ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 11, November 2014

Comparison of MOSFET Characteristic Using Spice and MATLAB Simulation

Archana Yadav[1], Gaurav Bhardwaj[2]

M.Tech Student, Dept. of ECE, RJIT, BSF Academy Tekanpur, Gwalior, M.P, India[1]

Assistant professor, Dept. of ECE, RJIT, BSF Academy Tekanpur, Gwalior, M.P, India[2]

ABSTRACT: In this paper, comparison of MOSFET characteristic have been performed with the help of LT-SPICE and MATLAB simulation. Firstly, using LT-spice MOSFET characteristic plots have been drawn after that these characteristic plots have been verified using MATLAB simulation. Simulation results of LT-SPICE and MATLAB are compared and it is found that both are in close agreement. Due to the effect of channel length modulation the characteristics behaviour of MOSFET is also studied using MATLAB& LT-spice.

KEYWORDS: MOSFET, Channel Length Modulation, MATLAB

I.INTRODUCTION

At the down of its fifth decade, the semiconductor industry continues to grow at a surprising pace. High speed and low-power integrated circuits are used in an ever expanding plethora of applications, permeating every aspect of our life. In the electronics industry, a simulation tool such as SPICE has created a need for an in-house capability for fast and accurate measurement of semiconductor device parameters.

SPICE is the most widely used electronic circuit simulation tool. It is widely used in industry for analog circuit simulation and electronic design verification. In the SPICE modelling of bipolar devices, the parameters can be extracted from two separately measured terminal I-V characteristics (input and output) [1]. However, SPICE models of the field-effect transistors like JFETs, MESFETs and MOSFETs require trans-conductive transfer characteristics in addition to the I-V characteristics measured at their output terminals. In this paper, there is a study of MOSFET drain-source current with drain-source voltage for the different value of gate-source voltage. In saturation region, if drain-source voltage exceeds, drain current does not follow the parabolic behaviour and it becomes relatively constant[2] .In channel length modulation, MOS enters into the saturation region the drain current should remain constant and channel length L being as a constant this is not so. The space charge region at the drain junction varies with the drain voltage. This makes length as a function of V_{DS}. As the channel length decreases with increasing V_{DS}, the drain current increases. For average channel length, we find I_D at a given V_{DS} and another I_D at another $V_{DS.}$

MATLAB is numeric computation software for engineering and scientific calculations [7]. The causes of MATLAB popularity are legion. Among them are its iterative mode of operation, built-in functions, simple programming, rich set of graphing facilities, possibilities for writing additional functions, and its extensive toolboxes. MATLAB is used to solving electronics problems and provide various ways to solve circuit analysis problems [4]. In this paper, MATLAB is used for the study of I-V characteristics of an n-channel enhancement type MOSFET for different values of gate-source voltage. Where I_{ds} denotes the drain-source current and V_{ds} denotes the drain-source voltage and V_{gs} denotes the voltage of gate-source.

II.SPICE SIMULATION

In fig.1 a circuit diagram has been shown for output characteristics. In this circuit diagram a NMOS transistor has been used and voltage parameter as shown in diagram. Simulation result of this circuit has been in fig.2 which shows the output characteristics of MOSFET.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 11, November 2014

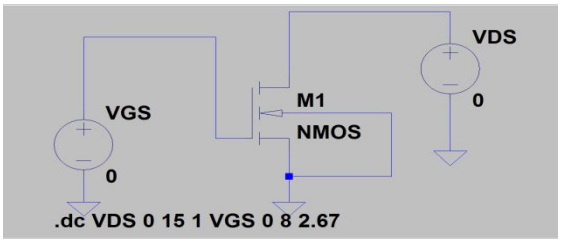

Fig.1 Circuit diagram of MOSFET used in extraction from I_{DS} Vs V_{DS} characteristic.

