# SERIES 1000, TYPE 1001 CHANNELS
# SC2 SUPERVISORY CONTROL SYSTEM

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## 1. GENERAL

**1.01** This appendix outlines the purpose, general description, and method of operation of the SC2 supervisory control system and describes the testing and trouble clearing procedures to be followed by the telegraph testboard when performing service maintenance work.

## 2. PURPOSE OF THE SC2 SUPERVISORY CONTROL SYSTEM

**2.01** The SC2 supervisory control system is a newly developed signaling system that allows centralized, fail safe control, and supervision of the facilities of right-of-way companies. It is composed of a control or main station where all control is centralized, and a number of controlled or satellite stations, which connect to the customer's equipment.

**2.02** The principal features of the system may be summarized as follows:

(a) At the main station, selective, decimal, time division order codes, generated by pushbutton-key operation, are used to address and control the operation of a plurality of 2-state devices located at remote points. Two-state functions, such as operating and tripping power switches, opening and closing valves, etc, are involved.

(b) Use is made of the same type signals to send inquiry codes, which simply determine or check the status of any 2-state device.

(c) After the transmission of either order or inquiry codes, simple signals are automatically returned from the satellite station to indicate the status of remote devices to the main station.

(d) The main station exhibits a continuous display of the status of all remotely controlled 2-state devices. Flashing lamps and audible alarms are used to alert the attendant when necessary.

(e) A roll call, which sends inquiry codes sequentially to all 2-state devices, is used to provide a complete check of the status of all devices in the system. In cases where a remote device operates by means other than an order, a roll call finds the device and alerts the main station attendant.

(f) All keys and lamps at the main station are mounted in a console. All codes are generated by pushbutton-key operation. Due to the nature of codes that are sent from the main station, and the checks that the system makes upon these codes, the system has fail safe reliability.

(g) Plug-in units provide for rapid and easy maintenance of customer station equipment.

## 3. DESCRIPTION OF CUSTOMER STATION EQUIPMENT

**3.01** Each individual SC2 supervisory control system circuit consists of one main station and a number of satellite stations. The individual circuits are usually linked together by a monitor station in order that certain control signals may be passed from one circuit to another on a network basis.

**3.02** ***Main Station:*** The main station has a console panel which contains the individual pushbutton keys used to initiate the transmission of signals to satellite stations, and individual lamps, which give a continuous display of the conditions of the controlled devices. A common control section of the panel contains keys and lamps common to the system.

**3.03** The main station transmits orders to the satellite stations, which perform these orders as directed, and then return acknowledgement signals that indicate the new condition of the customer device. The main station also transmits inquiry signals to the satellite stations and receives return signals indicating the condition of the device in question. A roll call provides means of checking the condition of all controlled devices. Audible and visual alarm signals indicate abnormal operating conditions and bring unexpected changes in conditions of devices to the dispatcher's attention.

**3.04** ***Satellite Station:*** The equipment at this station is designed to control various types of customer devices in response to a signal received from the main station and to transmit back information indicating the position of the devices. In general, customer's devices will be controlled in such a way that the satellite station operates the customer's interposer relays and receives the reply regarding the position of the device from the customer's indicating contacts.

**3.05** ***Monitor Station:*** Provision of a monitor station on an SC2 supervisory control system is optional. It is generally provided when more than one control system circuit, consisting of a main station and several satellites, is furnished. Briefly, the monitor is arranged to provide for the following:

(a) Receiving and registering information from the main station equipment

(b) Registering information sent from a satellite to the main station

(c) Transmitting information to the main station in response to inquiries

(d) Transmitting a system signal to the main station of a succeeding section (an optional feature)

