

## Application Note

### AP22652/53 Application Information and Demo Board User Guide

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#### Description

The AP22652 and AP22653 are single channel precision adjustable current-limited switches optimized for applications that require precision current limiting, or to provide up to 2.1 A of continuous load current during heavy loads/short circuits. These devices offer a programmable current-limit threshold between 125mA and 2665mA (typ) via an external resistor. Current limit accuracy  $\pm 10\%$  can be achieved at high current-limit settings. The rise and fall times are controlled to minimize current surges during turn on/off.

The devices have fast short-circuit response time for improved overall system robustness. They provide a complete protection solution for applications subject to heavy capacitive loads and the prospect of short circuit, offering reverse current blocking and limiting, over-current, over-temperature and short-circuit protection, as well as controlled rise time and under-voltage lockout functionality. A 6ms deglitch capability on the open-drain Flag output prevents false over-current reporting and does not require any external components.

AP22652 and AP22653 limits the output current to a safe level when the output current exceeds current-limit threshold.

All devices are available in SOT26 and W-DFN2020-6 packages.

#### Features

- Up to 2.1A Maximum Load Current
- Accurate Adjustable Current Limit, 125mA-2665mA
- $\pm 7\%$  Accurate Adjustable Current Limit, 1.735A with  $R_{LIM} = 15k\Omega$
- Constant-Current (AP22652, AP22653) During Over-Current
- Fast Short-Circuit Response Time: 5 $\mu$ s (typ)

- Reverse Current Blocking During Shutdown and Reverse Current Limiting During Enable
- Operating Range: 3.0V - 5.5V
- Built-in Soft-Start with 0.5ms Typical Rise Time
- Over-Current , Output Over-Voltage and Thermal Protection
- Fault Report (FAULT) with Blanking Time
- ESD Protection: 2kV HBM, 500V CDM
- Active Low (AP22652) or Active High (AP22653) Enable
- Ambient Temperature Range: -40°C to +85°C
- SOT26 and W-DFN2020-6 Package: Available in "Green" Molding Compound (No Br, Sb)
- Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)
- Halogen and Antimony Free. "Green" Device (Note 3)
- 15kV ESD Protection per IEC 61000-4-2 (with ext. capacitance)
- UL Recognized, File Number E322375, Vol. 1
- IEC60950-1 CB Scheme Certified

#### Applications

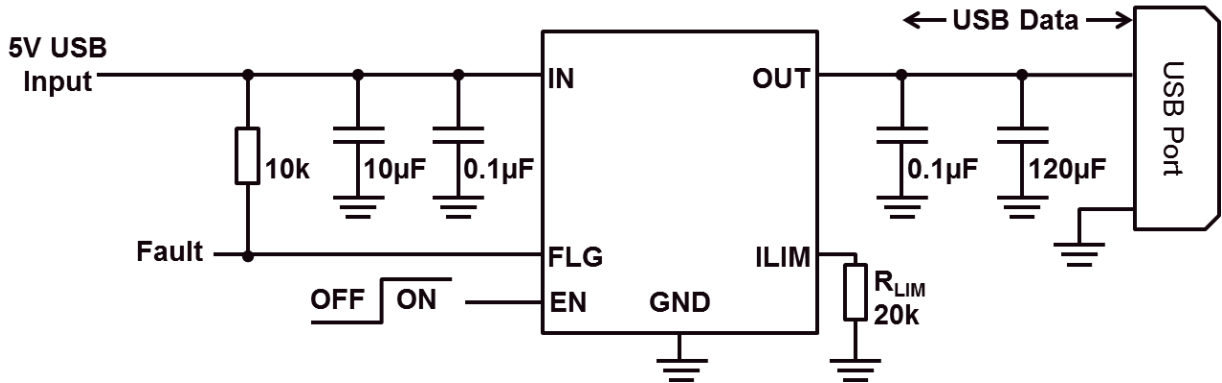
- Set-Top Boxes
- LCD TVs & Monitors
- Residential Gateways
- Laptops, Desktops, Servers, e-Readers, Printers, Docking Stations, HUBs

