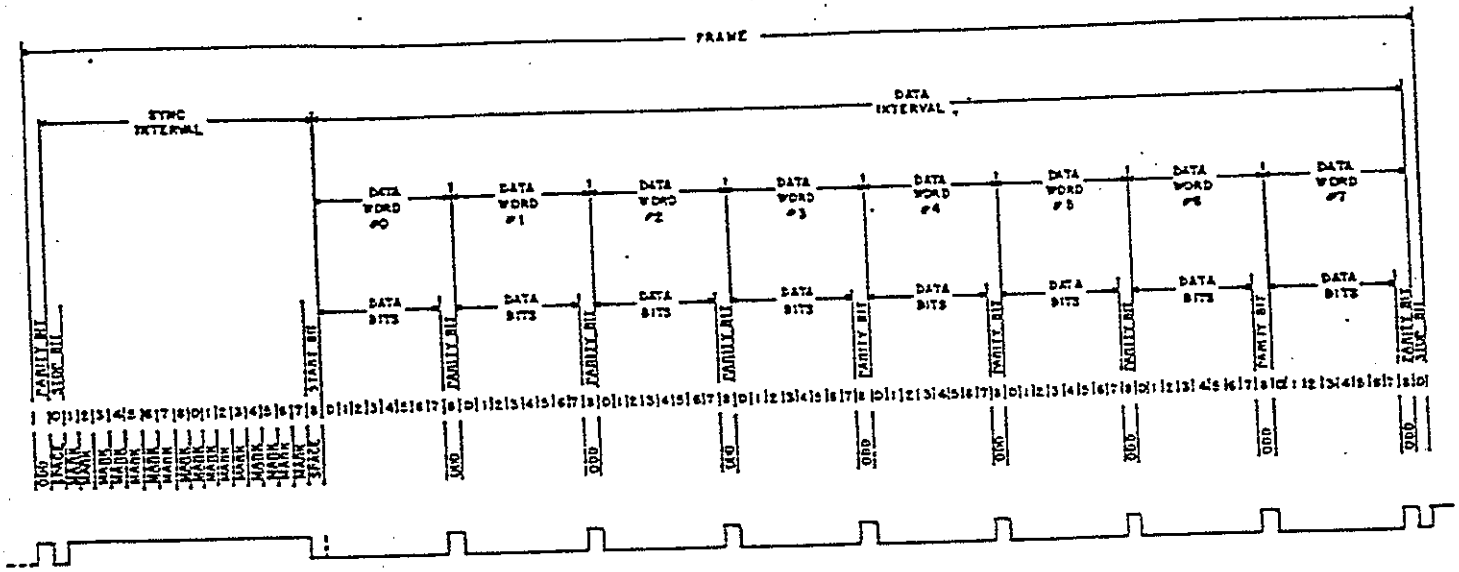


Fig. 4-1.0.a. Radio System Transmitted Signal Format.

WORD FORMATTING

Parity Bit

Bit Number

	0	1	2	3	4	5	6	7	P
CODE:									

CODE CLASSES: Access Code
Directional Code
Speed Code

DATA WORD #0

Use: Access Code

	0	1	2	3	4	5	6	7	P
CODE:	0	0	1	1	0	0	1	1	1

DATA WORD #1

Use: Aux. Function (warning device shown)

	0	1	2	3	4	5	6	7	P
CODE:	1	0	0	0	0	0	0	0	0

SYNC WORD

Start Bit

	0	1	2	3	4	5	6	7	8	
CODE:	1	1	1	1	1	1	1	1	0	--

DATA WORDS #2 thru #7
(general example shown)

