Single phase transformer

Transformer BEE2123 ELECTRICAL MACHINES Mohd Rusllim Bin Mohamed Ext: 2080 A1-E10-C09 edu. my © MRM 05 Learning Outcomes ? At the end of the lecture, student should to: ? Understand the principle and the nature of static machines of transformer. Perform an analysis on transformers which their principles are basic to the understanding of electrical machines. ? © MRM 05 Introduction ? ? ? ? A transformer is a static machines. The word „ transformer? comes form the word „ transform?.

Transformer is not an energy conversion device, but is a device that changes AC electrical power at one voltage level into AC electrical power at another voltage level through the action of magnetic field, without a change in frequency. It can be either to step-up or step down. Transmission System TX1 TX1 Generation Station 33/13. 5kV 13. 5/6. 6kV Distributions TX1 TX1 © MRM 05 6. 6kV/415V Consumer Transformer Construction ? Two types of iron-core construction: a) b) Core – type construction Shell – type construction ? Core – type construction © MRM 05 Transformer Construction ? Shell – type construction MRM 05 Ideal Transformer ? An ideal transformer is a transformer which has no loses, i. e. it? s winding has no ohmic resistance, no magnetic leakage, and therefore no I2 R and core loses. ? However, it is impossible to realize such a transformer in practice. ? Yet, the approximate characteristic of ideal transformer will be used in characterized the practical transformer. N1 : N2 I1 V1 E1 E2 I2 V2 V1 – Primary Voltage V2 – Secondary Voltage E1 – Primary induced Voltage E2 – secondary induced Voltage N1: N2 – Transformer ratio © MRM 05 Transformer Equation ? Faraday? s Law states that, ?

If the flux passes through a coil of wire, a voltage will be induced in the turns of wire. This voltage is directly proportional to the rate of change in the flux with respect of time. Vind ? Emf ind d? (t) ?? dt Lenz? s Law If we have N turns of wire, Vind ? Emf ind d? (t) ? ? N dt © MRM 05 Transformer Equation ? For an ac sources, ? Let V(t) = Vm sin? t i(t) = im sin? t Since the flux is a sinusoidal function; ?(t) ? ? m sin ? t Then: Therefore: d? m sin ? t Vind ? Emf ind ? ? N dt ? ? N?? m cos ? t Thus: Vind ? Emfind (max) ? N?? m ? 2? fN? m N?? m 2? fN? m ? ? ? 4. 44 fN? m 2 2 © MRM 05 Emf ind (rms) Transformer Equation For an ideal transformer E1 ?? 4. 44 fN1? m ………………… (i) ? In the equilibrium condition, both the input power will be equaled to the output power, and this condition is said to ideal condition of a transformer. E2 ?? 4. 44 fN 2? m Input power ? output power V1 I1 cos ? ? V2 I 2 cos ? ? V1 I 2 ? V2 I1 ? From the ideal transformer circuit, note that, E1 ? V1 and E2 ? V2 ? Hence, substitute in (i) © MRM 05 Transformer Equation Therefore, E1 N1 I 2 ? ? ? a E2 N 2 I1 Where, „ a? is the Voltage Transformation Ratio; which will determine whether the transformer is going to be step-up or step-down For a > 1 For a E2 E1 < E2 © MRM 05

Step-down Step-up Transformer Rating ? Transformer rating is normally written in terms of Apparent Power. ? Apparent power is actually the product of its rated current and rated voltage. VA ? V1I1 ? V2 I 2 ? Where, ? I1 and I2 = rated current on primary and secondary winding. ? V1 and V2 = rated voltage on primary and secondary winding. ? Rated currents are actually the full load currents in transformer © MRM 05 Example 1. 1. 5kVA single phase transformer has rated voltage of 144/240 V. Finds its full load current.

Solution 1500 I1FL ? ? 10. 45 A 144 1500 I 2 FL ? ? 6A 240 © MRM 05 Example 2.

