

# Qucs

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Compact device - circuit macromodel specification

A Curtice level 1 MESFET model

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## Introduction

The Metal and Semiconductor FET (MESFET) is a Schottky-barrier gate FET made from gallium arsenide. It is popular for high frequency applications because of its high electron mobility. The device was developed by Walter R. Curtice<sup>1</sup> in 1980 at the RCA Laboratory in Princeton, New Jersey. USA. The MESFET model presented below is based on a Qucs equation defined device (EDD) which functions as a Curtice level 1 MESFET model with interelectrode capacitances. Basic temperature effects are also included.

## Qucs EDD model for the Curtice MESFET

Parameters

Name	Symbol	Description	Unit	Default
RG	$R_G$	external gate resistance	$\Omega$	1m
RD	$R_D$	external drain resistance	$\Omega$	1m
RS	$R_S$	external source resistance	$\Omega$	1m
VBR	$V_{DR}$	GS breakdown voltage	V	$10^{10}$
LG	$L_G$	external gate lead inductance	H	0
LD	$L_D$	external drain lead inductance	H	0
LS	$L_S$	external source lead inductance	H	0
Is	$I_S$	diode saturation current	A	10f
N	$N$	diode emission coefficient		1
XTI	$X_{TI}$	diode saturation current temperature coefficient		0
EG	$E_G$	diode energy gap	eV	1.11
TAU	$\tau$	internal time delay from drain to source	s	10p
RIN	$R_{IN}$	series resistance to CGS	$\Omega$	1m
CGS	$C_{GS}$	interelectrode gate-source bias-independent capacitance	F	300f
CGD	$C_{GD}$	interelectrode gate-drain bias-independent capacitance	F	300f
CDS	$C_{DS}$	interelectrode drain-source bias-independent capacitance	F	300f
Tnom	$T_{NOM}$	device parameter measurement temperature	$^{\circ}\text{C}$	27
Temp	$T$	device temperature	$^{\circ}\text{C}$	27
Alpha	$\alpha$	coefficient of $V_{ds}$ in tanh function for quadratic model	1/V	0.8

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<sup>1</sup>W.R Curtice, 1980, A MESFET model for use in the design of GaAs integrated circuits, IEEE Transactions on Microwave Theory and Techniques, MTT-28, pp. 448-456.

Name	Symbol	Description	Unit	Default
Beta	$\beta$	transconductance parameter	A/V <sup>2</sup>	3m
Lambda	$\lambda$	channel length modulation parameter for quadratic model	1/V	40m
VTO	$V_{TO}$	quadratic model gate threshold voltage	V	-6