Output characteristics :- (I_{DS} V_S V_{DS} for values of V_{GS}=4V, 6V, 8V)

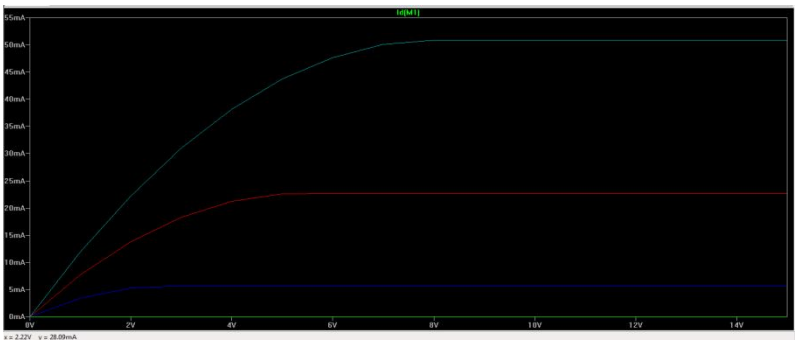

Fig.2 I_{DS} V_S V_{DS} characteristic

In fig.2 it is found that if device operates in saturation region and drain source voltage exceeds gate source voltage i.e. after saturation point, drain current becomes relatively constant as shown in fig 2. There is saturation for voltage 4V, 6V &8V after that current Id becomes constant.

According, to channel length modulation effect if MOS enter into the saturation region, the drain current should remain constant. Here L is a function of V_{DS}. As the channel length decreases with increasing V_{DS}, the drain current increases. This is easily modelled using a parameter λ which is a constant linearly proportional to V_{DS} .so, we find the I_{DS} for a given value of $V_{ds.}$

In fig.3 a circuit diagram has been shown for output characteristics. In this circuit diagram a NMOS AO6408 (.model AO6408 Vdmos (Rg =3m, Rd=4.8m, Rs=3.6m, Vt=1v,Kp=90,Vds=20v R=12m,Q=18n))model has been used and voltage parameter as shown in diagram. Simulation result of this circuit has been shown below which shows the output characteristics of MOSFET for $V_{GS=}$4v.

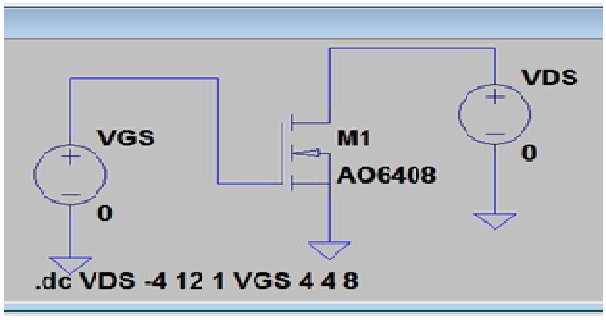

Fig.3 Circuit diagram for I_{DS} Vs V_{DS} at V_{GS}= 4V.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 11, November 2014

Output characteristics (I_{DS} V_S V_{DS} for V_{GS}=4v)

Fig.4 I_{DS} V_S V_{DS} characteristics.

In Fig.4 output characteristics I_{ds} Vs V_{ds} has been shown for MOSFET. If channel length decreases, there is a reverse saturation current below 0v as shown in figure. Here V[n002] is node 2 and is fixed for V_{gs}=4v. After a value of 4v for drain voltage the drain-source current is constant.

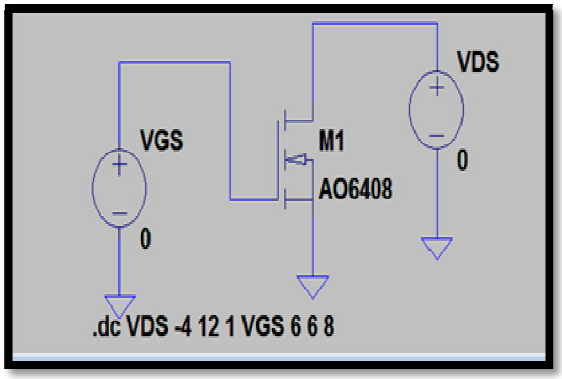

Fig.5 Circuit diagram for I_{DS} Vs V_{DS} at V_{GS}=6v

In fig.5 a circuit diagram has been shown for output characteristics. In this circuit diagram a NMOS A06408 (.model AO6408 Vdmos (Rg=3m, Rd=4.8m, Rs=3.6m,Vt=1v,Kp=90,Vds=20v R=12m,Q=18n)) model has been used and voltage parameter as shown in diagram. Simulation result of this circuit has been shown below which shows the output characteristics of MOSFET.

