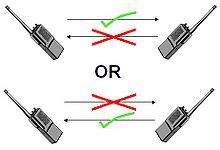
A **duplex** [communication system](https://en.wikipedia.org/wiki/Communication_system) is a [point-to-point](https://en.wikipedia.org/wiki/Point-to-point_(telecommunications)) system composed of two or more connected parties or devices that can communicate with one another in both directions. Duplex systems are employed in many communications networks, either to allow for simultaneous communication in both directions between two connected parties or to provide a reverse path for the monitoring and remote adjustment of equipment in the field. There are two types of duplex communication systems: full-duplex (FDX) and half-duplex (HDX).

In a **full-duplex** system, both parties can communicate with each other simultaneously. An example of a full-duplex device is [plain old telephone service](https://en.wikipedia.org/wiki/Plain_old_telephone_service); the parties at both ends of a call can speak and be heard by the other party simultaneously. The earphone reproduces the speech of the remote party as the microphone transmits the speech of the local party because there is a two-way communication channel between them, or more strictly speaking because there are two communication channels between them.

In a **half-duplex** or **semiduplex** system, both parties can communicate with each other, but not simultaneously; the communication is one direction at a time. An example of a half-duplex device is a [walkie-talkie](https://en.wikipedia.org/wiki/Walkie-talkie) two-way radio that has a "[push-to-talk](https://en.wikipedia.org/wiki/Push-to-talk)" button; when the local user wants to speak to the remote person they push this button, which turns on the transmitter but turns off the receiver, so they cannot hear the remote person. To listen to the other person they release the button, which turns on the receiver but turns off the transmitter.

Systems that do not need the duplex capability may instead use [simplex communication](https://en.wikipedia.org/wiki/Simplex_communication), in which one device transmits and the others can only "listen". Examples are [broadcast](https://en.wikipedia.org/wiki/Broadcast) radio and television, [garage door openers](https://en.wikipedia.org/wiki/Garage_door_opener), [baby monitors](https://en.wikipedia.org/wiki/Baby_monitor), [wireless microphones](https://en.wikipedia.org/wiki/Wireless_microphone), and [surveillance cameras](https://en.wikipedia.org/wiki/Surveillance_camera). In these devices, the communication is only in one direction.

**Half duplex**

[](https://en.wikipedia.org/wiki/File:HalfDuplex.JPG)

A simple illustration of a half-duplex communication system

A *half-duplex* (HDX) system provides communication in both directions, but only one direction at a time (not simultaneously). Typically, once a party begins receiving a signal, it must wait for the transmitter to stop transmitting, before replying.

An example of a half-duplex system is a two-party system such as a [walkie-talkie](https://en.wikipedia.org/wiki/Walkie-talkie), wherein one must use "over" or another previously designated keyword to indicate the end of transmission and ensure that only one party transmits at a time, because both parties transmit and receive on the same frequency. A good analogy for a half-duplex system would be a one-lane road with traffic controllers at each end, such as a two-lane bridge under re-construction. Traffic can flow in both directions, but only one direction at a time, regulated by the traffic controllers.

Half-duplex systems are usually used to conserve [bandwidth](https://en.wikipedia.org/wiki/Bandwidth_(signal_processing)) since only a single [communication channel](https://en.wikipedia.org/wiki/Communication_channel) is needed, which is shared alternately between the two directions. For example, a walkie-talkie requires only a single [frequency](https://en.wikipedia.org/wiki/Frequency) for bidirectional communication, while a [cell phone](https://en.wikipedia.org/wiki/Cell_phone), which is a full-duplex device, requires two frequencies to carry the two simultaneous voice channels, one in each direction.

In automatically run communications systems, such as two-way data-links, the time allocations for communications in a half-duplex system can be firmly controlled by the hardware. Thus, there is no waste of the channel for switching. For example, station A on one end of the data link could be allowed to transmit for exactly one second, then station B on the other end could be allowed to transmit for exactly one second, and then the cycle repeats.

In half-duplex systems, if more than one party transmits at the same time, a [collision](https://en.wikipedia.org/wiki/Collision_(telecommunications)) occurs, resulting in lost messages.

**Full duplex**

[](https://en.wikipedia.org/wiki/File:FullDuplex.JPG)

A simple illustration of a full-duplex communication system. Full-duplex is not common in handheld radios as shown here due to the cost and complexity of common duplexing methods, but is used in [telephones](https://en.wikipedia.org/wiki/Telephone), [cellphones](https://en.wikipedia.org/wiki/Cellphone) and [cordless phones](https://en.wikipedia.org/wiki/Cordless_phone).

