LESSON 4:
STROWGER STEP BY STEP SYSTEMS

Objective:

The objective here is to learn types switching systems like Strowger step-by-step system.

Introduction:

Almon B. Strowger was an undertaker in Kansas City, USA. The story goes that there was a competing undertaker locally whose wife was an operator at the local (manual) telephone exchange. Whenever a caller asked to be put through to Strowger, calls were deliberately put through to his competitor. This obviously frustrated Strowger greatly and he set about devising a system for doing away with the human part of the equation !

Strowger developed a system of automatic switching using an electromechanical switch based around around electromagnets and pawls. With the help of his nephew (Walter S. Strowger) he produced a working model in 1888 (US Patent No. 447918 10/6/1891). In this selector, a moving wiper (with contacts on the end) moved up to and around a bank of many other contacts, making a connection with any one of them.

Strowger did not invent the idea of automatic switching; it was first invented in 1879 by Connolly & McTigthe but Strowger was the first to put it to effective use. Together with Joseph B. Harris and Moses A. Meyer, Strowger formed his company 'Strowger Automatic Telephone Exchange' in October 1891.

In the late 1890's Almon B. Strowger retired and eventually died in 1902. In 1901, Joseph Harris licenced the Strowger selectors to the Automatic Electric Co. (AE); the two companies merged in 1908. The company still exists today as AG Communications Systems having undergone various corporate changes and buyouts along the way.

Strowger Switching Systems

Strowger switching system was the first automatic switching system. It was developed by Almon B. Strowger in 1889. Functionally, the system is classified as step-by-step switching system as the connections are established in a step-by-step manner.

Automatic switching systems have the following important advantages:

over the manual switching systems or exchanges: .

1. In manual switching system or exchange, the subscriber needs to communicate with the operator and a common language becomes an important factor. In multilingual areas this aspect will cause problems. But, the operation of an automatic exchange is language independent.
2. Grater accuracy is obtained in automatic exchanges, as no operator is normally involved in setting up and monitoring a call.
3. Establishment and release of calls are faster in automatic exchanges.
4. In an automatic exchange, the time required to establish and release a call remains more or less of the same order irrespective of the load on the system or the time of the day. In manual system, this is not true.

Rotary Dial Telephone

In manual telephone exchanges, a calling subscriber may communicate the identity of the called subscriber in a natural and informal language to the operator. For example, a called subscriber is identified by his name or profession or designation.

In automatic telephone switching system or exchange, informal communication is not possible and a formal numbering plan or addressing scheme is required to identify the subscribers. In numbering plan, a subscriber is identified by a number. It is more widely used than addressing scheme in which a subscriber is identified by alphanumeric strings. A mechanism to transmit the identity of the called subscriber to the exchange is now required at the telephone set.

Two methods of dialling are:

1. Pulse Dialling

2. Multifrequency Dialling

Pulse Dialling was originated in 1895. It is used extensively even today. In this form of dialling, a train of pulses is used to represent a digit in the subscriber number. The number of pulses in a train is equal to the digit value it represents except in the case of zero, which is represented by 10 pulses.

Successive digits in a number are represented by a series of pulse trains. Two successive trains are separated from one another by a pause in between them. This pause is known as the interdigit gap. The pulses are generated by alternatively breaking and making the loop circuit between the subscriber and the exchange. The pulsing pattern is illustrated in Fig.4.1 for digits 3 and 2.

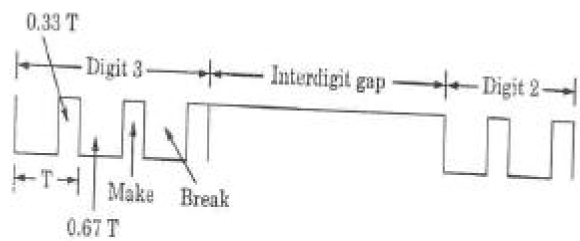


Fig.4.1 Pulse Dialling

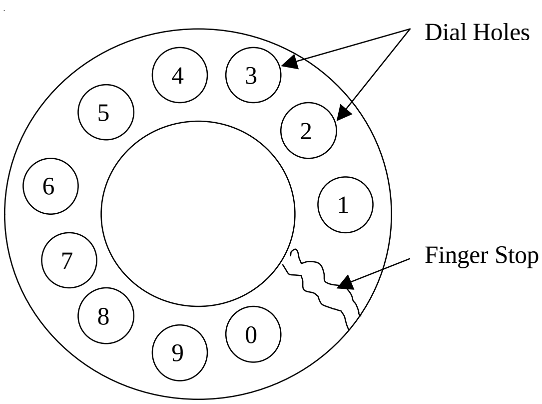
The pulse rate is usually 10 pulses per second with 10% tolerance. The interdigit gap is at least 200 ms. But in some designs the minimum gap requirement may be as much as 400 - 500 ms. In some modern electronic and crossbar telephone exchanges, there exists an upper limit for the interdigit gap. The duty ratio of the pulses is 33% nominally. We have following important points in the introduction of Dial pulsing mechanism in the telephone set:

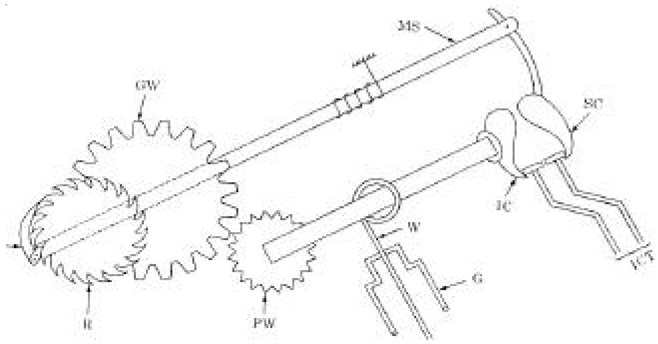
1. Since the pulses are produced by make and break of the subscriber loop, there is likelihood of sparking inside the telephone instrument.
2. The transmitter, receiver and the bell circuits of the telephone set may be damaged if the dialling pulses are passed through them.
3. The dialling habits of the users vary widely. Therefore, all timing aspects should be independent of user action.

For implementing pulse dialling, a rotary dial telephone uses following arrangement.

1. Finger plate and spring
2. Shaft, gear and pinion wheel
3. Pawl and ratchet mechanism
4. Implusing cam and suppressor cam or trigger mechanism
5. Impulsing contact
6. Centrifugal governer and worm gear
7. Transmitter, receiver and bell by-pass circuits.

Fig.4.2 (a) shows Finger plate arrangement. The dial is operated by placing a finger in the hole appropriate to the digit to be dialled, drawing the finger plate round in the clockwise direction to the finger stop position and letting the dial free by withdrawing the finger. The finger plate and the associated mechanism now return to the rest position under the influence of a spring. The dial pulses are produced during the return travel of finger plate. Therefore it eliminates the human element in pulse timings.





(**a) Finger plate arrangement**

(b) Impulsing mechanism.

(1) G = Governo (2) GW = Gear Wheel (3) IC = Impulsing Cam

(4) ICT = Impulsing Contact (5) MS = Main Shaft (6) P = Pawl

(7) PW = Pinion Wheel (8) R = Ratchet (9) SC = Suppressor Cam

(10) W **=** Worm Gear

Fig.4.2 Parts of Rotary Dial Telephone and its mechanism

A rotary dial telephone is of two types:

It may be cam type or trigger type depending on whether a cam mechanism or a trigger mechanism is used for operating the impulsing contact. The general operating principle of both the types is the same. Here we explain the operation by considering the cam type.

The internal mechanical arrangement of a rotary dial telephone is shown in Fig. 4.2(b). When the dial is in the rest position, the implusing contacts are kept away from the impulsing cam by the suppressor cam. When the dial is displaced from its rest position, it is said to be in off-normal position. In off-normal position, the implusing contacts come near the impulsing cam. The main shaft is also rotated due to rotation of the finger plate. The pawl slips over the ratchet during clockwise rotation. The ratchet, gear wheel, pinion wheel and the governer are all stationary during the clockwise movement of the dial. When the dial returns, the pawl engages and rotates the ratchet. During dial returning, gear wheel, pinion wheel and the governer all rotate.

The governer helps to maintain a uniform speed of rotation. The impulsing cam (which is attached to a pinion now) breaks and makes the impulsing contacts. Therefore it causes the pulses in the circuit. The shape of the impulsing cam is made to maintain the break and make periods in the ratio of 2 : 1. When the dial is about to reach the rest position, the suppressor cam moves the impulsing contacts away from the impulsing cam. This action provides the required interdigit gap timing independent of the pause that may occur between two successive digits, due to human dialling habit. Suppressor cam can also be designed such that the interdigit pause is provided prior to the commencement of the first pulse of a digit.

The trigger dial mechanism is an improvement over the cam dial mechanism. The precision of operation in cam dial mechanism is affected by the wear and tear of the cam elements and other function members in the mechanism. The trigger dial design eliminates friction members. It has following advantages over cam dial mechanism.

1. It provides more uniform impulse ratio.
2. There is larger interdigit pause.
3. It provides better stabilization of the return speed of the dial.

There is such an arrangement in trigger dial mechanism that the trigger is sprung away from the impulse contacts during the clockwise motion of the dial, thus preventing pulsing at this stage. The trigger is sprung back to the operative position during the initial return motion of the dial and there after operates the pulse contact. The time required to bring back the trigger to operative position provides the interdigit gap. The interdigit gap is about 240 ms.

When the subscriber lifts his handset (off-hook), the D.C. loop between the exchange and the subscriber is closed. Therefore, a steady current flows through the loop. The impulsing contact (ICO), which is normally closed, is in series with the DC loop. When operated by the cam or the trigger, it breaks and makes the circuit. Two bypass switches BP_1 and BP_2 are also shown in Fig. 4.3. These switches close as soon as the dial is moved from its position and hence are known as Dial-off normal contacts. The switch BP_2 bypasses the microphone M, the earphone E, and the bell B, during pulsing. The switch BP_1 provides a local RC loop with ICO for quenching the spark. This spark is produced when the circuit is broken.

