AUTOMATIC GAIN CONTROL REPEATERS AND THEIR APPLICATION TO COMMON MODE OPERATION

CONTENTS

1. GENERAL

1.1 This section discusses Automatic Gain Control (AGC) voice frequency repeaters and their application in Common Mode Operation (CMO).

1.2 This section has been revised to incorporate the use of AGC repeaters in the design of CMO systems. The application of fixed gain repeaters and long line adapters in CMO as an REA practice has been deleted. This revision replaces Issue No. 1, June 1967.

1.3 Design of subscriber loops using CMO should be as outlined in TE&CM 424, "Design of Two-Wire Subscriber Loop and PABX Trunk Plant". All procedures of TE&CM 424 should be followed with the exception of the application of repeaters and loop extension equipment which is discussed below.

2. AGC REPEATERS AND SELF-REGULATING LOOP EXTENDERS

2.1 AGC Repeaters

2.11 The basic AGC repeater consists of either an E6 type negative resistance repeater or a hybrid type repeater. The AGC repeater incorporates a control circuit which senses loop current and loop voltage to determine loop resistance. The control circuit then adjusts the gain according to the loop resistance. Depending on the type repeater, the gain may be adjusted in discrete steps at various resistance intervals or continuously as a linear function of loop resistance.

Continuous AGC repeaters begin to insert gain near 1100 ohms. Stepped gain repeaters generally insert their first gain step between 1300 and 1600 ohms. The resistance point where the first gain step is inserted depends on the number of gain steps peculiar to the repeater. Insertion gain may vary from 0 to 10dB as a function of the control circuit and the loop resistance.

2.12 Any AGC repeater suitable for use in CMO will maintain a 1000 Hz Circuit Net Loss (CNL) of approximately 3 to 8 dB for any loaded circuit up to 3000 ohms. The range of the CNL for loops treated with AGC repeaters depends on the number of gain steps that the particular repeater has. A three gain step repeater, with one step at unity gain (0 dB), provides the minimum acceptable steps for CMO use.

2.13 Step AGC Repeaters: Step AGC repeaters will create contrasts in CNL between subscriber loops at the switching points. The severity of the contrast will depend on the number of steps that a given AGC repeater has. The 3-step AGC repeater, although adequate for any CMO application, will create the greatest contrast for CNL between subscriber loops. Contrasts between subscriber loops will also occur when loaded loops with the same resistance have different end section lengths. (End sections are discussed in TE&CM 424.) Figure 1 illustrates the possible contrasts in CNL for each load point with end sections up to 12 kf (3.66 km) long. As can be seen from Figure 1, as much as 2 dB of contrast is possible for a given loop resistance as a result of different end section lengths. For example, a D66 loaded loop with 6 load sections and 2.25 kf (.69 km) end section has a dc resistance of about 1400 ohms and a CNL of about 6 dB. However, a 1400 ohm loop with only 4 load points and a 12 kf (3.66 km) end section has a CNL of about 8 dB. When a loop is treated with a 3-step AGC repeater as much as another 4 dB of contrast between subscribers is possible within the switching interval. One additional gain step will reduce the switching contrast to 2 dB from 4 dB.

2.14 Continuous AGC Repeaters: The continuous AGC repeater will provide a more uniform CNL than stepped gain repeaters for all loaded subscriber loops up to about 3000 ohms. Contrasts between subscriber loops will occur when loaded loops with the same loop resistance have different end section lengths as explained in paragraph 2.13 above. Figure 1 illustrates the CNL contrasts as a result of different end section lengths when treated with a continuous AGC repeater. End sections notwithstanding, the continuous AGC repeater should provide a CNL of approximately 4 to 6 dB for loaded circuits out to 3000 ohms.

2.15 Any AGC repeater in the REA "List of Materials" will automatically adjust its gain to meet the CNL objectives of TE&CM 424. However, these objectives impose constraints on the use of fixed gain repeaters. Because of the limitations of the fixed gain repeater the AGC repeater can be a more effective loop treatment tool.

Some advantages of AGC repeaters over fixed gain repeaters are as follows:

(a) No engineering required for installation

   (1) No loop calculations required
   (2) No consideration has to be given to end section lengths
   (3) No consideration has to be given to temperature correction
   (4) Loop resistance variations will not affect stability.

