

**Blue cell** is the input parameters

**Red cell** is the output parameters

**1. Define specifications of the SMPS**

<u>Minimum Line voltage (V_line.min)</u>	<u>85</u> V.rms
<u>Maximum Line voltage (V_line.max)</u>	<u>265</u> V.rms
<u>Line frequency (fL)</u>	<u>60</u> Hz

	Vo	Io	Po	KL
<u>1st output for feedback</u>	<u>5</u> V	<u>2.4</u> A	<u>12</u> W	<u>25</u> %
<u>2nd output</u>	<u>12</u> V	<u>3</u> A	<u>36</u> W	<u>75</u> %
<u>3rd output</u>	<u>0</u> V	<u>0</u> A	<u>0</u> W	<u>0</u> %
<u>4th output</u>	<u>0</u> V	<u>0</u> A	<u>0</u> W	<u>0</u> %
<u>5th output</u>	<u>0</u> V	<u>0</u> A	<u>0</u> W	<u>0</u> %
<u>6th output</u>	<u>0</u> V	<u>0</u> A	<u>0</u> W	<u>0</u> %
<b>Maximum output power (Po) =</b>	<b>48.0</b> W			
<b>Estimated efficiency (Eff)</b>	<b>80</b> %			
<b>Maximum input power (Pin) =</b>	<b>60.0</b> W			

**2. Calculate the minimum input voltage**

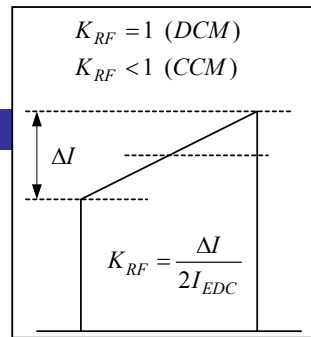
<u>DC link capacitor</u>	<u>100</u> uF
<b>DC link voltage ripple =</b>	<b>33</b> V
<b>Minimum DC link voltage =</b>	<b>87</b> V
<b>Maximum DC link voltage =</b>	<b>375</b> V

**3. Determine Maximum duty ratio (Dmax)**

<u>Maximum duty ratio</u>	<u>0.45</u>
<b>Maximum nominal MOSFET voltage =</b>	<b>446</b> V
<b>Output voltage reflected to primary =</b>	<b>71</b> V

**4. Determine transformer primary inductance (Lm)**

<u>Switching frequency of FPS (kHz)</u>	<u>67</u> kHz
<u>Ripple factor</u>	<u>0.28</u>
<b>Primary side inductance (Lm) =</b>	<b>680</b> uH
<b>Maximum peak drain current =</b>	<b>1.96</b> A
<b>RMS drain current</b>	<b>1.04</b> A
<b>Maximum DC link voltage in CCM</b>	<b>197</b> V



**5. Determine proper core and minimum primary turns**

<u>Current limit of FPS</u>	<u>2.20</u> A
<u>Maximum flux density swing</u>	<u>0.35</u> T

Saturation flux density (Bsat)	0.42 T
Estimated AP value of core =	3929 mm <sup>4</sup>
Cross sectional area of core (Ae)	69 mm <sup>2</sup>
Minimum primary turns =	51.6 T

6. Determine the number of turns for each outputs

	Vo	VF	# of turns
Vcc (Use Vcc start voltage)	12 V	1.2 V	9.6 => 10 T
1st output for feedback	5 V	0.5 V	4 => 4 T
2nd output	12 V	1.2 V	9.6 => 10 T
3rd output	0 V	0 V	0 => 0 T
4th output	0 V	0 V	0 => 0 T
5th output	0 V	0 V	0 => 0 T
6th output	0 V	0 V	0 => 0 T
VF : Forward voltage drop of rectifier diode			Primary turns = 52 T

->enough turns

AL value (no gap)	2130 nH/T <sup>2</sup>
Gap length (center pole gap)=	0.30044 mm