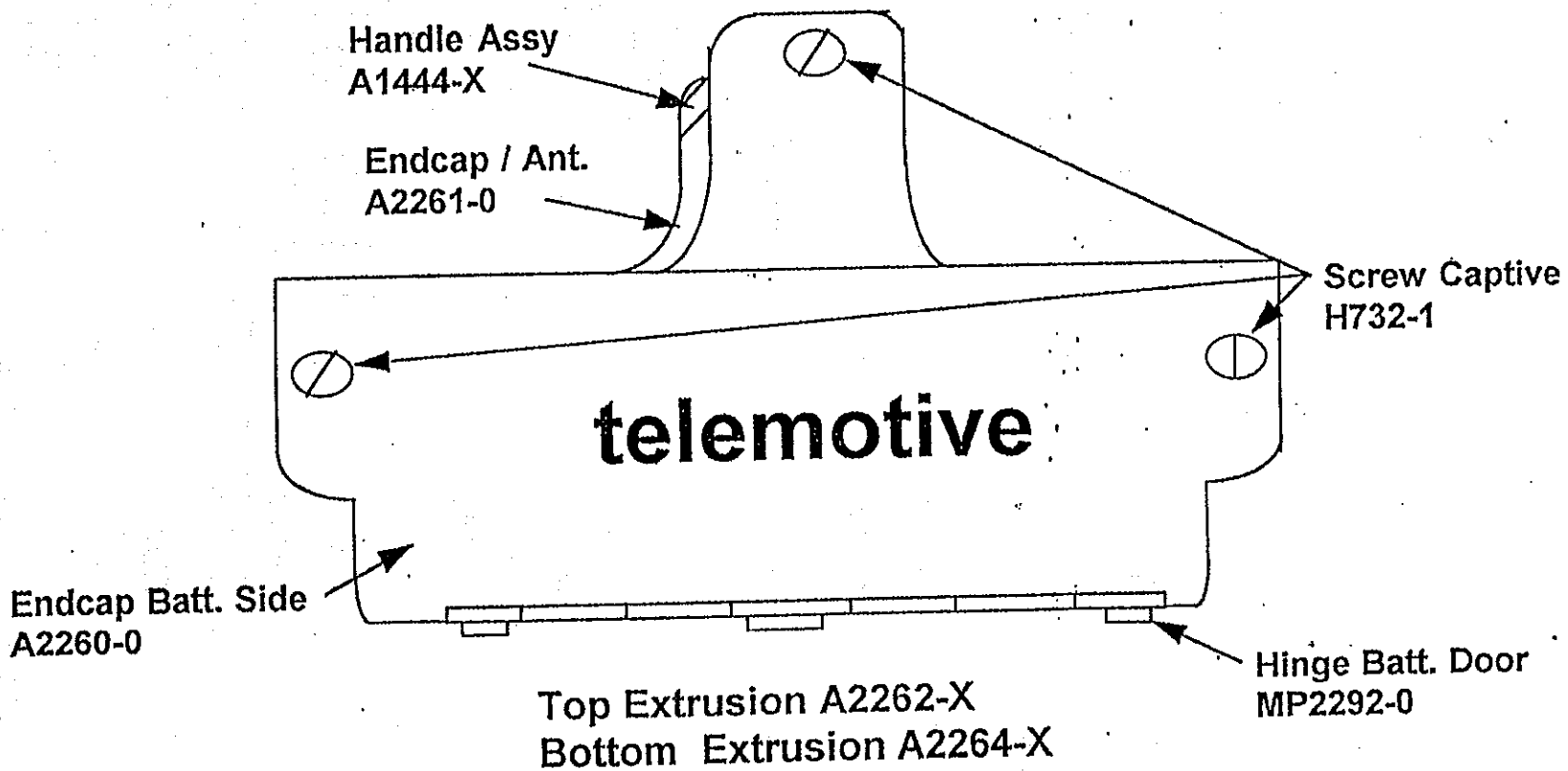
	0	1	2	3	4	5	6	7	P
CODE:	0	1	0	1	1	1	0	0	1

DIR Code= DIR 1

Speed Code= #3

Typical Series 8000 Data Coding Format.