(b) Administration and record keeping will be reduced

   (1) No zoning or special categories will be required for treated loops less than 3000 ohms
   (2) Treated loops may be interchanged without changing the numbering scheme

(c) All treated loops will have more uniform CNL's

2.2 Self-Regulating Loop Extenders

2.21 The loop extender regulates loop current to extend the central office signaling limit out to 4500 ohms including terminal resistance. This limit is dependent on the central office battery being at float voltage (51.6 volts). A minimum of 20 ma of dc loop current will be supplied for the longest loop.

2.22 The loop extender may provide a boost voltage regulated by the loop current or a constant current regulated by loop current. Dependent on the manufacturer and cost, the loop extender may provide pulse correction and inhibit boost voltage during dialing. All self-regulating loop extenders currently on the REA List of Materials inhibit boost voltage during idle periods to conserve battery power. Figure 2 illustrates loop current vs loop resistance for lines treated with various loop extenders.

2.3 Combination Loop Extender/AGC Repeater Units

2.31 The AGC repeater and loop extender may be mated to form a single unit which provides a complete line treatment package. The repeater may be an integral part of the loop extender or a stand-alone plug on module. There are definite space saving advantages to using combination units. Both the repeater and loop extender occupy the same slot in the card cell, thereby, requiring half the space of individual units.

3. APPLICATION OF AGC REPEATERS IN CMO

3.1 The main objective of CMO is to promote the use of fine guage cable by reducing the costs of loop treatment. A most effective means to reduce loop costs is to share equipment with a number of subscriber loops. This sharing is accomplished by placing the loop treatment equipment within the switching path. Loop treatment equipment consists of AGC repeaters and loop extension equipment, normally as combination units. Figure 3 illustrates the placement of the loop treatment equipment within S x S switching equipment. Fixed gain repeaters and fixed boost long line adapters should no longer be used for CMO in new installations. TE&CM 331, "Application of Common Mode Operation to Central Office Equipment" discusses the mechanics and central office aspects of applying loop treatment equipment within the switching equipment. TE&CM 332, "Guide for Utilization of Central Office Loop Extenders" discusses the application of loop extenders.

3.2 Use of AGC repeaters and self-regulating loop extenders allows great flexibility in designing systems with CMO. The limiting factor in CMO design is economics not the operating characteristics of the CMO equipment. However, there may be some problems in applying CMO to all loops as pointed out in paragraph 3.4. A possible application of CMO might be the treatment of all loaded loops as illustrated in Figure 4.

3.3 For loops beyond 3000 ohms the preferred treatment is with carrier derived circuits as discussed in TE&CM 230, "General Principles of Serving Area Value Engineering", and its companion publications. For those physical circuits beyong 3000 ohms treated with CMO equipment, a field mounted fixed gain repeater may be required. The field mounted repeater set for 4 dB of gain should be applied for the following conditions:

Max Gain CMO Repeater	Loop Greater Than
6.5 dB	3000 Ohms
8 dB	3400 Ohms
10 dB	3600 Ohms

3.4 All subscriber loops may be treated on a CMO basis. However, treating all circuits on a CMO basis will require additional planning and engineering time. As seen in Figures 1 and 3, the AGC repeater and loop extender provide minimum gain and boost voltage for loops less than 1000 ohms. Therefore, all loops should normally be able to be treated with CMO with no adverse effects. However, there may be some problem areas as listed below.

3.41 Loop extenders may cause bell tap during dialing when treating loops with straight line ringers. All loops treated on a CMO basis should use bridged 20 Hz ringers. Bell tap may be avoided by using a loop extender which inhibits boost voltage during dialing. Ringers are discussed in TE&CM 212.

3.42 Loop extenders may cause misdialing when treating nonloaded loops with multiple extension ringers. By multiple extension ringers, we mean more than two ringers per subscriber on single-party or multi-party lines. Should a subscriber require more than two extension ringers, dial pulse distortion may be avoided by the application of a ring-up relay.

Ring-up relays are discussed in TE&CM 212. Dial pulse distortion problems may also be avoided by using a loop extender with pulse correction.