Notes: 1. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS) & 2011/65/EU (RoHS 2) compliant.  
2. See [http://www.diodes.com/quality/lead\\_free.html](http://www.diodes.com/quality/lead_free.html) for more information about Diodes Incorporated's definitions of Halogen- and Antimony-free, "Green" and Lead-free.  
3. Halogen- and Antimony-free "Green" products are defined as those which contain <900ppm bromine, <900ppm chlorine (<1500ppm total Br + Cl) and <1000ppm antimony compounds

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#### Typical Applications Circuit



120µF Output Capacitance is a Requirement of USB

#### Absolute Maximum Ratings

Symbol	Parameter	Ratings	Unit	
ESD	HBM	Human Body Model ESD Protection	2	kV
	CDM	Charged Device Model ESD Protection	500	V
	IEC system level	Surges per IEC61000-4-2, 1999 Applied to Output Terminals of EVM	15	kV
$V_{IN}, V_{OUT}, V_{FAULT}, V_{ILIM}, V_{EN}, V_{\overline{EN}}$	Voltage on IN, OUT, $\overline{FAULT}$ , ILIM, EN, $\overline{EN}$	-0.3 to +6.0	V	
—	Continuous $\overline{FAULT}$ Sink Current	25	mA	
—	ILIM Source Current	1	mA	
$I_{LOAD}$	Maximum Continuous Load Current	Internal Limited	A	
$T_{J(MAX)}$	Maximum Junction Temperature	-40 to +150	°C	
$T_{ST}$	Storage Temperature Range	-65 to +150	°C	

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#### Recommended Operating Conditions

Symbol	Parameter	Min	Max	Unit
$V_{IN}$	Input Voltage	3	5.5	V
$I_{OUT}$	Continuous Output Current ( $-40^{\circ}\text{C} \leq T_A \leq +85^{\circ}\text{C}$ )	0	2.1	A
$V_{EN}, V_{\overline{EN}}$	Enable Voltage	0	5.5	V
$V_{IH}$	High-Level Input Voltage on EN or $\overline{EN}$	1.5	$V_{IN}$	V
$V_{IL}$	Low-Level Input Voltage on EN or $\overline{EN}$	0	0.4	V
$R_{LIM}$	Current-Limit Threshold Resistor Range (1% initial tolerance)	10	210	k $\Omega$
$I_O$	Continuous $\overline{FAULT}$ Sink Current	0	10	mA
---	Input De-Coupling Capacitance, IN to GND	0.1	-	$\mu\text{F}$
$T_A$	Operating Ambient Temperature	-40	+85	$^{\circ}\text{C}$
$T_J$	Operating Junction Temperature	-40	+125	$^{\circ}\text{C}$