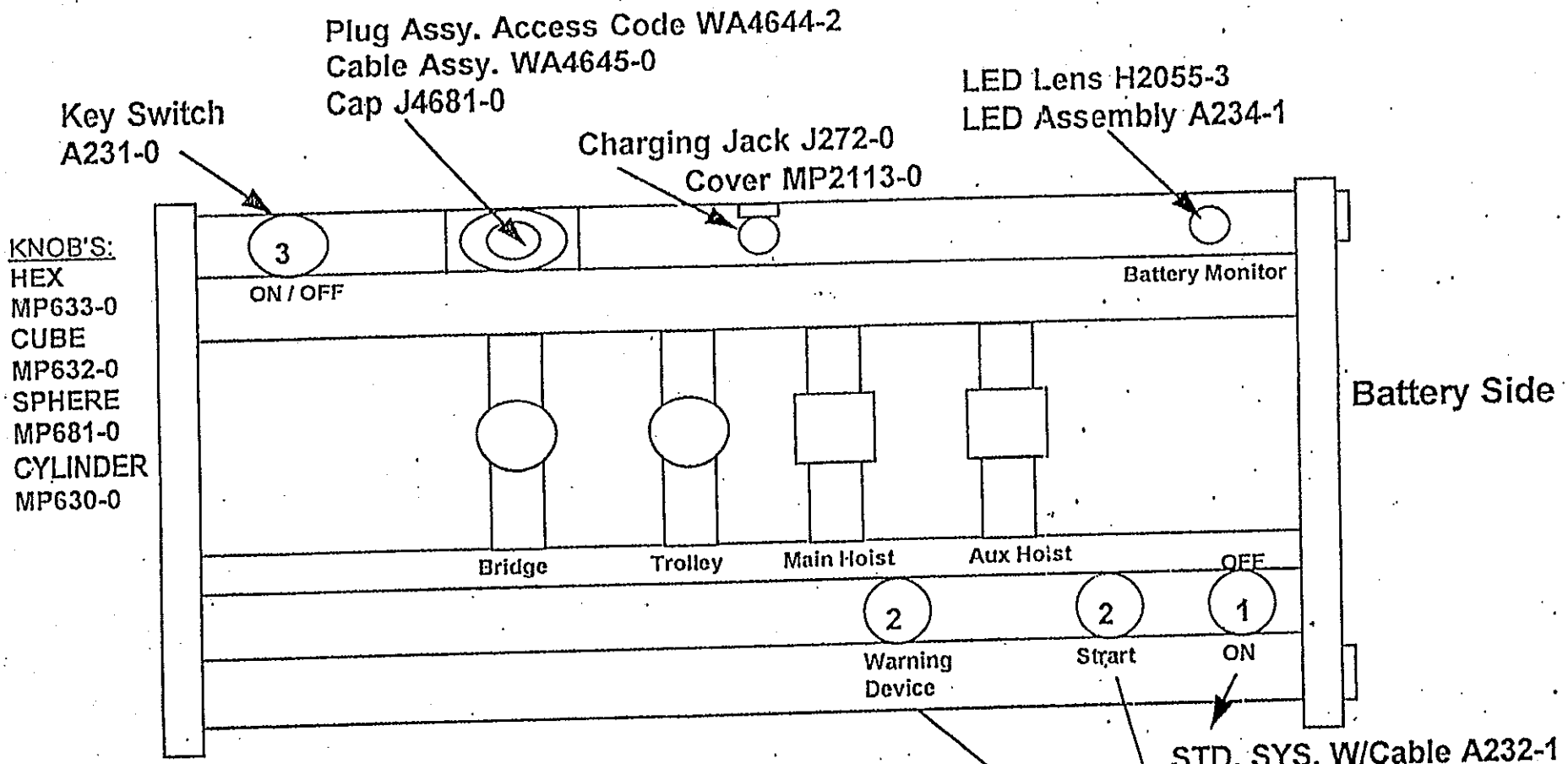
SLTX Transmitter



Right Side View

SLTX Transmitter

1. Toggle Maintained
2. Push Button
3. Key Switch

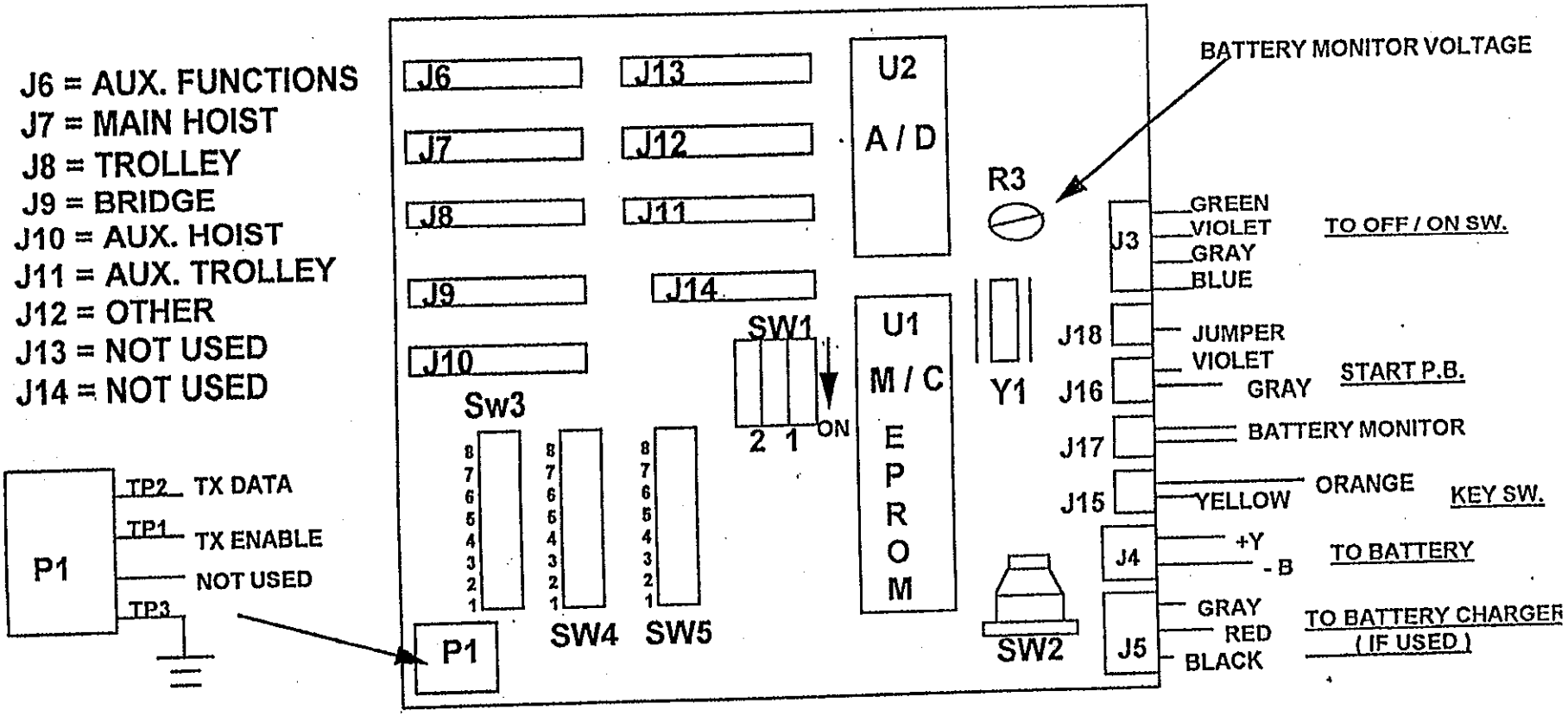


Motion Switch's:

S1005-101 = SW. Stepless W/Limit 18" cable
S1005-100 = SW. Stepless WO/ lLimit 18" cable
S764-5 = SW. 3 Speed 12" cable
S764-101 = SW. 3 Speed 8" cable
S763-5 = SW. 5 Speed 12" cable
S763-101 = SW. 5 Speed 8" cable

E7632-X MICROCOMPUTER MODULE SLTX TRANSMITTER

