CHANNEL LENGTH MODULATION

Channel length modulation (CLM) is an effect in field effect transistors, a shortening of the length of the inverted channel region with increase in drain bias for large drain biases. The result of CLM is an increase in current with drain bias and a reduction of output resistance. It is one of several short-channel effects in MOSFET scaling. It also causes distortion in JFET amplifiers.

To understand the effect, first the notion of pinch-off of the channel is introduced. The channel is formed by attraction of carriers to the gate, and the current drawn through the channel is nearly a constant independent of drain voltage in saturation mode. However, near the drain, the gate and drain jointly determine the electric field pattern. Instead of flowing in a channel, beyond the pinch-off point the carriers flow in a subsurface pattern made possible because the drain and the gate both control the current. In the figure at the right, the channel is indicated by a dashed line and becomes weaker as the drain is approached, leaving a gap of uninverted silicon between the end of the formed inversion layer and the drain (the pinch-off region).

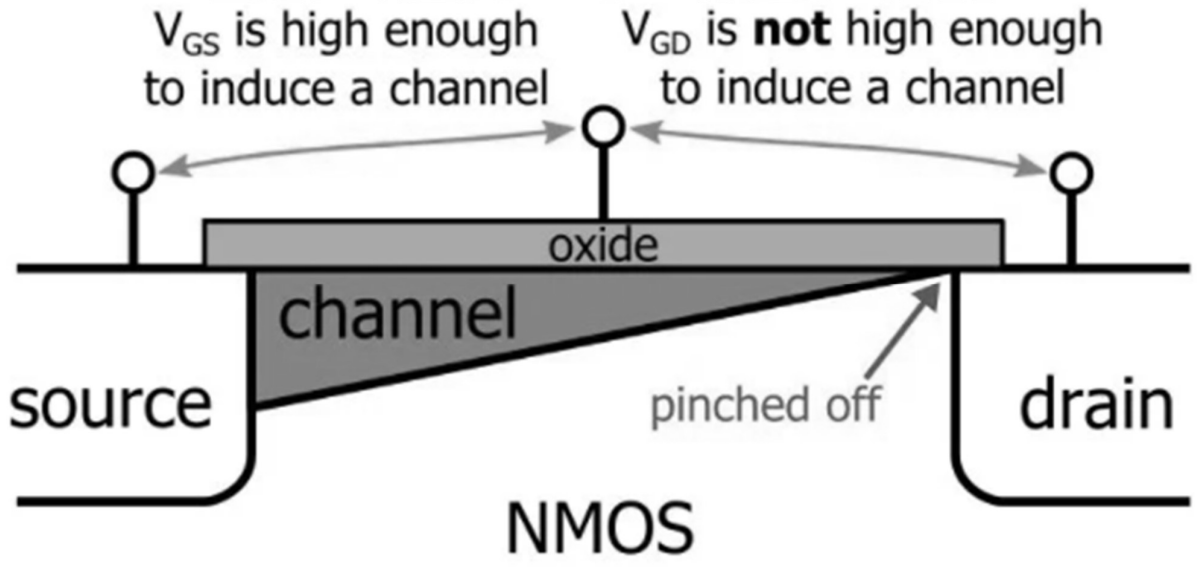

Fig: Pinch off Voltage

As the drain voltage increases, its control over the current extends further toward the source, so the uninverted region expands toward the source, shortening the length of the channel region, the effect called channel-length modulation. Because resistance is proportional to length, shortening the channel decreases its resistance, causing an increase in current with increase in drain bias for a MOSFET operating in saturation. The effect

is more pronounced the shorter the source-to-drain separation, the deeper the drain junction, and the thicker the oxide insulator.