A *full-duplex* (FDX) system, or sometimes called *double-duplex*, allows communication in both directions, and, unlike half-duplex, allows this to happen simultaneously. Land-line [telephone](https://en.wikipedia.org/wiki/Telephone) networks are full-duplex since they allow both callers to speak and be heard at the same time, with the transition from four to two wires being achieved by a [hybrid coil](https://en.wikipedia.org/wiki/Hybrid_coil) in a [telephone hybrid](https://en.wikipedia.org/wiki/Telephone_hybrid). Modern cell phones are also full-duplex.[[1]](https://en.wikipedia.org/wiki/Duplex_(telecommunications)#cite_note-1)

Technically, there is a distinction between full-duplex communication, using a single physical communication channel for both directions simultaneously and ***dual-simplex*** communication that uses two distinct channels, one for each direction. From the user perspective, the technical difference doesn't matter and both variants are commonly referred to as *full duplex*.

A good analogy for a full-duplex system is a two-lane road with one lane for each direction. Moreover, in most full-duplex mode systems carrying computer data, transmitted data does not appear to be sent until it has been received and an acknowledgment is sent back by the other party. In this way, such systems implement reliable transmission methods.

Two-way radios can be designed as full-duplex systems, transmitting on one frequency and receiving on another; this is also called frequency-division duplex. Frequency-division duplex systems can extend their range by using sets of simple repeater stations because the communications transmitted on any single frequency always travel in the same direction.

[Full-duplex Ethernet](https://en.wikipedia.org/wiki/Full-duplex_Ethernet) connections work by making simultaneous use of two physical [twisted pairs](https://en.wikipedia.org/wiki/Twisted_pair) inside the same jacket, which are directly connected to each networked device: one pair is for receiving packets, while the other pair is for sending packets. This effectively makes the cable itself a collision-free environment and doubles the maximum total transmission capacity supported by each Ethernet connection.

Full-duplex has also several benefits over the use of half-duplex. First, there are no collisions so time is not wasted by having to retransmit frames. Second, full transmission capacity is available in both directions because the send and receive functions are separate. Third, since there is only one transmitter on each twisted pair, stations (nodes) do not need to wait for others to complete their transmissions.

Some computer-based systems of the 1960s and 1970s required full-duplex facilities, even for half-duplex operation, since their poll-and-response schemes could not tolerate the slight delays in reversing the direction of transmission in a half-duplex line.

## Full-duplex emulation

Where [channel access methods](https://en.wikipedia.org/wiki/Channel_access_method) are used in [point-to-multipoint](https://en.wikipedia.org/wiki/Point-to-multipoint_communication) networks (such as [cellular networks](https://en.wikipedia.org/wiki/Cellular_network)) for dividing forward and reverse communication channels on the same physical communications medium, they are known as duplexing methods.

### Time-division duplexing

*Time-division duplexing* (TDD) is the application of [time-division multiplexing](https://en.wikipedia.org/wiki/Time-division_multiplexing) to separate outward and return signals. It emulates full duplex communication over a half duplex communication link.

Time-division duplexing is flexible in the case where there is [asymmetry](https://en.wikipedia.org/wiki/Asymmetry) of the [uplink](https://en.wikipedia.org/wiki/Telecommunications_link) and [downlink](https://en.wikipedia.org/wiki/Downlink) data rates. As the amount of uplink data increases, more communication capacity can be dynamically allocated, and as the traffic load becomes lighter, capacity can be taken away. The same applies in the downlink direction. The *transmit/receive transition gap* (TTG) is the gap (time) between a downlink burst and the subsequent uplink burst. Similarly, the *receive/transmit transition gap* (RTG) is the gap between an uplink burst and the subsequent downlink burst.[[2]](https://en.wikipedia.org/wiki/Duplex_(telecommunications)#cite_note-2)

For stationary radio systems, the uplink and downlink radio paths are likely to be very similar. This means that techniques such as [beamforming](https://en.wikipedia.org/wiki/Beamforming) work well with TDD systems.

Examples of time-division duplexing systems include:

* [UMTS](https://en.wikipedia.org/wiki/UMTS) 3G supplementary air interfaces [TD-CDMA](https://en.wikipedia.org/wiki/TD-CDMA) for indoor mobile telecommunications.
* The Chinese [TD-LTE](https://en.wikipedia.org/wiki/TD-LTE) [4-G](https://en.wikipedia.org/wiki/4-G), [TD-SCDMA](https://en.wikipedia.org/wiki/TD-SCDMA) [3-G](https://en.wikipedia.org/wiki/3G) mobile communications air interface.
* [DECT](https://en.wikipedia.org/wiki/DECT) wireless telephony
* Half-duplex [packet switched](https://en.wikipedia.org/wiki/Packet_switched) networks based on [carrier sense multiple access](https://en.wikipedia.org/wiki/Carrier_sense_multiple_access), for example 2-wire or [hubbed Ethernet](https://en.wikipedia.org/wiki/Ethernet_hub), [Wireless local area networks](https://en.wikipedia.org/wiki/Wireless_local_area_network) and [Bluetooth](https://en.wikipedia.org/wiki/Bluetooth), can be considered as time-division duplexing systems, albeit not TDMA with fixed frame-lengths.
* [IEEE 802.16](https://en.wikipedia.org/wiki/IEEE_802.16) [WiMAX](https://en.wikipedia.org/wiki/WiMAX)
* [PACTOR](https://en.wikipedia.org/wiki/PACTOR)
* ISDN BRI [U interface](https://en.wikipedia.org/wiki/U_interface), variants using the time-compression multiplex (TCM) line system
* [G.fast](https://en.wikipedia.org/wiki/G.fast), a [digital subscriber line](https://en.wikipedia.org/wiki/Digital_subscriber_line) (DSL) standard developed by the [ITU-T](https://en.wikipedia.org/wiki/ITU-T)

### Frequency-division duplexing

*Frequency-division duplexing* (FDD) means that the [transmitter](https://en.wikipedia.org/wiki/Transmitter) and [receiver](https://en.wikipedia.org/wiki/Receiver_(radio)) operate using different [carrier frequencies](https://en.wikipedia.org/wiki/Carrier_frequencies). The method is frequently used in [ham radio](https://en.wikipedia.org/wiki/Ham_radio) operation, where an operator is attempting to use a [repeater](https://en.wikipedia.org/wiki/Repeater) station. The repeater station must be able to send and receive a transmission at the same time and does so by slightly altering the frequency at which it sends and receives. This mode of operation is referred to as *duplex mode* or *offset mode*.

Uplink and downlink sub-bands are said to be separated by the *frequency offset*. Frequency-division duplexing can be efficient in the case of symmetric traffic. In this case, time-division duplexing tends to waste bandwidth during the switch-over from transmitting to receiving, has greater inherent [latency](https://en.wikipedia.org/wiki/Lag), and may require more complex [circuitry](https://en.wikipedia.org/wiki/Circuitry).

Another advantage of frequency-division duplexing is that it makes radio planning easier and more efficient since base stations do not "hear" each other (as they transmit and receive in different sub-bands) and therefore will normally not interfere with each other. Conversely, with time-division duplexing systems, care must be taken to keep guard times between neighboring base stations (which decreases [spectral efficiency](https://en.wikipedia.org/wiki/Spectral_efficiency)) or to synchronize base stations, so that they will transmit and receive at the same time (which increases network complexity and therefore cost, and reduces bandwidth allocation flexibility as all base stations and sectors will be forced to use the same uplink/downlink ratio)

Examples of frequency-division duplexing systems are:

* [ADSL](https://en.wikipedia.org/wiki/ADSL) and [VDSL](https://en.wikipedia.org/wiki/VDSL)
* Most [mobile technology](https://en.wikipedia.org/wiki/Mobile_technology), including the [UMTS](https://en.wikipedia.org/wiki/UMTS)/[WCDMA](https://en.wikipedia.org/wiki/WCDMA) use frequency-division duplexing mode and the [cdma2000](https://en.wikipedia.org/wiki/Cdma2000) system.
* [IEEE 802.16](https://en.wikipedia.org/wiki/IEEE_802.16) [WiMax](https://en.wikipedia.org/wiki/WiMax) also uses frequency-division duplexing mode.

### Echo cancellation

Full-duplex audio systems like telephones can create echo, which needs to be removed. Echo occurs when the sound coming out of the speaker, originating from the far end, re-enters the microphone and is sent back to the far end. The sound then reappears at the original source end but delayed. This feedback path may be acoustic, through the air, or it may be mechanically coupled, for example in a telephone handset. [Echo cancellation](https://en.wikipedia.org/wiki/Echo_cancellation) is a signal-processing operation that subtracts the far-end signal from the microphone signal before it is sent back over the network.

Echo cancellation is important technology allowing [modems](https://en.wikipedia.org/wiki/Modem) to achieve good full-duplex performance. The V.32, V.34, V.56, and V.90 [modem standards](https://en.wikipedia.org/wiki/ITU-T_V-Series_Recommendations) require echo cancellation.[[3]](https://en.wikipedia.org/wiki/Duplex_(telecommunications)#cite_note-3)

Echo cancelers are available as both software and hardware implementations. They can be independent components in a communications system or integrated into the communication system's [central processing unit](https://en.wikipedia.org/wiki/Central_processing_unit). Devices that do not eliminate echo sometimes will not produce good full-duplex performance.