#### Evaluation Board

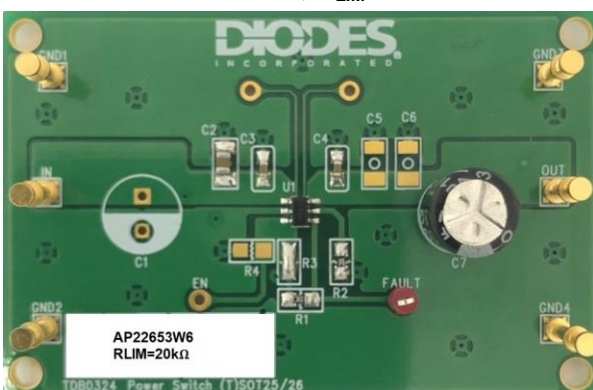
AP22652W6,  $R_{LIM}=20\text{k}\Omega$



AP22652FDZ,  $R_{LIM}=20\text{k}\Omega$



AP22653W6,  $R_{LIM}=20\text{k}\Omega$



AP22653FDZ,  $R_{LIM}=20\text{k}\Omega$



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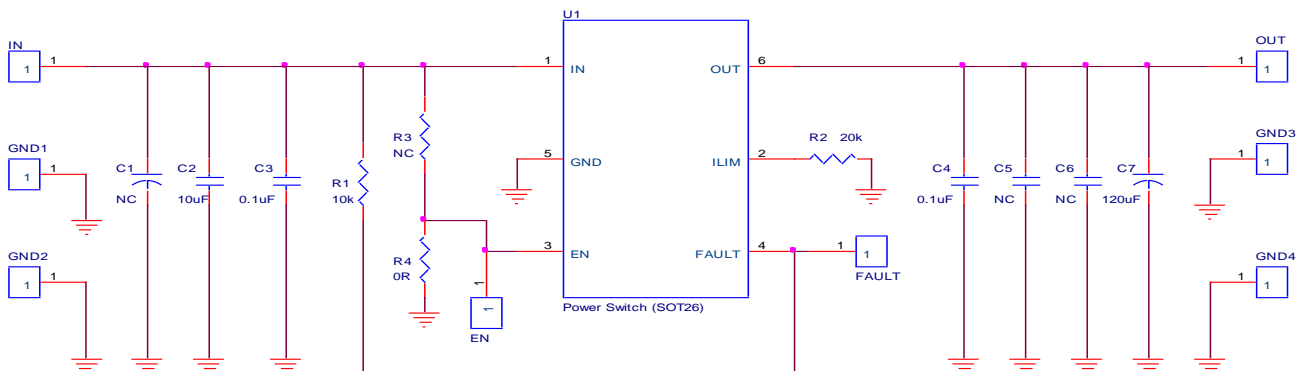
#### Quick Start Guide

The AP22652/53(Power Switch) evaluation modules (EVM) provide a means for the user to evaluate quickly the functionality and electrical performance of the AP22652/53 device. All inputs and outputs are brought out to test points for control and monitoring. All passive components are included on the EVM for device operation. The input pin should be connected to an external supply; the output should be connected to a load.

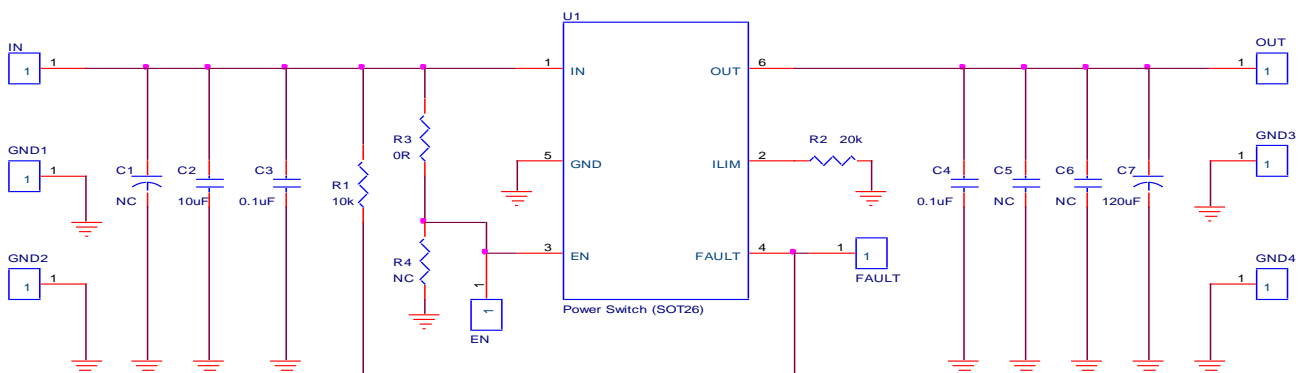
1. Connect a +5V power supply between IN and GND terminals.
2. Connect an adjustable current or resistive load to OUT and GND terminals.
3. Turn on the power supply.
4. Increase the load current of OUT and observe that the load current will stop increasing after reaching certain level. That is an indication that the device is limiting the load current.
5. Use an oscilloscope or a voltage meter to check that FAULT pin become low when the current limit is reached.