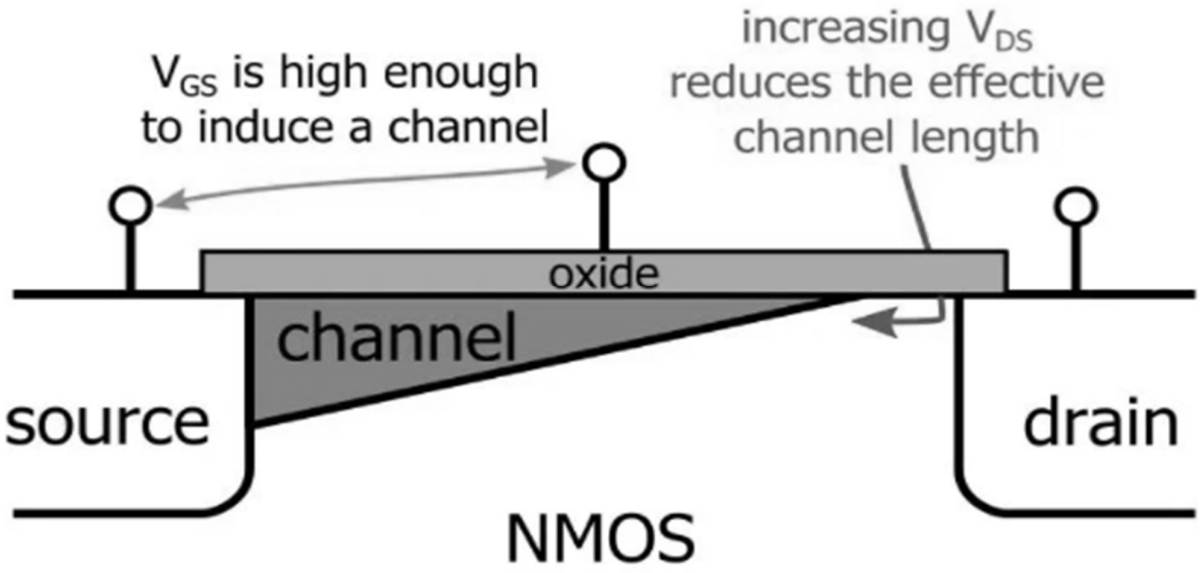

Fig: Channel-Length Modulation

In the weak inversion region, the influence of the drain analogous to channel-length modulation leads to poorer device turn off behavior known as drain-induced barrier lowering, a drain induced lowering of threshold voltage.

In bipolar devices, a similar increase in current is seen with increased collector voltage due to base-narrowing, known as the Early effect. The similarity in effect upon the current has led to use of the term "Early effect" for MOSFETs as well, as an alternative name for "channel-length modulation".

The effect of channel-length modulation upon the MOSFET output resistance varies both with the device, particularly its channel length, and with the applied bias. The main factor affecting the output resistance in longer MOSFETs is channel length modulation as just described. In shorter MOSFETs additional factors arise such as: drain-induced barrier lowering (which lowers the threshold voltage, increasing the current and decreasing the output resistance), velocity saturation (which tends to limit the increase in channel current with drain voltage, thereby increasing the output resistance) and ballistic transport (which modifies the collection of current by the drain, and modifies drain-induced barrier lowering so as to increase supply of carriers to the pinch-off region, increasing the current and decreasing the output resistance).

COMPARISON OF MOSFET WITH BJT.

Parameter	BJT	MOSFET
Full form	BJT stands for Bipolar Junction Transistor.	MOSFET stands for Metal Oxide Semiconductor Field Effect Transistor.
Definition	BJT is a three-terminal semiconductor device used for switching and amplification of signals.	MOSFET is a four-terminal semiconductor device which is used for switching applications.
Types	Based on the construction, BJTs are classified into two types: NPN and PNP.	Based on the construction and operation, the MOSFETs are classified into four types: P-channel enhancement MOSFET, N-channel enhancement MOSFET, P-channel depletion MOSFET and N-channel depletion MOSFET.
Terminals	BJT has three terminals viz. emitter, base and collector.	MOSFET has four terminals, i.e., source, drain, gate and body (or substrate).
Charge carriers	In BJT, both electrons and holes act as charge carriers	In MOSFET, either electrons or holes act as charge carriers depending on the type of channel between source and drain.
Polarity	BJT is a bipolar device.	MOSFET is a unipolar device.
Controlling quantity	BJT is a current controlled device.	MOSFET is a voltage controlled device.
Input impedance	BJT has low input impedance.	MOSFET has relatively high input impedance.
Temperature coefficient	BJT has negative temperature coefficient	MOSFET has positive temperature coefficient.
Switching frequency	The switching frequency BJT is low.	For MOSFET, the switching frequency is relatively high.
Power consumption	BJT consumes more power than MOSFET.	The power consumed by a MOSFET is less than BJT
Applications	BJT is preferred for the low current applications. It is widely used as amplifiers, oscillators and electronic switches.	MOSFET is suitable for high power applications. It is used in power supplies, etc