7. Determine proper wire for each output

	Diameter	Parallel	Irms	(A/mm <sup>2</sup> )
Primary winding	0.5 mm	1 T	1.04 A	5.31
Vcc winding	0.3 mm	1 T	0.10 A	1.42
1st output winding	0.4 mm	4 T	3.73 A	7.41
2nd output winding	0.4 mm	4 T	4.66 A	9.27
3rd output winding	0 mm	0 T	#### A	#DIV/0!
4th output winding	0 mm	0 T	#### A	#DIV/0!
5th output winding	0 mm	0 T	#### A	#DIV/0!
6th output winding	0 mm	0 T	#### A	#DIV/0!
Copper area =	17.8918 mm <sup>2</sup>			
Fill factor	0.2			
Required window area	89.459 mm <sup>2</sup>			

8. Determine the rectifier diodes in the secondary side

	Reverse voltage	Rms Current
Vcc diode	82 V	0.10 A
1st output diode	34 V	3.73 A
2nd output diode	82 V	4.66 A
3rd output diode	0 V	#### A
4th output diode	0 V	#### A

<u>5th output diode</u>	0	V	####	A
<u>6th output diode</u>	0	V	####	A

### 9. Determine the output capacitor

	Capacitance	ESR	Current ripple	Voltage Ripple
<u>1st output capacitor</u>	1000 uF	30 mΩ	2.8 V	0.21 V
<u>2nd output capacitor</u>	1000 uF	40 mΩ	4.0 V	0.33 V
<u>3rd output capacitor</u>	0 uF	50 mΩ	#### V	##### V
<u>4th output capacitor</u>	0 uF	50 mΩ	#### V	##### V
<u>5th output capacitor</u>	0 uF	50 mΩ	#### V	##### V
<u>6th output capacitor</u>	0 uF	50 mΩ	#### V	##### V

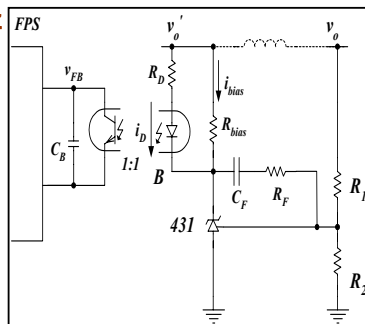
### 10. Design RCD snubber

<u>Primary side leakage inductance</u>	4 uH	
<u>Nominal Voltage of snubber capacitor</u>	120 V	
<u>Nominal snubber capacitor voltage ripple</u>	5 %	
<u>Snubber resistor =</u>	27.8821 kΩ	
<u>Snubber capacitor =</u>	10.7061 nF	
<u>Power loss in snubber resistor =</u>	0.51646 W	(In Normal Operation)
<u>Maximum snubber capacitor voltage=</u>	134.474 V	
<u>Maximum MOSFET voltage =</u>	509.24 V	