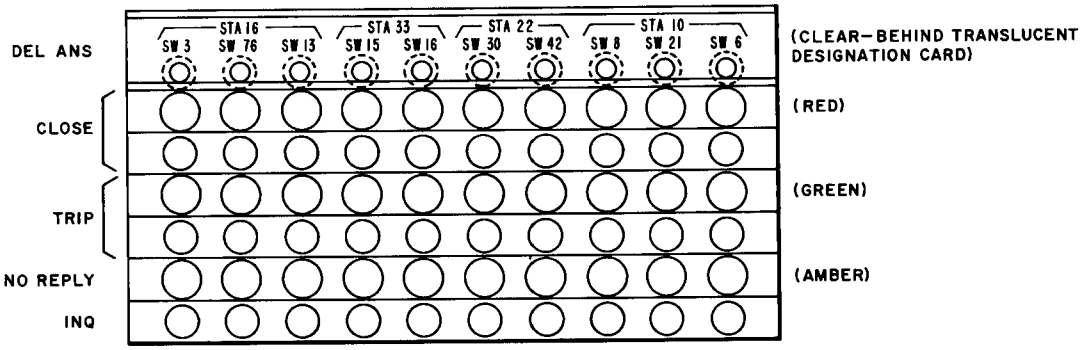
(e) Registering mutilated or incomplete signals.

**3.06** The monitor station provides at a remote location visual indications of the status of the controlled devices. Red and green lamps associated with each 2-state controlled device are kept in agreement with those at the main station. An audible alarm and flashing lamp occur whenever a change takes place. Keys are provided to retire each of these. The monitor station attendant can also start a roll call by pressing a key that sends a pulse back to the main station. Individual white lamps at a monitor station light momentarily each time an order or inquiry is received by the monitor. In this capacity, they serve as roll call progress lamps. Common red and green lamps light momentarily whenever a reply signal is sent from a satellite station. A mutilated code alarm lamp and buzzer indicate that a code was distorted. The monitor station can be located anywhere on the line.

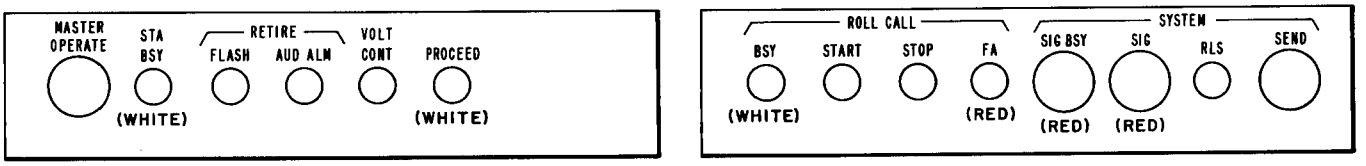
## 4. METHOD OF OPERATION

**4.01** Assume that a pipeline dispatcher wishes to operate a remotely located power switch from the open to closed position. Figure 1(a) shows the individual lamps and keys on the control panel relating to such a device. The common control section of the panel is shown in Fig. 1(b). Since the remote switch is presently open, the green lamp in Fig. 1(a) associated with this switch, is lighted.

**4.02** To close the remote switch, the dispatcher presses the CLOSE key and the MASTER OPERATE key simultaneously and a code is transmitted to all satellite stations. Within two




(A) INDIVIDUAL CONTROL KEYS AND LAMPS




(B) COMMON CONTROL KEYS AND LAMPS

**Fig. 1—Private Service System—SC2 Supervisory Control System, Main Station Console (a) Individual Control Keys and Lamps (b) Common Control Keys and Lamps**

or three seconds the transmission of the code is complete and the proper satellite station operates the designated switch. Within a second after this, the satellite station sends back a pulse indicating that the switch operated. At the main station, this extinguishes the green lamp and lights the red lamp. The dispatcher now has an indication that the operation was performed. This lamp display is continuous for all such devices, thus allowing the dispatcher to tell at a glance the condition of all devices under his control.

**4.03** If, in the above example, the remote switch fails to close immediately, the satellite station waits for the closure and sends back the reply as soon as the closure takes place. If the switch does not close within six seconds after initiating the order, the satellite sends back a reply indicating that the switch is still open. In this case, the green lamp associated with this switch changes from steady to flashing. The dispatcher may restore the lamp to the steady condition by pressing the RETIRE FLASH key shown in Fig. 1(b). Special arrangements are made for devices that are expected to take more than six seconds to operate after initiating the order.