Output characteristics (I_{DS} V_S V_{DS} for V_{GS}=6v)

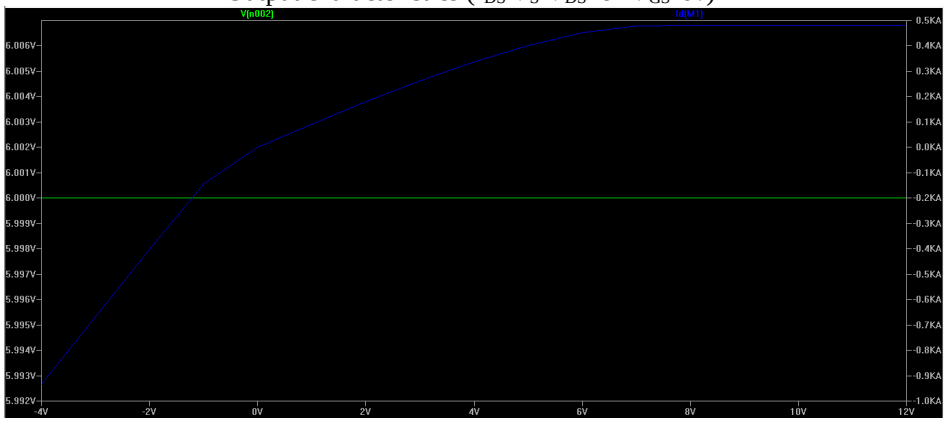

Fig.6 I_{DS} V_S V_{DS} characteristics

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 11, November 2014

In Fig.6 output characteristics I_{ds} V_s V_{ds} has been shown for mosfet . If channel length decreases , there is a reverse saturation current below 0v as shown in figure. Here V[n002] is node 2 and is fixed for V_{gs}=6v. After a value of 6v for drain voltage the drain-source current is constant and drain current is measured.

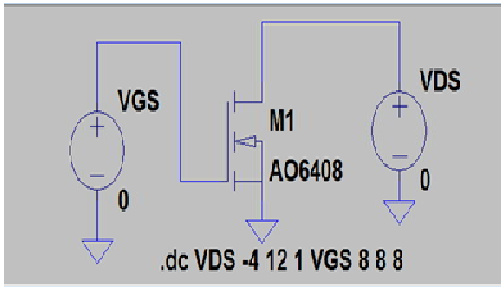

Fig.7 Circuit diagram for I_{DS} Vs V_{DS} at V_{GS}=8v

In fig.7 a circuit diagram has been shown for output characteristics. In this circuit diagram a NMOS A06408 (.model AO6408 Vdmos (Rg=3m, Rd=4.8m,Rs=3.6m,Vt=1v,Kp=90,Vds=20v R=12m,Q=18n)) model has been used and voltage parameter as shown in diagram. Simulation result of this circuit has been shown below which shows the output characteristics of MOSFET.
Output characteristics (I_{DS} V_S V_{DS} for V_{GS}=8v):