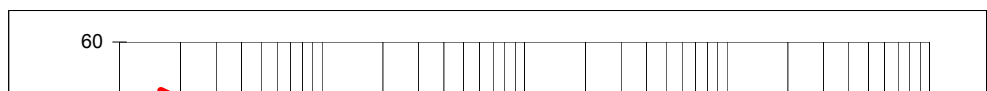
### 11. Design Feedback control loop

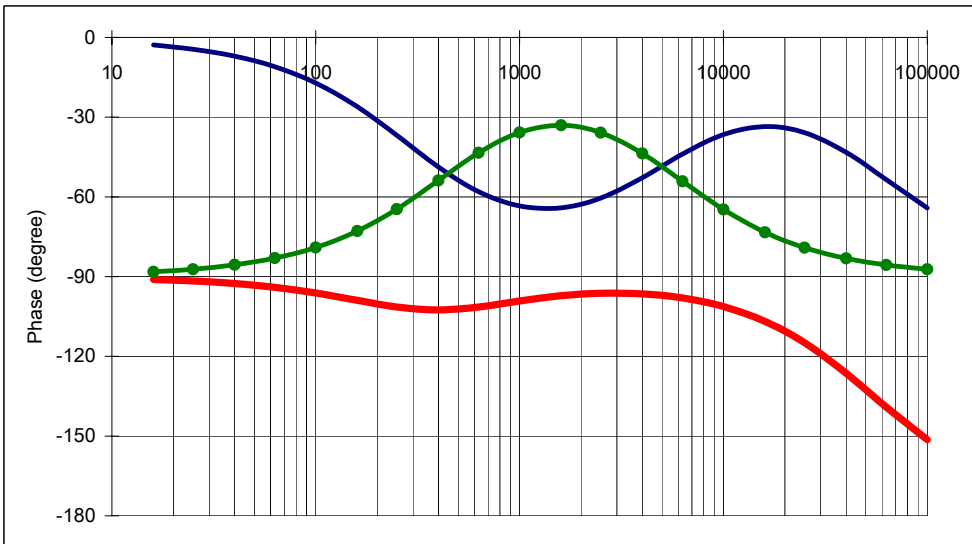
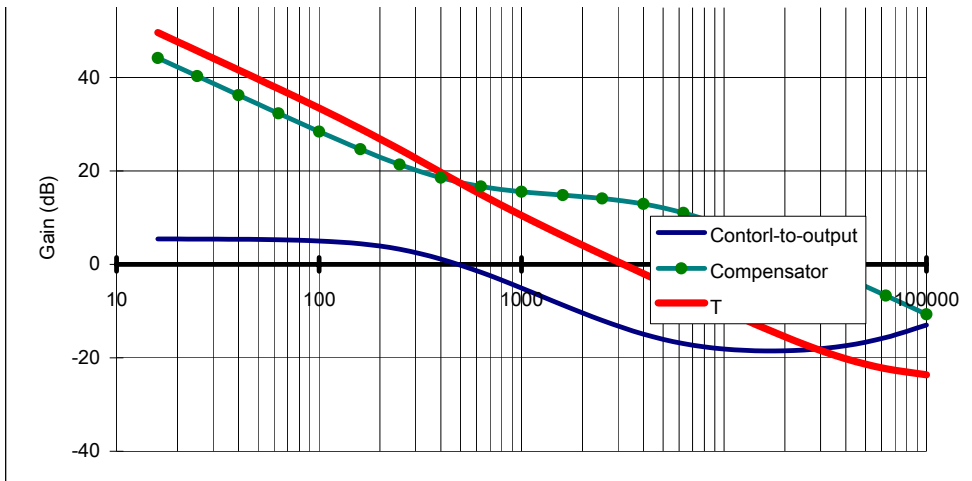
<u>Control-to-output DC gain =</u>	2
<u>Control-to-output zero =</u>	5,308 Hz
<u>Control-to-output RHP zero =</u>	54,862 Hz
<u>Control-to-output pole =</u>	306 Hz

<u>Voltage divider resistor (R1)</u>	5.6 kΩ
<u>Voltage divider resistor (R2)</u>	5.6 kΩ
<u>Opto coupler diode resistor (RD)</u>	1 kΩ
<u>431 Bias resistor (Rbias)</u>	1.2 kΩ
<u>Feedback pin capacitor (CB) =</u>	10 nF
<u>Feedback Capacitor (CF) =</u>	33 nF
<u>Feedback resistor (RF) =</u>	4.7 kΩ



<u>Feedback integrator gain (fi) =</u>	2,585 Hz
<u>Feedback zero (fz) =</u>	468.478 Hz
<u>Feedback pole (fp) =</u>	5307.86 Hz