3.43 If the loop extender applies boost voltage during its idle state, lines using single channel carrier may require an adapter pad at the subscriber terminal to reduce the battery charging current to normal. No loop extender/AGC repeater combination units and no self-regulating loop extender equipment currently on the REA List of Materials applies boost voltage during the idle state.

3.44 AGC repeaters will most likely become unstable when interfacing with intercept circuits, connector routine test circuits, and test and busy verification (both by operator and wire chiefs test set) circuits in S x S offices. Should these circuits exist in any system treated with CMO, they should be brought to the attention of the repeater manufacturer. Different manufacturers may have different solutions to prevent the repeater from singing.

3.5 Loop treatment with some digital Class 5 offices may have to be on a per line basis.

4. ADVANTAGES OF CMO

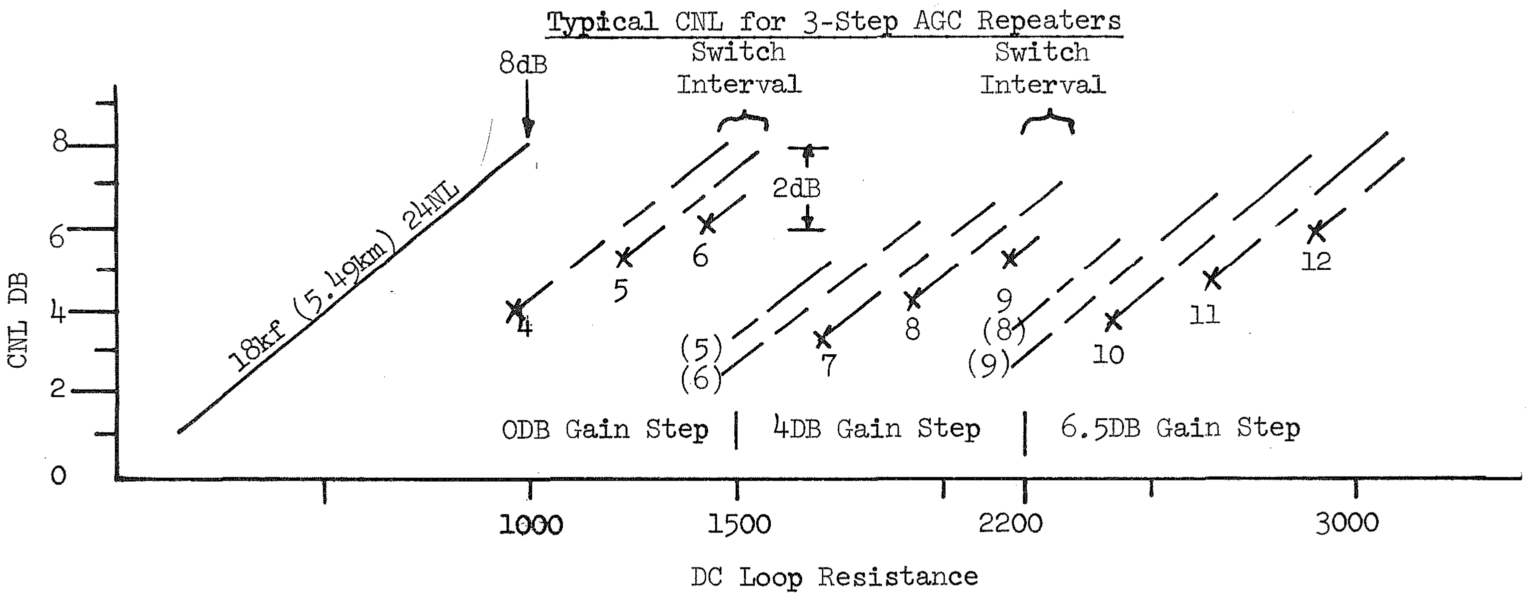
4.1 With the advent of the AGC repeater and the self-regulating loop extender, CMO is no longer relegated to long loops (1700 ohms or greater). The ability to treat a wide variety of loops, and with proper planning to treat all loops, has made CMO a very attractive alternative to loop treatment on a per line basis. Flexibility will depend on the number of lines treated. With only a portion of the lines treated, more attention is required for assignments, recording keeping and some number changes.