J6 = AUX. FUNCTIONS
J7 = MAIN HOIST
J8 = TROLLEY
J9 = BRIDGE
J10 = AUX. HOIST
J11 = AUX. TROLLEY
J12 = OTHER
J13 = NOT USED
J14 = NOT USED



SWITCH'S :

SW1-1 EMERGENCY STOP
SW1-2 TIME OUT DISABLE
SW2 OPTIONAL TILT SWITCH
SW3 USED FOR STEPLESS FUNTION
ONLY WORD # 1 THU 8
SW4 ACCESS CODE 12 BIT ONLY
SW5 ACCESS CODE

CHIPS

U1 = TRANSMITTER EPROM
U2 = USED FOR STEPLESS ONLY
A TO D CONVERTER

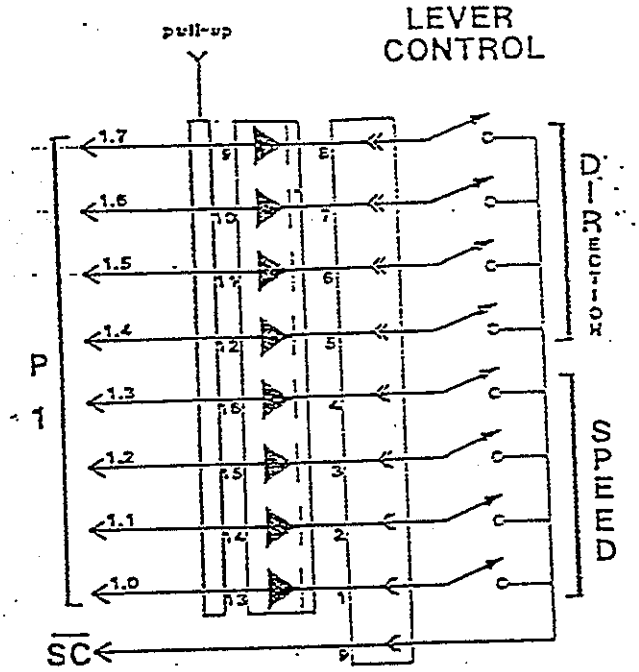
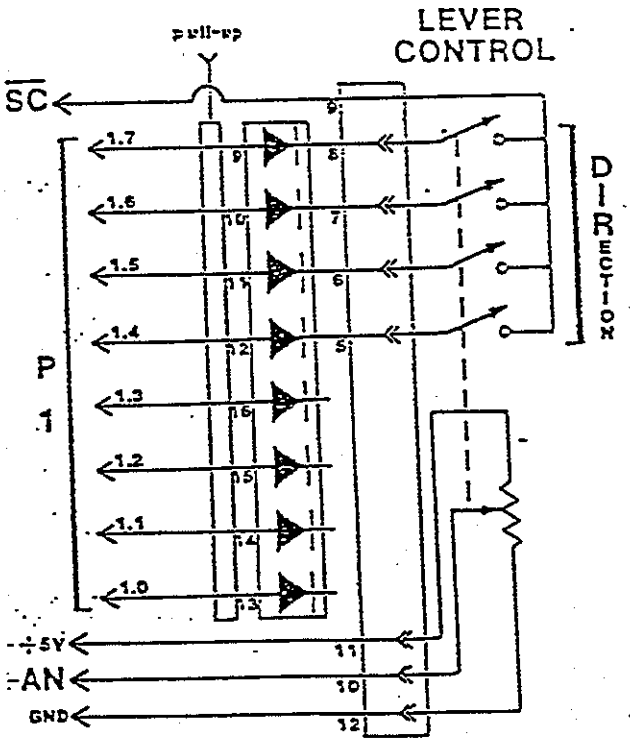