Device	Recommend New Device	Function					Protection Mode					Soft Start Option	PKG	Cross Reference	Application	Application Note www.fairchildsemi.com	Features	
		Vdmax (V)	Ipeak (A)	Pin(max)(W)_open frame		Fopr (KHz)	Rds(on) max (Ω)	Over Load	Over Current	Over Voltage	Thermal Shutdown							
				85-265VAC	230VAC													
<b>1st Generation 800V Class</b>																		
KA1M0280RB	KA5x0280R	800	1.2	25	30	67	7.0	A/R	NO	A/R	A/R	A/R	NO	TO-220F-4L	TOP223Y	DVD	AN4105	for flyback converter Optimized for forward converter
KA1x0380RB	KA5x0380R	800	2.15	40	50	67/50	5.0	A/R	NO	A/R	A/R	A/R	NO	TO-220F-4L	TOP224Y	VCR / DVD	AN4106	
KA1x0680B	KA5P0680C	800	4.0	80	100	100/67	2.0	Latch	NO	Latch	Latch	Latch	YES	TO-3P-5L	Original	PC, SMPS	AN4105 AN4104	
KA1H0680RFB	KA5P0680C	800	4.0	80	100	100	2.0	A/R	NO	A/R	A/R	A/R	YES	TO-3PF-5L				
KA1M0680RB	KA5P0680C	800	4.0	80	100	67	2.0	A/R	NO	A/R	A/R	A/R	YES	TO-3P-5L				
KA1x0880B	FS7M0880	800	5.0	110	130	67/50	1.5	Latch	NO	Latch	Latch	Latch	YES	TO-3P-5L	Original	PC, SMPS	AN4105	
KA1M0880BF	FS7M0880	800	5.0	110	130	67	1.5	Latch	NO	Latch	Latch	Latch	YES	TO-3PF-5L				
KA1M0880D	FS7M0880	800	5.0	110	130	67	1.5	Latch	NO	Latch	Latch	Latch	YES	TO-3P-5L	STR-F6653	Monitor	AN4105	
KA2S0680B	FS6S0765RCH	800	4.0	80	100	20~150	2.0	Latch	NO	Latch	Latch	Latch	YES	TO-3P-5L	STR-S6707	C-TV	AN4102	
KA3S0680RFB	KA5Q0765RTH	800	4.0	80	100	20~150	2.0	A/R	NO	A/R	A/R	A/R	YES	TO-3PF-5L	STR-S6707	C-TV	AN4105 AN4102	
KA3S0880RFB	KA5Q12656RT	800	5.0	110	130	20~150	1.5	A/R	NO	A/R	A/R	A/R	YES	TO-3PF-5L				
<b>1st Generation 650V Class</b>																		
KA1H0165RN	KA5x0165RN	650	0.6	10	10	100	10	A/R	NO	A/R	A/R	A/R	YES	8DIP	TOP222P	Charger	AN4105	Intelligent Power Saving Mode
KA1H0165R	KA5x0165R	650	0.6	15	15	100	10	A/R	NO	A/R	A/R	A/R	NO	TO-220F-4L	TOP222Y	Auxiliary Power	AN4101	
KA1M0265R	KA5x0265R	650	1.2	25	30	67	6.0	A/R	NO	A/R	A/R	A/R	NO	TO-220F-4L	TOP223Y	STB	AN4105	
KA1M0365R	KA5x0365R	650	2.15	40	50	67	4.5	A/R	NO	A/R	A/R	A/R	NO	TO-220F-4L	TOP224Y	STB	AN4106	
KA1x0565R		650	3.5	50	60	100/67	2.2	A/R	NO	A/R	A/R	A/R	NO	TO-220F-4L	TOP227Y	Note-PC Adaptor	AN4105	
KA1M0765R	KA5M0765RQC	650	5.0	100	120	67	1.6	A/R	NO	A/R	A/R	A/R	YES	TO-3P-5L	Original	SMPS	AN4105	
KA1M0965R	KA5M0965Q	650	6.0	120	145	67	1.2	A/R	NO	A/R	A/R	A/R	YES	TO-3P-5L				
KA5x0280R		800	1.2	25	30	100/67	7.0	A/R	A/R	A/R	A/R	A/R	NO	TO-220F-4L	TOP223Y	DVD	AN4105	
KA5x0380R		800	2.15	40	50	100/67/50	5.0	A/R	A/R	A/R	A/R	A/R	NO	TO-220F-4L	TOP224Y	STB	AN4106	
KA5P0680C		800	4.0	80	100	20~150	2.0	A/R	Latch	A/R	A/R	A/R	Latch	YES	TO-220-5L	Original	PC SMPS	AN4105, AN4104