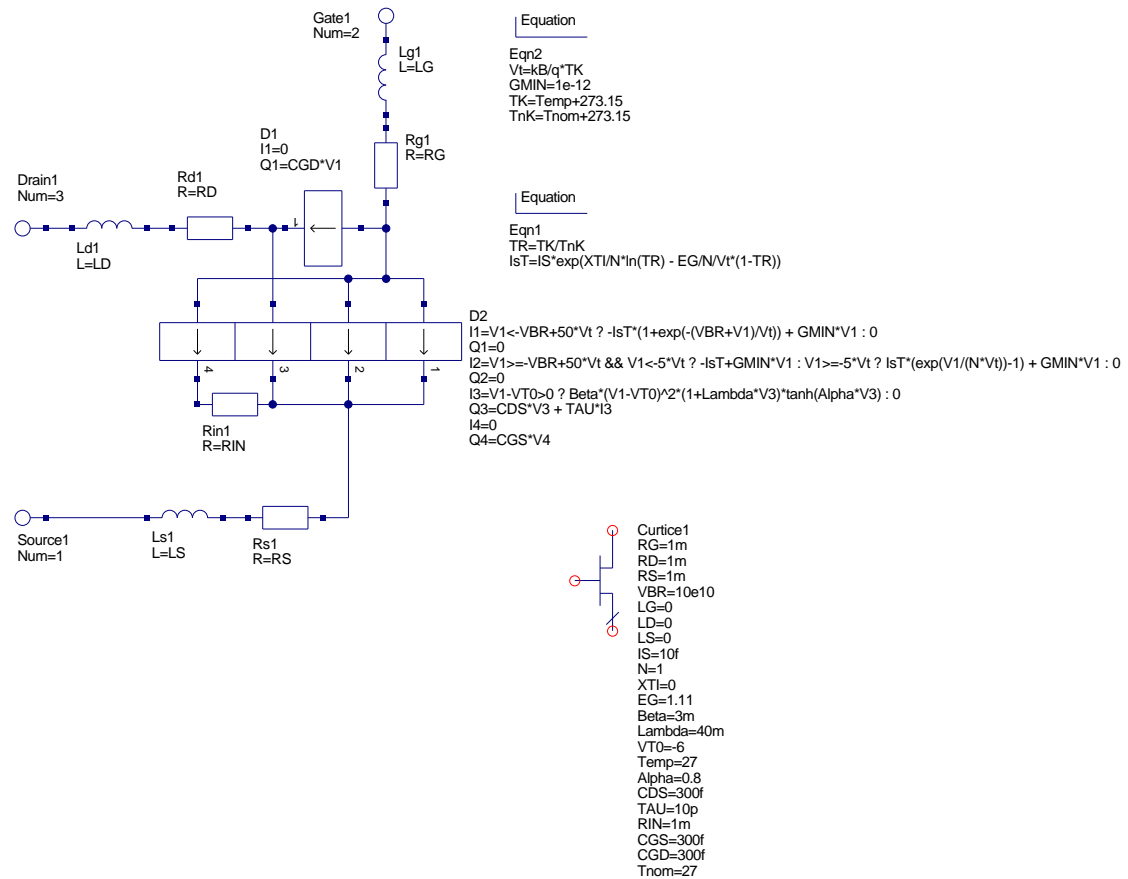


Figure 1: A Qucs EDD model for the Curtice MESFET

## The MESFET equations

- DC characteristics

1. for  $(V_{GS} < -V_{BR} + 50 \cdot V_T)$

$$I_{GS} = -I_S(T) \cdot \left(1 + \exp\left(-\frac{V_{BR} + V_{GS}}{V_T}\right)\right) + G_{MIN} \cdot V_{GS} \quad (1)$$

2. for  $(V_{GS} \geq -V_{BR} + 50 \cdot V_T)$  and  $(V_{GS} < -5 \cdot V_T)$

$$I_{GS} = -I_S(T) + G_{MIN} \cdot V_{GS} \quad (2)$$

3. for  $(V_{GS} \geq -5 \cdot V_T)$

$$I_{GS} = I_S(T) \cdot \left(\exp\left(\frac{V_{GS}}{N \cdot V_T}\right) - 1\right) + G_{MIN} \cdot V_{GS} \quad (3)$$

4. for  $(V_{GS} - V_{TO}) > 0$

$$I_{DS} = \beta \cdot (V_{GS} - V_{TO})^2 \cdot (1 + \lambda \cdot V_{DS}) \cdot \tanh(\alpha \cdot V_{DS}) \quad (4)$$

Where

$$I_S(T) = I_S \cdot \exp\left(\frac{X_{TI}}{N} \cdot \ln(TR) - (E_G/N/V_T) \cdot (1 - TR)\right) \quad (5)$$

$$Tr = \frac{TK}{TnK} \quad \text{and} \quad TK = T + 273.15, \quad TnK = T_{NOM} + 273.15 \quad (6)$$

- MESFET charge equations

- 1.

$$Q_{GS} = C_{GS} \cdot V_{GS} \quad (7)$$

- 2.

$$Q_{GD} = C_{GD} \cdot V_{GD} \quad (8)$$

- 3.