A single phase transformer has 400 primary and 1000 secondary turns. The net cross-sectional area of the core is 60m2. If the primary winding is connected to a 50Hz supply at 520V, calculate: a) The induced voltage in the secondary winding b) The peak value of flux density in the core Solution N1= 400 V1= 520V A= 60m2 N2= 1000 V2=? © MRM 05 Example 2 (Cont) a) Know that, N1 V1 a? ? N 2 V2 400 520 ? 1000 V2 V2 ? 1300V b) Emf, E ? 4. 44 fN ? m ? 4. 44 fN ? Bm ? A? known, E1 ? 520V , E2 ? 1300V E ? 4. 44 fN ? Bm ? A? 520 ? 4. 44(50)(400)(Bm)(60) Bm ? 0. 976 x10 ? 5Wb / m 2 (T) © MRM 05 Example 3.

A 25kVA transformer has 500 turns on the primary and 50 turns on the secondary winding. The primary is connected to 3000V, 50Hz supply. Find: Full load primary and secondary current b) The induced voltage in the secondary winding c) The maximum flux in the core Solution VA = 25kVA N1= 500 V1= 3000V N2= 50 V2=? a) © MRM 05 Example 3 (Cont) a) Know that, VA ? V ? I I1FL VA 25 ? 103 ? ? ? 8. 33 A V1 3000 b) Induced voltage, N1 I 2 a? ? N 2 I1 ? 8. 33 ? I 2 ? 500? ? ? 83. 3 A ? 50 ? I1 ? 8. 33 ? E2 ? E1 ? 3000? ? ? 300V I2 ? 83. 3 ? c) Max flux E ? 4. 44 fN ? 300 ? 4. 44(50)(50)? ? ? 27mWb © MRM 05

Practical Transformer (Equivalent Circuit) I1 R1 X1 Ic V1 RC Io I1 ’ Im Load Xm E1 E2 V2 N1: N2 I2 R2 X2 V1 = primary supply voltage V2 = 2nd terminal (load) voltage E1 = primary winding voltage E2 = 2nd winding voltage I1 = primary supply current I2 = 2nd winding current I1? = primary winding current Io = no load current Ic = core current Im = magnetism current R1= primary winding resistance R2= 2nd winding resistance X1= primary winding leakage reactance X2= 2nd winding leakage reactance Rc © MRM 05= core resistance Xm= magnetism reactance Single Phase Transformer (Referred to Primary) ? Actual Method

I1 R1 X1 Ic Io I2 ’ Im Load RC Xm E1 E2 V2 R2’ X2’ N1: N2 I2 V1 ? N1 ? R2 ‘ ? ? ? N ? R2 ? ? 2? ? N1 ? X2’? ? ? N ? X2 ? ? 2? 2 2 OR R2 ‘ ? a R2 2 ? N ? ‘ E1 ? V2 ? ? 1 ? V2 ? N ? ? 2? I I2 ‘ ? 2 a © MRM 05 OR V2 ‘ ? aV2 OR X 2 ‘ ? a2 X 2 Single Phase Transformer (Referred to Primary) ? Approximate Method I1 R1 X1 R2’ X2’ Ic V1 RC Io I2 ’ Im Load Xm E1 E2 N1: N2 I2 V2 ? N ? R2 ‘ ? ? 1 ? R2 ? N ? ? 2? ? N ? X2’? ? 1 ? X2 ? N ? ? 2? 2 2 OR R2 ‘ ? a R2 2 OR X 2 ‘ ? a2 X 2 ? N ? ‘ E1 ? V2 ? ? 1 ? V2 ? N ? ? 2? I I2 ‘ ? 2 a © MRM 05 OR V2 ‘ ? aV2 Single Phase Transformer (Referred to Primary) ? Approximate Method I1 R01 X01