**4.04** If the dispatcher has reason to doubt the condition of a device as displayed on its associated lamps, he may verify the condition of any controlled devices. For this purpose, an INQ (inquiry) key is associated with each controlled device. The operation of this key alone will transmit an inquiry signal. Following the transmittal of an inquiry signal, either a short or long pulse is returned from the satellite station, representing the up-to-the-minute condition of the device.

**4.05** Following the transmission of order and inquiry signals to satellite stations, long or short pulses are returned that indicate the up-to-the-minute condition of the remote device. Usually, a short pulse represents the off, or open (green lamp), condition and a long pulse represents the on, or closed (red lamp), condition.

**4.06** The lamp and alarm signals which result following an order or inquiry are as follows:

(a) The appropriate red or green lamp lights when an order signal succeeds in operating a device to the red or green condition respectively. The previous indication extinguishes.

(b) The red or green light that was lighted before an inquiry remains lighted when an inquiry signal finds a device in the same condition as previously indicated.

(c) A flashing red or green lamp, corresponding to the actual condition of a device, results if a device fails to respond to an order.

(d) A flashing red or green lamp, indicating the true condition of a device, and an audible bell results if, in response to an inquiry, a device is found to be in the condition opposite to that previously indicated.

(e) An amber lamp, audible bell, and the extinguishing of the previous red or green lamp results in the event that no return signal is received from an order or inquiry signal.

If a device changes condition by means other than a main station order, the satellite station sends back a single short pulse which initiates a roll call.

**4.07** A roll call is an automatic sequence of inquiries to all 2-state controlled devices. A roll call may be initiated by any of the following methods.

(a) If the device changes condition by any means except in direct and immediate (within 6 seconds) response to an order from the main station, a signal is transmitted to the main station alerting it to start a roll call to find the device. When the device is found, the correct lamp indications are established.

(b) In order to provide a check on the line facilities, roll calls are started automatically at periodic intervals.

(c) A roll call may be started at any time by depressing the ROLL CALL START key located on the control panel either at the main station or at a monitor station. At the monitor station a pulse is sent to the main station and treated the same as outlined in (a).

(d) In addition to the above, a momentary open on the circuit will automatically start a roll call.

**4.08** Roll calls start from the beginning of a sequence to make certain that all devices are checked. The most important functions are usually arranged to appear early in the sequence. White roll-call progress lamps at the main station light in sequence to show the progress of a roll call. In the event that a device changes condition, except by means of an order, during the time in which the system is occupied with a task, this change is stored in the satellite until the system is free, at which time the satellite sends in a pulse to start a roll call. If the change takes place during a roll call, then, by the same method, a new roll call starts at the completion of the first. If the change takes place during a roll call and is a device not yet reached, the roll call will catch it on the way.

**4.09** If a system signal (CRASH) feature is provided, the first action taken by the main station equipment when a roll call is requested is to send a system signal inquiry to the monitor equipment. The system signal is a signal that may originate at any main or satellite station requesting a shutdown of all customer owned equipment operating on the system. If the monitor replies that a system signal has been received, the main station relays this information to its satellites. This results in an overall shutdown.

**4.10** If the monitor's reply indicates that no system signal has been received, the main station then sends a system signal inquiry to each of its satellites in an attempt to locate the station originating the signal. If the reply is such that a satellite has originated the system signal, the main station proceeds to signal all its satellites to shut down. If the reply from the satellite stations indicates no system signal has been originated, the main station then proceeds with a normal roll-call operation.

**4.11** In addition to the basic features, the SC2 supervisory control system is arranged for a number of options, such as connecting telemeter transmitters and receivers to the line and for ringing a bell at a satellite station for alerting purposes. Other optional features include the provision for delayed operations, remote indication of momentary alarms at satellite stations, and the operation of device lock circuits to provide continuous closure paths to customer's devices. All stations are equipped with rectifier-type power supplies operating from 110 volts ac and standby batteries which will permit operating the system for a limited number of hours during a primary power failure.

