# Electronic Switching Systems (ESS)

## Introduction to Electronic Switching Systems

In telecommunications, an Electronic Switching System (ESS) is a telephone switch that utilizes solid-state electronics and computerized common control to connect telephone circuits and establish calls.

This represents a significant advancement over earlier telephone switches.

## Historical Context: Pre-Electronic Switching

Prior to the 1950s, telephone switches relied on purely electro-mechanical relay systems and analog voice paths.

These early systems often employed the "step-by-step" technique, which was slow and less efficient.

Example: Strowger switch.

## Early Electronic Switching Systems (1960s)

The first generation of ESS, introduced in the 1960s, were not fully digital.

They used reed relay-operated metallic paths or crossbar switches controlled by Stored Program Control (SPC) systems.

SPC systems used computers to control the switching functions, offering greater flexibility and features compared to electromechanical systems.

## Reed Relays: A Key Component

### Reed Relay Structure

Reed relays consist of:

A reed switch

A coil for generating a magnetic field

An optional diode to handle back EMF (electromotive force) from the coil

An encapsulating package with connection terminals

### Advantages of Reed Relays

When used correctly, reed relays offer several advantages:

Low-resistance metallic switch path: Ensures minimal signal loss.

Inherent isolation: Provides electrical isolation between the control voltage operating the coil and the signal being switched, preventing interference.

### Reed Switch Details

The reed switch contains:

Two shaped metal blades made of a ferromagnetic material (typically a 50:50 nickel-iron alloy).

A glass envelope: This holds the blades in place and provides a hermetic seal, preventing contaminants from entering the critical contact area.

Most reed switches are normally open (contacts are separated) in their resting state.

### Reed Relay Operation

When a magnetic field is applied along the axis of the reed blades:

The ferromagnetic nature of the blades intensifies the magnetic field within them.

The open contacts are attracted to each other due to the magnetic force.

The blades deflect and close the gap, making electrical contact.

### Reed Relay Advantages: Durability and Reliability

The reed switch has only one moving part: the deflection of the blades.

There are no pivot points or sliding materials, reducing wear and tear.

The contact area is enclosed in a hermetically sealed envelope with inert gasses or a vacuum (for high-voltage switches). This protects the contacts from external contamination.

This design gives reed switches an exceptionally long mechanical life and high reliability.

## Early Adoption of Electronic Switching

The first all-electronic central office customer trial commenced in Morris, Illinois, in November 1960 by Bell Laboratories.

The first large-scale ESS was the Number One Electronic Switching System (1ESS) of the Bell System, which went into service in Succasunna, New Jersey, in May 1965.

## Transition to Digital Telephony

The adoption of metal-oxide-semiconductor (MOS) technology and pulse-code modulation (PCM) in the 1970s facilitated the transition from analog to digital telephony.

PCM involves sampling the analog voice signal and converting each sample into a digital code.

Later ESS implemented digital representation of audio signals on subscriber loops by digitizing the analog signals and processing the resulting data for transmission between central offices.

## Time-Division Multiplexing (TDM)

Time-division multiplexing (TDM) allowed the simultaneous transmission of multiple telephone calls on a single wire connection between central offices or other electronic switches.

TDM dramatically improved the capacity of the telephone network by dividing the transmission channel into time slots, each allocated to a different call.

## Evolution of Electronic Switching

With the advancement of digital electronics starting in the 1960s, telephone switches increasingly used semiconductor device components.

By the late 20th century, most telephone exchanges without TDM processing were eliminated.

The term "electronic switching system" became largely a historical distinction for the older SPC systems. Modern switches are almost exclusively digital.

## 4ESS Electronic Switching System

The No. 4 Electronic Switching System (4ESS) was a Class 4 telephone ESS, the first digital electronic toll switch introduced by Western Electric.

It was introduced in Chicago in January 1976, replacing the 4A crossbar switch.

The last of the 145 systems in the AT&T network was installed in 1999 in Atlanta.

At the time of the Bell System divestiture, most of the 4ESS switches became assets of AT&T as part of the long-distance network, while others remained in the Regional Bell Operating Companies (RBOCs).

### 4ESS System Architecture

The 4ESS has three major components:

The Processor

The File Store (later known as the Attached Processor System (4EAPS))

The Peripheral Units

### 4ESS Processor

The processor acts as the CPU for the switch.

It includes a central control, call stores, and program stores.

It had access to additional units through the auxiliary unit bus (AUB) and peripheral unit bus (PUB).

A master control console (MCC) provided office technicians access to the switch through the processor peripheral interface (PPI).