V1 aV2 In some application, the excitation branch has a small current compared to load current, thus it may be neglected without causing serious error. ? N ? R2 ‘ ? ? 1 ? R2 ? N ? ? 2? ? N ? X2’? ? 1 ? X2 ? N ? ? 2? 2 2 OR R2 ‘ ? a R2 2 ? N ? ‘ V2 ? ? 1 ? V2 ? N ? ? 2? OR V2 ‘ ? aV2 OR X 2 ‘ ? a2 X 2 R01 ? R1 ? R2 ‘ © MRM 05 X 01 ? X 1 ? X 2 ‘ Single Phase Transformer (Referred to Secondary) ? Actual Method I1 ’ R1’ X1’ Ic Io I2 Im Xm’ R2 X2 V1 a RC’ V2 ? N ? R1 R1 ‘ ? ? 2 ? R1 OR R1 ‘ ? 2 ? N ? a ? 1? ? N ? X 1 ‘ ? ? 2 ? X 1 OR ? N ? ? 1? 2 2 ? N ? V V1 ‘ ? ? 2 ? V1 OR V1 ‘ ? 1 ? N ? a ? 1? © MRM 05 X1’ ? X1 a2

Single Phase Transformer (Referred to Secondary) ? Approximate Method I1 ’ R02 X02 Neglect the excitation branch V1 a V2 R02 ? R1 ‘? R2 X 02 ? X 1 ‘? X

2 ? N ? R1 R1 ‘ ? ? 2 ? R1 OR R1 ‘ ? 2 ? N ? a ? 1? ? N ? X 1 ‘ ? ? 2 ? X 1 OR ? N ? ? 1? 2 2 ? N2 ? V ? ? V1 OR V1 ‘ ? 1 V1 ‘ ? ? N1 ? a ? ? I1 ‘ ? aI1 © MRM 05 X1’ ? X1 a2 Example 4. For the parameters obtained from the test of 20kVA 2600/245 V single phase transformer, refer all the parameters to the high voltage side if all the parameters are obtained at lower voltage side side. Rc = 3. 3? , Xm = j1. 5? , R2 = 7. 5? , X2 = j12. 4? Solution Given Rc = 3. 3? , Xm = j1. 5? , R2 = 7. ? , X2 = j12. 4? © MRM 05 Example 4 (Cont) i) Refer to H. V side (primary) E1 V1 2600 a? ? ? ? 10. 61 E2 V2 245 R2 ‘ ? a 2 R2 2 V2 ‘ ? aV2 To refer parameters to primary, Use R2? =(10. 61)2 (7. 5) = 844. 65? , X2? = j(10. 61)2 (12. 4) = 1. 396k? Rc? and Xc? becoz parameters were read from secondary side Rc? =(10. 61)2 (3. 3) = 371. 6? , Xm? = j(10. 61)2 (1. 5) = j168. 9 ? © MRM 05 2nd I I2 ‘ ? 2 X2’? a X2 a Example (What if..) 4. For the parameters obtained from the test of 20kVA 245/2600 V single phase transformer, refer all the parameters to the high voltage side if all the parameters are obtained at lower voltage side side.

Rc = 3. 3? , Xm = j1. 5? , R2 = 7. 5? , X2 = j12. 4? Solution Given Rc = 3. 3? , Xm = j1. 5? , R2 = 7. 5? , X2 = j12. 4? © MRM 05 Power Factor ? Power factor = angle between Current and Voltage, cos ? V I ? I ? = -ve Lagging ? V I V ? = +ve Leading ?= 1 unity © MRM 05 Example 5. A 10 kVA single phase transformer 2000/440V has primary resistance and reactance of 5. 5? and 12? respectively, while the resistance and reactance of secondary winding is 0. 2? and 0. 45 ? respectively. Calculate: i. ii. The parameter referred to high voltage side and draw the equivalent circuit The approximate value of secondary voltage at full load of 0. lagging power factor, when primary supply is 2000V. © MRM 05 Example 5 (Cont) Solution R1= 5. 5 ? , X1= j12 ?