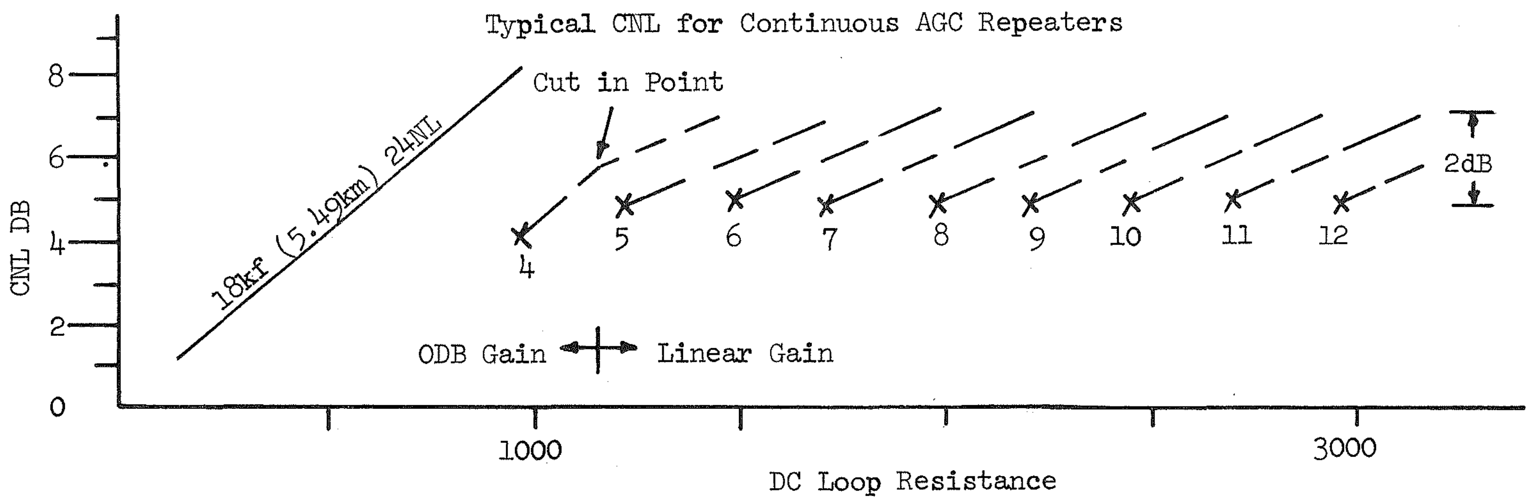
4.2 All of the advantages of the AGC repeater discussed in Paragraph 2.15 apply to CMO. Some additional advantages of CMO over per line treatment are as follows:

(a) Reduction in loop treatment cost because CMO equipment is shared.

(b) All loops out to 3000 ohms may be treated equally.

(c) Reduction in maintenance over per line treatment.





Dashed Lines (-•-) Represent CNL for excess end sections
Numbers 4 through 12 represent CNL for D66 load points with ideal end sections (2.25kf) (.69km)