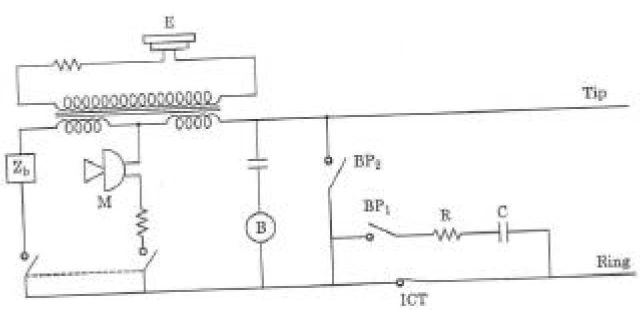


Fig.4.3 Impulsing circuit of a Rotary Dial Telephone.

In the absence of BP_1 the sparking voltage developed across impulsing contact (ICO) may affect adversely the other circuits in the telephone set. Once the dialling is complete, the dial is in the rest position, BP_1 and BP_2 are open, the ICO is closed. Thus, the transmitter and the receiver are ready for speech conversation.

The two wires connecting the telephone to the exchange are known as **ring** and **tip**. The central exchange battery voltage of -48 volt DC is connected through a relay to the ring lead. The tip lead is grounded. Ring lead is used to receive signals from the far end. The tip lead is used to transmit the signal.

Components of Strowger Switching Systems

In this switching system, there are two types of selectors which form the building blocks for the switching system.

- Uniselector.
- Two-motion selector

Uniselector:

These selectors are constructed using electromechanical rotary switches. The drive mechanism of rotary uniselector switch is illustrated in Fig. 4.4(a).

Whenever the electromagnet is energised, the armature is attracted to it and the pawl falls one position below the present tooth position. The ratchet wheel, however, does not move and is held in position by the detent.

When the electromagnet is deenergised, the armature is released and returns to its rest position due to the restoring action of the spring. During this reverse motion of the armature, the pawl moves the ratchet wheel one position up where it is held in position by the detent. The clearance between the armature and the electromagnet is such that during the forward movement of the armature the pawl slips over the ratchet exactly by one position. As the ratchet wheel rotates up by one position, the wiper moves across one contact position in the direction as shown. Thus, if the electromagnet is energised and de-energised five times by applying five pulses, the wiper moves by five contacts. The

mechanism shown in Fig.4.4 (a) is called reverse drive type because of the ratchet wheel moves when the armature returns to its rest position. It is possible to arrange the mechanism in such a way that the wheel moves during the forward motion of the armature. In this case, it is called forward drive type. Reverse drive type mechanism is generally used in uniselectors. The forward drive type mechanism is used in two-motion selectors.

A uniselector is one which has a single rotary switch with a bank of contacts. In a typical uniselector, there are four banks of which three are used for switching and the fourth one is used for homing. The three switching banks have 25 or 11 contacts each. The first contact in each bank is known as the home contact. The remaining other contacts are known as switching contacts. The homing bank has only two contacts.

1. The first contact is at the first position corresponding to the home contacts of the other banks.
2. The other contact is extending as an arc from the second position to the last position.

This arc contact is often called the homing arc. Depending upon the number of switching contacts, uniselectors are classified as 10-outlet or 24-outlet uniselectors on the basis of the number of switching contacts. A schematic representation of uniselectors is shown in Fig.4.4 (b).

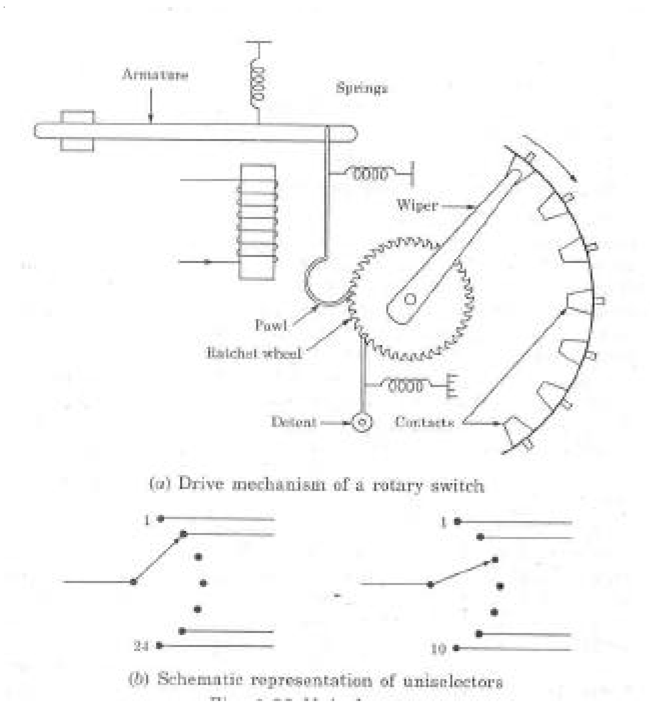


Fig.4.4 Uniselectors.