R2= 0. 2 ? , X2= j0. 45 ? i) Refer to H. V side (primary) E V 2000 a? 1 ? 1 ? ? 4. 55 E2 V2 440 I1 R01 9. 64 V1 X01 21. 32 aV2 R2? =(4. 55)2 (0. 2) = 4. 14? , X2? = j(4. 55)20. 45 = j9. 32 ? Therefore, R01= R1+R2? = 5. 5 + 4. 13 = 9. 64 ? © MRM X01= X1+X2? = j12 + j9. 32 = j21. 3205? Example 5 (Cont) Solution ii) Secondary voltage p. f = 0. 8 Cos ? = 0. 8 ? = 36. 87o 10 ? 103VA Full load, I FL ? ? 5A 2000V From eqn. cct, 1 V1? 0o ? (R01 ? jX 01)(I1? ? ? o) ? aV2 2000? 0o ? (9. 64 ? j 21. 32)(5? ? 36. 87 o) ? (4. 5)V2 V2 ? 422. 6? 0. 8o © MRM 05 Transformer Losses ? i. ii. Generally, there are two types of losses; Iron losses :- occur in core parameters Copper losses :- occur in winding resistance i. Iron Losses Piron ? Pc ? (I c) 2 Rc ? Popen circuit ii. Copper Losses Pcopper ? Pcu ? (I 1) 2 R1 ? (I 2) 2 R2 ? Pshort circuit or if referred , Pcu ? (I 1) 2 R01 ? (I 2) 2 R02 © MRM 05 Poc and Psc will be discusses later in transformer test Transformer Efficiency ? To check the performance of the device, by comparing the output with respect to the input. ? The higher the efficiency, the better the system. Efficiency ,? Output Power ? 100% Input Power Pout ? ? 100% Pout ? Plosses ? V2 I 2 cos ? ? 100% V2 I 2 cos ? ? Pc ? Pcu ? (fullload) ? ?(load n) ? VA cos ? ? 100% VA cos ? ? Pc ? Pcu nVA cos ? ? 100% 2 nVA cos ? ? Pc ? n Pcu Where, if ? load, hence n = ? , ? load, n= ? , 90% of full load, n = 0. 9 Where Pcu = Psc Pc = Poc © MRM 05 nmax ? ? Poc ?? VArated ?? ? P ? ? sc ? ? ? VArated ? ?? ?? ? ?? ?? ? ? Pc ?? VArated ?? ? P ? ? cu ? ? VArated ? ?? ?? ? ?? ? Voltage Regulation ? The measure of how well a power transformer maintains constant secondary voltage over a range of load currents is called the transformer’s voltage regulation ?

The purpose of voltage regulation is basically to determine the percentage of voltage drop between no load and full load. © MRM 05 Voltage Regulation ? For calculation of Voltage Regulation, terminologies may be quite confusing, hence you need always think in current, I (A) point of view “ Full-load” means the point at which the transformer ? is operating at maximum permissible secondary current ? When connected to load, current being drawn, hence Voltage drop) ? ? No Load means at Rated At no load, current almost zero, so takes Voltage at rated © MRM 05 value – think like an open circuit) Voltage Regulation Voltage Regulation can be determine based on 3 methods: a) b) c) Basic Definition Short – circuit Test Equivalent Circuit © MRM 05 Voltage Regulation (Basic Defination) ? In this method, all parameter are being referred to primary or secondary side. ? Can be represented in either ? Down – voltage Regulation Note that: VNL ? VFL V . R ? ? 100% VNL (at Rated Value) VNL ? Up – Voltage Regulation VNL ? VFL V . R ? ? 100% VFL © MRM 05 Voltage Regulation (Short – circuit Test) ? In this method, direct formula can be used. V . R ? V . R ? Vsc cos ?? sc ? ? p. f ? V1 ? 100% If s/c test on primary side Vsc cos ?? c ? ? p. f ? V2 ? 100% If s/c test on primary side Note that: „–? is for Lagging power factor „+? is for Leading power factor Must check that Isc must equal to IFL (I at Rated), otherwise © MRM 05 can? t use this formula Voltage Regulation (Equivalent Circuit) ? In this method, the parameters must be referred to primary or secondary V . R ? I1 R01 cos ? p. f ? X 01 sin ? p. f V1 I 2 R02 cos ? p. f ? X 02 sin ? p. f V2 ? ?? 100% ?? 100% If referred to primary side V . R ? ? If referred to secondary side Note that: „+? is for Lagging power factor „–? is for Leading power factor © MRM 05 assume j terms ~0