$$Q_{DS} = C_{DS} \cdot V_{DS} + \tau \cdot I_{DS} \quad (9)$$

## Test circuits and simulation results

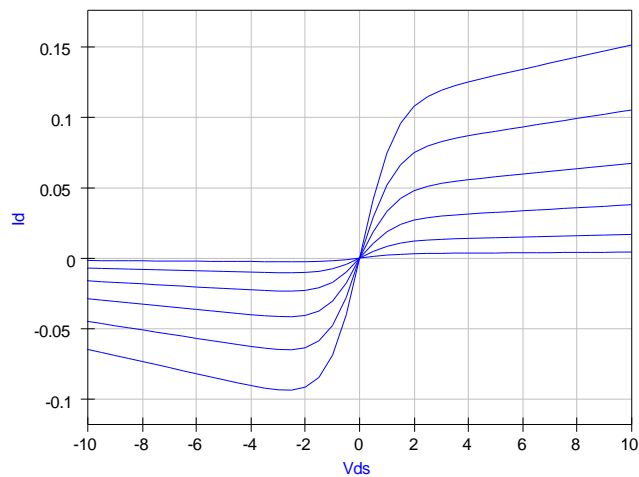
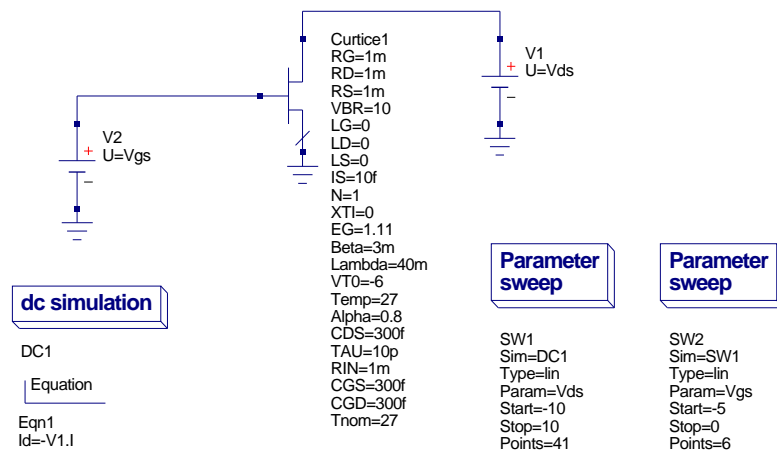


Figure 2: DC test circuit and  $I_d$ - $V_{ds}$  characteristics

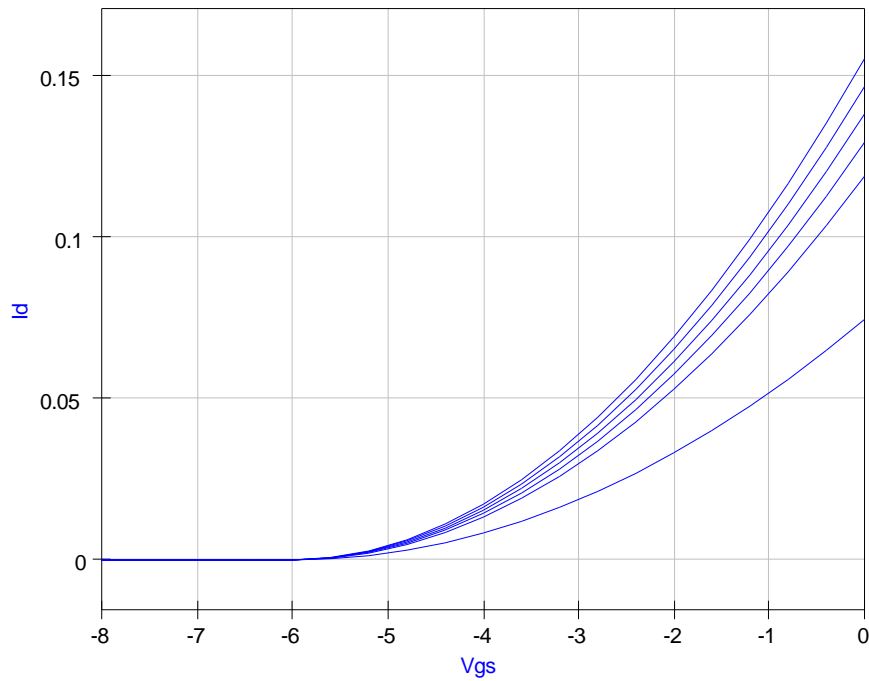
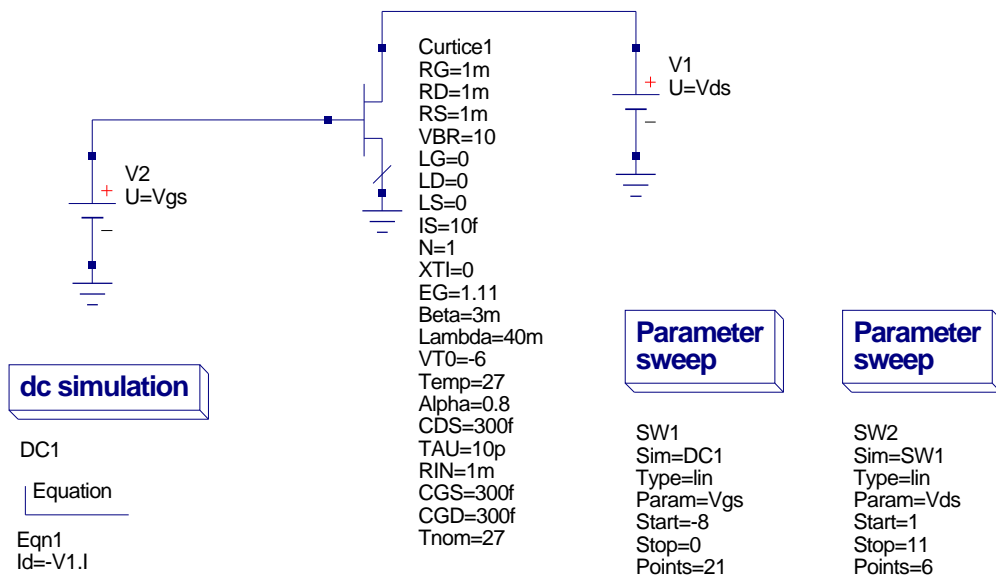