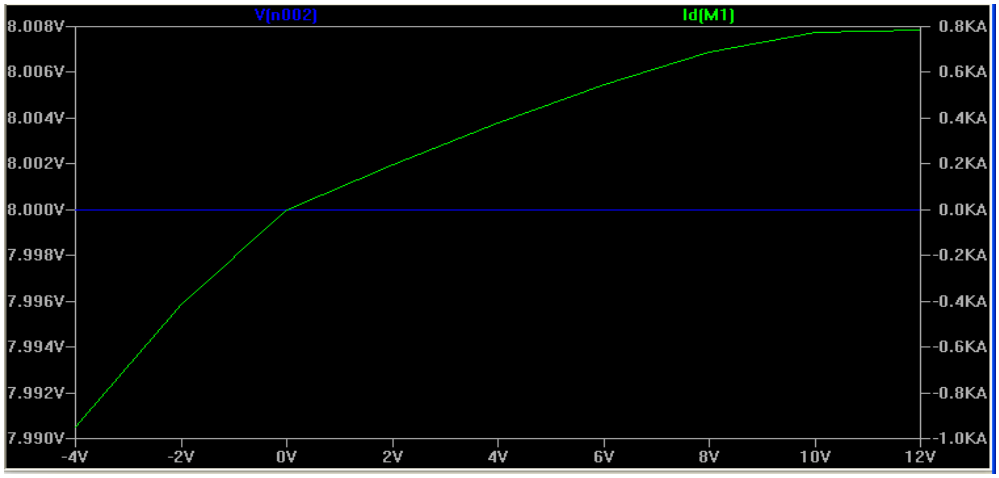

Fig.8 I_{DS} V_S V_{DS} characteristics

In Fig.8 output characteristics I_{ds} Vs V_{DS} has been shown for MOSFET. If channel length decreases, there is a reverse saturation current below 0v as shown in figure. Here V[n002] is node 2 and is fixed for V_{gs} = 8v. After a value of 8v for drain voltage the drain-source current is constant and drain current is measured from here.

III.MATLAB SIMULATION

For validation of result, MATLAB simulation has been performed and simulation result are shown in fig.1,2. Fig 1 is simulation result of output characteristics of MOSFET for V_{gs}=4v,6v, & 8v. In fig.2 channel length effect has been shown for V_{gs}=2.5v.

Output characteristics :- (I_{DS} V_S V_{DS} for different values of V_{GS})

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 11, November 2014

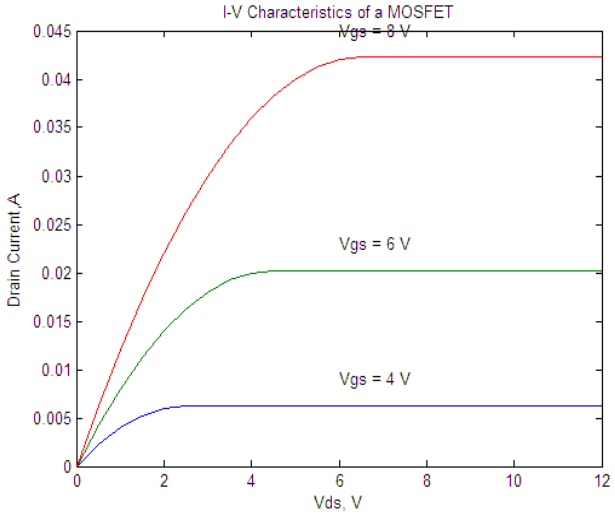

Fig.9 I-V characteristics of N-channel enhancement type MOSFET.

In the analysis of channel pinch off, is noted that the actual length of the inverted channel gradually decrease as the potential difference between the gate and the drain increases. The resistance between source and pinch-off point drops, so there results a lowering of output resistance with increase in drain bias. This phenomenon is called either channel-length modulation or the Early effect. If MOSFET enters into the saturation region, the drain current should remain constant, but this is not so. . The space charge region at the drain junction varies with the drain voltage. This makes L is a function of V_{DS}. As the channel length decreases with increasing V_{DS}, the drain current increases. Fig10. Shows the drain current with increasing drain source voltage and slope is obtained from channel length modulation effect.