The wipers associated with the banks of a uniselector are rigidly mounted to a wiper assembly. One wiper is used for each bank. Wiper moves whenever the ratchet wheel rotates. Consequently, all the wipers move simultaneously and there is no relative motion amongst them. All wipers lie in the same vertical plane such that each wiper touches the same corresponding bank contact at any instant. There is an interrupt contact associated with the uniselector. This contact remains closed normally and opens whenever the armature is closed to the end of its forward movement. It breaks the armature energising circuit to enable the armature to return to its rest position. Here we can note that if the drive circuit is permanently energised, the selector will step continuously owing to the constant breaking and making of the interrupter contact.

The proper functioning of a uniselector depends on a number of factors. Such as:

- Energising Current Level
- Inertia of Moving System
- Friction between wipers and bank contacts.
- Friction in drive assembly.
- Tension in restoring springs.
- Adjustment of interrupter contacts.

To illustrate the importance of above-mentioned factors for proper functioning, let us consider the adjustment of interrupter contacts as an example. The interrupter contacts must be adjusted so that they open and close at the correct instants in the stroke of the armature. If they open too soon, the armature may fail to complete its stroke and pawl may not engage the next ratchet tooth. On the other hand, if interrupt contacts close too soon during the return of the armature, the reverse movement is affected. Therefore, the stepping of the wiper assembly becomes uncertain. Wear and tear of the selector parts affect the proper functioning adversely and as a result, the selectors require frequent attention for maintenance.

Two-motion Selector

It is capable of horizontal as well as vertical stepping movement. It has two rotary switches. One rotary switch provides vertical motion for the wiper assembly.

The other rotary switch provides horizontal movement for the wipers. Here rotary switch means a switch that is used in a generic sense to imply a pawl and ratchet arrangement irrespective of whether such an arrangement is being used to cause vertical or horizontal motion. The horizontal movement rotary switch of a two-motion selector has an interrupter contact as in the case of uniselector. Normally, there are 11 vertical positions and 11 horizontal contacts in each vertical position. The lowest vertical position and the first horizontal contact in each vertical level are home positions. The remaining ones are the actual switching positions. Thus, the wiper in a two-motion selector has access to 100 switching contacts.

Access to any particular contact is obtained by moving the wiper assembly vertically to the required level and then rotating the wipers to the desired contact at that level. The arrangement for two-motion selector is shown in Fig.4.5 (a). At each level there are 3 or 4 banks of contacts.

On the basis of number of banks, a two-motion selector is sometimes called a 330-point or 440-point selector. For homing the wiper assembly, it is driven beyond the 11^{th} contact position by the horizontal rotary magnet and its interrupter contact. The wiper assembly then falls vertically to the home level. Therefore wiper assembly returns to the horizontal home position under the influence of a restoring spring. In some types of designs, a third magnet is also used for homing. This magnet is called release magnet. A set of off normal contacts are operated by the first vertical and horizontal movements of the wipers and they remain under operation until the wiper assembly returns to the home position. A schematic representation of a two-motion selector is shown in Fig.4.5 (b).

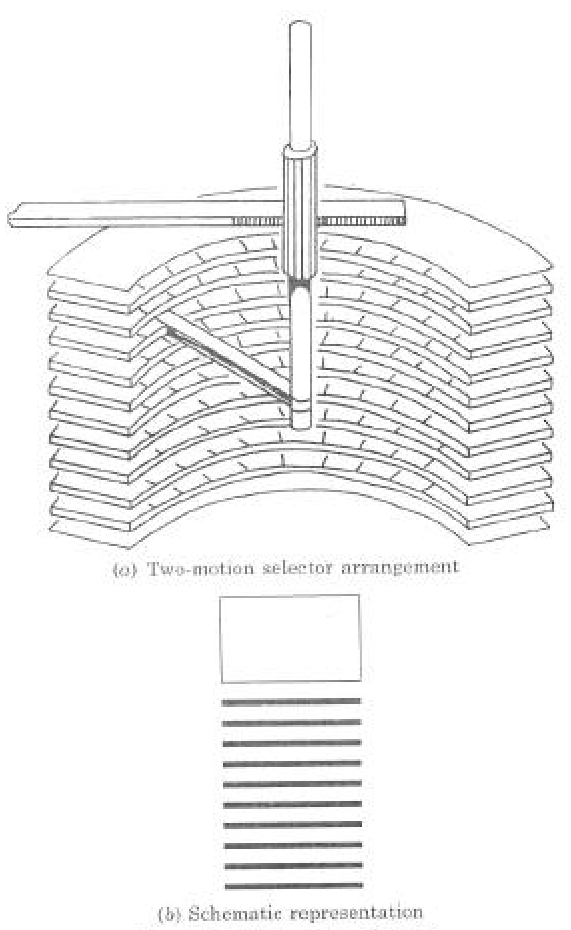


Fig.4.5 Two-motion selectors.

The vertical and horizontal motions in a two-motion selector is affected directly by using two impulse trains from subscriber dialling. The first impulse train corresponding to the first digit operates the vertical magnet. The second impulse train drives the horizontal rotary switch. In such a case, it follows that the bank contacts are so numbered as to correspond to the digits necessary to reach each contact. Table 4.1 shows the numbering scheme for two-motion selector contacts. This numbering scheme is valid for 100-contact bank. Here, we can note that the lowest vertical level commences with 11 and ends with 10, whilst the 10th level commences with 01 and ends with 00. This is due to the fact that digit zero produces 10 pulses when dialled].