#### Evaluation Board Schematic

For AP22652W6



For AP22653W6



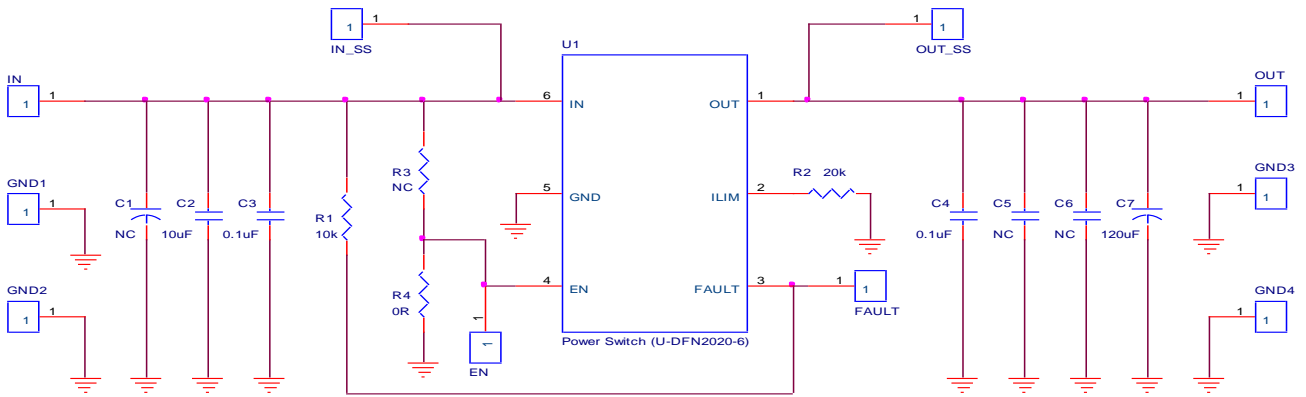
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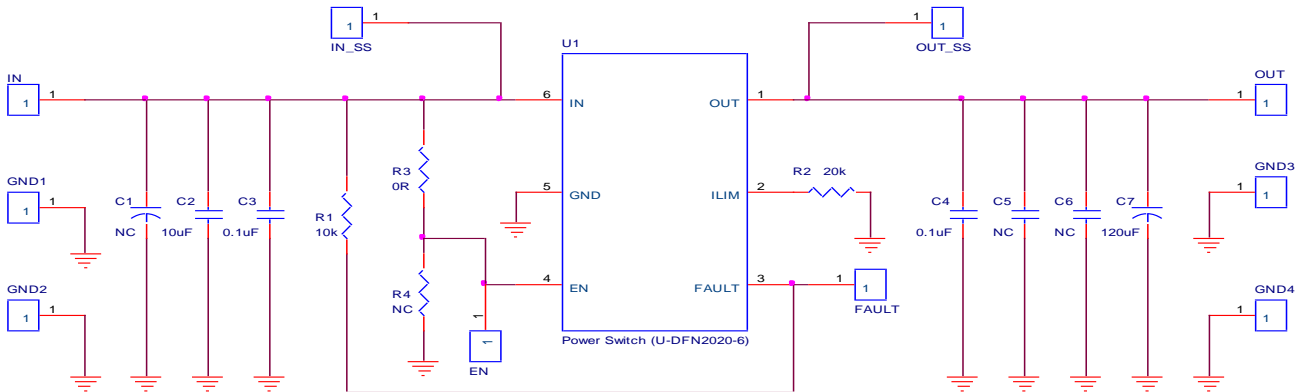
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**Evaluation Board Schematic**