## 5. SIGNALING CODES

**5.01** In the SC2 supervisory control system, codes transmitted from the main stations to satellite stations consist of a 150-millisecond prepare pulse and 50-millisecond short pulses, or long pulses made up of multiples of 50-millisecond pulses. Either 2- or 3-digit codes can be used, with each digit consisting of two long pulses and three short pulses. Any other combination represents a false code and is rejected by the receiving device at the satellite station. In addition, a parity check assures that the correct number of pulses is received, or no operation results.

**5.02** The five pulses are designated in order 0, 1, 2, 4, and 7. The value of any digit is given by adding the designations of the long pulses. An exception arises if the long pulses occur in positions 4 and 7. In this case the digit value is 0. A typical 2-digit code is shown in Fig. 2. As indicated in the figure, each code is preceded by a long prepare pulse.

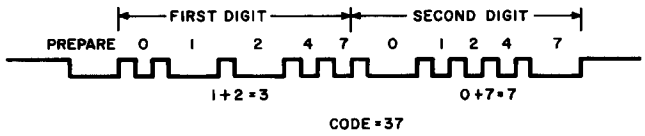



**Fig. 2—Private Service System—SC2 Supervisory Control System—A Typical 2-Digit, Single Transmission, Pulse Length Code**

**5.03** Since the individual digits are decimal, 100 codes numbered from 00 to 99 are available when using only 2-digit codes, and 1000 codes numbered from 000 to 999 are available when using only 3-digit codes. Although a large amount of flexibility in the assignment of codes is possible, the following fundamental rules are usually observed:

(a) Whenever possible, only 2-digit codes are used for inquiries. This saves time in a roll call when many such codes are transmitted sequentially. It should be noted that if a 3-digit code is used for the inquiry of a device, the circuitry requires that the order codes associated with this device also be three digits.

(b) If a system of 100 or almost 100 codes is installed, and is expected to expand to over 100 codes, the initial codes are usually assigned so that a minimum of cross-connection changes are necessary on customer station equipment when the system is expanded.

(c) At any satellite station, the number of different first digits for both 2- and 3-digit codes are kept as small as possible. For 3-digit codes that are alike in the first digit, it is desirable that the second digits be alike also. These factors keep the required number of translating relays in the customer station equipment to a minimum.

**5.04** In addition to the above, there are two restrictions in the assignment of codes:

(1) No 2-digit code can be the same as the first two digits of any 3-digit code. For example, if code 46 is used, then codes 460-469 cannot be used.

(2) If a 2-digit code and a 3-digit code are alike in the first digit, the second digit of each must be in a different 0-4 or 5-9 group. As an example, a very large satellite station could be arranged to receive the following codes:

00-34 (35 two-digit codes)

350-399 (50 three-digit codes)

40-59 (20 two-digit codes)

600-749 (150 three-digit codes)

75-99 (25 two-digit codes)

The above group thus contains 80 two-digit codes and 200 three-digit codes.

**5.05** At the main station, a common sending unit is used to transmit either 2- or 3-digit codes. At a satellite station, the same receiving circuit is used for the reception of both types of codes. The addition of one or more relays in the satellite translator of a 2-digit system easily expands it to a 3-digit system. A wiring option at both stations determines the number of digits in each code.

**5.06** In cases where extreme reliability is desired, provision is made for certain selected 2- or 3-digit codes to be automatically transmitted twice. In this case, a long pulse, like the prepare pulse,

precedes the second transmission. The two transmissions must agree with each other for any operation to take place.

## 6. CUSTOMER STATION TERMINATING ARRANGEMENTS

**6.01** Local loops should be terminated in a loop switchboard at the customer station. The switchboard should permit isolation of customer station equipment and provide means for opening and shorting the loop toward the STC.

**6.02** When the station is also served by a teletypewriter circuit, both facilities should, in addition to the above, be terminated in a manner that will facilitate their interchange between the STC and the customer station for the purpose of expediting test and trouble clearing operations.