Figure 3: DC test circuit and  $I_d$ - $V_{gs}$  characteristics

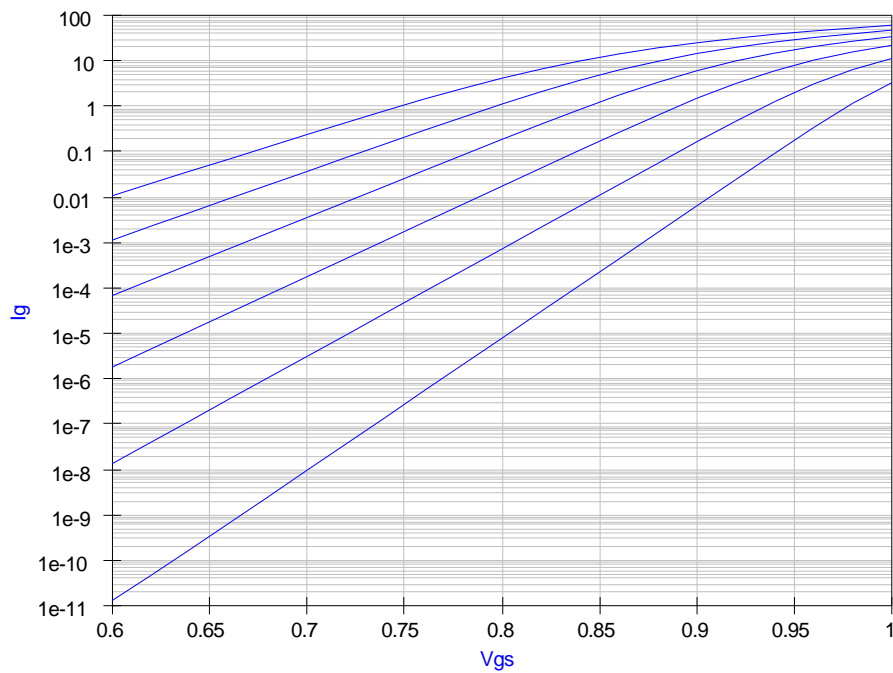
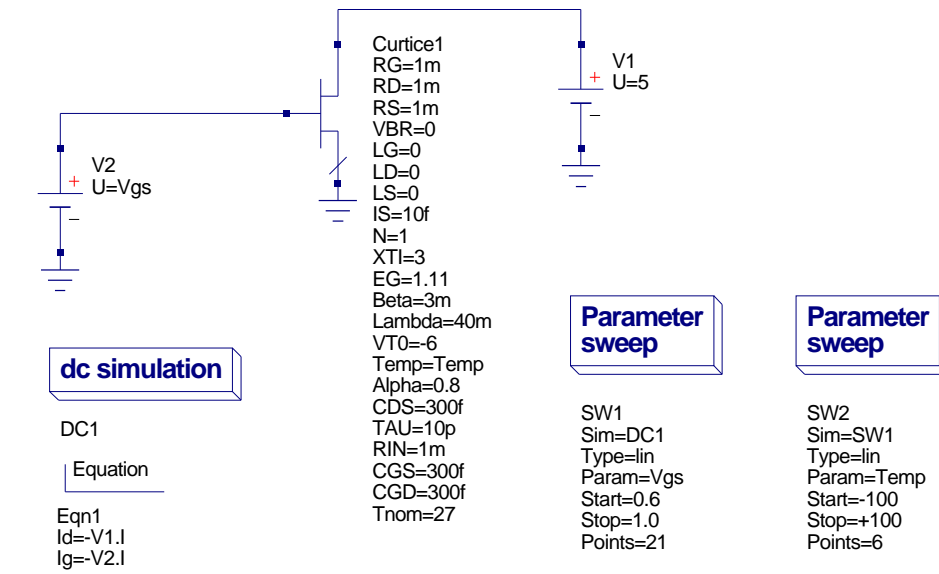