Table 4.1 Standard Numbering Scheme for Two-motion Selector Contacts

Level	Contacts									
	1	2	3	4	5	6	7	8	9	10
10	01	02	03	04	05	06	07	08	09	100
9	91	92	93	94	95	96	97	98	99	90
8	81	82	83	84	85	86	87	88	89	80
7	71	72	73	74	75	76	77	78	79	70
6	61	62	63	64	65	66	67	68	69	60
5	51	52	53	54	55	56	57	58	59	50
4	41	42	43	44	45	46	47	48	49	40
3	31	32	33	34	35	36	37	38	39	30
2	21	22	23	24	25	26	27	28	29	20
1	11	12	13	14	15	16	17	18	19	10

Strowger Step-by-Step Switching

A step-by-step switching system can be constructed using uniselectors or two-motion selectors or a combination of both. The wiper contacts of these selectors move in direct response to dial pulses or other signals such as off-hook from the subscriber telephone. The wiper moves (steps) forward by one contact at a time and moves by as many contacts (takes as many steps) as the number of dial pulses received or as required to satisfy certain signalling conditions. Therefore, this switching is called step-by-step switching. Most of the necessary control circuits are built in as an integral part of the selectors, thus enabling them to receive and respond to user signalling directly. The relevant signalling tones are sent out to the subscriber by the switching elements (selectors) at the appropriate stages of switching. Therefore, a step-by-step switching system is also a Direct Control System.

There are three major parts in a step-by-step switching system.

These parts are shown in Fig.4.6.

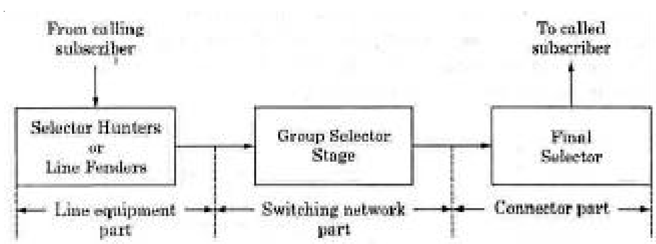


Fig.4.6 Block diagram of a step-by-step switching system.

The line equipment part consists of selector hunters or line finders. The other two parts consists of selectors. The selectors hunters and the line finders represent two fundamental ways in which a subscriber gains access to the common switching resources. A selector hunter searches and seizes a selector from the switching matrix part. One selector hunter is used for each subscriber. Usually, 24-outlet uniselectors are used as selector hunters. The selector hunter scheme is sometimes known as subscriber uniselector scheme because it uses a dedicated uniselector for each subscriber in the system. Line finders are associated with the first set of selectors in the switching matrix part. There is one line finder for each selector in the set. A line finder searches and finds the line of a subscriber to be connected to the first selector associated with it. Line finders are constructed using uniselectors or two motion selectors. The line equipment part is also known as preselector stage. The selector hunters and line finders are generically known as preselectors.

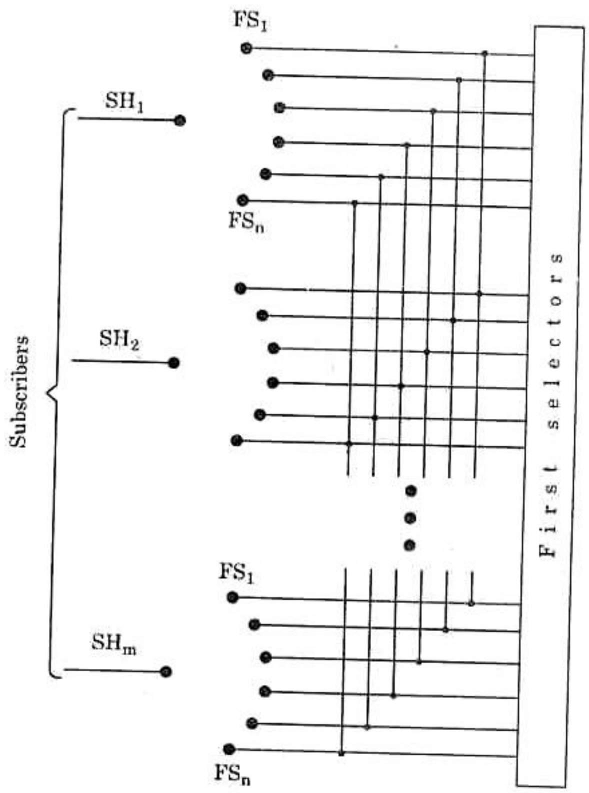
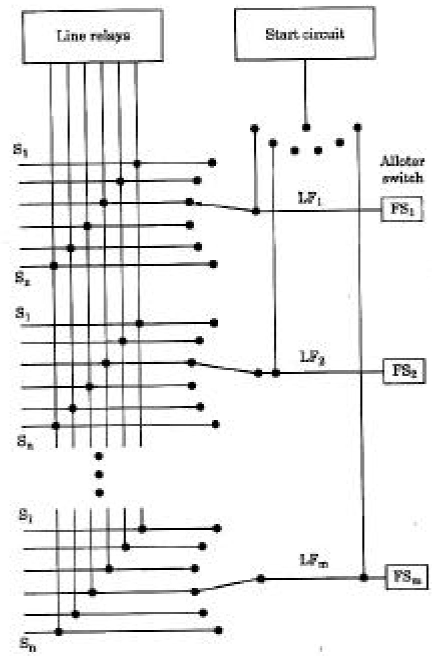


Fig.4.7 (a) Selector hunter based access

The switching matrix part consists of one or more sets of two motion selectors known as first group selector, second group selector, and so on. If the telephone exchange size is large, then we require larger number of group selector stages.