Comment on VR ? Purely Resistive Load ? > 3 % is considered poor VR Normally poor than Resistive Load ? Inductive Load ? ? Example of application Desired Poor VR ? ? Discharge lighting AC arc welders © MRM 05 Example 6. In example 5, determine the Voltage regulation by using down – voltage regulation and equivalent circuit. Question 5 A 10 kVA single phase transformer 2000/440V and V1? 0o ? (R01 ? jX 01)(I1? ? ? o) ? aV2 2000? 0o ? (9. 64 ? j 21. 32)(5? ? 36. 87 o) ? (4. 55)V2 V2 ? 422. 6? 0. 8o © MRM 05 Example Solution Down – voltage Regulation Know that, V2FL= 422. 6V V2NL= 440V Therefore, V .

R ? VNL ? VFL ? 100% VNL 440 ? 422. 6 ? ? 100% 440 ? 3. 95% © MRM 05 Example 6 (Cont) Equivalent Circuit I1= 5A R01= 9. 64? X01 = 21. 32? V1= 2000V, 0. 8 lagging p. f V . R ? I1 R01 cos ? p. f ? X 01 sin ? p. f V1 ? ?? 100% 5 ? 9. 64(0. 8) ? 21. 32(0. 6)? ? ? 100% 2000 ? 5. 12% © MRM 05 Example A short circuit test was performed at the secondary side of 10kVA, 240/100V transformer. Determine the voltage regulation at 0. 8 lagging power factor if Vsc = 18V Isc = 100 Psc= 240W Solution Check: 7. I FL2 I FL2 VA 10000 ? ? ? 100 A V 100 ? I sc , Hence, we can use short-circuit method V . R ? Vsc cos ?? sc ? ? p. ? V2 © MRM 05 ? 100% Example 7 (Cont) V . R ? Vsc cos ?? sc ? ? p. f ? V2 ? 100% Given p. f ? 0. 8 Hence, ? p. f ? cos ? 1 0. 8 ? 36. 87 o Know that , Psc ? Vsc I sc cos ? sc ? sc ? cos ? 1 ? ? ? Psc ? ? ? ? Vsc I sc ? 18 cos 82. 34o ? 36. 87 o V . R ? ? 100% 100 © MRM 05 ? 12. 62% ? ? 240 ? ? ? 82. 34 o ? cos ? 1 ? ? (18)(100) ? ? ? ? Example 8. The following data were obtained in test on 20kVA 2400/240V, 60Hz transformer. Vsc = 72V Isc = 8. 33A Psc= 268W Poc= 170W The measuring instrument are connected in the primary side for short circuit test. Determine the voltage regulation for 0. 8

lagging p. f. use all 3 methods), full load efficiency and half load efficiency. © MRM 05 Example 8 (Cont) V . R ? Vsc cos ?? sc ? ? p. f ? V2 ? 100% Given p. f ? 0. 8 Hence, ? p. f ? cos ? 1 0. 8 ? 36. 87 o Know that , Psc ? Vsc I sc cos ? sc ? Psc ? ? sc ? cos ? ? V I ? ? ? sc sc ? ? 268 ? ? ? 63. 4o ? cos ? 1 ? ? (72)(8. 33) ? ? ? ? 1 Z sc ? Vsc 72 ? ? 8. 64? I sc 8. 33 ? Z sc ? 8. 64? 63. 4o ? 3. 86 ? j 7. 72 ? R01 ? jX 01 because connected to primary side. © MRM 05 Example 8 (Cont) 1. Short Circuit method , V . R ? Vsc cos ?? sc ? ? p. f ? V1 ? 100% 72 cos 63. 4o ? 36. 87 o V . R ? ? 100% ? 2. 68% 2400 ? ? 2. Equivalent circuit , V .