I-V Characteristics of MOSFET for V_{gs} =2.5v

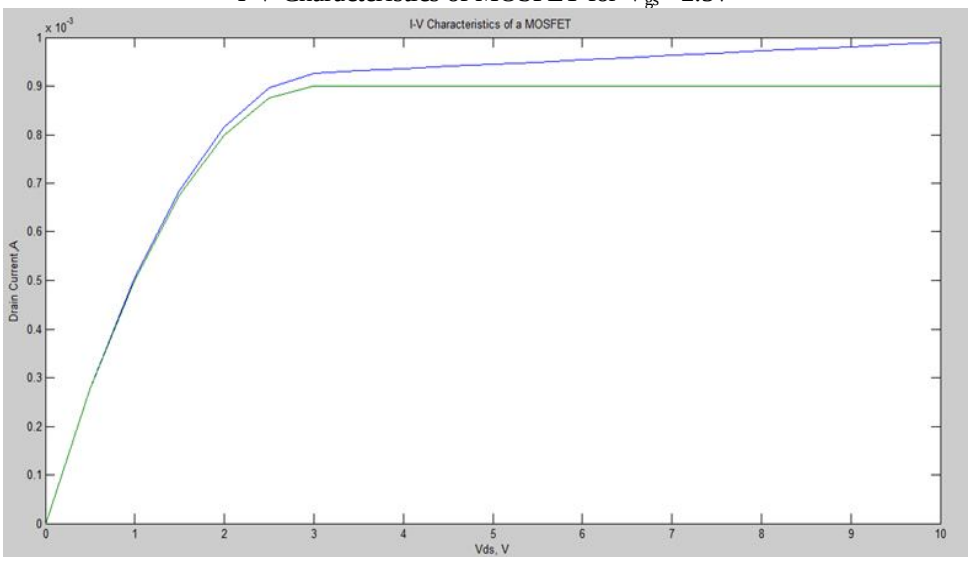

Fig.10: Finite saturation region slope resulting from channel-length modulation.

IV. COMPARISON OF RESULTS OF SPICE& MATLAB

In the below figures 10,11,12 there is a comparative study of drain-source current with drain-source voltage when different gate-source voltage is applied for MOSFET and behaviour of current has been shown from both simulation results.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 11, November 2014

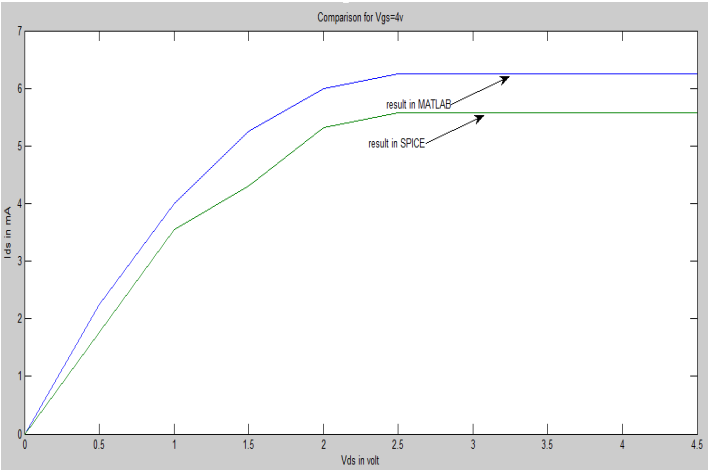

Fig.11 I-V curve obtained for applied gate-source voltage 4v.

The above figure shows that the value of drain current is in approximation for both Spice &MATLAB simulation results and after value 2.5v for drain source voltage the drain current becomes constant for both simulation results.

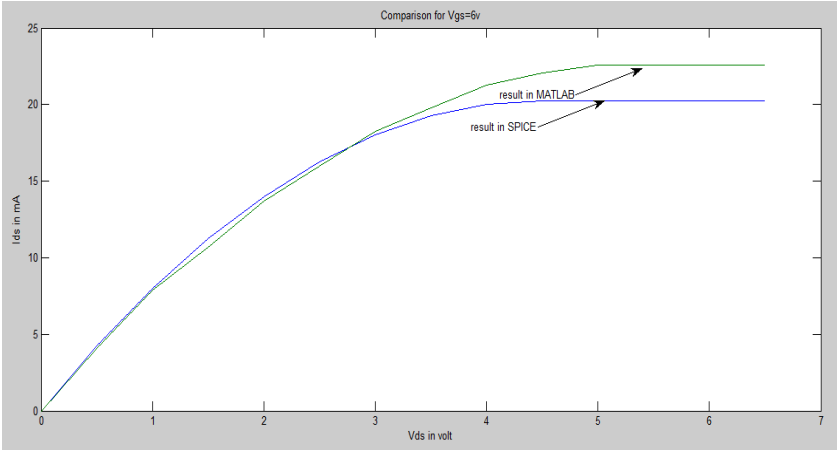

Fig.12 I-V curve obtained for applied gate-source voltage 6v.