## 7. CIRCUIT TESTS AND TROUBLE CLEARING PROCEDURES

**7.01** Since the SC2 circuit arrangement provides means for remotely controlling customer owned devices, ***it is imperative that no action be taken by Telephone Company personnel that will interfere with the normal function of the customer's equipment.*** Permission to proceed should first be obtained from the customer before performing tests on an in-service circuit. The customer will then arrange to disconnect station equipment from the line which, if permitted to respond to a false order code, would seriously affect the operation of the controlled devices.

**7.02** At no time should an attempt be made to transmit teletypewriter signals over the SC2 circuit while any portion of the customer's equipment is actively connected to the line. Line facility sections, suspected to be in trouble, should be patched promptly. When performing service maintenance work between the STC and the customer station, the local facility should be removed from the main portion of the circuit and terminated in an equivalent telegraph test terminal. The circuit control office should be kept fully informed at all times with respect to apparent conditions that may affect service on any portion of the circuit.

**7.03** Because the functional signals passed over SC2 supervisory control facilities differ from those employed in teletypewriter operation (approximately 10 pulses) they cannot be passed through a regenerative repeater. This is significant in that it limits the number of circuit sections that may be worked in tandem. Transmission-wise, however, the signals must be maintained at tolerances not exceeding an overall distortion of 25 percent between the main station and any other point on the circuit using 60-speed teletypewriter signals as a reference.

**7.04** Utilizing this reference, the initial lineup prior to connection of customer station equipment should be made in the same manner as if it were a 60-speed teletypewriter circuit. Transmission between the STC and the customer station should be checked and corrected using a suitable source of signals and a telegraph transmission measuring set.

**7.05** Frequently, the customer station is also served with a paralleling 60-speed teletypewriter circuit. In such instances, advantages are gained if transmission tolerances on the SC2 circuit are maintained in a manner that will readily permit interchanging the two facilities as may be required during trouble clearing and service maintenance operations.

## 8. TEST EQUIPMENT

**8.01** Signals transmitted over SC2 facilities can be checked with a Brush oscillograph recorder. Use of this type of recorder permits sampling of pulses without interfering with customer operations. It is not intended that the Brush recorder be used for extensive circuit monitoring. It should be used primarily as a tool for analyzing pulse composition with respect to signal transmission between the STC and the customer station.

**8.02** A pulse-length code test set has been designed to facilitate the testing of a satellite or monitor station from the telegraph testroom. It is capable of generating pulse-length code signals and can either send or receive a long or short reply signal. When this test circuit is used to test a satellite or monitor station, it simulates the main station in that it is capable of sending out the coded signals and also in that it is capable of detecting whether the satellite or monitor is sending back a long or short reply pulse. In addition, when testing a monitor station, this circuit is used to generate a short or long reply signal. In actual practice, this reply signal would be generated by a satellite station and "heard" by the monitor.

**8.03** The reply signal consists of one pulse of long duration (to indicate the closed position of a device or a positive answer) or one short pulse (to indicate the tripped position of a device or a negative answer). Pulses generated by the pulse length code test set should not be permitted to pass over the main portion of the circuit. In this respect, the precautions outlined in 7.01 and 7.02 must be strictly observed.

**8.04** Three sets of keys are provided for setting up the code, one set for each digit. The desired 2- or 3-digit code is set up on the (A) and (B) keys, or the (A), (B), and (C) keys, respectively. Each individual key supplies two grounds to the selector bank and are used in generating the long pulses. The selector terminals that are grounded for each key are shown in the following.