R ? I1 R01 cos ? p. f ? X 01 sin ? p. f V1 ? ? ? 100% 20000 ? 3. 86(0. 8) ? 7. 72(0. 6)? 2400 ? 100% ? 2. 68% 2400 © MRM 05 Example 8 (Cont) 3. Basic Defination , V1 ? I1Z 01 ? aV2 ? 20000 ? 2400 ? o? o 2400? 0 ? ? ? ? 36. 87 ? 8. 64? 63. 4 ? ? ? V2 ? 2400 ? ? 240 ? V2 ? 233. 58? 0. 79 o V o ? ? VNL ? VFL V . R ? ? 100% VNL ? 240 ? 233. 58 ? 100% 240 ? 2. 68% © MRM 05 Example 8 (Cont) ?(full load) (1)(20000)(0. 8) ? ? 100% ? 97. 34% 2 (1)(20000)(0. 8) ? 170 ? (1) (268) (0. 5)(20000)(0. 8) ? ? 100% ? 97. 12% 2 (0. 5)(20000)(0. 8) ? 170 ? (0. 5) (268) ?(half load) © MRM 05 Measurement on Transformer ? i. ii.

There are two test conducted on transformer. Open Circuit Test Short Circuit test ? ? ? The test is conducted to determine the parameter of the transformer. Open circuit test is conducted to determine magnetism parameter, Rc and Xm. Short circuit test is conducted to determine the copper parameter depending where the test is performed. If performed at primary, hence the parameters are R01 and©X0105and vice-versa. MRM Open-Circuit Test ? ? Voc Ic Measurement are at low voltage side Poc ? Voc I oc cos ? oc From a given test parameters, ? ? 1 ? P oc Voc ? oc ? cos ? Voc ? V I ? ? ? oc oc ? I sin? Im Ic oc oc Ioc Rc

Xm ? oc Ioccos? oc Hence, I c ? I oc cos ? oc ? Im I m ? I oc sin ? oc Then, Rc and X m , Voc Voc Rc ? , Xm ? Ic Im Note: If the question asked parameters referred to high voltage side, the parameters (Rc and Xm) obtained need to be referred to high voltage side © MRM 05 Short-Circuit Test ? ? Measurement are at high voltage side If the given test parameters are taken on primary side, R01 and X01 will be obtained. Or else, viceversa. R01 X01 Psc ? Vsc I sc cos ? sc ? Psc ? ? sc ? cos ? ? V I ? ? ? sc sc ? Hence, Vsc Z 01 ? ?? sc I sc ? 1 © MRM 05 For a case referred to Primary side Z 01 ? R01 ? jX 01 Example 9.

Given the test on 500kVA 2300/208V are as follows: Poc = 3800W Psc = 6200W Voc = 208V Vsc = 95V Ioc = 52. 5A Isc = 217. 4A Determine the transformer parameters and draw equivalent circuit referred to high voltage side. Also calculate appropriate value of V2 at full load, the full load efficiency, half load efficiency and voltage regulation, when power factor is 0. 866 lagging. © MRM 05 [1392? , 517. 2? , 0. 13? , 0. 44? , 202V, 97. 74%, 97. 59%, 3. 04%] Example 9 (Cont) From Open Circuit Test, Poc ? Voc I oc cos ? oc ? 3800 ? ? ? 69. 6o ? oc ? cos ? ? (52. 5)(208) ? ? ? I c ? I oc cos ? oc ? 1 Voc Ic Iocsin? oc Ioc