<b>2nd Generation 650V Class</b>																		
KA5x0165R		650	0.6	15	15	100/67/50	10	A/R	A/R	A/R	A/R	A/R	NO	TO-220F-4L	TOP222Y	Charger Auxiliary	AN4105	1.Burst Mode Operation for low stbby 2.Simple application with both primary and secondary side regulation
KA5x0165RN		650	0.6	10	10	100/67/50	10	A/R	A/R	A/R	A/R	A/R	NO	8DIP	TOP222P	Auxiliary Power	AN4101	
KA5x02659RN		650	0.9	15	17	100/67	6.0	A/R	A/R	A/R	A/R	A/R	NO	8DIP	TOP223Y	STB	AN4105	
KA5H0265RC		650	1.2	25	30	100	6.0	A/R	A/R	A/R	A/R	A/R	YES	TO-220-5L				
KA5x0265R		650	1.2	25	30	67/50	6.0	A/R	A/R	A/R	A/R	A/R	NO	TO-220F-4L	TOP224Y	STB	AN4106	
KA5x0365RN		650	2.15	25	30	67/50	4.5	A/R	A/R	A/R	A/R	A/R	NO	8DIP	TOP224P	SMPS	AN4105	
KA5x0365R		650	2.15	40	50	100/67/50	4.5	A/R	A/R	A/R	A/R	A/R	NO	TO-220F-4L				
KA5M0765RQC		650	5.0	100	120	67	1.6	A/R	A/R	A/R	A/R	A/R	YES	TO-220-5L	Original	Monitor	AN4105	
KA5M0965Q		650	6.0	120	145	67	1.2	Latch	Latch	Latch	Latch	Latch	YES	TO-3P-5L				
KA5S0765C	FS6S0765RCH	650	4.0	80	100	Sync.	1.6	Latch	Latch	Latch	Latch	Latch	YES	TO-220-5L	STR-F6653	C-TV	AN4105	
KA5S0965	FS6S0965RCB	650	6.0	120	145	Sync.	1.2	Latch	Latch	Latch	Latch	Latch	YES	TO-3P-5L				
KA5S12656	FS6S1265RE	650	6.0	120	145	Sync.	0.9	Latch	Latch	Latch	Latch	Latch	YES	TO-3P-5L	STR-F6654	Monitor	AN4103	
KA5S1265	FS6S1265RE	650	8.0	160	190	Sync.	0.9	Latch	Latch	Latch	Latch	Latch	YES	TO-3P-5L	STR-F6656	Monitor	AN4103	
KA5Q0656RT	KA5Q0765RTH	650	3.5	70	80	QRC	2.2	A/R	Latch	A/R	Latch	Latch	NO	TO-220F-5L	Original	C-TV	AN4105	
KA5Q0740RT	KA5Q0765RTH	400	5.0	100	-	QRC	1.1	A/R	Latch	A/R	Latch	Latch	NO	TO-220F-5L				
KA5Q0765RT	KA5Q12656RT	650	5.0	100	130	QRC	1.6	A/R	Latch	A/R	Latch	Latch	NO	TO-220F-5L				
KA5Q0765RTH	KA5Q12656RT	650	5.0	100	130	QRC	1.6	A/R	Latch	A/R	Latch	Latch	NO	TO-220F-5L				
KA5Q12656RT	KA5Q12656RT	650	6.0	150	180	QRC	0.9	A/R	Latch	A/R	Latch	Latch	NO	TO-220F-5L				
KA5Q12656RTH	KA5Q12656RTH	650	6.0	150	180	QRC	0.9	A/R	Latch	A/R	Latch	Latch	NO	TO-220F-5L				
KA5Q12656RFH	KA5Q12656RFH	650	6.0	150	180	QRC	0.9	A/R	Latch	A/R	Latch	Latch	NO	TO-220F-5L				
KA5Q12656RFH	KA5Q12656RFH	650	6.0	150	180	QRC	0.9	A/R	Latch	A/R	Latch	Latch	NO	TO-220F-5L				
KA5Q1565RF	KA5Q1565RF	650	8.0	200	230	QRC	0.9	A/R	Latch	A/R	Latch	Latch	NO	TO-3PF-5L				
KA5Q1565RFH	KA5Q1565RFH	650	11.5	270	300	QRC	0.65	A/R	Latch	A/R	Latch	Latch	NO	TO-3PF-5L				
KA5Q2065RFH	KA5Q2065RFH	650	11.5	270	300	QRC	0.65	A/R	Latch	A/R	Latch	Latch	NO	TO-3PF-5L				
<b>3rd Generation</b>																		