For AP22652FDZ



For AP22653FDZ



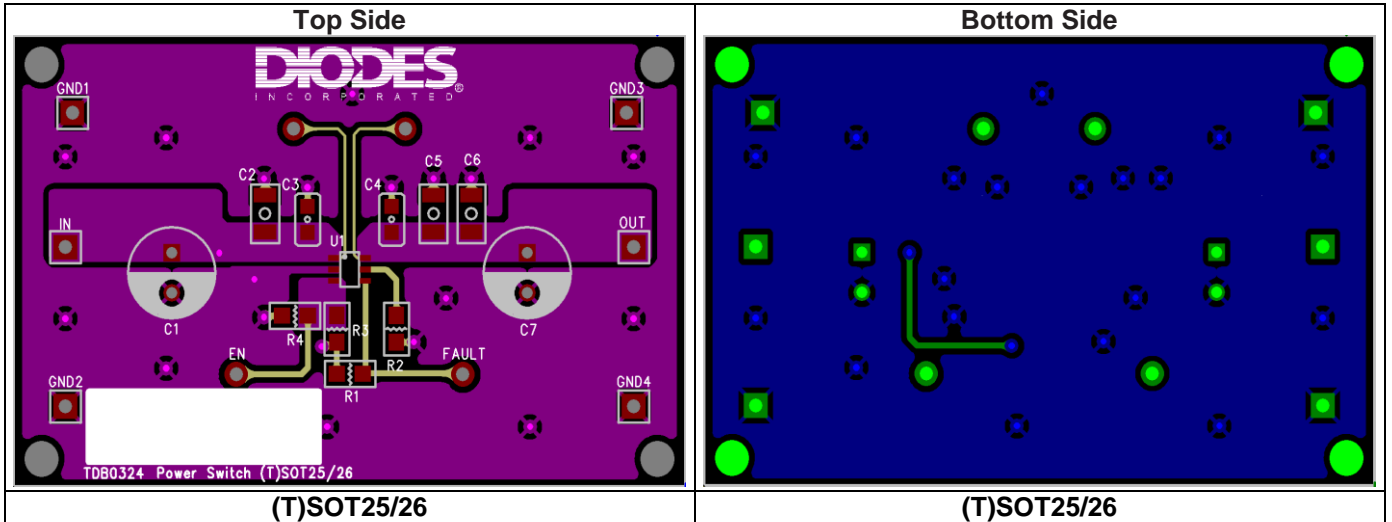
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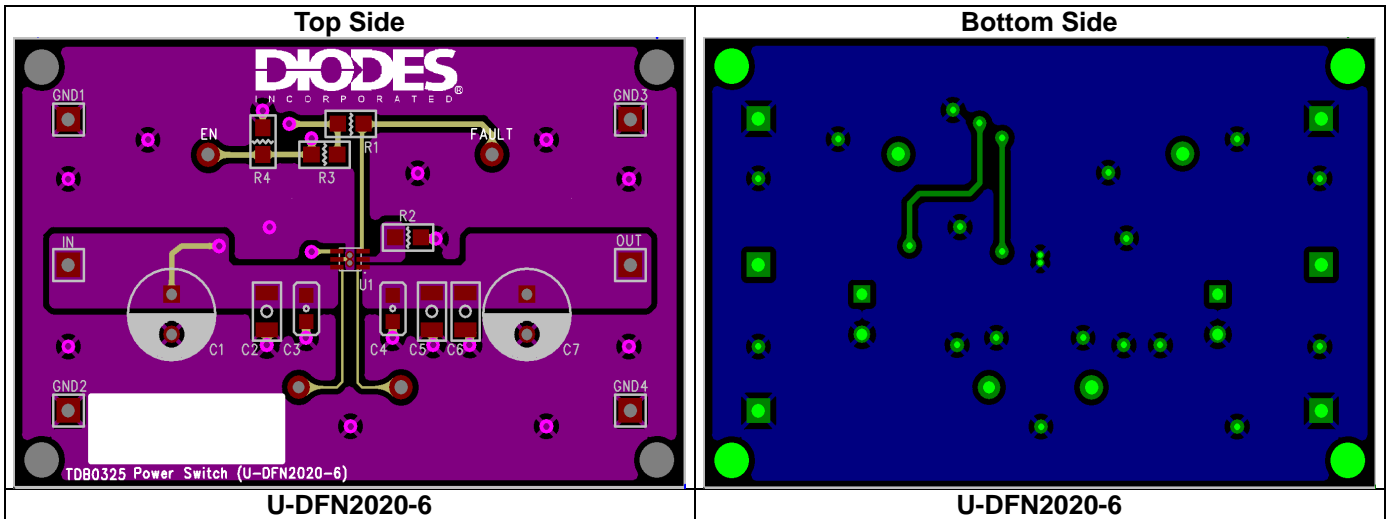
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**PCB Layout**