FIGURE 1 CNL vs DC Loop Resistance for AGC Repeaters

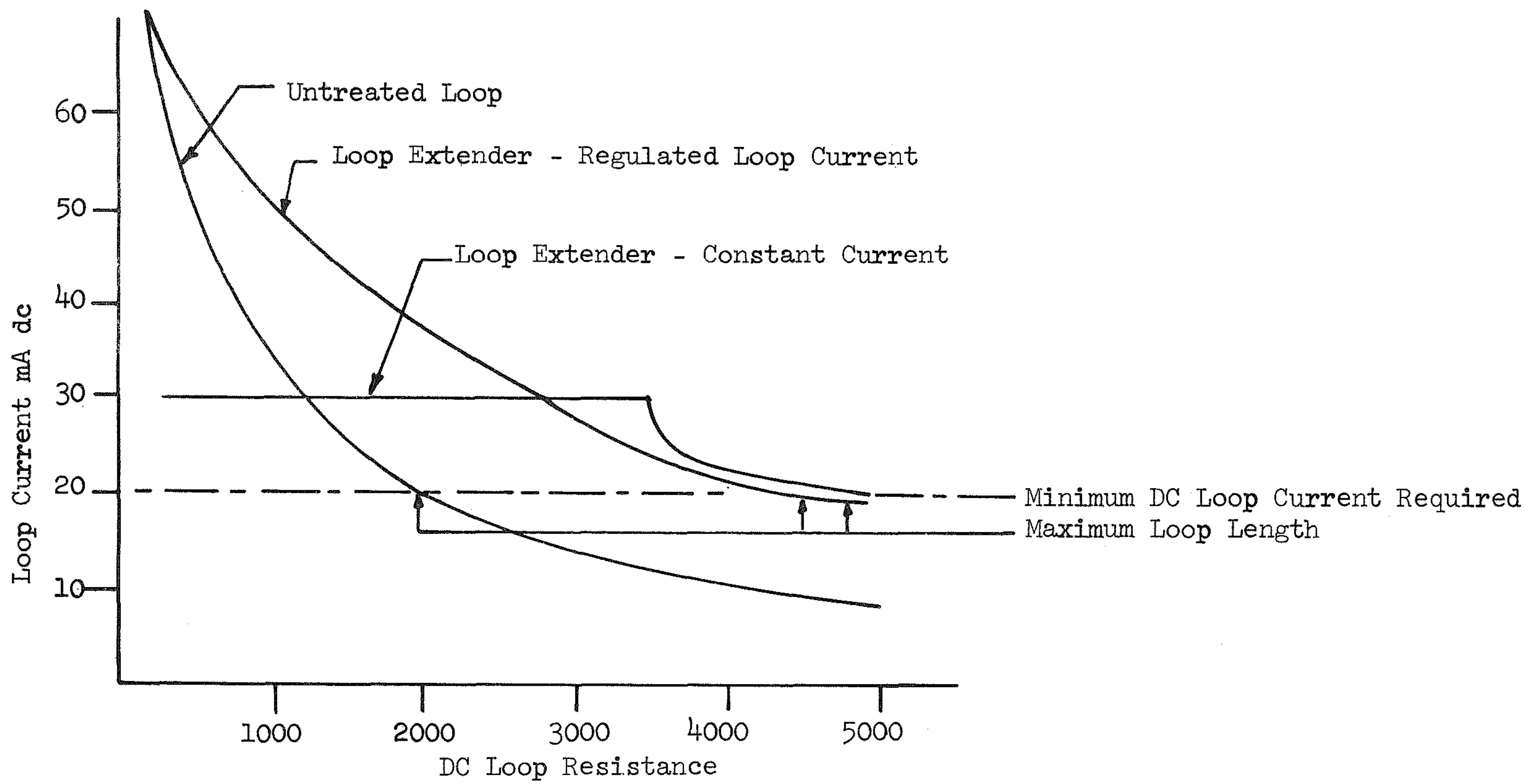


FIGURE 2 Loop Current vs Loop Resistance for Loop Extender Equipment

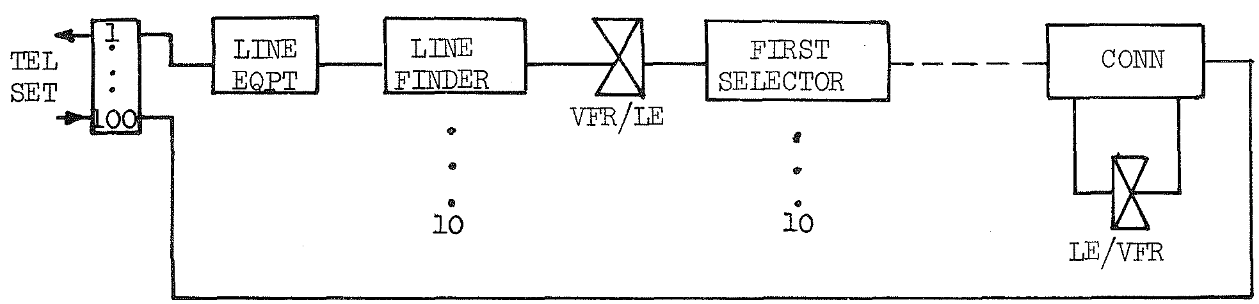
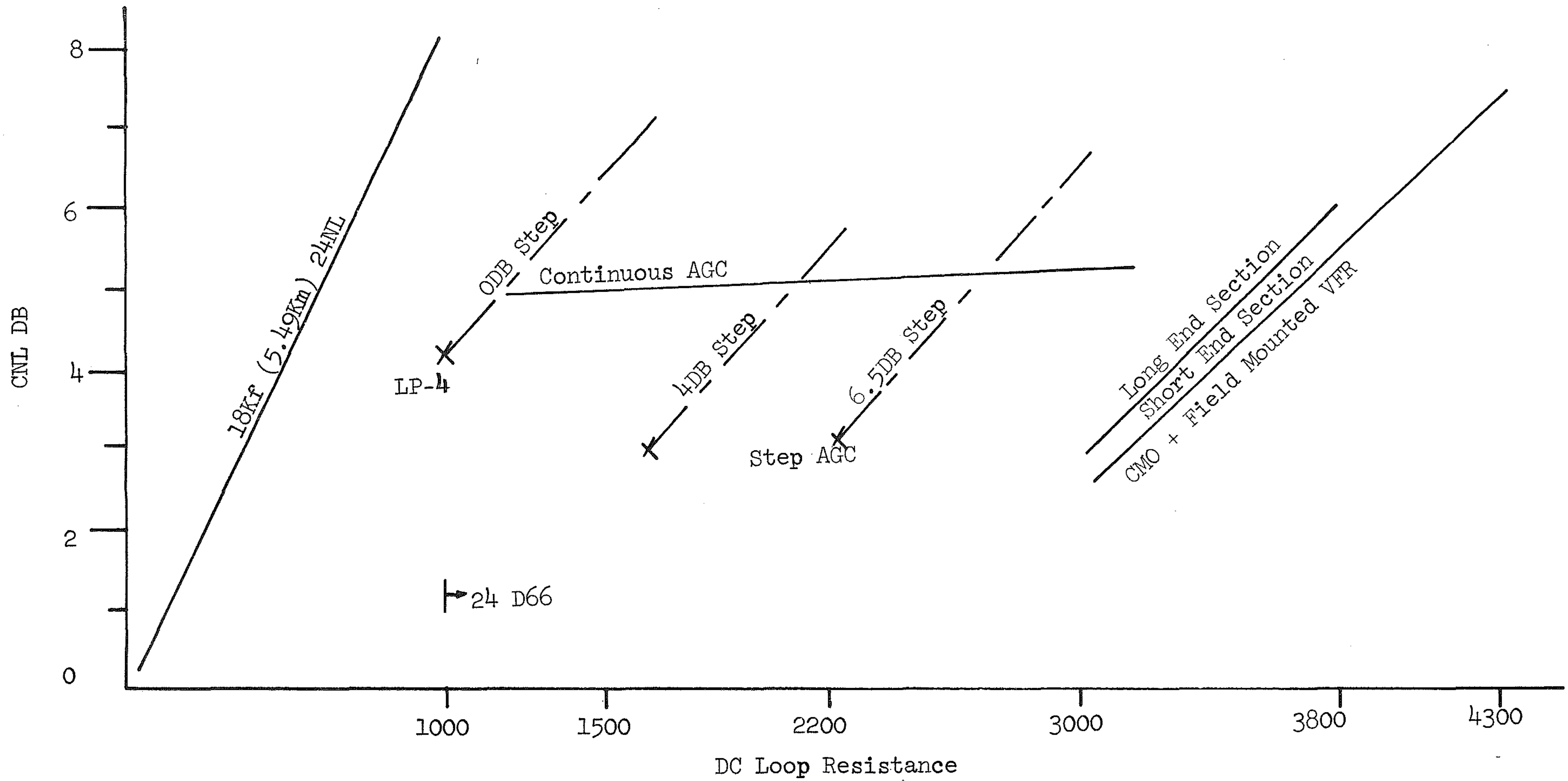


FIGURE 3 Typical S x S Switch Path With CMO



Notes:

1. Carrier is preferred loop treatment beyond 3000 ohms
2. CNL for loops up to 3000 ohms shown for ideal end sections (2.25 Kf) (.69 Km)
3. Gain for field VFR should be set for minimum CNL of 2.5dB

FIGURE 4 Typical CNL for Loops Treated With CMO