# UNIVERSAL PFC (Phase Fire Control) CONTROLLER



This universal controller is designed to provide a variety of functional blocks to fit applications such as kiln/oven temperature control, AC universal motors (DC motors), etc.
The circuit does not provide the power section, and it is meant to be connected to a DGTDMR thyristor insulated unit.
The DGTDMR unit expects a Syn signal from a photo-coupler, and a photo-coupler to receive the command that fires the gate of the thyristor.

The Universal PFC Controller has the following functional blocks, that can be combined together to fit specific application.

**1. Wien Bridge.** This is just a slot for resistors and a trimmers to adjust an external resistive source, such as a PTC. The output of the Wien bridge can be linked to the input of any other block.

**2. Instrumentation Amplifier, with attenuator and limiter**. The output of this block can be directly picked up or linked to the rectifier (see below, close JP3) and/or the input of the feedback (close JP7) of the main regulation loop (see below). The attenuator can be set with the required resistors, and optional capacitors to make a first order low pass filter. Through the jumpers JP5 and JP6 it is possible to include a limiter to protect the circuit against input over-voltage (R1 and R2 should be almost 1K or otherwise appropriately calculated).
This block can also be used as a differential input. R9 (gain) can be used to adjust the gain of the amplifier.

**3. Precision Rectifier**. Turns alternating signals into only positive signals. It can be used alone or linked to other blocks.

**4. Zero Cross Detector**. Detects when an alternating signal crosses its zero (which is the same as GND). Useful to convert sine waves from speed alternators into a squared signal. This allows to discriminate frequency from amplitude. This block can be linked to the F/V converter by closing JP4. The input is protected against over-voltage (R14 ≥ 1K), and R14 and R15 can be installed to make a voltage divider if required.

**5. F/V Converter**. It can accept a square wave signal at its input to convert it into a voltage proportional to the input frequency. R32 (gain) can be used to adjust the gain of the so converted frequency to the desired voltage ratio. The input of the F/V converter can be linked to the output of the Zero Cross Detector or to the output of a buffer that can accepts pulse signals such as those coming from an encoder. They can either come from a push-pull, totem pole or open collector output.

**6. Main Loop Control**. This block has an input buffer (Set Input Buffer) that can accept either a voltage control signal (0 to 5V) or the voltage from the wiper of an external potentiometer. The pin 3 of the _SET pinhead provides a suitable voltage (Vref) for an external potentiometer.
The Control Loop receives a feedback signal that can be provided using the previously described blocks (1 to 4) by connecting the appropriate output to the FB pinhead. It can alternatively receives the feedback signal from external sources. The feedback can be either positive (0 to +5V) or negative (0 to -5V). Set the jumper JP9 accordingly. The trimmer R45 (feedback gain) can be used to adjust the feedback intensity.
The Control Loop can even receive a current feedback (0 to 5V, positive only) that is compared against the limit set with R53 (current cutoff) to shut down the control signal.
The circuit has a complete PID control, and optional offset (trimmer R58).
The Control Loop is completed with a pulse generator that is synchronized with the mains' phase through the SYN input. The generated pulses can command the gate of a thyristor through an isolating opto-coupler (it is designed to control a DGTDMR unit).

## Power supply.

The circuit can be powered with a single 12V supply, or better with a dual +6/-6V supply.

## Calibration.

| SINGLE SUPPLY | | DUAL SUPPLY |
|---|---|---|
| JP2: open<br>JP1: 2-3 closed | | JP2: open<br>JP1: 2-3 closed |
| GND: | | |
| (default)<br>6V<br>VR1: n.i.<br>R34:33K0<br>R35:0<br>R33:33K0 | 5V<br>inst.<br>10K0<br>10K0<br>33K | |

***GND voltage***. Set GND voltage accordingly with the power supply in use:

***Sawtooth peak voltage***. Adjust R50 for -0.5V peak. The lower peak level is set by $V_{CE}$ voltage drop of T1, and by voltage drop of D10 and D11. The latter is shorted by default to provide a voltage floor of 1.15V. To increase the lower peak level add diode D11.