For SOT26 Package



For W-DFN2020-6 Package



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#### Bill of Materials

##### For AP22652W6

Component Location	Qty	Specification	Mark	Maker Part No.	Size
C2	1	Cap MLCC 10 $\mu$ F/16V/X5R	TAIYO YUDEN	EMK212ABJ106KG-T	C0805
C3, C4	2	Cap MLCC 0.1 $\mu$ F/50V/X7R	TAIYO YUDEN	UMK212B7104KG-T	C0603
C7	1	Aluminum Capacitor, 120 $\mu$ F /25V/SJ105 $^{\circ}$ C	TEAPO	KSJ127M025S1A5G11K	8X11
R1	1	Res 10k $\Omega$ (1%)	YAGEO	RC0603FR-SK	R0603
R2	1	Res 20k $\Omega$ (1%)	YAGEO	RC0603FR-SK	R0603
IN, OUT, GND1, GND2, GND3, GND4	6	Test pin	-	TEST-8	2.2mmX 13.5mm
FAULT	1	Test Point, Miniature, Red	Keystone	5000	Testpoint
R3	0	NC	-	-	-
R4	1	Short	-	-	-
C1, C5, C6	0	NC	-	-	-
U1	1	Precision Adjustable Current-Limited Power Switches, Up to 2.1A, Active Low	Diodes Inc.	AP22652W6	SOT26
PCB	1	Power Switch (T)SOT25/26	Diodes Inc.	TDB0324	61mmX39mm

##### For AP22653W6

Component Location	Qty	Specification	Mark	Maker Part No.	Size
C2	1	Cap MLCC 10 $\mu$ F/16V/X5R	TAIYO YUDEN	EMK212ABJ106KG-T	C0805
C3, C4	2	Cap MLCC 0.1 $\mu$ F/50V/X7R	TAIYO YUDEN	UMK212B7104KG-T	C0603
C7	1	Aluminum Capacitor, 120 $\mu$ F /25V/SJ105 $^{\circ}$ C	TEAPO	KSJ127M025S1A5G11K	8X11
R1	1	Res 10k $\Omega$ (1%)	YAGEO	RC0603FR-SK	R0603
R2	1	Res 20k $\Omega$ (1%)	YAGEO	RC0603FR-SK	R0603
IN, OUT, GND1, GND2, GND3, GND4	6	Test pin	-	TEST-8	2.2mmX 13.5mm
FAULT	1	Test Point, Miniature, Red	Keystone	5000	Testpoint
R3	1	Short	-	-	-
R4	0	NC	-	-	-
C1, C5, C6	0	NC	-	-	-
U1	1	Precision Adjustable Current-Limited Power Switches, Up to 2.1A, Active High	Diodes Inc.	AP22653W6	SOT26
PCB	1	Power Switch (T)SOT25/26	Diodes Inc.	TDB0324	61mmX39mm