FS6M07652RTC		650	2.0	55	65	70	1.6	A/R	A/R	A/R	A/R	Latch	YES	TO-220F-5L	Original	LCD Monitor	AN4105	
FS6M12653RTC		650	3.2	80	95	70	0.9	A/R	A/R	A/R	A/R	Latch	YES	TO-220F-5L				
FS6S0765RCB	FS6S0765RCH	650	4.0	80	100	Sync.	1.6	A/R	A/R	A/R	A/R	A/R	YES	TO-220-5L	STR-F6653	Monitor	AN4105	
FS6S0765RCH	FS6S0765RCH	650	4.0	80	100	Sync.	1.6	A/R	A/R	A/R	A/R	A/R	YES	TO-220-5L				
FS6S0965RT	FS6S0965RCB	650	6.0	120	145	Sync.	1.2	A/R	Latch	A/R	Latch	Latch	YES	TO-220F-5L				
FS6S0965R	FS6S0965RCB	650	6.0	120	145	Sync.	1.2	A/R	Latch	A/R	Latch	Latch	YES	TO-3P-5L				
FS6S0965RCB	FS6S0965RCB	650	6.0	120	145	Sync.	1.2	A/R	A/R	A/R	A/R	A/R	YES	TO-220-5L				
FS6S1265RE	FS6S1265RE	650	8.0	160	190	Sync.	0.9	A/R	A/R	A/R	A/R	A/R	YES	TO-3P-5L				
FS6S1565RB	FS6S1565RB	650	9.7	200	240	Sync.	0.65	A/R	A/R	A/R	A/R	A/R	YES	TO-3P-5L				
FS7M0680		800	4.0	80	100	66	2.0	Latch	Latch	Latch	Latch	Latch	YES	TO-3P-5L				Original
FS7M0880		800	5.0	110	130	66	1.5	Latch	Latch	Latch	Latch	Latch	YES	TO-3P-5L	Original	PDP, PC	AN4104	
FS8S0765RC		650	4.0	80	100	Sync.	1.6	A/R	A/R	NO	A/R	YES	TO-220-5L	STR-G5653	Monitor	AN4105		
FS8S0765RCA		650	4.0	80	100	Sync.	1.6	A/R	A/R	NO	A/R	YES	TO-220-5L	STR-G5653				
FS8S0765RCB		650	4.0	80	100	Sync.	1.6	A/R	A/R	NO	A/R	YES	TO-220-5L	STR-G5653				
FS6X1220RT		200	3.2	40	@36-75VDC	300	0.3	A/R	NO	A/R	A/R	A/R	NO	TO-220F-5L	DPA426R	DC/DC off-line	AN4111	
FS6X1220RD		200				300							NO	D2-PAK-5L	DC/DC off-line			
<b>BCDMOS / BICMOS</b>																		
FSDH0165	FSDH0165F	650	0.6	9 / [7]	9 / [7]	100	18	A/R	NO	NO	A/R	A/R	NO	8DIP	TNY266P	Charger	AN4105	
FSDH0165F	FSDH0165F	650	0.48	9 / [7]	9 / [7]	100	18	A/R	NO	NO	A/R	A/R	NO	8DIP	TNY266P	Charger	AN4111	
FSDH565		650	0.3	6 / [5]	6 / [5]	100	38	A/R	NO	NO	A/R	A/R	NO	8DIP	TNY264P	Charger	AN4111	
FSD200(M)		700				134								7DIP(7SMD)	Original	PC	AN4105	
FSD201(M)		700				134								7DIP(7SMD)				
FSDM311(M)		650	0.5			70	19	A/R	NO	A/R	A/R	YES	8DIP(8SMD)	Original	PC	AN4105		
FSD1000		700												12DIP			AN4105	
FSDL0165RN		650															AN4105	
FSDH0265RN		650	1.5	15	17	100	6.0	A/R	A/R	A/R	A/R	A/R	YES	8DIP	Auxiliary Power		AN4105	
FSDM0265RN		650	1.5	15	17	67	6.0	A/R	A/R	A/R	A/R	A/R	YES	8DIP	Auxiliary Power		AN4105	
FSDL0365RN		650	2.15	25	30	50	4.5	A/R	A/R	A/R	A/R	A/R	YES	8DIP	DVDP		AN4105	
FSDM0365RN		650	2.15	25	30	67	4.5	A/R	A/R	A/R	A/R	A/R	YES	8DIP	DVDP		AN4105	
FSDM0565R		650	2.0	50	60	70	2.2	A/R	A/R	A/R	Latch	Latch	YES	TO-220F-6L	LCD Monitor		AN4105	
FSDM07652R		650	2.0	55	65	70	1.6	A/R	A/R	A/R	Latch	Latch	YES	TO-220F-6L				
FSCM0765RD		650		55	65	70	1.6							D2-PAK-5L	STB		AN4105	