T1 (BC337-25)
$V_{CEsat}$ at $I_C$=7mA : 0.5V;
$V_{BE}$ : 0.65V,
$V_{BEsat}$ : 0.7V;
hFE@ $I_C$=2mA: 100

D10 (and D11)
$V_F$ @ $I_F$=2mA: 0.65V

Q2 (BC327-25)
$V_{BE}$ at $I_C$=0.4mA : 0.65V;
hFE @$I_C$=0.1mA: 40;
hFE@ $I_C$=0.4mA: 60

$$I_{discharge} = I_{CQ2} = \frac{\Delta V\ C}{t_{discharge}} = \frac{4.35V\ 2(470nF)}{10ms} = 409\mu A$$

$$I_{BEQ2} = \frac{I_{CQ2}}{hFE} = \frac{409\mu A}{60} = 6.8\mu A$$

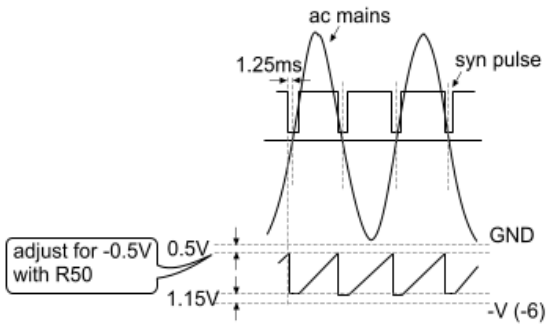
$V_{R48max}$ = R48 $I_{CQ2}$ = 2700Ω 409µA = 1.12V *(at $I_C$ peak)*

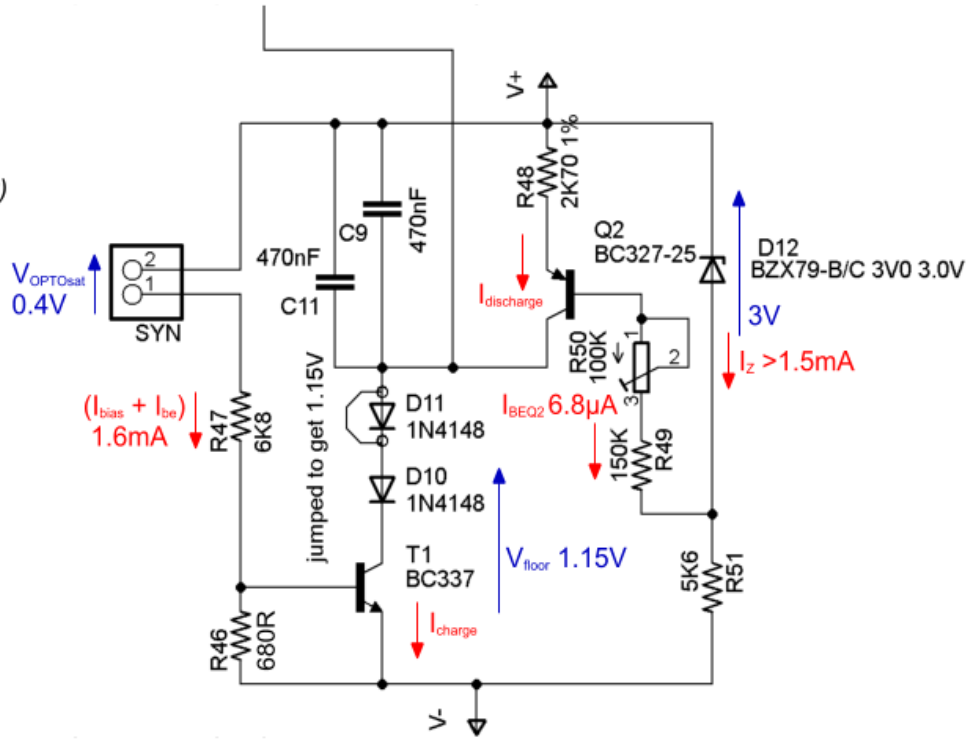
$I_Z$ = 1.5mA

$$I_{charge} = I_{CT1} = \frac{\Delta V\ C}{t_{charge}} = \frac{4.35V\ 2(470nF)}{2.5ms} = 1.6mA$$

$$I_{BET1} = \frac{I_C}{hFE} = \frac{1.6mA}{100} = 16\mu A$$

$V_{R47}$ = +V - $V_{OPTOsat}$ - $V_{BEsatT1}$ = 12V - 0.4V - 0.7V = 10.9V



## Adjustments.

***PID constant time, and PID***. Proportional, Integral and Derivative trimmers can be used to adjust the response of the main control loop. Timings are determined by the capacitor C6 for the derivative, C7 and C8 for the integral.
The default values are as following:
Integral: 200ms (2.5Hz), pole at 8Hz (125ms); Derivative: 15ms (33Hz), pole at 530Hz (2ms).