The connector part comprises of one set of two motion selectors known as final selectors. In small Strowger telephone exchanges, all the parts may not exist.

The selector hunter and line finder schemes are shown in the trunking diagrams of Fig.4.7. In selector hunter based approach, when a subscriber lifts his hand set, the interrupter mechanism in his selector hunter gets activated and the wiper steps until a free first group selector is found at the outlet. The status of the first group selector may be free or busy. The status of the first group selector is known by a signal in one of the bank contacts of the selector hunter.



(b) Line finder based access
FS = first selector LF = line finder SH = selector hunder

Fig.4.7 (b) Subscriber access to Strowger switching system.

Once a free first selector is sensed, the interrupter is disabled and the first selector is marked ‘busy’. Then, the first selector sends out a dial tone to the subscriber via the selector hunter. This selector hunter simply provides an electrical path. The first selector is now ready to receive the dialling pulse from the subscriber. It is possible that two selector hunters land on the same free first selector simultaneously and attempt to seize it. This problem is resolved by a suitable seizure circuit.

In the case of line finder based approach, the off-hook signal is sensed by all the line finders. Therefore, the interrupter mechanism of one of the finders (whose associated first selector is free) gets activated and the line finder wiper steps until it reaches the contact on to which the subscriber is terminated. After finding the line, the concerned first selector sends out the dial tone to the subscriber in readiness to receive the dial pulses.

The selection of one of the line finders out of many free line finders is obtained by means of an allotter switch in the start circuit of line finder. It is shown in Fig.4.7 (b). The circuit arrangements are such that the wiper of the allotter switch normally stands on a contact connected to a free line finder and the first selection. When a subscriber lifts his receiver, the start signal from his relay is passed to the particular line finders via the common start circuit and the allotter switch. The line finder then commences to hunt for the calling line. After finding the calling line, the allotter switch steps to the next free line finder. In fact, the line finder and the associated first selector is used for the next future call which is selected in advance by the allotter circuit. In practical designs, several allotter switches are provided in the system to serve calls that may originate in quick succession or simultaneously. Multiple allotter switches also avoid single-point failures. This leads to complete breakdown of the system.

Some practical limitations are encountered in the design of large telephone exchanges in both the above schemes of gaining access to switching resources. Large telephone exchanges are characterized by a large number of subscribers and first group selectors. It is not possible to provide a large number of outlets in the selector hunters or line finders such that any first group selector is accessible by any subscriber. Usually, subscribers are connected in the groups of 100 to different sets of line finders. In this case, line finders use two motion selectors. In similar fashion, sets of selector hunters are connected to different groups of 24 first selectors each. The approaches of line finder and selector hunter are useful for different sizes of telephone exchanges. If the telephone exchange is small and the volume of traffic low then line finder approach is economical. If the telephone exchange is large with fairly heavy traffic then selector hunter approach is more cost effective.

When the subscriber starts dialling, the first selector cuts off the dial tone and receives the pulse train corresponding to the first digit dialled by the subscriber. Its wiper assembly steps vertically as many steps as the number of dial pulses. The wipers then move in the horizontal plane across the contacts until they come across a contact to when a free second group selector is connected. The interdigit gap of about 240 ms is required to complete above horizontal stepping. Thereafter, the first group selector just provides an electrical path to the second group selector. Each group selector stage functions in a fashion similar to the first group selector by processing one digit of the number dialled by the subscriber and finding a group selector in the subsequent stage. The last two digits of the dialled number are processed by the final selector. The final selector steps vertically according to the last but one digit and steps horizontally according to the last digit.

Since the final selector responds to digits both in the vertical and horizontal directions unlike the group selectors. These selectors are known as Numerical Selector. If the called subscriber is free, as sensed from a signal at corresponding bank contact, the final selector sends out a ringing current to the called subscriber and a ringing tone to the calling subscriber. When the called subscriber lifts his handset, the ringing current and ringing tone are cut off and the call metering circuits are enabled by the control circuits associated with the final selectors. If the called subscriber is busy, the final selector sends out a busy tone to the calling subscriber. At any stage of switching, if there is no free selector at the next stage, a busy tone is returned to the calling subscriber.

The control functions in a Strowger Switching System are performed by circuits associated with the selectors. Control and supervisory signals are carried from stage-to-stage by means of contacts in one of the banks. The wire interconnecting these banks is known as Private Wire or P-wire.

Two other bank contacts are used for carrying voice signals and the associated wires are called negative and positive wires which extend up to the subscriber premises. A selector R is said to have seized another selector S in the next stage when the negative, positive and private wires of the selector R have been connected to the negative, positive and private wires respectively of the selector S. The complexity and functionality of the control circuits associated with a selector vary depending on the position of the selector in the switching stage.