Fig. 1-2.3.a. Stepped Lever Control

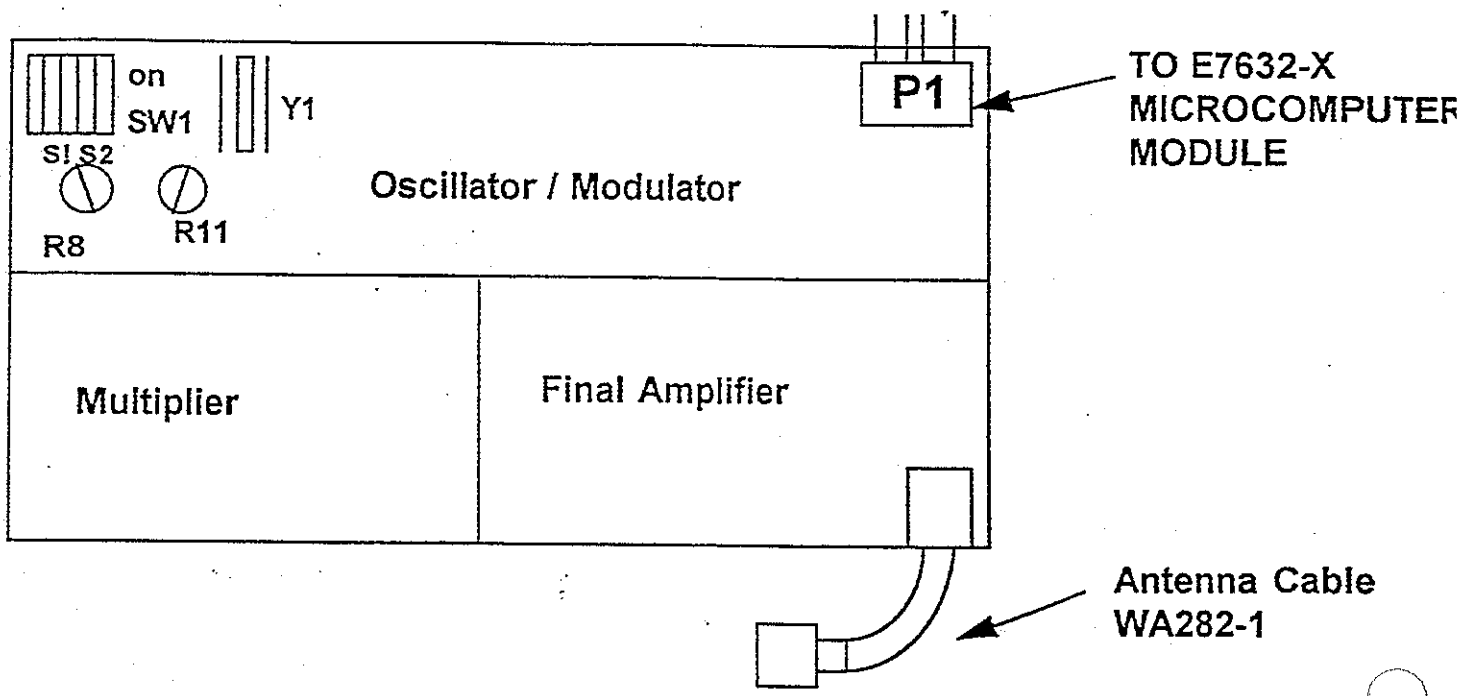
Each stepped lever control is composed of up to eight individual SPST switches which are actuated in combinations depending upon the direction and extent of travel the lever is moved.