Early versions used the same 1A processor as the contemporaneous improved 1AESS switch. All existing switches have been subsequently upgraded to use the 1B processor.

### 4ESS File Store and CNI Ring

The file store provides long-term storage (disk storage) of the processor programs (program store) and office data (call store).

It was first implemented using disk technology but was replaced by the 4E attached processor system (4EAPS).

The 4EAPS is a 3B computer running 4EAPS application software on the DMERT operating system.

The 4EAPS interfaces to the 4ESS processor via the attached processor interface (API) units.

The "1A file store" became partitions on the 3B computer disks.

At first, the 4EAPS just provided "file store," but soon it also provided access to the common-network interface ring (CNI ring) to provide common-channel signaling (CCS).

The 4EAPS originally used the 3B20D computer. These were all converted to the 3B21D around 1995.

### 4ESS Peripheral Units

The peripheral units include units that interface to the central control over the peripheral unit bus.

This includes the common channel interface signaling (CCIS) terminal, signal processors, time-slot interchanges (TSI), and time-multiplexed switches (TMS).

It also includes equipment not directly on the PUB, including terminating equipment used to connect the switch to the transport network and the TSIs and TMSs, which actually perform the "time-space-time" switching function.

Timing is provided by a high-speed, high-accuracy network clock.

## 5ESS Switching System

The 5ESS Switching System is a Class 5 telephone ESS developed by Western Electric for AT&T and the Bell System in the United States.

It came into service in 1982, and updated versions are still produced today.

### 5ESS Architecture

The 5ESS switch has three main types of modules:

The Administrative Module (AM)

The Communications Module (CM)

The Switching Module (SM)

### 5ESS Administrative Module (AM)

The Administrative Module (AM) contains the central computers.

It is a dual-processor mini mainframe computer of the AT&T 3B series, running UNIX-RTR.

AM contains the hard drives and tape drives used to load and back up the central and peripheral processor software and translations.

The Administrative Module is built on the 3B21D platform and is used to load software to the many microprocessors throughout the switch and to provide high-speed control functions.

It provides messaging and interface to control terminals.

The AM of a 5ESS consists of the 3B20x or 3B21D processor unit, including I/O, disks, and tape drive units.

Once the 3B21D has loaded the software into the 5ESS and the switch is activated, packet switching takes place without further action by the 3B21D, except for billing functions requiring records to be transferred to disk for storage.

Because the processor has duplex hardware (one active side and one standby side), a failure of one side of the processor will not necessarily result in a loss of switching.

### 5ESS Communication Module (CM)

The Communications Module (CM) forms the central time switch of the exchange.

5ESS uses a time-space-time (TST) topology in which the Time-Slot-Interchangers (TSI) in the Switching Modules assign each phone call to a time slot for routing through the CM.

CMs perform time-divided switching and are provided in pairs; each module (cabinet) belonging to Office Network and Timing Complex (ONTC) 0 or 1, roughly corresponding to the switch planes of other designs.

Each SM has four optical fiber links, two connecting to a CM belonging to ONTC 0 and two to ONTC 1.

CMs receive time-multiplexed signals on the receive fiber and send them to the appropriate destination SM on the send fiber.

### 5ESS Switching Module (SM)

The Switching Module (SM) makes up the majority of the equipment in most exchanges.

The SM performs multiplexing, analog and digital coding, and other work to interface with external equipment.

Each has a controller, a small computer with duplicated CPUs and memories, like most common equipment of the exchange, for redundancy.

Distributed systems lessen the load on the Central Administrative Module (AM) or main computer.

Each Switching Module (SM) handles several hundred to a few thousand telephone lines or several hundred trunks or a combination thereof.

Each has its own processors, also called Module Controllers, which perform most call handling processes, using their own memory boards.

Peripheral units are on shelves in the SM. In most exchanges, the majority are Line Units (LU) and Digital Line Trunk Units (DLTU).

Each SM has Local Digital Service Units (LDSU) to provide various services to lines and trunks in the SM, including tone generation and detection.

Global Digital Service Units (GDSU) provide less-frequently-used services to the entire exchange.

The Time Slot Interchanger (TSI) in the SM uses random-access memory to delay each speech sample to fit into a time slot which will carry its call through the exchange to another or, in some cases, the same SM.

### 5ESS Signaling

The 5ESS has two different signaling architectures:

Common Network Interface (CNI) Ring

Packet Switching Unit (PSU)-based SS7 Signaling

### 5ESS OAMP

OAMP stands for Operations, Administration, Maintenance, and Provisioning. These are the functions required to manage and operate the 5ESS switch.