All the selector control circuits are composed of one or more of the following basic circuits:

1. Guarding Circuit
2. Impulsing Circuit
3. Homing Circuit
4. Metering Circuit
5. Ring-trip Circuit
6. Alarm Circuit

Now we discuss the above circuits one by one.

Guarding Circuit

The guarding circuit is an essential feature or part of all the selectors. It guards the selector by making it busy as soon as it is seized, lest some other selector involved in setting up another call may also seize it. Once the guarding condition applied, this remains set as long as the call is not terminated. The guarding condition is indicated by an earth on the P-wire. An earth is supplied by the P-wire by home contact and the homing arc of the home bank. For avoiding any unguarded period during the transition of the wiper from the home contact to the homing arc, the wiper is of bridging type. The bridging-type wiper functions in make-before-break fashion. It touches the homing arc before it leaves the home contact.

Impulsing Circuit:

This circuit is an essential part of all those selectors which have to respond to dialling pulses. It is used in group and final selectors. But it is not used in line finders or selector hunters.

This circuit is usually designed around three relays. One relay is fast acting and other two relays are slow acting. The fast acting relay faithfully responds to the impulses and passes them on to the private wire (or P-wire) circuit. The fast action of the relay is achieved by using only one contact spring assembly and an isthmus armature. One of the slow acting relays serves to maintain guarding conditions on the P-wire of the incoming circuits. It also provides the connection of the selector magnet to the impulsing relay. The third relay (slow acting) is used to recognise the end of a pulse train corresponding to a single digit and prepare the circuit for the next stage in the switching process.

When a selector is searching for a free outlet, the condition on the P-wire must be tested to determine whether the outlet is free or not.

If an outlet is engaged, the wipers must be allowed to continue the hunting process. If the outlet is free, it must be seized immediately. Therefore, the incoming positive and negative wires must be switched through to the input of the next stage. At the same time, the hunting process must stop.

Once the connection is established, it must be held until the conversation lasts. All these functions are performed by the testing circuit. Therefore, this circuit is sometimes called hunting, testing, switching and holding circuit.

The free condition on the P-wire can be indicated by two methods.

- In first method, free condition on the P-wire can be indicated by means of a simple disconnection.
- In second method, free condition on the P-wire can be indicated by applying a battery to the P-wire.

The busy condition is indicated by an earth connection. Hence, a testing circuit has to distinguish between an earth and a disconnection in one case and between an earth and a battery in the other. Accordingly, the two methods are called earth testing and battery testing, respectively. Earth testing is more prone to false connection than battery testing. In any switching process (particularly electromechanical switching) momentary disconnections of lines do occur. Therefore, false switching may take place if the earth testing happens at an instant when a busy outlet is in the course of some switching or release process which temporarily disconnects the guarding earth from the P-wire. Such a problem does not occur in the case of battery testing.

Homing Circuit

At the end of a conversation between two consumers, all the selectors used for call are released and returned to their respective home positions. This operation is performed by homing circuits. The two-motion selectors are returned to their home position by actuating their self-dire mechanism using interrupt contact. The necessity of homing in the case of uniselectors arises only for the calling subscriber uniselector. The called subscriber uniselector is already in the home position. A finite time is required in homing operation. It must be ensured that a hunting selector may not seize a selector which is in the process of homing. Thus, the provision of guarding earth during homing in an integral feature of the homing circuit.

Metering Circuit

This circuit is a special feature of the final selectors. It registers a call against the calling party as soon as the called party answers. This circuit drives meter. This meter contains a simple ratchet-operated counting mechanism with a capacity of 4 to 5 digits. For local calls, the metering is usually independent of the duration of the call and the meter is pulsed only once by the final selector.

For long distance calls (established using subscriber trunk dialling (STD) facility), the metering is time dependent. Here meter is pulsed at an appropriate rate. In this case, the metering pulses are usually received from a remote exchange. Metering is achieved by connecting the meter to the P-wire of the subscriber uniselector through a rectifier and applying a positive voltage. This positive voltage makes the rectifier conduct and thereby pulse the meter. The use of the rectifier also ensures that P-wire remains guarded during metering.

Ring-trip Circuit:

This circuit is a part of final selectors. The attention of the called subscriber is drawn by ringing the bell of his telephone set. At the same time, a ringing tone is sent out from the final selector to the calling subscriber. Both the ringing current and ringing tone are cut off by the ring trip circuit as soon as the called party answers the call.

The ringing current in a Strowger Switching System is a 17 Hz AC. The ringing tone and the period of interruption of the ringing current are controlled by a relay. This relay is driven by suitable pulsing circuits. Interference of ringing current with speech circuit is prevented by isolating electrical power to the ringing circuit from the main exchange supply. As soon as the condition of main power being applied to the circuit is sensed, the ringing current is tripped.

A common fault of premature tripping of the ringing current occurs when the main supply battery gets connected to the circuit during ringing without the called subscriber actually lifting the handset. If premature tripping of the ringing current takes place, the bell at the called subscriber telephone set rings only once or twice.