On Transmitters equipped with one or more stepless controls, A/D converter U1 is furnished. The A/D converter is clocked using divided-down XC timing.

SW3 Station	Controlled Channel
0	J6
1	J7
2	J8
3	J9
4	J10
5	J11
6	J12

E7650-X R.F. Module , Sltx Transmitter



1. **Antenna cable** to 50 ohm antenna.
2. **P1 plug** to microcomputer module supplies tx enable, tx data input.
3. **S1/S2 switch** sets frequency range. Example:

Range	Freq.	S1	S2	
Low	72.177,000	on	off	R8 pot adjust low data freq.
Center	72.180,000	off	off	
High	73.183,000	on	on	R11 pot adjust high data freq.

Note: 6 khz between high and low data freq.

4. **Oscillator/ Modulator** acepts the digital signal from microprocessor module which modulates the crytal-controlled oscillator freq.
5. **The VHF freq. multiplier** triples then doubles the modulated freq.
6. **The final amplifier** amplifies the R.F. signal to a suitable power level and matches the impedance of the amplifier to the 50 ohm antenna.

Note: Any service of this module (other than the removal of the module) must be performed by technicians holding the proper FCC (or other) licences.

3.2 RF MODULE

3.20 Description

The RF MODULE converts serial TTL digital data to a VHF radio control signal suitable for radio transmission such that it can be received, demodulated, and decoded by its companion receiver. It provides all of the necessary digital shaping, deviation, modulation, multiplication, and amplification to accomplish the digital control signal to radio frequency conversion.

The RF MODULE provides effective filtering of undesired, internally generated products (spurious and harmonic) to minimize the possibility of interference to other radio services. It allows for a reliable radio control communications link to be established with its companion receiver.

The RF MODULE is fully capable of transmitting high quality frequency modulated, frequency shift keyed, VHF radio control signals in the 72-76 MHz band. It will reliably generate time multiple shared (TMS) and time division multiple access (TDMA) radio control formats at a data rate of 4800 band. In addition, it is backward compatible for use in standard SERIES 8000 product employing conventional radio control formats at 2400 band.

3.21 Theory of Operation

The RF MODULE accomplishes the serial TTL digital data to VHF radio control signal conversion through several key blocks (refer to Section 3.22, Block Diagram). A detailed explanation of how each stage within each block functions follows:

DATA/DEVIATION

Encoded digital TTL data from the DIGITAL CONTROL MODULE is applied to a squarer stage to insure proper shaping. Transmitter deviation is set such that a logical "high" shifts the VHF carrier 3 KHz above its center frequency, and a logical "low" shifts the VHF carrier 3 KHz below its center frequency. This corresponds to a deviation of +/- 3 KHz. The "shaped" data is further processed by a low pass filter to remove higher order harmonics.

MODULATOR/OSCILLATOR/MULTIPLIER

Processed digital data set at the correct deviation from the DATA/DEVIATION stage is applied to a multi-function, FM transmitter integrated circuit (IC). The digital data frequency modulates a 12 MHz crystal oscillator at the data rate. This 12 MHz direct FM signal is then buffered prior to