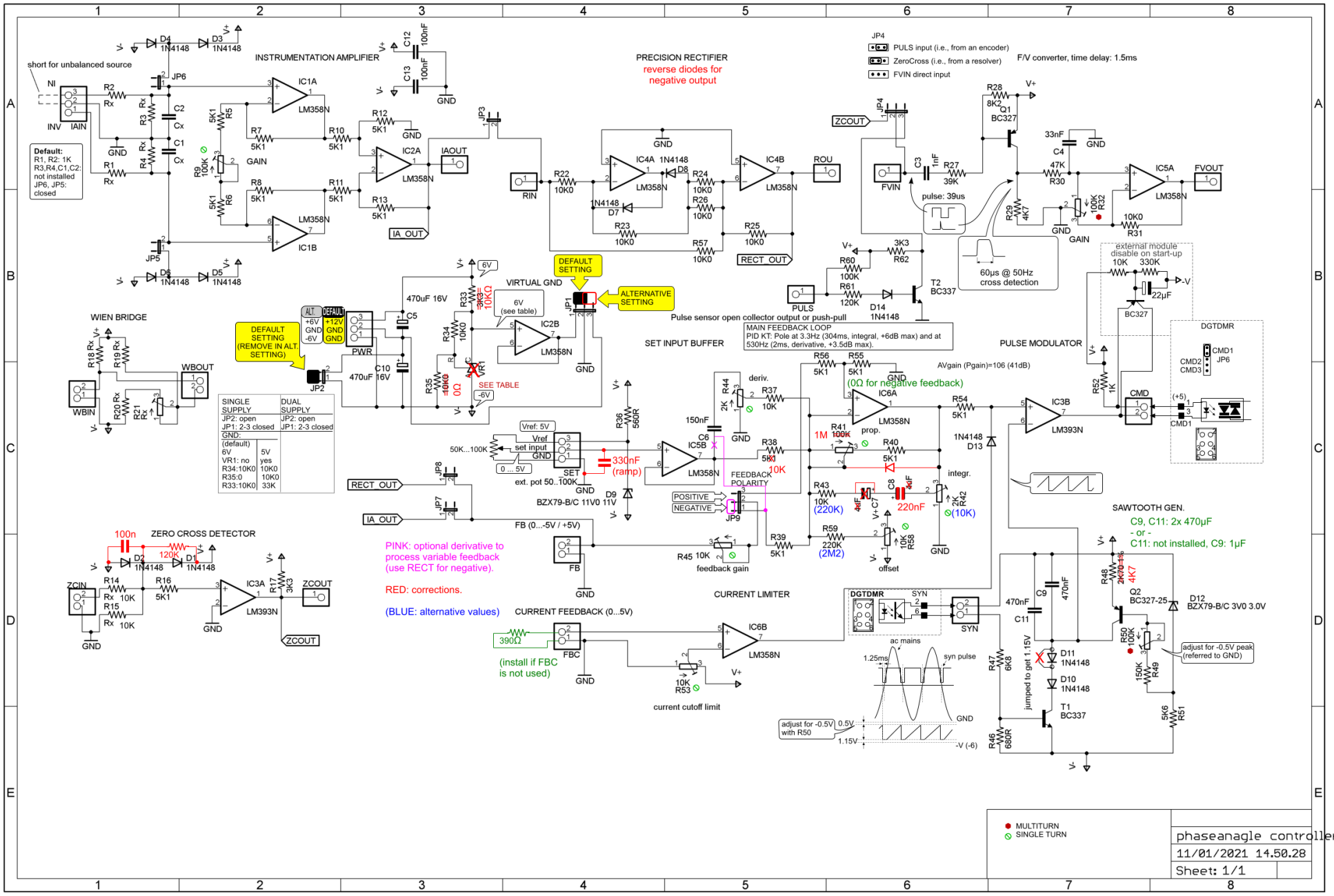
***Feedback polarity, feedback gain***. Set the polarity of the feedback, for positive signals close 2-3 of JP9, and for negative signals close 1-2 of JP9.