Figure 4: DC test circuit and  $I_g$ - $V_{gs}$  characteristics



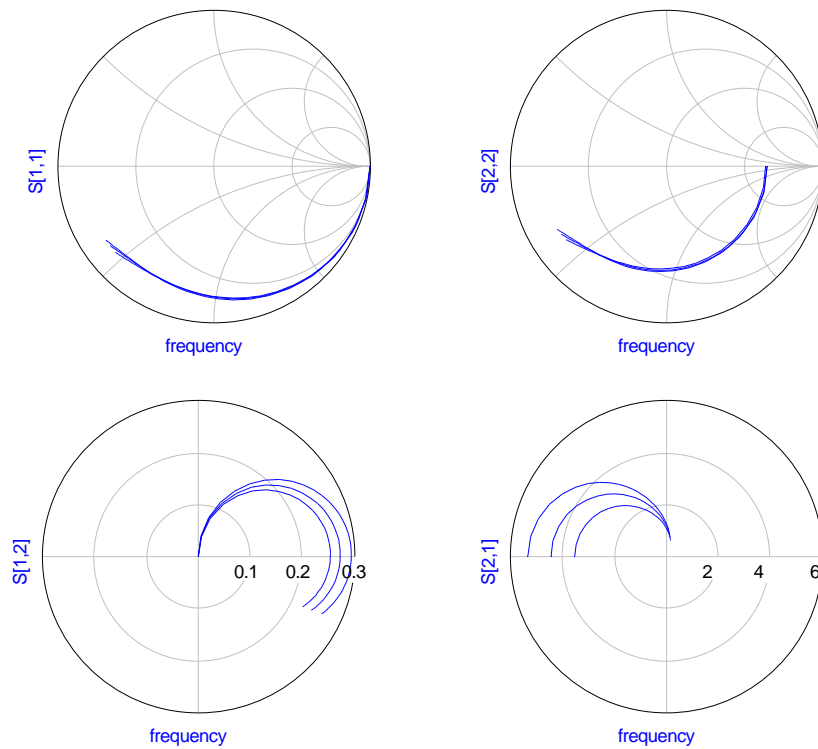
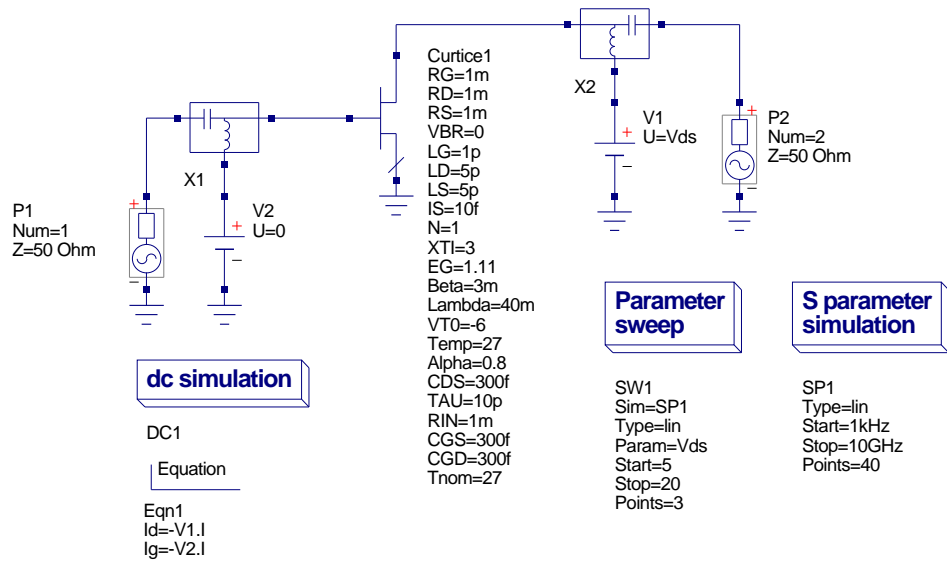


Figure 5: S parameter test circuit and characteristics