The above figure shows that the value of drain current is close to each other for both Spice &MATLAB simulation results and after value 4.5v for drain source voltage the drain current becomes constant for both simulation results.

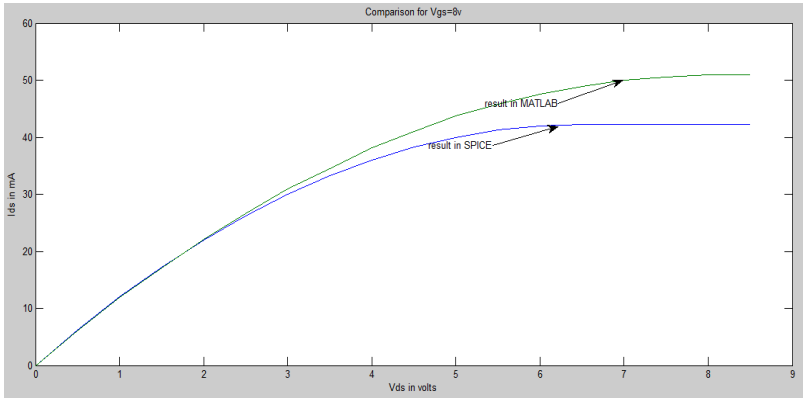

Fig.13 I-V curve obtained for applied gate-source voltage 8v

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 11, November 2014

From above figure it is clear that the value of drain current is highly closed for both Spice &MATLAB simulation results. it is concluded that after value 6.5v for drain source voltage the drain current becomes constant.

V. CONCLUSION

The paper presents the characteristic plots of MOSFET using MATLAB implementation of program codes. The characteristic plots of MOSFET are studied using LT-Spice and MATLAB. The I-V characteristics of MOSFET obtained from LT-spice and MATLAB simulation shows good accuracy in all operational regions. It is found that the simulation results for both Spice and MATLAB are suitable & close to each other and also verified using MATLAB. A new idea comes to share that other BJT, MOSFET model can also be studied by using MATLAB & LT-Spice.

REFERENCES

[1] Mustafa G. Guvench,"SPICE Parameter Extraction From Automated Measurement Of JFET and MOSFET Characteristics In The Computer-Integrated Electronics Laboratory," paper published in proceeding of A.S.E.E.,1994.
[2] Behzad Razavi, "Design of Analog CMOS Integrated circuit,"Tata McGrow-Hill Edition 2002.
[3] S Salivahanan and N Suresh Kumar, "Electronics Devices and Circuit,"3rd ed., McGrow-Hill Education pvt.2012.
[4] John O. Attia, "Electronic and Circuit Analysis using MATLAB,"CRC Press LLC New York Washington,D.C.1999.
[5] L.V. Hmurcik, M. Httinger, K.S. Gottschalk and F.L. Fitchen, "SPICE Applications to an Undergraduate Electronics Program," IEEE Trans. on Education, vol.33, pp.183-189, 1990.
[6] Le Duc Hung, Vo Thanh Tri, Nguyen Thi Thien Trang, "A MOSFET parameter extraction tool using EKV model and Matlab,"University of Science-VNUHCM.
[7] Rudra Pratap, "MATLAB A Quick Introduction for Scientist and Engineers,"Oxford University Press, New York 2002.
[8] Suayb YENER1, Hakan KUNTMAN2, "Algorithms on the Extraction of BSIM MOSFET Model Parameters via Measurement Data," Sakarya University, Turkey.