Ioccos? oc ? 52. 5 cos 69. 6o ? 18. 26 A I m ? I oc sin ? oc ? 52. 5 sin 69. 6o ? 49. 2 A ? oc Im ? © MRM 05 Example 9 (Cont) Since Voc= 208V i. e. low voltage side ? all reading are taken on the secondary side (low voltage side) Voc 208 Rc ? ? ? 11. 39? I c 18. 26 Voc 208 Xm ? ? ? 4. 23? I m 49. 21

Parameters referred to high voltage side, ? E1 ? ? 2300 ? Rc ‘ ? Rc ? ? ? 11. 39? ? ? 1392? ? E ? ? 208 ? ? 2? 2 2 ? E1 ? ? 2300 ? ? ? ? 4. 23? Xm’? Xm? ? ? 517 ? MRM 05 . 21? © ? 208 ? ? E2 ? 2 2 Example 9 (Cont) From Short Circuit Test, First, check the Isc I FL1 VA 500 ? 103 ? ? ? 217. 4 A V1 2300 Since IFL1 = Isc , ? ll reading are actually taken on the primary side Psc ? Vsc I sc cos ? sc ? 6200 ? ? ? 72. 53o ? sc ? cos ? ? (95)(217. 4) ? ? ? ? 1 ? V ? Z 01 ? ? sc ??? sc ? I ? ? sc ? ? 95 ? o o ?? ?? 72. 53 ? 0. 44? 72. 53 ? 217. 4 ? © MRM 05 ? 0. 13 ? j 0. 42? Example 9 (Cont) Equivalent circuit referred to high voltage side, R01 0. 13? X01 0. 42? V1 Rc 1392? Xm 517. 21? V2? = aV2 © MRM 05 Example 9 (Cont) For V2 at full load, neglect the magnetism parameters, R01 0. 13? X01 0. 42? v1 v2? pf ? cos ? ? 0. 866 ? ? cos ? 1 0. 866 ? 30o © MRM 05 Example 9 (Cont) Efficiency,? ? ? VA cos ? ? FL ? ? ? ? 100% ? VA cos ? ? Psc ? Poc ? ? ? 500 ? 103)(0. 866) ?? ? ? 100% (500 ? 103)(0. 866) ? 6200 ? 3800 ? ? ? 97. 74% ? ? nVA cos ? ? 1 L ? ? ? ? 100% 2 nVA cos ? ? n 2 Psc ? Poc ? ? ? ? (0. 5)(500 ? 103)(0. 866) ?? ? ? 100% 3 2 ? (0. 5)(500 ? 10)(0. 866) ? (6200)(0. 5) ? 3800 ? ? 97. 59% © MRM 05 Example 9 (Cont) Voltage Regulation, ? Vsc cos ? sc ? ? pf ? V . R ? ? ? ? 100% E1 ? ? ? (95) cos? 72. 53 ? 30?? ?? ? ? 100% 2300 ? ? ? 3. 04% ? ? © MRM 05 Test Yourself on Final Exam Q ? Following are the test result of a 12 kV A, 415 V / 240 V, 50 Hz, two winding single phase transformer: Open circuit test (reading taken on low voltage side) 240 V 4. 2 A 80 W

Short circuit test (reading taken on high voltage side) 9. 8 V ? Determine: i. 28. 9 A 185 W The values of Rp. Rs. Xp, Xs, Xm and Rc, assuming an approximate equivalent circuit. ii. The efficiency of the transformer at full load and 0. 8 lagging power factor. iii. The voltage regulation at full load and

0. 8 lagging power factor. © MRM 05 Solution i. Solution ? ? ? ? Eff = 97. 3 % ? V. R = 2. 31 % Z = 57. 14 ? Rc = 714. 3 ? Xm = 57. 31 a = 1. 73 R1 = 0. 11 ? R2 = 0. 037 ? X1 = 0. 13 ? X2 = 0. 043 ? ? Refer to Primary, ? ? ? ? ? © MRM 05 Any Questions ??? Test 1 – coming soon Make sure you prepared for that… © MRM 05