***F/V gain***. If the F/V block is used the ratio between the converted frequency to voltage can be adjusted by the mean of R32.

***Instrumentation Amplifier gain***. Adjust attenuation and gain (R9).

***Wien Bridge*** balance through R21.

Follows: Schematic with revisions, obsolete (first version) schematic, PCB layout.


INSTRUMENTATION AMPLIFIER
short for unbalanced source
Default:
R1, R2: 1K
R3,R4,C1,C2:
not installed
JP6, JP5:
closed
GAIN
PRECISION RECTIFIER
reverse diodes for
negative output
JP4
PULS input (i.e., from an encoder)
ZeroCross (i.e., from a resolver)
FVIN direct input
F/V converter, time delay: 1.5ms
pulse: 39us
60µs @ 50Hz
cross detection
external module
disable on start-up
WIEN BRIDGE
DEFAULT
SETTING
ALTERNATIVE
SETTING
VIRTUAL GND
6V
(see table)
DEFAULT SETTING
(REMOVE IN ALT SETTING)
SET INPUT BUFFER
Pulse sensor open collector output or push-pull
MAIN FEEDBACK LOOP
PID KT: Pole at 3.3Hz (304ms, integral, +6dB max) and at
530Hz (2ms, derivative, +3.5dB max).
PULSE MODULATOR
AVgain (Pgain)=106 (41dB)
(0Ω for negative feedback)
SINGLE SUPPLY
JP2: open
JP1: 2-3 closed
DUAL SUPPLY
JP2: open
JP1: 2-3 closed
SEE TABLE
ZERO CROSS DETECTOR
PINK: optional derivative to
process variable feedback
(use RECT for negative).
RED: corrections.
(BLUE: alternative values)
CURRENT FEEDBACK (0...5V)
(install if FBC
is not used)
CURRENT LIMITER
current cutoff limit
FEEDBACK
POLARITY
POSITIVE
NEGATIVE
feedback gain
offset
SAWTOOTH GEN.
C9, C11: 2x 470µF
- or -
C11: not installed, C9: 1µF
ac mains
syn pulse
adjust for -0.5V
with R50
jumped to get 1.15V
adjust for -0.5V peak
(referred to GND)
MULTITURN
SINGLE TURN
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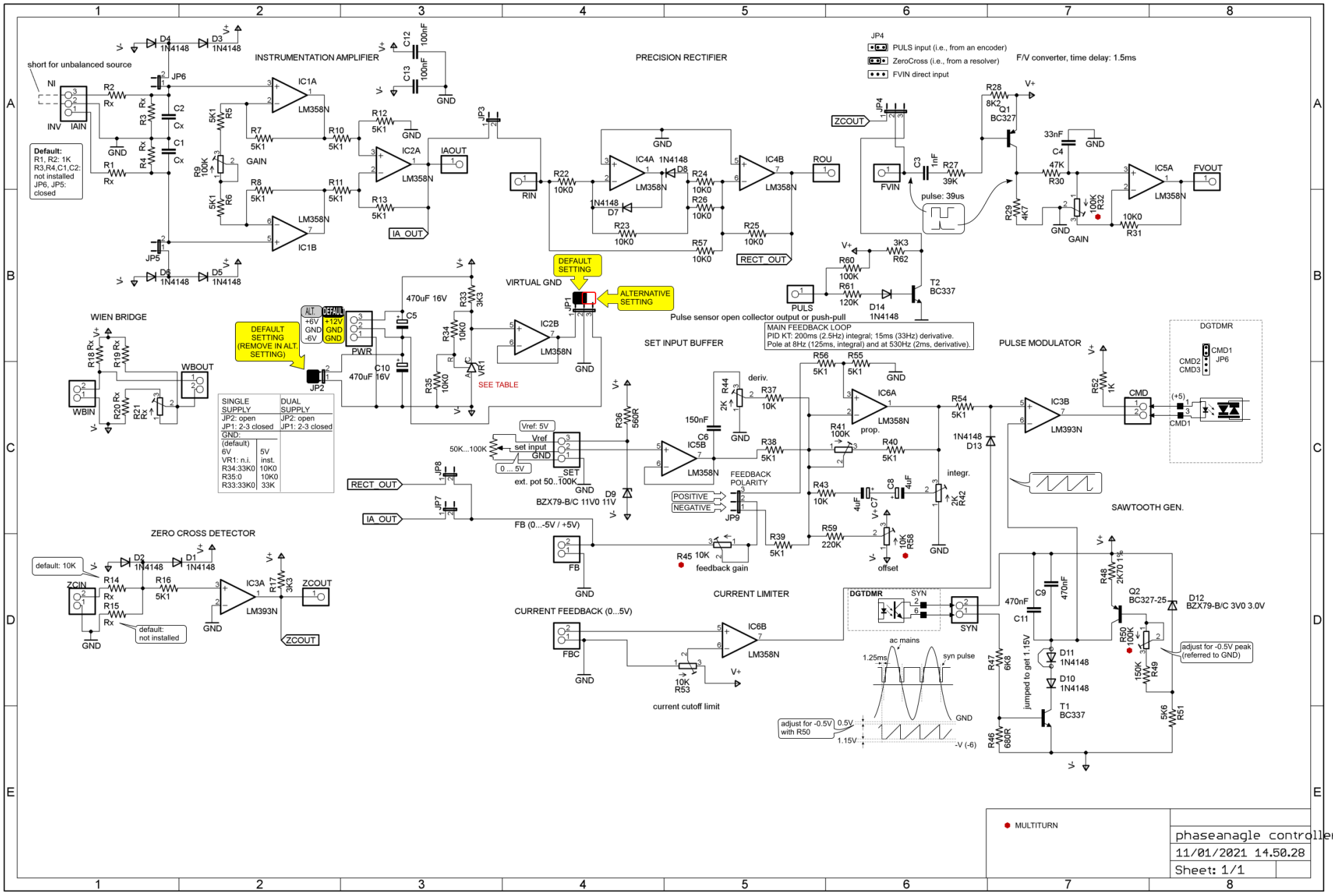
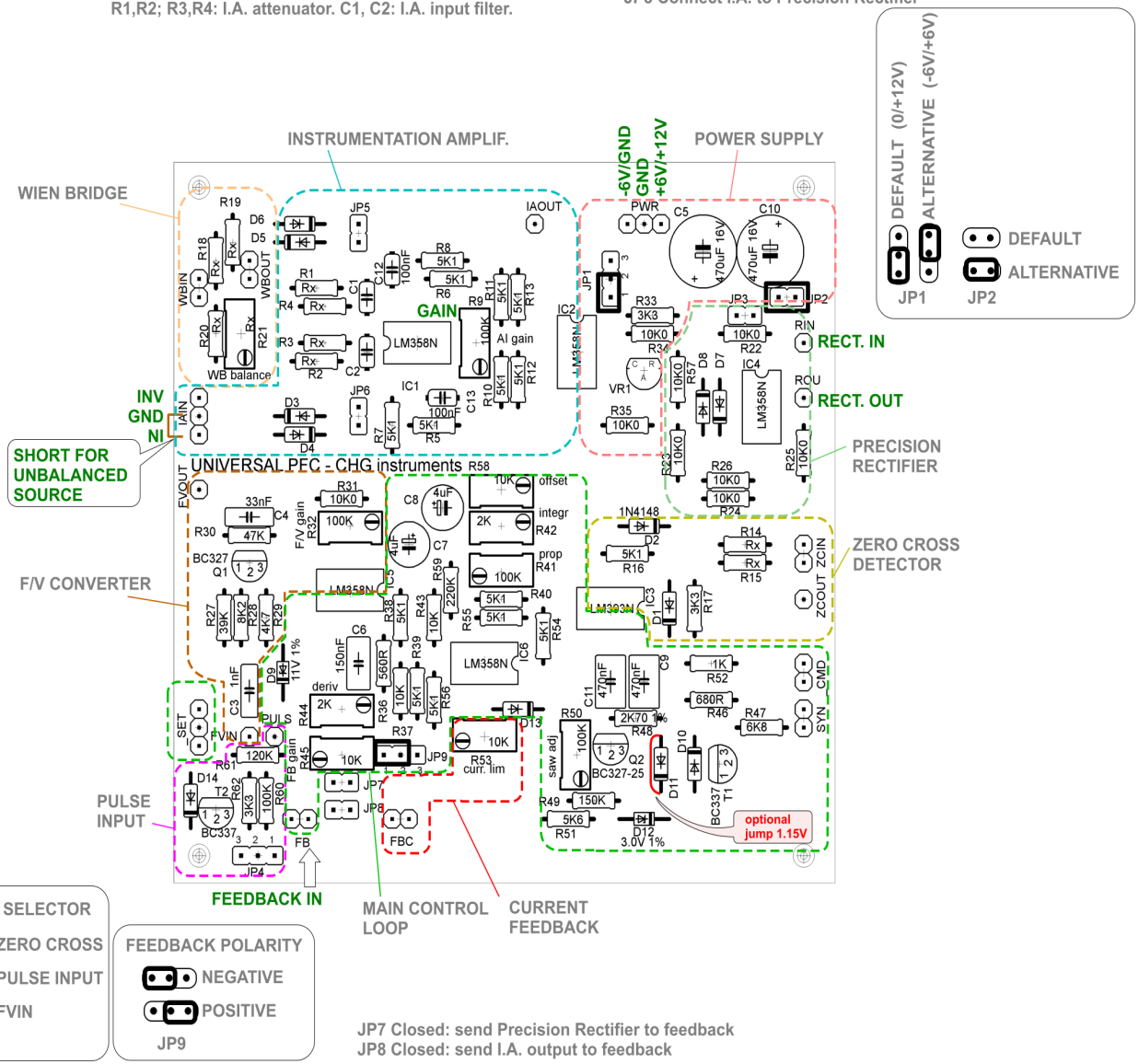