| KEY | A DIGIT | B DIGIT | C DIGIT |
|---|---|---|---|
| 0 | 4 and 6 | 11 and 13 | 18 and 20 |
| 1 | 1 and 3 | 8 and 10 | 15 and 17 |
| 2 | 1 and 4 | 8 and 11 | 15 and 18 |
| 3 | 2 and 4 | 9 and 11 | 16 and 18 |
| 4 | 1 and 5 | 8 and 12 | 15 and 19 |
| 5 | 2 and 5 | 9 and 12 | 16 and 19 |
| 6 | 3 and 5 | 10 and 12 | 17 and 19 |
| 7 | 1 and 6 | 8 and 13 | 15 and 20 |
| 8 | 2 and 6 | 9 and 13 | 16 and 20 |
| 9 | 3 and 6 | 10 and 13 | 17 and 20 |

**8.05** For example, if the desired code is 123, terminals 1, 3, 8, 11, 16, and 18 are grounded. This results in the first and second pulses being long pulses and the third, fourth, and fifth pulses being short for the A digit; the first and third pulses of the B digit will be long pulses and the second, fourth, and fifth will be short. The second and third pulses of the C digit will be long pulses while the first, fourth, and fifth pulses will be short pulses. Before the actual code is transmitted, a long prepare pulse is sent out to enable the receiving circuit.

**8.06** When testing a monitor station, the pulse length code test set is used to transmit either a long or short pulse. This pulse simulates a reply that a satellite station would normally send to the main station and is heard by the monitor station. To send a short pulse the SP key is operated. To send a long pulse the LP key is operated. A CAL jack is provided to facilitate the checking of the speed and percent break of the pulse generator. The procedure for making the necessary adjustments is shown on the circuit requirement table provided with the test set.

**8.07** To prevent a false pulse from being transmitted, the following procedure should be used in connecting the test set to the telegraph line test terminal. First, one end of the cord should be inserted in the jack-ended (L) jack of the pulse length code test set. The other end of the cord should then be inserted in the telegraph line test terminal. When the pulse generator is properly calibrated and the set is connected to the telegraph line terminal, use the following procedure:

(a) Operate the BCO key.

(b) Set up the desired code on the A, B, and C keys.

(c) Operate the desired digit key (2D) or (3D).

(d) Operate the ST key.

(e) Observe the SP and LP lamps—single transmission only.

(f) If double transmission is required, the ST key must be operated in approximately one second after the BSY lamp becomes extinguished.

(g) Observe the SP and LP lamps.

(h) If no answer is received for a code to which a reply is expected, 20 seconds must elapse before repeating that code or the sending of another code.

## 9. CUSTOMER STATION MAINTENANCE TESTS

**9.01** As a matter of information, the following trouble clearing procedures will usually be observed by the Telephone Company station maintenance employee if the reported trouble is of a general nature. This would include trouble due to occasional failure to register the proper code at the customer station, transmission of an improper reply, etc, assuming that signals to the monitor appear satisfactory as recorded at the STC.

(1) Replace the 255A (L) relay in the signaling circuit with one known to be in good condition.

(2) Check the voltage of the power supply. It should read between −45 and −50 volts.

(3) Check to see if any fuses have operated.

(4) Check the local dc circuit to the signaling circuit. The current reading should be between 60 and 62.5 milliamperes.

(5) Remove the cover from the 255A (L) relay in the signaling circuit and observe whether the armature is resting against the No. 4 contact.

(6) Insert an open plug in the set jack of the 63C1 switchboard and observe whether the armature moves toward the No. 5 contact.

(7) Remove the open plug from the 63C1 switchboard set jack.

(8) Check the signaling circuit with the STC for transmission limits.

**9.02** If the preliminary tests, outlined above, fail to locate the trouble condition, the maintenance employee may make certain routine tests for the purpose of checking the integrity of the internal circuit actions. During these tests the maintenance employee connects a dial test set to the station equipment so that it will simulate the external loop. After the tests have been completed, the maintenance employee will notify the STC accordingly and the STC should then make sure that the difficulty has been eliminated before dismissing the maintenance employee.

**9.03** Performing the above tests is likely to cause false operation of customer station equipment connected to the main portion of the circuit unless the station involved is removed and terminated in a telegraph line test terminal at the STC. The STC and the maintenance employee should have a thorough understanding with respect to the nature of any tests before the work is actually started in order that the necessary precautions may be exercised.