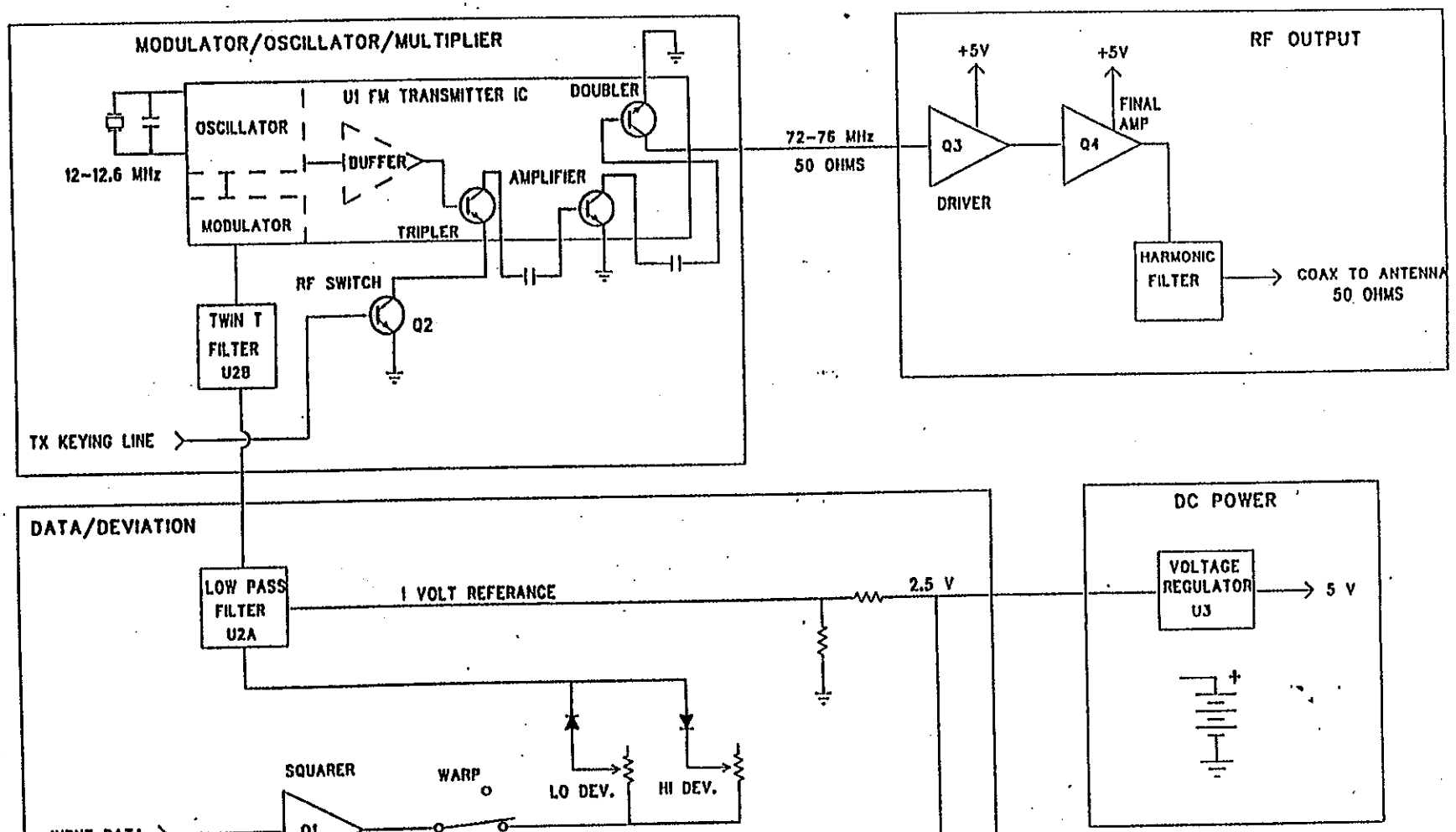
being multiplied by a tripler stage. The 36 MHz frequency modulated signal is further multiplied by a doubler stage producing the final desired output in the 72-76 MHz VHF band. This is now the low level, VHF radio control signal.

RF OUTPUT

The low level, frequency modulated, radio control signal is amplified to 100-400 milliwatts (depending on the specific model) by a driver transistor, and a final amplifier transistor, both operating as class C amplifiers for maximum efficiency. The amplified signal is filtered to reduce harmonic and spurious signals in accordance with current FCC requirements. The amplified, filtered output signal is fed to the ANTENNA MODULE.

DC POWER

Power for all electronic sub-assemblies is supplied by a 5.4 VDC, 10 amp-hour, disposable lithium battery. An "on-board" voltage regulator maintains the correct voltage level to the circuitry.