Alarm Circuits:

These circuits provide visual and audible indications of any fault or undesirable condition creeping into the selector circuits. These are three types of faults which are usually detected. These are:

- Off-hook condition
- Called-subscriber-held
- Release held.

Off-hook condition: In the event of a short-circuit in the subscriber line or the subscriber not having replaced his handset properly on the hook, his D.C. loop circuit remains closed. Therefore, his uniselector hunts and seizes a first selector unnecessarily. For avoiding this undesirable use of power and switching elements, every first selector is provided with a permanent glow alarm circuit. This circuit activates an audio and visual alarm if a selector remains seized for more than 6 minutes.

Called-subscriber-held alarm circuit: It is necessary in all telephone exchanges where the release of the switching stages is initiated by the calling subscriber replacing his handset. In case, the handset is not properly replaced, all the selectors and called subscriber line remain held, even though the called subscriber has replaced his handset properly. If called subscriber-held happens, neither the called subscriber is able to make any call himself nor can anybody else call him.

Thus, the subscriber's instrument remains paralysed. Anybody can easily create this situation by calling a number and then not replacing his handset on the hook. For preventing this situation, all final selectors are provided with called subscriber held alarm circuit. If the condition of the called-subscriber handset having been replaced and the calling subscriber handset not having been replaced lasts for over 3 minutes, this alarm circuit operates.

Release held alarm circuit: The third type of alarm circuit is called release-held alarm circuit. It senses the failure of a selector to return to home position.

Design parameters of a Telecommunications Switching System

When we consider the design of a switching system a number of design alternatives and options may be available. For example, a Strowger switching system may be designed entirely on the basis of uniselectors or two motion selectors, or a combination of both. It then becomes necessary to compare and evaluate designs to choose from the alternatives. Various design parameters assist us in this process. Here, we define a set of design parameters that characterise the switching systems. These parameters are generic in nature. Hence these parameters are applicable to all types of switching systems irrespective of the technology or architecture.

The switching network is a major component or part of any switching system. It is mainly composed of switching elements and the associated circuits.

Therefore, the cost of the switching network is directly proportional to the number of switching elements in the network. Hence, a good design of switching network will use a minimum number of switching elements in the system. When we consider the total switching system then there are other cost elements. For common control systems, the cost of the control subsystem must be taken into account. There is a cost associated with some fixed common hardware elements like ringing current generator, different tone generators and various power supplies. A switching network can be designed using one or more stages of switching elements. The higher the number of stages, the longer is the time taken to set up a call because switching operation is involved in every stage.

Every switching system is designed to support a certain maximum number of simultaneous calls. The maximum number of simultaneous call supported by a switching system is called switching capacity. In most of the designs, the entire switching resources are not utilized even when the switching capacity is fully utilized. Some of the resources remain idle. The fraction of the hardware actually used under full load conditions is an index of the design.

Design parameters of a switching system can be given below on the basis of factors that are taken into account.

1. Number of subscriber lines, N_L
2. Total number of switching elements, N_E
3. Cost of the switching system, C. The cost of the switching system can be given by,

$$C = (N_E \times C_E) + C_c + C_H$$

Where,

C_E = cost per switching element

C_c = cost of the common control system

C_H = cost of the common hardware

Since the control circuits are associated with switching elements in a Strowger switching system. Here, the cost of the common control system C_c is equal zero.

The common hardware is usually a small proportion of the total hardware except for the power supplies and its cost is of the same order in different comparable designs. Hence, we can neglect the cost of the common hardware C_H in most of our calculations.

4. Switching capacity, SC
5. Traffic handling capability, TC

1.Traffic handling capability, TC

$$\text{Traffic handling capability} = \frac{\text{Switching capacity}}{\text{Theoretical maximum load}}$$

Or

$$TC = \frac{SC}{[N_L / 2]} = \frac{2\,SC}{N_L}$$

6. Equipment utilization factor, it is denoted by f_{EU}. It is defined by the following expression

$$f_{EU} = \frac{\text{(No. of switching elements in operation when Switching Capacity (BC) is fully utilized)}}{\text{Total number of switching elements in the system}}$$

7. Number of switching stages, K
8. Average switching time per stage, T_{st}
9. Call set up time, Ts

   It is defined as

$$T_S = T_{st} \times K + T_0$$

where 'T_0' is the time required for functions other than switching. T_0 is a significant quantity in common control systems where control functions are separated from switching functions. In direct control systems (Strowger Switching Systems), time 'T_0' may be neglected.

10. Cost capacity Index (I_{CC})

$$I_{CC} = \frac{\text{Switching Capacity}}{\text{Cost per subscriber line}} = \frac{SC}{[C / N_L]} = \frac{N_L\,(SC)}{C}$$

The higher the value of cost capacity index I_{CC}, the better is the design. If we have given the traffic handling capability of a switching system (TC), the stochastic behaviour of the actual traffic and holding time characteristics of a call then it is possible to make reasonable estimates of the blocking probabilities.

Here we can note that the blocking probability is more of a performance parameter than a design parameter. However, at the design stage, the traffic handling capability (TC) of the switching system must be seized to achieve a low blocking probability in the field. This is done on the basis of the estimated traffic.