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#### **Bill of Materials**

##### For AP22652FDZ

Component Location	Qty	Specification	Mark	Maker Part No.	Size
C2	1	Cap MLCC 10 $\mu$ F/16V/X5R	TAIYO YUDEN	EMK212ABJ106KG-T	C0805
C3, C4	2	Cap MLCC 0.1 $\mu$ F/50V/X7R	TAIYO YUDEN	UMK212B7104KG-T	C0603
C7	1	Aluminum Capacitor, 120 $\mu$ F /25V/SJ105 $^{\circ}$ C	TEAPO	KSJ127M025S1A5G11K	8X11
R1	1	Res 10k $\Omega$ (1%)	YAGEO	RC0603FR-SK	R0603
R2	1	Res 20k $\Omega$ (1%)	YAGEO	RC0603FR-SK	R0603
IN, OUT, GND1, GND2, GND3, GND4,	6	Test pin	-	TEST-8	2.2mmX 13.5mm
FAULT	1	Test Point, Miniature, Red	Keystone	5000	Testpoint
R3	0	NC	-	-	-
R4	1	Short			
C1, C5, C6	0	NC	-	-	-
U1	1	Precision Adjustable Current-Limited Power Switches, Up to 2.1A, Active Low	Diodes Inc.	AP22652FDZ	W-DFN2020-6
PCB	1	Power Switch (U-DFN2020-6)	Diodes Inc.	TDB0325	61mmX39mm

##### For AP22653FDZ

Component Location	Qty	Specification	Mark	Maker Part No.	Size
C2	1	Cap MLCC 10 $\mu$ F/16V/X5R	TAIYO YUDEN	EMK212ABJ106KG-T	C0805
C3, C4	2	Cap MLCC 0.1 $\mu$ F/50V/X7R	TAIYO YUDEN	UMK212B7104KG-T	C0603
C7	1	Aluminum Capacitor, 120 $\mu$ F /25V/SJ105 $^{\circ}$ C	TEAPO	KSJ127M025S1A5G11K	8X11
R1	1	Res 10k $\Omega$ (1%)	YAGEO	RC0603FR-SK	R0603
R2	1	Res 20k $\Omega$ (1%)	YAGEO	RC0603FR-SK	R0603
IN, OUT, GND1, GND2, GND3, GND4,	6	Test pin	-	TEST-8	2.2mmX 13.5mm
FAULT	1	Test Point, Miniature, Red	Keystone	5000	Testpoint
R3	1	Short	-	-	-
R4	0	NC			
C1, C5, C6	0	NC	-	-	-
U1	1	Precision Adjustable Current-Limited Power Switches, Up to 2.1A, Active High	Diodes Inc.	AP22653FDZ	W-DFN2020-6
PCB	1	Power Switch (U-DFN2020-6)	Diodes Inc.	TDB0325	61mmX39mm

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#### Vendors of peripheral components

##### Suggested Capacitors :

Vendor	Capacitance	Type	Series
TAIYO YUDEN	Cap MLCC 10 $\mu$ F/16V/X5R	SMD	EMK212ABJ106KG-T
MURATA	Cap MLCC 10 $\mu$ F/16V/X6S	SMD	GRM21BC81C106KA73L
TAIYO YUDEN	Cap MLCC 0.1 $\mu$ F/100V/X5R	SMD	HMK107BJ104KA-T
TAIYO YUDEN	Cap MLCC 0.1 $\mu$ F/50V/X7R	SMD	UMK212B7104KG-T
MURATA	Cap MLCC 0.1 $\mu$ F/16V/X7R	SMD	GRM033Z71C104KE14
TEAPO	Aluminum Capacitor, 120 $\mu$ F /25V/SJ105°C	DIP	KSJ127M025S1A5G11K

##### Suggested Resistor :

Vendor	Type	Series
YAGEO	SMD	RC0603FR-SK

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