INSTRUMENTATION AMPLIFIER
PRECISION RECTIFIER
F/V converter, time delay: 1.5ms
JP4
PULS input (i.e., from an encoder)
ZeroCross (i.e., from a resolver)
FVIN direct input
short for unbalanced source
Default:
R1, R2: 1K
R3,R4,C1,C2:
not installed
JP6, JP5:
closed
GAIN
LM358N
LM393N
WIEN BRIDGE
VIRTUAL GND
DEFAULT SETTING
ALTERNATIVE SETTING
DEFAULT SETTING (REMOVE IN ALT. SETTING)
SEE TABLE
SINGLE SUPPLY
JP2: open
JP1: 2-3 closed
GND: (default)
6V
VR1: n.i.
R34:33K0
R35:0
R33:33K0
DUAL SUPPLY
JP2: open
JP1: 2-3 closed
5V inst.
10K0
10K0
33K
Pulse sensor open collector output or push-pull
MAIN FEEDBACK LOOP
PID KT: 200ms (2.5Hz) integral; 15ms (33Hz) derivative.
Pole at 8Hz (125ms, integral) and at 530Hz (2ms, derivative).
SET INPUT BUFFER
FEEDBACK POLARITY
POSITIVE
NEGATIVE
feedback gain
offset
PULSE MODULATOR
SAWTOOTH GEN.
ZERO CROSS DETECTOR
default: 10K
default: not installed
CURRENT FEEDBACK (0...5V)
CURRENT LIMITER
current cutoff limit
ac mains
syn pulse
adjust for -0.5V with R50
adjust for -0.5V peak (referred to GND)
jumped to get 1.15V
MULTITURN
phaseanagle controller
11/01/2021 14.50.28
Sheet: 1/1

JP5, JP6: Closed for overvoltage protection.
R1,R2; R3,R4: I.A. attenuator. C1, C2: I.A. input filter.

JP3 Connect I.A. to Precision Rectifier




JP7 Closed: send Precision Rectifier to feedback
JP8 Closed: send I.A. output to feedback

# ASSEMBLY FOR UNIVERSAL MOTOR (DC MOTOR) CONTROL

Install the following blocks: Power Supply (pink area), Main Control Loop (green area), Zero Cross Detector (ocre area), F/V Converter (brown area).

Connect FVOUT to FB Input.

The speed generator (on the motor) should be connected to the Zero Cross Detector's input.