telemotive — MAXTEC CORPORATION

BLOCK DIAGRAM

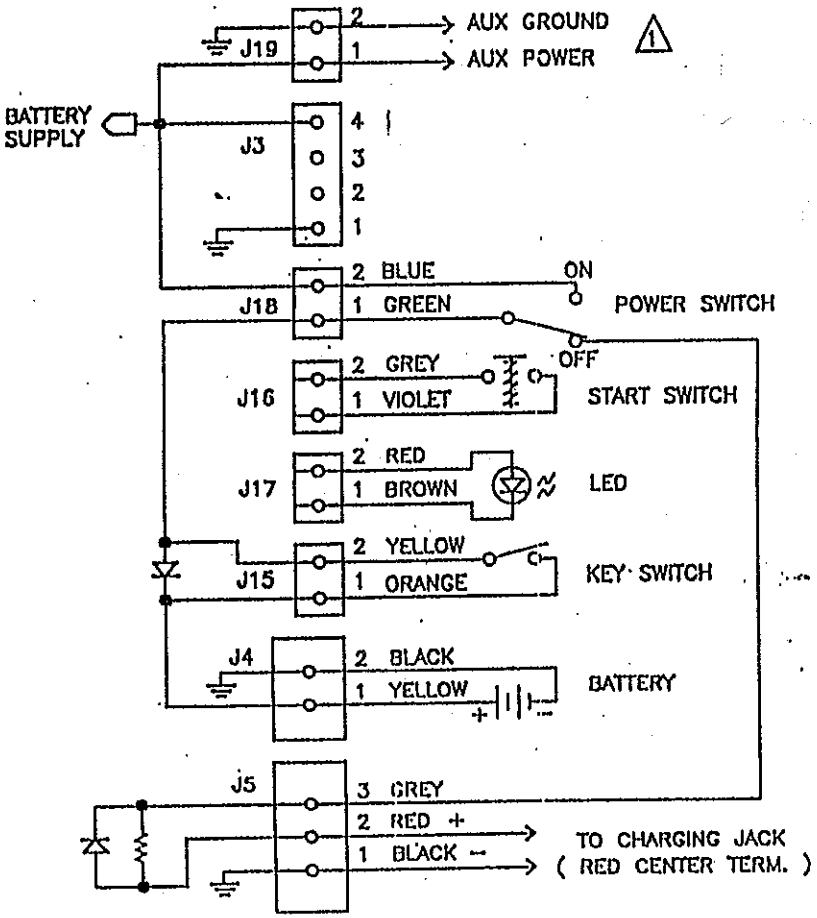
VHF RF TRANSMITTER MODULE

J.P.BATES

7/12/91

8D-E7650-0-0.0A-C

STANDARD SYSTEMS ONLY (WITHOUT ELECTRONIC SWITCH) ⚠2



⚠1 E7633-X ONLY LTX

⚠2 FOR ALL E7633-X
FOR E7632-X REV. "E" AND NEWER ONLY.
SLTX

DRAWING NO. ID-E7633-X-0.0A-A

SHEET 1 OF 1 | ISSUE A

REV.	DESCRIPTION

MAXTEC INTERNATIONAL CORPORATION
6470 W. CORTLAND CHICAGO, ILLINOIS 60635

☐ BK PRECISION ☒ telemotive

TITLE: SLTX AND LTX POWER & CHARGING CIRCUIT

UNLESS OTHERWISE SPECIFIED
1. ALL DIMENSIONS ARE IN INCHES
2. ALL BENDS ARE 90°
3. TOLERANCES:
FRACTIONS ±1/64
DECIMAL (TWO PLACE) ±.010
DECIMAL (THREE PLACE) ±.005
HOLES ±.003
ANGLES ±1°
DO NOT SCALE DRAWING.

DRAWN BY	DATE	DWG. SCALE	C.A.D. SCALE
S.F.C.	8/9/95	NONE	NONE

APPROVED M.Z. | 1ST MODEL/USER SLTX & LTX TX:

APPROVED 8/16/95 | SHEET 1 OF 1 | ISSUE A

DRAWING NO. ID-E7633-X-0.0A-A

MAXTEC INTERNATIONAL CORP.
TELEMOTIVE DIV.

GLOSSARY OF TERMS

A.G.C.: Automatic Gain Control (Maintains the gain of the master receiver constant.)

AMBIENT NOISE: The noise (electrical) that is normally found in the plant area.

ASSIGNED FREQUENCY: The frequency at which a transmitter's carrier signal is authorized to operate by the appropriate Governmental Body (FCC or IRAC) and specified in the Statement of Authorization.

AUTHORIZED POWER: The maximum R.F. power assigned to a radio transmitter.

CALLING RANGE: The maximum distance from the crane from where the operator may gain control of the system.

CARRIER: The radio wave having the assigned frequency of the transmitter.

CONTROLLED RANGE: System which provide maximum operating range of 80 to 150 feet.

CRANE NOISE: Reading taken with the radio transmitter in the "off" position, while the crane functions are activated manually.

DEMODULATION: The reverse of modulation. The process of extracting the intelligence signal from the carrier.

DROP OUT RANGE: Maximum distance from the crane that the operator can turn 360* and still operate the crane functions.

HERTZ: A unit of frequency equal to one cycle per second (Hz)

KILOHERTZ: Thousand cycles per second (KHZ)

LOW FREQUENCY: 200 to 400 kilohertz (KHZ)

MEGAHERTZ: million cycles per second (MHz)

MODULATION: The process by which the phase of the carrier is varied by the wave form of an intelligence signal.